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HARMONIZED TEST METHODS FOR LABORATORY DETERMINATION OF RESILIENT MODULUS FOR FLEXIBLE PAVEMENT DESIGN

FINAL REPORT

Volume II
Asphalt Concrete Material

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FOREWORD

This report deals with the use of the Indirect Tensile Test procedure for measuring the Resilient Modulus and Poisson's Ratio parameters for asphaltic mixtures. It is the second volume (Volume II) of the NCHRP 1-28A project dealing with the development of harmonized test protocol approaches to measure the resilient response of both unbound (soil subgrades, granular subbases and bases) and asphalt mixtures.

All of the testing for the Volume II report was completed while the Principal Investigator was on the faculty at the University of Maryland. The majority of the data analysis and report preparation was accomplished under the auspices of the Principal Investigator when he was affiliated with Arizona State University.

The comprehensive laboratory-testing program, contained in this report, was completed at the University of Maryland by Mrs Hallah Azari in the role of a Graduate Research Assistant. Her work was guided by both Dr. Waseem Mirza, Senior Research Associate at the University of Maryland and then subsequently at Arizona State University, and the Principal Investigator. Valuable discussions regarding the statistical interpretations of the test results were held with Dr. Richard McCuen, Professor of Civil Engineering at the University of Maryland. His assistance is acknowledged by the Project Principal Investigator. Special acknowledgement is also given to Dr. Mirza by the Research Team for his direct Project activity with the laboratory test program, data collection and analysis, and preparation assistance with the final report. Finally the assistance of Mr. Mohammed El-Basyouny, Graduate Research Assistant at Arizona State University, in the coordination of the final report, is also noted by the Principal Investigator.

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CHAPTER 1
INTRODUCTION AND RESEARCH APPROACH

BACKGROUND

The design of flexible and rigid pavements is going through a transition from empirical based designs to mechanistic-empirical or mechanistic design methodologies. At present several empirical and mechanistic procedures are available for the design of flexible and rigid pavement structures. Among those the most common and accepted empirical procedure by is the AASHTO Design methodology. However, in contrast to the AASHTO design methodology, no empirical-mechanistic or mechanistic design methodology is currently available that is universally accepted as a standard method for the design of flexible and/or rigid pavement structures.

As the name indicates, mechanistic based design procedures rely on theory of mechanics by making use of continuum mechanics and/or fracture mechanics models. This requires an understanding of the constitutive relationship or stress-strain behavior of the material. In structural mechanics, for most materials and design processes, elastic modulus of material is most commonly used to describe the stress-strain relationship. However, this may or may not be applicable for the asphalt concrete material. Asphalt being a special material that has elastic, viscous and plastic component even at very low stress levels cannot be fully characterize by elastic modulus only. The relative proportion of these components is highly dependent upon the stress level and the temperature. At very cold temperatures and low stress levels, asphalt behaves more like an elastic body with very little viscous and plastic component and can be characterized by elastic modulus. On the other hand, at relatively warmer temperatures and high stress level, its behavior is more viscous and plastic with a very small elastic component. That is, as in the case of other structural material, elastic modulus is not considered a good choice to describe the stress-strain relationship for asphalt mixes under the applied wheel load all conditions.

Within a pavement system, the mix and the structural design of the asphalt layer is done, such that the strains or deformations that occurs under the wheel load will have all three components (elastic, viscous and plastic). However, the major component of deformation is not viscous or plastic but elastic or it is recoverable. The modulus defined by this recoverable deformation is termed as the resilient modulus (M_R). Since resilient modulus is the major component for the design of pavement structures, it is appropriate to use resilient modulus as an input to determine the stress, strain and deflections in a pavement structure under wheel loading. The response obtained in terms of strains, stresses and deflections is then used for pavement performance evaluation. This is the key towards the development of empirical-mechanistic or mechanistic design procedure for the design of pavements.

LIMITATIONS OF EMPIRICAL DESIGN APPROCH

As mentioned earlier, at present AASHTO design procedure is the most commonly used and accepted empirical design methodology. The design procedure is based on the results of extensive AASHO Road Test conducted in Ottawa, Illinois, in the late 1950s and early 1960s. The AASHO committee on the Design first published an interim design guide in 1961. It was revised in 1972, 1981, 1986 and 1993. These versions of the AASHTO *Guide for Design of Pavement Structures* were based upon the empirical approach have served well for almost four decades. However, there are a number of serious limitations to their continued use as the nation's primary pavement design procedures. Because of this, the new *Guide for the Design of Pavement Structures for New and Rehabilitated Pavements Structures* (NCHRP 1-37A) is a shift from empirical to mechanistic-empirical design methodology. These limitations associated with the empirical design guide include:

- Pavement rehabilitation design procedures were not considered at the AASHO Road Test. Full consideration of rehabilitation design is required to meet today's needs.
- Since the road test was conducted at one specific geographic location, it is difficult to address the effects of differences in climatic conditions on pavement performance. For example, at the road test a significant amount of distress occurred in the pavements

during the spring thaw, a condition that does not exist in a significant portion of the country.

- One type of subgrade was used for all of the test sections at the road test. Many types exist nationally.
- Only un-stabilized, dense granular bases were included in the main pavement sections (limited use of treated bases was included for flexible pavements). Various stabilized types now are used routinely.
- Vehicle, suspension, axle configurations, and tire types were representative of the types used in the late 1950's. Many of these are outmoded in the 1990s.
- Pavement designs, materials, and construction were representative of those used at the time of the road test. No sub-drainage was included in the road test sections.

If we carefully think of the above limitations, most of them are mainly due to the empirical nature of the design approach. That is, if empirical design equations need to be used of other conditions, gross assumptions or a full scale field-testing is required to develop empirical relationships. In order to over come these problems, it was recognized during the development of the 1986 AASHTO Guide that the future design procedures would have to be based on mechanistic – empirical principles. In the 1986 AASHTO Guide, the M_R response of asphalt mixtures was introduced to establish an AASHTO layer coefficient "a_i" value for asphalt mixtures as a step towards mechanistic approach. However, the performance prediction and the design methodology are still based upon empirical relationship.

As mentioned earlier, the new 2002 Design Guide methodology has been completely changed from and empirical approach to a more realistic empirical-mechanistic design approach. The pavement materials are characterized by dynamic (or "resilient") moduli for both asphalt and unbound layers. These material properties are then directly used for the determination of the pavement response. The response obtained is then used to evaluate the effect of variations in materials (both inherent and due to construction procedures) on pavement performance. The 2002 Guide provides a rational relationship between construction and materials specification and the design of the pavement structure. Since the mechanistic procedures are able to better account for climate, aging, today's materials, and today's vehicle loadings, variation in performance in relation to design life should be reduced and the engineer's will be able to design pavements with better predictable performance. That feature will allow agency managers to make better decisions based on life cycle costs and cash flow.

In addition to the most recent 2002 AASHTO design methodology, other mechanistic analysis methodologies use dynamic (or "resilient") moduli of both asphalt and unbound (base/subbase/subgrade) materials have been extensively researched in the U.S. for well over 30 years. Dynamic moduli (hereafter referred to in this proposal as M_R – resilient modulus) were initially introduced in the first US mechanistic based design procedure by Witczak and Shook in 1972 (The Asphalt Institute MS-11 "Full Depth Asphalt Pavement Design of Air Carrier Airfields").

In summary, the determination of resilient modulus is a key input for the mechanistic design procedure. It is important that this input parameter be determined accurately for accurate pavement performance predictions. Inaccurate resilient modulus values will result in erroneous pavement response and pavement performance.

RESEARCH OBJECTIVE

As mentioned earlier, for mechanistic pavement design procedures, it is important to know the dynamic or resilient properties of material to estimate the pavement response and eventually the pavement performance. That is, for accurate determination of the pavement response, it is important to have a good estimate of the material properties (dynamic and resilient). However, with the current state of knowledge, laboratory determination of resilient modulus for asphalt materials is associated with some limitations and inherent problems in accurately measuring the M_R response for asphalt materials. The major issue relates to the accuracy, repeatability and reproducibility with the current measuring system. In addition, the industry needs a more realistic and standard data analysis technique to estimate resilient modulus and Poisson's ratio of asphalt mixes.

In summary, with the current state of knowledge, there still remains no nationally available standard and acceptable way to measure material M_R response into a mechanistically based design/analysis approach. Thus the major object of this study is to develop a protocol for accurate determination of resilient modulus and Poisson's ratio for asphalt mixes.

NCHRP 1-28 Project Objectives

In order to overcome the problems associated with the resilient modulus determination, the National Cooperative Highway Research Program (NCHRP) initiated NCHRP 1-28 Project, "Laboratory Determination of Resilient Modulus for Flexible Pavement Design". This study was awarded to the Georgia Institute of Technology (Dr. R. D. Barksdale et al) and North Carolina State University (Dr. P. N. Khosla et al).

The primary objective of this study was to develop and recommend laboratory test procedures for determining resilient moduli of component materials in a flexible pavement structure. The test procedures were to account for varying field conditions, such as temperature of the asphalt concrete surface layer and moisture content of the base, subbase and subgrade.

The specific objectives of the NCHRP 1-28 project were as follows:

1. Review the state-of-the-art procedures and equipment for laboratory resilient modulus testing.
2. Develop detailed laboratory test procedures for evaluating the resilient modulus of asphalt concrete, aggregate base/subbase materials, and subgrade soils.
3. Perform limited multi-lab validation testing to refine the proposed test procedures.
4. Compare and analyze field-determined moduli using common nondestructive devices with moduli determined using validated test procedures.
5. Review the "1986 AASHTO Guide for Design of Pavement Structures" assessing the applicability and constraints of using resilient moduli values to establish structural coefficients of base and subbase materials.

The NCHRP 1-28 study was completed and a Draft Final Report published as a Privileged Document in October 1996 (1). This study resulted in an excellent set of findings relative to the M_R characterization of asphalt mixtures through the indirect tensile (diametral) test and triaxial test for unbound base/subbase/subgrade soils. While the recommendations and findings covered a wide range of issues and topics relating to the M_R concept, perhaps none was more important than the set of recommendations eventually noted in NCHRP 1-28 for the recommended approach to conducting laboratory M_R tests.

For asphalt mixtures, the NCHRP 1-28 recommended test protocol for determining the M_R response of asphalt mixtures is found in Appendix C of the Draft Final Report (1). In essence, this "proposed" protocol represented an enhancement to ASTM, SHRP and AASHTO procedures. The initial diametral M_R protocol for AC mixtures was originally presented in ASTM D-4123-82. However, as noted in a 1989 M_R Workshop at Oregon State University, the D-4123 approach was found to be unnecessarily time consuming and yielded test results that were extremely difficult to reproduce.

The ASTM D-4123 test approach was then enhanced during the SHRP program and a provisional test protocol developed in November 1992 (SHRP P-07). Several years later this protocol, with minor enhancements, was adopted as an AASHTO test procedure (AASHTO TP 31-94; SHRP Product 5019).

NCHRP 1-28A Project Objectives

While the NCHRP 1-28 (1) study yielded many excellent findings, conclusions and recommendations; the major recommendations involving the development of "yet another set of test protocols" associated with the M_R response of asphaltic mixtures resulted in a significant difficulty relating to the standardization of a unified or "harmonized" test protocol that has universally accepted implementability in the pavement community. Of equal importance towards achieving the goal of implementation is the development of a practical and simple procedure to utilize the M_R test results directly into a mechanistic based approach. Thus, as a consequence of this limitation, the proposed research under NCHRP 1-28A has the following major objective:

> *A single test method for measurement of the resilient modulus of hot-mix asphalt that harmonizes the protocol proposed by the Project 1-28 Contractor (Appendix C of the Draft Final Report of Project 1-28) with the AASHTO TP-31 method and the FHWA-LTPP "Laboratory Start-Up and Quality Control Procedure (Report FHWA-RD-96-176)".*

Based upon the above mentioned objective, the work under NCHRP 1-28A concentrated on the following issues:

1. Preparation of "Harmonized Methods" from the NCHRP 1-28 and existing ASTM/AASHTO/FHWA methods.
2. Conducting necessary laboratory testing and analysis to verify that the harmonized methods provide consistent, reliable results to the existing methods.
3. Preparation of a verified method in Standard AASHTO format for submission to AASHTO.

Development of AASHTO Style Protocol

As mentioned earlier, one of the major recommendations for the NCHRP 1-28 project is to develop a recommended approach to conducting laboratory M_R tests. That is the ultimate objective of this study was to develop AASHTO style final recommended protocol. In essence, this "recommended" protocol represent an enhancement to ASTM, SHRP, AASHTO and NCHRP 1-28 procedures.

The final recommended approach provides guidelines on specimen size, measuring device and selection of transducers. In addition, the protocol also provides guidelines on analysis methodology for the determination of resilient modulus and Poisson's ratio.

RESEARCH APPROACH AND WORK PLAN

For purposes of this project, the work approach has been subdivided into two major work Tasks. They are:

Task 1: Develop Implementable M_R Protocol for AC Mixtures
Task 2: Develop Implementable M_R Protocol for Unbound Materials

In the development of this work plan, greatest majority of effort and resources were focused upon Task 2 dealing with the M_R Protocols for Unbound Materials. The level of effort and cost estimates is 2/3 for Task 2 and 1/3 for the asphalt layer for the development of resilient modulus prediction for asphalt mixes. This is because the Task 2 Effort on Unbound materials can, in reality, be subdivided into two separate component materials (aggregates and soils), the proposed plan can be generally viewed as focusing equal efforts on the three major materials to be investigated: (a) asphalt mixtures (b) unbound aggregate and (c) fine grained subgrades.

This report covers the details related to the work plan description for the asphalt mixture. The description for the unbound is covered in another report. In order to accomplish the above-mentioned objective, the overall work for asphalt mixtures was divided into four subtasks. They are as follows:

Subtask A: Literature Review
Subtask B: Conduct Lab Tests
Subtask C: Analysis of the Results
Subtask D: Develop AASHTO Style Protocol

A more detailed description of the proposed work elements follows.

Subtask A: Literature Review

This subtask had three individual work elements. They are:

A.1: Conduct Literature Review

A.2: Identify Major Protocol Differences

A.3: Recommend Provisional Protocol

As can be observed, a major objective of this subtask effort was to develop a clear and concise identification of all significant protocol differences existing between FHWA/ASTM/AASHTO and the NCHRP 1-28 proposed approaches for the M_R evaluation of asphalt mixtures (Task 1). This comparison was considered to be vitally important to study the pros and cons associated with each protocol. It was after this comparison study, the research team was able to formulate a provisional protocol to be used in this current research work (NCHRP 1-28A).

Subtask B: Conduct Lab Tests

Using the provisional protocol recommended in Subtask A, laboratory testing was conducted to evaluate the M_R response on pre-selected materials. For Task 1 (AC mixtures), the three mixtures with nominal aggregate size of 12.5, 19.0 and 37.5mm were evaluated. The gradation was based upon Superpave mix design approach and the binder used was PG 64-22. The details of the binder, aggregate and mixture designs used for evaluation of the resilient modulus protocol are discussed in detail in Chapter 5.

Under this study testing for resilient modulus for asphalt mixes was carried using the SHRP load guide device (LGD). A The SHRP load guide device (LGD) has been modified to have the capability of testing 4-inch and 6-inch diameter specimens. In addition, the device has also been modified to have capability of measuring "off-sample" and "on-sample" measurements. That is, in total, one can have 7 deformation measurements. These include, one vertical external (off-sample) LVDT for measurement of tensile strength of asphalt mixture, two external horizontals and four on-sample mounted LVDTs. For the 7-LVDT's and the load, data acquisition program was used during the testing to capture the data for analysis. In addition, the counter weights on the LGD were replaced by compression springs. The selection of the spring were done such that minimal applied load is transferred to the springs. The objective of the springs was to balance the load of the top base plate, so that it is not transferred to the specimen during the test. This is shown in Figure 1.1.

A summary of the test plan to study the sensitivity of various parameters is provided in Table 1.1 and the details are provided in Chapter 6. Under this plan, three mixes were considered and are discussed in detail in Chapter 5. These mixes were tested using different gage lengths to study the effect of gage on the aggregate and specimen size. All tests were conducted at one controlled temperature (25°C), since the outcome of these tests were not temperature sensitive and the results can be applied to different temperatures.

Subtask C: Analysis of Results

One of the major tasks was to analyze the results obtained under Subtask B (Conduct Lab Tests). An analysis program was developed at University of Maryland and used to automatically estimate the resilient modulus and Poisson's ratio from the raw data obtained during the test. The raw data was obtained by using a data acquisition program also developed at the University of Maryland. The analysis program was able to analyze the results for different gage lengths and for both 4-inch and 6-inch diameter specimens.

Subtask D: Develop AASHTO Style Protocol

This subtask involves the development of a final test protocol for M_R that will be prepared in an AASHTO style format. Final recommended protocols for M_R test developed under this project for asphalt mixes is presented in Appendix B of this report.

REPORT ORGANIZATION

This report is divided into eight chapters and two appendices. The following briefly summarizes the content included in each of these chapters and appendices.

Chapter 2 discusses the various methods of obtaining resilient modulus for asphalt mixes, however, the concentration is placed on indirect (diametral) tensile test system. It includes a detailed discussion on the theoretical background for indirect (diametral) testing, which included the elastic solutions presented by Hondros and Frocht. Using the elastic solution presented by Hondros, the chapter discusses the details for determination of materials properties such as the resilient modulus and Poisson's ratio. Finally, using the elastic solutions presented by Hondros and Frocht, sensitivity analysis for specimen size, loading strip width, eccentricity of horizontal deflection transducer, eccentricity of vertical loading strip and vertical and horizontal specimen eccentricities are discussed in detail.

Chapter 3 discusses the details of the indirect tensile measurement system. This included problems with the existing measurement and analysis systems. The chapter includes details for most commonly used devices for resilient modulus test of asphalt mixes. Finally, details of recommended and proposed measuring system for resilient modulus measurement is presented.

Chapter 4 discusses the details of the existing protocols for determination of resilient modulus of asphalt mixes. This included ASTM D-4123-82, SHRP P-07, AASHTO TP31-94 and NCHRP 1-28. In addition, it also details the specification for the new proposed protocol under NCHRP 1-28A project.

Chapter 5 discusses the Superpave mixture used in this study. This includes surface course mixture with nominal maximum size of 12.5 mm and 19.0 mm, and a base course mixture with a nominal maximum size of 37.5 mm. The chapter provides details of aggregate, binder and the mix design for the asphalt mixes used in this study.

Chapter 6 provides information on the laboratory-testing program used for this research effort. It discusses the basic goals of the laboratory study, description of the test method utilized, experimental plan and the estimation of variance components for final analysis.

Chapter 7 is the most important chapter that includes the data analysis results. It provides the data summaries along with the variance components for the variables used in this study. It provided the details of the effect of gage length on the specimen and aggregate size. Finally, summary of results and major finding are included in the chapter.

Chapter 8 is the summary chapter that summarizes the finding. Based upon the finding, final recommendations for the harmonized protocol is presented in this chapter.

Appendix A is the summary of all the test data generated during this project.

Appendix B is the summary of component variance analysis of all the test data generated during this project.

Appendix C finally contains the final recommended protocol. The protocol is presented in an AASHTO format.

CHAPTER 2
THEORETICAL BACKGROUND

INRODUCTION

The design of flexible and rigid pavements is going through a transition from empirical based procedure to mechanistic-empirical or mechanistic design methodologies. The new *Guide for the Design of Pavement Structures* (NCHRP 1-37A) for new and rehabilitated highway pavements will be based upon mechanistic-empirical procedures. It clearly states that the empirical design approaches often are inadequate and mechanistic-empirical approaches are more realistic to characterize in-service pavements and improve the reliability of designs. Because of this, the current AASHTO design procedure for the design of new and rehabilitated pavements is being modified from empirical to mechanistic-empirical design approach. The new guide under the NCHRP 1-37A is based (2002 Guide) is based upon mechanistic principles. The pavement system can be treated as linearly elastic and uses JULEA (layer elastic analysis program) for pavement response. Since most pavement materials, especially the unbound material can have non-linear behavior; can be analyzed by using Finite Element Analysis for the determination of the pavement response.

In general, the mechanistic based procedures rely on theory of mechanics by making use of continuum mechanics and/or fracture mechanics models. The use of mechanistic based models requires an understanding of the stress-strain behavior of the material. This relationship can then be used for predicting stresses, strains, and deflections induced in a layered pavement structure.

In structural mechanics, for most materials and design processes elastic modulus of material is most commonly used to describe the stress-strain relationship. Asphalt being a special material that has elastic, viscous and plastic component even at very low stress levels cannot be fully characterize by elastic modulus only. The relative proportion of these components is highly dependent upon the stress level and the temperature. At very cold temperatures and low stress levels, asphalt behaves more like an elastic body with very little viscous and plastic component. On the other hand, at relatively warmer temperatures and high stress level, its behavior is more viscous and plastic with a very small elastic component. That is, as in the case of other structural material, elastic modulus is not considered a good choice to describe the stress-strain relationship for asphalt mixes under the applied wheel load.

Within a pavement system, the mix and the structural design of the asphalt layer is done, such that the strains or deformations that occurs under the wheel load will have all three components (elastic, viscous and plastic). However, the major component of deformation is not viscous or permanent but elastic or it is recoverable. The modulus defined by this recoverable deformation is termed as the resilient modulus. Since resilient modulus is the major component, it is appropriate to use resilient modulus as an input to determine the stress, strain and deflections in a pavement structure under wheel loading.

RESILIENT MODULUS

In definition, resilient modulus is defined as elastic modulus based on the recoverable strain under repeated load. Mathematically this is defined as:

$$M_R = \frac{\sigma_d}{\varepsilon_r} \qquad (2.1)$$

In the above equation, σ_d is the deviator stress and ε_r is the recoverable strain. Because the applied load is usually small, the resilient modulus test is a nondestructive test and the same sample can be used for many tests under different loading and temperature conditions.

Figure 2.1 shows the load and deformation plot as a function of time obtained from the resilient modulus testing. Under the SHRP P07 Protocol, haversine load pulse is used with constant amplitude during the test. The type and duration of the loading used in the repeated load test simulates the stress pulse that actually occurs in the field. When a wheel load is at a considerable distance from a given point in the pavement, the stress at that point is zero. When the load is above the given point, the stress at the point is maximum resulting in a haversine waveform. The duration of which depends on the vehicle speed and the depth of the point below the pavement surface.

Under the SHRP P07 Protocol, it was recommended to use a load pulse of 0.1 second with a rest period of 0.9 second as shown in Figure 2.1. This result is a cycle time of 1.0 second. A typical plot deformation will result in considerable permanent deformation for the initial cycles. As the number of cycles increases, the plastic strain due to each load repetition decreases. A stage will arise (typically between 100 to 200 cycles), when the strain is practically recoverable. This recoverable strain (ε_r) is then used in Equation 2.1 for the calculation of resilient modulus.

The deformation plot shown in Figure 2.1, identifies two possible measurements of vertical and horizontal recoverable deformations to be used for resilient modulus evaluation. These two deformations are called the instantaneous (Δ_I) and the total (Δ_T). The details of estimating these deformations are provided in SHRP Protocol, P07 and is also presented in the current protocol as is attached in Appendix B.

The instantaneous deformation represent purely the elastic recoverable portion, whereas, the total represents the viscous or the time-delayed component. This time-delayed component represents the viscosity and the difference between the two measurements can be regarded as an approximate measure of material viscous response at specified load conditions. Note that in purely elastic material, no delay of deformation takes place resulting in only one response and one modulus value. The recoverable deformations obtained under the given load are then used to estimate the resilient modulus of the mix. The details of which are presented in the remaining chapter.

INDIRECT (DIAMETRAL) TENSILE TEST SYSTEMS

Over the past five decades, a number of test systems and procedures have been used to determine the resilient properties of asphalt mixes. However, the main feature for all the test method was that it should be able to apply repeated cyclic loading on the test specimen. The response of the specimen is usually measured by using some deflection/strain measurement device. The most common among the deflection measurement devices are the LVDTs, whereas the strain is usually measured by the strain gage. The LVDT's are becoming more popular because of cost, reusability and easier to handle. In addition, with the recent development in technology, smaller, miniature, light weight LVDT's are commercially available that can easily be mounted on the test specimen for deformation measurements.

To date, several resilient modulus measurement devices and procedures have been developed with an objective to accurately measure the resilient modulus of the asphalt mixes. Unfortunately, all these procedures and methodologies are associated with certain limitations and disadvantages. Among these methodologies and procedures the most commonly used procedures are:

1. Direct tension
2. Flexural beam (bending)
3. Indirect diametral tension
4. Triaxial compression

A complete discussion of all the above-mentioned procedures is beyond the scope of this report. The intent for all the test procedures is to simulate the actual field condition to the maximum possible extent in terms of load applied and the response for the computation of the resilient modulus of asphalt mixes.

Figure 2.2 schematically illustrates the stresses induced by a wheel load in a layered pavement system. As shown in the figure several different types of stresses at different location occur within the pavement layer. These can be divided into four general cases (2):

1. Triaxial compression at the surface and immediately underneath the wheel.
2. Longitudinal and transverse tension combined with vertical compression at the bottom of the asphalt concrete layer and immediately underneath the load.
3. Longitudinal or transverse tension at the surface at some distance from the load.
4. Longitudinal or transverse compression at the bottom of the asphalt layer at some distance from the load.

It is obvious that one test procedure cannot account for all types of stresses that occur in the asphalt layer under the wheel load. Certain testing modes are more appropriate for evaluating the specific stress condition that exists under the pavement surface. However, it is not important to have a test procedure that can simulate all stress states that occur under the wheel load. The important issue is to predict or simulate the critical stress that causes distress within the pavement surface.

The critical location for the load-induced cracking is generally considered to be at the bottom of the asphalt concrete layer and immediately under the load, where the stress state is longitudinal and transverse tension combined with the vertical compression as shown in Figure 2.2. A test procedure that can simulate this stress state is probably the one that should be used to predict the load-induced cracking in the pavement layer.

Figure 2.3 (3) shows the state of stress in an indirect tensile stress step up. It was observed that the state of stress in the vicinity of center of the specimen face is very similar to recommended stress state, except tension is induced in one direction rather than two axes. Roque and Ruth (4) showed that modulus values determined using strain gage measurements obtained in this zone of the indirect tension specimen resulted in excellent prediction of strains and deflections measured on a full scale pavements at low-service temperatures (< 30°C), when the moduli were used in elastic layer analysis.

In addition, to the stress states that occurs within the test specimen, other important features that make this test one of the most widely used are:

- it is considered to be the simplest and most cost effective,
- can be run on relatively small samples obtained from the field,
- can be used for determination of tensile strength, elastic modulus and Poisson's ratio,
- can be used for both static as well as dynamic loading,
- and can be used to determine the elastic, fatigue, permanent deformation and moisture susceptibility characteristics of the material.

THEORETICAL BACKGROUND

In most of test methods mentioned earlier, a uniaxial state of stress exists within the test specimen, making it easier to analyze by using the theory of mechanics. However, in the case of an indirect tensile test, the state of stress is biaxial making it more difficult to analyze. This section provides a brief discussion on the theoretical background of indirect tensile testing along with the applicability of the existing ASTM D 4123 equations in predicting the Poisson's ratio and modulus values through the use of an indirect diametral tensile test.

The word "diametral" is used because the specimen is loaded along its diameter, which produces compressive stresses in the vertical direction and tensile stresses in the horizontal direction along the vertical diameter. The word "indirect" is used because direct tensile force is not used to produce the tensile stresses used in determining the material properties.

With regard to the practical significance, the test can be used for determining the tensile strength along with other material properties such as the elastic modulus and the Poisson's ratio. The tensile strength of the material is important to define the fatigue properties of bound pavement layers. Whereas, the determination of elastic (resilient) modulus and the Poisson's ratio is essential to both the multi-layer elastic or finite element methods for pavement structural design.

Several researchers including Wright, Olszak Kajfasz and Pietrzykowski, Timoshenko, Frocht, Muskhelishvili and Sokolnikoff (3,5,6,7,8,9) solved the stress equations of the circular element subjected to concentrated forces. However, the standard test requires a strip load on the specimen rather than the concentrated force. Hondros (10) took the next step and developed a closed form solution of stresses along the horizontal and vertical diametral axis due to a strip loading along the diametral axis. Stresses along the principal diameters are given by the following equations.

Stresses along the Horizontal Diameter (OX) - Hondros Solution

$$\sigma_{\theta x} = \sigma_{yx} = -\frac{2P}{\pi a t}\left[\frac{(1 - r^2/R^2)\sin 2\alpha}{(1 + 2r^2/R^2\cos 2\alpha + r^4/R^4)} + \tan^{-1}\frac{(1 - r^2/R^2)}{(1 + r^2/R^2)}\tan\alpha\right] \qquad (2.2a)$$

$$\sigma_{rx} = \sigma_{xx} = +\frac{2P}{\pi a t}\left[\frac{(1 - r^2/R^2)\sin 2\alpha}{(1 + 2r^2/R^2\cos 2\alpha + r^4/R^4)} - \tan^{-1}\frac{(1 - r^2/R^2)}{(1 + r^2/R^2)}\tan\alpha\right] \qquad (2.2b)$$

Stresses along the Vertical Diameter (OY) - Hondros Solution

$$\sigma_{\theta y} = \sigma_{xy} = +\frac{2P}{\pi a t}\left[\frac{(1 - r^2/R^2)\sin 2\alpha}{(1 - 2r^2/R^2\cos 2\alpha + r^4/R^4)} - \tan^{-1}\frac{(1 + r^2/R^2)}{(1 - r^2/R^2)}\tan\alpha\right] \qquad (2.2c)$$

$$\sigma_{ry} = \sigma_{yy} = -\frac{2P}{\pi a t}\left[\frac{(1 - r^2/R^2)\sin 2\alpha}{(1 - 2r^2/R^2\cos 2\alpha + r^4/R^4)} + \tan^{-1}\frac{(1 + r^2/R^2)}{(1 - r^2/R^2)}\tan\alpha\right] \qquad (2.2d)$$

In the above equations, a double subscript notation is employed for stresses, the first indicating the direction of the stress and the second refers to the axis. The variable "t" represents thickness of the circular element, the remaining variables are shown graphically in Figure 2.4(a).

The graphical representation of the stresses along the principal planes corresponding to the diameters through the OX and OY axes for a loading strip width of 12.7 mm (0.5 inch) are shown in Figure 2.4(b). The data in the figure are normalized to $2P/\pi at$. The figure shows that the tangential (xy) and radial (yy) stresses along the y-axis converge to a high compressive stress values at the strips, equal to the applied pressure. Tangential (yx) and radial (xx) stresses along x-axis reach a value of zero at the boundary. In addition, the tangential (xy) stresses along the vertical diameter are approximately constant from the center to r/R = 0.60, whereas, other stresses suffer relatively greater changes near the center of the element. As mentioned earlier, stress equations provided by Hondros are only applicable for vertical diametral loading and no account of misalignment can be made. Thus, if the sample is not properly aligned, Hondros equations are not applicable to estimate the stresses within the test specimen.

In order to account for misalignment of load and to study the sensitivity of misalignment on the results, stress equations developed by Frocht (3) are considered for the analysis. The equations are given below:

Stresses in X-direction - Frocht Solution

$$\sigma_{xx} \text{ or } \sigma_{xy} = -\frac{2P}{\pi t}\left[\frac{(y_1 - y)(x - x_1)^2}{r_1^4} + \frac{(y_1 + y)(x - x_1)^2}{r_2^4} - \frac{\sin(\pi/2 + \alpha)}{d}\right] \quad (2.3a)$$

Stresses in Y-direction - Frocht Solution

$$\sigma_{yy} \text{ or } \sigma_{yx} = -\frac{2P}{\pi t}\left[\frac{(y_1 - y)^3}{r_1^4} + \frac{(y_1 + y)^3}{r_2^4} - \frac{\sin(\pi/2 + \alpha)}{d}\right] \quad (2.3b)$$

where

$$r_1^2 = (x - x_1)^2 + (y_1 - y)^2 \quad (2.3c)$$

$$r_2^2 = (x - x_1)^2 + (y_1 + y)^2 \quad (2.3d)$$

The variables used in the above equation are graphically represented in Figure 2.5 (a). The point "M" represents the point of stress determination. In contrast to the Hondros solution, which is for strip loading, Frocht's equations are for a concentrated load. The graphical representation of the calculated stresses for a concentrated load along the vertical and horizontal diametral axis are shown in Figure 2.5(b). Similar to Figure 2.4(b), the stresses are normalized to 2P/πat. A comparison of Figure 2.4(b) and Figure 2.5(b) shows a similar trend in the stress distribution. However, the small difference in the stresses along the y-axis is due to the difference in loading style; that is, strip loading versus concentrated load.

The stress solutions presented both by Hondros and Frocht are both based upon the two-dimensional analysis. This is because of the inherent complexity of the general three-dimensional analysis. Mathematically, the generalized three dimensional stress equations of equilibrium (presented by Malvern (12)) is given as:

$$\nabla^2\left[\alpha\nabla\phi + \nabla\times\psi\right] = -\frac{\rho b}{G} \qquad (2.4a)$$

where

$$\alpha = \frac{2(1-\mu)}{1-2\mu} \qquad (2.4b)$$

In the above equation, ϕ is the Airy's stress function, Ψ is a displacement field, ∇ is the Laplacian operator, ρ is the density, b are body forces, G is the shear modulus and μ is the Poisson's ratio. The left side of the equation represents the deformations and the rigid body motion, whereas the right hand side of the equation represents the body force. The equation shows that the stresses within the element are dependent upon the Poisson's ratio, μ, that is, the stresses are dependent upon the material properties. In the case of a two dimensional analysis, the stress equilibrium equation based upon the theory of elasticity for plane stress and plane strain, excluding body forces, is given as:

$$\nabla^4\phi = 0 \qquad (2.4c)$$

The above equation is a biharmonic equation and is independent of the Poisson's ratio or the elastic constants. This is a very important simplification, since it indicates that the stresses obtained from two materials are identical, if the body forces are ignored. The stress equations developed by Hondros and Frocht are based upon the two dimensional analysis by ignoring the body forces. Because of the simplifications used in the development of the two dimensional equations, it is important to evaluate the applicability of the above stress equations to the testing conditions used in the indirect tensile test.

DETERMINATION OF MATERIAL PROPERTIES BY INDIRECT TENSILE TEST

The two properties of interest that will be discussed in this chapter are the elastic (resilient) modulus and the Poisson's ratio. Elastic modulus and Poisson's ratio are used in the structural response analysis models to calculate the pavement structural response to wheel loads, and with pavement design procedures to design pavement structures. Before going into the details of the material properties, a short description of the theory of elasticity and stress-strain relationship is presented.

Theory of Elasticity

The equations developed by Hondros and Frocht are based upon a two dimensional elastic analysis. The application of elastic theory assumes that the material is homogeneous, isotropic, and linear elastic. However, in the case of asphalt mixtures these assumptions may or may not be true and the material may be far from being homogeneous and isotropic. According to Timoshenko, "the assumption of homogeneity can be applied as long as the geometrical dimensions defining the form of a body are very large in comparison with the dimension of a single crystal, and if the crystals are oriented at random the material can be treated as isotropic".

In addition, for the material to be homogeneous and isotropic, it is important that the material response under load is elastic and that micro-fractures under the load do not occur. In situations where either the formation of micro-cracking has initiated or the elastic range of the material has been exceeded by the applied loading, these violations of the model assumption will invalidate the diametral theory.

Stress-Strain Relationship

The fundamental assumption underlying the interpretation of the diametral compression test according to procedures described in ASTM D4123-82, and SHRP Protocol P07 (1993), is that the stresses and strains in the cylindrical specimen can be derived from linear elastic solution. That means that asphalt concrete can be regarded as a linear elastic material, with the stresses and strains satisfying the generalized Hooke's law. According to Hooke's law, the state of stress at any given point of interest within a body, the magnitude and direction of the resultant stress on any plane can be defined by nine Cartesian components. This includes three normal stresses and six shear stresses.

$$\varepsilon_{xx} = \frac{1}{E}[\sigma_{xx} - \mu(\sigma_{yy} + \sigma_{zz})] \quad (2.5a)$$

$$\varepsilon_{yy} = \frac{1}{E}[\sigma_{yy} - \mu(\sigma_{xx} + \sigma_{zz})] \quad (2.5b)$$

$$\varepsilon_{zz} = \frac{1}{E}[\sigma_{zz} - \mu(\sigma_{xx} + \sigma_{yy})] \quad (2.5c)$$

$$\varepsilon_{xy} = \frac{1+\mu}{E}\sigma_{xy} \quad (2.5d)$$

$$\varepsilon_{xz} = \frac{1+\mu}{E}\sigma_{xz} \quad (2.5e)$$

$$\varepsilon_{yz} = \frac{1+\mu}{E}\sigma_{yz} \quad (2.5f)$$

Where σ_{xx}, σ_{yy}, σ_{zz} and ε_{xx}, ε_{yy}, ε_{zz} are the normal stresses and strains, σ_{xy}, σ_{xz}, σ_{yz} and ε_{xy}, ε_{xz}, ε_{yz} are the shear stresses and strains respectively. In the case of the indirect tensile test, if the element is diametrically loaded along the vertical axis, all shear stresses equal zero. The three dimensional strains developed because of the normal stresses can be rewritten as:

$$\varepsilon_{x} = \frac{1}{E}[\sigma_{x} - \mu(\sigma_{y} + \sigma_{z})] \quad (2.5g)$$

$$\varepsilon_{y} = \frac{1}{E}[\sigma_{y} - \mu(\sigma_{x} + \sigma_{z})] \quad (2.5h)$$

and

$$\varepsilon_{z} = \frac{1}{E}[\sigma_{z} - \mu(\sigma_{x} + \sigma_{y})] \quad (2.5i)$$

For the purpose of simplification of the analysis, the three dimensional analysis can be reduced to a two dimensional analysis for special element size and loading conditions. The two extreme conditions for the two dimensional analysis are the (a) plane stress and (b) plane strain. The applicability of these two types of analyses is a function of the size of the element.

In the case of a thin plate, the stress along the thickness, σ_z is zero on both faces of the plate, and it may be assumed tentatively that they are zero also within the plate. Additionally, the strain in the z direction (ε_z) may be neglected for further simplification. The state of stress is then specified by σ_x and σ_y only, and is called plane stress. The above relationships can be simplified and reduced to:

$$\varepsilon_x = \frac{1}{E}(\sigma_x - \mu\sigma_y) \qquad (2.6a)$$

and

$$\varepsilon_y = \frac{1}{E}(\sigma_y - \mu\sigma_x) \qquad (2.6b)$$

A similar simplification is possible at the other extreme when the dimension of the body in the *z* direction (along the thickness) is very large. In this case, strain in the *z* direction at the ends and at the midsection equal zero, with the corresponding simplification of eliminating the σ_z component. The above equation can then be modified as:

$$\varepsilon_x = \frac{1+\mu}{E}[(1-\mu)\sigma_x - \mu\sigma_y] \qquad (2.7a)$$

and

$$\varepsilon_y = \frac{1+\mu}{E}[(1-\mu)\sigma_y - \mu\sigma_x] \qquad (2.7b)$$

In the above two sets of equations, if the stress and strains within the specimen are known. Equations 2.6 or Equations 2.7 can be solved to obtain the two unknown material properties modulus (E) and the Poisson's Ratio (μ). Thus, the key is to estimate the stresses and strain within the test specimen.

Elastic Modulus and Poisson's Ratio

The equations presented by the theory of elasticity are a function of material properties and can thus be used for the prediction of material properties, both for the plane stress and plain strain situation and is discussed below.

Plane Stress Solution

For a circular disk, the total deformation, δ, in the x and y directions can be obtained by integrating the plane stress equation over the radius from -r to +r. This will result in the following equations:

$$\delta_{yy} = \int_{-r}^{+r} \varepsilon_{yy} = \int_{-r}^{+r} \frac{1}{E}(\sigma_{yy} - \mu\sigma_{xy}) \tag{2.8a}$$

and

$$\delta_{xx} = \int_{-r}^{+r} \varepsilon_{xx} = \int_{-r}^{+r} \frac{1}{E}(\sigma_{xx} - \mu\sigma_{yx}) \tag{2.8b}$$

The second subscript in the above equations refers to the horizontal (subscript x) and vertical (subscript y) axis. Solving the above two equations for Poisson's ratio, μ, will result in the following form:

$$\mu = \frac{\delta_{yy} \int_{-r}^{+r} \sigma_{xx} - \delta_{xx} \int_{-r}^{+r} \sigma_{yy}}{\delta_{yy} \int_{-r}^{+r} \sigma_{yx} - \delta_{xx} \int_{-r}^{+r} \sigma_{xy}} = \frac{\int_{-r}^{+r} \sigma_{xx} - \frac{\delta_{xx}}{\delta_{yy}} \int_{-r}^{+r} \sigma_{yy}}{\int_{-r}^{+r} \sigma_{yx} - \frac{\delta_{xx}}{\delta_{yy}} \int_{-r}^{+r} \sigma_{xy}} \tag{2.9}$$

After obtaining the Poisson's ratio, the modulus can be obtained from equations (2.8a) or (2.8b) for a known corresponding deflection value. The deflection values can be obtained from the laboratory indirect tensile test. The deflection in the vertical direction, δ_{yy}, is compressive and is negative and should be entered as a negative value in the above equations. Both horizontal and vertical deformations should result in a unique modulus value.

Plane Strain Solution

Similar to the plane stress analysis, the total deformation in the x and y directions can be obtained by integrating the plane strain equation over the radius from -r to +r. This will result in the following equations:

$$\delta_{xx} = \int_{-r}^{+r} \varepsilon_{xx} = \int_{-r}^{+r} \frac{1+\mu}{E}[(1-\mu)\sigma_{xx} - \mu\sigma_{yx}] \tag{2.10a}$$

and

$$\delta_{yy} = \int_{-r}^{+r} \varepsilon_{yy} = \int_{-r}^{+r} \frac{1+\mu}{E}[(1-\mu)\sigma_{yy} - \mu\sigma_{xy}] \tag{2.10b}$$

Solving the above two equations for Poisson's ratio, μ, will result in the following form:

$$\mu = \frac{(1-\mu)\sigma_{xx} - \mu\sigma_{yx}}{(1-\mu)\sigma_{yy} - \mu\sigma_{xy}} = \frac{\int_{-r}^{+r}\sigma_{xx} - \frac{\delta_{xx}}{\delta_{yy}}\int_{-r}^{+r}\sigma_{yy}}{\int_{-r}^{+r}\sigma_{xx} + \int_{-r}^{+r}\sigma_{yx} - \frac{\delta_{xx}}{\delta_{yy}}\int_{-r}^{+r}\sigma_{yy} - \frac{\delta_{xx}}{\delta_{yy}}\int_{-r}^{+r}\sigma_{xy}} \tag{2.11}$$

Similar to the plane stress case, δ_{yy} is compressive and should be entered as a negative value. After obtaining the Poisson's ratio, the modulus can be obtained from equations (2.10a) or (2.10b) for a corresponding known deflection value.

Evaluation of Stress Integrals

The prediction of elastic modulus and the Poisson's ratio requires the determination of the integrals used in the above equations. A closed form solution of each equation involves a complicated mathematical integral; therefore, integration of the above equations is determined through numerical integration. In the case of the Hondros solution, single integration over the gage length was carried out by using the Gauss-Legendre solution approach. Mathematically, this is defined as:

$$Integrated\ Stress = \int_{-r}^{+r} f(x)dx \tag{2.12}$$

The limits ±r define the gage length over which the stresses are desired for the calculation of deformations. These deformations over the specific gage length can then be compared with the experimental results for the verification of the two dimensional model. Using numerical integration techniques, Table 2.1 provides the results of integrated stresses for several gage lengths and a strip width of 12.7 mm (0.5 inch) for a 100 mm (4 inch) diameter specimen. The graphical representations of the integrated stresses normalized by $2P/\pi at$ is shown in Figures 2.3c. The figure shows that relatively high compressive stresses are developed close to the loading strips. This may result in the punching or flow of material, violating the assumptions of elastic theory. A remedial measure may be the use a gage length of less than 100 mm (4 inch).

In the case of the Frocht solution, double integration is required to determine the stresses over a desired gage length. The first integration is required to determine the stresses due to a strip load, whereas, the second integration is required to find the stresses over a desired gage length. In this analysis, double integration is carried out using a composite Simpson solution method. Mathematically, this is defined as:

$$Integrated\ Stress = \int_{-r}^{+r} \int_{-b}^{+b} f(x,s)\, ds\, dx \qquad (2.13)$$

In the above equation ± b represents the lower and upper integration limits of the strip that is the width of the strip. To include the effects of misalignment, the lower and upper limits are mathematically defined as:

$$Lower\ Limit = -b = -\left[X_{offset} - \left\{ R\left(\frac{X_{offset}}{R} Cos\frac{SW}{2R} - \frac{\sqrt{R^2 - X_{offset}{}^2}}{R} Sin\frac{SW}{2R} \right) \right\} \right] \qquad (2.14a)$$

and

$$Upper\ Limit = +b = -\left[\left\{ R\left(\frac{X_{offset}}{R} Cos\frac{SW}{2R} + \frac{\sqrt{R^2 - X_{offset}{}^2}}{R} Sin\frac{SW}{2R} \right) \right\} - X_{offset} \right] \qquad (2.14b)$$

In the above equations, SW defines the loading strip width and X_{offset} defines the misalignment of load with respect to the y-axis. The results of integration from the Frocht solution without misalignment are graphically shown in Figure 2.4c (normalized by $2P/\pi at$) for a strip width of 12.7 mm (0.5 inch) and a specimen diameter of 100 mm (4 inch).

Figure 2.3c and Figure 2.4c shows similar trends for the two solutions. As mentioned earlier, the reason for performing the Frocht analysis is so that the effects of misalignment of the specimen can be estimated. Observations from these plots include:

- tangential stresses along the x-axis and radial stress along the y-axis are negative, whereas, radial stress along the x-axis and tangential stress along the y-axis are positive.
- the stresses are directly proportional to the load and inversely proportional to the thickness.
- the greatest change in stresses with gage length occurs in the radial stress along the y-axis, whereas, the least change occurs in radial stresses along the x-axis.
- for a gage length of 100 mm (4 inch), the value of tangential stress along the y-axis is close to zero and can be ignored in the calculation of material properties without making a significant error in the final results.

SENSITIVITY ANALYSIS

A sensitivity analysis was carried out to theoretically analyze the affect of independent parameters on the predicted material properties. This was done using Hondros and Frocht equations. The parameters considered in this study included:

- specimen size,
- loading strip width,
- eccentric horizontal deflection transducers,
- eccentric vertical loading strip,
- vertical and horizontal eccentricity.

Specimen Size

Specimen size refers to the thickness and the radius of the specimen. Poisson's ratio is independent of the thickness of the specimen in the two dimensional analysis. With regard to the radius of the specimen, Figure 2.6a shows the plot of the percent change in Poisson's ratio and the elastic modulus with a change in the specimen radius from the standard 50 mm (2 inch). The results are shown both for plane stress, "Sts" and plane strain, "Stn" equations. The plot shows less than 6 percent error in the predicted values for a radius measurement error of 5 mm (.2 inch). Poisson's ratio appeared to be more sensitive as compared to the elastic modulus. In addition, the plane stress analysis is relatively more sensitive as compared to the plane strain analysis.

However, this is not considered to be very sensitive since the likely hood of making an error in specimen diameter is very small. This is because, test specimen in the laboratory are prepared using standard molds that has very precise dimensions.

Loading Strip Width

The sensitivity analysis for the loading strip (Figure 2.6b) demonstrates a similar magnitude of influence. That is, a 10% error in strip width induces a maximum error of approximately 6% in the response. However, unlike the specimen radius, the response increases with increasing strip width. Since the loading strips are machined to high tolerances, any small change in the strip width, due to machining tolerances, does not significantly effect the determination of material properties.

Eccentric Horizontal Deflection Transducers

This refers to the offset of the horizontal transducers in the vertical direction. The offset may be due to specimen size, the loading device or the compression of the specimen to elliptical shape due to load. The effect of misalignment on material properties is shown in Figure 2.7a. The figure shows that for a 12.7 mm (0.5 inch) offset, the error in the material properties is less than 12%. However, it should be

realized that a 12.7 mm (0.5 inch) offset is a very high number in a practical situation. For a 2.5 mm (0.1 inch) misalignment, the estimated error reduces to less than 1%.

Eccentric Vertical Loading Strip

Horizontal eccentricity refers to the offset of the loading strip from the vertical diametral axis. Figure 2.7b presents the results obtained due to this misalignment. These results follow very similar trends to those obtained by horizontal transducer misalignment.

Vertical and Horizontal Eccentricity

Results from the analysis of misaligning the specimen both vertically and horizontally by an equal amount are shown in Figure 2.7c. The resultant summing of the errors demonstrates that the error caused by the two eccentricities is independent. That is, the total error is the sum of the errors caused by the vertical and horizontal eccentricities.

PRACTICAL APPLICATIONS OF THEORETICAL ANALYSIS

The theoretical analysis presented can be used for various practical applications. A few most important factors include:

- Selection of Deflection of Measuring Device,
- Quality Control through Deflection Ratio,
- Effect of Size of Aggregate in Asphalt Mixes,
- Errors in Vertical/Horizontal Deformation.

Selection of Deflection of Measuring Device

If the material is tested within the elastic range, the theory discussed can be used in the selection of the range of the deflection-measuring device, i.e., strain gage or LVDT. Figures 2.8a and 2.8b shows the plot of horizontal and vertical deflection factors for various Poisson's ratios as a function of gage length. These deflection factors, when multiplied with 2P/πatE (E is the elastic modulus), will give an estimate of the total elastic deformation for a specific material and size. The mathematical representation of the figures is given by the following equations:

$$HDEF = 0.1057 - 0.3009\,\mu + 0.1282\,GL + 0.4289\,\mu\,GL - 0.00077\,GL^2 - 0.0023\,\mu\,GL^2 \quad (2.15a)$$

$$VDEF = 3.082 + 4.88\,\mu + 0.0654\,GL + 0.00586\,GL^2 \quad (2.15b)$$

where

HDEF = horizontal deflection factor,

VDEF = vertical deflection factor,

μ = Poisson's ratio,

GL = gage length (mm.)

From a review of the figures, it can be observed that both of the deflection responses are approximately linear up to a gage length of 50 mm (2 inch). In the case of vertical deformations, the nonlinearity beyond this point may lead to the amplification of errors resulting from departures from the model's linear elastic assumptions. Conversely, the horizontal deformations demonstrate a dampening effect or reduced sensitivity to modeling errors.

In the measurement of material properties, one should measure strains (displacements) or stresses (loads) in areas of uniformity of the response variable. Since the modeling of the material typically assumes both homogeneity and isotropy, any localized departure from these assumptions will be

minimized in zones of constant stress or strain. In materials, which conveniently meet the elastic assumptions on a macroscopic level, measurement over non-uniform responses has less effect on the desired outcome. That is, for materials where localized departures from the linear elastic assumptions are not as readily evident, the model is more forgiving and one has greater freedom upon the location of measurements.

Quality Control through Deflection Ratio

Deflection ratio is defined as the ratio of the vertical deflection to horizontal deflections. This ratio is a function of the Poisson's ratio but independent of the elastic modulus, specimen size and the applied load. Figure 2.8c, shows the deflection ratio as a function of the Poisson's ratio for different gage lengths. In general, the larger the gage length, the greater the deflection ratio. It can be seen that the ratio is relatively constant for a gage length of 50 mm or less, and relatively independent of the Poisson's ratio. This results in a reduction of the sensitivity of the Poisson's ratio on the vertical deflection.

The modeling process for determination of both modulus and Poisson's ratio assumes that the material is in the linear elastic range and that the measurements are not being affected by outside influences such as aggregates, rigid body movement of the sample relative to the reference plane, seating loads and other contributory factors. From experience, the operator may enter the gage length used, along with the anticipated range of Poisson's ratio. Given this information and modern computer controlled data collection, the testing could be automatically aborted after a set number of cycles if the deflection ratio is not met. Thus, with early detection of detrimental testing conditions, the operator may investigate, and resolve the problem prior to significant specimen damage.

For example, with asphalt mixes at 70°F, the Poisson's ratio is close to 0.35. This should result in a deflection ratio close to 6, for a gage length of 100 mm (4 inch). The user may set the controlling deflection ratios at 5 to 7 at the end of 20 exercising cycles. If the ratio is exceeded during the preconditioning, the test is aborted. Thus, deviations from the theoretical deflection ratio, which may result in significant deviations from the elastic theory, can be easily avoided.

Effect of Size of Aggregate in Asphalt Mixes

The measurement of total displacement along the x-axis (horizontally) is robust concerning the influence of aggregate particles. Approximately 85 % of the total deflections are generated within the central linear strain region. Thus the influence of local perturbations in the strain field is quickly muted by particle rearrangement or strain dissipation occurring in the outer half of the core. The vertical displacement, however, does not share this excellent property. Since only 30% of the total displacement is generated within this central core region, the influence of local perturbations in the strain is magnified in the outer nonlinear zone.

Thus, the determination of Poisson's ratio from horizontal and vertical displacement must be carefully reviewed. For example, assuming that a 5 mm (0.2 inch) aggregate is resting on the top and bottom platens and that these aggregates are relatively incompressible compared to the overall behavior of the asphalt mix, the error in vertical response may be as high as 40% in the calculation of Poisson's ratio as shown in Figure 2.9. Extrapolating to the placement of a 12.7 mm (1/2 inch) aggregate at both platens, this error increases to approximately 120%.

However, the determination of the Resilient Modulus from the horizontal displacements by use of an assumed Poisson's ratio demonstrates remarkable robustness to the presence of aggregates along the measurement path. Thus, the presence of larger aggregates does not appear to significantly affect the determined modulus values.

Error in Vertical/Horizontal Deformation

The correct horizontal and vertical deformations are very critical to the predicted Poisson's ratio and eventually the elastic modulus. The effect of the percent change in the deflections on Poisson's ratio is graphically shown in Figure 2.10. Some of the important factors that may contribute to the error in the deformation include:

- error due to the slack in mechanical equipment,
- error due to the seating of loading strip,
- error due to rigid body motion of the specimen relative to the reference plane,
- error due to compression of the specimen surface,
- error due to punching of the specimen.

It is important to realize that most of the causes of error relate to the vertical deformation, which is also most sensitive to the predictive Poisson's ratio as shown in Figure 2.10. These errors may be minimized by taking the measurements on the specimen rather than making deflection measurements externally. Use of strain gages for determining the vertical and horizontal displacements seems to be more promising in defining the material properties.

GENERAL OBSERVATIONS

1. The use of two-dimensional elastic solutions allows determination of the theoretical displacements independent of the material properties. In contrast, in the three dimensional solution, this convenient simplification does not occur. Since the determination of material properties employs the two dimensional simplification, further work in the comparative analysis of two versus three-dimensional analysis may be justified to assess the sensitivity of this assumption.

2. The two dimensional theory does not support the concerns for loading and measurement misalignment. The theoretical displacements (individually or combined) are not sensitive to rather gross misalignments in the vertical and horizontal directions or the presence of localized contact loading.

3. The determination of the Poisson's ratio in the plane stress model is the most sensitive parameter to departures in the dimensions or elastic assumptions used in the analysis model.

4. The previous trends of obtaining rather consistent, reasonable modulus values derived from the horizontal measurements with assumed Poisson's ratio is substantiated by the stability of the horizontal measurement to departures in the underlying model assumptions.

5. The use of exercising cycles to reduce variation may result in creating another problem while solving the first. The benefits derived from the reduction of seating variation and surface boundary consolidation in the vertical deflection measurement may be counter-balanced by the introduction of internal heat (hysteresis losses) and development of micro-fractures within the specimen.

6. The theoretical strain responses, up to a gage length of 50 mm (2 inch), are approximately linear and beyond this range, non-linearities appear. Measurement devices, which determine deformations by an average strain over length, such are strain gages, are highly suited for these types of measurement.

7. The generation of internal heat or formation of micro-cracks will occur within the regions of higher stresses. The central linear strain, portion of the specimen, gage length up to 50 mm (2 inch), is outside this high stress region. Thus, measurements obtained within this portion of the sample will be least affected and thus result in more robust measurements.

8. Since the vertical measurements are on the order of 2 to 15 microns, sources of vertical displacement error may arise from one or more of the following:

    - Movement of the reference plane with respect to the specimen by either rigid body or thermal movements. Assuming 125 mm between the datum and the top reference head, a 3-degree change in temperature may result in a 2 microns change in the top datum. As the dynamic test is performed over short time duration of 1 second intervals, it is unlikely that temperature effects would become as presented in the illustration above. Similarly, rocking or vibration in the top reference plate may also add to potential errors.

- Seating displacement at the loading strip - specimen interface may also be a source of variation. After multiple exercising cycles, this error is minimized in total displacement, but may still be a contributory factor in increasing the total vertical measurement.
- The contact pressures at the loading strip may result in either compression within the surface micro-texture or localized punching of the specimen. In the case of field cores, both the heat generated by the coring operations coupled with the possible water asphalt interactions may increase the materials susceptibility to these factors. However, these interactions will typically be limited to the immediate area of the loading strips resulting primarily in an increase in the vertical measurement. The influence of this factor was beyond the scope of the current study.
- Incompressible (or a high modular ratio between the aggregate and the binder approximating incompressibility) inclusions are assumed to be randomly distributed throughout the matrix. The presence of these aggregates close to the loading strips, where higher localized strains exist, may reduce the deflection measurement.

9. The horizontal measurements are on the order of 0.5 to 3 microns. Thus, the precision of the measurement must be increased to maintain reliable results. The possible sources of error include:

- Movement of the reference plane with respect to the specimen by either rigid body or thermal movements.
- Incompressible (or a high modular ratio between the aggregate and the binder approximating incompressibility) inclusions are assumed to be randomly distributed through the matrix. The presences of these aggregates do not appear to have much impact on the magnitude of the horizontal deflection measurement error.
- Seating displacement at the measurement point - specimen interface may also be a source of variation. After multiple exercising cycles, this error may be minimized in total displacement, but it must be correlated to the average texture depth on the cylinder surface and thus may still be a contributory factor in increasing the total variation in measurement.

10. Use of strain gages for determining the vertical and horizontal displacements for a gage length of 50 mm (2 inch) may have the following advantages:

- Being on the body itself, the effects of movements of the datum may be eliminated.
- A 50 mm (2 inch) gage length measures the strains in an area where theoretically the strains should be nearly linear. Also, the gage length is at least 4 times the nominal maximum aggregate size recommended for 100 mm (4 inch) samples. Thus, it is easier to justify the concept of homogeneity over this range.
- The horizontal measurements could be easily measured by a extensometer for total displacement, however if one is to maintain balance in the data acquisition system, it is advisable to use similar measurement techniques to those employed in the vertical direction.

CHAPTER 3

INDIRECT TENSILE MEASUREMENT SYSTEM

INRODUCTION

Chapter 2 discusses the sensitivity of various parameters upon the measured resilient modulus and the Poisson's ratio in the indirect mode of testing. Results in Chapter 2 clearly indicated that Poisson's ratio is more sensitive to the irregularities compared to the resilient modulus. Significantly error in the measured response may be due to the stress concentration at the loading strips. It was found that measurements taken away from loading strips in order to reduce the effect stress concentration would result in more reliable results. This was shown theoretical that the strain response, up to a gage length of 50 mm for a 100mm diameter sample, is approximately linear and beyond this range, non-linearities appear. These non-linearities may result in a modulus that is not elastic due to the excessive damage in the non-linear zone. It was concluded that measurements taken at the center of the specimen would provide better estimate of the material properties.

Similar, conclusions were made by Roque (13) under the SHRP A-357 study. In his report he has well documented the problems with the existing measurement system and made recommendations for the new revised systems that will reduce the effects of boundary conditions (stress concentration at the loading strips). Details of the method proposed by Roque (13) are discussed in this chapter.

PROBLEM WITH THE EXISTING MEASUREMENT AND ANALYSIS SYSTEMS

As mentioned earlier in Chapter 2, for asphalt mixtures, the indirect tensile mode is most commonly used test procedure to determine the resilient modulus and indirect tensile strength. Traditionally, resilient modulus values were computed using exterior measurements on the specimen (ASTM D 4123). No on-sample measurements were required by the existing ASTM procedure. Poisson's ratio was either assumed or determined by using vertical deformation measurements of the loading strips.

Work done by Roque, Heinicke and Vinson (14) showed that resilient modulus values determined using Poisson's ratio determined from exterior measured vertical deformation could be significantly in error. They concluded that accurate measurement of Poisson's ratio is very important to accurately estimate the resilient modulus of the asphalt mix. The findings were based upon finite element study that included the following cases.

Case 1: Plane stress, with uniform distributed load applied directly to the circular model.

Case 2: Plane stress, with a uniform distributed load applied to the circular model through a steel loading platen.

Case 3 Three dimensional, with a point load applied to the cylindrical model through a steel loading platen.

Case 4 Three dimensional, with a point load applied to the cylindrical model through Teflon coated steel loading platen.

The output from the finite element analysis includes values of horizontal and vertical deflections and stresses at each nodal point. These deflections obtained were used as input to the Hondros theoretical equations to compare the different between the finite element solution and the Hondros equations (details of Hondros equations are presented in Chapter 2). Further, the stress output at each nodal point was compared to Hondros theoretical stress distribution. Figure 3.1 illustrates Hondros theoretical unit stress distribution with the nodal unit stress for Cases 1 through 4 (with $\mu = 0.35$) superimposed. In all the four cases a clear difference in stresses along the vertical axes was observed close to the loading strips. The difference in the stress may be attributed to the effect of surface traction forces that result from the material incompatibility at the loading interface. However, no significant difference in stresses was observed along the horizontal axis. The study clearly indicated that the problem exists in the stress solution close to the loading strips along the vertical axis.

Another study by Mamlouk and Sarofim (15) showed that the plane stress condition assumed to determine moduli from the test do not apply for standard size specimen (2.5 inch thick and 4.0 inch

diameter). That is, thickness of 2.5 inches as specified in the ASTM (4123) does not justify a plane stress solution. This thickness may be more appropriate for three-dimensional analysis rather than using a plane stress solution. In order to verify the validity of a plane stress solution, a comparison study, using the two extreme cases, plane stress and plane strain was carried out and no significant difference was observed with the material properties as discussed in Chapter 2. Thus, according to the analysis presented, three-dimensional analysis is not significantly important to be used for the analysis. Error caused by using two-dimensional analysis is significantly less than the other sources of error discussed in Chapter 2. This was also concluded by Heinicke and Vinson (14) and supported that the standard testing mode is adequate for plane stress analysis. Their conclusions were based upon the fact that correct value of Poisson's ratio is known. A review of Heinicke and Vinson computations performed by Roque (13) indicated that the moduli would be significantly in error if they had assumed Poisson's ratio, which is the only thing that one can do in practice when no vertical deformation are obtained.

In addition, other researchers including Sousa et al. (16) has reported that highly variable stress state exists within the indirect tensile specimen, and therefore, the modulus obtain from the measurement of the specimen exterior was some sort of an average modulus which represented the composite response of the material. This variable response of the stresses is discussed in Chapter 2 and is also shown in Figure 3.1. According to Sousa this is definitely true at temperatures above which the material response becomes stress dependent. The load and temperature level above which this becomes significant is unknown. Based upon the works done by Sousa and other researchers, it is important that the deformation measurements be made within the specimen, where the stresses are relatively uniform and within the elastic range of the material.

Numerous systems have been designed to reduce the effect of these problems discussed earlier. Barksdale at el. (17) has presented a summary of these devices and his findings are presented below.

Retsina Device

The Retsina device is the most simple and the first available device used for resilient modulus estimation. This device uses a fixed bottom loading strip with an independent loading strip that is placed on the to of the specimen. The load is transferred through a small (0.5 inch diameter) metal ball that rests on an inverted conical groove on the top of the upper loading strip. For this device to work properly, the loading plane should be perfectly aligned with the vertical diametral plane of the specimen, and the loading system should be very accurately aligned. Due to the absence of a rigid connection between the loading strip and the load cell, or the loading system, which applies load through the ball, a tendency exists for separation of the loading system (ram) from the loading strip. Also, there is a tendency for the upper loading strip to move during testing.

Since there is no room on the upper loading strip to measure the deformation using a spring loaded LVDT, the vertical deformation of the ram was used to calculate resilient modulus. Deflection in the horizontal diametral plane was measured using both mountable and stand-alone measurement devices (extensometers and LVDT's). LVDT's were attached to the sidewall of the bottom portion of the servo-hydraulic device, which acted as the fixed bottom-loading strip. A high degree of freedom exists in the Retsina device, and hence it is more liable to equipment and operator errors. This fixture can be easily used in many standard environmental chambers with modifications.

In general, the device relies on external measurements using LVDT's. In this system, Poisson's ratio is assumed for the estimations of the resilient modulus. As indicated earlier, assuming the Poisson's ratio for resilient modulus estimation can result in incorrect values. However, Poisson's ratio can be estimated using the deformations from the loading. Sufficient evidence is available in the literature and also discussed earlier that Poisson's ratio from external measurements in not correct.

MTS Device

An MTS Model 643.01A resilient modulus fixture can be installed in a load unit having either a crosshead or a base plate mounted actuator. It is small and simple enough to be used in many small environmental chambers. The MTS device has an upper and lower platen (loading plates). A pull rod (ram) connects the upper platen to the load cell. To insure that the longitudinal center line of the loading strips remain in the vertical diametral plane of the test specimen throughout the testing, an alignment bar is connected to one side of the upper loading platen. This alignment bar is guided between two cam rollers mounted on the side plate of the lower loading platen hence preventing the rotation of the upper plate in a horizontal plane. The specimen seats between the loading strips attached to the upper and lower loading platen. Different loading strips are used for 4 inch and 6-inch diameter specimens.

Extensometer assemblies supplied by MTS measure the deformations. A vertical extensometer can be mounted between the upper and the lower platen on one sidewall of the lower platen (wall opposite to the one with the alignment bar and cam rollers). A horizontal extensometer assembly can be mounted on the specimen to measure horizontal deformation. Two slots are provided in each sidewall of the lower platen to help mount the extensometer on to the specimen. Four thumbscrews are provided with the device. These hold the extensometer assemble in place while a new specimen is put in or replaced. The specimen can be rocked in the lower platen to make sure that it has full contact with the extensometer assembly and ascertaining the longitudinal alignment of the specimen with the loading strips. Once that is accomplished, the thumbscrews are unscrewed which pulls the extensometer assembly on to the specimen in the horizontal diametral plane.

To facilitate the simultaneous use of the stand-alone and mountable measurement devices for the horizontal deformation, holes were drilled in the plates to mount spring-loaded LVDTs. Also, long arm attachments were designed and fabricated to hold vertical LVDTs (that could be spring-loaded on the top of the upper platen on opposite sides of the ram). These were fixed to the base of the sidewalls of the lower platens with a rotating arm on the top, which held the

LVDTs. The same attachment was used for the SHRP load guide device setup for measurement of vertical deformation.

A Marking device was used to accurately mark mutually perpendicular axes on both faces of the specimen with precision. The specimens were then aligned between the loading strips and the extensometer assembly using the marked axes as datum. This was generally observed to provide a good control on rocking. Very thin lines were precisely drawn at the ends of the loading strips to facilitate alignment of the specimen. However, it should be ensured that the loading system is perfectly aligned to minimize rocking. The alignment of the MTS loading system was periodically checked.

The MTS device is a simple in design. The upper loading platen is thinner than those used in the Baladi and SHRP devices. However, only the MTS is rigidly connected to the loading system. A little control over the rotation of the upper platen is provided by the presence of an alignment bar and cam rollers, but careful alignment of the loading system is still required. Due to the absence of heavy guide columns, friction is not a major concern to the movement of the device in either the transverse or the vertical direction. The absence of resistance to the movement in the transverse direction might be considered as a drawback of the device. However, absence of resistance friction in the vertical direction ensures that the load cell measures the full load applied to the specimen. The MTS device is open enough to be adaptable to different measurement systems, a flexibility compromised to a varying extent in the SHRP load guide and Baladi's device.

Baladi's Device

The Baladi device was manufactured by Gilson Company, Inc. (Ohio) as model MS-40. This device can only be loaded from the top. The Baladi device consists mainly of a fixed top and bottom cylindrical assembly supported by four columns, two on the side and one each in the front and back of the specimen (when installed). Holes are drilled in these columns so that the deformation can be obtained by use of LVDTs mounted through them. A short attachment is made on the fixed upper part of the device to obtain measurements in the vertical direction with a LVDT mounted through it. The Baladi device is the only one to permit deformation measurements in three dimensions. The upper part has five holes, one for the loading piston and four for the low friction guideposts, and through which the upper plate moves. The load is applied through a standard 1-inch diameter steel ball that rests on the upper loading plate in an inverted conical groove on the center. The Baladi device, in contrast to the others, has a hinged upper loading strip so as to accommodate a non-uniform diameter specimen. The device is compacted, and hence it is very cumbersome to put the extensometer assembly on the specimen. Also, the installation of the specimen is not easy, although a rubber stopper is provided at the top to assist in the installation of specimen. Centerlines were marked on the end of the loading strips to help in the alignment of the specimens. Friction in the vertical direction generated by the use of four guideposts, reducing the load applied to the specimen, is a concern. To overcome this problem, a load cell can be placed between the lower curved loading strip and the lower stationary plate.

The three devices discussed, rely on the external measurements either by LVDTs or the extensometers. For these devices, the both horizontal and vertical deformations are measured for the estimation of the Poisson's ratio.

SHRP Load Guide (LG) Device

The SHRP LG device was developed as part of the Strategic Highway Research Program's Long-Term Pavement Performance project. The device has to be used under a top loading system. The device is a die set with upper and lower loading platens constrained to remain parallel during testing by the presence of two heavy guideposts. The guideposts are in line with the loading strip hence assuring minimal lateral movement of the top-loading strip with reference to the lower. The loading platens are very heavy and rigid. The loading system is connected to the device with a complex arrangement using a metal ball and springs between two flanges. The loading system is a compromise between the very rigid connection used in the MTS device and a free connection used in Baladi's device. A counterweight system prevents the heavy weight f the loading system from being applied to the specimen (which is very critical at high temperature).

Two standoff horizontal transducer holders are attached to the lower platen of the load frame such that the LVDTs can be positioned at the mid height of the specimen on either side. The holders are movable by a fine screw adjustment that makes it very easy to zero the LVDTs prior to testing. Steel loading strips, curved to a diameter of 4-inch specimen, are fixed to the platens. The outer edges of these strips are rounded to remove sharp edges that might cut specimens during testing. The LVDTs and the extensometers cannot be used simultaneously for the measurement of horizontal deformation. Therefore, two sets of tests had to be performed to evaluate these measurement systems with the SHRP device.

The bulky guide columns and the counterbalance systems could be a source of appreciable friction to the vertical movement and causing a lower load to be applied to the system. Due to the size of the device and counterbalance system, the device cannot be conveniently used within a conventional environmental chamber. During this study the device was slightly modified by replacing the counterweights with reaction springs. This made it possible to use this device in any environmental chamber. Also, the loading strips are not easily removable, and hence it would be difficult, but not impossible, to test 6-inch diameter specimens in this device. Installing specimens in the device is cumbersome and require a significant amount of time and patience to obtain proper alignment.

In summary, all the above systems were designed to reduce the error caused by misalignment and specimen rotation. This was done at an expense of reducing the load on the test specimen due to the friction caused by the guided rods. Diametral yokes, which hold the LVDTs and are mounted on the specimen, such as the Retsina may induce restraint and unknown stresses in the specimen because pressure must be applied to the specimen to support them.

The review presented above indicates that the following improvements and considerations should be taken into account when designing a measurement and analysis system to determine accurate properties of asphalt mixtures from the indirect tensile mode (13):

- Effects of localized stress concentration caused by the steel loading strip must be considered when appropriate gage location and length.

- Because the specimen is of finite thickness, 3-D effects must be accounted for in the analysis of measurements obtained from the test and is found to be not very critical.
- Measurements, which allow for accurate determination of Poisson's ratio, are needed.
- Measurements obtained in zones within the specimen where the stress states are relatively uniform will reduce the effects of nonlinear behavior on the modulus or stiffness predicted. Additional evidence to this effect will be presented later in this chapter. It should be noted that the stress-states should be representative of stress-states induced by traffic load and/or temperature changes.
- The measurement and loading system used should reduce the effects of specimen rotation without inducing restraint or unknown stresses in the specimen.

Tasking in account the above consideration, Roque at el. (13) developed a measuring system for the estimation of the resilient modulus. The details of which are discussed in the next section.

PROPOSED MEASUREMENT SYSTEM

As shown in Chapter 2 (Figure 2.2) both vertical and horizontal stress distribution is fairly uniform near the center of the face of the indirect tensile specimen. Although not show, the strain distribution is also fairly uniform. If it can be shown that the stresses in this zone are relatively unaffected by end effects near the loading heads (and non-linearity), then measurements obtained in this zone will reduce or eliminate the effects of local stress concentrations around the steel loading strips. Also, if accurate and interpretable vertical and horizontal measurements can be obtained in this zone, then an accurate estimate of Poisson's ratio can be made. Which can then be used to estimate the resilient modulus of the mix.

Some of the key factors that need to be considered are; appropriate sensors, sensor spacing, and measurement analysis methods be selected to complete the system design. In the development of the system, Roque (13) considered numerous sensors and mounting systems, including strain gages, gage point-mounted LVDTs, surface-mounted bracket system developed by Hugo and Nachenius (18), and a miniature banana plug-mounted LVDT system. Although strain gages provide superior precision and accuracy, they are time consuming to mount properly and expensive in the long run, since they cannot be reused. This is particularly true if rosettes that allow for both vertical and horizontal measurements are used. Therefore, it was decided that an LVDT system should be developed.

Roque at el. (13) concluded that a modified version gage point-mounted LVDTs provide superior precision and accuracy, as well as easily interpreted measurements. It was determined that measurements obtained using Hugo and Nachenius's bracket are affected by specimen bulging for which would be impossible to account when analyzing the measurements (the effects of bulging will be discussed later). Other potential problems with this system include effects of bracket rotation and unknown stress and constraint effects caused by the mounting system. The banana plug system is not stable enough and is excessively affected by specimen bulging effects.

Other important consideration in the design of the measuring system includes: aggregate size effects, uniformity of stresses over the measurement area, and bulging effects. For this gage length of the measurement sensor is an important consideration. Minimum length of the gage is mainly governed by the aggregate size. It is not recommended to have the measurement device in the zone that is mainly influenced by a single aggregate. On the other hand the maximum gage length is dictated by the stress distribution within the test specimen. The measurement should be taken in the linear zone away from the loading strips where the stresses are more likely to be non-linear.

Three-dimensional finite element analyses of the deformations, stresses, and strains induced in the indirect tensile specimen loaded with a steel-loading strip indicated that larger measurement errors would result for longer gage lengths and is discussed in the next section. The analyses also indicated that the stresses and strains began to drop off very quickly at a distance of one-eighth of the specimen diameter (0.5 inch for 4-inch diameter, 0.75 inch for 6-inch diameter) from the center of the specimen. This effect can be seen in Figure 2.2 (Chapter 2), which is the two-dimensional plane stress solution. Based on these observations by Roque, a gage length of 1.0-inch can be recommended for 4-inch diameter samples, and a gage length of 1.5-inch is recommended for 6-inch diameter samples.

A schematic of the LVDT mounting system is shown in Figure 3.2. The mounting system features a coil assembly, which securely holds a sub-miniature LVDT (Schaevitz Model XSB-099: +/- 0.1 inch linear range) and a core assembly, which centers the LVDT core within the coil. Both assemblies firmly clamp on to 5/16-inch diameter x 1/8 inch round brass gage points. The system has adjustment capabilities for centering of the LVDT core. Centering of the core within the coil is essential to reduce the noise created by scraping of a misaligned core against the interior of the coil. One of the features of the system is that the LVDT is located as closely as possible to the specimen's face to reduce the effects of bulging. Sample measurements and mixture properties obtained with the proposed system are presented later.

3-Dimensional Finite Element Analyses to Evaluate Indirect Tension Specimen Deformation, Stresses, and Strains (13)

The 3-D finite element model was used to analyze a Marshall-size indirect tension specimen, loaded with a 0.5-inch wide steel-loading strip (13). The computer program ANSYS (1991) was used for analysis. In order to save on solution time, symmetry was used in all three dimensions. Thus, the quarter-circle, half-thickness model uses only $1/8^{th}$ as many elements as a full model, without sacrificing any accuracy or information. The model uses 1400 linear elastic, 8-noded isoperimetric brick elements. Thus 11,200 elements were used to represent the Marshall specimen. Because it is very difficult to mesh an irregular volume with brick elements, and because highly skewed brick elements are undesirable, special care was taken to fill the volume with a combination of varying sized brick and wedge elements. The wedge elements, also known as prisms or degenerated brick elements, are necessary to avoid skewed brick elements, but were kept in low stress gradient regions, as recommended by ANSYS. Roller supports were supplied at each node along planes of symmetry.

The analyses were performed assuming a modulus of 200,000 psi and three values of Poisson's ration: 0.20, 0.35, and 0.45. These analyses showed three important differences between the theoretical plane stress solution and the results of the 3-dimensional model of the indirect tensile test: 1) there is a significant variation in horizontal tensile stress along the z-axis for specimens thicker than one inch; 2) there is significant and non-uniform specimen bulging on the face and edges of the specimen; and 3) Poisson's ratio had a significant effect on the stress distribution within the specimen. All of these discrepancies must be considered in the accurate determination of properties from measurements obtained from the indirect tensile test.

The horizontal stress (σ_x) distributions along the z-axis for specimens of different thicknesses are shown in Figure 3.3. The horizontal stress predicted by the plane stress solution is also shown on the figure. The horizontal stress for a specimen thickness of 1 inch is fairly uniform and nearly equal to that predicted by plane stress. Given that thinner samples approach plane stress conditions, this result validates the accuracy of the finite element model used for the analyses presented in this paper.

For specimen thickness of 2.5 inch and greater, Figure 3.3 shows that the horizontal stress varies from a minimum of about 107 psi at the center of the specimen to a maximum of about 148 psi at the face of the specimen. A stress of 127 psi is predicted by the plane stress solution. The higher stress on the specimen's face should be used in computing properties using measurements obtained on the face. It is clear that the plane stress solution, which is generally applied to compute moduli from measurements on the specimen's exterior, is not representative of the stresses induced in the specimen for standard loading conditions.

The surface deformations for a 2.5-inch thick specimen are shown in Figure 3.4. As shown in the figure, non-uniform bulging on the x- and y- axes will affect the measurements obtained from the surface mounted sensors by causing the sensors to rotate. Therefore, measurements obtained with the system proposed must be adjusted for the effects of specimens bulging. Adjustment procedures will be presented later in the chapter.

Figure 3.4 also shows that there is non-uniform bulging along the z-axis. It will be shown later that, depending on the analysis method used, significant differences in computed moduli will result if exterior deformations are measured near the face of the specimen or halfway between the two faces along the z-

axis. Conventional measurement systems measure halfway between the two faces (point B on Figure 3.4).

It was found that the stress distributions shown in Figure 3.3, as well as all other stresses within the sample, were a function of Poisson's ratio. The magnitude of the bulge shown in Figure 3.4 was also found to be a function of Poisson's ratio. This implies that both the predicted stresses and measured deformations should be corrected for Poisson's ratios. Correction procedures were developed for this purpose and will be presented later. These effects emphasize the need to develop a measurement system that allows for an accurate determination of Poisson's ratio, if properties are to be determined accurately from the indirect tensile mode. It should be noted that the 2-D plane stress solution is independent of Poisson's ratio.

Analyses were conducted to evaluate the effects of local stress concentrations near the steel loading strips on the stress states in the vicinity of the center of the specimen's face. Similar to Heinicke and Vinson (2), Roque (1) also concluded that significant stress state changes occurring near the loads have a negligible effect on the horizontal and vertical stresses occurring near the center of the specimen. These findings also appear to imply that localized damage and possibly material nonlinearity have a negligible effect on the stresses predicted near the center of the specimen, since both of these phenomena essentially result in a redistribution of stresses in areas where stress states exceed some critical value. Unfortunately, sufficiently accurate 3-D finite element models that consider nonlinear response and damage were not available to evaluate these effects directly.

Development of Simple and Accurate Analysis Procedures to Determine Properties Using the Measurement System Proposed (1)

The 3-D finite element analyses of the indirect tensile specimen indicated that the following corrections needed to be made to determine properties accurately when using the measurement system in Figure 3.2 (1):

- The deformations obtained from surface-mounted L VDTs must be corrected for specimen bulging.
- The average strain determined using deformations from a specific gage length (1.0-in. for 4-in. diameter and 1.5-in. for 6-in. diameter specimens) must be converted to point strains occurring at the center of the face of the specimen.
- Stresses predicted by 2-D plane stress solution must be adjusted for 3-D effects.

Figure 3.4 shows how specimen bulging affects measurements obtained from surface-mounted L VDTs. Bulging was found to be a function of Poisson's ratio and specimen thickness. Based on 3-D finite element analyses performed for a range of Poisson's ratio and specimen thicknesses, correction factors were developed to adjust deformations obtained with the proposed measurement system for specimen bulging effects.

Bulging Correction Factor

Correction factors were computed by analyzing the geometry of the deformed specimen (see Figure 3.4) for a range of specimen thicknesses and Poisson's ratios. Correction factors for bulging developed for a range of Poisson's ratios and t / D values are given in Table 3.1. Simple piecewise linear relationships can be used to represent C_{Bx} and C_{By} as functions of t / D and Poisson's ratio. These relationships are as follows:

$$C_{B_x} = 1 - [0.111 + 0.2064\ (\nu - 0.2)](\frac{t}{D}) \qquad (3.1a)$$

for t / D < 0.5

$$C_{B_Y} = 1 - [0.0766 + 0.3072\ (\nu - 0.2)](\frac{t}{D}) \qquad (3.1b)$$

for t/D < 0.4

$$C_{B_X} = 1.005 - 0.11 * (\nu) - 0.075 * (\frac{t}{D}) \quad (3.1c)$$

for t/D $\geq$ 0.5

$$C_{B_Y} = 0.994 - 0.128 * (\nu) \quad (3.1d)$$

for t/D $\geq$ 0.4

where:

C_{Bx} = H / H_M = factor applied to the measured horizontal deformation to correct for specimen bulging

H = corrected horizontal deformation

H_M = measured horizontal deformation

ν = Poisson's ratio

t = measured specimen thickness

C_{By} = Y / Y_M = correction factor applied to the measured vertical deformation to correct for specimen bulging

Y = corrected vertical deformation

Y_M = measured vertical deformation

Values of C_{Bx} and C_{By} are tabulated in Table 3.1.

These correction factors apply to both 4-in. diameter (1.0-in. gage length) and 6-in. diameter (1.5-in. gage length) specimens. In fact, the equations apply to specimens of any diameter as long as the gage length to diameter ratio is 1:4. The equations apply only for the gage mounting system shown in Figure 3.2, where the center of the LVDT rests exactly 0.25 in. above the surface of the specimen. For the standard ASTM (4123) procedure, the thickness to diameter ratio recommended is 0.625. For a Poisson's ration of 0.35, the correction factors from Table 3.1 are 0.9179 and 0.9473 for the horizontal and vertical deformation. That is an error of 5 to 10 percent for the two-dimensional analysis, if no correction is applied.

Point Strain Correction

Given that only average strains can be determined from finite gage lengths, correction factors were developed to convert the average strains determined from the L VDTs mounted on the center of the face of the specimen. It was determined that point strains were required to accurately determine both modulus and Poisson's ratio. The relationships between average and point strain were found to be independent of Poisson's ratio and specimen thickness. The following constant correction factors were obtained:

$$C_{\varepsilon_X} = 1.072 \tag{3.2}$$

$$C_{\varepsilon_Y} = 0.977 \tag{3.3}$$

where:

$C_{\varepsilon X}$ = correction factor applied to the average strain determination from the corrected horizontal deformation measurement to obtain the horizontal point strain occurring at the center of the specimen's face.

$C_{\varepsilon Y}$ = correction factor applied to the average strain determined from the corrected vertical deformation measurements to obtain the vertical point strain occurring at the center of the specimen's face.

Point strains at the center of the specimen's face can be obtained from the following equations:

$$\varepsilon_{CTR_X} = \left(\frac{H_M}{GL}\right) * C_{B_X} * C_{\varepsilon_X} \tag{3.4}$$

$$\varepsilon_{CTR_Y} = \left(\frac{Y_M}{GL}\right) * C_{B_Y} * C_{\varepsilon_Y} \tag{3.5}$$

where:

ε_{CTRx} = horizontal point strain at the center of the specimen's face

ε_{CTRy} = vertical point strain at the center of the specimen's face

GL = gage length = distance over which horizontal and vertical deformation measurements are obtained

Point Stress Correction

As shown in Figure 3.3, the horizontal stresses predicted by 2-D plane stress analysis are significantly lower than those occurring on the face of standard Marshall-size indirect tensile specimen. Therefore, stress correction factors must be applied if 2-D plane stress equations are to be used for analysis on measurements obtained on the face of the specimen. Based on the 3-D finite element analyses performed, it was found that stresses on the face of the specimen were a function of Poisson's ratio and specimen thickness. The correction factors for both the horizontal and the vertical stress are given in Table 3.2.

The corrected point stresses can be obtained from the following equations:

$$\sigma_{X_{CORR}} = \frac{2*P}{\pi*D*t}*C_{\sigma_{XCTR}} \tag{3.6}$$

$$\sigma_{Y_{CORR}} = \frac{6*P}{\pi*D*t}*C_{\sigma_{YCTR}} \tag{3.7}$$

where:

σ_{xcorr} = corrected horizontal point stress occurring at the center of the specimen's face

σ_{ycorr} = corrected vertical point stress occurring at the center of the specimen's face

C_{axCTR} = correction factor applied to the horizontal point stress occurring at the center of the specimen's face as predicted by 2-D plane stress solution to account for 3-D effects

C_{ayCTR} = correction factor applied to the vertical point stress occurring at the center of the specimen's face as predicted by 2-D plane stress solution to account for 3-D effects

P = total load applied to the specimen

t_{std} = as defined earlier

The corrected point strains and stresses can be used to obtain Poisson's ratio by means of the following equation, which was derived from Hooke's law with $\sigma_z = 0$ at the outer face of the specimen:

$$\nu = \frac{\sigma_{X_{CORR}} - \left(\frac{\varepsilon_{CTR_X}}{\varepsilon_{CTR_Y}}\right) * \sigma_{Y_{CORR}}}{\sigma_{Y_{CORR}} - \left(\frac{\varepsilon_{CTR_X}}{\varepsilon_{CTR_Y}}\right) * \sigma_{X_{CORR}}} \tag{3.8}$$

For a linear elastic material, the modulus can be obtained using Hooke's law as follows:

$$E = \frac{1}{\varepsilon_{CTR_X}} * (\sigma_{X_{CORR}} - (\nu) * \sigma_{Y_{CORR}}) \tag{3.9}$$

The time-dependent creep compliance of a visco-elastic material can be determined as follows:

$$E = \varepsilon_{CTR_X}(t) / (\sigma_{X_{CORR}} - (\nu) * \sigma_{Y_{CORR}}) \tag{3.10}$$

Given that the correction factor equations presented above are a function of Poisson's ratio, and that Poisson's ratio is not known a priori, an iterative scheme was developed to solve for asphalt concrete modulus and Poisson's ratio. The iterative scheme, which is shown in Figure 3.5, requires that Poisson's ratio be assumed initially. The Poisson's ratio computed from deformation measurements and the equations presented above are compared to the assumed value of Poisson's ratio. If these differ by more than 0.01, then the computed Poisson's ratio is used to determine an updated value of Poisson's

ratio using the equations. The process is repeated until convergence is achieved. It was found that convergence is achieved very quickly using this scheme.

For linear elastic and linear visco-elastic materials, Poisson's ratio is constant regardless of loading time. For such materials, the ratio of vertical deformation to horizontal deformation is likewise constant. Thus, for a given test specimen, by knowing t, D, and Y / X, Poisson's ratio can be obtained by using the iterative scheme just described.

Theoretical Analysis to Evaluate and Compare the Accuracy of the Proposed Measurement System to That of Existing Measurement Systems (13)

Comparisons of moduli and Poisson's ratios determined by using the measurement and analysis system proposed to those determined by using existing measurement systems, clearly indicate the superior accuracy of the system proposed. Indirect tensile specimen deformations were obtained by using known values of modulus and Poisson's ratios in the 3-D finite element model described earlier. The standard test configuration was used (i.e. Marshall-size specimen; 0.5-in. steel loading strip; full friction between the loading strip and the specimen). Deformations corresponding to different measurement systems were obtained from the analyses and used to compute moduli and Poisson's ratios using different analysis methods. The results are given in Table 3.3.

The error in predicted modulus is 0.5 percent, and the error in predicted Poisson's ratio is from 1.3 to 2.1 percent when the measurement and analysis system proposed are used. The errors are slightly larger (-2.4 percent to -7.0 percent for modulus and 2.1 percent to 5.8 percent for Poisson's ratio) when interior measurements are used but no corrections are made for 3-D effects.

The error in predicted moduli and Poisson's ratios increases dramatically when conventional diametral measurements obtained on the exterior of the sample are used. The error in the predicted modulus

ranges from 19 percent to 28 percent depending on Poisson's ratio and whether horizontal measurements are obtained near the face of the specimen or halfway between the faces. Errors in predicted Poisson's ratios vary from - 4.5 percent to 68 percent in this case.

If vertical measurements are not obtained, and Poisson's ratio is assumed to b~ 0.35, the error in the predicted modulus is significant, regardless of whether interior or exterior measurements are used. For interior measurements the modulus error varies from 2.1 percent to 36 percent depending on Poisson's ratio and the analysis method used. The modulus error for exterior measurements varies from -22.8 percent to 38.1 percent depending on Poisson's ratio and the location of the measurement. This clearly indicates the importance of obtaining measurements from which Poisson's ratio can be determined accurately.

CONCLUSIONS

The following conclusions are extracted based upon the work done by Roque at el. (13).

1. The indirect tensile testing mode is both practical and versatile for determining properties of asphalt concrete.
2. The stress states induced in the vicinity of the center of the specimen's face are relevant for the prediction of both traffic-load induced and thermally-induced response at low in-service temperatures (< 30°C/86°F).
3. The indirect tensile mode has the unique advantage that the failure plane is known a priori at low in-service temperatures. Therefore, failure limits can be measured directly on the failure plane.
4. Very serious errors result in modulus (-9.6% to 38.1% regardless of whether Poisson's ratio is assumed or calculated) and Poisson's ratio (-4.5% to 68%) determined from the standard indirect tension mode (Marshall-size specimen, steel loading strip: full friction) when conventional measurements (LVDTs located on the exterior of the specimen) and analysis (2-D plane stress solution) system are used.

5. It appears that the use of low modulus and/or frictionless materials for the loading strip would not significantly reduce error in properties determined using conventional systems or the proposed measurement and analysis system.
6. Measurement systems, which allow for accurate determination of Poisson's ratio, are needed to determine asphalt concrete properties accurately with the indirect tension-testing mode.
7. Asphalt concrete properties determined from the indirect tension mode, using the measurement and analysis system developed and presented in this chapter are far more accurate (within 0.5% error for modulus and less than 2.1% error for Poisson's ratio) than properties determined from conventional measurement and analysis systems.
8. The analysis performed appear to indicate that the measurement and analysis system presented would reduce or eliminate the effect of non-linearity and damage on the asphalt concrete properties determined from the test. However, more definitive analyses should be performed to verify this inference.
9. Laboratory evaluations to date indicate that accurate deformations can be obtained using proposed measurement system.
10. Test results to date have also revealed that by having an accurate measure of Poisson's ratio, it appears that the onset of inelastic material response during testing can be detected.

CHAPTER 4
LITERATURE REVIEW OF EXISTING PROTOCOLS

INTRODUCTION

This chapter compares the existing protocols for the evaluation of resilient modulus and Poisson's ratio of asphalt mixes. The chapter also provides comparison and brief details of the new protocol developed under NCHRP 1-28A. In additions details are also provided for different factors considered in the development of the final protocol. This included; testing machine, loading device, deformation measurement device and the data acquisition system.

The measurement of the resilient properties of asphalt concrete has the subject with the pavement industry for the last three decades. Significant amount of research has been done in order to develop a testing and measurement system that can produce accurate, repeatable and reproducible resilient modulus properties of asphalt mixes. This resulted in the determining the resilient properties by two approaches: (1) predict the resilient modulus using physical and mechanical properties of the mixture using available correlations, and (2) measure the resilient modulus by laboratory testing.

Among the empirical predictive equations the most commonly used methodologies are the Shell Nomograph, and the Asphalt Institute (witczak's predictive equation for dynamic modulus) predictive models. The Shell Nomograph was originally developed by Van der Poel (18) and defined the stiffness as a modulus, which is a function of temperature and loading time. Later Heukelom and Klomp (19) developed a relationship between bitumen stiffness and the mixture stiffness based on the volume concentration of aggregate. After McLeod (20) modified the nomograph by changing the entry temperature criterion, finally Claessen et. al. (21) produced a pair of nomographs used in the current Shell design manual.

In addition to the nomographic solutions, The Asphalt Institute (AI) predictive dynamic (resilient) modulus equation was originally developed by Kallas (22) using cyclic triaxial test results. The equation was later refined by Witczak (23) in developing the DAMA computer program for Asphalt Institute. The equation developed was function of frequency of load, mix temperature, percentage of weight of aggregate passing through a No. 200 sieve, volume of air voids, asphalt viscosity at 70°F and volume of bitumen. It was observed that the factors considered by Asphalt Institute are mostly same as those by Shell with the following exceptions (23):

1. The percentage of fines passing through a No. 200 sieve is considered by AI but not by Shell.
2. The viscosity or penetration of asphalt considered by Shell is determined from the recovered asphalt, or the asphalt actually present in the mix, while that by AI is the original asphalt.
3. The temperature and viscosity of asphalt are considered by AI, whereas the normalized temperature, which is the temperature above or below TR&B, and penetration index, which indicates the temperature sensitivity of the asphalt, are used by Shell.

When considering the laboratory methods, the determination of resilient modulus of asphalt concrete involves using various types of repeated load tests. The most commonly used test used for determination of resilient modulus includes:

- Uniaxial tension test
- Uniaxial compression test
- Beam flexure (bending or rotating cantilever) test
- Indirect diametral tension test
- Triaxial compression test

Among the test mentioned above the most commonly used procedure is the indirect diametral tension test. This is mainly due to the fact that Marshall size specimen can be tested in addition to the cores obtained from the field.

DIAMETRAL RESILIENT MODULUS TESTING DEVICES AND MEASUREMENT SYSTEM

As mentioned earlier, significant amount of research effort has been devoted in the past for determination of the resilient modulus that is accurate, repeatable and reproducible. In order to achieve the above objective major research efforts were concentrated on the following issues:

- Testing machine
- Loading devices
- Deformation measurement devices
- Data Acquisition

Testing Machine

Several loading system are currently available with various capabilities that range from static to dynamic loading system, pneumatic or hydraulic and top or bottom loading. Under the NCHRP 1-28, it is recommended:

> *The testing machine shall be top loading, closed loop, electro-hydraulic testing machine with a function generator which is capable of applying a haversine shaped load pulse over a range of load durations, load levels, and rest periods.*

Loading Devices

As discussed earlier the diametral test loading system is the most commonly and recommended procedure for resilient modulus of asphalt mixes. Because of the popularity of the diametral test method, a number of test apparatuses have been developed which have important fundamental differences in equipment design concepts. Under the NCHRP 1-28 (1) project, an experiment was designed to identify the most reliable and accurate diametral test apparatus available and then to develop appropriate test procedures to allow the device to be used for routine testing. A representative group of the most promising diametral testing devices was carefully selected for evaluation in the testing program. The testing devices chosen were: Retsina device, MTS device, Baladi's device and SHRP Load Guide device.

The comparison between the test devices was made with respect to loading configurations and diametrical deformation systems. The Retsina device has fully independent aligned upper and loading strips and LVTDs that are clamped on the specimen to measure deformation. The MTS system has a guide rod that semi-rigidly aligns the upper and lower loading platens and extensometers that clamp on to the specimen for deformation measurements. Both the Baladi and SHRP devices have heavy guideposts that rigidly align the upper and lower loading strips. Both system measure diametral deformation by LVDTs mounted to the fixture itself, with only the LVDT cores touching the test specimen.

No specific device was recommended, however guidelines for the recommended device as given the NCHRP 1-28 protocol are given below:

> *The loading device should be capable of testing 4 inch and 6-inch diameter specimen with thickness up to 4.5 inches. The device should be compact enough to be used within the environmental chamber. It should have a fixed bottom loading plate and moving upper loading plate. The movement of the upper plate should be guided by two columns, one on each side of the specimen and equidistance from the loading axis and the loading strips, to ensure it has minimal translational or rotational motion during loading of specimen. The guide columns shall have a frictionless bearing surface that shall be kept well lubricated. The surface of the guide columns shall be frequently inspected for any grooves caused due to friction. Alignment of the device, within the loading system, shall be achieved so that such is limited to the minimum possible extent. The upper plate shall be rigid enough to prevent any deflections during loading. If heavyweight plates are used to achieve rigidity, the testing system should be able to counteract all the weight, such that no more than 2 lbs. of load is transferred to the specimen when the load is not being applied. It is recommended that high strength material be used to achieve rigidity and keep the weight small. The loading strips shall preferable be perpendicular to the line connecting the two guide columns, so that visual alignment of the sample in the device is easier.*

For current research (NCHRP 1-28A), SHRP load guide device was used. In order to counter the weight of the upper plate, springs were used to counter the weight. The design of the springs was such that minimal load less than 2 lbs. were applied on to the specimen when the test load is not being applied.

To apply the load to the specimen, steel loading strips, with concave sample contact surfaces, machined to the radius of curvature of a 4.000 ± 0.004 inch diameter specimen or a 6.000 ± 0.006 inch diameter specimen are required to apply load to the test specimen. The contact area of the loading strip shall be ½ inches wide and ¾ inches for 4-inch and 6-inch diameter specimen respectively. The outer edges of the curved surfaces shall be filed lightly to remove sharp edges that might cut the specimen during testing. Thin lines should be drawn along the length of the strip at its center, to help alignment. Also, appropriate marking should be made so as to center the specimen within the length of the strips. This could be either done by matching the center of specimen with a mark at the center of the strip or by positioning the specimen between two marks at the ends of the specimen thickness, or both.

Deformation Measurement devices

The resilient modulus and Poisson's ratio is a function of the applied load and the deformations measured in the horizontal and vertical directions. The amount of deformation measured in both horizontal and vertical direction is extremely small, requiring measuring device with a high resolution. That is a small error in deformation can result in significant error in the prediction of the Poisson's ratio and eventually the resilient modulus. For small measurements three commonly used devices include: spring loaded LVDTs, mountable devices such as extensometers and gage point mounting setup.

In order reduce the effect of rocking and stress concentration it is important to have on-sample measurement away from the zone of stress concentration. Thus, it is important to have a device that is small and lightweight such that it does not creep or move under its own weight when the mix is tested under higher temperatures. It was found that gage point mounting may be the most appropriate device because of its lightweight and relatively smaller in size.

With the Gage Point Mounted (GPM) device, small mounting blocks are glued directly to the sample and small LVDTs are mounted on the blocks to measure the deformations. When using this type of device, following factors much be considered (1):

- Weight of the measurement devices and their mounts
- Alignment of these measurement devices with the axis of measurement
- Whether the LVDT is parallel to the surface of the specimen
- The size of the mount (glue points)
- Measurement gage length relative to aggregate size
- Type of glue used
- The surface characteristics and aggregate fabric near the glue points
- Sensitivity of LVDTs

LVDT model 099 XS-B (0.1 in travel) manufactured by Schaevitz was used in the gage-point-mounted (GPM) system. These LVDTs weigh less than 5 grams. Lightweight mounts were made of brass and can be mounted on the specimen with a thin layer of glue. A non-sag epoxy can be used to glue the mounts on the surface of the specimen.

The advantage of measuring between gage points is that extraneous deformation is eliminated including the effects of rotation and rocking. Again, as with mountable devices, it does not ensure that the resilient modulus measured during the rocking is perfect. The gage point mounted is not as expansive as the extensometer system but is not as simple as a standalone system. The GPM method requires a significant amount of care on the part of the operator, and the procedure is somewhat cumbersome. A waiting period is required for the epoxy to dry before the testing can begin. With proper care the gage point mounted system offers good reference test method for resilient modulus measurement that can be used for routine testing.

It is important for the LVDTs to be aligned properly on to the specimen. A marking device must be used to mark mutually perpendicular axes on the front and back faces of the specimen through the center. The device shall be capable of marking axes on different sizes (thickness and diameter) of specimens. The axes shall be simultaneously marked on the front and back faces of the specimen to ensure that axes on the front and back lie in a single plane.

Data Acquisition

One of major factor that contribute to the overall results is the data acquisition system. The recording system should be capable of recording the applied load and sample response both in the horizontal and vertical direction in the range of 0.00001 inch (0.00025 mm) of deformation. Load cells need to be accurate calibrated with a resolution of ± 1.0 lb. or better.

In order to achieve the above-mentioned resolution for data acquisition, it is recommended to have at least a 16-bit data acquisition system. As mentioned earlier, the recommended approach is to use the gage point mounting system with a recommended travel of ± 0.1 inch (e.g. LVDT model 099 XS-B ± 0.1, manufactured by Schaevitz). The 16-bit system will have a resolution of $2^{15} = 32768$ bits. Thus, 0.1-inch range LVDT will provide a resolution of (0.1/32768 = 3.05 x 10^{-6} inch) 3.05 micro inch sufficient to meet the required criteria for resilient modulus testing.

Another important issue with regards to data acquisition is the frequency of data stored for data analysis. The measuring or recording devices must be capable of providing real time deformation and load information and should be capable of monitoring readings on tests conducted to 1 Hz. The data acquisition must be capable of collecting at least 200 scans per second (a scan includes all deformation and load values at a given point of time). For a resilient modulus test that is usually conducted with a pulse load of 0.1 second and a rest period of 0.9 will result in 20 data points (0.1 x 200 = 20) in the load pulse. This is required as a minimum to completely define the load and unload portion for the computation of instantaneous and total resilient modulus values.

COMPARISON AND REVIEW OF PROTOCOLS

Recognizing the importance and existing problems of resilient modulus testing of asphalt concrete, pavement industry has been struggling for the last three decades to develop a standardized protocol resilient modulus evaluation. In coarse of this struggle several protocols have been developed in the past each with a small modification to the previous. Given below is the list of protocols developed in sequential order:

- ASTM D4123-82
- SHRP P07 (10/92)
- AASHTO TP31-94
- NCHRP 1-28
- NCHRP 1-28A

All the above-mentioned protocols follow the same philosophy of measuring the sample response under applied load. Table 4.1 summarizes the major features for each of the above-mentioned protocol. The major difference among these is the approach used for measuring the sample response under the applied load. A brief discussion for each of the above mentioned protocol is given below.

ASTM D4123-82

This analysis is adopted from the ASTM D4123-82 for the resilient modulus testing of asphalt concrete. Absolute values of all deformations are to be taken for the purpose of this analysis. Poisson's ratio (μ) and resilient modulus (M_r) are determined by the following equations:

$$\mu = 3.59\frac{\delta_x}{\delta_y} - 0.27$$

$$M_R = \frac{P}{t\,\delta_x}(\mu + 0.27)$$

where

P	=	applied representative load
t	=	thickness of the specimen
M_R	=	resilient modulus
μ	=	resilient Poisson's ratio
δ_x, δ_y	=	measured deformation in x and y-axis.

According to ASTM D4123-82, a Poisson's ratio of 0.35 can be assumed, if necessary at a temperature of 77°F. The above equations are used to calculate the instantaneous or the total Poisson's ratio and resilient modulus depending upon whether instantaneous or total deformation is used. The deformation measurements are taken off sample and no on sample LVDTs mounting is required. The gage length equals the diameter of the specimen. The test is applicable for both 4-inch and 6-inch diameter cores.

SHRP P07 (10/92)

This analysis is adopted from the SHRP P07 Protocol (November 1992) for resilient modulus testing of asphalt concrete specimen. Absolute values of all deformation that included both horizontal and vertical deformation are used for the estimation of Poisson's ratio and the resilient modulus. To improve the accuracy of the calculated values of Poisson's ratio, the SHRP P07 (November 1992) procedure used compliance factor applied to the measured vertical deformation. The equation for Poisson's ratio is given by the following relationship.

$$\mu = \frac{0.859 - 0.08R}{0.285R - 0.04}$$

In general, "R" value is defined by the following relationship:

$$R = \frac{\delta_y - V_o}{\delta_x}$$

In the above equation, V_o is the vertical compliance factor. The use of a compliance factor V_o would improve the value of the vertical deformation for the purpose of calculation of Poisson's ratio. However, a compliance factor will have to be determined for each setup.

The SHRP procedure limits Poisson's ratio to a range of 0.1 to 0.5, even when the calculated values go outside these bounds. The resilient modulus is then calculated according to the following equation.

$$M_R = \frac{PD(0.08 + 0.297\mu + 0.0425\mu^2}{tH}$$

where

H	=	is the recoverable instantaneous or total horizontal deformation, in.
P	=	applied repetitive load, lbs.
t	=	sample thickness, in.
D	=	sample diameter, in.

With this protocol (P07) the major addition made to the existing ASTM D4123-82 includes:

- Description of specimen requirements and measurements: this basically includes general specification for taking cores from the field, specimen thickness measurement, specimen diameter and specimen marking.
- Procedure related to alignment and specimen seating: requirements are added to P07 for aligning and seating the specimen. Marking the specimen and matching it with the markings on the load strips carry out the alignment. A seating load is specified as a function of the tensile strength of the test specimen. Additional requirements with

respect to the contact surface between the specimen and the loading strips are added to the P07 protocol.

- Quality assurance/quality control with synthetic specimens: prior to the start of resilient modulus testing each week, the laboratory testing personnel shall perform testing on one or more of in-house QA/QC specimens (Lucite, Polyethylene and Teflon) specimens to verify the system response.
- New equation for calculations: equations have been modified as discussed earlier to account for the compliance in the system.
- Load level requirements: instead of specifying load levels between 10 to 50% of the indirect tensile strength, P07 specifies 30%, 15%, and 5% of the indirect tensile strength for test temperatures of 41, 77, 104°F respectively.
- Load duration: Under the ASTM D4123-82 protocol, the recommended load duration is 0.1 to 0.4 s, with 0.1 s being the more representative of transient pavement loading. Recommended frequencies are 0.33, 0.5 and 1 Hz. However, under the P07, load duration of 0.1 s and rest period of 0.9 s is recommended.

AASHTO TP31-94

This analysis is adopted from AASHTO TP31 (September 1992) for resilient modulus testing of asphalt concrete specimen. Absolute values of all deformation that included both horizontal and vertical deformation are used for the computation of Poisson's ratio and the resilient modulus. The protocol does the address the issue of system compliance as was done in the P07 protocol.

Under this protocol, SHRP load guide device has been identified as a loading setup for the measurement of the resilient modulus. It states that the "Sample loading apparatus and deformation sensor mounting system shall be a load guide system having two vertical posts and a rigid upper and lower platens. The lower platen shall be fixed firmly to the base plate of the testing machine. The center third of the bottom surface of the lower platen shall be in firm contact with the base plate of the testing machine as determined by use of a machinists layout dye compound. The load guide device (LGD) shall be clamped to the testing frame to prevent movement relative to the loading frame".

Under the P07 no specific guidelines were provided with regards to the specimen height. However, under this protocol, it state that the specimen shall have a height of 38 mm (1.5 in.) minimum to 76 mm (3.0 in.) maximum and the diameter shall be 97.8 mm (3.85 in.) minimum to 105.4 mm (4.15 in.) maximum. Additional requirement for measuring the thickness and diameter are added. According to the AASHTO TP31-94, the thickness (t) of each specimen shall be measured to the nearest 0.25 mm (0.01 in.) prior to testing. The thickness shall be determined by averaging four measurements located at quarter points around the sample perimeter, and 13 to 25 mm (0.5 to 1.0 in.) in from the specimen edge. The diameter (D) of each test specimen prior to testing to the nearest 0.25 mm (0.01 in.) by average diametral measurements. Measure the diameter of the specimen at the mid-height along (1) the axis parallel to the direction of traffic and (2) the axis perpendicular (90 degrees) to the axis measured in (1) above. The two measurements shall be averaged to determine the diameter of the test specimen.

Another major changes from P07 protocols relates to the preconditioning of the test specimen. Gives below are the modifications to the P07 protocol:

1. Seating Load: Under this protocol, resilient modulus is required at three temperatures. Load levels corresponding to tensile stress levels of 30, 15, and 5 percent of the tensile strength measured at 25oC, are to be used in conducting the resilient modulus determinations at the test temperatures of 5, 25 and 40 ± 1°C respectively. At each test temperature, 10 percent of the load level established shall be used as the contact load required to maintain a positive contact between the loading strips and the specimen during the resilient modulus testing. Under the P07 protocol, 3%, 1.5% and 0.5% of indirect tensile strength is used for test temperatures of 5, 25 and 40 ± 1°C respectively.

2. Horizontal and Vertical Deformation: The two vertical deformation response curves are viewed in real time to insure that acceptable vertical deformation ratios are being measured. Similar to the vertical deformations, horizontal deformations are measured to make sure that they are acceptable. The ratio of deformation from two pairs of LVDTs should be within the range specified during the preconditioning.

<u>NCHRP 1-28 (10/1996)</u>

The main objective under this research work was to develop a final protocol by reviewing the state-of-the-art procedures and equipment for laboratory resilient modulus testing. Using this information, develop a laboratory test procedure for evaluating the resilient modulus of asphalt concrete. Based upon the extensive work done, a protocol was proposed in October 1996.

The protocol was developed based upon the work done under NCHRP 1-28 and the information from the previous exiting protocols. No major changes were proposed under this protocol form the existing protocol except for the deformation measurement for the computation of Poisson's ratio and the resilient modulus values.

Under this protocol, on-sample deformation measurements are recommended instead of the off-sample measurements as was proposed in all the previous protocol. This was a major change to minimize the effects for specimen moving or rocking on the material properties. In addition, this also helps to take measurements away from the zone of high stress concentration.

According to the NCHRP 1-28, the vertical deformation shall be measured on the surface of the specimen by mounting a LVDT between the gage points along the vertical diameter. The gage length shall be three quarters the diameter of the specimen. If possible, two LVDTs, one each on the front and back faces of the specimen, should be used and the deformation averaged. Extensometers (or a comparable mountable device) should be used for the measurement of the horizontal deformation. This was the major modification done from the existing previous protocols.

The revised equations that are based upon the gage length that is three quarter the diameter of the specimen are given below for the Poisson's ratio and the resilient modulus:

$$\mu = \frac{-1.9345 - 0.2699\frac{\delta_v}{\delta_h}}{-0.4309 + \frac{\delta_v}{\delta_h}}$$

where

m = instantaneous or total Poisson's ratio

δ_v = recoverable vertical deformation over a gage length equal to three quarters of the diameter of the specimen, inches and

δ_v = recoverable horizontal deformation over the horizontal diameter of the specimen, inches.

The calculated Poisson's ratio shall be subject to the following ranges:

41°F: 0.1 – 0.3

77°F: 0.25 – 0.45

104°F: 0.4 – 0.5

The upper and lower limits may be used for resilient modulus calculations, depending upon whether the calculated Poisson's was greater the upper limit or lower than the lower limit, respectively. However, when in doubt about the validity of the calculated Poisson's ratio, the calculated values shall be reported but following values shall be assumed for the resilient modulus calculation:

41°F: 0.2

77°F: 0.35

104°F: 0.5

When the calculated Poisson's ratio is outside of the ranges defined above, the calculated values shall be reported and a visual inspection of the specimen should be made to study the deformation in shape and/or presence of cracks due to damage, and so reported.

The resilient modulus can then be calculated from the Poisson's ratio obtained from the following equation:

$$M_R = \frac{P_{cyclic}}{\delta_h t}(0.2699 + \mu)$$

where

P_{cyclic} = P_{max} - $P_{contact}$

P_{max} = maximum applied load, lbs.

$P_{contact}$ = contact load, lbs.

t = thickness of the specimen

M_R = resilient modulus

μ = resilient Poisson's ratio

δ_h = measured deformation in x and y-axis.

<u>NCHRP 1-28A</u>

While the NCHRP 1-28 study yielded many excellent findings, conclusions and recommendations; the major recommendations involving the development of "yet another set of test protocols" associated with the M_r response of asphaltic mixtures resulted in a significant difficulty relating to the standardization of a unified or "harmonized" test protocol that has universally accepted implementability in the pavement community. Work was carried out with this specific objective and the finally proposed protocol is attached in appendix B.

Most of the protocol follows the guidelines presented under NCHRP 1-28. However, the major change deals with the deformation measurement for the estimation of the Poisson's ratio and the resilient modulus.

The gage length specified under this protocol is a function of the specimen size and the aggregate size of the mix under consideration (summary of details to be added after finalizing the protocol).

CHAPTER 5
AC MIXTURES USED IN STUDY

INTRODUCTION

Three Superpave mixtures were used in laboratory experiments in the (NCHRP 1-28A) project. These include surface course mixtures with nominal maximum sizes of 12.5 mm and 19.0 mm, and a base course mixture with a nominal maximum size of 37.5 mm. These three mixtures were also used in the Superpave Support and Performance Models Management project (NCHRP 9-19). This fact allowed for use of material data tested under NCHRP 9-19 for these mixes.

This chapter documents the design of the three mixtures and presents laboratory test data characterizing the rheological properties of the asphalt binder. The Superpave mixtures use 100 percent crushed limestone from Maryland and an unmodified PG 64-22 binder. The mixture designs were based on preliminary designs supplied by the Maryland State Highway Administration.

SUPEPRAVE MIXTURE DESIGNS

Aggregates

The three Superpave mixtures were produced with limestone aggregate from Redland Genstar's Frederick Maryland quarry. Materials from seven stockpiles were used to produce the mixtures. Additionally, fines obtained from the dust collection system of a hot mix plant at the quarry were included to increase the filler content of the mixtures to that typical of plant production. Table 5.1 summarizes pertinent test data for each stockpile. The aggregate is hard and durable with low Los Angles abrasion and sodium sulfate soundness loss.

The coarse aggregate stockpiles have water absorption of less than 0.5 percent. All stockpiles except the # 8 meet the Superpave consensus aggregate criteria for the highest traffic level. The # 8 stockpile has 10.4 percent flat and elongated pieces. The Superpave consensus criteria for this property for traffic greater than 1 million 80 kN equivalent single axle loads (ESAL) is a maximum of 10 percent.

Asphalt Binder

The asphalt binder used in each of the three Superpave mixtures was an unmodified PG 64-22 obtained from the Paulsboro, New Jersey terminal of the Citgo Asphalt Refining Company. An extensive testing program was performed to characterize the rheological properties of the binder over a wide range of temperatures using both conventional and Superpave tests. The testing program and the results are described in detail in a later section of this chapter. Table 5.2 summarizes AASHTO MP1 (24) grading data for the binder obtained from the manufacturer's certification report (25). Mixing and compaction temperatures are presented in Table 5.3 (25).

Preliminary Designs

Preliminary designs for each of the Superpave mixtures were obtained from the Maryland State Highway Administration (MSHA). These designs are summarized in Table 5.4 and described below.

12.5 mm Mixture

The 12.5 mm mixture design was a plant verified design for the aggregate from the Frederick quarry used by the MSHA on a project with design traffic of 3 to 10 million 80 kN ESAL.

The design asphalt content and volumetric properties are based on a design gyration level of 96. The minus 0.075 mm content of 5.1 percent for this mixture is representative of plant production. It is approximately 1.5 percent greater than that obtained from the stockpile gradations.

19.0 mm Mixture

The 19.0 mm mixture design was a laboratory design for the aggregate from the Frederick quarry that was not plant verified. The minus 0.075 mm content of 3.0 percent was based on the stockpile gradations and was not adjusted to reflect plant production. The typical practice used by contractors in Maryland is to develop a laboratory design based on the stockpile gradations that gives an air void content of approximately 5.0 percent. This design is then verified through the plant and adjustments are made to produce acceptable volumetric properties. Typically, the air voids and VMA decrease and the percent passing the 0.075 mm sieve increases for the plant-produced mixtures. These adjustments were not made to the 19.0 mm design listed in Table 5.4.

37.5 mm Mixture

The 37.5 mm design is the job mix formula used by the MSHA on a widening project on I-695, the Baltimore Beltway. The mixture for the Beltway project used a different aggregate source than the Redland Genstar Frederick quarry.

Alterations

The preliminary designs listed in Table 5.4 were altered for use in this research project. The rationale for the alterations that were made is described in this section. New optimum asphalt contents for the 12.5 mm and 19.0 mm mixture were then determined.

The 37.5 mm mixture was completely redesigned since the preliminary design provided by the MSHA used a different aggregate source.

Short-Term Oven Aging

The preliminary mixture designs provided by the MSHA included short-term oven aging as part of the volumetric mixture design process. Since many of the experiments planned for the project involve testing a large number of specimens, the short-term aging normally used in volumetric mixture design was eliminated to conserve time and project resources.

Design Gyration Level

The preliminary designs provide by the MSHA used different levels of design gyrations because they represented mixtures from projects with different traffic levels. Design gyration levels of 96, 109, and 126 were used in the MSHA designs for the 12.5, 19.0, and 37.5 mm mixtures, respectively. For this project it is desirable to have all mixtures designed for the same level of traffic. A design gyration level of 109, representing a traffic level of 10 to 30 million 80 kN ESAL was selected.

Filler Content

The percent passing the 0.075 mm sieve was increased in each of the mixtures to represent plant production. Using the plant verified 12.5 mm mixture as a guide, the percent passing the 0.075 mm sieve was increased approximately 2 percent above that obtained from the stockpile gradations.

Final Surface Course Mixture Designs

The optimum binder content for the 12.5 mm and 19.0 mm mixtures were determined using sequential trial batches to estimate the design asphalt content. Specimens were fabricated using the MSHA provided aggregate gradations adjusted with additional minus 0.075 mm material to represent plant production. Using an initial trial asphalt content estimated from the preliminary MSHA designs, two specimens were then compacted in the Superpave gyratory compactor to 174 gyrations and average volumetric properties were calculated for a design level of 109 gyrations. From these compacted specimens, the optimum asphalt content and volumetric properties at the optimum asphalt content were estimated using the method described in Asphalt Institute Publication SP-2 (28). If the estimated optimum asphalt content differed from the trial asphalt content by more than 0.3 percent, the estimated optimum asphalt content was then used as the trial asphalt content of a second iteration of the procedure. This process was continued until the trial and estimated asphalt contents converged to within 0.1 percent. Both surface course mixtures required only one iteration. Tables 5.5 and 5.6 summarize the results of the iterative verification process for the 12.5 and 19.0 mm mixtures, respectively. The final design and volumetric properties for these two mixtures are presented in Tables 5.7 and 5.8. Figures 5.1 and 5.2 present gradation and gyratory compaction data for the 12.5 mm mixture. Figures 5.3 and 5.4 present the same data for the 19.0 mm mixture. Since the 12.5 mm and 19.0 mm mixtures were not compacted at the optimum asphalt content, the compactions curves shown in Figures 5.2 and 5.4 used the trial asphalt contents listed in Tables 5.5 and 5.6.

The final designs for both surface course mixtures meet all of the current Superpave criteria except the requirements on the filler to effective asphalt content ratio. The design value of 1.3 for both mixes exceeds the current Superpave maximum limit of 1.2. Guidance recently issued by the Superpave Lead States recommends that the upper limit for the filler to effective asphalt content ratio be increased to 1.6, and it is likely that AASHTO MP2 will be modified in the future to increase the upper limit to 1.6 (29).

Final Base Course Mixture Design

The same iterative verification process described for the surface course mixtures was planned for the 37.5 mm mixture. However, when the initial trials were performed using the MSHA preliminary design information, the VMA of the mixture at the estimated optimum asphalt content was found to be below the Superpave minimum value of 11.0. Several trial blends were then developed and evaluated. Table 5.9 summarizes the evaluation of the various trial blends. Trial blend 5 was selected as the final design. The final design and volumetric properties for the 37.5 mm mixture are presented in Table 5.10. Figures 5.5 and 5.6 present gradation and gyratory compaction data for the 37.5 mm mixture. The final design for the 37.5 mm mixture meets all of the current Superpave criteria. The density at $N_{maximum}$ is at the Superpave upper limit of 98.0 percent of theoretical maximum.

BINDER CHARACTERIZATION

Objective

A comprehensive characterization of the rheological properties of the Citgo PG 64-22 that was used in the laboratory mixtures was conducted using both Superpave and conventional binder tests. The objective of this work was to provide rheological characterization the binder over a wide range of temperatures and rates of loading. Superpave and conventional binder tests were performed for tank conditions.

Test Methods

Superpave Tests

Table 5.11 summarizes the Superpave characterization tests that were conducted. Intermediate and high temperature characterization involved measuring the complex shear modulus, G*, and the phase angle, δ, of the binder with a dynamic shear rheometer (DSR) over a range of temperatures and loading rates. High temperature viscosity was also measured at six temperatures using the Brookfield viscometer. The temperature range for the viscosity and DSR data overlap. Low temperature properties of the binders were measured with the bending beam rheometer (BBR) and the direct tension (DT) test. The BBR was used to measure the flexural creep stiffness as a function of time at temperatures bracketing the corresponding test temperatures for the low temperature grade. Stress strain curves to failure were developed with the DT to characterize the fracture properties of the binders. These were conducted at the same three temperatures as the BBR tests.

The DSR, Brookfield, and BBR tests were conducted in accordance with the June 1998 Revision of the AASHTO Provisional Standards (24). The DT tests were also conducted in accordance with the June 1998 Revision of the AASHTO Provisional Standards, except a

video extensometer was used in place of the specified laser extensometer, and metal molds were used in place of the specified silicone molds. Future revisions of AASHTO TP3 will incorporate the metal molds used in this study and a mechanical strain measuring system. The video extensometer used in this study compares well with the proposed future mechanical system.

Conventional Tests

Table 5.12 summarizes the conventional binder characterization tests that were conducted. These tests combined with the Brookfield viscosity data from Table 11 provide data for the characterization of the ASTM Viscosity Temperature Susceptibility relationship, Equation 1, for the binders over a very wide range of temperatures (27).

$$\log\log\eta = A + VTS\log T_R \tag{5.1}$$

where:

η = viscosity, cP

T_R = temperature, Rankine

A = regression intercept

VTS = regression slope of Viscosity Temperature Susceptibility

Although Equation 5.1 is usually used with data from capillary viscosity measurements at 60 and 135 °C to develop mixing and compaction temperatures, it can be extended to lower temperatures using ring and ball softening point and penetration data.

Research by Shell that was later confirmed by Mirza and Witczak (30) indicate that for most unmodified asphalts, the ring and ball softening point corresponds to a viscosity of 13,000 poise. Penetrations from tests using 100 g, 5 sec loading can be converted to viscosity using Equation 2 developed by Mirza and Witczak.

$$\log \eta = 10.5012 - 2.2601\log(Pen) + 0.00389[\log(Pen)]^2 \quad (5.2)$$

where:

η = viscosity, P

Pen = measured penetration for 100g, 5 sec loading, 0.10 mm

Thus, from a combination of penetration, ring and ball softening point, and capillary viscosity measurements that are routinely measured to insure compliance with viscosity grading, the viscosity of the binder over a wide range of temperatures can be determined from Equations 5.1 and 5.2.

Test Results

Superpave High and Intermediate Temperature Properties

Table 5.13 summarizes the G* and phase angle data collected for all combinations of temperature, and frequency. Figures 5.7 and 5.8 present isochronal plots of G* and phase angle for the tank condition using the 10 rad/sec data. Table 5.14 and Figure 5.9 present Brookfield viscosity measured.

Superpave Low Temperature Properties

Table 5.15 presents flexural creep stiffness and m-value data obtained with the bending beam rheometer. Figures 5.10 and 5.11 show stiffness and m-value data as a function of temperature for the loading time of 60 sec, which is the loading time, reported in normal

Superpave Performance Grading tests. For tank condition, the flexural creep stiffness decreases and the m-value increases with increasing temperature.

Figure 5.12 presents low temperature stress-strain data from DT tests for the tank conditions. Figures 5.13 and 5.14 show fracture strain and strength data as a function of temperature. The strain at failure increases with increasing temperature. The fracture strength increases with increasing temperature for tank condition.

Conventional Properties

Table 5.16 summarizes the conventional properties measured for the tank condition. These data were combined with the Brookfield viscosity data in Table 5.14 to calculate the A and VTS parameters using Equations 5.1 and 5.2. Table 5.17 summarizes the resulting parameters, A and VTS.

Specimen Preparation

Specimens were fabricated by sawing appropriate size test specimens from the 150 \ 100 mm diameter gyratory compacted specimens. All specimens were compacted using approved Superpave gyratory compactors. A double bladed saw was used to ensure parallel specimens ends.

To ensure uniform specimen production, the aggregate stockpile samples were dried, combined in the appropriate percentages, then dry sieves into individual sizes through the 0.075 mm sieve. Appropriate size batches were produced by weighting material from the individual sizes. The amount passing the 0.075 mm sieve was adjusted to account for fine material retained on the larger aggregates during the dry sieving process.

All specimens were fabricated at the optimum asphalt content listed before in general accordance with AASHTO TP4. The short term aging procedure normally used in volumetric mixture design, and the preparation of performance test specimens was eliminated to conserve time and resources. The target air void content for the test specimens was 4.0 percent for the three Superpave mixtures. An air void tolerance of ± 0.5 percent was used for the two surface course Superpave mixtures. For the 37.5mm mixture, the tolerance was expanded to ± 1.0 percent. The tolerance was applied to the final test specimen. To limit variations in material properties caused by aging, all test specimens were wrapped in polyethylene bags prior to testing. The maximum shelf life for the wrapped specimen was 14 days.

CHAPTER 6
LAB TESTING PROGRAM

BASIC GOALS OF THE LABORATORY STUDY

The major goals of the overall project study have previously been stated in Chapter 1 of this report. As an integral part of developing recommendations for a "Harmonized" test protocol for the testing of asphalt mixtures with the indirect (diametral) device; one of the most critical lab issues focused on the selection of the appropriate gage lengths to be used on differing mixtures (in reality, nominal aggregate sizes) for the use of "On-Specimen Mounted LVDT" systems.

Work on the aspect of the gage length to be employed during a given test is considered to be of extreme importance to the final accuracy of the deformation measurement, and the subsequent accuracy of the predictions of the Modulus and Poisson Ratio. It should not be difficult to visualize that the use of a 1.5 inch (37.5 mm) gage length on an asphalt mixture specimen having a nominal aggregate size of 1.5 inch (37.5 mm) may result in significant error if the gage (or a major portion of it) is placed over a single, large aggregate particle. For such a situation, one will never be sure if the measurements truly reflect the mix, an aggregate particle, or some combination of the two.

In order to focus the majority of the testing resources to investigate this particular aspect of the test protocol; the major emphasis of the experimental test plan was placed upon the combination of using 3 differing mixtures (nominal aggregate sizes of : 12.5, 19.0 and 37.5 mm) with 3 differing ratios of Gage Length to Specimen Diameter (Ratio : 0.25, 0.50 and 0.75). Coupled with this testing program, an important part of the lab study developed was to use an generalized ANOVA approach to develop provisional variance estimates of all major variables influencing the Modulus and Poisson Ratio prediction. The specific variance components developed reflected variation due to: cycle, repeat, rotational, (between) face and specimen. Each of these components of variance was determined independently for each combination of mix type and gage length. Such an experimental testing plan, coupled with the method of analysis, was critical for the study to quantify the impact of gage length and mix type upon the predictive accuracy of the Diametral Modulus test.

Because of budgetary considerations, the experimental test program was limited to only a single temperature (70 deg F). However, separate analysis was conducted for 4 independent measurement variables: instantaneous $M_{R,}$ total MR, instantaneous μ and the total μ.

DESCRIPTION OF TEST METHOD UTILIZED

Testing Device

The Indirect-testing device used in the testing program was the SHRP Load Guide device. As a result of a comparison study of NCHRP 1-28 between test devices, it was concluded that the SHRP device, with some modification, was the best device among other systems available in regard to control of rocking and frictional load.

The SHRP LG was developed as apart of the Strategic Highway Research Program's Long Term Pavement Performance Project. The device has upper and lower loading platens constrained to remain parallel during testing by the presence of two heavy guideposts. The SHRP LG device with heavy guideposts can rigidly align the upper and lower loading strips. The guideposts are in line with the loading strips to assure minimal lateral movement of the top-loading strip with reference to the lower. A spring counterweight system prevents the heavy weight of the loading platen being applied to the system.

Two standoff horizontal transducer holders are attached to the lower platen of the load frame such that the LVDT's could be positioned at mid-height of the samples at either end. The holders are movable by a screw adjustment that makes it possible to adjust the position of the LVDT's for either 4" diameter or 6" diameter specimens. Steel loading strips, curved to 4" and 6" diameter specimen curvature, are tightened to the platens by screws. The load is transferred through a small (0.5 " diameter) metal ball, which rests on an inverted conical groove on the top of the short rod connected, to the upper loading platen.

Device Modification

The SHRP device used in this study was upgraded by the following modifications. Firstly, ball bearings were installed within the guideposts to reduce the friction load resisting the vertical movement of the upper load platen. The friction load will tend to cause less load than the load measured by the load cell being applied to the specimen.

The pulley counter balance, which was the SHRP load guide device main feature in eliminating the application of heavy weight load of the upper load platen to the specimen, was replaced with springs, Due to the replacement of the couter balance with springs, the size of the device was decreased tremendously. This allowed the entire test device to conveniently fit within a conventional environmental chamber.

In addition, removable loading strips made it possible to be able to replace the 0.5 " loading strip, suitable for 4" diameter specimens; with a 0.75" loading strip with the curvature for 6" diameter specimens. This modification allowed both 4" and 6" diameter samples to be conveniently tested in the device.

Finally, a marking device was developed to accurately mark mutually perpendicular axes on both faces of the specimen with precision. The specimen was aligned between the loading strips and the marked axes were then used as a datum. This approach was generally observed to provide good control for specimen rocking. Lines were precisely drawn at the ends of the loading strips to facilitate alignment of the specimen. In retrospect, it was the experience of the test team that the installation of the specimens in the device required a significant amount of time and patience to obtain proper alignment.

Deformation Measurement System

Indirect measurement of the Resilient Modulus and Poisson Ratio of asphaltic specimens are computed by entering measured deformations during the diametral test into elasticity equations.

Since these diametral deformations are generally quite small; it is important to measure deformations using accurate deformation measurement systems. In this study, both stand alone and mountable gage point LVDT's were employed. However, because numerous studies have demonstrated the superiority of LVDT systems that are mounted on the specimen; this report utilizes only these measurement systems in the analysis. As a consequence, the Mounted Gage Point LVDT system is presented in the following paragraph.

Mounted Gage Point LVDT's are mounted directly on the specimen, instead of being attached to a stationary object outside of the specimen. The procedure for mounting the LVDT's on the faces of specimens is described as follows. With the use of a marking plate, the location of 4 gage points along two perpendicular diameter faces are marked. The height of the gage points is slightly different to allow the crossing of the horizontal and vertical LVDT's. Four small buttons are then epoxied at the marked locations and four small cylinders are then attached to the buttons by use of very fine screws. The LVDT's are placed and screwed between the two cylinders to measure the deformations. When using this set-up, several factors must be considered:

- Weight of the LVDT's and their mounting pieces
- Alignment of the measurement devices with the principal diameters of specimen (loading axis and perpendicular to the loading axis)
- Parallelness of the LVDT's to the surface of the specimen
- Size of the mount (glue points)
- Distance of the LVDT's from the surface to the specimen
- Type of glue used
- Surface characteristic and aggregate fabric near the glue points
- Sensitivity of the LVDT's used

LVDT's, manufactured by Schaevitz, with a span length of 0.2 inches were used in the study. These LVDT's weigh less than 5 grams. The gage points (buttons) are very light weight with diameters of 0.275 inches to minimize the contact surface and the two differing heights of 0.156" and 0.25" to minimize the distance of the LVDT's from the surface of the specimen. The gage points were attached to the surface of the specimen with a very thin layer of fast drying, non-sag epoxy. Prior to the marking of the gage point locations, a thorough inspection of the specimen was done in order to choose the smoothest surface with no obvious air voids. Also, care was taken to avoid the presence of big aggregate particles, as much as possible, between gage points. Otherwise the measured deformation would represent the deformation of the aggregate.

A major advantage of measuring between gage points is that the measurement of the specimen deformation due to rocking and rotation is eliminated. However, it should be recognized that this measurement approach does not necessarily eliminate the movement of the sample itself. It is very important to control this form of rocking since the load applied and stress/strain pattern in the sample will change when this rocking occurs. In summary, the Mounted Gage Point LVDT approach is not as simple as a stand-alone LVDT measurement system. It will require a significant amount of time and patience to prepare the specimen for test evaluation. However, it unquestionably leads to a much more accurate assessment of the specimen deformations during the testing sequence.

Marking Device

To properly align the specimen, a specially developed marking plate (template) was made. This device was fabricated to mark two perpendicular diametral axes on each face of a 4" or 6" diameter specimen. This was done to insure that the two mutually perpendicular diametral axes go through the center of the specimen. Along diametral axes, the position of the gage points for mounting different gage length LVDT's could also be marked using the marking plate. Finally, four notches at the edge of the plate along the diametral axes, made it possible to mark the position of the loading strip at the top and bottom of the sample at both a 0 and 90-degree rotation position.

EXPERIMENTAL TEST PLAN

In the experimental test plan, three separate specimens per asphalt mix were tested, three MSHA Superpave mixtures, having nominal aggregate sizes of 12.5 mm, 19.0 mm and 37.5 mm), and 2 different diameter specimens (4" and 6" diameter). All specimens were compacted with the

SHRP-Superpave Gyratory Compaction device to a target air voids of 7.0% +/- 0.5%. The 4" diameter specimens were cored from 6" gyratory plugs. All specimens manufactured were approximately 6" in height. From these samples, "3 test specimens", of approximate 2" thickness were then cut from the 6" high sample to obtain 3 separate test specimens. These test specimens were identified as specimens; A, B, and C.

For each factorial combination; on-specimen gages, having a "Gage Length to Diameter ratio" of: 0.25, 0.5 and 0.75 were used. This implied that gage lengths of: 1", 2" and 3" were used with the 4" diameter specimens while gage lengths of: 1.5", 3.0" and 4.5" were used with the 6" diameter specimens. These gages were mounted on each specimen face, at 0 and 90 degree orientation, to measure strain in the x-y plane (along horizontal and vertical diametral).

The experimental test procedure used was to apply 100 cycles of load and record the 95-99th cycles for the Moduli and Poisson ratio computations. A haversine pulse load, with a 0.1 sec load and 0.9 sec dwell time was used. Upon completion, the load actuator was then removed from contact with the specimen and then repositioned for a "repeat" set of cyclic measurements. After the completion of this process, the specimen was rotated 90 degrees and the same test process repeated again. When this portion of the test sequence was finished, the specimen face was rotated 180 degrees in the x-z plane and the exact test procedure, involving cycles, repeat loading and sample rotations in the x-y and x-z planes were conducted. During a given test, one specimen face was always seen or was "Observable" to the test operator, while the other face was placed away or "Hidden" from the operator. In the summary of results, presented in the next Chapter of this report, the terms "Observable and Hidden" face, are denoted in the data results to distinguish what face the results were obtained from.

The calculation of the Total and Instantaneous Resilient Modulus and Poisson Ratio was accomplished by using the deformation measurements, obtained from the "On-Specimen" LVDT's, during the applied loading sequence. This task was accomplished by means of a computer program developed on the original Hondros stress and strain equations. The program accounted for the use of any combination of gage lengths (equal or different gage lengths for horizontal and vertical measurements). All testing noted in this report was evaluated only at one temperature condition (70 deg F), due to time and budgetary considerations. All testing was conducted within an environmental test chamber and the test temperature controlled to within +/- 1 F degree.

ESTIMATION OF VARIANCE COMPONENTS

General Background

As previously noted, the most salient aspect of the lab study was to develop a provisional estimate of the probable variance for all components involved with the measurement of the Resilient Modulus and Poisson Ratio (both Total and Instantaneous). This was accomplished through a generalized (practical) ANOVA approach. These ANOVA studies were generated independently for each mix (Dnom size) and Gage Length in order to carefully examine in detail the influence of the individual variance components as a function of Mix Type and Gage Length.

Within the total testing plan, 9 individual factors were evaluated. They were:

• Nominal Agg Size	3 levels	12.5; 19.0 and 37.5 mm
• Gage Length/Dia Ratio	3	0.25, 0.5 and 0.75
• Spec Diameter	2	4" and 6" dia
• Cycle (Repetition)	5	95-99th cycles
• Repeat (Replicate)	2	
• Within Face Rotation	2	0 and 90 deg (x-y)
• Face	2	Observable/Hidden
• Between Face Rotation	2	0 and 180 deg (x-z)
• Specimen	3	A, B and C (approx 2")

This test procedure resulted in 4320 estimates of each of the 4 major parameters measured (instantaneous $M_{R,}$ total $M_{R,}$ instantaneous μ and the total μ). Thus, a total of 17,280 test measurement results were analyzed in the overall study.

It has already been noted that the generalized ANOVA used to estimate the variance components was independently (separately) completed for each combination of mix type (nominal aggregate size) and gage length (3 per specimen diameter). In addition, the influence of the "Observable-Hidden" variables, including the Between Face Rotation in the x-z plane, was treated in the analysis as simply another set of "between face" variance values.

As a consequence, the specific analysis of variance procedure resulted in provisional estimates of the following variance components:

σ^2_{cycle}	i = 1…5
σ^2_{repeat}	j = 1…2
$\sigma^2_{rotation}$	k = 1…2
$\sigma^2_{between\ face}$	l = 1…2 (limit 2)
σ^2_{sample}	m = 1…3

Estimation of the Variance Components

General: The generalized scheme used to estimate the probable variance magnitude of the key variables analyzed was based upon the simple and fundamental statistical principle that indicates that the total variance of a measurement is due to the sum of all variance components that impact upon the overall average measurement. Thus if the average estimate of a variable is a function of two effects, "i" and "j", then the total variance of the average value is due to the sum of the variances of "i" and "j" or:

$$\sigma^2_{total} = \sigma^2_i + \sigma^2_j \qquad (6.1)$$

The details of the specific approach applied for each of the 5 major variables previously defined is presented in the following paragraphs. It should be recalled that the methodology used was completed independently for each combination of mix type and gage length to ascertain what , if any, influence these variables have upon the specific components of variance developed.

Cycle Effect Variance: The variance of the measurement, associated with the cycle (load repetition) effect is quite direct. It has already been noted that the average of the 95-99th cycle was used to compute the measurement parameter in question. Thus, the standard deviation (and hence variance) of the 5 individual cycle measurements, at a given, specimen, face, rotation and repeat number represents an estimate of the σ^2_{cycle} value. For each combination of mix type and gage length, there are 16 separate estimates of this variance component. These individual values were then pooled (average of the 16 individual variance estimates) to obtain the "best estimate " of the true σ^2_{cycle} value.

Repeat Effect Variance: As was previously noted, a full repeat of the measurement process was undertaken by fully removing the load and then completely re-doing the test. Thus from an analysis of variance viewpoint, the sample variance of the two repeat measurements is equal to the sum of the true repeat variance and the pooled cycle variance for repeat 1 and 2, adjusted for the number of cycle measurements. Mathematically, the estimate of the "true" repeat variance is found from:

$$\sigma^2_{repeat} = \sigma^2_{\bar{x}r} - \left(\frac{\sigma^2_{Pooled\ Cycle}}{n_i} \right) \tag{6.2}$$

where:

σ^2_{repeat}	:	true repeat variance
$\sigma^2_{\bar{x}r}$	:	sample repeat variance from the averages of the repeat 1 and repeat 2 measurements
$\sigma^2_{Pooled\ Cycle}$	:	pooled cycle variance from repeat 1 and repeat 2 measurements
n_i	:	number of cycles used to obtain the average cycle effect

For each sample (specimen), a total of 8 estimates of the true repeat variance can be computed for each combination of mix type and gage length. As is customarily done in practice, any negative estimate of the variance is assumed to be equal to zero. The "pooled" variance for the "true repeat effect" is taken as the average of the 8 individually computed variance estimates.

Rotation (Within Face) Effect Variance: The within face rotational effect is the variance associated with measurement differences caused by rotating the specimen a fixed angle in the x-y plane. In this particular study, using "On Specimen Mounted LVDT's" limited the number of levels evaluated to 2 (0 and 90 deg). From an analysis of variance viewpoint, the rotational (within face) sample variance of the two directional measurements is equal to the sum of the true rotational variance, the true repeat variance and the pooled cycle variance, adjusted for the number of cycle measurements. Mathematically, the estimate of the "true" rotation variance is found from:

$$\sigma^2_{rotation} = \sigma^2_{\bar{x}rot} - \left(\frac{\sigma^2_{repeat}}{n_i}\right) - \left(\frac{\sigma^2_{cycle}}{n_i n_j}\right) \tag{6.3}$$

with

$$\sigma^2_{repeat} = \left(\frac{\sigma^2_{rep\,0} + \sigma^2_{rep\,90}}{2}\right) \tag{6.3a}$$

$$\sigma^2_{cycle} = \left(\frac{\sigma^2_{cycle\,0-1} + \sigma^2_{cycle\,0-2} + \sigma^2_{cycle\,90-1} + \sigma^2_{cycle\,90-2}}{4}\right) \tag{6.3b}$$

where:

$\sigma^2_{rotation}$	:	true rotation variance
$\sigma^2_{\bar{x}rot}$	:	sample rotation variance from the average of rotations at 0^o and 90^o
$\sigma^2_{rep\,0}$	:	sample repeat variance from the averages of repeat 1 and repeat 2 at 0^o rotation
$\sigma^2_{rep\,90}$	:	sample repeat variance from the averages of repeat 1 and repeat 2 at 90^o rotation
$\sigma^2_{cycle\,0-1}$	:	sample cycle variance at 0^o rotation and repeat 1
$\sigma^2_{cycle\,0-2}$	:	sample cycle variance at 0^o rotation and repeat 2
$\sigma^2_{cycle\,90-1}$	:	sample cycle variance at 90^o rotation and repeat 1
$\sigma^2_{cycle\,90-2}$	:	sample cycle variance at 90^o rotation and repeat 2

n_i : number of cycles used to obtain the average cycle effect

n_j : number of repeats used to obtain the average repeat effect

For each combination of specimen (sample), mix type and gage length, a total of 8 estimates of the true rotational variance can be computed. Again, any negative estimate of the variance is assumed to be equal to zero. The “pooled” variance for the “true rotational" variance is the average of the 8 rotational variances computed.

Between Face Effect Variance: The between face variance is the variance that is associated with measurement differences between each of the two faces of a given specimen. In essence, it is the variance between all "Observable-Hidden" face combinations noted in the experiment. From an analysis of variance viewpoint, the between face sample variance is equal to the sum of the true between face variance and the pooled cycle variance, adjusted for the number of cycle measurements across all combinations of "observable and Hidden" faces. Mathematically, the true between face variance is given by:

$$\sigma^2_{bf} = \sigma^2_{\bar{x}bf} - \left(\frac{\sigma^2_{Pooled\ Cycle}}{n_i}\right) \tag{6.4}$$

where:

σ^2_{bf} : true between face variance

$\sigma^2_{\bar{x}bf}$: sample between variance from the average of the observable face and hidden face

$\sigma^2_{Pooled\ Cycle}$: sample cycle variance representing average cycle variance of observable face and hidden face measurements

n_i : number of cycles used to obtain the average cycle effect

For each combination of specimen (sample), mix type and gage length, a total of 8 estimates of the true between face variance can be computed. Any negative variance computation is assumed to be equal to zero. The "pooled" variance for the "true between face" is the average of the 8 variances computed.

Sample (Specimen) Effect Variance: The sample (specimen) variance is associated with average measurements between cut specimens from a single core. In this study, the 6" high gyratory compacted plug was sawn (cut) into 3 - 2" (approximate) thick specimens. Thus, this variance does not incorporate the variance that would also exist between manufactured plugs or possibly between cores obtained from random locations along a given route. This important aspect of this study should be clearly understood by the reader as the true inherent total variability of a field core study will be much greater than the total variability found in this lab study.

From an analysis of variance viewpoint, the within sample (between specimens from one plug) variance is equal to the sum of the true sample (specimen) variance, rotational variance, between face variance, repeat variance and cycle variance. All variances are likewise adjusted for the levels (degrees of freedom) associated with each effect. Mathematically, the true specimen variance is given by:

$$\sigma^2_{sample} = \sigma^2_{\bar{x}s} - \left(\frac{\sigma^2_{rot}}{2n_k n_l}\right) - \left(\frac{\sigma^2_{bf}}{n_j n_k n_l}\right) - \left(\frac{\sigma^2_{repeat}}{2n_j n_k n_l}\right) - \left(\frac{\sigma^2_{cycle}}{2n_i n_j n_k n_l}\right) \quad (6.4)$$

where:

σ^2_{sample} : true sample variance

$\sigma^2_{\bar{x}s}$: sample specimen variance from distribution of plug specimen average values

σ^2_{rot} : sample rotation variance

σ^2_{bf} : sample between face variance

σ^2_{repeat} : sample repeat variance

σ^2_{cycle} : sample cycle variance

n_i : number of cycles used to obtain the average cycle effect

n_j : number of repeats used to obtain the average repeat effect

n_k : number of rotations (within face) measurements used to obtain average rotation effect

n_l : number of between face measurements used to obtain average face effect (note: number of faces = $2n_l$)

For each combination of mix type and gage length, there are 3 estimates of the estimated sample (specimen) variance. The pooled estimate of these three variances therefore represents the "true sample (specimen) variance for a given plug.

Summary: The previous sections of this Chapter have described the component variance approach used in the study. For each combination of mix type (nominal aggregate size) and gage length; individual estimates of variance for 5 major components were developed. These 5 effects were the:

- Cycle Effect Variance
- Repeat Effect Variance
- Rotation (Within Face) Effect Variance
- Between Face Effect Variance
- Sample (Specimen) Effect Variance

The next Chapter of this report summarizes and discusses the results of the variance analysis for the Modulus and Poisson Ratio's parameters as a function of the gage length, for a particular type of mix, as denoted by the nominal aggregate size.

CHAPTER 7
ANALYSIS OF RESULTS

SUMMARY OF RESULTS

General

The master summary of all test results and analysis is contained in two major Appendices of this report. Appendix A is the "Summary of Test Results" and Appendix B is the "Summary of Component Variance Analysis Results".

Individual Test Results

Appendix A is comprised of 24 separate Annexes. There are 6 separate Annexes for each of the four major parameters measured in the study: Mri (instantaneous Resilient Modulus); Mrt (total Resilient modulus); ui (instantaneous Poisson's Ratio) and ut (total Poisson's Ratio). Each of the six sets of Annexes is provided for the combination of the three mix types (nominal aggregate sizes) and the two specimen diameters evaluated.

Each annex is comprised of nine pages of test results. Each of the nine pages summarizes test results for a given mix type, diameter, gage length (3 levels) and specimen (3 levels). Each page has a total of 80 test results and indicates the fundamental test results by: cycle effect (5 levels), repeat effect (2 levels), rotational effect (2 levels) and face effect (4 levels-observable/hidden). For each parameter-plug combination, there are a total of 9 pages detailing the results for the three specimens and three gage lengths used. This results in a total of 720 test results for each mix type -diameter combination or a total of 4320 test results for each of the four basic test parameters evaluated.

Component Variance Analysis Results

Appendix B presents the results of the detailed component variance analysis described in Chapter 6. Like Appendix A, there are 24 Annexes in Appendix B, 6 each for the four major test parameters evaluated: Mri, Mrt, ui and ut. Each of the 6 Annexes noted are summaries for the combinations of mix types (nominal aggregate sizes)-3 levels and specimen diameters -2 levels analyzed.

Each page presents a summary of the variance magnitude and the percent of the total variance, by gage length, for the five major variance components analyzed (cycle, repeat, rotational, face and specimen effects). Also included are plots showing the variance magnitude and percent of the total variance, by gage length and component variance effect.

ESTIMATION OF MEAN VALUES

Table 7.1 and Figure 7.1 summarize the average results of the Instantaneous and Total Resilient Moduli and Poisson's Ratio; found in the testing program, by the mix type (nominal aggregate size), specimen diameter and gage length. As a general trend, the results support the fact that the 6" diameter specimen results appear to be more reasonable, representative and consistent for gage lengths that are equal to, or greater than, 3.0 inches. This is particularly true for the values measured for both the instantaneous and total Poisson's Ratio for all three-mix types evaluated.

In contrast to the 6" diameter specimens; the 4" diameter samples exhibited results that were generally of larger magnitude, greater variation across the gage lengths and

somewhat unreasonable estimates of the modulus and Poisson's ratio values. In fact, it can be observed that the values of both modulus and Poisson's ratio, for the 4" diameter-37.5 mm mix type, are radically different than the other mix - diameter combinations evaluated.

Figure 7.2 illustrates the overall average response (across all gage lengths) for the four material parameters, as a function of the mix type and specimen diameter. These plots very clearly show that, for all four of the mix parameters, that:

- The average value increases with an increase in the nominal aggregate size (this conclusion would be in agreement with general experience) and
- The 6" diameter specimens yield a lower mean response than the 4" diameter test specimens. This finding can be seen to be true across all parameters (Moduli and Poisson's Ratio) and mix types.

Based upon the results and analysis presented, as well as a more detailed discussion of the variance that will be presented in the following sections of this report; it is the opinion of the research team that the most accurate estimates of the true values of the four mix parameters measured are found with a gage length of 3" using a 6" diameter specimen. As a consequence, a summary of these values is shown in Table 7.2.

ESTIMATION OF VARIANCE

General

The previous section of this chapter has presented the results of the typical (mean-average) test properties measured in the study. Equally as important to the final recommendations of this study are the results found from the variability (component variance) portion of this study. In Chapter 6, the specific details of the analysis used to estimate the individual variance components were described. The specific results of this

analysis, for all four properties investigated in the study, has been noted to be found in Appendix B. In the ensuing paragraphs, the term "total variance" is used as the algebraic sum of all of the five individual variance components investigated (i.e. i, j, k, l and m =1). Obviously, the use of different levels (numbers) for each variable will decrease the "total variance" for a specific methodology or combination of levels used for each component. An analysis of such an approach to arrive at the "optimum test methodology" will be described at the end of this chapter.

Influence of Mix Type and Diameter Upon Total Variance

One of the initial considerations of the variance (variability) analysis is to obtain a general perspective of how the mix type and specimen diameter influence the total variance of each test parameter, across all gage lengths. Figure 7.3 illustrates this plot by showing the influence of mix type (nominal aggregate size) and specimen diameter upon the total variance of the instantaneous and total Modulus and Poisson's Ratio. The total variance shown represents the average total variance for all three-gage length combinations studied.

The individual plots (for each test parameter) shown in the figure, are quite powerful and provide for a very strong set of conclusions for the variance associated with the Indirect Resilient Modulus test procedure. It can be observed that for all parameters (instantaneous and total Modulus and Poisson's Ratio):

- As the nominal aggregate size increases from 12.5 mm to 19.0 mm to 37.5 mm; it can be seen that the total test variance also increases, particularly for the 37.5 mm nominal aggregate size mix type.

- As the specimen diameter is increased from 4" to 6" diameter; the total variance, for all test parameters and mix types, is also significantly decreased for all measurements.

In order to quantify the impact of mix type (nominal aggregate size) and specimen diameter better; the summary of the computed total variance magnitude is shown in Table 7.3. In this table, the total variance magnitudes are shown for all four-test variables measured, mix type and specimen diameter.

The table also summarizes the ratios of the total variance in two manners. The first ratio represents the variance of a given test parameter for a particular mix type and diameter to the variance for a 12.5 mm mix and 4" diameter specimen. The second ratio approach computed, and shown in the table, represents the total variance ratio of a 6" diameter specimen to that for a 4" specimen diameter test.

These computed variance ratios clearly point out the extreme beneficial effect in achieving an accurate measurement of any modulus or Poisson's ratio value by always utilizing a 6" diameter specimen over a 4" diameter specimen. It can be stated that the total variance for modulus can be ***reduced*** by: 30-40%, 25-30% and nearly 70% for 12.5 mm, 19.0 mm and 37.5 mm nominal aggregate size mixtures if 6" specimens are used, rather than 4" diameter plugs. The typical values for variance reduction associated for the Poisson's ratio values can be seen to be: 60%, 65% and 45-60%, respectively, if 6" specimens are used rather than 4" diameter plugs.

The impact of the nominal aggregate size upon increasing the total variance of any test parameter can also be observed from the results presented in the table. For the resilient modulus testing using 4" diameter specimens, it can be observed that the total variance for testing 19.0 mm mix types is about 3 times as variable as a 12.5 mm mix; while for testing the Poisson's ratio of a 19.0 mm mix, the total variance is about 2 times as variable. These total variance ratios dramatically increase for the 37.5 mm mixture compared to the 12.5 mixture. For testing 4" diameter specimens, Modulus values are about 35-40 times as variable as the 12.5 mm mix type and approximately 5 times as variable when the Poisson's ratio is measured.

The results for the ratios of the total variance are nearly the same for comparing the results of the 6" diameter specimens to those obtained for the 4" diameter specimens. For all practical purposes, when testing 6" diameter specimens for modulus, the total variance for testing 19.0 mm mix types is about 3 times as variable as the 12.5 mm mix; while for testing the Poisson's ratio of a 19.0 mm mix, the total variance is about 2 times as variable. These ratios are the same as the values noted for the 4" diameter specimens. While the total variance ratios still increase for the 37.5 mm mixture compared to the 12.5 mixture, the beneficial influence of testing the larger 6" diameter specimens, reduces the ratio of the total variance to only approximately 17.5 times as variable for the large size nominal aggregate (37.5 mm) to the 12.5 mm mix type for modulus testing and approximately 5 times as variable when the Poisson's ratio is measured (identical for the 4" diameter specimens).

Influence of Gage Length Upon Total Variance

One of the most significant factors investigated in this study was to quantify the influence of the gage lengths used for the on-mounted LVDT system employed in the experiment. While the detailed values of each variance component, as a function of gage length, are summarized in the Annexes of Appendix B; the reader will gain a more global understanding of the influence of gage length upon the "total variance" is described.

Figure 7.4 and Figure 7.5 illustrate the influence of gage length upon the total variance for all four-test parameters (instantaneous and total Modulus and Poisson's ratio), specimen diameter and mix type (nominal aggregate size). In general, these plots support the prior conclusions that 4" diameter specimens yield greater total variance values than 6" diameter specimens and that the total variance generally increases as the nominal aggregate size is increased. These facts can be observed by comparing any pair of horizontally aligned plots in Figures 7.4 and 7.5, for any of the four test parameters. This comparison provides a clear influence of specimen diameter effect, for each gage length examined.

These plots also reinforce the prior conclusion that the variability, at any combination of test parameter, diameter and gage length, generally increases with increasing nominal aggregate size.

Finally, it can also be observed that for almost all combinations of factors examined; a general decrease in the total variance occurs as the gage length is increased. In particular, the total variance dramatically decreases as the gage length ratio (gage length to diameter ratio) increases from a value of 0.25 to 0.50+.

In order to visualize this conclusion more efficiently; Table 7.4 and Figure 7.6 summarize the influence of gage lengths upon mix type, for each of the four test parameters evaluated. These results, however, are only shown for the 6" diameter specimens. It should be recalled that it has been previously noted, on several occasions, that the total variance for the larger diameter specimens is much less (smaller) than the variance associated with the smaller 4" plug diameters.

The data in the table summarizes the total variance magnitudes for the variables noted (gage length, mix type and test parameter). In addition, total variance ratios; referenced to the total variance at the smallest gage length used on the 6" diameter specimens (GL=1.5" and a length to diameter ratio of 0.25) are also summarized. The minimum ratios achieved within each combination are highlighted. Figure 7.6 illustrates these results in graphical form.

The most salient conclusion that can be extracted from these results is that a 3.0" gage length, mounted on a 6" diameter specimen, yields a total variance that is either the minimum value computed for all gage lengths or has a total variance magnitude that is not significantly different from the minimum value found at the 4.5" gage length (length to diameter ratio of 0.75). In addition, the 3.0" gage length should have the potential for possessing the minimum amount of possible problems associated with the on - sample measurement system to be eventually recommended.

In general, it can therefore be concluded that a recommended gage length of 3.0", mounted on a 6" diameter specimen, regardless of the mix type being evaluated; will yield total variance values that are as close to the most likely minimum values possible. Furthermore, this conclusion appears to be true for each of the four test parameters (instantaneous and total modulus and Poisson's Ratio) that can be found from the Indirect Tensile test mode.

Variance Components Analysis

The prior conclusions reached to this point in the study clearly show that the total variance of measurement is always less for the 6" diameter specimens, compared to 4" diameter specimens; increasing the nominal aggregate size of the AC mixture will increase the total variance; and the minimum total variance is generally at / or near the use of a 3.0" gage length, when used on a 6" diameter plug.

While the individual variance component magnitudes are presented in Appendix B; Tables 7.5 thru 7.8 summarize the actual variance magnitudes by: variance component, specimen diameter, mix type and test parameter. In the study, the research team attempted to ascertain major trends with the variance components numerical magnitude. However, it became quite clear (and quite important to the analysis presentation) that the use of expressing the percentage of the total variance, by each component, gave a very accurate, standardized and normalized approach to explaining the influence of the major factors studied upon the various components.

This is shown in the tabular summaries of Tables 7.9 thru 7.12. Thus, while the actual variance magnitudes shown in Tables 7.5 – 7.8 vary considerably; the normalized percentage values, by component, can be observed to exhibit a more restrictive range of numerical values in Tables 7.9 – 7.12. This appears to be true for the influence of both key variables of gage length and mix type (nominal aggregate size). This implies that, in general, these parameters do not influence the percentage values. Table 7.13 is a summary of the average variance component percentages for the four test parameters

evaluated, and specimen diameters. From this table, it can also be observed that the average percentage differences between instantaneous and total parameters (modulus and Poisson's ratio) are not significantly different and as such can also be lumped together for an average variance response.

Figure 7.7 is a plot of the data shown in Table 7.13. This plot identifies the percent of the total variation by major variable component, for different combinations of specimen diameter and test parameter. From the table and figure; it is very obvious that the following conclusions can be reached:

- The percentage values, by variance component, appear to be generally independent of the specimen diameter, gage length, mix type and type of parameter (instantaneous versus total).
- The percentages values, by variance components, appear to be somewhat independent of the test parameter, although there does appear to be a slight difference in mean values between variance components for the modulus and Poisson's ratio.
- In general, the percentage contributions to the total variance are nearly insignificant for the: cycle, repeat and specimen variances.
- In contrast, the greatest percentage of the total variance of the measurement is overwhelmingly dominated by the: rotational effect and between face effects.

From Table 7.13 it can be observed that there is not a significant difference in average component values for the effect of specimen diameter (4" versus 6"). Thus, using the average effect for Resilient Modulus, approximately 90% of the total measurement variance is caused by the "rotational and between face" effects and only 10% of the total variance is attributable to the effects of "cycle, repeats and samples (specimens)" within a given gyratory plug compacted to a 6" height. For the average Poisson's ratio effect; the respective values are nearly identical (85% and 15% respectively).

Typical Variance Components Results

Based upon the previous discussions, a set of "typical variance component values" has been selected from the study. These values are considered to be applicable for all combinations of mix types, specimen diameters, gage lengths and either instantaneous or total test parameters.

For the Resilient Modulus parameter, typical variance component percentages found from this study are as follows:

1. Cycle Effect 3%
2. Repeat effect 4%
3. Rotational Effect 35%
4. Between Face Effect 55%
5. Sample Effect* 3%

For the Poisson's Ratio parameter, typical variance component percentages found from this study are as follows:

1. Cycle Effect 7%
2. Repeat Effect 7%
3. Rotational Effect 48%
4. Between Face Effect 35%
5. Sample Effect* 2%

Finally, it should be noted, and understood by the reader, that the variability values shown above do not reflect the spatial variability between field cores obtained from along a section of roadway. The above components represent the variances associated with testing a single field core or a single gyratory plug made in the laboratory for mix design / research purposes. Thus, the added variance of the "within section" effect would have to be considered if one were to estimate the true variability of a given parameter within a field project.

POTENTIAL TEST PROTOCOL

Summary of Typical Mean-Variance Values

At the focal point of this study has been the effort to estimate magnitudes of the various variance components associated with the measurement of both the Resilient Modulus and Poisson's Ratio (total and instantaneous) of three AC mixtures, fabricated in the laboratory using Gyratory compaction techniques. In order to analyze the impact of these variance components upon confidence intervals associated with the prediction of the mean (average) parameters, it is necessary to select the best estimate of the mix mean response and magnitude of the variance components found in this study.

Table 7.14 presents the summary of these best estimate values of the means and variances for each typical mixture. These values are representative of "Laboratory Prepared Gyratory Specimens", conducted at the most optimal (most accurate) conditions. As such, the results shown in the table are associated with the 6" diameter testing using a 3.0" gage length. The typical mean values have been selected from Table 7.2, previously shown. The total variance values have been selected from Table 7.3. Finally, the percent variance component values were obtained from the prior text section entitled "Typical Variance Component Results". It should be recalled that these percentage values were found to be applicable for all combinations of mix types, specimen diameters, gage lengths and either instantaneous or total test parameters.

Using these three sources of information, the individual variance component magnitudes, shown in Table 7.14 can be easily computed. The reader should clearly recognize that the total variances shown in Table 7.14 are for a single level associated with each component variance parameter. That is, the total variance shown represents the expected variance in either Resilient Modulus or Poisson's Ratio, if one single specimen (out of 3

potential specimens obtained from one 6" high gyratory plug) were tested on one face, at a single rotation, using only one replicate (repeat) test, having the parameter be measured at one single cycle of load. Obviously multiple levels of the various components (cycles, repeats, rotations, between faces and specimens) will tend to decrease the "total" variance of the estimate.

It is important to also recognize that the test program, reported in this study was based upon laboratory-fabricated specimens. In field forensic studies, the total variance is much greater than those values reported, because another variance component, associated with the "within project (section) variance" must also be included. In other words, estimating mean responses of laboratory prepared specimens is less variable compared to estimating the mean properties of the exact same mix from field cores, obtained from a particular field project. While the influence of this "within section variance" was not evaluated in this study; other studies in the literature have indicated a general estimate of this component that can be used to also assess the increase in variance for the field core studies.

Witczak and Ayres (31, 32) conducted a series of nested ANOVA on field demonstration projects. While these studies focused on asphalt rubber mixtures, field variance component values were determined for comparable test parameters investigated in this study (Resilient Modulus and Poisson's Ratio from indirect tensile test techniques). In these studies, it was found that a typical value of the "within project variance" (i.e. associated with core to core variation) was a 15% Coefficient of Variation value (CV%) for Resilient Modulus and a 20% Coefficient of Variation (CV%) for Poisson's Ratio.

By incorporating these estimated values within the variance component approach presented; an expanded summary of typical mean and variance component parameters are presented in Table 7.15. This table is comparable to Table 7.14, with the specific exception that Table 7.15 would be applicable for field studies using cores. As previously noted, Table 7.14 is representative of lab prepared specimens, developed from 6" diameter gyratory plugs.

Estimation of Confidence Intervals

General: The concept of a Confidence Interval (when applied to mean parameters) describes a range of values about the sample mean which is indicative of where the true population mean value will fall, with a desired degree of confidence or certainty. The Confidence Interval Range is expressed by:

$$CR = \pm K_{\alpha}\,\sigma \qquad (7.1)$$

In this equation, the Ka term is the normal deviate associated with a particular confidence level (two-tailed). The following values have been used in this study:

$K\alpha = 1.645$	$\alpha = 90\%$
$K\alpha = 1.960$	$\alpha = 95\%$
$K\alpha = 2.570$	$\alpha = 99\%$

The standard deviation value, σ, is, in general the square root of the variance, itself a sum of the individual variance components.

In this analysis, two separate conditions for expressing the "total standard deviation" will be defined and discussed. They are the: "Lab Prepared Specimens" condition and the "Field Core Specimens" condition. The former will be associated with the development of Confidence Intervals associated with the measurement of specimens that have been fabricated in the laboratory from gyratory compacted specimens. The latter condition will relate to Confidence Intervals associated with the measurements obtained from field cores on a particular project (statistically homogeneous asphalt mixtures). As previously discussed, a different set of variance components is applicable for each condition and as a consequence, different Confidence Intervals must occur for the same mixture.

For the "Lab Prepared Specimen" condition, the overall variance is defined by:

$$\sigma_t^2 = \frac{\sigma_{sample}^2}{n_m} + \left(\frac{\sigma_{bf}^2}{n_j n_k n_l n_m}\right) + \left(\frac{\sigma_{rotation}^2}{2 n_k n_l n_m}\right) + \left(\frac{\sigma_{repeat}^2}{2 n_j n_k n_l n_m}\right) + \left(\frac{\sigma_{cycle}^2}{2 n_i n_j n_k n_l n_m}\right) \tag{7.2}$$

For the case of the "Field Core Specimens", the overall variance is expressed by:

$$\sigma_t^2 = \frac{\sigma_{betcores}^2}{n_n} + \frac{\sigma_{sample}^2}{n_m n_n} + \left(\frac{\sigma_{bf}^2}{n_j n_k n_l n_m n_n}\right) + \left(\frac{\sigma_{rotation}^2}{2 n_k n_l n_m n_n}\right) + \left(\frac{\sigma_{repeat}^2}{2 n_j n_k n_l n_m n_n}\right) + \left(\frac{\sigma_{cycle}^2}{2 n_i n_j n_k n_l n_m n_n}\right) \tag{7.3}$$

In these equations, the definition of new terms introduced is as follows:

$\sigma_{betcores}^2$: true variance between cores from a given project

n_m : number of specimens from a single gyratory plug or the number of specimens obtained from a single field core.

n_n : number of field core within a project.

Case Descriptions: In order to assess the impact of the various combinations of the component levels, that can be employed by the Engineer, upon the ultimate Confidence Interval of the test measurement; a series of "test combination cases" have been developed and are presented in the ensuing paragraphs.

Lab Prepared Specimens

For the case of the "Lab Prepared Specimens", 5 separate cases have been developed to assess their impact upon the Confidence Intervals for both Resilient Modulus and Poisson's Ratio of the mixtures analyzed.

Case 1

The Case 1 condition is based upon the worst-case scenario for testing. In this situation, all component values are equal to one (ni=1, nj=1,nk=1,nl=1 and nm=1). In this scenario, only one test specimen would be evaluated from the full 6" high gyratory plug. Measurements would be determined on both faces only at one given load cycle (eg..98^{th}) and at one specimen orientation (rotation). There would be no repeat or replicate tests (measurements) conducted.

Case 2

Case 2 is identical to Case 1 with the exception that the average of the load cycle effect would be conducted over 5 cycles (ni=5). In addition, the specimen would be rotated through two directions, 0 and 90 degrees (nk=2). When the rotational influence would be completed, the specimen would be rotated about the vertical axis so that the "hidden" face would become the "observable" face (nl=2).

Case 3

Case 3 is identical to the previous Case 2. The only difference is that 3 specimens, from a given 6" high gyratory plug, would be tested (nm=3). This would obviously encompass the added variability caused by subtle differences in mix composition, with depth, within the total gyratory compacted plug.

Case 4

The fourth case is the same as Case 3, except instead of using measurements obtained across 5 cycles, measurements are obtained from 10 cycles of load. This would imply a ni=10 value.

Case 5

In essence, the Case 5 scenario represents the most optimum testing condition that can be conducted. It is identical to the Case 4 scenario, except a second replicate set of measurements is conducted after the 2 rotations are completed (nj=2). This is comparable to the testing methodology that was used in this study with the minor exception that ni=5 was used in the study, rather than the ni=10 value, used in the Case 5 example.

Case Summary

In summary, five differing component test combination case scenarios were developed to assess their impact upon the Confidence interval associated with the Resilient Modulus and Poisson's Ratio. The summary of the component levels used, by case, is as follows:

Component	Case 1	Case 2	Case 3	Case 4	Case 5
Cycle	1	5	5	10	10
Repeat	1	1	1	1	2
Rotation	1	2	2	2	2
Face	1	2	2	2	2
Specimen	1	1	3	3	3

Field Core Specimens

For the case of the "Field Core Specimens", 5 separate cases were also developed to assess their impact upon the Confidence Intervals for both Resilient Modulus and Poisson's Ratio of the mixtures analyzed. For this case, where it is desirable to evaluate the mean population parameters from a specific field project; the level nm represents the number of specimens that can be obtained from a given core. This number will obviously be highly dependent upon the core thickness. For example, if a core is only 3" thick; it is highly probable that only one test specimen would be able to be obtained from each of the nm field cores obtained within the project. On the other hand, if a core is 8" high; it may be possible to obtain as many as 4 specimens per core. These limitations should be kept in mind by the reader as the following cases are presented.

Case 1

The Case 1 condition is based upon the worst-case scenario for testing. In this situation, all component values are equal to one (ni=1, nj=1, nk=1, nl=1, nm=1 and nn=1). Only one test specimen would be evaluated from one field core obtained from the project. Test measurements would be determined on both faces only at one given load cycle (eg..98^{th}) and at one specimen orientation (rotation). There would be no repeat or replicate tests (measurements) conducted.

Case 2

Case 2 is identical to Case 1 with the following exceptions. The average of the load cycle effect would be conducted over 5 cycles (ni=5), the specimen would be rotated through two directions, 0 and 90 degrees (nk=2) and when the rotational influence would be completed, the specimen would be rotated about the vertical axis so that the "hidden" face would become the "observable" face (nl=2). Like Case 1, only a single test specimen would be obtained from a single project core.

Case 3

Case 3 is identical to the previous Case 2 with the noted exceptions that 3 specimens, from each of three field cores, would be tested (nm=3 and nn=3). This case would encompass the added variability caused by subtle differences in mix composition, with depth, within a given core, as well as the spatial variation of the material within a given "statistically homogeneous" project.

Case 4

The fourth case is the same as Case 3, except instead of using measurements obtained across 5 cycles, measurements are obtained from 10 cycles of load. This would imply a ni=10 value.

Case 5

The Case 5 scenario represents a comprehensive testing scenario to ascertain the mean parameters of a given material type on a specific project. It differs from the Case 4 scenario in that a second replicate set of measurements is conducted after the 2 rotations are completed (nj=2). Another important attribute of this case is that a total of 6 field cores (nn=6) are used, rather than the three in the previous case.

Case Summary

In summary, five differing component test combination case scenarios were developed to assess their impact upon the Confidence interval associated with the Resilient Modulus and Poisson's Ratio for the "Field Core Specimens" scenario. The summary of the component levels used, by case, are as follows:

Component	Case 1	Case 2	Case 3	Case 4	Case 5
Cycle	1	5	5	10	10
Repeat	1	1	1	1	2
Rotation	1	2	2	2	2
Face	1	2	2	2	2
Spec / core	1	1	3	3	3
Field Cores	1	1	3	3	6

Confidence Interval Results

General: Using the previous results of the Resilient Modulus and Poisson's Ratio mean and variance component equations and values; Confidence Interval values were determined for each mixture at three confidence levels (90%, 95% and 99%). This was accomplished for each of the 5 cases described for the "Lab Prepared Specimen" and "Field Core Specimen" scenario.

Results:

Lab Prepared Specimens

Tables 7.16 through 7.20 summarize the Confidence Interval values, for the Resilient Modulus and Poisson's Ratio, for each of the three mixtures (nominal aggregate size) evaluated at the three levels of Confidence noted (90%, 95% and 99%). It should be recalled that the values shown are for the "best scenario" testing associated with a 6" diameter test specimen, using a 3" gage length for on-specimen mounted conditions. Each table presents the values for one of the 5 case scenarios described. In addition to the tables, these results are also presented in graphical form in Figure 7.8 for Resilient Modulus results and Figure 7.9 for Poisson's Ratio results.

Field Core Specimens

The comparable results for the "Field Core Specimen" cases are presented in tabular summary form within Tables 7.21 to 7.25. The graphical results of the confidence interval values are presented in Figures 7.10 and 7.11.

Discussion of Results:

Lab Prepared Specimens

As previously concluded, the tabular and graphical results of the variance (and hence Confidence Interval) analysis, clearly point out the fact that the most accurate estimates of either Resilient Modulus or Poisson's ratio are always associated with the finer aggregate mix (12.5 mm nominal aggregate size). Additionally, this variation increases with increasing aggregate size.

Case 1

Case 1 is the worst-case test scenario for the Modulus and Poisson's Ratio measurements as all components have a number (level) of one. The 95% Confidence Interval values found for this case are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	421 to 1105	(-.01) to 0.80
19.0 mm Dnom	272 to 1478	(-.13) to 0.97
37.5 mm Dnom	(-265) to 2557	(-.55) to 1.41

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 342	+/-R= 0.40

19.0 mm Dnom	+/-R= 603	+/-R= 0.55
37.5 mm Dnom	+/-R= 1411	+/-R= 0.98

It is obvious from these results that the indirect test measurement for either Modulus or Poisson's Ratio is extremely variable. Furthermore, the magnitudes of the Confidence values shown attest to the significant increases in variability as the nominal aggregate size is increased from a 12.5 mm mix to the large stone 37.5 mm mixture. As can be observed from the values noted, it is obvious, due to the very large variance values generated, that the use of a Normal probability distribution is probably not the most efficient probability distribution to utilize as negative lower limits are seen to be computed.

Case 2

The Case 2 scenario significantly increases the number of test measurements taken. In this scenario, measurements are taken at 5 load cycles, 2 within plane rotations and 2 between face rotations. Recalling that the rotational and between face variance components are the largest sources of variation; increasing the component levels should cause significant reductions in the Confidence values evaluated. The 95% Confidence Intervals for this case are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	584 to 942	0.18 to 0.61
19.0 mm Dnom	559 to 1191	0.13 to 0.71
37.5 mm Dnom	406 to 1886	(-0.08) to 0.94

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 179	+/-R= 0.21
19.0 mm Dnom	+/-R= 316	+/-R= 0.29

37.5 mm Dnom	+/-R= 740	+/-R= 0.51

As can be seen, a significant increase in the prediction accuracy is achieved by the Case 2 scenario. In fact, the Confidence Range (+/- R values) for the Case 2 are 52.4% of those shown for the Case 1 condition (Modulus and Poisson's Ratio for all three mixtures). Thus the measurement accuracy is nearly doubled between these 2 cases. In addition, it can be observed that the only non-positive limit is shown for the lower limit of the Poisson's Ratio for the 37.5 mm mixture.

Case 3

Case 3 is identical to Case 2 with the exception that 3 test specimens (from a single 6" high lab prepared gyratory specimen) are used to estimate the mean mix parameters. This has a twofold impact upon the Confidence values. First, the mean estimates of the mix will now account for variations in the mix properties within the full gyratory specimen. Secondly, the fact that there will be 3 times (ie 3 specimens) the measurements conducted compared to a single test specimen should significantly increase the overall accuracy of the mean measurements for each mix. The 95% Confidence Interval for the three mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	660 to 866	0.27 to 0.52
19.0 mm Dnom	692 to 1058	0.25 to 0.59
37.5 mm Dnom	719 to 1573	0.13 to 0.73

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 103	+/-R= 0.12
19.0 mm Dnom	+/-R= 183	+/-R= 0.17
37.5 mm Dnom	+/-R= 427	+/-R= 0.30

The reduction in the Confidence Range from previous cases is substantial. In fact, the +/-R-values shown for the Case 3 are now only 30.3% of the values shown for the Case 1 (worst scenario). In addition, it can be seen that while the Confidence range of Poisson's Ratio is still large; all three mixtures, including the 37.5 mm mix, have positive values for the lower limit.

Case 4

Case 4 is a scenario almost identical to the Case 3 except that 10 cycles of load are used in the measurement protocol compared to the 5 load cycles used in the prior case. Because the cycle variance component was found to be quite small; the anticipated impact of this change (recall that it would double the number of test points / data collected) should be very small. The 95% Confidence Interval for all three mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	660 to 866	0.27 to 0.52
19.0 mm Dnom	693 to 1057	0.25 to 0.59
37.5 mm Dnom	719 to 1573	0.13 to 0.73

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 103	+/-R= 0.12
19.0 mm Dnom	+/-R= 182	+/-R= 0.17
37.5 mm Dnom	+/-R= 427	+/-R= 0.30

A comparison of these results with the Case 3 summary clearly indicates the futility of this case. In essence, the Confidence Intervals and Ranges are identical due to the fact that the overall standard deviation for modulus is reduced at the first decimal point and the third decimal point for the Poisson's Ratio value. Thus doubling the number of test points, without regard to which variance component is selected, may wind up doing absolutely no good towards improving the accuracy of the measurement parameter.

Case 5

The Case 5 condition is similar to Case 4 with the exception that a second repeat measurement methodology is used. This obviously leads to a doubling of the data measurements. The 95% Confidence Intervals for the three mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	678 to 848	0.29 to 0.49
19.0 mm Dnom	726 to 1024	0.28 to 0.56
37.5 mm Dnom	797 to 1495	0.18 to 0.67

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 85	+/-R= 0.10
19.0 mm Dnom	+/-R= 149	+/-R= 0.14
37.5 mm Dnom	+/-R= 349	+/-R= 0.24

The impact of using a replicate test in the methodology can be seen to result in a further increase in the accuracy of the expected mean values. The Case 5 scenario results in levels of Confidence ranges that are 24.9% of the Case 1 scenario.

While this is obviously a substantial increase in accuracy, this strategy does lead to a large degree of testing. While the +/- values for the Confidence Range are not excessive for the 12.5 mm; the values become quite large as the nominal aggregate size is increased. For example, the CI, for the 37.5 mm mixture, is approximately 800 to 1500 ksi for modulus and 0.2 to 0.65 for Poisson's Ratio. It is highly likely that the use of engineering judgment and / or simple predictive models, available in the literature, can provide equally accurate estimates when compared to values obtained from measurements from the Indirect Tensile process.

Finally, it again should be recognized the discussions that have been presented to date only reflect variability solely for test specimens that have been gyratory compacted in the lab. The next section of this report will deal with the impact of various case scenarios involving field core specimens from a given project.

Field Core Specimens

The analysis of the test parameter accuracy for evaluating field cores from a given "statistically homogeneous" field project adds another tier of variability to those components described in the "Lab Prepared Specimen" section. This additional variability is associated with the variance between the cores (spatial project variance) within a given site. The discussions for the various cases previously described follows.

Case 1

The Case 1 scenario for the "Field Core Specimens" is also the worst case combination of testing that can be accomplished. In this case, all levels are equal to one. This implies that only one test specimen is tested from one core. Estimates of the modulus and Poisson's Ratio are obtained from one load cycle, one repeat, one within face rotation and one between face condition (both sides but no face rotation). The Confidence Intervals for the mixtures for this case are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	354 to 1172	(-0.04) to 0.83
19.0 mm Dnom	219 to 1531	(-0.16) to 1.00
37.5 mm Dnom	(-305) to 2597	(-0.57) to 1.43

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 409	+/-R= 0.43
19.0 mm Dnom	+/-R= 656	+/-R= 0.58
37.5 mm Dnom	+/-R= 1451	+/-R= 0.99

The values indicate that the variability of estimating Modulus and Poisson's Ratio from a single field core is obviously greater than for laboratory compacted specimens. In fact, the Confidence Values average approximately 7.5% more than those obtained in the "Lab Prepared Specimen" case due to the additional variability caused by the variance associated with field cores within a project. Like the Lab Prepared scenario; the influence of increasing variability, as a function of increasing mix aggregate size, is clearly illustrated by the Confidence Interval and Range magnitudes summarized. The use of the normal probability distribution to compute the upper and lower levels is also questionable for this case due to the negative lower limit values that have been generated.

Case 2

The Case 2 scenario is comparable to the Case 2 in the "Lab Prepared Specimen" analysis. In this case, five load cycles, two within face rotations and two between face rotations are used on one specimen cut from one field core. The 95% Confidence Intervals, for the three mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	476 to 1050	0.13 to 0.66
19.0 mm Dnom	467 to 1283	0.09 to 0.75
37.5 mm Dnom	333 to 1959	(-0.11) to 0.97

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 287	+/-R= 0.26

19.0 mm Dnom	+/-R= 408	+/-R= 0.33
37.5 mm Dnom	+/-R= 813	+/-R= 0.54

The impact in the Case 2 can be seen to cause an improvement in the measurement accuracy. The Confidence ranges for this case are approximately 60.1% of Case 1 and approximately 64.9% of the Case 1 "Lab Prepared Specimen" condition.

Case 3

The Case 3 scenario takes into account an increased level of testing associated with both the vertical variability within a given core, as well as, the spatial variability between cores from a project. In this case, 3 specimens are tested from each of three different field cores within a project. The 95% Confidence Intervals are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	620 to 906	0.28 to 0.51
19.0 mm Dnom	693 to 1057	0.28 to 0.55
37.5 mm Dnom	832 to 1460	0.23 to 0.63

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 143	+/-R= 0.11
19.0 mm Dnom	+/-R= 182	+/-R= 0.14
37.5 mm Dnom	+/-R= 314	+/-R= 0.20

It can be seen that the Case 3 test protocol leads to a very significant increase in the overall accuracy of parameters. The Confidence Ranges shown represent about 25.7% of the Case 1 values. Quite obviously, the enhanced degree of accuracy is directly associated with the fact that a greater number of field cores, as well as, test specimens per core are present in this test condition. (It should be recalled that there are physical limits to the number of test specimens that can be obtained from a given field core. As previously noted, these limits are directly related to the thickness of the field core that can be obtained from any given project).

Case 4

The Case 4 scenario is identical to the Case 3 scenario with the one exception that 10 load cycles is used, rather than 5. Like the prior discussion for the "Lab Prepared Specimen" condition; the expected impact of this change should be very small as the load cycle variance value is somewhat insignificant. The 95% Confidence Intervals for this case are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	620 to 906	0.28 to 0.51
19.0 mm Dnom	693 to 1057	0.28 to 0.55
37.5 mm Dnom	832 to 1460	0.23 to 0.63

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 143	+/-R= 0.11
19.0 mm Dnom	+/-R= 182	+/-R= 0.14
37.5 mm Dnom	+/-R= 314	+/-R= 0.20

As shown, there is absolutely no impact upon measured Confidence Intervals or Ranges between the Case 4 (10 cycles) versus Case 3 (5 cycles) test scenarios. This is true even though twicw as many measurements would have to be collected and analyzed for the Case 4 scenario. This is the exact conclusion also reached in the "Lab Prepared Specimen" discussion.

Case 5

The Case 5 is the same scenario as the Case 4 with two important differences. The first difference is that a second replicate is introduced into the test scheme. The second change is that 6 field cores are used rather than the 3 cores that were used in Case 4. This is, obviously, a very comprehensive and intensive testing program. The 95% Confidence Intervals found for this combination are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	665 to 861	0.32 to 0.47
19.0 mm Dnom	754 to 996	0.33 to 0.51
37.5 mm Dnom	948 to 1344	0.31 to 0.55

The 95% Confidence Range found for the mixtures are:

	Modulus (ksi)	Poisson's Ratio
12.5 mm Dnom	+/-R= 98	+/-R= 0.08
19.0 mm Dnom	+/-R= 121	+/-R= 0.09
37.5 mm Dnom	+/-R= 198	+/-R= 0.12

The Case 5 scenario leads to a very good estimation of the field project level test parameters. The Confidence values for this case are approximately 17.0% of the Case 1 procedure. However, the price to achieve this accuracy is a very substantial testing program. Even then, it is up to the engineer to truly decide whether the Confidence Ranges that can be achieved are truly worth the testing program time and cost. As stated repeatedly, the variability associated with increasing larger size aggregate mixtures must be carefully scrutinized with regard to estimates achievable by either engineering experience or simple predictive models available in the literature.

Recommended Testing Methodology

Lab Prepared Specimens

The previous sections of this report have focused upon an assessment of the various combinations or levels, of each potential test aspect, upon the ultimate accuracy of the measured parameter (Modulus and Poisson's Ratio). Additionally, an effort was made to illustrate, in general terms, the significance or lack thereof of any given variance component upon the ultimate test accuracy achieved. In this portion of the report, the final recommendations for the most efficient testing mode are presented and discussed.

The effect of the number of load cycles (ni) used to estimate the parameter is not very significant, when viewed relative to the overall variance of the entire test methodology. It is recommended that the average of 5 load cycles (ie 95 to 99^{th} cycles) be used in the analysis. Using a larger number will not significantly decrease the variability and only serve to increase the amount of data (test results) that would be obtained in any given test.

The number of repeat measurement sequences (nj) was also found to not be a major factor affecting the overall variance. This is considered to be a fortunate conclusion , because using a value of nj, greater than nj=1, would cause a significant increase in the testing time, as well as the amount of data, that would need to be collected. Thus, it is recommended that a final value of nj=1 be used.

The within face rotational effect was found to contribute a large percentage of the total variance and hence it is considered to be a very significant test sequence parameter. However, there is a very subtle and practical limitation that will restrict the number of rotations that can be practically used with "on-specimen mounted LVDT systems". For this LVDT mounting approach, it should be recognized that a 0 – 90 deg rotation of the LVDT's is already necessary in order to estimate the Poisson's Ratio. For the "on specimen mounting system", each directional LVDT must be mounted in a tiered or stacked arrangement, located around the center of the specimen face. If for example, 4 rotations were desired (ie..0 – 90 deg and 45 – 135 deg); this would necessitate a series of

4 separate stacking of LVDTs about the geometric center of the specimen. For all practical purposes, it is the opinion of the research team that such a instrumentation set-up would be very difficult, if not impossible, to achieve. As a consequence, it is felt that the maximum value of the rotational effect, that can be practically achieved is nk=2. This is the recommended value for this variance component.

Like the within face rotational effect, the between face rotational effect plays a key part in defining the overall variability associated with the Indirect Testing approach on asphalt mixtures. Variations due to this component are highly attributable to any rotational effect of the specimen, during the pulse loading sequence, about the x-y axis (plane through the thin side (thickness) of the specimen). It should be recalled that if the nl value of nl=1 is used, this implies a test methodology in which the "hidden face" or face away from the lab technician is not rotated to become the "observable face" during the test methodology. There is an obvious limitation in the fact that the nl value can only take on a value of nl=1 or nl=2. Because of its significance to the overall variance; it is recommended that the maximum level of nl=2 be used in the test methodology.

Finally, when one is concerned with the accuracy of test specimens that are prepared from laboratory gyratory compaction conditions; current state of the art technology allows for the preparation of 6" diameter specimens that can easily exceed 6 – 7" in height. As a result, it may be possible to obtain (as a maximum) up to 4 specimens having a thickness of approximately 1.5". Wherever possible, a minimum of 3 and maximum of 4 specimens should be employed in the scenario. In the following, a value of nm=4 is recommended.

Based upon the recommendations presented for the lab prepared specimens, Confidence Ranges, for each of the three mixtures evaluated, were computed. The resulting +/- R-values (95%) are as follows:

	Resilient Modulus	Poisson's Ratio
Dnom = 12.5 mm	+/- R= 90 ksi	+/- R= 0.11

Dnom = 19.0 mm	+/- R= 158 ksi	+/- R= 0.15
Dnom = 37.5 mm	+/- R= 370 ksi	+/- R= 0.26

It can be observed that the computed Confidence Ranges are generally comparable to the Case 5 conditions presented. However, the recommended approach is felt to be the most practical and optimal test methodology that can be used with the Indirect Tensile method. Nonetheless, the reader should note that the magnitude of the Confidence Interval (Range) is still very large, particularly as the nominal size of the aggregate is increased from the finer 12.5 mm mixture to the 37.5 mm mix. This is true for both the Resilient Modulus as well as the Poisson's Ratio.

Field Core Specimens

The overall logic for the selection of the test sequence for field core (project) specimens is very comparable to that presented for "Lab Prepared Specimen" case. However, there are two important assumptions used in the following discussion that the user should be aware of. First of all, it is assumed that the variance within a lab prepared specimen (ie vertical variation) is similar to what one would find in the field, at a given horizontal location on a project. While this is probably not 100% true, the difference is still assumed to be small, particularly for discussion purposes in this report.

The second assumption relates to the fact that a variance, reflecting the core-to-core variability within a given project, was selected for use in the study of the Confidence Intervals. Based upon literature results, a variance for between cores, was selected to be representative of a CV = 15% for Modulus and CV = 20% for Poisson's Ratio.

The recommended values and logic for: load cycles (ni), repeats (nj), within face rotation (nk) and between face rotation (nl) are identical to those already described for the "lab Prepared Specimen" discussion. However, a significant point in question relates to the accuracy trade-off between the number of specimens (nm) at a given core location, versus the number of core locations (nn), within a given project, used to estimate the population mean values. It should be clearly understood that the real question to be resolved concerns the issue if it is better to test one specimen from 3 core locations or 3 specimens (if possible) from one core. In either case, the total number of specimens that would be required to be tested would be 3 for both combinations. Obviously, the accuracy between these two potential choices will not be the same.

In order to quantify the differences in accuracy (ie Confidence Ranges) for the trade off between specimens from a single core and the number of cores; estimates of predicted Confidence ranges, for all three mixtures evaluated in this study, were developed for two cases. The first case examined was based upon the use of nm = 1 (one specimen) and 6 cores (nn = 6). The second case used nm = 3 (3 specimens per core) and nm = 2 (2 field cores).

The computed 95% Confidence Ranges for both Resilient Modulus and Poisson's Ratio are as follows:

(1 Specimen per core / 6 cores)

	Resilient Modulus	Poisson's Ratio
Dnom = 12.5 mm	+/- R= 117 ksi	+/- R= 0.11
Dnom = 19.0 mm	+/- R= 166 ksi	+/- R= 0.14
Dnom = 37.5 mm	+/- R= 332 ksi	+/- R= 0.22

(3 Specimens per core / 2 cores)

	Resilient Modulus	Poisson's Ratio
Dnom = 12.5 mm	+/- R= 175 ksi	+/- R= 0.14
Dnom = 19.0 mm	+/- R= 223 ksi	+/- R= 0.17
Dnom = 37.5 mm	+/- R= 385 ksi	+/- R= 0.24

From the results shown, it is obvious that it is much more accurate to test fewer specimens from a given core location, and test more cores, randomly distributed within the project, to obtain the most accurate assessment of the true population parameters.

One apparent factor that should not be lost upon the reader is that the previous example comparison had two options that would require the testing of the same number of specimens (6) for both case. Thus the time, effort and data collection process would be equivalent for both conditions. The only difference is, depending upon the testing and sampling sequence; one approach would yield estimates that would be approximately 1/3 more accurate for estimating the mean modulus and approximately 20% more accurate for estimating the Poisson's Ratio. It is obvious that a greater degree of accuracy can be obtained by maximizing the number of core locations, within a given trade-off between specimens from a given core and core locations.

This is illustrated in Figure 7.12. In this plot, the influence of the number of cores upon the 95% Confidence Range (for ni =5, nj =1, nk =2, nl =2 and nm =1) for both the Modulus and Poisson's Ratio are shown for each AC mixture evaluated. The relationships (plots) shown illustrate a very fundamental fact regarding statistical sampling theory. That is, the relationship between the number of samples used to evaluate the parameter is never linearly related to the accuracy of the estimate. All 6 of the curves shown in Figure 7.12 indicate the hyperbolic nature of Confidence Ranges and clearly show that while significant changes in enhancing the accuracy of an estimate occur as the number of tests increase from 1 to 2 or 3; there is always a "presumptive number of tests" (3 to 6) after which little, if any, increase in accuracy is achieved by increasing the number of tests used in the estimation. As a general recommendation for field evaluation of material properties of AC mixtures, it is suggested that 6 field cores be obtained per project and only one specimen be obtained, per AC material type, per core.

CHAPTER 8
SIGNIFICANT FINDINGS AND RECOMMENDATIONS

SUMMARY OF FINDINGS

The major goal of this study was to develop recommendations for a "Harmonized" test protocol for the testing of AC mixtures with an indirect (diametral) tensile device. In order to meet this objective a comprehensive lab study was undertaken to measure thr instantaneous and total responses of the Resilient Modulus and Poisson's Ratio of three differing AC mixtures. These mixtures were developed from Maryland State Highway Administration mixtures of three separate nominal aggregate sizes: 12.5 mm; 19.0 mm and a 37.5 mm Superpave grading. The study also involved the use of different diameter test specimens (4" and 6") as well as three different gage lengths to specimen diameter ratios of 0.25, 0.50 and 0.75. Gage lengths reflected span lengths for LVDT measurement systems that were mounted with "on-specimen" techniques. Finally the study relied heavily upon the use of a statistical analysis procedure that was aimed at determining the actual magnitudes of certain variance components of the testing methodology. This philosophy provides the strongest ultimate basis for the selection of the final recommended protocol.

Equipment

The SHRP Load Guide device, with some modifications, is considered to be the best device amongst all other systems available, in regard to controlling the undesirable influence of rocking and frictional loads during the test. Modifications that were developed by the Research Team included:

- Installation of ball-bearings within the guideposts to reduce friction load resisting the vertical movement of the upper load platen

- Replacement of the SHRP pulley counter balance system with springs. This reduced the size of the device quite significantly and allowed the system to fit within the environmental control chamber.
- A marking plate (template) was developed to accurately mark mutually perpendicular axes on both faces of the specimens. Specimens were then aligned between the loading strips and the marked axes were then used as the datum. This approach provided good to excellent control for specimen rocking

On specimen mounted gage systems were employed for the LVDT's. This approach is considered superior to LVDT systems that employ off specimen LVDT instrumentation set-ups. However, extra care and consideration must be made with using this system and the marking template (previously noted) is considered mandatory to insure proper installation and location occurs for the LVDT's.

Mean (Average) Results

It was concluded that the average mix values for both Resilient Modulus and Poisson's Ratio were more reasonable, representative and consistent for the use of 6" diameter specimens with a gage length of 3.0" (or greater). In general the results from the 4" diameter specimens resulted in much larger (and questionable) values and, as will be detailed in paragraphs that follow, extremely large variability values. As a general rule, both the Resilient Modulus and Poisson's Ratio values tended to increase with increasing nominal aggregate size of the mix. The best estimates of the mean (average) values for all mixtures and test parameters are summarized in Table 7.2.

Variance Results

Results of the variability study yielded very significant findings. The conclusions that follow were found to be the same for all four-test parameters measured (instantaneous and total Resilient Modulus and Poisson's Ratio). It was concluded that:

- As the specimen diameter was increased from 4" to 6", the total variance of the measurement (all parameters and mix types) significantly decreased. It was found that the Resilient Modulus values had variance reductions in the order of 25 to 40% for the 12.5 and 19.0 mm mixtures, while a 70% reduction for the 37.5 mm mixture was found. The typical reduction in the variance for the Poisson's Ration values was typically around 60 to 65%.
- As the nominal aggregate size of the mix increased from 12.5 to 19.0 to 37.5 mm; the total variance also increased. This was particularly true for the 37.5 mm mixture. Compared to the variance associated with Resilient Modulus measurements for the 12.5 mm mixture; total variance for the 19.0 mm mixture was 3 times as large, while for the 37.5 mm mixture, the total variance was found to be 35 to 40 times as large. In measurement of the Poisson's Ratio value, the comparable ratios were found to be about 2 times the variance for the 19.0 mm mixture and about 5 times the total variance for the 37.5 mm mixture.

Influence of Gage Length

For almost all of the various combinations of factors examined in the study, a general decrease in the total variance was found to occur as the gage length was increased. In particular, there was a dramatic decrease in the total variance as the gage length ratio (gage length to specimen diameter) increased from a value of 0.25 to a value of 0.50. In summary, the most salient finding is that a 3" gage length, mounted on a 6" diameter specimen, yields a total variance that is either the minimum value compared to all gage lengths or has a total variance that does not significantly differ from the minimum value found at a gage length ratio of 0.75

Variance Components

It was concluded that the best way to characterize the magnitudes of each component variance investigated was to normalize the values by using the percent component contribution of the total variance. An analysis of these percentage values found that:

- The percentage values, by variance component, appear to be generally independent of the specimen diameter, gage length, mix type and type of parameter (instantaneous or total)
- The percentage values, by variance components, appear to be somewhat independent of the test parameter, although there does appear to be a slight difference in mean values between variance components for the Resilient Modulus and Poisson's Ratio.
- In general, the greatest percentage of the total variance of the measurement is overwhelmingly dominated by the rotational effect (within face rotation) and the between face (face to face rotation). For Resilient Modulus estimates these two components cause nearly 90% of the total variance. For Poisson's Ratio estimates, these two variance components are responsible for about 85% of the total variance.
- The percentage contributions to the total variance are nearly insignificant for the: cycle, repeat and specimen variances. All three of these components combined cause a total of 10% of the total variance for Modulus computations and 15% for estimation of the Poisson's Ratio.

Test Protocol

The general approach used to develop a final set of protocol recommendations employed the concept of selecting the proper number of replicates for each component that, in the final result, would yield the lowest Confidence range of the estimate. These combinations selected must be (and were) tempered with the most practical limitations of time and cost associated with the test sequence for the recommended methodology.

In this study, two conditions were evaluated. The first condition "Lab Prepared Specimens" focuses upon the most accurate assessment of determining the Modulus and / or Poisson's Ratio for test specimens manufactured in the laboratory from gyratory compacted specimens. The second set of recommendations focused upon the most accurate assessment of estimating material properties from a specific field project through field cores "Field Core Specimens".

The recommended test protocol for the "Lab Prepared Specimen" case resulted in the use of: 5 load cycles (ie 95 to 99^{th} cycles); 1 repeat condition, 2 within face rotations, 2 between face rotations and 4 specimens from a particular gyratory plug. For these conditions and on the three mixtures evaluated in this study, the 95% Confidence Limits of Modulus would be: (673 to 853 ksi; 717 to 1033 ksi and 776 to 1516 ksi) for the 12.5 mm, 19.0 mm and 37.5 mm mixtures, respectively. For estimating the Poisson's Ratio the comparable limit values would be: (0.29 to 0.50; 0.27 to 0.56 and 0.17 to 0.69).

The recommended test protocol for the "Field Core Specimens" would yield the same replicate values for the: cycle, repeat, within face rotations and the between face rotations. Here, however, it should be recognized that the number of test specimens to be tested will always be the product of specimens per core times the number of field cores used. Thus it is imperative that the correct emphasis is selected to minimize the Confidence Range (increase in accuracy) that is obtained. Not surprising, the optimum (most accurate) combination will always occur when one specimen per core is used (ie maximize the number of field cores to maximize accuracy). For this case, the Research team recommends that 6 field cores be used with only one specimen cut from each core.

Another important aspect that must not be overlooked relates to the fact that the Confidence Range is a hyperbolic function with the number of field cores tested. This fact implies that the Confidence Range (=/- R) is not linearly related to the number of field cores. In reality, there is a presumptive number (near 4 to 6) beyond which very little, if any, increase in accuracy will occur by increasing the number of test specimens to be evaluated.

Using the report recommended testing methodology on the three mixtures evaluated in this study, the 95% Confidence Limits of Modulus would be: (646 to 880 ksi; 709 to 1041 ksi and 814 to 1478 ksi) for the 12.5 mm, 19.0 mm and 37.5 mm mixtures, respectively. For estimating the Poisson's Ratio the comparable limit values would be: (0.29 to 0.50; 0.28 to 0.56 and 0.21 to 0.65).

Summary Assessment

From an overall assessment viewpoint, the results of the study clearly show that the Indirect Tensile (Diametral) approach for measuring the Resilient Modulus and Poisson's Ratio of a given asphaltic mix material is a highly variable testing methodology. The values of the Confidence Limits computed from the results of even this very comprehensive lab testing evaluation quantifies the range of values over which the engineer can be confident that the true material mean value will fall. Because of this, the engineer must truly assess the validity and utility for using this variable test measurement approach in lieu of current engineering experience / judgment available for estimating typical values and / or the availability of several simple predictive models available in the literature to estimate these parameters.

RECOMMENDATIONS

The results of this study have left the Research Team with two possible recommendations for future research that need to be considered.

1. One limitation of the existing study is the fact that the test results were only conducted at a single temperature value (70 deg F). Because of this, one should consider the expansion of similar studies for a cooler temperature (40 deg F) and a warmer temperature (85 – 100 deg F). The scope and test parameters considered should be identical to those evaluated in this study. It is cautioned that care should be taken in selecting an appropriate upper temperature limit to insure that

localized material damage, due to excessive deformations at or near the loading strip, is not present in the testing evaluation.

2. It is to be noted that the Indirect Tensile Test will be used as the test methodology in the forthcoming 2002 Design Guide to predict the quantity of transverse Thermal fracture that will occur in a given asphaltic mixture, within a unique geographic location. The use of the IDT methodology will be to develop Creep Curves (to establish a Master Curve for Compliance measurements) and Indirect Tensile Strength curves at 0, -10 and –20 deg C. This input will be used for the Level I and II input approach in the new Mechanistic-Empirical methodology developed.

   It is highly recommended that a comparable study be undertaken, using the Creep Compliance and Indirect Strength parameters, to quantify the impact of specimen diameter, gage length, mix types and component variance magnitudes to establish an enhanced and very rational approach for the material test protocol that would be used in the 2002 design guide approach.

Because the use of the Indirect Tensile device will not be applicable for use in the 2002 Design Guide for characterizing the Modulus and Poisson's Ratio for asphaltic mixtures, it is the recommendation of the Research Team that recommendation #1 (continued Modulus and Poisson's ratio study) be given a low priority and recommendation #2 (Thermal Fracture study) be given a very high priority.

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APPENDIX A

NCHRP 1-28A Project

Summary of Test Results

Annex 1

NCHRP 1-28A Project

Diametral Test Results

Mr Instantaneous

12.5 mm
4 inch Dia.

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	595.0	HF2	0	1	95	952.0		773.5
				96	615.0				96	819.0		717.0
				97	595.0				97	977.0		786.0
				98	611.0				98	835.0		723.0
				99	612.0				99	947.0		779.5
				Avg:	605.6				Avg:	906.0	Avg:	755.8
				Std Dev:	9.788				Std Dev:	73.226	Std Dev:	33.047
	OF1	0	2	95	573.0	HF2	0	2	95	918.0		745.5
				96	541.0				96	1101.0		821.0
				97	594.0				97	820.0		707.0
				98	576.0				98	845.0		710.5
				99	552.0				99	814.0		683.0
				Avg:	567.2				Avg:	899.6	Avg:	733.4
				Std Dev:	20.897				Std Dev:	119.943	Std Dev:	53.809
	OF1	90	1	95	609.0	HF2	90	1	95	703.0		656.0
				96	690.0				96	671.0		680.5
				97	698.0				97	662.0		680.0
				98	667.0				98	614.0		640.5
				99	580.0				99	553.0		566.5
				Avg:	648.8				Avg:	640.6	Avg:	644.7
				Std Dev:	51.882				Std Dev:	58.432	Std Dev:	46.873
	OF1	90	2	95	658.0	HF2	90	2	95	674.0		666.0
				96	704.0				96	635.0		669.5
				97	646.0				97	611.0		628.5
				98	637.0				98	644.0		640.5
				99	668.0				99	632.0		650.0
				Avg:	662.6				Avg:	639.2	Avg:	650.9
				Std Dev:	25.958				Std Dev:	22.906	Std Dev:	17.210
A	OF2	0	1	95	855.0	HF1	0	1	95	512.0		683.5
				96	1040.0				96	567.0		803.5
				97	999.0				97	537.0		768.0
				98	1134.0				98	527.0		830.5
				99	985.0				99	538.0		761.5
				Avg:	1002.6				Avg:	536.2	Avg:	769.4
				Std Dev:	100.962				Std Dev:	20.142	Std Dev:	55.541
	OF2	0	2	95	899.0	HF1	0	2	95	502.0		700.5
				96	987.0				96	506.0		746.5
				97	1145.0				97	552.0		848.5
				98	1091.0				98	526.0		808.5
				99	923.0				99	513.0		718.0
				Avg:	1009.0				Avg:	519.8	Avg:	764.4
				Std Dev:	106.301				Std Dev:	20.179	Std Dev:	62.398
	OF2	90	1	95	860.0	HF1	90	1	95	595.0		727.5
				96	713.0				96	524.0		618.5
				97	681.0				97	474.0		577.5
				98	801.0				98	542.0		671.5
				99	772.0				99	550.0		661.0
				Avg:	765.4				Avg:	537.0	Avg:	651.2
				Std Dev:	70.939				Std Dev:	43.863	Std Dev:	56.637
	OF2	90	2	95	817.0	HF1	90	2	95	597.0		707.0
				96	811.0				96	615.0		713.0
				97	747.0				97	615.0		681.0
				98	739.0				98	641.0		690.0
				99	716.0				99	570.0		643.0
				Avg:	766.0				Avg:	607.6	Avg:	686.8
				Std Dev:	45.321				Std Dev:	26.226	Std Dev:	27.644

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Mr Avg (Ksi)
A	OF1	0	1	95	564.0	HF2	0	1	95	679.0	621.5
				96	551.0				96	693.0	622.0
				97	551.0				97	660.0	605.5
				98	544.0				98	708.0	626.0
				99	573.0				99	658.0	615.5
				Avg:	556.6				Avg:	679.6	Avg: 618.1
				Std Dev:	11.675				Std Dev:	21.431	Std Dev: 7.980
	OF1	0	2	95	561.0	HF2	0	2	95	784.0	672.5
				96	575.0				96	773.0	674.0
				97	571.0				97	765.0	668.0
				98	572.0				98	779.0	675.5
				99	558.0				99	850.0	704.0
				Avg:	567.4				Avg:	790.2	Avg: 678.8
				Std Dev:	7.436				Std Dev:	34.172	Std Dev: 14.364
	OF1	90	1	95	687.0	HF2	90	1	95	574.0	630.5
				96	683.0				96	557.0	620.0
				97	653.0				97	590.0	621.5
				98	631.0				98	579.0	605.0
				99	661.0				99	589.0	625.0
				Avg:	663.0				Avg:	577.8	Avg: 620.4
				Std Dev:	22.935				Std Dev:	13.442	Std Dev: 9.509
	OF1	90	2	95	681.0	HF2	90	2	95	577.0	629.0
				96	653.0				96	604.0	628.5
				97	666.0				97	559.0	612.5
				98	648.0				98	609.0	628.5
				99	627.0				99	592.0	609.5
				Avg:	655.0				Avg:	588.2	Avg: 621.6
				Std Dev:	20.211				Std Dev:	20.462	Std Dev: 9.737
A	OF2	0	1	95	608.0	HF1	0	1	95	776.0	692.0
				96	565.0				96	713.0	639.0
				97	574.0				97	703.0	638.5
				98	587.0				98	742.0	664.5
				99	605.0				99	733.0	669.0
				Avg:	587.8				Avg:	733.4	Avg: 660.6
				Std Dev:	18.807				Std Dev:	28.413	Std Dev: 22.509
	OF2	0	2	95	743.0	HF1	0	2	95	798.0	770.5
				96	710.0				96	828.0	769.0
				97	703.0				97	855.0	779.0
				98	631.0				98	790.0	710.5
				99	659.0				99	773.0	716.0
				Avg:	689.2				Avg:	808.8	Avg: 749.0
				Std Dev:	44.206				Std Dev:	32.614	Std Dev: 32.915
	OF2	90	1	95	632.0	HF1	90	1	95	703.0	667.5
				96	616.0				96	683.0	649.5
				97	591.0				97	667.0	629.0
				98	634.0				98	647.0	640.5
				99	701.0				99	720.0	710.5
				Avg:	634.8				Avg:	684.0	Avg: 659.4
				Std Dev:	40.813				Std Dev:	28.792	Std Dev: 31.844
	OF2	90	2	95	642.0	HF1	90	2	95	819.0	730.5
				96	569.0				96	744.0	656.5
				97	622.0				97	821.0	721.5
				98	666.0				98	803.0	734.5
				99	648.0				99	791.0	719.5
				Avg:	629.4				Avg:	795.6	Avg: 712.5
				Std Dev:	37.240				Std Dev:	31.350	Std Dev: 31.914

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	990.0	HF2	0	1	95	735.0		862.5
				96	982.0				96	736.0		859.0
				97	1005.0				97	714.0		859.5
				98	970.0				98	726.0		848.0
				99	970.0				99	744.0		857.0
			Avg:		983.4			Avg:		731.0	Avg:	857.2
			Std Dev:		14.758			Std Dev:		11.446	Std Dev:	5.507
	OF1	0	2	95	922.0	HF2	0	2	95	799.0		860.5
				96	920.0				96	818.0		869.0
				97	892.0				97	780.0		836.0
				98	917.0				98	784.0		850.5
				99	870.0				99	770.0		820.0
			Avg:		904.2			Avg:		790.2	Avg:	847.2
			Std Dev:		22.632			Std Dev:		18.714	Std Dev:	19.547
	OF1	90	1	95	780.0	HF2	90	1	95	768.0		774.0
				96	787.0				96	807.0		797.0
				97	792.0				97	777.0		784.5
				98	802.0				98	756.0		779.0
				99	812.0				99	764.0		788.0
			Avg:		794.6			Avg:		774.4	Avg:	784.5
			Std Dev:		12.602			Std Dev:		19.731	Std Dev:	8.789
	OF1	90	2	95	838.0	HF2	90	2	95	758.0		798.0
				96	835.0				96	796.0		815.5
				97	827.0				97	811.0		819.0
				98	826.0				98	797.0		811.5
				99	837.0				99	787.0		812.0
			Avg:		832.6			Avg:		789.8	Avg:	811.2
			Std Dev:		5.683			Std Dev:		19.741	Std Dev:	7.973
A	OF2	0	1	95	795.0	HF1	0	1	95	931.0		863.0
				96	821.0				96	895.0		858.0
				97	774.0				97	899.0		836.5
				98	779.0				98	905.0		842.0
				99	763.0				99	905.0		834.0
			Avg:		786.4			Avg:		907.0	Avg:	846.7
			Std Dev:		22.512			Std Dev:		14.071	Std Dev:	13.046
	OF2	0	2	95	832.0	HF1	0	2	95	979.0		905.5
				96	896.0				96	995.0		945.5
				97	879.0				97	1006.0		942.5
				98	880.0				98	1012.0		946.0
				99	814.0				99	973.0		893.5
			Avg:		860.2			Avg:		993.0	Avg:	926.6
			Std Dev:		35.202			Std Dev:		16.808	Std Dev:	25.136
	OF2	90	1	95	789.0	HF1	90	1	95	996.0		892.5
				96	709.0				96	901.0		805.0
				97	776.0				97	979.0		877.5
				98	734.0				98	942.0		838.0
				99	748.0				99	918.0		833.0
			Avg:		751.2			Avg:		947.2	Avg:	849.2
			Std Dev:		32.136			Std Dev:		40.021	Std Dev:	35.416
	OF2	90	2	95	777.0	HF1	90	2	95	920.0		848.5
				96	808.0				96	988.0		898.0
				97	795.0				97	955.0		875.0
				98	752.0				98	927.0		839.5
				99	755.0				99	936.0		845.5
			Avg:		777.4			Avg:		945.2	Avg:	861.3
			Std Dev:		24.460			Std Dev:		27.289	Std Dev:	24.614

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	946.0	HF2	0	1	95	586.0		766.0
				96	999.0				96	687.0		843.0
				97	1060.0				97	646.0		853.0
				98	1020.0				98	675.0		847.5
				99	997.0				99	612.0		804.5
			Avg:		1004.4			Avg:		641.2	Avg:	822.8
			Std Dev:		41.319			Std Dev:		42.317	Std Dev:	37.052
	OF1	0	2	95	1013.0	HF2	0	2	95	624.0		818.5
				96	1009.0				96	635.0		822.0
				97	843.0				97	561.0		702.0
				98	875.0				98	606.0		740.5
				99	991.0				99	620.0		805.5
			Avg:		946.2			Avg:		609.2	Avg:	777.7
			Std Dev:		80.828			Std Dev:		26.874	Std Dev:	53.652
	OF1	90	1	95	901.0	HF2	90	1	95	1661.0		1281.0
				96	820.0				96	1189.0		1004.5
				97	787.0				97	1890.0		1338.5
				98	957.0				98	1231.0		1094.0
				99	915.0				99	1444.0		1179.5
			Avg:		876.0			Avg:		1483.0	Avg:	1179.5
			Std Dev:		70.292			Std Dev:		295.294	Std Dev:	135.571
	OF1	90	2	95	896.0	HF2	90	2	95	1177.0		1036.5
				96	735.0				96	1453.0		1094.0
				97	812.0				97	1314.0		1063.0
				98	796.0				98	1221.0		1008.5
				99	794.0				99	1607.0		1200.5
			Avg:		806.6			Avg:		1354.4	Avg:	1080.5
			Std Dev:		57.921			Std Dev:		176.371	Std Dev:	74.176
B	OF2	0	1	95	749.0	HF1	0	1	95	1305.0		1027.0
				96	768.0				96	1276.0		1022.0
				97	663.0				97	1150.0		906.5
				98	765.0				98	1192.0		978.5
				99	698.0				99	1150.0		924.0
			Avg:		728.6			Avg:		1214.6	Avg:	971.6
			Std Dev:		46.188			Std Dev:		72.110	Std Dev:	55.138
	OF2	0	2	95	764.0	HF1	0	2	95	1086.0		925.0
				96	810.0				96	1073.0		941.5
				97	687.0				97	1108.0		897.5
				98	753.0				98	1117.0		935.0
				99	604.0				99	1124.0		864.0
			Avg:		723.6			Avg:		1101.6	Avg:	912.6
			Std Dev:		80.008			Std Dev:		21.455	Std Dev:	31.940
	OF2	90	1	95	985.0	HF1	90	1	95	978.0		981.5
				96	1071.0				96	1041.0		1056.0
				97	1187.0				97	1051.0		1119.0
				98	1009.0				98	1157.0		1083.0
				99	975.0				99	1075.0		1025.0
			Avg:		1045.4			Avg:		1060.4	Avg:	1052.9
			Std Dev:		87.515			Std Dev:		64.806	Std Dev:	52.823
	OF2	90	2	95	925.0	HF1	90	2	95	861.0		893.0
				96	1025.0				96	955.0		990.0
				97	1160.0				97	996.0		1078.0
				98	970.0				98	1143.0		1056.5
				99	1045.0				99	985.0		1015.0
			Avg:		1025.0			Avg:		988.0	Avg:	1006.5
			Std Dev:		88.952			Std Dev:		101.632	Std Dev:	72.179

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Mr Avg (Ksi)
B	OF1	0	1	95	851.0	HF2	0	1	95	804.0	827.5
				96	816.0				96	854.0	835.0
				97	827.0				97	787.0	807.0
				98	797.0				98	725.0	761.0
				99	770.0				99	744.0	757.0
			Avg:		812.2			Avg:		782.8	Avg: 797.5
			Std Dev:		30.622			Std Dev:		50.948	Std Dev: 36.637
	OF1	0	2	95	803.0	HF2	0	2	95	903.0	853.0
				96	804.0				96	763.0	783.5
				97	766.0				97	797.0	781.5
				98	806.0				98	878.0	842.0
				99	803.0				99	855.0	829.0
			Avg:		796.4			Avg:		839.2	Avg: 817.8
			Std Dev:		17.038			Std Dev:		57.907	Std Dev: 33.333
	OF1	90	1	95	834.0	HF2	90	1	95	755.0	794.5
				96	812.0				96	839.0	825.5
				97	849.0				97	850.0	849.5
				98	849.0				98	773.0	811.0
				99	874.0				99	754.0	814.0
			Avg:		843.6			Avg:		794.2	Avg: 818.9
			Std Dev:		22.766			Std Dev:		46.698	Std Dev: 20.382
	OF1	90	2	95	861.0	HF2	90	2	95	776.0	818.5
				96	824.0				96	735.0	779.5
				97	811.0				97	711.0	761.0
				98	798.0				98	641.0	719.5
				99	821.0				99	662.0	741.5
			Avg:		823.0			Avg:		705.0	Avg: 764.0
			Std Dev:		23.548			Std Dev:		54.594	Std Dev: 37.769
B	OF2	0	1	95	832.0	HF1	0	1	95	771.0	801.5
				96	876.0				96	755.0	815.5
				97	797.0				97	754.0	775.5
				98	801.0				98	758.0	779.5
				99	731.0				99	741.0	736.0
			Avg:		807.4			Avg:		755.8	Avg: 781.6
			Std Dev:		53.144			Std Dev:		10.710	Std Dev: 30.275
	OF2	0	2	95	764.0	HF1	0	2	95	754.0	759.0
				96	716.0				96	748.0	732.0
				97	708.0				97	722.0	715.0
				98	746.0				98	751.0	748.5
				99	817.0				99	773.0	795.0
			Avg:		750.2			Avg:		749.6	Avg: 749.9
			Std Dev:		43.649			Std Dev:		18.257	Std Dev: 30.237
	OF2	90	1	95	740.0	HF1	90	1	95	1017.0	878.5
				96	717.0				96	1088.0	902.5
				97	683.0				97	1027.0	855.0
				98	660.0				98	998.0	829.0
				99	649.0				99	1016.0	832.5
			Avg:		689.8			Avg:		1029.2	Avg: 859.5
			Std Dev:		38.271			Std Dev:		34.492	Std Dev: 31.183
	OF2	90	2	95	689.0	HF1	90	2	95	1020.0	854.5
				96	737.0				96	1079.0	908.0
				97	730.0				97	1087.0	908.5
				98	726.0				98	1054.0	890.0
				99	732.0				99	1017.0	874.5
			Avg:		722.8			Avg:		1051.4	Avg: 887.1
			Std Dev:		19.305			Std Dev:		32.424	Std Dev: 23.047

Mix Type=	12.5mm
Diam.=	4.00 in
Gage Length=	3.0 in
Instant	

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	746.0	HF2	0	1	95	820.0		783.0
				96	758.0				96	780.0		769.0
				97	746.0				97	752.0		749.0
				98	717.0				98	788.0		752.5
				99	732.0				99	769.0		750.5
			Avg:		739.8			Avg:		781.8	Avg:	760.8
			Std Dev:		15.723			Std Dev:		25.263	Std Dev:	14.784
	OF1	0	2	95	881.0	HF2	0	2	95	895.0		888.0
				96	838.0				96	926.0		882.0
				97	845.0				97	917.0		881.0
				98	871.0				98	927.0		899.0
				99	851.0				99	898.0		874.5
			Avg:		857.2			Avg:		912.6	Avg:	884.9
			Std Dev:		18.116			Std Dev:		15.241	Std Dev:	9.222
	OF1	90	1	95	1054.0	HF2	90	1	95	794.0		924.0
				96	1020.0				96	773.0		896.5
				97	994.0				97	711.0		852.5
				98	980.0				98	722.0		851.0
				99	1009.0				99	746.0		877.5
			Avg:		1011.4			Avg:		749.2	Avg:	880.3
			Std Dev:		28.210			Std Dev:		34.579	Std Dev:	30.868
	OF1	90	2	95	1019.0	HF2	90	2	95	820.0		919.5
				96	1036.0				96	817.0		926.5
				97	1037.0				97	774.0		905.5
				98	1068.0				98	796.0		932.0
				99	1048.0				99	817.0		932.5
			Avg:		1041.6			Avg:		804.8	Avg:	923.2
			Std Dev:		18.036			Std Dev:		19.715	Std Dev:	11.200
B	OF2	0	1	95	783.0	HF1	0	1	95	873.0		828.0
				96	765.0				96	849.0		807.0
				97	787.0				97	878.0		832.5
				98	791.0				98	881.0		836.0
				99	761.0				99	868.0		814.5
			Avg:		777.4			Avg:		869.8	Avg:	823.6
			Std Dev:		13.520			Std Dev:		12.637	Std Dev:	12.356
	OF2	0	2	95	808.0	HF1	0	2	95	916.0		862.0
				96	761.0				96	875.0		818.0
				97	757.0				97	891.0		824.0
				98	755.0				98	892.0		823.5
				99	783.0				99	887.0		835.0
			Avg:		772.8			Avg:		892.2	Avg:	832.5
			Std Dev:		22.632			Std Dev:		14.923	Std Dev:	17.607
	OF2	90	1	95	798.0	HF1	90	1	95	939.0		868.5
				96	815.0				96	884.0		849.5
				97	853.0				97	968.0		910.5
				98	875.0				98	983.0		929.0
				99	834.0				99	914.0		874.0
			Avg:		835.0			Avg:		937.6	Avg:	886.3
			Std Dev:		30.389			Std Dev:		40.054	Std Dev:	32.524
	OF2	90	2	95	842.0	HF1	90	2	95	1019.0		930.5
				96	888.0				96	981.0		934.5
				97	864.0				97	981.0		922.5
				98	841.0				98	1005.0		923.0
				99	872.0				99	939.0		905.5
			Avg:		861.4			Avg:		985.0	Avg:	923.2
			Std Dev:		20.120			Std Dev:		30.430	Std Dev:	11.122

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	390.0	HF2	0	1	95	457.0		423.5
				96	384.0				96	438.0		411.0
				97	383.0				97	410.0		396.5
				98	406.0				98	460.0		433.0
				99	402.0				99	478.0		440.0
			Avg:		393.0			Avg:		448.6	Avg:	420.8
			Std Dev:		10.488			Std Dev:		25.822	Std Dev:	17.402
	OF1	0	2	95	496.0	HF2	0	2	95	435.0		465.5
				96	495.0				96	530.0		512.5
				97	491.0				97	468.0		479.5
				98	474.0				98	480.0		477.0
				99	494.0				99	472.0		483.0
			Avg:		490.0			Avg:		477.0	Avg:	483.5
			Std Dev:		9.138			Std Dev:		34.234	Std Dev:	17.489
	OF1	90	1	95	570.0	HF2	90	1	95	684.0		627.0
				96	627.0				96	650.0		638.5
				97	657.0				97	687.0		672.0
				98	636.0				98	653.0		644.5
				99	721.0				99	652.0		686.5
			Avg:		642.2			Avg:		665.2	Avg:	653.7
			Std Dev:		54.568			Std Dev:		18.593	Std Dev:	24.695
	OF1	90	2	95	652.0	HF2	90	2	95	699.0		675.5
				96	674.0				96	701.0		687.5
				97	706.0				97	622.0		664.0
				98	608.0				98	722.0		665.0
				99	705.0				99	654.0		679.5
			Avg:		669.0			Avg:		679.6	Avg:	674.3
			Std Dev:		40.927			Std Dev:		40.636	Std Dev:	9.941
C	OF2	0	1	95	423.0	HF1	0	1	95	341.0		382.0
				96	430.0				96	338.0		384.0
				97	371.0				97	319.0		345.0
				98	386.0				98	319.0		352.5
				99	395.0				99	320.0		357.5
			Avg:		401.0			Avg:		327.4	Avg:	364.2
			Std Dev:		24.930			Std Dev:		11.104	Std Dev:	17.743
	OF2	0	2	95	446.0	HF1	0	2	95	452.0		449.0
				96	478.0				96	451.0		464.5
				97	468.0				97	429.0		448.5
				98	467.0				98	461.0		464.0
				99	488.0				99	470.0		479.0
			Avg:		469.4			Avg:		452.6	Avg:	461.0
			Std Dev:		15.614			Std Dev:		15.274	Std Dev:	12.703
	OF2	90	1	95	789.0	HF1	90	1	95	683.0		736.0
				96	762.0				96	676.0		719.0
				97	876.0				97	639.0		757.5
				98	661.0				98	628.0		644.5
				99	716.0				99	640.0		678.0
			Avg:		760.8			Avg:		653.2	Avg:	707.0
			Std Dev:		80.677			Std Dev:		24.591	Std Dev:	45.504
	OF2	90	2	95	771.0	HF1	90	2	95	660.0		715.5
				96	636.0				96	730.0		683.0
				97	686.0				97	630.0		658.0
				98	803.0				98	645.0		724.0
				99	738.0				99	593.0		665.5
			Avg:		726.8			Avg:		651.6	Avg:	689.2
			Std Dev:		66.699			Std Dev:		50.401	Std Dev:	29.480

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	648.0	HF2	0	1	95	1271.0		959.5
				96	616.0				96	1140.0		878.0
				97	614.0				97	1036.0		825.0
				98	645.0				98	1095.0		870.0
				99	643.0				99	1103.0		873.0
			Avg:		633.2			Avg:		1129.0	Avg:	881.1
			Std Dev:		16.724			Std Dev:		87.701	Std Dev:	48.714
	OF1	0	2	95	652.0	HF2	0	2	95	1036.0		844.0
				96	653.0				96	1028.0		840.5
				97	652.0				97	1089.0		870.5
				98	644.0				98	1078.0		861.0
				99	658.0				99	1116.0		887.0
			Avg:		651.8			Avg:		1069.4	Avg:	860.6
			Std Dev:		5.020			Std Dev:		36.943	Std Dev:	19.201
	OF1	90	1	95	620.0	HF2	90	1	95	646.0		633.0
				96	594.0				96	638.0		616.0
				97	560.0				97	596.0		578.0
				98	592.0				98	625.0		608.5
				99	611.0				99	646.0		628.5
			Avg:		595.4			Avg:		630.2	Avg:	612.8
			Std Dev:		22.996			Std Dev:		20.957	Std Dev:	21.762
	OF1	90	2	95	610.0	HF2	90	2	95	611.0		610.5
				96	602.0				96	613.0		607.5
				97	624.0				97	619.0		621.5
				98	618.0				98	626.0		622.0
				99	631.0				99	668.0		649.5
			Avg:		617.0			Avg:		627.4	Avg:	622.2
			Std Dev:		11.402			Std Dev:		23.437	Std Dev:	16.574
C	OF2	0	1	95	801.0	HF1	0	1	95	793.0		797.0
				96	789.0				96	780.0		784.5
				97	793.0				97	749.0		771.0
				98	764.0				98	763.0		763.5
				99	763.0				99	777.0		770.0
			Avg:		782.0			Avg:		772.4	Avg:	777.2
			Std Dev:		17.436			Std Dev:		16.876	Std Dev:	13.447
	OF2	0	2	95	872.0	HF1	0	2	95	827.0		849.5
				96	853.0				96	822.0		837.5
				97	858.0				97	786.0		822.0
				98	859.0				98	757.0		808.0
				99	833.0				99	795.0		814.0
			Avg:		855.0			Avg:		797.4	Avg:	826.2
			Std Dev:		14.160			Std Dev:		28.501	Std Dev:	17.090
	OF2	90	1	95	635.0	HF1	90	1	95	626.0		630.5
				96	638.0				96	615.0		626.5
				97	645.0				97	623.0		634.0
				98	658.0				98	659.0		658.5
				99	660.0				99	644.0		652.0
			Avg:		647.2			Avg:		633.4	Avg:	640.3
			Std Dev:		11.389			Std Dev:		17.813	Std Dev:	14.092
	OF2	90	2	95	616.0	HF1	90	2	95	616.0		616.0
				96	605.0				96	596.0		600.5
				97	654.0				97	641.0		647.5
				98	637.0				98	639.0		638.0
				99	640.0				99	622.0		631.0
			Avg:		630.4			Avg:		622.8	Avg:	626.6
			Std Dev:		19.655			Std Dev:		18.431	Std Dev:	18.572

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	919.0	HF2	0	1	95	841.0		880.0
				96	949.0				96	881.0		915.0
				97	951.0				97	860.0		905.5
				98	987.0				98	896.0		941.5
				99	958.0				99	904.0		931.0
			Avg:		952.8			Avg:		876.4	Avg:	914.6
			Std Dev:		24.273			Std Dev:		25.929	Std Dev:	23.836
	OF1	0	2	95	962.0	HF2	0	2	95	865.0		913.5
				96	985.0				96	903.0		944.0
				97	966.0				97	896.0		931.0
				98	957.0				98	925.0		941.0
				99	964.0				99	898.0		931.0
			Avg:		966.8			Avg:		897.4	Avg:	932.1
			Std Dev:		10.710			Std Dev:		21.478	Std Dev:	11.929
	OF1	90	1	95	763.0	HF2	90	1	95	936.0		849.5
				96	807.0				96	1058.0		932.5
				97	732.0				97	982.0		857.0
				98	705.0				98	903.0		804.0
				99	777.0				99	940.0		858.5
			Avg:		756.8			Avg:		963.8	Avg:	860.3
			Std Dev:		39.575			Std Dev:		59.667	Std Dev:	46.134
	OF1	90	2	95	802.0	HF2	90	2	95	1063.0		932.5
				96	850.0				96	1157.0		1003.5
				97	877.0				97	1129.0		1003.0
				98	828.0				98	1106.0		967.0
				99	831.0				99	1090.0		960.5
			Avg:		837.6			Avg:		1109.0	Avg:	973.3
			Std Dev:		27.880			Std Dev:		36.021	Std Dev:	30.258
C	OF2	0	1	95	683.0	HF1	0	1	95	922.0		802.5
				96	634.0				96	891.0		762.5
				97	683.0				97	930.0		806.5
				98	637.0				98	895.0		766.0
				99	653.0				99	891.0		772.0
			Avg:		658.0			Avg:		905.8	Avg:	781.9
			Std Dev:		23.937			Std Dev:		18.727	Std Dev:	20.957
	OF2	0	2	95	695.0	HF1	0	2	95	967.0		831.0
				96	679.0				96	935.0		807.0
				97	702.0				97	961.0		831.5
				98	682.0				98	886.0		784.0
				99	674.0				99	896.0		785.0
			Avg:		686.4			Avg:		929.0	Avg:	807.7
			Std Dev:		11.675			Std Dev:		36.885	Std Dev:	23.382
	OF2	90	1	95	928.0	HF1	90	1	95	974.0		951.0
				96	956.0				96	1040.0		998.0
				97	927.0				97	975.0		951.0
				98	932.0				98	922.0		927.0
				99	958.0				99	990.0		974.0
			Avg:		940.2			Avg:		980.2	Avg:	960.2
			Std Dev:		15.466			Std Dev:		42.204	Std Dev:	26.883
	OF2	90	2	95	870.0	HF1	90	2	95	929.0		899.5
				96	870.0				96	867.0		868.5
				97	804.0				97	879.0		841.5
				98	803.0				98	876.0		839.5
				99	829.0				99	877.0		853.0
			Avg:		835.2			Avg:		885.6	Avg:	860.4
			Std Dev:		33.432			Std Dev:		24.694	Std Dev:	24.714

Annex 2

NCHRP 1-28A Project

Diametral Test Results

Mr Instantaneous

19.0 mm
4 inch Dia.

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1680.0	HF2	0	1	95	793.0		1236.5
				96	1538.0				96	805.0		1171.5
				97	1642.0				97	801.0		1221.5
				98	1759.0				98	730.0		1244.5
				99	1650.0				99	728.0		1189.0
			Avg:		1653.8			Avg:		771.4	Avg:	1212.6
			Std Dev:		79.556			Std Dev:		38.953	Std Dev:	31.282
	OF1	0	2	95	2112.0	HF2	0	2	95	817.0		1464.5
				96	1918.0				96	749.0		1333.5
				97	1941.0				97	820.0		1380.5
				98	2568.0				98	767.0		1667.5
				99	2528.0				99	896.0		1712.0
			Avg:		2213.4			Avg:		809.8	Avg:	1511.6
			Std Dev:		314.825			Std Dev:		57.260	Std Dev:	169.993
	OF1	90	1	95	786.0	HF2	90	1	95	1419.0		1102.5
				96	740.0				96	1472.0		1106.0
				97	780.0				97	1578.0		1179.0
				98	682.0				98	1403.0		1042.5
				99	682.0				99	1317.0		999.5
			Avg:		734.0			Avg:		1437.8	Avg:	1085.9
			Std Dev:		50.656			Std Dev:		96.155	Std Dev:	68.366
	OF1	90	2	95	710.0	HF2	90	2	95	1491.0		1100.5
				96	769.0				96	1360.0		1064.5
				97	762.0				97	1534.0		1148.0
				98	790.0				98	1622.0		1206.0
				99	686.0				99	1243.0		964.5
			Avg:		743.4			Avg:		1450.0	Avg:	1096.7
			Std Dev:		43.541			Std Dev:		149.390	Std Dev:	90.976
A	OF2	0	1	95	875.0	HF1	0	1	95	1188.0		1031.5
				96	953.0				96	1514.0		1233.5
				97	849.0				97	1515.0		1182.0
				98	845.0				98	1490.0		1167.5
				99	869.0				99	1527.0		1198.0
			Avg:		878.2			Avg:		1446.8	Avg:	1162.5
			Std Dev:		43.717			Std Dev:		145.295	Std Dev:	77.246
	OF2	0	2	95	896.0	HF1	0	2	95	1882.0		1389.0
				96	923.0				96	1698.0		1310.5
				97	833.0				97	1778.0		1305.5
				98	805.0				98	1876.0		1340.5
				99	809.0				99	1764.0		1286.5
			Avg:		853.2			Avg:		1799.6	Avg:	1326.4
			Std Dev:		53.359			Std Dev:		78.554	Std Dev:	39.997
	OF2	90	1	95	1422.0	HF1	90	1	95	739.0		1080.5
				96	1349.0				96	759.0		1054.0
				97	1199.0				97	719.0		959.0
				98	1278.0				98	815.0		1046.5
				99	1431.0				99	725.0		1078.0
			Avg:		1335.8			Avg:		751.4	Avg:	1043.6
			Std Dev:		98.391			Std Dev:		38.740	Std Dev:	49.545
	OF2	90	2	95	1592.0	HF1	90	2	95	754.0		1173.0
				96	1466.0				96	751.0		1108.5
				97	1529.0				97	856.0		1192.5
				98	1428.0				98	732.0		1080.0
				99	1531.0				99	814.0		1172.5
			Avg:		1509.2			Avg:		781.4	Avg:	1145.3
			Std Dev:		63.606			Std Dev:		51.825	Std Dev:	48.356

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	897.0	HF2	0	1	95	873.0		885.0
				96	976.0				96	904.0		940.0
				97	921.0				97	913.0		917.0
				98	917.0				98	966.0		941.5
				99	900.0				99	994.0		947.0
			Avg:		922.2			Avg:		930.0	Avg:	926.1
			Std Dev:		31.823			Std Dev:		49.005	Std Dev:	25.687
	OF1	0	2	95	969.0	HF2	0	2	95	860.0		914.5
				96	972.0				96	872.0		922.0
				97	949.0				97	900.0		924.5
				98	967.0				98	863.0		915.0
				99	951.0				99	834.0		892.5
			Avg:		961.6			Avg:		865.8	Avg:	913.7
			Std Dev:		10.761			Std Dev:		23.774	Std Dev:	12.622
	OF1	90	1	95	1104.0	HF2	90	1	95	929.0		1016.5
				96	1154.0				96	887.0		1020.5
				97	1155.0				97	885.0		1020.0
				98	1147.0				98	878.0		1012.5
				99	1190.0				99	832.0		1011.0
			Avg:		1150.0			Avg:		882.2	Avg:	1016.1
			Std Dev:		30.684			Std Dev:		34.492	Std Dev:	4.292
	OF1	90	2	95	1229.0	HF2	90	2	95	777.0		1003.0
				96	1354.0				96	754.0		1054.0
				97	1331.0				97	772.0		1051.5
				98	1248.0				98	758.0		1003.0
				99	1334.0				99	755.0		1044.5
			Avg:		1299.2			Avg:		763.2	Avg:	1031.2
			Std Dev:		56.513			Std Dev:		10.569	Std Dev:	25.977
A	OF2	0	1	95	908.0	HF1	0	1	95	825.0		866.5
				96	910.0				96	785.0		847.5
				97	880.0				97	811.0		845.5
				98	972.0				98	807.0		889.5
				99	968.0				99	854.0		911.0
			Avg:		927.6			Avg:		816.4	Avg:	872.0
			Std Dev:		40.507			Std Dev:		25.452	Std Dev:	28.107
	OF2	0	2	95	925.0	HF1	0	2	95	821.0		873.0
				96	899.0				96	819.0		859.0
				97	898.0				97	813.0		855.5
				98	831.0				98	803.0		817.0
				99	843.0				99	816.0		829.5
			Avg:		879.2			Avg:		814.4	Avg:	846.8
			Std Dev:		40.239			Std Dev:		7.057	Std Dev:	22.904
	OF2	90	1	95	985.0	HF1	90	1	95	1021.0		1003.0
				96	955.0				96	1032.0		993.5
				97	898.0				97	974.0		936.0
				98	899.0				98	988.0		943.5
				99	894.0				99	1076.0		985.0
			Avg:		926.2			Avg:		1018.2	Avg:	972.2
			Std Dev:		41.409			Std Dev:		40.015	Std Dev:	30.415
	OF2	90	2	95	877.0	HF1	90	2	95	1091.0		984.0
				96	881.0				96	1077.0		979.0
				97	939.0				97	1129.0		1034.0
				98	973.0				98	1112.0		1042.5
				99	943.0				99	1173.0		1058.0
			Avg:		922.6			Avg:		1116.4	Avg:	1019.5
			Std Dev:		41.938			Std Dev:		37.347	Std Dev:	35.784

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	2096.0	HF2	0	1	95	1016.0		1556.0
				96	1996.0				96	1014.0		1505.0
				97	2030.0				97	1023.0		1526.5
				98	2081.0				98	973.0		1527.0
				99	2115.0				99	1023.0		1569.0
			Avg:		2063.6			Avg:		1009.8	Avg:	1536.7
			Std Dev:		49.227			Std Dev:		20.969	Std Dev:	25.587
	OF1	0	2	95	1901.0	HF2	0	2	95	997.0		1449.0
				96	2055.0				96	971.0		1513.0
				97	1964.0				97	934.0		1449.0
				98	2021.0				98	932.0		1476.5
				99	1894.0				99	951.0		1422.5
			Avg:		1967.0			Avg:		957.0	Avg:	1462.0
			Std Dev:		71.334			Std Dev:		27.322	Std Dev:	34.313
	OF1	90	1	95	1587.0	HF2	90	1	95	952.0		1269.5
				96	1573.0				96	900.0		1236.5
				97	1632.0				97	868.0		1250.0
				98	1567.0				98	878.0		1222.5
				99	1622.0				99	887.0		1254.5
			Avg:		1596.2			Avg:		897.0	Avg:	1246.6
			Std Dev:		29.252			Std Dev:		32.924	Std Dev:	17.897
	OF1	90	2	95	1517.0	HF2	90	2	95	861.0		1189.0
				96	1536.0				96	885.0		1210.5
				97	1474.0				97	892.0		1183.0
				98	1584.0				98	872.0		1228.0
				99	1589.0				99	864.0		1226.5
			Avg:		1540.0			Avg:		874.8	Avg:	1207.4
			Std Dev:		48.057			Std Dev:		13.368	Std Dev:	20.813
A	OF2	0	1	95	1226.0	HF1	0	1	95	1219.0		1222.5
				96	1230.0				96	1236.0		1233.0
				97	1209.0				97	1258.0		1233.5
				98	1148.0				98	1228.0		1188.0
				99	1147.0				99	1252.0		1199.5
			Avg:		1192.0			Avg:		1238.6	Avg:	1215.3
			Std Dev:		41.382			Std Dev:		16.273	Std Dev:	20.563
	OF2	0	2	95	990.0	HF1	0	2	95	1136.0		1063.0
				96	1032.0				96	1148.0		1090.0
				97	980.0				97	1107.0		1043.5
				98	972.0				98	1160.0		1066.0
				99	975.0				99	1129.0		1052.0
			Avg:		989.8			Avg:		1136.0	Avg:	1062.9
			Std Dev:		24.560			Std Dev:		20.062	Std Dev:	17.601
	OF2	90	1	95	938.0	HF1	90	1	95	1184.0		1061.0
				96	945.0				96	1190.0		1067.5
				97	959.0				97	1212.0		1085.5
				98	953.0				98	1219.0		1086.0
				99	936.0				99	1155.0		1045.5
			Avg:		946.2			Avg:		1192.0	Avg:	1069.1
			Std Dev:		9.783			Std Dev:		25.328	Std Dev:	17.173
	OF2	90	2	95	900.0	HF1	90	2	95	1251.0		1075.5
				96	944.0				96	1245.0		1094.5
				97	906.0				97	1205.0		1055.5
				98	974.0				98	1258.0		1116.0
				99	974.0				99	1223.0		1098.5
			Avg:		939.6			Avg:		1236.4	Avg:	1088.0
			Std Dev:		35.648			Std Dev:		21.904	Std Dev:	23.179

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1086.0	HF2	0	1	95	1218.0		1152.0
				96	914.0				96	954.0		934.0
				97	1019.0				97	1274.0		1146.5
				98	942.0				98	999.0		970.5
				99	966.0				99	949.0		957.5
				Avg:	985.4				Avg:	1078.8	Avg:	1032.1
				Std Dev:	68.204				Std Dev:	155.138	Std Dev:	107.757
	OF1	0	2	95	816.0	HF2	0	2	95	998.0		907.0
				96	822.0				96	1165.0		993.5
				97	785.0				97	1168.0		976.5
				98	834.0				98	1479.0		1156.5
				99	807.0				99	1249.0		1028.0
				Avg:	812.8				Avg:	1211.8	Avg:	1012.3
				Std Dev:	18.377				Std Dev:	175.071	Std Dev:	91.874
	OF1	90	1	95	707.0	HF2	90	1	95	913.0		810.0
				96	678.0				96	970.0		824.0
				97	681.0				97	997.0		839.0
				98	675.0				98	938.0		806.5
				99	674.0				99	906.0		790.0
				Avg:	683.0				Avg:	944.8	Avg:	813.9
				Std Dev:	13.693				Std Dev:	38.480	Std Dev:	18.528
	OF1	90	2	95	635.0	HF2	90	2	95	924.0		779.5
				96	666.0				96	986.0		826.0
				97	601.0				97	939.0		770.0
				98	669.0				98	867.0		768.0
				99	681.0				99	910.0		795.5
				Avg:	650.4				Avg:	925.2	Avg:	787.8
				Std Dev:	32.416				Std Dev:	43.321	Std Dev:	23.960
B	OF2	0	1	95	961.0	HF1	0	1	95	1088.0		1024.5
				96	867.0				96	1027.0		947.0
				97	839.0				97	981.0		910.0
				98	991.0				98	1077.0		1034.0
				99	980.0				99	1059.0		1019.5
				Avg:	927.6				Avg:	1046.4	Avg:	987.0
				Std Dev:	69.648				Std Dev:	43.241	Std Dev:	55.228
	OF2	0	2	95	1147.0	HF1	0	2	95	909.0		1028.0
				96	1082.0				96	890.0		986.0
				97	1166.0				97	824.0		995.0
				98	1106.0				98	895.0		1000.5
				99	895.0				99	820.0		857.5
				Avg:	1079.2				Avg:	867.6	Avg:	973.4
				Std Dev:	108.151				Std Dev:	42.229	Std Dev:	66.659
	OF2	90	1	95	966.0	HF1	90	1	95	676.0		821.0
				96	905.0				96	660.0		782.5
				97	836.0				97	654.0		745.0
				98	878.0				98	651.0		764.5
				99	905.0				99	685.0		795.0
				Avg:	898.0				Avg:	665.2	Avg:	781.6
				Std Dev:	47.344				Std Dev:	14.687	Std Dev:	29.003
	OF2	90	2	95	816.0	HF1	90	2	95	733.0		774.5
				96	908.0				96	646.0		777.0
				97	764.0				97	631.0		697.5
				98	797.0				98	714.0		755.5
				99	782.0				99	617.0		699.5
				Avg:	813.4				Avg:	668.2	Avg:	740.8
				Std Dev:	56.239				Std Dev:	51.949	Std Dev:	39.506

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	779.0	HF2	0	1	95	732.0		755.5
				96	788.0				96	749.0		768.5
				97	778.0				97	736.0		757.0
				98	782.0				98	860.0		821.0
				99	790.0				99	814.0		802.0
			Avg:		783.4			Avg:		778.2	Avg:	780.8
			Std Dev:		5.367			Std Dev:		56.438	Std Dev:	29.254
	OF1	0	2	95	745.0	HF2	0	2	95	734.0		739.5
				96	796.0				96	788.0		792.0
				97	749.0				97	769.0		759.0
				98	742.0				98	771.0		756.5
				99	752.0				99	767.0		759.5
			Avg:		756.8			Avg:		765.8	Avg:	761.3
			Std Dev:		22.242			Std Dev:		19.639	Std Dev:	19.035
	OF1	90	1	95	869.0	HF2	90	1	95	891.0		880.0
				96	904.0				96	906.0		905.0
				97	907.0				97	870.0		888.5
				98	891.0				98	875.0		883.0
				99	903.0				99	880.0		891.5
			Avg:		894.8			Avg:		884.4	Avg:	889.6
			Std Dev:		15.659			Std Dev:		14.363	Std Dev:	9.717
	OF1	90	2	95	889.0	HF2	90	2	95	982.0		935.5
				96	918.0				96	1002.0		960.0
				97	960.0				97	1085.0		1022.5
				98	911.0				98	1070.0		990.5
				99	916.0				99	1050.0		983.0
			Avg:		918.8			Avg:		1037.8	Avg:	978.3
			Std Dev:		25.762			Std Dev:		44.184	Std Dev:	32.754
B	OF2	0	1	95	903.0	HF1	0	1	95	550.0		726.5
				96	998.0				96	556.0		777.0
				97	985.0				97	550.0		767.5
				98	976.0				98	554.0		765.0
				99	892.0				99	543.0		717.5
			Avg:		950.8			Avg:		550.6	Avg:	750.7
			Std Dev:		49.434			Std Dev:		4.980	Std Dev:	26.769
	OF2	0	2	95	1019.0	HF1	0	2	95	617.0		818.0
				96	1060.0				96	613.0		836.5
				97	954.0				97	578.0		766.0
				98	904.0				98	580.0		742.0
				99	860.0				99	587.0		723.5
			Avg:		959.4			Avg:		595.0	Avg:	777.2
			Std Dev:		81.626			Std Dev:		18.615	Std Dev:	48.552
	OF2	90	1	95	991.0	HF1	90	1	95	928.0		959.5
				96	979.0				96	920.0		949.5
				97	929.0				97	955.0		942.0
				98	972.0				98	912.0		942.0
				99	918.0				99	856.0		887.0
			Avg:		957.8			Avg:		914.2	Avg:	936.0
			Std Dev:		32.275			Std Dev:		36.335	Std Dev:	28.317
	OF2	90	2	95	944.0	HF1	90	2	95	973.0		958.5
				96	984.0				96	934.0		959.0
				97	993.0				97	957.0		975.0
				98	1010.0				98	923.0		966.5
				99	1042.0				99	958.0		1000.0
			Avg:		994.6			Avg:		949.0	Avg:	971.8
			Std Dev:		35.914			Std Dev:		20.137	Std Dev:	17.134

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	945.0	HF2	0	1	95	733.0		839.0
				96	968.0				96	782.0		875.0
				97	987.0				97	767.0		877.0
				98	895.0				98	724.0		809.5
				99	869.0				99	717.0		793.0
			Avg:		932.8			Avg:		744.6	Avg:	838.7
			Std Dev:		49.560			Std Dev:		28.378	Std Dev:	37.835
	OF1	0	2	95	1005.0	HF2	0	2	95	760.0		882.5
				96	1006.0				96	733.0		869.5
				97	995.0				97	722.0		858.5
				98	980.0				98	698.0		839.0
				99	1034.0				99	746.0		890.0
			Avg:		1004.0			Avg:		731.8	Avg:	867.9
			Std Dev:		19.761			Std Dev:		23.647	Std Dev:	20.172
	OF1	90	1	95	1328.0	HF2	90	1	95	975.0		1151.5
				96	1315.0				96	930.0		1122.5
				97	1512.0				97	1000.0		1256.0
				98	1379.0				98	1019.0		1199.0
				99	1387.0				99	1013.0		1200.0
			Avg:		1384.2			Avg:		987.4	Avg:	1185.8
			Std Dev:		77.966			Std Dev:		36.267	Std Dev:	51.204
	OF1	90	2	95	1592.0	HF2	90	2	95	945.0		1268.5
				96	1381.0				96	954.0		1167.5
				97	1326.0				97	953.0		1139.5
				98	1405.0				98	904.0		1154.5
				99	1297.0				99	880.0		1088.5
			Avg:		1400.2			Avg:		927.2	Avg:	1163.7
			Std Dev:		115.472			Std Dev:		33.417	Std Dev:	65.808
B	OF2	0	1	95	827.0	HF1	0	1	95	707.0		767.0
				96	822.0				96	717.0		769.5
				97	796.0				97	690.0		743.0
				98	862.0				98	708.0		785.0
				99	826.0				99	715.0		770.5
			Avg:		826.6			Avg:		707.4	Avg:	767.0
			Std Dev:		23.512			Std Dev:		10.644	Std Dev:	15.153
	OF2	0	2	95	885.0	HF1	0	2	95	973.0		929.0
				96	822.0				96	946.0		884.0
				97	851.0				97	926.0		888.5
				98	839.0				98	939.0		889.0
				99	867.0				99	954.0		910.5
			Avg:		852.8			Avg:		947.6	Avg:	900.2
			Std Dev:		24.397			Std Dev:		17.530	Std Dev:	19.107
	OF2	90	1	95	787.0	HF1	90	1	95	859.0		823.0
				96	785.0				96	890.0		837.5
				97	807.0				97	859.0		833.0
				98	809.0				98	825.0		817.0
				99	809.0				99	888.0		848.5
			Avg:		799.4			Avg:		864.2	Avg:	831.8
			Std Dev:		12.280			Std Dev:		26.565	Std Dev:	12.342
	OF2	90	2	95	852.0	HF1	90	2	95	863.0		857.5
				96	842.0				96	834.0		838.0
				97	820.0				97	804.0		812.0
				98	851.0				98	834.0		842.5
				99	866.0				99	892.0		879.0
			Avg:		846.2			Avg:		845.4	Avg:	845.8
			Std Dev:		16.976			Std Dev:		33.374	Std Dev:	24.765

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	926.0	HF2	0	1	95	904.0		915.0
				96	975.0				96	950.0		962.5
				97	929.0				97	936.0		932.5
				98	1035.0				98	989.0		1012.0
				99	1008.0				99	975.0		991.5
			Avg:		974.6			Avg:		950.8	Avg:	962.7
			Std Dev:		47.972			Std Dev:		33.372	Std Dev:	40.148
	OF1	0	2	95	1163.0	HF2	0	2	95	1011.0		1087.0
				96	1118.0				96	999.0		1058.5
				97	1157.0				97	999.0		1078.0
				98	1047.0				98	1019.0		1033.0
				99	1096.0				99	1042.0		1069.0
			Avg:		1116.2			Avg:		1014.0	Avg:	1065.1
			Std Dev:		47.578			Std Dev:		17.804	Std Dev:	20.828
	OF1	90	1	95	1068.0	HF2	90	1	95	1083.0		1075.5
				96	1042.0				96	1042.0		1042.0
				97	1085.0				97	1062.0		1073.5
				98	1102.0				98	1024.0		1063.0
				99	953.0				99	963.0		958.0
			Avg:		1050.0			Avg:		1034.8	Avg:	1042.4
			Std Dev:		58.579			Std Dev:		45.790	Std Dev:	49.017
	OF1	90	2	95	918.0	HF2	90	2	95	1321.0		1119.5
				96	1017.0				96	1316.0		1166.5
				97	960.0				97	1278.0		1119.0
				98	821.0				98	995.0		908.0
				99	939.0				99	1056.0		997.5
			Avg:		931.0			Avg:		1193.2	Avg:	1062.1
			Std Dev:		71.711			Std Dev:		155.492	Std Dev:	106.480
C	OF2	0	1	95	879.0	HF1	0	1	95	1368.0		1123.5
				96	1053.0				96	1422.0		1237.5
				97	988.0				97	1289.0		1138.5
				98	1011.0				98	1337.0		1174.0
				99	1017.0				99	1337.0		1177.0
			Avg:		989.6			Avg:		1350.6	Avg:	1170.1
			Std Dev:		66.074			Std Dev:		48.901	Std Dev:	44.090
	OF2	0	2	95	791.0	HF1	0	2	95	1140.0		965.5
				96	956.0				96	1201.0		1078.5
				97	905.0				97	1155.0		1030.0
				98	1104.0				98	1400.0		1252.0
				99	1006.0				99	1304.0		1155.0
			Avg:		952.4			Avg:		1240.0	Avg:	1096.2
			Std Dev:		116.367			Std Dev:		110.048	Std Dev:	111.253
	OF2	90	1	95	1133.0	HF1	90	1	95	656.0		894.5
				96	1060.0				96	647.0		853.5
				97	1074.0				97	614.0		844.0
				98	1157.0				98	656.0		906.5
				99	1196.0				99	629.0		912.5
			Avg:		1124.0			Avg:		640.4	Avg:	882.2
			Std Dev:		56.899			Std Dev:		18.420	Std Dev:	31.396
	OF2	90	2	95	947.0	HF1	90	2	95	656.0		801.5
				96	890.0				96	625.0		757.5
				97	916.0				97	708.0		812.0
				98	995.0				98	645.0		820.0
				99	1106.0				99	708.0		907.0
			Avg:		970.8			Avg:		668.4	Avg:	819.6
			Std Dev:		85.092			Std Dev:		37.819	Std Dev:	54.499

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	1170.0	HF2	0	1	95	798.0		984.0
				96	1121.0				96	789.0		955.0
				97	1063.0				97	812.0		937.5
				98	1111.0				98	800.0		955.5
				99	1104.0				99	815.0		959.5
			Avg:		1113.8			Avg:		802.8	Avg:	958.3
			Std Dev:		38.389			Std Dev:		10.663	Std Dev:	16.683
	OF1	0	2	95	1218.0	HF2	0	2	95	831.0		1024.5
				96	1205.0				96	854.0		1029.5
				97	1294.0				97	866.0		1080.0
				98	1234.0				98	834.0		1034.0
				99	1224.0				99	792.0		1008.0
			Avg:		1235.0			Avg:		835.4	Avg:	1035.2
			Std Dev:		34.612			Std Dev:		28.228	Std Dev:	26.904
	OF1	90	1	95	813.0	HF2	90	1	95	739.0		776.0
				96	812.0				96	733.0		772.5
				97	803.0				97	739.0		771.0
				98	798.0				98	740.0		769.0
				99	791.0				99	757.0		774.0
			Avg:		803.4			Avg:		741.6	Avg:	772.5
			Std Dev:		9.343			Std Dev:		9.044	Std Dev:	2.693
	OF1	90	2	95	873.0	HF2	90	2	95	776.0		824.5
				96	844.0				96	751.0		797.5
				97	833.0				97	716.0		774.5
				98	854.0				98	735.0		794.5
				99	857.0				99	725.0		791.0
			Avg:		852.2			Avg:		740.6	Avg:	796.4
			Std Dev:		14.957			Std Dev:		23.671	Std Dev:	18.050
C	OF2	0	1	95	853.0	HF1	0	1	95	978.0		915.5
				96	832.0				96	1001.0		916.5
				97	835.0				97	1034.0		934.5
				98	806.0				98	997.0		901.5
				99	823.0				99	1072.0		947.5
			Avg:		829.8			Avg:		1016.4	Avg:	923.1
			Std Dev:		17.196			Std Dev:		37.045	Std Dev:	17.981
	OF2	0	2	95	1000.0	HF1	0	2	95	1148.0		1074.0
				96	931.0				96	1139.0		1035.0
				97	903.0				97	1120.0		1011.5
				98	811.0				98	1020.0		915.5
				99	837.0				99	1067.0		952.0
			Avg:		896.4			Avg:		1098.8	Avg:	997.6
			Std Dev:		75.490			Std Dev:		54.099	Std Dev:	63.735
	OF2	90	1	95	1073.0	HF1	90	1	95	769.0		921.0
				96	1024.0				96	692.0		858.0
				97	971.0				97	724.0		847.5
				98	1001.0				98	756.0		878.5
				99	1055.0				99	721.0		888.0
			Avg:		1024.8			Avg:		732.4	Avg:	878.6
			Std Dev:		40.917			Std Dev:		30.534	Std Dev:	28.626
	OF2	90	2	95	970.0	HF1	90	2	95	695.0		832.5
				96	1034.0				96	724.0		879.0
				97	1066.0				97	686.0		876.0
				98	1077.0				98	701.0		889.0
				99	1145.0				99	708.0		926.5
			Avg:		1058.4			Avg:		702.8	Avg:	880.6
			Std Dev:		63.862			Std Dev:		14.342	Std Dev:	33.596

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Mr Avg (Ksi)
C	OF1	0	1	95	1084.0	HF2	0	1	95	622.0	853.0
				96	1003.0				96	579.0	791.0
				97	929.0				97	573.0	751.0
				98	953.0				98	577.0	765.0
				99	948.0				99	587.0	767.5
				Avg:	983.4				Avg:	587.6	Avg: 785.5
				Std Dev:	62.532				Std Dev:	19.895	Std Dev: 40.376
	OF1	0	2	95	1096.0	HF2	0	2	95	757.0	926.5
				96	1169.0				96	740.0	954.5
				97	946.0				97	752.0	849.0
				98	955.0				98	763.0	859.0
				99	897.0				99	746.0	821.5
				Avg:	1012.6				Avg:	751.6	Avg: 882.1
				Std Dev:	114.601				Std Dev:	9.017	Std Dev: 55.935
	OF1	90	1	95	744.0	HF2	90	1	95	1362.0	1053.0
				96	760.0				96	1341.0	1050.5
				97	717.0				97	1269.0	993.0
				98	718.0				98	1327.0	1022.5
				99	715.0				99	1329.0	1022.0
				Avg:	730.8				Avg:	1325.6	Avg: 1028.2
				Std Dev:	20.192				Std Dev:	34.566	Std Dev: 24.608
	OF1	90	2	95	770.0	HF2	90	2	95	1324.0	1047.0
				96	747.0				96	1442.0	1094.5
				97	736.0				97	1333.0	1034.5
				98	730.0				98	1226.0	978.0
				99	706.0				99	1377.0	1041.5
				Avg:	737.8				Avg:	1340.4	Avg: 1039.1
				Std Dev:	23.435				Std Dev:	79.173	Std Dev: 41.508
C	OF2	0	1	95	775.0	HF1	0	1	95	965.0	870.0
				96	825.0				96	977.0	901.0
				97	816.0				97	988.0	902.0
				98	789.0				98	937.0	863.0
				99	831.0				99	1008.0	919.5
				Avg:	807.2				Avg:	975.0	Avg: 891.1
				Std Dev:	24.129				Std Dev:	26.486	Std Dev: 23.760
	OF2	0	2	95	834.0	HF1	0	2	95	1080.0	957.0
				96	835.0				96	1078.0	956.5
				97	782.0				97	1079.0	930.5
				98	803.0				98	1037.0	920.0
				99	823.0				99	1091.0	957.0
				Avg:	815.4				Avg:	1073.0	Avg: 944.2
				Std Dev:	22.678				Std Dev:	20.797	Std Dev: 17.694
	OF2	90	1	95	1033.0	HF1	90	1	95	1124.0	1078.5
				96	1064.0				96	1128.0	1096.0
				97	1025.0				97	1153.0	1089.0
				98	1046.0				98	1166.0	1106.0
				99	1033.0				99	1140.0	1086.5
				Avg:	1040.2				Avg:	1142.2	Avg: 1091.2
				Std Dev:	15.287				Std Dev:	17.470	Std Dev: 10.372
	OF2	90	2	95	1055.0	HF1	90	2	95	1112.0	1083.5
				96	1111.0				96	1243.0	1177.0
				97	1160.0				97	1172.0	1166.0
				98	998.0				98	1111.0	1054.5
				99	1098.0				99	1198.0	1148.0
				Avg:	1084.4				Avg:	1167.2	Avg: 1125.8
				Std Dev:	61.109				Std Dev:	56.839	Std Dev: 53.859

Annex 3

NCHRP 1-28A Project

Diametral Test Results

Mr Instantaneous

37.5 mm
4 inch Dia.

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1397.0	HF2	0	1	95	1584.0		1490.5
				96	1547.0				96	1657.0		1602.0
				97	1449.0				97	1474.0		1461.5
				98	1420.0				98	1349.0		1384.5
				99	1614.0				99	1436.0		1525.0
			Avg:		1485.4			Avg:		1500.0	Avg:	1492.7
			Std Dev:		91.855			Std Dev:		121.735	Std Dev:	80.118
	OF1	0	2	95	1592.0	HF2	0	2	95	1513.0		1552.5
				96	1698.0				96	1499.0		1598.5
				97	1408.0				97	1455.0		1431.5
				98	2022.0				98	1426.0		1724.0
				99	1492.0				99	1591.0		1541.5
			Avg:		1642.4			Avg:		1496.8	Avg:	1569.6
			Std Dev:		238.375			Std Dev:		63.049	Std Dev:	105.863
	OF1	90	1	95	702.0	HF2	90	1	95	654.0		678.0
				96	699.0				96	643.0		671.0
				97	622.0				97	597.0		609.5
				98	698.0				98	559.0		628.5
				99	725.0				99	670.0		697.5
			Avg:		689.2			Avg:		624.6	Avg:	656.9
			Std Dev:		39.162			Std Dev:		45.632	Std Dev:	36.557
	OF1	90	2	95	812.0	HF2	90	2	95	578.0		695.0
				96	743.0				96	615.0		679.0
				97	759.0				97	596.0		677.5
				98	846.0				98	594.0		720.0
				99	839.0				99	646.0		742.5
			Avg:		799.8			Avg:		605.8	Avg:	702.8
			Std Dev:		46.666			Std Dev:		26.023	Std Dev:	28.015
A	OF2	0	1	95	1250.0	HF1	0	1	95	929.0		1089.5
				96	1200.0				96	923.0		1061.5
				97	1641.0				97	1020.0		1330.5
				98	1374.0				98	929.0		1151.5
				99	1368.0				99	972.0		1170.0
			Avg:		1366.6			Avg:		954.6	Avg:	1160.6
			Std Dev:		170.809			Std Dev:		41.501	Std Dev:	104.777
	OF2	0	2	95	1474.0	HF1	0	2	95	1129.0		1301.5
				96	1607.0				96	1173.0		1390.0
				97	1619.0				97	1148.0		1383.5
				98	1445.0				98	1287.0		1366.0
				99	1424.0				99	1019.0		1221.5
			Avg:		1513.8			Avg:		1151.2	Avg:	1332.5
			Std Dev:		92.378			Std Dev:		96.043	Std Dev:	71.259
	OF2	90	1	95	641.0	HF1	90	1	95	702.0		671.5
				96	664.0				96	743.0		703.5
				97	624.0				97	701.0		662.5
				98	664.0				98	755.0		709.5
				99	599.0				99	756.0		677.5
			Avg:		638.4			Avg:		731.4	Avg:	684.9
			Std Dev:		27.736			Std Dev:		27.772	Std Dev:	20.538
	OF2	90	2	95	587.0	HF1	90	2	95	665.0		626.0
				96	624.0				96	721.0		672.5
				97	600.0				97	653.0		626.5
				98	592.0				98	671.0		631.5
				99	567.0				99	642.0		604.5
			Avg:		594.0			Avg:		670.4	Avg:	632.2
			Std Dev:		20.724			Std Dev:		30.411	Std Dev:	24.813

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	659.0	HF2	0	1	95	2927.0		1793.0
				96	662.0				96	2692.0		1677.0
				97	636.0				97	2848.0		1742.0
				98	615.0				98	2556.0		1585.5
				99	635.0				99	2211.0		1423.0
			Avg:		641.4			Avg:		2646.8	Avg:	1644.1
			Std Dev:		19.373			Std Dev:		282.490	Std Dev:	145.909
	OF1	0	2	95	652.0	HF2	0	2	95	2720.0		1686.0
				96	689.0				96	2595.0		1642.0
				97	676.0				97	2802.0		1739.0
				98	666.0				98	2445.0		1555.5
				99	699.0				99	2318.0		1508.5
			Avg:		676.4			Avg:		2576.0	Avg:	1626.2
			Std Dev:		18.528			Std Dev:		197.420	Std Dev:	94.076
	OF1	90	1	95	769.0	HF2	90	1	95	782.0		775.5
				96	692.0				96	765.0		728.5
				97	671.0				97	762.0		716.5
				98	679.0				98	763.0		721.0
				99	706.0				99	762.0		734.0
			Avg:		703.4			Avg:		766.8	Avg:	735.1
			Std Dev:		39.004			Std Dev:		8.585	Std Dev:	23.567
	OF1	90	2	95	652.0	HF2	90	2	95	867.0		759.5
				96	658.0				96	857.0		757.5
				97	655.0				97	875.0		765.0
				98	641.0				98	846.0		743.5
				99	624.0				99	840.0		732.0
			Avg:		646.0			Avg:		857.0	Avg:	751.5
			Std Dev:		13.874			Std Dev:		14.440	Std Dev:	13.477
A	OF2	0	1	95	1702.0	HF1	0	1	95	482.0		1092.0
				96	1797.0				96	493.0		1145.0
				97	1927.0				97	488.0		1207.5
				98	1879.0				98	472.0		1175.5
				99	1893.0				99	471.0		1182.0
			Avg:		1839.6			Avg:		481.2	Avg:	1160.4
			Std Dev:		90.542			Std Dev:		9.680	Std Dev:	44.240
	OF2	0	2	95	1986.0	HF1	0	2	95	540.0		1263.0
				96	2200.0				96	522.0		1361.0
				97	2635.0				97	509.0		1572.0
				98	2536.0				98	525.0		1530.5
				99	2638.0				99	524.0		1581.0
			Avg:		2399.0			Avg:		524.0	Avg:	1461.5
			Std Dev:		292.300			Std Dev:		11.023	Std Dev:	142.086
	OF2	90	1	95	704.0	HF1	90	1	95	635.0		669.5
				96	694.0				96	651.0		672.5
				97	723.0				97	653.0		688.0
				98	728.0				98	629.0		678.5
				99	734.0				99	637.0		685.5
			Avg:		716.6			Avg:		641.0	Avg:	678.8
			Std Dev:		16.906			Std Dev:		10.488	Std Dev:	7.997
	OF2	90	2	95	686.0	HF1	90	2	95	653.0		669.5
				96	723.0				96	699.0		711.0
				97	729.0				97	698.0		713.5
				98	737.0				98	680.0		708.5
				99	750.0				99	710.0		730.0
			Avg:		725.0			Avg:		688.0	Avg:	706.5
			Std Dev:		24.031			Std Dev:		22.327	Std Dev:	22.330

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1030.0	HF2	0	1	95	2562.0		1796.0
				96	1057.0				96	2536.0		1796.5
				97	1002.0				97	2444.0		1723.0
				98	1011.0				98	2361.0		1686.0
				99	984.0				99	2098.0		1541.0
			Avg:		1016.8			Avg:		2400.2	Avg:	1708.5
			Std Dev:		27.923			Std Dev:		186.682	Std Dev:	105.087
	OF1	0	2	95	1154.0	HF2	0	2	95	1488.0		1321.0
				96	1132.0				96	1498.0		1315.0
				97	1128.0				97	1519.0		1323.5
				98	1160.0				98	1543.0		1351.5
				99	1121.0				99	1574.0		1347.5
			Avg:		1139.0			Avg:		1524.4	Avg:	1331.7
			Std Dev:		17.029			Std Dev:		34.847	Std Dev:	16.600
	OF1	90	1	95	1379.0	HF2	90	1	95	640.0		1009.5
				96	1470.0				96	645.0		1057.5
				97	1529.0				97	649.0		1089.0
				98	1375.0				98	626.0		1000.5
				99	1554.0				99	636.0		1095.0
			Avg:		1461.4			Avg:		639.2	Avg:	1050.3
			Std Dev:		82.875			Std Dev:		8.871	Std Dev:	43.853
	OF1	90	2	95	1387.0	HF2	90	2	95	588.0		987.5
				96	1458.0				96	566.0		1012.0
				97	1468.0				97	575.0		1021.5
				98	1482.0				98	608.0		1045.0
				99	1624.0				99	864.0		1244.0
			Avg:		1483.8			Avg:		640.2	Avg:	1062.0
			Std Dev:		86.523			Std Dev:		126.100	Std Dev:	103.807
A	OF2	0	1	95	2073.0	HF1	0	1	95	947.0		1510.0
				96	1901.0				96	912.0		1406.5
				97	1851.0				97	898.0		1374.5
				98	1958.0				98	935.0		1446.5
				99	1810.0				99	913.0		1361.5
			Avg:		1918.6			Avg:		921.0	Avg:	1419.8
			Std Dev:		102.549			Std Dev:		19.660	Std Dev:	60.160
	OF2	0	2	95	1531.0	HF1	0	2	95	954.0		1242.5
				96	1523.0				96	932.0		1227.5
				97	1467.0				97	958.0		1212.5
				98	1604.0				98	953.0		1278.5
				99	1609.0				99	952.0		1280.5
			Avg:		1546.8			Avg:		949.8	Avg:	1248.3
			Std Dev:		59.843			Std Dev:		10.208	Std Dev:	30.401
	OF2	90	1	95	482.0	HF1	90	1	95	1249.0		865.5
				96	485.0				96	1239.0		862.0
				97	471.0				97	1208.0		839.5
				98	476.0				98	1196.0		836.0
				99	479.0				99	1209.0		844.0
			Avg:		478.6			Avg:		1220.2	Avg:	849.4
			Std Dev:		5.413			Std Dev:		22.599	Std Dev:	13.460
	OF2	90	2	95	371.0	HF1	90	2	95	972.0		671.5
				96	377.0				96	1026.0		701.5
				97	379.0				97	1057.0		718.0
				98	386.0				98	1020.0		703.0
				99	398.0				99	1079.0		738.5
			Avg:		382.2			Avg:		1030.8	Avg:	706.5
			Std Dev:		10.330			Std Dev:		40.641	Std Dev:	24.589

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	831.0	HF2	0	1	95	1915.0		1373.0
				96	927.0				96	2052.0		1489.5
				97	934.0				97	1905.0		1419.5
				98	940.0				98	1923.0		1431.5
				99	939.0				99	1819.0		1379.0
				Avg:	914.2				Avg:	1922.8	Avg:	1418.5
				Std Dev:	46.794				Std Dev:	83.434	Std Dev:	47.015
	OF1	0	2	95	1002.0	HF2	0	2	95	2248.0		1625.0
				96	891.0				96	1878.0		1384.5
				97	948.0				97	1676.0		1312.0
				98	914.0				98	2018.0		1466.0
				99	963.0				99	1913.0		1438.0
				Avg:	943.6				Avg:	1946.6	Avg:	1445.1
				Std Dev:	43.154				Std Dev:	209.165	Std Dev:	116.447
	OF1	90	1	95	2519.0	HF2	90	1	95	8230.0		5374.5
				96	3846.0				96	6578.0		5212.0
				97	5165.0				97	5045.0		5105.0
				98	3204.0				98	4801.0		4002.5
				99	2519.0				99	3578.0		3048.5
				Avg:	3450.6				Avg:	5646.4	Avg:	4548.5
				Std Dev:	1105.902				Std Dev:	1795.657	Std Dev:	997.537
	OF1	90	2	95	2707.0	HF2	90	2	95	4118.0		3412.5
				96	3301.0				96	4229.0		3765.0
				97	3594.0				97	5832.0		4713.0
				98	3949.0				98	10706.0		7327.5
				99	3491.0				99	9185.0		6338.0
				Avg:	3408.4				Avg:	6814.0	Avg:	5111.2
				Std Dev:	457.443				Std Dev:	2986.816	Std Dev:	1678.796
B	OF2	0	1	95	1642.0	HF1	0	1	95	993.0		1317.5
				96	1710.0				96	1030.0		1370.0
				97	2178.0				97	981.0		1579.5
				98	1857.0				98	1007.0		1432.0
				99	1607.0				99	1039.0		1323.0
				Avg:	1798.8				Avg:	1010.0	Avg:	1404.4
				Std Dev:	232.615				Std Dev:	24.393	Std Dev:	108.147
	OF2	0	2	95	1674.0	HF1	0	2	95	1166.0		1420.0
				96	1379.0				96	1064.0		1221.5
				97	1503.0				97	1223.0		1363.0
				98	1837.0				98	1101.0		1469.0
				99	2246.0				99	1280.0		1763.0
				Avg:	1727.8				Avg:	1166.8	Avg:	1447.3
				Std Dev:	337.471				Std Dev:	87.850	Std Dev:	199.358
	OF2	90	1	95	3840.0	HF1	90	1	95	3353.0		3596.5
				96	4175.0				96	3131.0		3653.0
				97	6874.0				97	2806.0		4840.0
				98	4899.0				98	1907.0		3403.0
				99	3620.0				99	2882.0		3251.0
				Avg:	4681.6				Avg:	2815.8	Avg:	3748.7
				Std Dev:	1317.745				Std Dev:	551.890	Std Dev:	630.570
	OF2	90	2	95	4808.0	HF1	90	2	95	3912.0		4360.0
				96	4180.0				96	3539.0		3859.5
				97	5674.0				97	3155.0		4414.5
				98	3297.0				98	3787.0		3542.0
				99	3987.0				99	4129.0		4058.0
				Avg:	4389.2				Avg:	3704.4	Avg:	4046.8
				Std Dev:	897.849				Std Dev:	373.966	Std Dev:	361.707

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1347.0	HF2	0	1	95	1200.0		1273.5
				96	1400.0				96	1225.0		1312.5
				97	1341.0				97	1280.0		1310.5
				98	1253.0				98	1138.0		1195.5
				99	1334.0				99	1213.0		1273.5
				Avg:	1335.0				Avg:	1211.2	Avg:	1273.1
				Std Dev:	52.749				Std Dev:	51.017	Std Dev:	47.363
	OF1	0	2	95	1350.0	HF2	0	2	95	1320.0		1335.0
				96	1376.0				96	1280.0		1328.0
				97	1388.0				97	1278.0		1333.0
				98	1428.0				98	1279.0		1353.5
				99	1335.0				99	1229.0		1282.0
				Avg:	1375.4				Avg:	1277.2	Avg:	1326.3
				Std Dev:	36.067				Std Dev:	32.275	Std Dev:	26.579
	OF1	90	1	95	1354.0	HF2	90	1	95	1226.0		1290.0
				96	1393.0				96	1133.0		1263.0
				97	1473.0				97	1143.0		1308.0
				98	1381.0				98	1132.0		1256.5
				99	1389.0				99	1148.0		1268.5
				Avg:	1398.0				Avg:	1156.4	Avg:	1277.2
				Std Dev:	44.598				Std Dev:	39.488	Std Dev:	21.321
	OF1	90	2	95	1366.0	HF2	90	2	95	1033.0		1199.5
				96	1501.0				96	1048.0		1274.5
				97	1549.0				97	1050.0		1299.5
				98	1332.0				98	1070.0		1201.0
				99	1428.0				99	1077.0		1252.5
				Avg:	1435.2				Avg:	1055.6	Avg:	1245.4
				Std Dev:	90.514				Std Dev:	17.785	Std Dev:	44.447
B	OF2	0	1	95	1262.0	HF1	0	1	95	1467.0		1364.5
				96	1230.0				96	1436.0		1333.0
				97	1208.0				97	1405.0		1306.5
				98	1189.0				98	1445.0		1317.0
				99	1251.0				99	1366.0		1308.5
				Avg:	1228.0				Avg:	1423.8	Avg:	1325.9
				Std Dev:	30.042				Std Dev:	39.239	Std Dev:	23.972
	OF2	0	2	95	1411.0	HF1	0	2	95	1366.0		1388.5
				96	1491.0				96	1420.0		1455.5
				97	1397.0				97	1392.0		1394.5
				98	1227.0				98	1453.0		1340.0
				99	1335.0				99	1523.0		1429.0
				Avg:	1372.2				Avg:	1430.8	Avg:	1401.5
				Std Dev:	98.363				Std Dev:	60.858	Std Dev:	43.796
	OF2	90	1	95	832.0	HF1	90	1	95	2214.0		1523.0
				96	806.0				96	2338.0		1572.0
				97	787.0				97	2609.0		1698.0
				98	821.0				98	2698.0		1759.5
				99	791.0				99	2305.0		1548.0
				Avg:	807.4				Avg:	2432.8	Avg:	1620.1
				Std Dev:	19.217				Std Dev:	208.908	Std Dev:	103.006
	OF2	90	2	95	893.0	HF1	90	2	95	2363.0		1628.0
				96	934.0				96	1992.0		1463.0
				97	871.0				97	2145.0		1508.0
				98	914.0				98	2296.0		1605.0
				99	931.0				99	2571.0		1751.0
				Avg:	908.6				Avg:	2273.4	Avg:	1591.0
				Std Dev:	26.614				Std Dev:	219.532	Std Dev:	112.292

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1281.0	HF2	0	1	95	1006.0		1143.5
				96	1297.0				96	1000.0		1148.5
				97	1288.0				97	976.0		1132.0
				98	1265.0				98	991.0		1128.0
				99	1254.0				99	1046.0		1150.0
			Avg:		1277.0			Avg:		1003.8	Avg:	1140.4
			Std Dev:		17.393			Std Dev:		26.157	Std Dev:	9.896
	OF1	0	2	95	1257.0	HF2	0	2	95	987.0		1122.0
				96	1259.0				96	1022.0		1140.5
				97	1184.0				97	989.0		1086.5
				98	1246.0				98	1010.0		1128.0
				99	1257.0				99	1032.0		1144.5
			Avg:		1240.6			Avg:		1008.0	Avg:	1124.3
			Std Dev:		32.052			Std Dev:		19.862	Std Dev:	23.012
	OF1	90	1	95	1150.0	HF2	90	1	95	1477.0		1313.5
				96	1103.0				96	1455.0		1279.0
				97	1098.0				97	1516.0		1307.0
				98	1065.0				98	1512.0		1288.5
				99	1132.0				99	1560.0		1346.0
			Avg:		1109.6			Avg:		1504.0	Avg:	1306.8
			Std Dev:		32.792			Std Dev:		40.231	Std Dev:	25.929
	OF1	90	2	95	1119.0	HF2	90	2	95	1481.0		1300.0
				96	1128.0				96	1558.0		1343.0
				97	1103.0				97	1575.0		1339.0
				98	1120.0				98	1707.0		1413.5
				99	1080.0				99	1612.0		1346.0
			Avg:		1110.0			Avg:		1586.6	Avg:	1348.3
			Std Dev:		19.066			Std Dev:		82.531	Std Dev:	40.938
B	OF2	0	1	95	1001.0	HF1	0	1	95	944.0		972.5
				96	1045.0				96	953.0		999.0
				97	974.0				97	930.0		952.0
				98	1022.0				98	1010.0		1016.0
				99	970.0				99	942.0		956.0
			Avg:		1002.4			Avg:		955.8	Avg:	979.1
			Std Dev:		31.848			Std Dev:		31.388	Std Dev:	27.700
	OF2	0	2	95	901.0	HF1	0	2	95	1107.0		1004.0
				96	900.0				96	1131.0		1015.5
				97	857.0				97	1097.0		977.0
				98	884.0				98	1082.0		983.0
				99	938.0				99	1105.0		1021.5
			Avg:		896.0			Avg:		1104.4	Avg:	1000.2
			Std Dev:		29.453			Std Dev:		17.827	Std Dev:	19.598
	OF2	90	1	95	1177.0	HF1	90	1	95	1354.0		1265.5
				96	1088.0				96	1240.0		1164.0
				97	1052.0				97	1222.0		1137.0
				98	1124.0				98	1298.0		1211.0
				99	1179.0				99	1295.0		1237.0
			Avg:		1124.0			Avg:		1281.8	Avg:	1202.9
			Std Dev:		55.484			Std Dev:		52.376	Std Dev:	52.448
	OF2	90	2	95	1380.0	HF1	90	2	95	1181.0		1280.5
				96	1385.0				96	1166.0		1275.5
				97	1351.0				97	1153.0		1252.0
				98	1331.0				98	1177.0		1254.0
				99	1341.0				99	1200.0		1270.5
			Avg:		1357.6			Avg:		1175.4	Avg:	1266.5
			Std Dev:		23.870			Std Dev:		17.530	Std Dev:	12.840

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	3857.0	HF2	0	1	95	1339.0		2598.0
				96	6147.0				96	1252.0		3699.5
				97	6321.0				97	1536.0		3928.5
				98	6609.0				98	1303.0		3956.0
				99	4946.0				99	1432.0		3189.0
				Avg:	5576.0				Avg:	1372.4	Avg:	3474.2
				Std Dev:	1151.088				Std Dev:	112.633	Std Dev:	578.434
	OF1	0	2	95	3209.0	HF2	0	2	95	1677.0		2443.0
				96	1029.0				96	1360.0		1194.5
				97	5697.0				97	1515.0		3606.0
				98	11232.0				98	1443.0		6337.5
				99	7354.0				99	1535.0		4444.5
				Avg:	5704.2				Avg:	1506.0	Avg:	3605.1
				Std Dev:	3916.694				Std Dev:	117.737	Std Dev:	1957.809
	OF1	90	1	95	611.0	HF2	90	1	95	1010.0		810.5
				96	617.0				96	972.0		794.5
				97	629.0				97	900.0		764.5
				98	646.0				98	1000.0		823.0
				99	608.0				99	988.0		798.0
				Avg:	622.2				Avg:	974.0	Avg:	798.1
				Std Dev:	15.547				Std Dev:	43.726	Std Dev:	21.884
	OF1	90	2	95	659.0	HF2	90	2	95	909.0		784.0
				96	636.0				96	931.0		783.5
				97	590.0				97	933.0		761.5
				98	631.0				98	926.0		778.5
				99	582.0				99	1044.0		813.0
				Avg:	619.6				Avg:	948.6	Avg:	784.1
				Std Dev:	32.562				Std Dev:	54.160	Std Dev:	18.559
C	OF2	0	1	95	1900.0	HF1	0	1	95	2142.0		2021.0
				96	1869.0				96	1888.0		1878.5
				97	1634.0				97	1942.0		1788.0
				98	1438.0				98	1974.0		1706.0
				99	1578.0				99	2192.0		1885.0
				Avg:	1683.8				Avg:	2027.6	Avg:	1855.7
				Std Dev:	196.935				Std Dev:	132.101	Std Dev:	118.000
	OF2	0	2	95	1824.0	HF1	0	2	95	2323.0		2073.5
				96	2530.0				96	1732.0		2131.0
				97	2162.0				97	2106.0		2134.0
				98	1996.0				98	2069.0		2032.5
				99	1758.0				99	2194.0		1976.0
				Avg:	2054.0				Avg:	2084.8	Avg:	2069.4
				Std Dev:	309.079				Std Dev:	220.131	Std Dev:	67.212
	OF2	90	1	95	1050.0	HF1	90	1	95	516.0		783.0
				96	1123.0				96	522.0		822.5
				97	1006.0				97	482.0		744.0
				98	1000.0				98	507.0		753.5
				99	1215.0				99	530.0		872.5
				Avg:	1078.8				Avg:	511.4	Avg:	795.1
				Std Dev:	90.613				Std Dev:	18.461	Std Dev:	52.985
	OF2	90	2	95	922.0	HF1	90	2	95	527.0		724.5
				96	1063.0				96	546.0		804.5
				97	1096.0				97	532.0		814.0
				98	1062.0				98	513.0		787.5
				99	1004.0				99	537.0		770.5
				Avg:	1029.4				Avg:	531.0	Avg:	780.2
				Std Dev:	68.570				Std Dev:	12.268	Std Dev:	35.294

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	2915.0	HF2	0	1	95	1247.0		2081.0
				96	3011.0				96	1206.0		2108.5
				97	2878.0				97	1118.0		1998.0
				98	2851.0				98	1204.0		2027.5
				99	2759.0				99	1094.0		1926.5
				Avg:	2882.8				Avg:	1173.8	Avg:	2028.3
				Std Dev:	91.968				Std Dev:	64.786	Std Dev:	71.574
	OF1	0	2	95	3039.0	HF2	0	2	95	1165.0		2102.0
				96	3120.0				96	1133.0		2126.5
				97	3005.0				97	1091.0		2048.0
				98	3219.0				98	1109.0		2164.0
				99	3444.0				99	1044.0		2244.0
				Avg:	3165.4				Avg:	1108.4	Avg:	2136.9
				Std Dev:	176.251				Std Dev:	45.440	Std Dev:	73.202
	OF1	90	1	95	1082.0	HF2	90	1	95	1323.0		1202.5
				96	1093.0				96	1379.0		1236.0
				97	1074.0				97	1407.0		1240.5
				98	1048.0				98	1358.0		1203.0
				99	974.0				99	1223.0		1098.5
				Avg:	1054.2				Avg:	1338.0	Avg:	1196.1
				Std Dev:	47.804				Std Dev:	71.225	Std Dev:	57.397
	OF1	90	2	95	1057.0	HF2	90	2	95	1329.0		1193.0
				96	1001.0				96	1246.0		1123.5
				97	956.0				97	1265.0		1110.5
				98	965.0				98	1250.0		1107.5
				99	1012.0				99	1190.0		1101.0
				Avg:	998.2				Avg:	1256.0	Avg:	1127.1
				Std Dev:	40.431				Std Dev:	49.754	Std Dev:	37.738
C	OF2	0	1	95	955.0	HF1	0	1	95	2189.0		1572.0
				96	938.0				96	2171.0		1554.5
				97	1027.0				97	2054.0		1540.5
				98	1028.0				98	1978.0		1503.0
				99	1101.0				99	2323.0		1712.0
				Avg:	1009.8				Avg:	2143.0	Avg:	1576.4
				Std Dev:	65.389				Std Dev:	132.708	Std Dev:	79.942
	OF2	0	2	95	1237.0	HF1	0	2	95	2142.0		1689.5
				96	1070.0				96	1848.0		1459.0
				97	1011.0				97	2045.0		1528.0
				98	986.0				98	2134.0		1560.0
				99	1017.0				99	1757.0		1387.0
				Avg:	1064.2				Avg:	1985.2	Avg:	1524.7
				Std Dev:	101.325				Std Dev:	174.071	Std Dev:	113.681
	OF2	90	1	95	1049.0	HF1	90	1	95	971.0		1010.0
				96	1025.0				96	1029.0		1027.0
				97	1045.0				97	1053.0		1049.0
				98	1126.0				98	1007.0		1066.5
				99	1178.0				99	1019.0		1098.5
				Avg:	1084.6				Avg:	1015.8	Avg:	1050.2
				Std Dev:	64.856				Std Dev:	30.219	Std Dev:	34.476
	OF2	90	2	95	1102.0	HF1	90	2	95	1031.0		1066.5
				96	1196.0				96	1063.0		1129.5
				97	1212.0				97	1056.0		1134.0
				98	1226.0				98	975.0		1100.5
				99	1298.0				99	967.0		1132.5
				Avg:	1206.8				Avg:	1018.4	Avg:	1112.6
				Std Dev:	70.379				Std Dev:	44.964	Std Dev:	29.203

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	3033.0	HF2	0	1	95	1704.0		2368.5
				96	3345.0				96	1728.0		2536.5
				97	3125.0				97	1770.0		2447.5
				98	3172.0				98	1559.0		2365.5
				99	3445.0				99	1609.0		2527.0
			Avg:		3224.0			Avg:		1674.0	Avg:	2449.0
			Std Dev:		167.681			Std Dev:		87.295	Std Dev:	82.455
	OF1	0	2	95	3202.0	HF2	0	2	95	1788.0		2495.0
				96	2916.0				96	1812.0		2364.0
				97	2989.0				97	1746.0		2367.5
				98	3059.0				98	1718.0		2388.5
				99	3075.0				99	1662.0		2368.5
			Avg:		3048.2			Avg:		1745.2	Avg:	2396.7
			Std Dev:		106.619			Std Dev:		59.069	Std Dev:	55.784
	OF1	90	1	95	1121.0	HF2	90	1	95	1418.0		1269.5
				96	1113.0				96	1366.0		1239.5
				97	1124.0				97	1348.0		1236.0
				98	1096.0				98	1397.0		1246.5
				99	1078.0				99	1487.0		1282.5
			Avg:		1106.4			Avg:		1403.2	Avg:	1254.8
			Std Dev:		19.243			Std Dev:		54.108	Std Dev:	20.247
	OF1	90	2	95	1096.0	HF2	90	2	95	1179.0		1137.5
				96	1193.0				96	1307.0		1250.0
				97	1145.0				97	1252.0		1198.5
				98	1159.0				98	1233.0		1196.0
				99	1140.0				99	1259.0		1199.5
			Avg:		1146.6			Avg:		1246.0	Avg:	1196.3
			Std Dev:		35.047			Std Dev:		46.325	Std Dev:	39.863
C	OF2	0	1	95	1036.0	HF1	0	1	95	2101.0		1568.5
				96	1020.0				96	1954.0		1487.0
				97	1040.0				97	1899.0		1469.5
				98	1093.0				98	1929.0		1511.0
				99	1027.0				99	1974.0		1500.5
			Avg:		1043.2			Avg:		1971.4	Avg:	1507.3
			Std Dev:		28.908			Std Dev:		77.694	Std Dev:	37.571
	OF2	0	2	95	1017.0	HF1	0	2	95	1317.0		1167.0
				96	965.0				96	1255.0		1110.0
				97	1027.0				97	1422.0		1224.5
				98	1000.0				98	1408.0		1204.0
				99	988.0				99	1388.0		1188.0
			Avg:		999.4			Avg:		1358.0	Avg:	1178.7
			Std Dev:		24.419			Std Dev:		70.331	Std Dev:	43.820
	OF2	90	1	95	1229.0	HF1	90	1	95	1260.0		1244.5
				96	1284.0				96	1285.0		1284.5
				97	1238.0				97	1212.0		1225.0
				98	1262.0				98	1246.0		1254.0
				99	1243.0				99	1291.0		1267.0
			Avg:		1251.2			Avg:		1258.8	Avg:	1255.0
			Std Dev:		21.948			Std Dev:		31.933	Std Dev:	22.503
	OF2	90	2	95	1352.0	HF1	90	2	95	1213.0		1282.5
				96	1338.0				96	1196.0		1267.0
				97	1405.0				97	1196.0		1300.5
				98	1376.0				98	1190.0		1283.0
				99	1375.0				99	1182.0		1278.5
			Avg:		1369.2			Avg:		1195.4	Avg:	1282.3
			Std Dev:		25.646			Std Dev:		11.393	Std Dev:	12.045

Annex 4

NCHRP 1-28A Project

Diametral Test Results

Mr Instantaneous

12.5 mm
6 inch Dia.

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	829.0	HF2	0	1	95	541.0		685.0
				96	857.0				96	522.0		689.5
				97	898.0				97	541.0		719.5
				98	793.0				98	502.0		647.5
				99	870.0				99	510.0		690.0
			Avg:		849.4			Avg:		523.2	Avg:	686.3
			Std Dev:		40.129			Std Dev:		17.740	Std Dev:	25.658
	OF1	0	2	95	938.0	HF2	0	2	95	534.0		736.0
				96	889.0				96	542.0		715.5
				97	843.0				97	538.0		690.5
				98	816.0				98	539.0		677.5
				99	932.0				99	523.0		727.5
			Avg:		883.6			Avg:		535.2	Avg:	709.4
			Std Dev:		53.734			Std Dev:		7.396	Std Dev:	24.735
	OF1	90	1	95	956.0	HF2	90	1	95	610.0		783.0
				96	881.0				96	659.0		770.0
				97	893.0				97	640.0		766.5
				98	905.0				98	678.0		791.5
				99	926.0				99	613.0		769.5
			Avg:		912.2			Avg:		640.0	Avg:	776.1
			Std Dev:		29.592			Std Dev:		29.300	Std Dev:	10.697
	OF1	90	2	95	863.0	HF2	90	2	95	628.0		745.5
				96	966.0				96	673.0		819.5
				97	948.0				97	687.0		817.5
				98	896.0				98	567.0		731.5
				99	849.0				99	622.0		735.5
			Avg:		904.4			Avg:		635.4	Avg:	769.9
			Std Dev:		51.355			Std Dev:		47.406	Std Dev:	44.663
A	OF2	0	1	95	496.0	HF1	0	1	95	765.0		630.5
				96	471.0				96	785.0		628.0
				97	528.0				97	778.0		653.0
				98	516.0				98	729.0		622.5
				99	500.0				99	750.0		625.0
			Avg:		502.2			Avg:		761.4	Avg:	631.8
			Std Dev:		21.638			Std Dev:		22.501	Std Dev:	12.230
	OF2	0	2	95	513.0	HF1	0	2	95	828.0		670.5
				96	538.0				96	833.0		685.5
				97	541.0				97	790.0		665.5
				98	504.0				98	790.0		647.0
				99	583.0				99	759.0		671.0
			Avg:		535.8			Avg:		800.0	Avg:	667.9
			Std Dev:		30.785			Std Dev:		30.635	Std Dev:	13.863
	OF2	90	1	95	600.0	HF1	90	1	95	1083.0		841.5
				96	629.0				96	1086.0		857.5
				97	655.0				97	979.0		817.0
				98	643.0				98	828.0		735.5
				99	669.0				99	907.0		788.0
			Avg:		639.2			Avg:		976.6	Avg:	807.9
			Std Dev:		26.423			Std Dev:		112.050	Std Dev:	48.243
	OF2	90	2	95	689.0	HF1	90	2	95	862.0		775.5
				96	653.0				96	811.0		732.0
				97	689.0				97	816.0		752.5
				98	660.0				98	883.0		771.5
				99	609.0				99	1005.0		807.0
			Avg:		660.0			Avg:		875.4	Avg:	767.7
			Std Dev:		32.909			Std Dev:		78.596	Std Dev:	27.952

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

<u>*Mr Analysis*</u>

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	675.0	HF2	0	1	95	759.0		717.0
				96	741.0				96	775.0		758.0
				97	703.0				97	805.0		754.0
				98	694.0				98	749.0		721.5
				99	733.0				99	781.0		757.0
				Avg:	709.2				Avg:	773.8	Avg:	741.5
				Std Dev:	27.463				Std Dev:	21.568	Std Dev:	20.427
	OF1	0	2	95	727.0	HF2	0	2	95	853.0		790.0
				96	704.0				96	816.0		760.0
				97	730.0				97	842.0		786.0
				98	747.0				98	869.0		808.0
				99	692.0				99	830.0		761.0
				Avg:	720.0				Avg:	842.0	Avg:	781.0
				Std Dev:	21.897				Std Dev:	20.433	Std Dev:	20.469
	OF1	90	1	95	779.0	HF2	90	1	95	780.0		779.5
				96	754.0				96	764.0		759.0
				97	793.0				97	801.0		797.0
				98	711.0				98	727.0		719.0
				99	702.0				99	715.0		708.5
				Avg:	747.8				Avg:	757.4	Avg:	752.6
				Std Dev:	40.332				Std Dev:	35.976	Std Dev:	38.111
	OF1	90	2	95	728.0	HF2	90	2	95	792.0		760.0
				96	716.0				96	788.0		752.0
				97	747.0				97	793.0		770.0
				98	744.0				98	778.0		761.0
				99	728.0				99	759.0		743.5
				Avg:	732.6				Avg:	782.0	Avg:	757.3
				Std Dev:	12.798				Std Dev:	14.160	Std Dev:	10.010
A	OF2	0	1	95	852.0	HF1	0	1	95	741.0		796.5
				96	861.0				96	729.0		795.0
				97	772.0				97	726.0		749.0
				98	742.0				98	717.0		729.5
				99	832.0				99	725.0		778.5
				Avg:	811.8				Avg:	727.6	Avg:	769.7
				Std Dev:	52.203				Std Dev:	8.706	Std Dev:	29.497
	OF2	0	2	95	889.0	HF1	0	2	95	766.0		827.5
				96	880.0				96	730.0		805.0
				97	838.0				97	751.0		794.5
				98	944.0				98	769.0		856.5
				99	887.0				99	749.0		818.0
				Avg:	887.6				Avg:	753.0	Avg:	820.3
				Std Dev:	37.753				Std Dev:	15.604	Std Dev:	23.808
	OF2	90	1	95	781.0	HF1	90	1	95	787.0		784.0
				96	814.0				96	845.0		829.5
				97	772.0				97	817.0		794.5
				98	771.0				98	764.0		767.5
				99	774.0				99	816.0		795.0
				Avg:	782.4				Avg:	805.8	Avg:	794.1
				Std Dev:	18.091				Std Dev:	31.092	Std Dev:	22.714
	OF2	90	2	95	789.0	HF1	90	2	95	806.0		797.5
				96	816.0				96	831.0		823.5
				97	797.0				97	793.0		795.0
				98	773.0				98	792.0		782.5
				99	824.0				99	841.0		832.5
				Avg:	799.8				Avg:	812.6	Avg:	806.2
				Std Dev:	20.560				Std Dev:	22.345	Std Dev:	20.939

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	790.0	HF2	0	1	95	911.0		850.5
				96	792.0				96	913.0		852.5
				97	782.0				97	903.0		842.5
				98	771.0				98	855.0		813.0
				99	777.0				99	950.0		863.5
			Avg:		782.4			Avg:		906.4	Avg:	844.4
			Std Dev:		8.792			Std Dev:		33.982	Std Dev:	19.087
	OF1	0	2	95	760.0	HF2	0	2	95	920.0		840.0
				96	760.0				96	895.0		827.5
				97	721.0				97	883.0		802.0
				98	767.0				98	886.0		826.5
				99	747.0				99	914.0		830.5
			Avg:		751.0			Avg:		899.6	Avg:	825.3
			Std Dev:		18.262			Std Dev:		16.622	Std Dev:	14.074
	OF1	90	1	95	812.0	HF2	90	1	95	1004.0		908.0
				96	769.0				96	1021.0		895.0
				97	757.0				97	1000.0		878.5
				98	743.0				98	1011.0		877.0
				99	762.0				99	1005.0		883.5
			Avg:		768.6			Avg:		1008.2	Avg:	888.4
			Std Dev:		26.063			Std Dev:		8.167	Std Dev:	13.036
	OF1	90	2	95	716.0	HF2	90	2	95	1159.0		937.5
				96	701.0				96	1144.0		922.5
				97	698.0				97	1100.0		899.0
				98	660.0				98	1056.0		858.0
				99	733.0				99	1136.0		934.5
			Avg:		701.6			Avg:		1119.0	Avg:	910.3
			Std Dev:		27.098			Std Dev:		41.364	Std Dev:	32.929
A	OF2	0	1	95	639.0	HF1	0	1	95	1005.0		822.0
				96	655.0				96	1030.0		842.5
				97	657.0				97	1029.0		843.0
				98	670.0				98	1002.0		836.0
				99	648.0				99	996.0		822.0
			Avg:		653.8			Avg:		1012.4	Avg:	833.1
			Std Dev:		11.476			Std Dev:		15.947	Std Dev:	10.502
	OF2	0	2	95	660.0	HF1	0	2	95	1072.0		866.0
				96	688.0				96	1092.0		890.0
				97	660.0				97	1073.0		866.5
				98	671.0				98	1126.0		898.5
				99	668.0				99	1138.0		903.0
			Avg:		669.4			Avg:		1100.2	Avg:	884.8
			Std Dev:		11.480			Std Dev:		30.401	Std Dev:	17.566
	OF2	90	1	95	809.0	HF1	90	1	95	804.0		806.5
				96	820.0				96	833.0		826.5
				97	824.0				97	814.0		819.0
				98	856.0				98	805.0		830.5
				99	825.0				99	806.0		815.5
			Avg:		826.8			Avg:		812.4	Avg:	819.6
			Std Dev:		17.513			Std Dev:		12.178	Std Dev:	9.423
	OF2	90	2	95	908.0	HF1	90	2	95	894.0		901.0
				96	881.0				96	848.0		864.5
				97	860.0				97	845.0		852.5
				98	878.0				98	905.0		891.5
				99	828.0				99	877.0		852.5
			Avg:		871.0			Avg:		873.8	Avg:	872.4
			Std Dev:		29.530			Std Dev:		26.864	Std Dev:	22.568

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	871.0	HF2	0	1	95	1079.0		975.0
				96	881.0				96	1117.0		999.0
				97	777.0				97	1106.0		941.5
				98	708.0				98	1163.0		935.5
				99	885.0				99	1324.0		1104.5
			Avg:		824.4			Avg:		1157.8	Avg:	991.1
			Std Dev:		78.809			Std Dev:		97.733	Std Dev:	68.434
	OF1	0	2	95	745.0	HF2	0	2	95	1314.0		1029.5
				96	835.0				96	1192.0		1013.5
				97	786.0				97	1215.0		1000.5
				98	841.0				98	1027.0		934.0
				99	789.0				99	1148.0		968.5
			Avg:		799.2			Avg:		1179.2	Avg:	989.2
			Std Dev:		39.512			Std Dev:		104.588	Std Dev:	38.137
	OF1	90	1	95	863.0	HF2	90	1	95	887.0		875.0
				96	783.0				96	1083.0		933.0
				97	740.0				97	1054.0		897.0
				98	712.0				98	800.0		756.0
				99	887.0				99	960.0		923.5
			Avg:		797.0			Avg:		956.8	Avg:	876.9
			Std Dev:		76.036			Std Dev:		117.093	Std Dev:	71.315
	OF1	90	2	95	718.0	HF2	90	2	95	872.0		795.0
				96	721.0				96	989.0		855.0
				97	626.0				97	834.0		730.0
				98	644.0				98	868.0		756.0
				99	783.0				99	996.0		889.5
			Avg:		698.4			Avg:		911.8	Avg:	805.1
			Std Dev:		63.744			Std Dev:		75.174	Std Dev:	66.645
B	OF2	0	1	95	950.0	HF1	0	1	95	776.0		863.0
				96	862.0				96	973.0		917.5
				97	915.0				97	971.0		943.0
				98	817.0				98	971.0		894.0
				99	924.0				99	753.0		838.5
			Avg:		893.6			Avg:		888.8	Avg:	891.2
			Std Dev:		53.454			Std Dev:		113.764	Std Dev:	41.699
	OF2	0	2	95	813.0	HF1	0	2	95	883.0		848.0
				96	877.0				96	806.0		841.5
				97	970.0				97	857.0		913.5
				98	1054.0				98	835.0		944.5
				99	944.0				99	982.0		963.0
			Avg:		931.6			Avg:		872.6	Avg:	902.1
			Std Dev:		91.729			Std Dev:		67.397	Std Dev:	55.308
	OF2	90	1	95	979.0	HF1	90	1	95	651.0		815.0
				96	938.0				96	647.0		792.5
				97	933.0				97	690.0		811.5
				98	862.0				98	780.0		821.0
				99	897.0				99	761.0		829.0
			Avg:		921.8			Avg:		705.8	Avg:	813.8
			Std Dev:		44.302			Std Dev:		61.771	Std Dev:	13.632
	OF2	90	2	95	937.0	HF1	90	2	95	904.0		920.5
				96	910.0				96	918.0		914.0
				97	942.0				97	705.0		823.5
				98	986.0				98	731.0		858.5
				99	954.0				99	723.0		838.5
			Avg:		945.8			Avg:		796.2	Avg:	871.0
			Std Dev:		27.644			Std Dev:		105.336	Std Dev:	44.068

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	768.0	HF2	0	1	95	1107.0		937.5
				96	734.0				96	1098.0		916.0
				97	748.0				97	1055.0		901.5
				98	729.0				98	1076.0		902.5
				99	761.0				99	1079.0		920.0
				Avg:	748.0				Avg:	1083.0	Avg:	915.5
				Std Dev:	16.778				Std Dev:	20.310	Std Dev:	14.744
	OF1	0	2	95	711.0	HF2	0	2	95	1067.0		889.0
				96	775.0				96	1067.0		921.0
				97	707.0				97	1060.0		883.5
				98	735.0				98	1085.0		910.0
				99	744.0				99	1079.0		911.5
				Avg:	734.4				Avg:	1071.6	Avg:	903.0
				Std Dev:	27.564				Std Dev:	10.139	Std Dev:	15.980
	OF1	90	1	95	765.0	HF2	90	1	95	644.0		704.5
				96	713.0				96	653.0		683.0
				97	687.0				97	641.0		664.0
				98	699.0				98	657.0		678.0
				99	696.0				99	667.0		681.5
				Avg:	712.0				Avg:	652.4	Avg:	682.2
				Std Dev:	31.064				Std Dev:	10.431	Std Dev:	14.554
	OF1	90	2	95	741.0	HF2	90	2	95	633.0		687.0
				96	780.0				96	700.0		740.0
				97	753.0				97	642.0		697.5
				98	681.0				98	629.0		655.0
				99	698.0				99	610.0		654.0
				Avg:	730.6				Avg:	642.8	Avg:	686.7
				Std Dev:	40.538				Std Dev:	34.040	Std Dev:	35.468
B	OF2	0	1	95	685.0	HF1	0	1	95	747.0		716.0
				96	657.0				96	736.0		696.5
				97	721.0				97	766.0		743.5
				98	670.0				98	794.0		732.0
				99	695.0				99	744.0		719.5
				Avg:	685.6				Avg:	757.4	Avg:	721.5
				Std Dev:	24.511				Std Dev:	23.234	Std Dev:	17.702
	OF2	0	2	95	860.0	HF1	0	2	95	787.0		823.5
				96	830.0				96	762.0		796.0
				97	789.0				97	742.0		765.5
				98	878.0				98	698.0		788.0
				99	828.0				99	745.0		786.5
				Avg:	837.0				Avg:	746.8	Avg:	791.9
				Std Dev:	34.073				Std Dev:	32.614	Std Dev:	20.957
	OF2	90	1	95	685.0	HF1	90	1	95	747.0		716.0
				96	657.0				96	736.0		696.5
				97	721.0				97	766.0		743.5
				98	670.0				98	794.0		732.0
				99	695.0				99	744.0		719.5
				Avg:	685.6				Avg:	757.4	Avg:	721.5
				Std Dev:	24.511				Std Dev:	23.234	Std Dev:	17.702
	OF2	90	2	95	860.0	HF1	90	2	95	787.0		823.5
				96	830.0				96	762.0		796.0
				97	789.0				97	742.0		765.5
				98	878.0				98	698.0		788.0
				99	828.0				99	745.0		786.5
				Avg:	837.0				Avg:	746.8	Avg:	791.9
				Std Dev:	34.073				Std Dev:	32.614	Std Dev:	20.957

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	789.0	HF2	0	1	95	870.0		829.5
				96	777.0				96	846.0		811.5
				97	793.0				97	834.0		813.5
				98	777.0				98	847.0		812.0
				99	769.0				99	827.0		798.0
				Avg:	781.0				Avg:	844.8	Avg:	812.9
				Std Dev:	9.798				Std Dev:	16.392	Std Dev:	11.188
	OF1	0	2	95	794.0	HF2	0	2	95	841.0		817.5
				96	788.0				96	820.0		804.0
				97	787.0				97	797.0		792.0
				98	780.0				98	830.0		805.0
				99	785.0				99	851.0		818.0
				Avg:	786.8				Avg:	827.8	Avg:	807.3
				Std Dev:	5.070				Std Dev:	20.777	Std Dev:	10.826
	OF1	90	1	95	785.0	HF2	90	1	95	935.0		860.0
				96	767.0				96	957.0		872.0
				97	757.0				97	899.0		828.0
				98	781.0				98	856.0		818.5
				99	793.0				99	932.0		862.5
				Avg:	780.6				Avg:	915.8	Avg:	846.2
				Std Dev:	13.885				Std Dev:	39.328	Std Dev:	23.454
	OF1	90	2	95	829.0	HF2	90	2	95	842.0		835.5
				96	836.0				96	881.0		858.5
				97	803.0				97	815.0		809.0
				98	777.0				98	864.0		820.5
				99	744.0				99	825.0		784.5
				Avg:	797.8				Avg:	845.4	Avg:	821.6
				Std Dev:	38.036				Std Dev:	27.227	Std Dev:	27.799
B	OF2	0	1	95	786.0	HF1	0	1	95	870.0		828.0
				96	802.0				96	882.0		842.0
				97	748.0				97	844.0		796.0
				98	730.0				98	836.0		783.0
				99	771.0				99	866.0		818.5
				Avg:	767.4				Avg:	859.6	Avg:	813.5
				Std Dev:	28.858				Std Dev:	19.047	Std Dev:	23.896
	OF2	0	2	95	762.0	HF1	0	2	95	870.0		816.0
				96	750.0				96	853.0		801.5
				97	776.0				97	865.0		820.5
				98	778.0				98	841.0		809.5
				99	708.0				99	825.0		766.5
				Avg:	754.8				Avg:	850.8	Avg:	802.8
				Std Dev:	28.517				Std Dev:	18.281	Std Dev:	21.516
	OF2	90	1	95	830.0	HF1	90	1	95	826.0		828.0
				96	867.0				96	823.0		845.0
				97	837.0				97	782.0		809.5
				98	834.0				98	797.0		815.5
				99	837.0				99	755.0		796.0
				Avg:	841.0				Avg:	796.6	Avg:	818.8
				Std Dev:	14.816				Std Dev:	29.602	Std Dev:	18.630
	OF2	90	2	95	873.0	HF1	90	2	95	805.0		839.0
				96	846.0				96	782.0		814.0
				97	804.0				97	764.0		784.0
				98	876.0				98	777.0		826.5
				99	825.0				99	748.0		786.5
				Avg:	844.8				Avg:	775.2	Avg:	810.0
				Std Dev:	30.931				Std Dev:	21.230	Std Dev:	24.277

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	763.0	HF2	0	1	95	569.0		666.0
				96	721.0				96	626.0		673.5
				97	724.0				97	599.0		661.5
				98	701.0				98	557.0		629.0
				99	714.0				99	622.0		668.0
				Avg:	724.6				Avg:	594.6	Avg:	659.6
				Std Dev:	23.223				Std Dev:	30.924	Std Dev:	17.640
	OF1	0	2	95	786.0	HF2	0	2	95	585.0		685.5
				96	748.0				96	628.0		688.0
				97	713.0				97	606.0		659.5
				98	689.0				98	560.0		624.5
				99	689.0				99	598.0		643.5
				Avg:	725.0				Avg:	595.4	Avg:	660.2
				Std Dev:	41.791				Std Dev:	25.215	Std Dev:	27.234
	OF1	90	1	95	818.0	HF2	90	1	95	943.0		880.5
				96	756.0				96	951.0		853.5
				97	820.0				97	988.0		904.0
				98	899.0				98	909.0		904.0
				99	1027.0				99	911.0		969.0
				Avg:	864.0				Avg:	940.4	Avg:	902.2
				Std Dev:	104.295				Std Dev:	32.539	Std Dev:	42.753
	OF1	90	2	95	991.0	HF2	90	2	95	1035.0		1013.0
				96	1055.0				96	891.0		973.0
				97	1028.0				97	975.0		1001.5
				98	995.0				98	1005.0		1000.0
				99	838.0				99	930.0		884.0
				Avg:	981.4				Avg:	967.2	Avg:	974.3
				Std Dev:	84.305				Std Dev:	57.612	Std Dev:	52.569
C	OF2	0	1	95	665.0	HF1	0	1	95	688.0		676.5
				96	630.0				96	715.0		672.5
				97	658.0				97	723.0		690.5
				98	681.0				98	743.0		712.0
				99	643.0				99	740.0		691.5
				Avg:	655.4				Avg:	721.8	Avg:	688.6
				Std Dev:	19.705				Std Dev:	22.197	Std Dev:	15.534
	OF2	0	2	95	510.0	HF1	0	2	95	651.0		580.5
				96	601.0				96	723.0		662.0
				97	688.0				97	747.0		717.5
				98	619.0				98	730.0		674.5
				99	693.0				99	698.0		695.5
				Avg:	622.2				Avg:	709.8	Avg:	666.0
				Std Dev:	74.818				Std Dev:	37.292	Std Dev:	52.252
	OF2	90	1	95	752.0	HF1	90	1	95	1075.0		913.5
				96	691.0				96	816.0		753.5
				97	775.0				97	876.0		825.5
				98	715.0				98	965.0		840.0
				99	742.0				99	1485.0		1113.5
				Avg:	735.0				Avg:	1043.4	Avg:	889.2
				Std Dev:	32.688				Std Dev:	265.466	Std Dev:	137.653
	OF2	90	2	95	693.0	HF1	90	2	95	1351.0		1022.0
				96	728.0				96	1779.0		1253.5
				97	770.0				97	1411.0		1090.5
				98	652.0				98	1061.0		856.5
				99	702.0				99	890.0		796.0
				Avg:	709.0				Avg:	1298.4	Avg:	1003.7
				Std Dev:	43.692				Std Dev:	342.626	Std Dev:	183.764

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	769.0	HF2	0	1	95	902.0		835.5
				96	781.0				96	917.0		849.0
				97	789.0				97	940.0		864.5
				98	747.0				98	893.0		820.0
				99	780.0				99	887.0		833.5
				Avg:	773.2				Avg:	907.8	Avg:	840.5
				Std Dev:	16.285				Std Dev:	21.253	Std Dev:	16.900
	OF1	0	2	95	805.0	HF2	0	2	95	944.0		874.5
				96	790.0				96	975.0		882.5
				97	799.0				97	984.0		891.5
				98	782.0				98	870.0		826.0
				99	827.0				99	926.0		876.5
				Avg:	800.6				Avg:	939.8	Avg:	870.2
				Std Dev:	17.155				Std Dev:	45.477	Std Dev:	25.577
	OF1	90	1	95	588.0	HF2	90	1	95	672.0		630.0
				96	599.0				96	703.0		651.0
				97	585.0				97	728.0		656.5
				98	585.0				98	667.0		626.0
				99	635.0				99	717.0		676.0
				Avg:	598.4				Avg:	697.4	Avg:	647.9
				Std Dev:	21.256				Std Dev:	27.024	Std Dev:	20.452
	OF1	90	2	95	589.0	HF2	90	2	95	657.0		623.0
				96	605.0				96	679.0		642.0
				97	579.0				97	681.0		630.0
				98	594.0				98	682.0		638.0
				99	620.0				99	668.0		644.0
				Avg:	597.4				Avg:	673.4	Avg:	635.4
				Std Dev:	15.726				Std Dev:	10.738	Std Dev:	8.764
C	OF2	0	1	95	773.0	HF1	0	1	95	677.0		725.0
				96	887.0				96	738.0		812.5
				97	847.0				97	727.0		787.0
				98	811.0				98	700.0		755.5
				99	842.0				99	712.0		777.0
				Avg:	832.0				Avg:	710.8	Avg:	771.4
				Std Dev:	42.638				Std Dev:	23.784	Std Dev:	33.052
	OF2	0	2	95	868.0	HF1	0	2	95	772.0		820.0
				96	874.0				96	779.0		826.5
				97	881.0				97	759.0		820.0
				98	846.0				98	759.0		802.5
				99	888.0				99	775.0		831.5
				Avg:	871.4				Avg:	768.8	Avg:	820.1
				Std Dev:	16.056				Std Dev:	9.284	Std Dev:	10.962
	OF2	90	1	95	673.0	HF1	90	1	95	547.0		610.0
				96	686.0				96	616.0		651.0
				97	706.0				97	629.0		667.5
				98	668.0				98	557.0		612.5
				99	695.0				99	622.0		658.5
				Avg:	685.6				Avg:	594.2	Avg:	639.9
				Std Dev:	15.598				Std Dev:	38.958	Std Dev:	26.813
	OF2	90	2	95	709.0	HF1	90	2	95	608.0		658.5
				96	664.0				96	574.0		619.0
				97	743.0				97	591.0		667.0
				98	646.0				98	576.0		611.0
				99	683.0				99	597.0		640.0
				Avg:	689.0				Avg:	589.2	Avg:	639.1
				Std Dev:	38.164				Std Dev:	14.342	Std Dev:	24.234

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	727.0	HF2	0	1	95	901.0		814.0
				96	727.0				96	941.0		834.0
				97	717.0				97	929.0		823.0
				98	733.0				98	904.0		818.5
				99	737.0				99	877.0		807.0
				Avg:	728.2				Avg:	910.4	Avg:	819.3
				Std Dev:	7.563				Std Dev:	25.136	Std Dev:	10.122
	OF1	0	2	95	755.0	HF2	0	2	95	883.0		819.0
				96	755.0				96	862.0		808.5
				97	720.0				97	861.0		790.5
				98	749.0				98	893.0		821.0
				99	758.0				99	892.0		825.0
				Avg:	747.4				Avg:	878.2	Avg:	812.8
				Std Dev:	15.662				Std Dev:	15.738	Std Dev:	13.877
	OF1	90	1	95	716.0	HF2	90	1	95	739.0		727.5
				96	739.0				96	734.0		736.5
				97	716.0				97	741.0		728.5
				98	703.0				98	714.0		708.5
				99	697.0				99	740.0		718.5
				Avg:	714.2				Avg:	733.6	Avg:	723.9
				Std Dev:	16.146				Std Dev:	11.283	Std Dev:	10.714
	OF1	90	2	95	832.0	HF2	90	2	95	761.0		796.5
				96	791.0				96	743.0		767.0
				97	778.0				97	717.0		747.5
				98	801.0				98	749.0		775.0
				99	749.0				99	723.0		736.0
				Avg:	790.2				Avg:	738.6	Avg:	764.4
				Std Dev:	30.458				Std Dev:	18.298	Std Dev:	23.673
C	OF2	0	1	95	904.0	HF1	0	1	95	755.0		829.5
				96	924.0				96	756.0		840.0
				97	896.0				97	730.0		813.0
				98	907.0				98	735.0		821.0
				99	945.0				99	766.0		855.5
				Avg:	915.2				Avg:	748.4	Avg:	831.8
				Std Dev:	19.537				Std Dev:	15.241	Std Dev:	16.616
	OF2	0	2	95	904.0	HF1	0	2	95	852.0		878.0
				96	900.0				96	857.0		878.5
				97	874.0				97	852.0		863.0
				98	834.0				98	814.0		824.0
				99	912.0				99	876.0		894.0
				Avg:	884.8				Avg:	850.2	Avg:	867.5
				Std Dev:	31.768				Std Dev:	22.521	Std Dev:	26.674
	OF2	90	1	95	608.0	HF1	90	1	95	883.0		745.5
				96	613.0				96	892.0		752.5
				97	612.0				97	915.0		763.5
				98	589.0				98	864.0		726.5
				99	579.0				99	885.0		732.0
				Avg:	600.2				Avg:	887.8	Avg:	744.0
				Std Dev:	15.320				Std Dev:	18.404	Std Dev:	15.042
	OF2	90	2	95	614.0	HF1	90	2	95	907.0		760.5
				96	600.0				96	918.0		759.0
				97	603.0				97	908.0		755.5
				98	628.0				98	1025.0		826.5
				99	608.0				99	917.0		762.5
				Avg:	610.6				Avg:	935.0	Avg:	772.8
				Std Dev:	11.082				Std Dev:	50.562	Std Dev:	30.128

Annex 5

NCHRP 1-28A Project

Diametral Test Results

Mr Instantaneous

19.0 mm
6 inch Dia.

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	453.0	HF2	0	1	95	1743.0		1098.0
				96	457.0				96	1807.0		1132.0
				97	416.0				97	1664.0		1041.0
				98	419.0				98	1383.0		901.0
				99	433.0				99	2492.0		1462.5
				Avg:	436.0				Avg:	1817.8	Avg:	1126.9
				Std Dev:	18.385				Std Dev:	410.172	Std Dev:	207.303
	OF1	0	2	95	470.0	HF2	0	2	95	1650.0		1060.0
				96	474.0				96	1522.0		998.0
				97	486.0				97	1366.0		926.0
				98	467.0				98	1773.0		1120.0
				99	471.0				99	1577.0		1024.0
				Avg:	473.6				Avg:	1577.6	Avg:	1025.6
				Std Dev:	7.369				Std Dev:	151.071	Std Dev:	72.075
	OF1	90	1	95	889.0	HF2	90	1	95	897.0		893.0
				96	940.0				96	1053.0		996.5
				97	779.0				97	868.0		823.5
				98	694.0				98	866.0		780.0
				99	785.0				99	1159.0		972.0
				Avg:	817.4				Avg:	968.6	Avg:	893.0
				Std Dev:	97.351				Std Dev:	131.481	Std Dev:	92.942
	OF1	90	2	95	837.0	HF2	90	2	95	995.0		916.0
				96	712.0				96	758.0		735.0
				97	791.0				97	955.0		873.0
				98	803.0				98	1095.0		949.0
				99	871.0				99	782.0		826.5
				Avg:	802.8				Avg:	917.0	Avg:	859.9
				Std Dev:	59.592				Std Dev:	143.804	Std Dev:	83.626
A	OF2	0	1	95	1507.0	HF1	0	1	95	486.0		996.5
				96	1558.0				96	481.0		1019.5
				97	1795.0				97	439.0		1117.0
				98	1417.0				98	453.0		935.0
				99	1544.0				99	437.0		990.5
				Avg:	1564.2				Avg:	459.2	Avg:	1011.7
				Std Dev:	140.227				Std Dev:	23.091	Std Dev:	66.544
	OF2	0	2	95	1640.0	HF1	0	2	95	515.0		1077.5
				96	1515.0				96	516.0		1015.5
				97	2136.0				97	463.0		1299.5
				98	1285.0				98	446.0		865.5
				99	1759.0				99	493.0		1126.0
				Avg:	1667.0				Avg:	486.6	Avg:	1076.8
				Std Dev:	315.508				Std Dev:	31.294	Std Dev:	158.447
	OF2	90	1	95	812.0	HF1	90	1	95	692.0		752.0
				96	733.0				96	754.0		743.5
				97	790.0				97	775.0		782.5
				98	768.0				98	806.0		787.0
				99	803.0				99	768.0		785.5
				Avg:	781.2				Avg:	759.0	Avg:	770.1
				Std Dev:	31.618				Std Dev:	42.012	Std Dev:	20.686
	OF2	90	2	95	970.0	HF1	90	2	95	804.0		887.0
				96	855.0				96	887.0		871.0
				97	949.0				97	855.0		902.0
				98	890.0				98	764.0		827.0
				99	939.0				99	798.0		868.5
				Avg:	920.6				Avg:	821.6	Avg:	871.1
				Std Dev:	46.971				Std Dev:	48.932	Std Dev:	28.103

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	938.0	HF2	0	1	95	797.0		867.5
				96	975.0				96	794.0		884.5
				97	943.0				97	785.0		864.0
				98	933.0				98	764.0		848.5
				99	953.0				99	835.0		894.0
			Avg:		948.4			Avg:		795.0	Avg:	871.7
			Std Dev:		16.607			Std Dev:		25.817	Std Dev:	17.863
	OF1	0	2	95	905.0	HF2	0	2	95	788.0		846.5
				96	918.0				96	777.0		847.5
				97	889.0				97	742.0		815.5
				98	864.0				98	781.0		822.5
				99	874.0				99	799.0		836.5
			Avg:		890.0			Avg:		777.4	Avg:	833.7
			Std Dev:		22.034			Std Dev:		21.478	Std Dev:	14.307
	OF1	90	1	95	948.0	HF2	90	1	95	972.0		960.0
				96	891.0				96	1001.0		946.0
				97	947.0				97	952.0		949.5
				98	911.0				98	961.0		936.0
				99	918.0				99	927.0		922.5
			Avg:		923.0			Avg:		962.6	Avg:	942.8
			Std Dev:		24.464			Std Dev:		27.135	Std Dev:	14.224
	OF1	90	2	95	1054.0	HF2	90	2	95	946.0		1000.0
				96	935.0				96	929.0		932.0
				97	993.0				97	932.0		962.5
				98	1035.0				98	978.0		1006.5
				99	964.0				99	926.0		945.0
			Avg:		996.2			Avg:		942.2	Avg:	969.2
			Std Dev:		49.089			Std Dev:		21.429	Std Dev:	32.994
A	OF2	0	1	95	866.0	HF1	0	1	95	760.0		813.0
				96	943.0				96	759.0		851.0
				97	895.0				97	767.0		831.0
				98	848.0				98	718.0		783.0
				99	840.0				99	761.0		800.5
			Avg:		878.4			Avg:		753.0	Avg:	815.7
			Std Dev:		41.837			Std Dev:		19.812	Std Dev:	26.400
	OF2	0	2	95	925.0	HF1	0	2	95	784.0		854.5
				96	812.0				96	810.0		811.0
				97	824.0				97	761.0		792.5
				98	887.0				98	790.0		838.5
				99	826.0				99	779.0		802.5
			Avg:		854.8			Avg:		784.8	Avg:	819.8
			Std Dev:		48.925			Std Dev:		17.768	Std Dev:	25.864
	OF2	90	1	95	908.0	HF1	90	1	95	928.0		918.0
				96	937.0				96	884.0		910.5
				97	1001.0				97	974.0		987.5
				98	978.0				98	924.0		951.0
				99	943.0				99	934.0		938.5
			Avg:		953.4			Avg:		928.8	Avg:	941.1
			Std Dev:		36.432			Std Dev:		32.019	Std Dev:	30.527
	OF2	90	2	95	938.0	HF1	90	2	95	965.0		951.5
				96	997.0				96	915.0		956.0
				97	1007.0				97	921.0		964.0
				98	970.0				98	973.0		971.5
				99	959.0				99	901.0		930.0
			Avg:		974.2			Avg:		935.0	Avg:	954.6
			Std Dev:		28.084			Std Dev:		32.000	Std Dev:	15.738

Mix Type=	19.0 mm	
Diam.=	6.00 in.	***Mr Analysis***
Gage Length=	4.5 in.	
Instant		

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	686.0	HF2	0	1	95	811.0		748.5
				96	696.0				96	797.0		746.5
				97	666.0				97	778.0		722.0
				98	673.0				98	762.0		717.5
				99	683.0				99	761.0		722.0
			Avg:		680.8			Avg:		781.8	Avg:	731.3
			Std Dev:		11.649			Std Dev:		21.925	Std Dev:	14.919
	OF1	0	2	95	735.0	HF2	0	2	95	764.0		749.5
				96	734.0				96	753.0		743.5
				97	712.0				97	735.0		723.5
				98	720.0				98	734.0		727.0
				99	724.0				99	771.0		747.5
			Avg:		725.0			Avg:		751.4	Avg:	738.2
			Std Dev:		9.695			Std Dev:		16.712	Std Dev:	12.081
	OF1	90	1	95	854.0	HF2	90	1	95	1013.0		933.5
				96	847.0				96	983.0		915.0
				97	833.0				97	1018.0		925.5
				98	824.0				98	1010.0		917.0
				99	841.0				99	1017.0		929.0
			Avg:		839.8			Avg:		1008.2	Avg:	924.0
			Std Dev:		11.735			Std Dev:		14.446	Std Dev:	7.866
	OF1	90	2	95	867.0	HF2	90	2	95	1003.0		935.0
				96	846.0				96	1001.0		923.5
				97	858.0				97	1014.0		936.0
				98	853.0				98	961.0		907.0
				99	852.0				99	1038.0		945.0
			Avg:		855.2			Avg:		1003.4	Avg:	929.3
			Std Dev:		7.855			Std Dev:		27.898	Std Dev:	14.618
A	OF2	0	1	95	932.0	HF1	0	1	95	709.0		820.5
				96	938.0				96	714.0		826.0
				97	961.0				97	705.0		833.0
				98	925.0				98	696.0		810.5
				99	935.0				99	707.0		821.0
			Avg:		938.2			Avg:		706.2	Avg:	822.2
			Std Dev:		13.627			Std Dev:		6.611	Std Dev:	8.251
	OF2	0	2	95	917.0	HF1	0	2	95	713.0		815.0
				96	901.0				96	708.0		804.5
				97	881.0				97	685.0		783.0
				98	941.0				98	705.0		823.0
				99	924.0				99	722.0		823.0
			Avg:		912.8			Avg:		706.6	Avg:	809.7
			Std Dev:		22.852			Std Dev:		13.686	Std Dev:	16.747
	OF2	90	1	95	944.0	HF1	90	1	95	784.0		864.0
				96	935.0				96	775.0		855.0
				97	949.0				97	772.0		860.5
				98	941.0				98	777.0		859.0
				99	947.0				99	777.0		862.0
			Avg:		943.2			Avg:		777.0	Avg:	860.1
			Std Dev:		5.495			Std Dev:		4.416	Std Dev:	3.399
	OF2	90	2	95	868.0	HF1	90	2	95	840.0		854.0
				96	869.0				96	831.0		850.0
				97	880.0				97	841.0		860.5
				98	868.0				98	845.0		856.5
				99	882.0				99	851.0		866.5
			Avg:		873.4			Avg:		841.6	Avg:	857.5
			Std Dev:		6.986			Std Dev:		7.335	Std Dev:	6.315

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
B	OF1	0	1	95	1197.0	HF2	0	1	95	805.0		1001.0
				96	1338.0				96	725.0		1031.5
				97	1274.0				97	693.0		983.5
				98	1411.0				98	668.0		1039.5
				99	1243.0				99	894.0		1068.5
			Avg:		1292.6			Avg:		757.0	Avg:	1024.8
			Std Dev:		83.704			Std Dev:		92.350	Std Dev:	33.327
	OF1	0	2	95	1355.0	HF2	0	2	95	783.0		1069.0
				96	1245.0				96	1029.0		1137.0
				97	1242.0				97	758.0		1000.0
				98	1260.0				98	669.0		964.5
				99	1323.0				99	824.0		1073.5
			Avg:		1285.0			Avg:		812.6	Avg:	1048.8
			Std Dev:		51.034			Std Dev:		133.639	Std Dev:	67.612
	OF1	90	1	95	1348.0	HF2	90	1	95	1048.0		1198.0
				96	1189.0				96	1097.0		1143.0
				97	1250.0				97	763.0		1006.5
				98	1318.0				98	797.0		1057.5
				99	1419.0				99	937.0		1178.0
			Avg:		1304.8			Avg:		928.4	Avg:	1116.6
			Std Dev:		88.734			Std Dev:		147.840	Std Dev:	81.712
	OF1	90	2	95	1122.0	HF2	90	2	95	686.0		904.0
				96	1299.0				96	963.0		1131.0
				97	1277.0				97	1023.0		1150.0
				98	1387.0				98	838.0		1112.5
				99	1351.0				99	744.0		1047.5
			Avg:		1287.2			Avg:		850.8	Avg:	1069.0
			Std Dev:		101.937			Std Dev:		142.277	Std Dev:	99.981
B	OF2	0	1	95	868.0	HF1	0	1	95	1191.0		1029.5
				96	1126.0				96	1211.0		1168.5
				97	867.0				97	1485.0		1176.0
				98	885.0				98	1106.0		995.5
				99	966.0				99	1199.0		1082.5
			Avg:		942.4			Avg:		1238.4	Avg:	1090.4
			Std Dev:		110.432			Std Dev:		143.954	Std Dev:	80.939
	OF2	0	2	95	1084.0	HF1	0	2	95	1265.0		1174.5
				96	985.0				96	1258.0		1121.5
				97	688.0				97	1089.0		888.5
				98	999.0				98	994.0		996.5
				99	1212.0				99	1212.0		1212.0
			Avg:		993.6			Avg:		1163.6	Avg:	1078.6
			Std Dev:		193.239			Std Dev:		118.179	Std Dev:	133.895
	OF2	90	1	95	989.0	HF1	90	1	95	1354.0		1171.5
				96	727.0				96	1295.0		1011.0
				97	1187.0				97	1423.0		1305.0
				98	857.0				98	1335.0		1096.0
				99	702.0				99	1271.0		986.5
			Avg:		892.4			Avg:		1335.6	Avg:	1114.0
			Std Dev:		200.614			Std Dev:		58.735	Std Dev:	129.399
	OF2	90	2	95	833.0	HF1	90	2	95	1620.0		1226.5
				96	1030.0				96	1798.0		1414.0
				97	723.0				97	1488.0		1105.5
				98	1046.0				98	1747.0		1396.5
				99	884.0				99	1287.0		1085.5
			Avg:		903.2			Avg:		1588.0	Avg:	1245.6
			Std Dev:		136.234			Std Dev:		206.764	Std Dev:	155.527

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1198.0	HF2	0	1	95	910.0		1054.0
				96	1238.0				96	948.0		1093.0
				97	1164.0				97	934.0		1049.0
				98	1156.0				98	978.0		1067.0
				99	1184.0				99	999.0		1091.5
			Avg:		1188.0			Avg:		953.8	Avg:	1070.9
			Std Dev:		32.465			Std Dev:		35.259	Std Dev:	20.574
	OF1	0	2	95	1144.0	HF2	0	2	95	904.0		1024.0
				96	1182.0				96	973.0		1077.5
				97	1126.0				97	926.0		1026.0
				98	1122.0				98	900.0		1011.0
				99	1127.0				99	902.0		1014.5
			Avg:		1140.2			Avg:		921.0	Avg:	1030.6
			Std Dev:		24.844			Std Dev:		30.903	Std Dev:	26.962
	OF1	90	1	95	1228.0	HF2	90	1	95	646.0		937.0
				96	1288.0				96	642.0		965.0
				97	1173.0				97	633.0		903.0
				98	1145.0				98	617.0		881.0
				99	1210.0				99	607.0		908.5
			Avg:		1208.8			Avg:		629.0	Avg:	918.9
			Std Dev:		54.760			Std Dev:		16.598	Std Dev:	32.597
	OF1	90	2	95	1143.0	HF2	90	2	95	634.0		888.5
				96	1203.0				96	645.0		924.0
				97	1238.0				97	626.0		932.0
				98	1177.0				98	636.0		906.5
				99	1126.0				99	649.0		887.5
			Avg:		1177.4			Avg:		638.0	Avg:	907.7
			Std Dev:		45.148			Std Dev:		9.138	Std Dev:	20.213
B	OF2	0	1	95	719.0	HF1	0	1	95	1339.0		1029.0
				96	748.0				96	1372.0		1060.0
				97	729.0				97	1360.0		1044.5
				98	735.0				98	1323.0		1029.0
				99	716.0				99	1384.0		1050.0
			Avg:		729.4			Avg:		1355.6	Avg:	1042.5
			Std Dev:		12.896			Std Dev:		24.664	Std Dev:	13.519
	OF2	0	2	95	802.0	HF1	0	2	95	1356.0		1079.0
				96	774.0				96	1334.0		1054.0
				97	752.0				97	1340.0		1046.0
				98	789.0				98	1323.0		1056.0
				99	773.0				99	1348.0		1060.5
			Avg:		778.0			Avg:		1340.2	Avg:	1059.1
			Std Dev:		18.802			Std Dev:		12.696	Std Dev:	12.300
	OF2	90	1	95	612.0	HF1	90	1	95	1175.0		893.5
				96	612.0				96	1202.0		907.0
				97	592.0				97	1227.0		909.5
				98	624.0				98	1181.0		902.5
				99	613.0				99	1214.0		913.5
			Avg:		610.6			Avg:		1199.8	Avg:	905.2
			Std Dev:		11.567			Std Dev:		21.879	Std Dev:	7.662
	OF2	90	2	95	615.0	HF1	90	2	95	1285.0		950.0
				96	608.0				96	1247.0		927.5
				97	607.0				97	1357.0		982.0
				98	589.0				98	1367.0		978.0
				99	584.0				99	1319.0		951.5
			Avg:		600.6			Avg:		1315.0	Avg:	957.8
			Std Dev:		13.353			Std Dev:		50.020	Std Dev:	22.429

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	911.0	HF2	0	1	95	832.0		871.5
				96	850.0				96	862.0		856.0
				97	911.0				97	834.0		872.5
				98	788.0				98	850.0		819.0
				99	748.0				99	816.0		782.0
			Avg:		841.6			Avg:		838.8	Avg:	840.2
			Std Dev:		73.036			Std Dev:		17.697	Std Dev:	39.081
	OF1	0	2	95	822.0	HF2	0	2	95	833.0		827.5
				96	799.0				96	819.0		809.0
				97	809.0				97	852.0		830.5
				98	808.0				98	843.0		825.5
				99	784.0				99	818.0		801.0
			Avg:		804.4			Avg:		833.0	Avg:	818.7
			Std Dev:		14.046			Std Dev:		14.849	Std Dev:	12.945
	OF1	90	1	95	723.0	HF2	90	1	95	683.0		703.0
				96	722.0				96	678.0		700.0
				97	712.0				97	688.0		700.0
				98	705.0				98	666.0		685.5
				99	696.0				99	659.0		677.5
			Avg:		711.6			Avg:		674.8	Avg:	693.2
			Std Dev:		11.459			Std Dev:		12.029	Std Dev:	11.116
	OF1	90	2	95	815.0	HF2	90	2	95	691.0		753.0
				96	797.0				96	721.0		759.0
				97	774.0				97	681.0		727.5
				98	775.0				98	681.0		728.0
				99	778.0				99	692.0		735.0
			Avg:		787.8			Avg:		693.2	Avg:	740.5
			Std Dev:		17.852			Std Dev:		16.407	Std Dev:	14.612
B	OF2	0	1	95	932.0	HF1	0	1	95	709.0		820.5
				96	938.0				96	714.0		826.0
				97	961.0				97	705.0		833.0
				98	925.0				98	696.0		810.5
				99	935.0				99	707.0		821.0
			Avg:		938.2			Avg:		706.2	Avg:	822.2
			Std Dev:		13.627			Std Dev:		6.611	Std Dev:	8.251
	OF2	0	2	95	885.0	HF1	0	2	95	968.0		926.5
				96	901.0				96	1011.0		956.0
				97	892.0				97	975.0		933.5
				98	910.0				98	985.0		947.5
				99	914.0				99	982.0		948.0
			Avg:		900.4			Avg:		984.2	Avg:	942.3
			Std Dev:		12.095			Std Dev:		16.362	Std Dev:	11.982
	OF2	90	1	95	658.0	HF1	90	1	95	943.0		800.5
				96	659.0				96	986.0		822.5
				97	657.0				97	976.0		816.5
				98	642.0				98	965.0		803.5
				99	674.0				99	1001.0		837.5
			Avg:		658.0			Avg:		974.2	Avg:	816.1
			Std Dev:		11.336			Std Dev:		21.902	Std Dev:	15.010
	OF2	90	2	95	671.0	HF1	90	2	95	989.0		830.0
				96	678.0				96	990.0		834.0
				97	684.0				97	995.0		839.5
				98	675.0				98	992.0		833.5
				99	675.0				99	971.0		823.0
			Avg:		676.6			Avg:		987.4	Avg:	832.0
			Std Dev:		4.827			Std Dev:		9.450	Std Dev:	6.072

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Mr Avg (Ksi)
C	OF1	0	1	95	685.0	HF2	0	1	95	407.0	546.0
				96	730.0				96	455.0	592.5
				97	726.0				97	466.0	596.0
				98	698.0				98	417.0	557.5
				99	662.0				99	472.0	567.0
				Avg:	700.2				Avg:	443.4	Avg: 571.8
				Std Dev:	28.499				Std Dev:	29.518	Std Dev: 21.836
	OF1	0	2	95	639.0	HF2	0	2	95	436.0	537.5
				96	638.0				96	439.0	538.5
				97	680.0				97	435.0	557.5
				98	694.0				98	465.0	579.5
				99	677.0				99	456.0	566.5
				Avg:	665.6				Avg:	446.2	Avg: 555.9
				Std Dev:	25.560				Std Dev:	13.517	Std Dev: 18.119
	OF1	90	1	95	672.0	HF2	90	1	95	572.0	622.0
				96	653.0				96	659.0	656.0
				97	618.0				97	564.0	591.0
				98	660.0				98	592.0	626.0
				99	640.0				99	636.0	638.0
				Avg:	648.6				Avg:	604.6	Avg: 626.6
				Std Dev:	20.659				Std Dev:	41.277	Std Dev: 23.891
	OF1	90	2	95	680.0	HF2	90	2	95	616.0	648.0
				96	668.0				96	583.0	625.5
				97	612.0				97	635.0	623.5
				98	625.0				98	613.0	619.0
				99	696.0				99	562.0	629.0
				Avg:	656.2				Avg:	601.8	Avg: 629.0
				Std Dev:	36.114				Std Dev:	29.012	Std Dev: 11.219
C	OF2	0	1	95	560.0	HF1	0	1	95	909.0	734.5
				96	633.0				96	837.0	735.0
				97	633.0				97	855.0	744.0
				98	549.0				98	1023.0	786.0
				99	543.0				99	912.0	727.5
				Avg:	583.6				Avg:	907.2	Avg: 745.4
				Std Dev:	45.506				Std Dev:	72.610	Std Dev: 23.440
	OF2	0	2	95	545.0	HF1	0	2	95	849.0	697.0
				96	530.0				96	899.0	714.5
				97	646.0				97	848.0	747.0
				98	633.0				98	981.0	807.0
				99	514.0				99	943.0	728.5
				Avg:	573.6				Avg:	904.0	Avg: 738.8
				Std Dev:	61.321				Std Dev:	58.387	Std Dev: 42.315
	OF2	90	1	95	668.0	HF1	90	1	95	682.0	675.0
				96	595.0				96	777.0	686.0
				97	533.0				97	706.0	619.5
				98	616.0				98	681.0	648.5
				99	613.0				99	650.0	631.5
				Avg:	605.0				Avg:	699.2	Avg: 652.1
				Std Dev:	48.575				Std Dev:	47.819	Std Dev: 28.168
	OF2	90	2	95	1111.0	HF1	90	2	95	658.0	884.5
				96	1199.0				96	643.0	921.0
				97	1430.0				97	614.0	1022.0
				98	1067.0				98	610.0	838.5
				99	1120.0				99	665.0	892.5
				Avg:	1185.4				Avg:	638.0	Avg: 911.7
				Std Dev:	144.780				Std Dev:	25.070	Std Dev: 68.409

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	694.0	HF2	0	1	95	747.0		720.5
				96	690.0				96	731.0		710.5
				97	664.0				97	715.0		689.5
				98	653.0				98	718.0		685.5
				99	665.0				99	735.0		700.0
				Avg:	673.2				Avg:	729.2	Avg:	701.2
				Std Dev:	17.852				Std Dev:	13.046	Std Dev:	14.524
	OF1	0	2	95	748.0	HF2	0	2	95	715.0		731.5
				96	718.0				96	733.0		725.5
				97	702.0				97	731.0		716.5
				98	708.0				98	719.0		713.5
				99	729.0				99	721.0		725.0
				Avg:	721.0				Avg:	723.8	Avg:	722.4
				Std Dev:	18.248				Std Dev:	7.823	Std Dev:	7.301
	OF1	90	1	95	753.0	HF2	90	1	95	823.0		788.0
				96	742.0				96	790.0		766.0
				97	703.0				97	780.0		741.5
				98	731.0				98	814.0		772.5
				99	714.0				99	781.0		747.5
				Avg:	728.6				Avg:	797.6	Avg:	763.1
				Std Dev:	20.305				Std Dev:	19.731	Std Dev:	18.886
	OF1	90	2	95	771.0	HF2	90	2	95	768.0		769.5
				96	714.0				96	790.0		752.0
				97	740.0				97	793.0		766.5
				98	754.0				98	755.0		754.5
				99	766.0				99	789.0		777.5
				Avg:	749.0				Avg:	779.0	Avg:	764.0
				Std Dev:	22.935				Std Dev:	16.688	Std Dev:	10.642
C	OF2	0	1	95	722.0	HF1	0	1	95	779.0		750.5
				96	754.0				96	799.0		776.5
				97	692.0				97	752.0		722.0
				98	709.0				98	743.0		726.0
				99	734.0				99	795.0		764.5
				Avg:	722.2				Avg:	773.6	Avg:	747.9
				Std Dev:	23.647				Std Dev:	25.175	Std Dev:	23.721
	OF2	0	2	95	758.0	HF1	0	2	95	777.0		767.5
				96	719.0				96	773.0		746.0
				97	713.0				97	795.0		754.0
				98	719.0				98	780.0		749.5
				99	754.0				99	754.0		754.0
				Avg:	732.6				Avg:	775.8	Avg:	754.2
				Std Dev:	21.548				Std Dev:	14.755	Std Dev:	8.159
	OF2	90	1	95	725.0	HF1	90	1	95	777.0		751.0
				96	731.0				96	775.0		753.0
				97	717.0				97	786.0		751.5
				98	738.0				98	785.0		761.5
				99	703.0				99	756.0		729.5
				Avg:	722.8				Avg:	775.8	Avg:	749.3
				Std Dev:	13.498				Std Dev:	12.071	Std Dev:	11.856
	OF2	90	2	95	718.0	HF1	90	2	95	811.0		764.5
				96	713.0				96	817.0		765.0
				97	714.0				97	798.0		756.0
				98	720.0				98	785.0		752.5
				99	706.0				99	768.0		737.0
				Avg:	714.2				Avg:	795.8	Avg:	755.0
				Std Dev:	5.404				Std Dev:	19.842	Std Dev:	11.418

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	679.0	HF2	0	1	95	710.0		694.5
				96	720.0				96	728.0		724.0
				97	724.0				97	713.0		718.5
				98	709.0				98	693.0		701.0
				99	697.0				99	706.0		701.5
				Avg:	705.8				Avg:	710.0	Avg:	707.9
				Std Dev:	18.295				Std Dev:	12.629	Std Dev:	12.646
	OF1	0	2	95	673.0	HF2	0	2	95	691.0		682.0
				96	691.0				96	706.0		698.5
				97	680.0				97	681.0		680.5
				98	682.0				98	701.0		691.5
				99	664.0				99	708.0		686.0
				Avg:	678.0				Avg:	697.4	Avg:	687.7
				Std Dev:	10.124				Std Dev:	11.283	Std Dev:	7.387
	OF1	90	1	95	618.0	HF2	90	1	95	714.0		666.0
				96	645.0				96	727.0		686.0
				97	643.0				97	707.0		675.0
				98	612.0				98	684.0		648.0
				99	603.0				99	683.0		643.0
				Avg:	624.2				Avg:	703.0	Avg:	663.6
				Std Dev:	18.860				Std Dev:	19.196	Std Dev:	18.064
	OF1	90	2	95	652.0	HF2	90	2	95	709.0		680.5
				96	652.0				96	694.0		673.0
				97	639.0				97	689.0		664.0
				98	632.0				98	719.0		675.5
				99	620.0				99	709.0		664.5
				Avg:	639.0				Avg:	704.0	Avg:	671.5
				Std Dev:	13.675				Std Dev:	12.247	Std Dev:	7.150
C	OF2	0	1	95	653.0	HF1	0	1	95	784.0		718.5
				96	665.0				96	794.0		729.5
				97	653.0				97	756.0		704.5
				98	658.0				98	772.0		715.0
				99	656.0				99	777.0		716.5
				Avg:	657.0				Avg:	776.6	Avg:	716.8
				Std Dev:	4.950				Std Dev:	14.170	Std Dev:	8.927
	OF2	0	2	95	692.0	HF1	0	2	95	813.0		752.5
				96	691.0				96	827.0		759.0
				97	671.0				97	791.0		731.0
				98	665.0				98	809.0		737.0
				99	691.0				99	817.0		754.0
				Avg:	682.0				Avg:	811.4	Avg:	746.7
				Std Dev:	12.961				Std Dev:	13.221	Std Dev:	12.029
	OF2	90	1	95	719.0	HF1	90	1	95	870.0		794.5
				96	734.0				96	841.0		787.5
				97	727.0				97	855.0		791.0
				98	735.0				98	868.0		801.5
				99	711.0				99	834.0		772.5
				Avg:	725.2				Avg:	853.6	Avg:	789.4
				Std Dev:	10.208				Std Dev:	15.978	Std Dev:	10.773
	OF2	90	2	95	756.0	HF1	90	2	95	857.0		806.5
				96	768.0				96	871.0		819.5
				97	730.0				97	840.0		785.0
				98	782.0				98	890.0		836.0
				99	753.0				99	893.0		823.0
				Avg:	757.8				Avg:	870.2	Avg:	814.0
				Std Dev:	19.292				Std Dev:	22.354	Std Dev:	19.316

Annex 6

NCHRP 1-28A Project

Diametral Test Results

Mr Instantaneous

37.5 mm
6 inch Dia.

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	948.0	HF2	0	1	95	1050.0		999.0
				96	979.0				96	1171.0		1075.0
				97	1039.0				97	1613.0		1326.0
				98	935.0				98	1119.0		1027.0
				99	1046.0				99	1185.0		1115.5
			Avg:		989.4			Avg:		1227.6	Avg:	1108.5
			Std Dev:		51.101			Std Dev:		221.860	Std Dev:	129.528
	OF1	0	2	95	1113.0	HF2	0	2	95	1490.0		1301.5
				96	1030.0				96	1123.0		1076.5
				97	1174.0				97	1150.0		1162.0
				98	1062.0				98	1228.0		1145.0
				99	1114.0				99	1179.0		1146.5
			Avg:		1098.6			Avg:		1234.0	Avg:	1166.3
			Std Dev:		55.171			Std Dev:		148.302	Std Dev:	82.473
	OF1	90	1	95	931.0	HF2	90	1	95	777.0		854.0
				96	936.0				96	728.0		832.0
				97	952.0				97	791.0		871.5
				98	882.0				98	739.0		810.5
				99	977.0				99	677.0		827.0
			Avg:		935.6			Avg:		742.4	Avg:	839.0
			Std Dev:		34.918			Std Dev:		44.875	Std Dev:	23.909
	OF1	90	2	95	852.0	HF2	90	2	95	708.0		780.0
				96	904.0				96	769.0		836.5
				97	894.0				97	814.0		854.0
				98	960.0				98	668.0		814.0
				99	964.0				99	771.0		867.5
			Avg:		914.8			Avg:		746.0	Avg:	830.4
			Std Dev:		47.320			Std Dev:		57.676	Std Dev:	34.568
A	OF2	0	1	95	1164.0	HF1	0	1	95	1731.0		1447.5
				96	1077.0				96	2007.0		1542.0
				97	974.0				97	1532.0		1253.0
				98	1025.0				98	1837.0		1431.0
				99	970.0				99	1493.0		1231.5
			Avg:		1042.0			Avg:		1720.0	Avg:	1381.0
			Std Dev:		80.941			Std Dev:		213.923	Std Dev:	133.770
	OF2	0	2	95	867.0	HF1	0	2	95	2048.0		1457.5
				96	907.0				96	1742.0		1324.5
				97	923.0				97	1538.0		1230.5
				98	905.0				98	1981.0		1443.0
				99	1193.0				99	1680.0		1436.5
			Avg:		959.0			Avg:		1797.8	Avg:	1378.4
			Std Dev:		132.416			Std Dev:		212.514	Std Dev:	98.216
	OF2	90	1	95	644.0	HF1	90	1	95	913.0		778.5
				96	718.0				96	1079.0		898.5
				97	700.0				97	1030.0		865.0
				98	696.0				98	922.0		809.0
				99	697.0				99	1220.0		958.5
			Avg:		691.0			Avg:		1032.8	Avg:	861.9
			Std Dev:		27.749			Std Dev:		126.308	Std Dev:	71.475
	OF2	90	2	95	617.0	HF1	90	2	95	1099.0		858.0
				96	697.0				96	1081.0		889.0
				97	673.0				97	950.0		811.5
				98	624.0				98	1123.0		873.5
				99	679.0				99	964.0		821.5
			Avg:		658.0			Avg:		1043.4	Avg:	850.7
			Std Dev:		35.440			Std Dev:		80.420	Std Dev:	33.276

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1042.0	HF2	0	1	95	1355.0		1198.5
				96	1028.0				96	1236.0		1132.0
				97	1021.0				97	1291.0		1156.0
				98	1072.0				98	1350.0		1211.0
				99	1027.0				99	1233.0		1130.0
			Avg:		1038.0			Avg:		1293.0	Avg:	1165.5
			Std Dev:		20.506			Std Dev:		59.047	Std Dev:	37.523
	OF1	0	2	95	1039.0	HF2	0	2	95	1295.0		1167.0
				96	1034.0				96	1297.0		1165.5
				97	997.0				97	1246.0		1121.5
				98	993.0				98	1363.0		1178.0
				99	991.0				99	1267.0		1129.0
			Avg:		1010.8			Avg:		1293.6	Avg:	1152.2
			Std Dev:		23.626			Std Dev:		44.168	Std Dev:	25.211
	OF1	90	1	95	792.0	HF2	90	1	95	1018.0		905.0
				96	782.0				96	938.0		860.0
				97	796.0				97	970.0		883.0
				98	780.0				98	971.0		875.5
				99	782.0				99	1018.0		900.0
			Avg:		786.4			Avg:		983.0	Avg:	884.7
			Std Dev:		7.127			Std Dev:		34.598	Std Dev:	18.329
	OF1	90	2	95	760.0	HF2	90	2	95	964.0		862.0
				96	743.0				96	977.0		860.0
				97	773.0				97	991.0		882.0
				98	759.0				98	1054.0		906.5
				99	761.0				99	1053.0		907.0
			Avg:		759.2			Avg:		1007.8	Avg:	883.5
			Std Dev:		10.686			Std Dev:		42.798	Std Dev:	22.902
A	OF2	0	1	95	938.0	HF1	0	1	95	1078.0		1008.0
				96	925.0				96	1067.0		996.0
				97	895.0				97	1052.0		973.5
				98	891.0				98	1054.0		972.5
				99	868.0				99	1067.0		967.5
			Avg:		903.4			Avg:		1063.6	Avg:	983.5
			Std Dev:		28.023			Std Dev:		10.691	Std Dev:	17.561
	OF2	0	2	95	916.0	HF1	0	2	95	1153.0		1034.5
				96	945.0				96	1129.0		1037.0
				97	935.0				97	1079.0		1007.0
				98	956.0				98	1090.0		1023.0
				99	879.0				99	1139.0		1009.0
			Avg:		926.2			Avg:		1118.0	Avg:	1022.1
			Std Dev:		30.211			Std Dev:		31.984	Std Dev:	13.930
	OF2	90	1	95	1074.0	HF1	90	1	95	832.0		953.0
				96	981.0				96	810.0		895.5
				97	982.0				97	807.0		894.5
				98	955.0				98	820.0		887.5
				99	1017.0				99	821.0		919.0
			Avg:		1001.8			Avg:		818.0	Avg:	909.9
			Std Dev:		45.986			Std Dev:		9.925	Std Dev:	26.864
	OF2	90	2	95	975.0	HF1	90	2	95	811.0		893.0
				96	949.0				96	827.0		888.0
				97	1017.0				97	812.0		914.5
				98	1004.0				98	742.0		873.0
				99	1014.0				99	799.0		906.5
			Avg:		991.8			Avg:		798.2	Avg:	895.0
			Std Dev:		29.115			Std Dev:		32.950	Std Dev:	16.198

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1156.0	HF2	0	1	95	998.0		1077.0
				96	1188.0				96	1037.0		1112.5
				97	1134.0				97	1047.0		1090.5
				98	1132.0				98	999.0		1065.5
				99	1170.0				99	1010.0		1090.0
			Avg:		1156.0			Avg:		1018.2	Avg:	1087.1
			Std Dev:		23.875			Std Dev:		22.510	Std Dev:	17.562
	OF1	0	2	95	1178.0	HF2	0	2	95	1067.0		1122.5
				96	1178.0				96	1071.0		1124.5
				97	1172.0				97	1047.0		1109.5
				98	1162.0				98	1039.0		1100.5
				99	1148.0				99	1157.0		1152.5
			Avg:		1167.6			Avg:		1076.2	Avg:	1121.9
			Std Dev:		12.759			Std Dev:		47.108	Std Dev:	19.718
	OF1	90	1	95	1018.0	HF2	90	1	95	751.0		884.5
				96	1006.0				96	742.0		874.0
				97	989.0				97	740.0		864.5
				98	1001.0				98	745.0		873.0
				99	1014.0				99	755.0		884.5
			Avg:		1005.6			Avg:		746.6	Avg:	876.1
			Std Dev:		11.415			Std Dev:		6.269	Std Dev:	8.510
	OF1	90	2	95	1526.0	HF2	90	2	95	1090.0		1308.0
				96	1590.0				96	1069.0		1329.5
				97	1435.0				97	1068.0		1251.5
				98	1502.0				98	1070.0		1286.0
				99	1524.0				99	1131.0		1327.5
			Avg:		1515.4			Avg:		1085.6	Avg:	1300.5
			Std Dev:		55.667			Std Dev:		26.969	Std Dev:	32.548
A	OF2	0	1	95	1181.0	HF1	0	1	95	963.0		1072.0
				96	1173.0				96	972.0		1072.5
				97	1254.0				97	998.0		1126.0
				98	1205.0				98	981.0		1093.0
				99	1153.0				99	997.0		1075.0
			Avg:		1193.2			Avg:		982.2	Avg:	1087.7
			Std Dev:		38.758			Std Dev:		15.353	Std Dev:	23.097
	OF2	0	2	95	1174.0	HF1	0	2	95	1024.0		1099.0
				96	1170.0				96	1023.0		1096.5
				97	1118.0				97	1014.0		1066.0
				98	1206.0				98	1001.0		1103.5
				99	1203.0				99	1027.0		1115.0
			Avg:		1174.2			Avg:		1017.8	Avg:	1096.0
			Std Dev:		35.415			Std Dev:		10.569	Std Dev:	18.211
	OF2	90	1	95	1148.0	HF1	90	1	95	1368.0		1258.0
				96	1181.0				96	1353.0		1267.0
				97	1108.0				97	1376.0		1242.0
				98	1150.0				98	1273.0		1211.5
				99	1130.0				99	1331.0		1230.5
			Avg:		1143.4			Avg:		1340.2	Avg:	1241.8
			Std Dev:		26.978			Std Dev:		41.288	Std Dev:	22.041
	OF2	90	2	95	1269.0	HF1	90	2	95	1224.0		1246.5
				96	1323.0				96	1193.0		1258.0
				97	1224.0				97	1161.0		1192.5
				98	1239.0				98	1094.0		1166.5
				99	1278.0				99	1175.0		1226.5
			Avg:		1266.6			Avg:		1169.4	Avg:	1218.0
			Std Dev:		38.384			Std Dev:		48.284	Std Dev:	38.036

Mix Type=	37.5 mm
Diam.=	6.00 in.
Gage Length=	1.5 in.
Instant	

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	619.0	HF2	0	1	95	1776.0		1197.5
				96	619.0				96	2584.0		1601.5
				97	631.0				97	1705.0		1168.0
				98	551.0				98	1834.0		1192.5
				99	640.0				99	2346.0		1493.0
			Avg:		612.0			Avg:		2049.0	Avg:	1330.5
			Std Dev:		35.228			Std Dev:		391.639	Std Dev:	201.858
	OF1	0	2	95	638.0	HF2	0	2	95	2709.0		1673.5
				96	610.0				96	2109.0		1359.5
				97	629.0				97	2088.0		1358.5
				98	598.0				98	2916.0		1757.0
				99	562.0				99	1374.0		968.0
			Avg:		607.4			Avg:		2239.2	Avg:	1423.3
			Std Dev:		29.830			Std Dev:		605.631	Std Dev:	312.059
	OF1	90	1	95	453.0	HF2	90	1	95	691.0		572.0
				96	430.0				96	613.0		521.5
				97	460.0				97	670.0		565.0
				98	459.0				98	670.0		564.5
				99	439.0				99	662.0		550.5
			Avg:		448.2			Avg:		661.2	Avg:	554.7
			Std Dev:		13.180			Std Dev:		29.012	Std Dev:	20.133
	OF1	90	2	95	458.0	HF2	90	2	95	570.0		514.0
				96	459.0				96	669.0		564.0
				97	450.0				97	607.0		528.5
				98	453.0				98	620.0		536.5
				99	457.0				99	694.0		575.5
			Avg:		455.4			Avg:		632.0	Avg:	543.7
			Std Dev:		3.782			Std Dev:		49.563	Std Dev:	25.438
B	OF2	0	1	95	1885.0	HF1	0	1	95	790.0		1337.5
				96	1701.0				96	837.0		1269.0
				97	1458.0				97	800.0		1129.0
				98	1928.0				98	814.0		1371.0
				99	1643.0				99	807.0		1225.0
			Avg:		1723.0			Avg:		809.6	Avg:	1266.3
			Std Dev:		190.642			Std Dev:		17.700	Std Dev:	95.650
	OF2	0	2	95	1934.0	HF1	0	2	95	859.0		1396.5
				96	1801.0				96	854.0		1327.5
				97	2592.0				97	778.0		1685.0
				98	1337.0				98	770.0		1053.5
				99	2557.0				99	878.0		1717.5
			Avg:		2044.2			Avg:		827.8	Avg:	1436.0
			Std Dev:		532.558			Std Dev:		50.002	Std Dev:	274.264
	OF2	90	1	95	584.0	HF1	90	1	95	727.0		655.5
				96	526.0				96	739.0		632.5
				97	611.0				97	710.0		660.5
				98	549.0				98	692.0		620.5
				99	641.0				99	764.0		702.5
			Avg:		582.2			Avg:		726.4	Avg:	654.3
			Std Dev:		46.235			Std Dev:		27.501	Std Dev:	31.547
	OF2	90	2	95	594.0	HF1	90	2	95	667.0		630.5
				96	660.0				96	664.0		662.0
				97	559.0				97	688.0		623.5
				98	646.0				98	727.0		686.5
				99	563.0				99	622.0		592.5
			Avg:		604.4			Avg:		673.6	Avg:	639.0
			Std Dev:		46.651			Std Dev:		38.266	Std Dev:	36.263

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1304.0	HF2	0	1	95	1641.0		1472.5
				96	1405.0				96	1509.0		1457.0
				97	1296.0				97	1645.0		1470.5
				98	1313.0				98	1725.0		1519.0
				99	1403.0				99	1414.0		1408.5
			Avg:		1344.2			Avg:		1586.8	Avg:	1465.5
			Std Dev:		54.924			Std Dev:		123.831	Std Dev:	39.552
	OF1	0	2	95	1308.0	HF2	0	2	95	1620.0		1464.0
				96	1396.0				96	1508.0		1452.0
				97	1359.0				97	1324.0		1341.5
				98	1343.0				98	1583.0		1463.0
				99	1362.0				99	1427.0		1394.5
			Avg:		1353.6			Avg:		1492.4	Avg:	1423.0
			Std Dev:		31.973			Std Dev:		119.759	Std Dev:	53.797
	OF1	90	1	95	1294.0	HF2	90	1	95	1238.0		1266.0
				96	1564.0				96	1335.0		1449.5
				97	1324.0				97	1201.0		1262.5
				98	1368.0				98	1213.0		1290.5
				99	1376.0				99	1224.0		1300.0
			Avg:		1385.2			Avg:		1242.2	Avg:	1313.7
			Std Dev:		105.372			Std Dev:		53.644	Std Dev:	77.563
	OF1	90	2	95	1296.0	HF2	90	2	95	1382.0		1339.0
				96	2406.0				96	982.0		1694.0
				97	1849.0				97	1099.0		1474.0
				98	2067.0				98	948.0		1507.5
				99	2099.0				99	999.0		1549.0
			Avg:		1943.4			Avg:		1082.0	Avg:	1512.7
			Std Dev:		412.773			Std Dev:		176.871	Std Dev:	128.339
B	OF2	0	1	95	861.0	HF1	0	1	95	1339.0		1100.0
				96	917.0				96	1329.0		1123.0
				97	819.0				97	1279.0		1049.0
				98	870.0				98	1360.0		1115.0
				99	850.0				99	1360.0		1105.0
			Avg:		863.4			Avg:		1333.4	Avg:	1098.4
			Std Dev:		35.613			Std Dev:		33.261	Std Dev:	29.014
	OF2	0	2	95	905.0	HF1	0	2	95	1275.0		1090.0
				96	853.0				96	1200.0		1026.5
				97	884.0				97	1264.0		1074.0
				98	879.0				98	1255.0		1067.0
				99	875.0				99	1201.0		1038.0
			Avg:		879.2			Avg:		1239.0	Avg:	1059.1
			Std Dev:		18.660			Std Dev:		35.854	Std Dev:	26.207
	OF2	90	1	95	511.0	HF1	90	1	95	1818.0		1164.5
				96	511.0				96	1977.0		1244.0
				97	488.0				97	1851.0		1169.5
				98	491.0				98	1943.0		1217.0
				99	497.0				99	1745.0		1121.0
			Avg:		499.6			Avg:		1866.8	Avg:	1183.2
			Std Dev:		10.900			Std Dev:		94.097	Std Dev:	48.076
	OF2	90	2	95	499.0	HF1	90	2	95	1926.0		1212.5
				96	528.0				96	2035.0		1281.5
				97	500.0				97	2042.0		1271.0
				98	511.0				98	2060.0		1285.5
				99	499.0				99	2007.0		1253.0
			Avg:		507.4			Avg:		2014.0	Avg:	1260.7
			Std Dev:		12.582			Std Dev:		52.759	Std Dev:	29.733

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1290.0	HF2	0	1	95	931.0		1110.5
				96	1315.0				96	904.0		1109.5
				97	1287.0				97	904.0		1095.5
				98	1288.0				98	914.0		1101.0
				99	1301.0				99	936.0		1118.5
				Avg:	1296.2				Avg:	917.8	Avg:	1107.0
				Std Dev:	11.904				Std Dev:	15.007	Std Dev:	8.930
	OF1	0	2	95	1315.0	HF2	0	2	95	923.0		1119.0
				96	1314.0				96	900.0		1107.0
				97	1339.0				97	934.0		1136.5
				98	1305.0				98	952.0		1128.5
				99	1323.0				99	896.0		1109.5
				Avg:	1319.2				Avg:	921.0	Avg:	1120.1
				Std Dev:	12.775				Std Dev:	23.452	Std Dev:	12.497
	OF1	90	1	95	4155.0	HF2	90	1	95	646.0		2400.5
				96	3902.0				96	634.0		2268.0
				97	4077.0				97	643.0		2360.0
				98	3970.0				98	646.0		2308.0
				99	3682.0				99	644.0		2163.0
				Avg:	3957.2				Avg:	642.6	Avg:	2299.9
				Std Dev:	181.950				Std Dev:	4.980	Std Dev:	91.593
	OF1	90	2	95	3065.0	HF2	90	2	95	625.0		1845.0
				96	2741.0				96	622.0		1681.5
				97	3083.0				97	602.0		1842.5
				98	2835.0				98	613.0		1724.0
				99	2962.0				99	608.0		1785.0
				Avg:	2937.2				Avg:	614.0	Avg:	1775.6
				Std Dev:	147.601				Std Dev:	9.566	Std Dev:	72.280
B	OF2	0	1	95	817.0	HF1	0	1	95	1558.0		1187.5
				96	790.0				96	1507.0		1148.5
				97	753.0				97	1519.0		1136.0
				98	788.0				98	1572.0		1180.0
				99	794.0				99	1538.0		1166.0
				Avg:	788.4				Avg:	1538.8	Avg:	1163.6
				Std Dev:	22.941				Std Dev:	26.809	Std Dev:	21.423
	OF2	0	2	95	793.0	HF1	0	2	95	1588.0		1190.5
				96	798.0				96	1565.0		1181.5
				97	770.0				97	1548.0		1159.0
				98	748.0				98	1509.0		1128.5
				99	816.0				99	1523.0		1169.5
				Avg:	785.0				Avg:	1546.6	Avg:	1165.8
				Std Dev:	26.401				Std Dev:	31.722	Std Dev:	24.020
	OF2	90	1	95	1225.0	HF1	90	1	95	1188.0		1206.5
				96	1167.0				96	1202.0		1184.5
				97	1287.0				97	1150.0		1218.5
				98	1242.0				98	1185.0		1213.5
				99	1202.0				99	1256.0		1229.0
				Avg:	1224.6				Avg:	1196.2	Avg:	1210.4
				Std Dev:	44.792				Std Dev:	38.525	Std Dev:	16.637
	OF2	90	2	95	1136.0	HF1	90	2	95	1248.0		1192.0
				96	1051.0				96	1166.0		1108.5
				97	1097.0				97	1160.0		1128.5
				98	1090.0				98	1220.0		1155.0
				99	1101.0				99	1205.0		1153.0
				Avg:	1095.0				Avg:	1199.8	Avg:	1147.4
				Std Dev:	30.340				Std Dev:	37.030	Std Dev:	31.419

Mix Type=	37.5 mm
Diam.=	6.00 in.
Gage Length=	1.5 in.
Instant	

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	979.0	HF2	0	1	95	653.0		816.0
				96	968.0				96	708.0		838.0
				97	955.0				97	736.0		845.5
				98	1034.0				98	653.0		843.5
				99	1044.0				99	661.0		852.5
			Avg:		996.0			Avg:		682.2	Avg:	839.1
			Std Dev:		40.317			Std Dev:		37.798	Std Dev:	13.917
	OF1	0	2	95	1031.0	HF2	0	2	95	726.0		878.5
				96	973.0				96	648.0		810.5
				97	933.0				97	721.0		827.0
				98	1091.0				98	764.0		927.5
				99	1040.0				99	689.0		864.5
			Avg:		1013.6			Avg:		709.6	Avg:	861.6
			Std Dev:		61.513			Std Dev:		43.524	Std Dev:	45.949
	OF1	90	1	95	976.0	HF2	90	1	95	1556.0		1266.0
				96	1102.0				96	1159.0		1130.5
				97	1003.0				97	2214.0		1608.5
				98	1197.0				98	1612.0		1404.5
				99	911.0				99	1456.0		1183.5
			Avg:		1037.8			Avg:		1599.4	Avg:	1318.6
			Std Dev:		112.444			Std Dev:		385.451	Std Dev:	192.238
	OF1	90	2	95	1130.0	HF2	90	2	95	1294.0		1212.0
				96	1235.0				96	1978.0		1606.5
				97	1352.0				97	1469.0		1410.5
				98	969.0				98	1392.0		1180.5
				99	1282.0				99	2057.0		1669.5
			Avg:		1193.6			Avg:		1638.0	Avg:	1415.8
			Std Dev:		149.256			Std Dev:		353.049	Std Dev:	222.294
C	OF2	0	1	95	570.0	HF1	0	1	95	948.0		759.0
				96	682.0				96	1127.0		904.5
				97	594.0				97	1086.0		840.0
				98	595.0				98	1039.0		817.0
				99	664.0				99	1062.0		863.0
			Avg:		621.0			Avg:		1052.4	Avg:	836.7
			Std Dev:		48.929			Std Dev:		66.830	Std Dev:	54.141
	OF2	0	2	95	744.0	HF1	0	2	95	1063.0		903.5
				96	617.0				96	1179.0		898.0
				97	642.0				97	1024.0		833.0
				98	650.0				98	1247.0		948.5
				99	602.0				99	1157.0		879.5
			Avg:		651.0			Avg:		1134.0	Avg:	892.5
			Std Dev:		55.426			Std Dev:		90.089	Std Dev:	41.823
	OF2	90	1	95	2131.0	HF1	90	1	95	685.0		1408.0
				96	3421.0				96	683.0		2052.0
				97	2300.0				97	690.0		1495.0
				98	2178.0				98	695.0		1436.5
				99	3040.0				99	627.0		1833.5
			Avg:		2614.0			Avg:		676.0	Avg:	1645.0
			Std Dev:		581.959			Std Dev:		27.785	Std Dev:	284.307
	OF2	90	2	95	3278.0	HF1	90	2	95	732.0		2005.0
				96	2150.0				96	713.0		1431.5
				97	3824.0				97	726.0		2275.0
				98	3095.0				98	685.0		1890.0
				99	2424.0				99	761.0		1592.5
			Avg:		2954.2			Avg:		723.4	Avg:	1838.8
			Std Dev:		672.509			Std Dev:		27.736	Std Dev:	334.317

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	757.0	HF2	0	1	95	1647.0		1202.0
				96	745.0				96	1759.0		1252.0
				97	778.0				97	1824.0		1301.0
				98	737.0				98	1823.0		1280.0
				99	755.0				99	1672.0		1213.5
				Avg:	754.4				Avg:	1745.0	Avg:	1249.7
				Std Dev:	15.453				Std Dev:	82.846	Std Dev:	42.252
	OF1	0	2	95	754.0	HF2	0	2	95	1530.0		1142.0
				96	743.0				96	1435.0		1089.0
				97	737.0				97	1483.0		1110.0
				98	742.0				98	1507.0		1124.5
				99	713.0				99	721.0		717.0
				Avg:	737.8				Avg:	1335.2	Avg:	1036.5
				Std Dev:	15.189				Std Dev:	345.148	Std Dev:	179.661
	OF1	90	1	95	1437.0	HF2	90	1	95	845.0		1141.0
				96	1453.0				96	821.0		1137.0
				97	1511.0				97	845.0		1178.0
				98	1360.0				98	866.0		1113.0
				99	1291.0				99	833.0		1062.0
				Avg:	1410.4				Avg:	842.0	Avg:	1126.2
				Std Dev:	85.789				Std Dev:	16.703	Std Dev:	42.763
	OF1	90	2	95	1439.0	HF2	90	2	95	830.0		1134.5
				96	1460.0				96	856.0		1158.0
				97	1436.0				97	852.0		1144.0
				98	1435.0				98	858.0		1146.5
				99	1371.0				99	842.0		1106.5
				Avg:	1428.2				Avg:	847.6	Avg:	1137.9
				Std Dev:	33.566				Std Dev:	11.610	Std Dev:	19.447
C	OF2	0	1	95	1119.0	HF1	0	1	95	810.0		964.5
				96	1108.0				96	821.0		964.5
				97	1222.0				97	786.0		1004.0
				98	1070.0				98	823.0		946.5
				99	1040.0				99	785.0		912.5
				Avg:	1111.8				Avg:	805.0	Avg:	958.4
				Std Dev:	69.125				Std Dev:	18.480	Std Dev:	33.175
	OF2	0	2	95	1235.0	HF1	0	2	95	799.0		1017.0
				96	1260.0				96	793.0		1026.5
				97	1087.0				97	782.0		934.5
				98	1255.0				98	779.0		1017.0
				99	1080.0				99	796.0		938.0
				Avg:	1183.4				Avg:	789.8	Avg:	986.6
				Std Dev:	91.708				Std Dev:	8.815	Std Dev:	46.143
	OF2	90	1	95	724.0	HF1	90	1	95	1968.0		1346.0
				96	688.0				96	1965.0		1326.5
				97	716.0				97	1847.0		1281.5
				98	710.0				98	2028.0		1369.0
				99	677.0				99	2020.0		1348.5
				Avg:	703.0				Avg:	1965.6	Avg:	1334.3
				Std Dev:	19.748				Std Dev:	72.328	Std Dev:	33.133
	OF2	90	2	95	674.0	HF1	90	2	95	2495.0		1584.5
				96	710.0				96	2208.0		1459.0
				97	688.0				97	2196.0		1442.0
				98	663.0				98	2233.0		1448.0
				99	677.0				99	2145.0		1411.0
				Avg:	682.4				Avg:	2255.4	Avg:	1468.9
				Std Dev:	17.813				Std Dev:	137.725	Std Dev:	67.034

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	877.0	HF2	0	1	95	1378.0		1127.5
				96	916.0				96	1472.0		1194.0
				97	890.0				97	1492.0		1191.0
				98	890.0				98	1456.0		1173.0
				99	885.0				99	1408.0		1146.5
			Avg:		891.6			Avg:		1441.2	Avg:	1166.4
			Std Dev:		14.639			Std Dev:		47.023	Std Dev:	28.808
	OF1	0	2	95	886.0	HF2	0	2	95	1366.0		1126.0
				96	898.0				96	1437.0		1167.5
				97	889.0				97	1497.0		1193.0
				98	874.0				98	1457.0		1165.5
				99	887.0				99	1393.0		1140.0
			Avg:		886.8			Avg:		1430.0	Avg:	1158.4
			Std Dev:		8.585			Std Dev:		51.798	Std Dev:	26.071
	OF1	90	1	95	1018.0	HF2	90	1	95	751.0		884.5
				96	1006.0				96	742.0		874.0
				97	989.0				97	740.0		864.5
				98	1001.0				98	745.0		873.0
				99	1014.0				99	755.0		884.5
			Avg:		1005.6			Avg:		746.6	Avg:	876.1
			Std Dev:		11.415			Std Dev:		6.269	Std Dev:	8.510
	OF1	90	2	95	1091.0	HF2	90	2	95	751.0		921.0
				96	1129.0				96	771.0		950.0
				97	1076.0				97	759.0		917.5
				98	1116.0				98	766.0		941.0
				99	1084.0				99	746.0		915.0
			Avg:		1099.2			Avg:		758.6	Avg:	928.9
			Std Dev:		22.399			Std Dev:		10.310	Std Dev:	15.630
C	OF2	0	1	95	1368.0	HF1	0	1	95	1014.0		1191.0
				96	1351.0				96	1027.0		1189.0
				97	1429.0				97	1009.0		1219.0
				98	1341.0				98	987.0		1164.0
				99	1381.0				99	1016.0		1198.5
			Avg:		1374.0			Avg:		1010.6	Avg:	1192.3
			Std Dev:		34.380			Std Dev:		14.741	Std Dev:	19.779
	OF2	0	2	95	1425.0	HF1	0	2	95	1056.0		1240.5
				96	1387.0				96	1051.0		1219.0
				97	1411.0				97	1049.0		1230.0
				98	1370.0				98	993.0		1181.5
				99	1340.0				99	1036.0		1188.0
			Avg:		1386.6			Avg:		1037.0	Avg:	1211.8
			Std Dev:		33.605			Std Dev:		25.681	Std Dev:	25.939
	OF2	90	1	95	715.0	HF1	90	1	95	1345.0		1030.0
				96	710.0				96	1369.0		1039.5
				97	719.0				97	1348.0		1033.5
				98	727.0				98	1415.0		1071.0
				99	720.0				99	1330.0		1025.0
			Avg:		718.2			Avg:		1361.4	Avg:	1039.8
			Std Dev:		6.301			Std Dev:		33.035	Std Dev:	18.223
	OF2	90	2	95	728.0	HF1	90	2	95	1266.0		997.0
				96	725.0				96	1305.0		1015.0
				97	718.0				97	1304.0		1011.0
				98	704.0				98	1244.0		974.0
				99	702.0				99	1291.0		996.5
			Avg:		715.4			Avg:		1282.0	Avg:	998.7
			Std Dev:		11.908			Std Dev:		26.429	Std Dev:	16.084

Annex 7

NCHRP 1-28A Project

Diametral Test Results

Mr Total

12.5 mm
4 inch Dia.

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	492.0	HF2	0	1	95	719.0		605.5
				96	486.0				96	592.0		539.0
				97	487.0				97	701.0		594.0
				98	509.0				98	690.0		599.5
				99	519.0				99	768.0		643.5
			Avg:		498.6			Avg:		694.0	Avg:	596.3
			Std Dev:		14.673			Std Dev:		64.362	Std Dev:	37.454
	OF1	0	2	95	436.0	HF2	0	2	95	733.0		584.5
				96	428.0				96	818.0		623.0
				97	463.0				97	688.0		575.5
				98	443.0				98	748.0		595.5
				99	438.0				99	656.0		547.0
			Avg:		441.6			Avg:		728.6	Avg:	585.1
			Std Dev:		13.126			Std Dev:		61.861	Std Dev:	27.788
	OF1	90	1	95	502.0	HF2	90	1	95	523.0		512.5
				96	584.0				96	537.0		560.5
				97	571.0				97	551.0		561.0
				98	543.0				98	530.0		536.5
				99	499.0				99	497.0		498.0
			Avg:		539.8			Avg:		527.6	Avg:	533.7
			Std Dev:		38.829			Std Dev:		19.995	Std Dev:	28.263
	OF1	90	2	95	547.0	HF2	90	2	95	591.0		569.0
				96	603.0				96	569.0		586.0
				97	551.0				97	528.0		539.5
				98	508.0				98	535.0		521.5
				99	562.0				99	507.0		534.5
			Avg:		554.2			Avg:		546.0	Avg:	550.1
			Std Dev:		34.054			Std Dev:		33.615	Std Dev:	26.550
A	OF2	0	1	95	657.0	HF1	0	1	95	414.0		535.5
				96	785.0				96	449.0		617.0
				97	712.0				97	435.0		573.5
				98	799.0				98	427.0		613.0
				99	858.0				99	440.0		649.0
			Avg:		762.2			Avg:		433.0	Avg:	597.6
			Std Dev:		78.484			Std Dev:		13.285	Std Dev:	43.854
	OF2	0	2	95	685.0	HF1	0	2	95	392.0		538.5
				96	740.0				96	408.0		574.0
				97	738.0				97	439.0		588.5
				98	749.0				98	409.0		579.0
				99	775.0				99	410.0		592.5
			Avg:		737.4			Avg:		411.6	Avg:	574.5
			Std Dev:		32.792			Std Dev:		17.009	Std Dev:	21.427
	OF2	90	1	95	731.0	HF1	90	1	95	437.0		584.0
				96	647.0				96	406.0		526.5
				97	605.0				97	396.0		500.5
				98	638.0				98	427.0		532.5
				99	584.0				99	423.0		503.5
			Avg:		641.0			Avg:		417.8	Avg:	529.4
			Std Dev:		56.325			Std Dev:		16.544	Std Dev:	33.560
	OF2	90	2	95	608.0	HF1	90	2	95	477.0		542.5
				96	616.0				96	478.0		547.0
				97	638.0				97	473.0		555.5
				98	651.0				98	498.0		574.5
				99	621.0				99	476.0		548.5
			Avg:		626.8			Avg:		480.4	Avg:	553.6
			Std Dev:		17.427			Std Dev:		10.015	Std Dev:	12.582

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Mr Analysis

Specimen	***Observable Face***	***Rotation Effect***	***Repeat***	***Cycle***	***Mr(Ksi)***	***Hidden Face***	***Rotation Effect***	***Repeat***	***Cycle***	***Mr(Ksi)***		***Mr Avg (Ksi)***
A	OF1	0	1	95	457.0	HF2	0	1	95	567.0		512.0
				96	449.0				96	579.0		514.0
				97	452.0				97	562.0		507.0
				98	454.0				98	583.0		518.5
				99	470.0				99	546.0		508.0
				Avg:	456.4				Avg:	567.4	Avg:	511.9
				Std Dev:	8.142				Std Dev:	14.707	Std Dev:	4.669
	OF1	0	2	95	440.0	HF2	0	2	95	570.0		505.0
				96	455.0				96	587.0		521.0
				97	459.0				97	587.0		523.0
				98	459.0				98	592.0		525.5
				99	452.0				99	615.0		533.5
				Avg:	453.0				Avg:	590.2	Avg:	521.6
				Std Dev:	7.842				Std Dev:	16.177	Std Dev:	10.425
	OF1	90	1	95	610.0	HF2	90	1	95	502.0		556.0
				96	611.0				96	487.0		549.0
				97	607.0				97	516.0		561.5
				98	610.0				98	500.0		555.0
				99	621.0				99	491.0		556.0
				Avg:	611.8				Avg:	499.2	Avg:	555.5
				Std Dev:	5.357				Std Dev:	11.256	Std Dev:	4.444
	OF1	90	2	95	551.0	HF2	90	2	95	446.0		498.5
				96	530.0				96	451.0		490.5
				97	560.0				97	441.0		500.5
				98	552.0				98	472.0		512.0
				99	535.0				99	455.0		495.0
				Avg:	545.6				Avg:	453.0	Avg:	499.3
				Std Dev:	12.582				Std Dev:	11.853	Std Dev:	8.051
A	OF2	0	1	95	498.0	HF1	0	1	95	632.0		565.0
				96	483.0				96	589.0		536.0
				97	497.0				97	595.0		546.0
				98	491.0				98	627.0		559.0
				99	490.0				99	602.0		546.0
				Avg:	491.8				Avg:	609.0	Avg:	550.4
				Std Dev:	6.058				Std Dev:	19.352	Std Dev:	11.546
	OF2	0	2	95	574.0	HF1	0	2	95	645.0		609.5
				96	550.0				96	657.0		603.5
				97	561.0				97	649.0		605.0
				98	551.0				98	634.0		592.5
				99	575.0				99	638.0		606.5
				Avg:	562.2				Avg:	644.6	Avg:	603.4
				Std Dev:	12.029				Std Dev:	9.072	Std Dev:	6.485
	OF2	90	1	95	487.0	HF1	90	1	95	552.0		519.5
				96	483.0				96	543.0		513.0
				97	484.0				97	583.0		533.5
				98	471.0				98	530.0		500.5
				99	470.0				99	506.0		488.0
				Avg:	479.0				Avg:	542.8	Avg:	510.9
				Std Dev:	7.906				Std Dev:	28.367	Std Dev:	17.476
	OF2	90	2	95	552.0	HF1	90	2	95	667.0		609.5
				96	513.0				96	671.0		592.0
				97	499.0				97	660.0		579.5
				98	533.0				98	661.0		597.0
				99	510.0				99	687.0		598.5
				Avg:	521.4				Avg:	669.2	Avg:	595.3
				Std Dev:	21.055				Std Dev:	10.918	Std Dev:	10.901

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.00 in
Total

<u>Mr Analysis</u>

Specimen	***Observable Face***	***Rotation Effect***	***Repeat***	***Cycle***	***Mr(Ksi)***	***Hidden Face***	***Rotation Effect***	***Repeat***	***Cycle***	***Mr(Ksi)***		***Mr Avg (Ksi)***
A	OF1	0	1	95	836.0	HF2	0	1	95	648.0		742.0
				96	810.0				96	632.0		721.0
				97	844.0				97	642.0		743.0
				98	790.0				98	615.0		702.5
				99	828.0				99	667.0		747.5
			Avg:		821.6			Avg:		640.8	Avg:	731.2
			Std Dev:		21.698			Std Dev:		19.254	Std Dev:	19.035
	OF1	0	2	95	703.0	HF2	0	2	95	638.0		670.5
				96	700.0				96	639.0		669.5
				97	689.0				97	622.0		655.5
				98	688.0				98	620.0		654.0
				99	666.0				99	613.0		639.5
			Avg:		689.2			Avg:		626.4	Avg:	657.8
			Std Dev:		14.550			Std Dev:		11.546	Std Dev:	12.775
	OF1	90	1	95	656.0	HF2	90	1	95	641.0		648.5
				96	669.0				96	648.0		658.5
				97	687.0				97	642.0		664.5
				98	691.0				98	631.0		661.0
				99	687.0				99	644.0		665.5
			Avg:		678.0			Avg:		641.2	Avg:	659.6
			Std Dev:		14.967			Std Dev:		6.301	Std Dev:	6.804
	OF1	90	2	95	703.0	HF2	90	2	95	620.0		661.5
				96	685.0				96	629.0		657.0
				97	705.0				97	646.0		675.5
				98	685.0				98	635.0		660.0
				99	721.0				99	655.0		688.0
			Avg:		699.8			Avg:		637.0	Avg:	668.4
			Std Dev:		15.205			Std Dev:		13.802	Std Dev:	13.064
A	OF2	0	1	95	618.0	HF1	0	1	95	738.0		678.0
				96	644.0				96	724.0		684.0
				97	623.0				97	719.0		671.0
				98	618.0				98	725.0		671.5
				99	641.0				99	731.0		686.0
			Avg:		628.8			Avg:		727.4	Avg:	678.1
			Std Dev:		12.716			Std Dev:		7.301	Std Dev:	6.914
	OF2	0	2	95	634.0	HF1	0	2	95	711.0		672.5
				96	612.0				96	687.0		649.5
				97	622.0				97	696.0		659.0
				98	643.0				98	737.0		690.0
				99	616.0				99	731.0		673.5
			Avg:		625.4			Avg:		712.4	Avg:	668.9
			Std Dev:		12.876			Std Dev:		21.606	Std Dev:	15.441
	OF2	90	1	95	584.0	HF1	90	1	95	758.0		671.0
				96	533.0				96	695.0		614.0
				97	583.0				97	774.0		678.5
				98	581.0				98	809.0		695.0
				99	560.0				99	753.0		656.5
			Avg:		568.2			Avg:		757.8	Avg:	663.0
			Std Dev:		22.016			Std Dev:		41.385	Std Dev:	30.706
	OF2	90	2	95	547.0	HF1	90	2	95	674.0		610.5
				96	582.0				96	731.0		656.5
				97	575.0				97	704.0		639.5
				98	585.0				98	739.0		662.0
				99	588.0				99	762.0		675.0
			Avg:		575.4			Avg:		722.0	Avg:	648.7
			Std Dev:		16.592			Std Dev:		33.904	Std Dev:	24.866

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle		Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle		Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1		95	747.0	HF2	0	1		95	461.0		604.0
					96	735.0					96	477.0		606.0
					97	710.0					97	429.0		569.5
					98	749.0					98	474.0		611.5
					99	741.0					99	468.0		604.5
				Avg:		736.4				Avg:		461.8	Avg:	599.1
				Std Dev:		15.742				Std Dev:		19.331	Std Dev:	16.813
	OF1	0	2		95	804.0	HF2	0	2		95	520.0		662.0
					96	767.0					96	498.0		632.5
					97	728.0					97	528.0		628.0
					98	734.0					98	553.0		643.5
					99	735.0					99	489.0		612.0
				Avg:		753.6				Avg:		517.6	Avg:	635.6
				Std Dev:		32.036				Std Dev:		25.344	Std Dev:	18.599
	OF1	90	1		95	701.0	HF2	90	1		95	1413.0		1057.0
					96	645.0					96	1071.0		858.0
					97	605.0					97	1314.0		959.5
					98	698.0					98	958.0		828.0
					99	643.0					99	1093.0		868.0
				Avg:		658.4				Avg:		1169.8	Avg:	914.1
				Std Dev:		40.777				Std Dev:		187.389	Std Dev:	93.765
	OF1	90	2		95	650.0	HF2	90	2		95	887.0		768.5
					96	574.0					96	1141.0		857.5
					97	640.0					97	965.0		802.5
					98	623.0					98	953.0		788.0
					99	637.0					99	1228.0		932.5
				Avg:		624.8				Avg:		1034.8	Avg:	829.8
				Std Dev:		29.995				Std Dev:		143.189	Std Dev:	66.266
B	OF2	0	1		95	527.0	HF1	0	1		95	869.0		698.0
					96	542.0					96	909.0		725.5
					97	515.0					97	874.0		694.5
					98	559.0					98	887.0		723.0
					99	540.0					99	900.0		720.0
				Avg:		536.6				Avg:		887.8	Avg:	712.2
				Std Dev:		16.592				Std Dev:		16.903	Std Dev:	14.742
	OF2	0	2		95	554.0	HF1	0	2		95	833.0		693.5
					96	601.0					96	808.0		704.5
					97	544.0					97	834.0		689.0
					98	594.0					98	833.0		713.5
					99	502.0					99	857.0		679.5
				Avg:		559.0				Avg:		833.0	Avg:	696.0
				Std Dev:		40.274				Std Dev:		17.335	Std Dev:	13.285
	OF2	90	1		95	819.0	HF1	90	1		95	829.0		824.0
					96	934.0					96	875.0		904.5
					97	926.0					97	823.0		874.5
					98	809.0					98	880.0		844.5
					99	768.0					99	848.0		808.0
				Avg:		851.2				Avg:		851.0	Avg:	851.1
				Std Dev:		74.483				Std Dev:		25.952	Std Dev:	38.842
	OF2	90	2		95	845.0	HF1	90	2		95	735.0		790.0
					96	868.0					96	808.0		838.0
					97	859.0					97	828.0		843.5
					98	758.0					98	832.0		795.0
					99	833.0					99	773.0		803.0
				Avg:		832.6				Avg:		795.2	Avg:	813.9
				Std Dev:		43.787				Std Dev:		40.960	Std Dev:	25.021

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	667.0	HF2	0	1	95	647.0		657.0
				96	647.0				96	663.0		655.0
				97	684.0				97	651.0		667.5
				98	652.0				98	662.0		657.0
				99	649.0				99	651.0		650.0
				Avg:	659.8				Avg:	654.8	Avg:	657.3
				Std Dev:	15.643				Std Dev:	7.225	Std Dev:	6.380
	OF1	0	2	95	655.0	HF2	0	2	95	699.0		677.0
				96	637.0				96	677.0		657.0
				97	627.0				97	691.0		659.0
				98	651.0				98	693.0		672.0
				99	665.0				99	692.0		678.5
				Avg:	647.0				Avg:	690.4	Avg:	668.7
				Std Dev:	15.033				Std Dev:	8.112	Std Dev:	10.085
	OF1	90	1	95	713.0	HF2	90	1	95	694.0		703.5
				96	671.0				96	723.0		697.0
				97	717.0				97	704.0		710.5
				98	696.0				98	700.0		698.0
				99	752.0				99	738.0		745.0
				Avg:	709.8				Avg:	711.8	Avg:	710.8
				Std Dev:	29.744				Std Dev:	18.226	Std Dev:	19.858
	OF1	90	2	95	703.0	HF2	90	2	95	692.0		697.5
				96	641.0				96	631.0		636.0
				97	673.0				97	645.0		659.0
				98	640.0				98	633.0		636.5
				99	665.0				99	633.0		649.0
				Avg:	664.4				Avg:	646.8	Avg:	655.6
				Std Dev:	26.015				Std Dev:	25.869	Std Dev:	25.297
B	OF2	0	1	95	671.0	HF1	0	1	95	626.0		648.5
				96	700.0				96	634.0		667.0
				97	624.0				97	607.0		615.5
				98	646.0				98	630.0		638.0
				99	649.0				99	604.0		626.5
				Avg:	658.0				Avg:	620.2	Avg:	639.1
				Std Dev:	28.784				Std Dev:	13.755	Std Dev:	19.898
	OF2	0	2	95	618.0	HF1	0	2	95	651.0		634.5
				96	634.0				96	641.0		637.5
				97	616.0				97	628.0		622.0
				98	672.0				98	661.0		666.5
				99	668.0				99	660.0		664.0
				Avg:	641.6				Avg:	648.2	Avg:	644.9
				Std Dev:	26.885				Std Dev:	13.882	Std Dev:	19.485
	OF2	90	1	95	579.0	HF1	90	1	95	866.0		722.5
				96	565.0				96	869.0		717.0
				97	559.0				97	845.0		702.0
				98	567.0				98	843.0		705.0
				99	572.0				99	811.0		691.5
				Avg:	568.4				Avg:	846.8	Avg:	707.6
				Std Dev:	7.537				Std Dev:	23.242	Std Dev:	12.326
	OF2	90	2	95	623.0	HF1	90	2	95	849.0		736.0
				96	606.0				96	844.0		725.0
				97	603.0				97	928.0		765.5
				98	586.0				98	863.0		724.5
				99	553.0				99	813.0		683.0
				Avg:	594.2				Avg:	859.4	Avg:	726.8
				Std Dev:	26.508				Std Dev:	42.477	Std Dev:	29.620

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	653.0	HF2	0	1	95	739.0		696.0
				96	642.0				96	686.0		664.0
				97	650.0				97	693.0		671.5
				98	626.0				98	714.0		670.0
				99	671.0				99	726.0		699.5
			Avg:		648.4			Avg:		712.0	Avg:	680.2
			Std Dev:		16.410			Std Dev:		22.506	Std Dev:	16.312
	OF1	0	2	95	641.0	HF2	0	2	95	695.0		668.0
				96	632.0				96	706.0		669.0
				97	627.0				97	685.0		656.0
				98	630.0				98	693.0		661.5
				99	624.0				99	687.0		655.5
			Avg:		630.8			Avg:		693.2	Avg:	662.0
			Std Dev:		6.458			Std Dev:		8.258	Std Dev:	6.393
	OF1	90	1	95	862.0	HF2	90	1	95	641.0		751.5
				96	859.0				96	647.0		753.0
				97	832.0				97	611.0		721.5
				98	839.0				98	605.0		722.0
				99	822.0				99	602.0		712.0
			Avg:		842.8			Avg:		621.2	Avg:	732.0
			Std Dev:		17.283			Std Dev:		21.171	Std Dev:	18.918
	OF1	90	2	95	832.0	HF2	90	2	95	663.0		747.5
				96	840.0				96	662.0		751.0
				97	860.0				97	663.0		761.5
				98	864.0				98	671.0		767.5
				99	879.0				99	665.0		772.0
			Avg:		855.0			Avg:		664.8	Avg:	759.9
			Std Dev:		18.947			Std Dev:		3.633	Std Dev:	10.485
B	OF2	0	1	95	637.0	HF1	0	1	95	674.0		655.5
				96	588.0				96	633.0		610.5
				97	560.0				97	615.0		587.5
				98	578.0				98	632.0		605.0
				99	584.0				99	643.0		613.5
			Avg:		589.4			Avg:		639.4	Avg:	614.4
			Std Dev:		28.684			Std Dev:		21.801	Std Dev:	25.086
	OF2	0	2	95	660.0	HF1	0	2	95	705.0		682.5
				96	633.0				96	677.0		655.0
				97	596.0				97	655.0		625.5
				98	606.0				98	671.0		638.5
				99	664.0				99	703.0		683.5
			Avg:		631.8			Avg:		682.2	Avg:	657.0
			Std Dev:		30.744			Std Dev:		21.476	Std Dev:	25.937
	OF2	90	1	95	679.0	HF1	90	1	95	782.0		730.5
				96	715.0				96	767.0		741.0
				97	653.0				97	748.0		700.5
				98	670.0				98	783.0		726.5
				99	678.0				99	749.0		713.5
			Avg:		679.0			Avg:		765.8	Avg:	722.4
			Std Dev:		22.661			Std Dev:		17.021	Std Dev:	15.710
	OF2	90	2	95	696.0	HF1	90	2	95	830.0		763.0
				96	644.0				96	735.0		689.5
				97	734.0				97	823.0		778.5
				98	705.0				98	838.0		771.5
				99	691.0				99	756.0		723.5
			Avg:		694.0			Avg:		796.4	Avg:	745.2
			Std Dev:		32.535			Std Dev:		47.353	Std Dev:	37.719

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	300.0	HF2	0	1	95	360.0		330.0
				96	304.0				96	362.0		333.0
				97	302.0				97	350.0		326.0
				98	312.0				98	374.0		343.0
				99	307.0				99	352.0		329.5
			Avg:		305.0			Avg:		359.6	Avg:	332.3
			Std Dev:		4.690			Std Dev:		9.529	Std Dev:	6.477
	OF1	0	2	95	373.0	HF2	0	2	95	339.0		356.0
				96	381.0				96	383.0		382.0
				97	385.0				97	364.0		374.5
				98	371.0				98	376.0		373.5
				99	389.0				99	390.0		389.5
			Avg:		379.8			Avg:		370.4	Avg:	375.1
			Std Dev:		7.694			Std Dev:		20.007	Std Dev:	12.477
	OF1	90	1	95	486.0	HF2	90	1	95	605.0		545.5
				96	511.0				96	591.0		551.0
				97	519.0				97	617.0		568.0
				98	491.0				98	582.0		536.5
				99	553.0				99	572.0		562.5
			Avg:		512.0			Avg:		593.4	Avg:	552.7
			Std Dev:		26.683			Std Dev:		17.925	Std Dev:	12.721
	OF1	90	2	95	532.0	HF2	90	2	95	523.0		527.5
				96	521.0				96	521.0		521.0
				97	543.0				97	499.0		521.0
				98	478.0				98	533.0		505.5
				99	523.0				99	494.0		508.5
			Avg:		519.4			Avg:		514.0	Avg:	516.7
			Std Dev:		24.724			Std Dev:		16.703	Std Dev:	9.305
C	OF2	0	1	95	323.0	HF1	0	1	95	253.0		288.0
				96	412.0				96	314.0		363.0
				97	366.0				97	288.0		327.0
				98	368.0				98	293.0		330.5
				99	363.0				99	294.0		328.5
			Avg:		366.4			Avg:		288.4	Avg:	327.4
			Std Dev:		31.533			Std Dev:		22.143	Std Dev:	26.602
	OF2	0	2	95	370.0	HF1	0	2	95	372.0		371.0
				96	375.0				96	375.0		375.0
				97	384.0				97	365.0		374.5
				98	372.0				98	385.0		378.5
				99	394.0				99	386.0		390.0
			Avg:		379.0			Avg:		376.6	Avg:	377.8
			Std Dev:		9.950			Std Dev:		8.905	Std Dev:	7.319
	OF2	90	1	95	621.0	HF1	90	1	95	539.0		580.0
				96	574.0				96	494.0		534.0
				97	655.0				97	499.0		577.0
				98	570.0				98	506.0		538.0
				99	601.0				99	521.0		561.0
			Avg:		604.2			Avg:		511.8	Avg:	558.0
			Std Dev:		35.195			Std Dev:		18.295	Std Dev:	21.369
	OF2	90	2	95	578.0	HF1	90	2	95	514.0		546.0
				96	502.0				96	551.0		526.5
				97	550.0				97	501.0		525.5
				98	628.0				98	511.0		569.5
				99	573.0				99	493.0		533.0
			Avg:		566.2			Avg:		514.0	Avg:	540.1
			Std Dev:		45.795			Std Dev:		22.293	Std Dev:	18.356

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	540.0	HF2	0	1	95	817.0		678.5
				96	524.0				96	841.0		682.5
				97	519.0				97	792.0		655.5
				98	542.0				98	793.0		667.5
				99	552.0				99	865.0		708.5
			Avg:		535.4			Avg:		821.6	Avg:	678.5
			Std Dev:		13.594			Std Dev:		31.525	Std Dev:	19.786
	OF1	0	2	95	544.0	HF2	0	2	95	881.0		712.5
				96	532.0				96	834.0		683.0
				97	548.0				97	845.0		696.5
				98	543.0				98	859.0		701.0
				99	546.0				99	876.0		711.0
			Avg:		542.6			Avg:		859.0	Avg:	700.8
			Std Dev:		6.229			Std Dev:		19.962	Std Dev:	12.003
	OF1	90	1	95	506.0	HF2	90	1	95	549.0		527.5
				96	506.0				96	537.0		521.5
				97	483.0				97	516.0		499.5
				98	494.0				98	530.0		512.0
				99	504.0				99	527.0		515.5
			Avg:		498.6			Avg:		531.8	Avg:	515.2
			Std Dev:		10.040			Std Dev:		12.235	Std Dev:	10.581
	OF1	90	2	95	484.0	HF2	90	2	95	511.0		497.5
				96	495.0				96	512.0		503.5
				97	513.0				97	521.0		517.0
				98	488.0				98	513.0		500.5
				99	500.0				99	523.0		511.5
			Avg:		496.0			Avg:		516.0	Avg:	506.0
			Std Dev:		11.336			Std Dev:		5.568	Std Dev:	8.062
C	OF2	0	1	95	623.0	HF1	0	1	95	654.0		638.5
				96	604.0				96	646.0		625.0
				97	614.0				97	619.0		616.5
				98	618.0				98	625.0		621.5
				99	600.0				99	626.0		613.0
			Avg:		611.8			Avg:		634.0	Avg:	622.9
			Std Dev:		9.602			Std Dev:		15.116	Std Dev:	9.858
	OF2	0	2	95	718.0	HF1	0	2	95	685.0		701.5
				96	736.0				96	680.0		708.0
				97	701.0				97	655.0		678.0
				98	666.0				98	633.0		649.5
				99	686.0				99	677.0		681.5
			Avg:		701.4			Avg:		666.0	Avg:	683.7
			Std Dev:		27.218			Std Dev:		21.726	Std Dev:	22.991
	OF2	90	1	95	505.0	HF1	90	1	95	512.0		508.5
				96	507.0				96	510.0		508.5
				97	524.0				97	510.0		517.0
				98	527.0				98	521.0		524.0
				99	513.0				99	515.0		514.0
			Avg:		515.2			Avg:		513.6	Avg:	514.4
			Std Dev:		9.910			Std Dev:		4.615	Std Dev:	6.494
	OF2	90	2	95	537.0	HF1	90	2	95	500.0		518.5
				96	534.0				96	478.0		506.0
				97	569.0				97	505.0		537.0
				98	545.0				98	518.0		531.5
				99	555.0				99	515.0		535.0
			Avg:		548.0			Avg:		503.2	Avg:	525.6
			Std Dev:		14.283			Std Dev:		15.865	Std Dev:	13.112

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Mr Avg (Ksi)
C	OF1	0	1	95	771.0	HF2	0	1	95	696.0	733.5
				96	784.0				96	717.0	750.5
				97	794.0				97	708.0	751.0
				98	769.0				98	698.0	733.5
				99	790.0				99	730.0	760.0
				Avg:	781.6				Avg:	709.8	Avg: 745.7
				Std Dev:	11.194				Std Dev:	14.078	Std Dev: 11.761
	OF1	0	2	95	706.0	HF2	0	2	95	649.0	677.5
				96	739.0				96	676.0	707.5
				97	722.0				97	676.0	699.0
				98	728.0				98	694.0	711.0
				99	717.0				99	691.0	704.0
				Avg:	722.4				Avg:	677.2	Avg: 699.8
				Std Dev:	12.300				Std Dev:	17.824	Std Dev: 13.232
	OF1	90	1	95	543.0	HF2	90	1	95	691.0	617.0
				96	594.0				96	773.0	683.5
				97	678.0				97	868.0	773.0
				98	635.0				98	817.0	726.0
				99	597.0				99	708.0	652.5
				Avg:	609.4				Avg:	771.4	Avg: 690.4
				Std Dev:	50.401				Std Dev:	73.989	Std Dev: 61.159
	OF1	90	2	95	602.0	HF2	90	2	95	769.0	685.5
				96	622.0				96	792.0	707.0
				97	629.0				97	813.0	721.0
				98	623.0				98	786.0	704.5
				99	609.0				99	767.0	688.0
				Avg:	617.0				Avg:	785.4	Avg: 701.2
				Std Dev:	11.113				Std Dev:	18.796	Std Dev: 14.640
C	OF2	0	1	95	514.0	HF1	0	1	95	712.0	613.0
				96	506.0				96	696.0	601.0
				97	525.0				97	720.0	622.5
				98	497.0				98	693.0	595.0
				99	515.0				99	693.0	604.0
				Avg:	511.4				Avg:	702.8	Avg: 607.1
				Std Dev:	10.502				Std Dev:	12.438	Std Dev: 10.784
	OF2	0	2	95	534.0	HF1	0	2	95	733.0	633.5
				96	527.0				96	713.0	620.0
				97	542.0				97	742.0	642.0
				98	523.0				98	703.0	613.0
				99	529.0				99	702.0	615.5
				Avg:	531.0				Avg:	718.6	Avg: 624.8
				Std Dev:	7.314				Std Dev:	18.064	Std Dev: 12.453
	OF2	90	1	95	642.0	HF1	90	1	95	666.0	654.0
				96	671.0				96	714.0	692.5
				97	672.0				97	694.0	683.0
				98	666.0				98	674.0	670.0
				99	659.0				99	706.0	682.5
				Avg:	662.0				Avg:	690.8	Avg: 676.4
				Std Dev:	12.309				Std Dev:	20.474	Std Dev: 14.855
	OF2	90	2	95	654.0	HF1	90	2	95	698.0	676.0
				96	657.0				96	670.0	663.5
				97	634.0				97	662.0	648.0
				98	636.0				98	667.0	651.5
				99	655.0				99	684.0	669.5
				Avg:	647.2				Avg:	676.2	Avg: 661.7
				Std Dev:	11.212				Std Dev:	14.670	Std Dev: 11.835

Annex 8

NCHRP 1-28A Project

Diametral Test Results

Mr Total

19.0 mm
4 inch Dia.

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1345.0	HF2	0	1	95	627.0		986.0
				96	1201.0				96	582.0		891.5
				97	1347.0				97	644.0		995.5
				98	1338.0				98	630.0		984.0
				99	1318.0				99	572.0		945.0
				Avg:	1309.8				Avg:	611.0	Avg:	960.4
				Std Dev:	61.893				Std Dev:	31.890	Std Dev:	43.095
	OF1	0	2	95	1544.0	HF2	0	2	95	635.0		1089.5
				96	1545.0				96	622.0		1083.5
				97	1513.0				97	633.0		1073.0
				98	1698.0				98	616.0		1157.0
				99	1719.0				99	600.0		1159.5
				Avg:	1603.8				Avg:	621.2	Avg:	1112.5
				Std Dev:	96.725				Std Dev:	14.202	Std Dev:	42.189
	OF1	90	1	95	691.0	HF2	90	1	95	1190.0		940.5
				96	604.0				96	1263.0		933.5
				97	638.0				97	1182.0		910.0
				98	691.0				98	1275.0		983.0
				99	593.0				99	1151.0		872.0
				Avg:	643.4				Avg:	1212.2	Avg:	927.8
				Std Dev:	46.511				Std Dev:	54.025	Std Dev:	40.839
	OF1	90	2	95	599.0	HF2	90	2	95	1272.0		935.5
				96	643.0				96	1056.0		849.5
				97	592.0				97	1148.0		870.0
				98	652.0				98	1241.0		946.5
				99	593.0				99	1208.0		900.5
				Avg:	615.8				Avg:	1185.0	Avg:	900.4
				Std Dev:	29.235				Std Dev:	85.504	Std Dev:	41.449
A	OF2	0	1	95	640.0	HF1	0	1	95	974.0		807.0
				96	681.0				96	1206.0		943.5
				97	729.0				97	1155.0		942.0
				98	635.0				98	1162.0		898.5
				99	727.0				99	1203.0		965.0
				Avg:	682.4				Avg:	1140.0	Avg:	911.2
				Std Dev:	45.297				Std Dev:	95.643	Std Dev:	63.058
	OF2	0	2	95	723.0	HF1	0	2	95	1521.0		1122.0
				96	691.0				96	1326.0		1008.5
				97	713.0				97	1264.0		988.5
				98	619.0				98	1361.0		990.0
				99	687.0				99	1213.0		950.0
				Avg:	686.6				Avg:	1337.0	Avg:	1011.8
				Std Dev:	40.655				Std Dev:	117.535	Std Dev:	65.177
	OF2	90	1	95	1040.0	HF1	90	1	95	574.0		807.0
				96	1000.0				96	608.0		804.0
				97	1067.0				97	591.0		829.0
				98	992.0				98	605.0		798.5
				99	1105.0				99	635.0		870.0
				Avg:	1040.8				Avg:	602.6	Avg:	821.7
				Std Dev:	47.050				Std Dev:	22.568	Std Dev:	29.385
	OF2	90	2	95	1078.0	HF1	90	2	95	565.0		821.5
				96	1071.0				96	558.0		814.5
				97	1060.0				97	575.0		817.5
				98	1181.0				98	626.0		903.5
				99	1143.0				99	556.0		849.5
				Avg:	1106.6				Avg:	576.0	Avg:	841.3
				Std Dev:	52.719				Std Dev:	28.922	Std Dev:	37.459

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	771.0	HF2	0	1	95	767.0		769.0
				96	844.0				96	802.0		823.0
				97	791.0				97	821.0		806.0
				98	806.0				98	782.0		794.0
				99	787.0				99	805.0		796.0
			Avg:		799.8			Avg:		795.4	Avg:	797.6
			Std Dev:		27.671			Std Dev:		21.078	Std Dev:	19.680
	OF1	0	2	95	795.0	HF2	0	2	95	713.0		754.0
				96	783.0				96	677.0		730.0
				97	780.0				97	677.0		728.5
				98	794.0				98	680.0		737.0
				99	776.0				99	634.0		705.0
			Avg:		785.6			Avg:		676.2	Avg:	730.9
			Std Dev:		8.503			Std Dev:		28.066	Std Dev:	17.665
	OF1	90	1	95	948.0	HF2	90	1	95	751.0		849.5
				96	915.0				96	721.0		818.0
				97	962.0				97	701.0		831.5
				98	976.0				98	713.0		844.5
				99	946.0				99	700.0		823.0
			Avg:		949.4			Avg:		717.2	Avg:	833.3
			Std Dev:		22.711			Std Dev:		20.813	Std Dev:	13.521
	OF1	90	2	95	977.0	HF2	90	2	95	647.0		812.0
				96	1007.0				96	634.0		820.5
				97	1095.0				97	683.0		889.0
				98	976.0				98	671.0		823.5
				99	1039.0				99	669.0		854.0
			Avg:		1018.8			Avg:		660.8	Avg:	839.8
			Std Dev:		49.832			Std Dev:		19.829	Std Dev:	31.754
A	OF2	0	1	95	838.0	HF1	0	1	95	742.0		790.0
				96	863.0				96	716.0		789.5
				97	806.0				97	726.0		766.0
				98	831.0				98	733.0		782.0
				99	864.0				99	760.0		812.0
			Avg:		840.4			Avg:		735.4	Avg:	787.9
			Std Dev:		24.214			Std Dev:		16.727	Std Dev:	16.600
	OF2	0	2	95	720.0	HF1	0	2	95	687.0		703.5
				96	697.0				96	679.0		688.0
				97	726.0				97	699.0		712.5
				98	748.0				98	688.0		718.0
				99	720.0				99	686.0		703.0
			Avg:		722.2			Avg:		687.8	Avg:	705.0
			Std Dev:		18.199			Std Dev:		7.190	Std Dev:	11.407
	OF2	90	1	95	802.0	HF1	90	1	95	774.0		788.0
				96	794.0				96	828.0		811.0
				97	801.0				97	806.0		803.5
				98	806.0				98	779.0		792.5
				99	838.0				99	888.0		863.0
			Avg:		808.2			Avg:		815.0	Avg:	811.6
			Std Dev:		17.210			Std Dev:		46.249	Std Dev:	30.123
	OF2	90	2	95	793.0	HF1	90	2	95	847.0		820.0
				96	759.0				96	806.0		782.5
				97	809.0				97	879.0		844.0
				98	797.0				98	836.0		816.5
				99	736.0				99	868.0		802.0
			Avg:		778.8			Avg:		847.2	Avg:	813.0
			Std Dev:		30.285			Std Dev:		28.578	Std Dev:	22.768

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1619.0	HF2	0	1	95	807.0		1213.0
				96	1585.0				96	784.0		1184.5
				97	1619.0				97	799.0		1209.0
				98	1592.0				98	764.0		1178.0
				99	1720.0				99	841.0		1280.5
			Avg:		1627.0			Avg:		799.0	Avg:	1213.0
			Std Dev:		54.236			Std Dev:		28.627	Std Dev:	40.649
	OF1	0	2	95	1534.0	HF2	0	2	95	799.0		1166.5
				96	1555.0				96	786.0		1170.5
				97	1569.0				97	775.0		1172.0
				98	1602.0				98	791.0		1196.5
				99	1519.0				99	763.0		1141.0
			Avg:		1555.8			Avg:		782.8	Avg:	1169.3
			Std Dev:		32.167			Std Dev:		14.078	Std Dev:	19.731
	OF1	90	1	95	1348.0	HF2	90	1	95	756.0		1052.0
				96	1280.0				96	742.0		1011.0
				97	1393.0				97	746.0		1069.5
				98	1353.0				98	763.0		1058.0
				99	1327.0				99	748.0		1037.5
			Avg:		1340.2			Avg:		751.0	Avg:	1045.6
			Std Dev:		41.264			Std Dev:		8.426	Std Dev:	22.521
	OF1	90	2	95	1259.0	HF2	90	2	95	714.0		986.5
				96	1228.0				96	710.0		969.0
				97	1287.0				97	728.0		1007.5
				98	1251.0				98	704.0		977.5
				99	1313.0				99	708.0		1010.5
			Avg:		1267.6			Avg:		712.8	Avg:	990.2
			Std Dev:		32.997			Std Dev:		9.230	Std Dev:	18.274
A	OF2	0	1	95	899.0	HF1	0	1	95	924.0		911.5
				96	926.0				96	950.0		938.0
				97	910.0				97	966.0		938.0
				98	868.0				98	942.0		905.0
				99	923.0				99	971.0		947.0
			Avg:		905.2			Avg:		950.6	Avg:	927.9
			Std Dev:		23.424			Std Dev:		18.942	Std Dev:	16.454
	OF2	0	2	95	769.0	HF1	0	2	95	893.0		831.0
				96	774.0				96	896.0		835.0
				97	776.0				97	882.0		829.0
				98	766.0				98	911.0		838.5
				99	803.0				99	891.0		847.0
			Avg:		777.6			Avg:		894.6	Avg:	836.1
			Std Dev:		14.741			Std Dev:		10.550	Std Dev:	7.110
	OF2	90	1	95	785.0	HF1	90	1	95	953.0		869.0
				96	793.0				96	1004.0		898.5
				97	822.0				97	1022.0		922.0
				98	795.0				98	1021.0		908.0
				99	783.0				99	994.0		888.5
			Avg:		795.6			Avg:		998.8	Avg:	897.2
			Std Dev:		15.614			Std Dev:		28.190	Std Dev:	20.027
	OF2	90	2	95	745.0	HF1	90	2	95	1005.0		875.0
				96	756.0				96	970.0		863.0
				97	756.0				97	1002.0		879.0
				98	770.0				98	987.0		878.5
				99	768.0				99	996.0		882.0
			Avg:		759.0			Avg:		992.0	Avg:	875.5
			Std Dev:		10.198			Std Dev:		14.089	Std Dev:	7.416

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	918.0	HF2	0	1	95	957.0		937.5
				96	809.0				96	744.0		776.5
				97	946.0				97	867.0		906.5
				98	864.0				98	862.0		863.0
				99	842.0				99	772.0		807.0
			Avg:		875.8			Avg:		840.4	Avg:	858.1
			Std Dev:		55.796			Std Dev:		84.766	Std Dev:	66.971
	OF1	0	2	95	662.0	HF2	0	2	95	819.0		740.5
				96	699.0				96	961.0		830.0
				97	677.0				97	950.0		813.5
				98	687.0				98	917.0		802.0
				99	706.0				99	978.0		842.0
			Avg:		686.2			Avg:		925.0	Avg:	805.6
			Std Dev:		17.513			Std Dev:		63.305	Std Dev:	39.477
	OF1	90	1	95	579.0	HF2	90	1	95	716.0		647.5
				96	584.0				96	808.0		696.0
				97	542.0				97	784.0		663.0
				98	579.0				98	712.0		645.5
				99	587.0				99	703.0		645.0
			Avg:		574.2			Avg:		744.6	Avg:	659.4
			Std Dev:		18.322			Std Dev:		47.915	Std Dev:	21.764
	OF1	90	2	95	508.0	HF2	90	2	95	689.0		598.5
				96	543.0				96	693.0		618.0
				97	524.0				97	703.0		613.5
				98	526.0				98	659.0		592.5
				99	572.0				99	719.0		645.5
			Avg:		534.6			Avg:		692.6	Avg:	613.6
			Std Dev:		24.306			Std Dev:		22.064	Std Dev:	20.677
B	OF2	0	1	95	777.0	HF1	0	1	95	939.0		858.0
				96	808.0				96	856.0		832.0
				97	719.0				97	834.0		776.5
				98	826.0				98	991.0		908.5
				99	922.0				99	956.0		939.0
			Avg:		810.4			Avg:		915.2	Avg:	862.8
			Std Dev:		74.453			Std Dev:		67.221	Std Dev:	63.864
	OF2	0	2	95	900.0	HF1	0	2	95	707.0		803.5
				96	815.0				96	714.0		764.5
				97	791.0				97	676.0		733.5
				98	904.0				98	728.0		816.0
				99	760.0				99	648.0		704.0
			Avg:		834.0			Avg:		694.6	Avg:	764.3
			Std Dev:		65.081			Std Dev:		32.261	Std Dev:	46.889
	OF2	90	1	95	720.0	HF1	90	1	95	535.0		627.5
				96	661.0				96	533.0		597.0
				97	645.0				97	575.0		610.0
				98	653.0				98	518.0		585.5
				99	671.0				99	572.0		621.5
			Avg:		670.0			Avg:		546.6	Avg:	608.3
			Std Dev:		29.563			Std Dev:		25.442	Std Dev:	17.272
	OF2	90	2	95	625.0	HF1	90	2	95	571.0		598.0
				96	713.0				96	551.0		632.0
				97	622.0				97	484.0		553.0
				98	628.0				98	556.0		592.0
				99	607.0				99	536.0		571.5
			Avg:		639.0			Avg:		539.6	Avg:	589.3
			Std Dev:		42.149			Std Dev:		33.501	Std Dev:	29.752

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	621.0	HF2	0	1	95	598.0		609.5
				96	621.0				96	576.0		598.5
				97	594.0				97	528.0		561.0
				98	581.0				98	574.0		577.5
				99	578.0				99	549.0		563.5
				Avg:	599.0				Avg:	565.0	Avg:	582.0
				Std Dev:	20.964				Std Dev:	27.000	Std Dev:	21.401
	OF1	0	2	95	593.0	HF2	0	2	95	584.0		588.5
				96	571.0				96	569.0		570.0
				97	597.0				97	616.0		606.5
				98	599.0				98	617.0		608.0
				99	587.0				99	615.0		601.0
				Avg:	589.4				Avg:	600.2	Avg:	594.8
				Std Dev:	11.261				Std Dev:	22.287	Std Dev:	15.845
	OF1	90	1	95	793.0	HF2	90	1	95	785.0		789.0
				96	766.0				96	804.0		785.0
				97	838.0				97	830.0		834.0
				98	779.0				98	777.0		778.0
				99	790.0				99	838.0		814.0
				Avg:	793.2				Avg:	806.8	Avg:	800.0
				Std Dev:	27.197				Std Dev:	26.846	Std Dev:	23.356
	OF1	90	2	95	724.0	HF2	90	2	95	782.0		753.0
				96	707.0				96	790.0		748.5
				97	730.0				97	806.0		768.0
				98	741.0				98	785.0		763.0
				99	733.0				99	778.0		755.5
				Avg:	727.0				Avg:	788.2	Avg:	757.6
				Std Dev:	12.748				Std Dev:	10.872	Std Dev:	7.837
B	OF2	0	1	95	729.0	HF1	0	1	95	434.0		581.5
				96	712.0				96	431.0		571.5
				97	724.0				97	436.0		580.0
				98	758.0				98	443.0		600.5
				99	675.0				99	427.0		551.0
				Avg:	719.6				Avg:	434.2	Avg:	576.9
				Std Dev:	30.121				Std Dev:	5.975	Std Dev:	17.942
	OF2	0	2	95	658.0	HF1	0	2	95	437.0		547.5
				96	670.0				96	441.0		555.5
				97	690.0				97	434.0		562.0
				98	670.0				98	434.0		552.0
				99	628.0				99	435.0		531.5
				Avg:	663.2				Avg:	436.2	Avg:	549.7
				Std Dev:	22.786				Std Dev:	2.950	Std Dev:	11.471
	OF2	90	1	95	804.0	HF1	90	1	95	849.0		826.5
				96	803.0				96	836.0		819.5
				97	721.0				97	818.0		769.5
				98	777.0				98	890.0		833.5
				99	755.0				99	811.0		783.0
				Avg:	772.0				Avg:	840.8	Avg:	806.4
				Std Dev:	35.000				Std Dev:	31.300	Std Dev:	28.369
	OF2	90	2	95	709.0	HF1	90	2	95	714.0		711.5
				96	726.0				96	737.0		731.5
				97	740.0				97	809.0		774.5
				98	697.0				98	711.0		704.0
				99	699.0				99	732.0		715.5
				Avg:	714.2				Avg:	740.6	Avg:	727.4
				Std Dev:	18.431				Std Dev:	39.841	Std Dev:	28.183

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	670.0	HF2	0	1	95	545.0		607.5
				96	668.0				96	566.0		617.0
				97	694.0				97	579.0		636.5
				98	667.0				98	568.0		617.5
				99	665.0				99	551.0		608.0
			Avg:		672.8			Avg:		561.8	Avg:	617.3
			Std Dev:		11.987			Std Dev:		13.700	Std Dev:	11.740
	OF1	0	2	95	797.0	HF2	0	2	95	586.0		691.5
				96	795.0				96	584.0		689.5
				97	778.0				97	584.0		681.0
				98	856.0				98	607.0		731.5
				99	794.0				99	573.0		683.5
			Avg:		804.0			Avg:		586.8	Avg:	695.4
			Std Dev:		30.042			Std Dev:		12.398	Std Dev:	20.629
	OF1	90	1	95	1068.0	HF2	90	1	95	799.0		933.5
				96	1111.0				96	804.0		957.5
				97	1037.0				97	774.0		905.5
				98	1079.0				98	760.0		919.5
				99	1079.0				99	754.0		916.5
			Avg:		1074.8			Avg:		778.2	Avg:	926.5
			Std Dev:		26.556			Std Dev:		22.543	Std Dev:	20.000
	OF1	90	2	95	1056.0	HF2	90	2	95	698.0		877.0
				96	1137.0				96	775.0		956.0
				97	1069.0				97	772.0		920.5
				98	1080.0				98	759.0		919.5
				99	1050.0				99	759.0		904.5
			Avg:		1078.4			Avg:		752.6	Avg:	915.5
			Std Dev:		34.761			Std Dev:		31.389	Std Dev:	28.655
B	OF2	0	1	95	714.0	HF1	0	1	95	611.0		662.5
				96	680.0				96	590.0		635.0
				97	700.0				97	610.0		655.0
				98	682.0				98	595.0		638.5
				99	645.0				99	545.0		595.0
			Avg:		684.2			Avg:		590.2	Avg:	637.2
			Std Dev:		25.965			Std Dev:		26.863	Std Dev:	26.193
	OF2	0	2	95	702.0	HF1	0	2	95	751.0		726.5
				96	661.0				96	726.0		693.5
				97	665.0				97	725.0		695.0
				98	661.0				98	732.0		696.5
				99	670.0				99	740.0		705.0
			Avg:		671.8			Avg:		734.8	Avg:	703.3
			Std Dev:		17.283			Std Dev:		10.849	Std Dev:	13.714
	OF2	90	1	95	640.0	HF1	90	1	95	677.0		658.5
				96	616.0				96	686.0		651.0
				97	626.0				97	678.0		652.0
				98	633.0				98	651.0		642.0
				99	626.0				99	683.0		654.5
			Avg:		628.2			Avg:		675.0	Avg:	651.6
			Std Dev:		8.955			Std Dev:		13.910	Std Dev:	6.097
	OF2	90	2	95	729.0	HF1	90	2	95	728.0		728.5
				96	645.0				96	649.0		647.0
				97	649.0				97	666.0		657.5
				98	722.0				98	726.0		724.0
				99	739.0				99	767.0		753.0
			Avg:		696.8			Avg:		707.2	Avg:	702.0
			Std Dev:		45.882			Std Dev:		48.597	Std Dev:	46.884

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	711.0	HF2	0	1	95	821.0		766.0
				96	748.0				96	814.0		781.0
				97	805.0				97	925.0		865.0
				98	791.0				98	939.0		865.0
				99	788.0				99	766.0		777.0
			Avg:		768.6			Avg:		853.0	Avg:	810.8
			Std Dev:		38.553			Std Dev:		75.323	Std Dev:	49.782
	OF1	0	2	95	834.0	HF2	0	2	95	829.0		831.5
				96	831.0				96	938.0		884.5
				97	843.0				97	816.0		829.5
				98	815.0				98	794.0		804.5
				99	836.0				99	837.0		836.5
			Avg:		831.8			Avg:		842.8	Avg:	837.3
			Std Dev:		10.378			Std Dev:		55.648	Std Dev:	29.150
	OF1	90	1	95	833.0	HF2	90	1	95	944.0		888.5
				96	766.0				96	1022.0		894.0
				97	766.0				97	1039.0		902.5
				98	873.0				98	1025.0		949.0
				99	710.0				99	992.0		851.0
			Avg:		789.6			Avg:		1004.4	Avg:	897.0
			Std Dev:		63.815			Std Dev:		37.859	Std Dev:	35.112
	OF1	90	2	95	736.0	HF2	90	2	95	1110.0		923.0
				96	730.0				96	1004.0		867.0
				97	769.0				97	1097.0		933.0
				98	647.0				98	953.0		800.0
				99	670.0				99	1000.0		835.0
			Avg:		710.4			Avg:		1032.8	Avg:	871.6
			Std Dev:		50.312			Std Dev:		67.740	Std Dev:	56.787
C	OF2	0	1	95	763.0	HF1	0	1	95	989.0		876.0
				96	755.0				96	1046.0		900.5
				97	848.0				97	976.0		912.0
				98	719.0				98	998.0		858.5
				99	825.0				99	1004.0		914.5
			Avg:		782.0			Avg:		1002.6	Avg:	892.3
			Std Dev:		53.066			Std Dev:		26.454	Std Dev:	24.271
	OF2	0	2	95	706.0	HF1	0	2	95	839.0		772.5
				96	764.0				96	951.0		857.5
				97	800.0				97	884.0		842.0
				98	799.0				98	1029.0		914.0
				99	848.0				99	994.0		921.0
			Avg:		783.4			Avg:		939.4	Avg:	861.4
			Std Dev:		52.581			Std Dev:		77.931	Std Dev:	60.444
	OF2	90	1	95	962.0	HF1	90	1	95	497.0		729.5
				96	1004.0				96	461.0		732.5
				97	980.0				97	474.0		727.0
				98	1068.0				98	489.0		778.5
				99	946.0				99	464.0		705.0
			Avg:		992.0			Avg:		477.0	Avg:	734.5
			Std Dev:		47.645			Std Dev:		15.636	Std Dev:	26.886
	OF2	90	2	95	810.0	HF1	90	2	95	524.0		667.0
				96	771.0				96	458.0		614.5
				97	822.0				97	548.0		685.0
				98	898.0				98	493.0		695.5
				99	847.0				99	531.0		689.0
			Avg:		829.6			Avg:		510.8	Avg:	670.2
			Std Dev:		47.056			Std Dev:		35.605	Std Dev:	32.884

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	993.0	HF2	0	1	95	676.0		834.5
				96	931.0				96	684.0		807.5
				97	938.0				97	694.0		816.0
				98	985.0				98	699.0		842.0
				99	964.0				99	683.0		823.5
			Avg:		962.2				Avg:	687.2	Avg:	824.7
			Std Dev:		27.526				Std Dev:	9.203	Std Dev:	13.859
	OF1	0	2	95	949.0	HF2	0	2	95	621.0		785.0
				96	973.0				96	627.0		800.0
				97	1041.0				97	652.0		846.5
				98	985.0				98	615.0		800.0
				99	1017.0				99	596.0		806.5
			Avg:		993.0				Avg:	622.2	Avg:	807.6
			Std Dev:		36.332				Std Dev:	20.315	Std Dev:	23.134
	OF1	90	1	95	655.0	HF2	90	1	95	673.0		664.0
				96	684.0				96	671.0		677.5
				97	675.0				97	677.0		676.0
				98	657.0				98	668.0		662.5
				99	678.0				99	660.0		669.0
			Avg:		669.8				Avg:	669.8	Avg:	669.8
			Std Dev:		13.027				Std Dev:	6.380	Std Dev:	6.806
	OF1	90	2	95	689.0	HF2	90	2	95	633.0		661.0
				96	666.0				96	632.0		649.0
				97	643.0				97	629.0		636.0
				98	679.0				98	654.0		666.5
				99	678.0				99	647.0		662.5
			Avg:		671.0				Avg:	639.0	Avg:	655.0
			Std Dev:		17.649				Std Dev:	10.886	Std Dev:	12.465
C	OF2	0	1	95	680.0	HF1	0	1	95	810.0		745.0
				96	696.0				96	815.0		755.5
				97	693.0				97	847.0		770.0
				98	700.0				98	816.0		758.0
				99	722.0				99	865.0		793.5
			Avg:		698.2				Avg:	830.6	Avg:	764.4
			Std Dev:		15.271				Std Dev:	24.152	Std Dev:	18.538
	OF2	0	2	95	687.0	HF1	0	2	95	857.0		772.0
				96	658.0				96	822.0		740.0
				97	667.0				97	850.0		758.5
				98	662.0				98	810.0		736.0
				99	675.0				99	795.0		735.0
			Avg:		669.8				Avg:	826.8	Avg:	748.3
			Std Dev:		11.520				Std Dev:	26.300	Std Dev:	16.300
	OF2	90	1	95	957.0	HF1	90	1	95	651.0		804.0
				96	1022.0				96	611.0		816.5
				97	909.0				97	575.0		742.0
				98	902.0				98	590.0		746.0
				99	977.0				99	572.0		774.5
			Avg:		953.4				Avg:	599.8	Avg:	776.6
			Std Dev:		49.722				Std Dev:	32.522	Std Dev:	33.469
	OF2	90	2	95	840.0	HF1	90	2	95	517.0		678.5
				96	856.0				96	553.0		704.5
				97	901.0				97	537.0		719.0
				98	847.0				98	535.0		691.0
				99	887.0				99	556.0		721.5
			Avg:		866.2				Avg:	539.6	Avg:	702.9
			Std Dev:		26.471				Std Dev:	15.710	Std Dev:	18.335

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	871.0	HF2	0	1	95	487.0		679.0
				96	838.0				96	470.0		654.0
				97	820.0				97	477.0		648.5
				98	837.0				98	473.0		655.0
				99	826.0				99	476.0		651.0
				Avg:	838.4				Avg:	476.6	Avg:	657.5
				Std Dev:	19.731				Std Dev:	6.427	Std Dev:	12.288
	OF1	0	2	95	1003.0	HF2	0	2	95	642.0		822.5
				96	806.0				96	613.0		709.5
				97	821.0				97	640.0		730.5
				98	767.0				98	640.0		703.5
				99	970.0				99	655.0		812.5
				Avg:	873.4				Avg:	638.0	Avg:	755.7
				Std Dev:	105.756				Std Dev:	15.313	Std Dev:	57.408
	OF1	90	1	95	635.0	HF2	90	1	95	1084.0		859.5
				96	566.0				96	1002.0		784.0
				97	639.0				97	1035.0		837.0
				98	612.0				98	1008.0		810.0
				99	612.0				99	1071.0		841.5
				Avg:	612.8				Avg:	1040.0	Avg:	826.4
				Std Dev:	29.029				Std Dev:	36.708	Std Dev:	29.592
	OF1	90	2	95	643.0	HF2	90	2	95	1036.0		839.5
				96	622.0				96	1060.0		841.0
				97	625.0				97	1092.0		858.5
				98	615.0				98	999.0		807.0
				99	594.0				99	1037.0		815.5
				Avg:	619.8				Avg:	1044.8	Avg:	832.3
				Std Dev:	17.740				Std Dev:	34.259	Std Dev:	20.834
C	OF2	0	1	95	600.0	HF1	0	1	95	722.0		661.0
				96	642.0				96	761.0		701.5
				97	631.0				97	715.0		673.0
				98	626.0				98	696.0		661.0
				99	608.0				99	708.0		658.0
				Avg:	621.4				Avg:	720.4	Avg:	670.9
				Std Dev:	17.141				Std Dev:	24.643	Std Dev:	18.050
	OF2	0	2	95	624.0	HF1	0	2	95	790.0		707.0
				96	661.0				96	820.0		740.5
				97	615.0				97	793.0		704.0
				98	656.0				98	829.0		742.5
				99	637.0				99	829.0		733.0
				Avg:	638.6				Avg:	812.2	Avg:	725.4
				Std Dev:	19.857				Std Dev:	19.280	Std Dev:	18.538
	OF2	90	1	95	822.0	HF1	90	1	95	884.0		853.0
				96	805.0				96	856.0		830.5
				97	824.0				97	886.0		855.0
				98	860.0				98	942.0		901.0
				99	805.0				99	908.0		856.5
				Avg:	823.2				Avg:	895.2	Avg:	859.2
				Std Dev:	22.466				Std Dev:	32.019	Std Dev:	25.663
	OF2	90	2	95	901.0	HF1	90	2	95	914.0		907.5
				96	823.0				96	894.0		858.5
				97	834.0				97	828.0		831.0
				98	864.0				98	916.0		890.0
				99	811.0				99	870.0		840.5
				Avg:	846.6				Avg:	884.4	Avg:	865.5
				Std Dev:	36.212				Std Dev:	36.590	Std Dev:	32.513

Annex 9

NCHRP 1-28A Project

Diametral Test Results

Mr Total

37.5 mm
4 inch Dia.

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	1198.0	HF2	0	1	95	1135.0		1166.5
				96	1356.0				96	1060.0		1208.0
				97	1254.0				97	1244.0		1249.0
				98	1213.0				98	1048.0		1130.5
				99	1380.0				99	1281.0		1330.5
			Avg:		1280.2			Avg:		1153.6	Avg:	1216.9
			Std Dev:		83.164			Std Dev:		105.666	Std Dev:	77.491
	OF1	0	2	95	1328.0	HF2	0	2	95	1086.0		1207.0
				96	1324.0				96	1311.0		1317.5
				97	1169.0				97	1174.0		1171.5
				98	1455.0				98	1320.0		1387.5
				99	1208.0				99	1224.0		1216.0
			Avg:		1296.8			Avg:		1223.0	Avg:	1259.9
			Std Dev:		112.870			Std Dev:		97.883	Std Dev:	89.638
	OF1	90	1	95	507.0	HF2	90	1	95	453.0		480.0
				96	506.0				96	444.0		475.0
				97	490.0				97	447.0		468.5
				98	507.0				98	420.0		463.5
				99	537.0				99	477.0		507.0
			Avg:		509.4			Avg:		448.2	Avg:	478.8
			Std Dev:		17.038			Std Dev:		20.413	Std Dev:	16.965
	OF1	90	2	95	594.0	HF2	90	2	95	426.0		510.0
				96	510.0				96	441.0		475.5
				97	591.0				97	446.0		518.5
				98	549.0				98	428.0		488.5
				99	544.0				99	425.0		484.5
			Avg:		557.6			Avg:		433.2	Avg:	495.4
			Std Dev:		35.232			Std Dev:		9.628	Std Dev:	18.091
A	OF2	0	1	95	1124.0	HF1	0	1	95	716.0		920.0
				96	949.0				96	702.0		825.5
				97	1246.0				97	786.0		1016.0
				98	1136.0				98	701.0		918.5
				99	1156.0				99	754.0		955.0
			Avg:		1122.2			Avg:		731.8	Avg:	927.0
			Std Dev:		108.006			Std Dev:		37.138	Std Dev:	69.153
	OF2	0	2	95	1238.0	HF1	0	2	95	816.0		1027.0
				96	1098.0				96	837.0		967.5
				97	1433.0				97	853.0		1143.0
				98	1147.0				98	916.0		1031.5
				99	1419.0				99	788.0		1103.5
			Avg:		1267.0			Avg:		842.0	Avg:	1054.5
			Std Dev:		153.673			Std Dev:		47.995	Std Dev:	69.079
	OF2	90	1	95	499.0	HF1	90	1	95	560.0		529.5
				96	481.0				96	596.0		538.5
				97	456.0				97	540.0		498.0
				98	475.0				98	581.0		528.0
				99	447.0				99	570.0		508.5
			Avg:		471.6			Avg:		569.4	Avg:	520.5
			Std Dev:		20.611			Std Dev:		21.185	Std Dev:	16.670
	OF2	90	2	95	434.0	HF1	90	2	95	500.0		467.0
				96	437.0				96	521.0		479.0
				97	443.0				97	503.0		473.0
				98	445.0				98	493.0		469.0
				99	433.0				99	510.0		471.5
			Avg:		438.4			Avg:		505.4	Avg:	471.9
			Std Dev:		5.367			Std Dev:		10.644	Std Dev:	4.588

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	514.0	HF2	0	1	95	3506.0		2010.0
				96	521.0				96	2604.0		1562.5
				97	511.0				97	2687.0		1599.0
				98	497.0				98	2676.0		1586.5
				99	515.0				99	2916.0		1715.5
			Avg:		511.6			Avg:		2877.8	Avg:	1694.7
			Std Dev:		8.933			Std Dev:		370.199	Std Dev:	185.869
	OF1	0	2	95	505.0	HF2	0	2	95	2335.0		1420.0
				96	517.0				96	2099.0		1308.0
				97	514.0				97	2079.0		1296.5
				98	522.0				98	2443.0		1482.5
				99	531.0				99	2503.0		1517.0
			Avg:		517.8			Avg:		2291.8	Avg:	1404.8
			Std Dev:		9.628			Std Dev:		194.800	Std Dev:	99.945
	OF1	90	1	95	641.0	HF2	90	1	95	642.0		641.5
				96	593.0				96	621.0		607.0
				97	588.0				97	658.0		623.0
				98	576.0				98	672.0		624.0
				99	595.0				99	655.0		625.0
			Avg:		598.6			Avg:		649.6	Avg:	624.1
			Std Dev:		24.825			Std Dev:		19.217	Std Dev:	12.219
	OF1	90	2	95	561.0	HF2	90	2	95	647.0		604.0
				96	541.0				96	634.0		587.5
				97	552.0				97	650.0		601.0
				98	556.0				98	638.0		597.0
				99	547.0				99	646.0		596.5
			Avg:		551.4			Avg:		643.0	Avg:	597.2
			Std Dev:		7.765			Std Dev:		6.708	Std Dev:	6.231
A	OF2	0	1	95	1656.0	HF1	0	1	95	389.0		1022.5
				96	1664.0				96	402.0		1033.0
				97	1844.0				97	396.0		1120.0
				98	1926.0				98	381.0		1153.5
				99	1675.0				99	377.0		1026.0
			Avg:		1753.0			Avg:		389.0	Avg:	1071.0
			Std Dev:		124.121			Std Dev:		10.320	Std Dev:	61.295
	OF2	0	2	95	1844.0	HF1	0	2	95	408.0		1126.0
				96	1738.0				96	397.0		1067.5
				97	1917.0				97	399.0		1158.0
				98	2025.0				98	403.0		1214.0
				99	1786.0				99	402.0		1094.0
			Avg:		1862.0			Avg:		401.8	Avg:	1131.9
			Std Dev:		112.993			Std Dev:		4.207	Std Dev:	57.097
	OF2	90	1	95	646.0	HF1	90	1	95	548.0		597.0
				96	635.0				96	539.0		587.0
				97	659.0				97	566.0		612.5
				98	694.0				98	569.0		631.5
				99	692.0				99	549.0		620.5
			Avg:		665.2			Avg:		554.2	Avg:	609.7
			Std Dev:		26.771			Std Dev:		12.795	Std Dev:	17.863
	OF2	90	2	95	591.0	HF1	90	2	95	540.0		565.5
				96	597.0				96	585.0		591.0
				97	609.0				97	613.0		611.0
				98	621.0				98	580.0		600.5
				99	599.0				99	576.0		587.5
			Avg:		603.4			Avg:		578.8	Avg:	591.1
			Std Dev:		11.781			Std Dev:		26.090	Std Dev:	16.976

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	874.0	HF2	0	1	95	2295.0		1584.5
				96	892.0				96	2152.0		1522.0
				97	851.0				97	1997.0		1424.0
				98	870.0				98	2282.0		1576.0
				99	837.0				99	1988.0		1412.5
				Avg:	864.8				Avg:	2142.8	Avg:	1503.8
				Std Dev:	21.300				Std Dev:	148.195	Std Dev:	81.793
	OF1	0	2	95	936.0	HF2	0	2	95	1324.0		1130.0
				96	894.0				96	1304.0		1099.0
				97	915.0				97	1314.0		1114.5
				98	908.0				98	1351.0		1129.5
				99	882.0				99	1266.0		1074.0
				Avg:	907.0				Avg:	1311.8	Avg:	1109.4
				Std Dev:	20.616				Std Dev:	31.019	Std Dev:	23.536
	OF1	90	1	95	991.0	HF2	90	1	95	579.0		785.0
				96	1024.0				96	574.0		799.0
				97	1103.0				97	612.0		857.5
				98	991.0				98	589.0		790.0
				99	1091.0				99	605.0		848.0
				Avg:	1040.0				Avg:	591.8	Avg:	815.9
				Std Dev:	53.917				Std Dev:	16.362	Std Dev:	34.177
	OF1	90	2	95	1031.0	HF2	90	2	95	541.0		786.0
				96	1039.0				96	535.0		787.0
				97	1062.0				97	539.0		800.5
				98	1078.0				98	557.0		817.5
				99	1107.0				99	571.0		839.0
				Avg:	1063.4				Avg:	548.6	Avg:	806.0
				Std Dev:	30.664				Std Dev:	15.060	Std Dev:	22.430
A	OF2	0	1	95	1621.0	HF1	0	1	95	760.0		1190.5
				96	1584.0				96	729.0		1156.5
				97	1520.0				97	735.0		1127.5
				98	1717.0				98	760.0		1238.5
				99	1649.0				99	745.0		1197.0
				Avg:	1618.2				Avg:	745.8	Avg:	1182.0
				Std Dev:	73.367				Std Dev:	14.167	Std Dev:	42.160
	OF2	0	2	95	1219.0	HF1	0	2	95	728.0		973.5
				96	1235.0				96	731.0		983.0
				97	1161.0				97	729.0		945.0
				98	1208.0				98	734.0		971.0
				99	1285.0				99	750.0		1017.5
				Avg:	1221.6				Avg:	734.4	Avg:	978.0
				Std Dev:	44.898				Std Dev:	9.017	Std Dev:	26.189
	OF2	90	1	95	419.0	HF1	90	1	95	915.0		667.0
				96	416.0				96	884.0		650.0
				97	408.0				97	909.0		658.5
				98	405.0				98	892.0		648.5
				99	409.0				99	908.0		658.5
				Avg:	411.4				Avg:	901.6	Avg:	656.5
				Std Dev:	5.857				Std Dev:	13.012	Std Dev:	7.492
	OF2	90	2	95	310.0	HF1	90	2	95	750.0		530.0
				96	311.0				96	735.0		523.0
				97	324.0				97	830.0		577.0
				98	327.0				98	787.0		557.0
				99	320.0				99	770.0		545.0
				Avg:	318.4				Avg:	774.4	Avg:	546.4
				Std Dev:	7.635				Std Dev:	36.801	Std Dev:	21.606

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	703.0	HF2	0	1	95	1471.0		1087.0
				96	760.0				96	1660.0		1210.0
				97	762.0				97	1286.0		1024.0
				98	787.0				98	1382.0		1084.5
				99	805.0				99	1623.0		1214.0
				Avg:	763.4				Avg:	1484.4	Avg:	1123.9
				Std Dev:	38.566				Std Dev:	158.172	Std Dev:	84.299
	OF1	0	2	95	779.0	HF2	0	2	95	1492.0		1135.5
				96	710.0				96	1689.0		1199.5
				97	724.0				97	1334.0		1029.0
				98	744.0				98	1435.0		1089.5
				99	779.0				99	1683.0		1231.0
				Avg:	747.2				Avg:	1526.6	Avg:	1136.9
				Std Dev:	31.444				Std Dev:	156.139	Std Dev:	81.647
	OF1	90	1	95	2910.0	HF2	90	1	95	4292.0		3601.0
				96	2965.0				96	2032.0		2498.5
				97	3946.0				97	1344.0		2645.0
				98	6011.0				98	2653.0		4332.0
				99	3003.0				99	1868.0		2435.5
				Avg:	3767.0				Avg:	2437.8	Avg:	3102.4
				Std Dev:	1325.606				Std Dev:	1136.894	Std Dev:	833.544
	OF1	90	2	95	2592.0	HF2	90	2	95	3792.0		3192.0
				96	2493.0				96	3708.0		3100.5
				97	2986.0				97	4120.0		3553.0
				98	4470.0				98	3285.0		3877.5
				99	2957.0				99	4198.0		3577.5
				Avg:	3099.6				Avg:	3820.6	Avg:	3460.1
				Std Dev:	796.376				Std Dev:	364.841	Std Dev:	315.367
B	OF2	0	1	95	1246.0	HF1	0	1	95	913.0		1079.5
				96	1162.0				96	923.0		1042.5
				97	1277.0				97	954.0		1115.5
				98	1317.0				98	947.0		1132.0
				99	1303.0				99	996.0		1149.5
				Avg:	1261.0				Avg:	946.6	Avg:	1103.8
				Std Dev:	61.608				Std Dev:	32.331	Std Dev:	42.921
	OF2	0	2	95	1228.0	HF1	0	2	95	1046.0		1137.0
				96	1131.0				96	964.0		1047.5
				97	1193.0				97	1029.0		1111.0
				98	1129.0				98	948.0		1038.5
				99	1557.0				99	1073.0		1315.0
				Avg:	1247.6				Avg:	1012.0	Avg:	1129.8
				Std Dev:	178.013				Std Dev:	53.773	Std Dev:	111.594
	OF2	90	1	95	4850.0	HF1	90	1	95	3218.0		4034.0
				96	5720.0				96	4034.0		4877.0
				97	5722.0				97	4858.0		5290.0
				98	4817.0				98	2206.0		3511.5
				99	4155.0				99	2744.0		3449.5
				Avg:	5052.8				Avg:	3412.0	Avg:	4232.4
				Std Dev:	670.030				Std Dev:	1050.725	Std Dev:	822.499
	OF2	90	2	95	4229.0	HF1	90	2	95	2968.0		3598.5
				96	3499.0				96	4498.0		3998.5
				97	6431.0				97	4207.0		5319.0
				98	3513.0				98	3294.0		3403.5
				99	4075.0				99	3473.0		3774.0
				Avg:	4349.4				Avg:	3688.0	Avg:	4018.7
				Std Dev:	1208.883				Std Dev:	641.351	Std Dev:	759.293

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1198.0	HF2	0	1	95	998.0		1098.0
				96	1266.0				96	997.0		1131.5
				97	1232.0				97	1115.0		1173.5
				98	1155.0				98	1058.0		1106.5
				99	1184.0				99	1086.0		1135.0
			Avg:		1207.0			Avg:		1050.8	Avg:	1128.9
			Std Dev:		43.070			Std Dev:		52.666	Std Dev:	29.537
	OF1	0	2	95	1247.0	HF2	0	2	95	1167.0		1207.0
				96	1232.0				96	1174.0		1203.0
				97	1225.0				97	1114.0		1169.5
				98	1276.0				98	1075.0		1175.5
				99	1273.0				99	1121.0		1197.0
			Avg:		1250.6			Avg:		1130.2	Avg:	1190.4
			Std Dev:		23.244			Std Dev:		40.825	Std Dev:	16.857
	OF1	90	1	95	1185.0	HF2	90	1	95	895.0		1040.0
				96	1138.0				96	867.0		1002.5
				97	1165.0				97	875.0		1020.0
				98	1175.0				98	874.0		1024.5
				99	1258.0				99	927.0		1092.5
			Avg:		1184.2			Avg:		887.6	Avg:	1035.9
			Std Dev:		44.819			Std Dev:		24.368	Std Dev:	34.346
	OF1	90	2	95	1190.0	HF2	90	2	95	960.0		1085.0
				96	1177.0				96	958.0		1067.5
				97	1186.0				97	945.0		1065.5
				98	1152.0				98	954.0		1053.0
				99	1189.0				99	960.0		1074.5
			Avg:		1178.8			Avg:		959.4	Avg:	1069.1
			Std Dev:		15.834			Std Dev:		12.876	Std Dev:	11.797
B	OF2	0	1	95	1009.0	HF1	0	1	95	1286.0		1147.5
				96	1094.0				96	1340.0		1217.0
				97	1111.0				97	1265.0		1188.0
				98	1049.0				98	1234.0		1141.5
				99	1085.0				99	1263.0		1174.0
			Avg:		1069.6			Avg:		1277.6	Avg:	1173.6
			Std Dev:		40.753			Std Dev:		39.488	Std Dev:	30.833
	OF2	0	2	95	978.0	HF1	0	2	95	1182.0		1080.0
				96	985.0				96	1237.0		1111.0
				97	1063.0				97	1265.0		1164.0
				98	976.0				98	1253.0		1114.5
				99	1001.0				99	1294.0		1147.5
			Avg:		1000.6			Avg:		1246.2	Avg:	1123.4
			Std Dev:		36.239			Std Dev:		41.505	Std Dev:	32.961
	OF2	90	1	95	749.0	HF1	90	1	95	2229.0		1489.0
				96	735.0				96	1964.0		1349.5
				97	719.0				97	2215.0		1467.0
				98	772.0				98	2665.0		1718.5
				99	775.0				99	2264.0		1519.5
			Avg:		750.0			Avg:		2267.4	Avg:	1508.7
			Std Dev:		23.958			Std Dev:		252.175	Std Dev:	133.795
	OF2	90	2	95	692.0	HF1	90	2	95	1843.0		1267.5
				96	710.0				96	1856.0		1283.0
				97	704.0				97	1903.0		1303.5
				98	702.0				98	1812.0		1257.0
				99	707.0				99	2003.0		1355.0
			Avg:		703.0			Avg:		1883.4	Avg:	1293.2
			Std Dev:		6.856			Std Dev:		74.447	Std Dev:	38.731

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	1030.0	HF2	0	1	95	803.0		916.5
				96	1043.0				96	853.0		948.0
				97	1027.0				97	828.0		927.5
				98	1022.0				98	820.0		921.0
				99	1024.0				99	863.0		943.5
			Avg:		1029.2			Avg:		833.4	Avg:	931.3
			Std Dev:		8.289			Std Dev:		24.460	Std Dev:	13.850
	OF1	0	2	95	1007.0	HF2	0	2	95	830.0		918.5
				96	1009.0				96	826.0		917.5
				97	984.0				97	830.0		907.0
				98	987.0				98	796.0		891.5
				99	1009.0				99	815.0		912.0
			Avg:		999.2			Avg:		819.4	Avg:	909.3
			Std Dev:		12.578			Std Dev:		14.450	Std Dev:	10.969
	OF1	90	1	95	1009.0	HF2	90	1	95	1308.0		1158.5
				96	949.0				96	1293.0		1121.0
				97	954.0				97	1283.0		1118.5
				98	949.0				98	1260.0		1104.5
				99	971.0				99	1273.0		1122.0
			Avg:		966.4			Avg:		1283.4	Avg:	1124.9
			Std Dev:		25.472			Std Dev:		18.393	Std Dev:	20.061
	OF1	90	2	95	949.0	HF2	90	2	95	1325.0		1137.0
				96	936.0				96	1351.0		1143.5
				97	899.0				97	1309.0		1104.0
				98	934.0				98	1334.0		1134.0
				99	908.0				99	1285.0		1096.5
			Avg:		925.2			Avg:		1320.8	Avg:	1123.0
			Std Dev:		20.873			Std Dev:		25.124	Std Dev:	21.216
B	OF2	0	1	95	789.0	HF1	0	1	95	780.0		784.5
				96	774.0				96	791.0		782.5
				97	883.0				97	799.0		841.0
				98	849.0				98	860.0		854.5
				99	845.0				99	818.0		831.5
			Avg:		828.0			Avg:		809.6	Avg:	818.8
			Std Dev:		45.255			Std Dev:		31.405	Std Dev:	33.252
	OF2	0	2	95	708.0	HF1	0	2	95	889.0		798.5
				96	701.0				96	882.0		791.5
				97	728.0				97	907.0		817.5
				98	743.0				98	902.0		822.5
				99	747.0				99	921.0		834.0
			Avg:		725.4			Avg:		900.2	Avg:	812.8
			Std Dev:		20.501			Std Dev:		15.320	Std Dev:	17.491
	OF2	90	1	95	1003.0	HF1	90	1	95	1099.0		1051.0
				96	963.0				96	994.0		978.5
				97	970.0				97	1003.0		986.5
				98	1002.0				98	1069.0		1035.5
				99	1044.0				99	1050.0		1047.0
			Avg:		996.4			Avg:		1043.0	Avg:	1019.7
			Std Dev:		32.223			Std Dev:		44.334	Std Dev:	34.548
	OF2	90	2	95	1216.0	HF1	90	2	95	933.0		1074.5
				96	1208.0				96	949.0		1078.5
				97	1192.0				97	941.0		1066.5
				98	1121.0				98	904.0		1012.5
				99	1207.0				99	975.0		1091.0
			Avg:		1188.8			Avg:		940.4	Avg:	1064.6
			Std Dev:		38.681			Std Dev:		25.745	Std Dev:	30.439

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	3867.0	HF2	0	1	95	1459.0		2663.0
				96	3633.0				96	1233.0		2433.0
				97	4591.0				97	1288.0		2939.5
				98	5499.0				98	1295.0		3397.0
				99	3401.0				99	1108.0		2254.5
				Avg:	4198.2				Avg:	1276.6	Avg:	2737.4
				Std Dev:	853.089				Std Dev:	126.556	Std Dev:	449.250
	OF1	0	2	95	2927.0	HF2	0	2	95	1600.0		2263.5
				96	3126.0				96	1129.0		2127.5
				97	5742.0				97	1388.0		3565.0
				98	4591.0				98	1598.0		3094.5
				99	4906.0				99	1314.0		3110.0
				Avg:	4258.4				Avg:	1405.8	Avg:	2832.1
				Std Dev:	1202.709				Std Dev:	200.010	Std Dev:	612.983
	OF1	90	1	95	512.0	HF2	90	1	95	934.0		723.0
				96	498.0				96	934.0		716.0
				97	488.0				97	836.0		662.0
				98	544.0				98	876.0		710.0
				99	491.0				99	883.0		687.0
				Avg:	506.6				Avg:	892.6	Avg:	699.6
				Std Dev:	22.865				Std Dev:	41.831	Std Dev:	24.986
	OF1	90	2	95	480.0	HF2	90	2	95	775.0		627.5
				96	522.0				96	830.0		676.0
				97	471.0				97	854.0		662.5
				98	470.0				98	785.0		627.5
				99	479.0				99	840.0		659.5
				Avg:	484.4				Avg:	816.8	Avg:	650.6
				Std Dev:	21.501				Std Dev:	34.838	Std Dev:	21.984
C	OF2	0	1	95	1622.0	HF1	0	1	95	1441.0		1531.5
				96	1682.0				96	1386.0		1534.0
				97	1801.0				97	1467.0		1634.0
				98	1598.0				98	1450.0		1524.0
				99	1535.0				99	1471.0		1503.0
				Avg:	1647.6				Avg:	1443.0	Avg:	1545.3
				Std Dev:	100.634				Std Dev:	34.139	Std Dev:	51.061
	OF2	0	2	95	1483.0	HF1	0	2	95	1627.0		1555.0
				96	1888.0				96	1328.0		1608.0
				97	2038.0				97	1508.0		1773.0
				98	2179.0				98	1572.0		1875.5
				99	1579.0				99	1482.0		1530.5
				Avg:	1833.4				Avg:	1503.4	Avg:	1668.4
				Std Dev:	296.556				Std Dev:	113.167	Std Dev:	149.462
	OF2	90	1	95	1063.0	HF1	90	1	95	383.0		723.0
				96	1101.0				96	382.0		741.5
				97	1018.0				97	349.0		683.5
				98	918.0				98	364.0		641.0
				99	1068.0				99	386.0		727.0
				Avg:	1033.6				Avg:	372.8	Avg:	703.2
				Std Dev:	71.058				Std Dev:	15.865	Std Dev:	40.873
	OF2	90	2	95	809.0	HF1	90	2	95	366.0		587.5
				96	930.0				96	398.0		664.0
				97	1002.0				97	402.0		702.0
				98	954.0				98	370.0		662.0
				99	849.0				99	371.0		610.0
				Avg:	908.8				Avg:	381.4	Avg:	645.1
				Std Dev:	78.605				Std Dev:	17.141	Std Dev:	45.908

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	2745.0	HF2	0	1	95	1038.0		1891.5
				96	2780.0				96	997.0		1888.5
				97	2708.0				97	924.0		1816.0
				98	2769.0				98	1046.0		1907.5
				99	2696.0				99	1033.0		1864.5
			Avg:		2739.6			Avg:		1007.6	Avg:	1873.6
			Std Dev:		36.828			Std Dev:		50.362	Std Dev:	35.680
	OF1	0	2	95	2696.0	HF2	0	2	95	906.0		1801.0
				96	2827.0				96	917.0		1872.0
				97	2574.0				97	905.0		1739.5
				98	2822.0				98	947.0		1884.5
				99	2730.0				99	890.0		1810.0
			Avg:		2729.8			Avg:		913.0	Avg:	1821.4
			Std Dev:		104.121			Std Dev:		21.296	Std Dev:	58.728
	OF1	90	1	95	882.0	HF2	90	1	95	1189.0		1035.5
				96	884.0				96	1211.0		1047.5
				97	929.0				97	1187.0		1058.0
				98	915.0				98	1189.0		1052.0
				99	859.0				99	1148.0		1003.5
			Avg:		893.8			Avg:		1184.8	Avg:	1039.3
			Std Dev:		27.995			Std Dev:		22.808	Std Dev:	21.647
	OF1	90	2	95	807.0	HF2	90	2	95	1061.0		934.0
				96	809.0				96	1047.0		928.0
				97	796.0				97	1112.0		954.0
				98	772.0				98	1113.0		942.5
				99	779.0				99	1054.0		916.5
			Avg:		792.6			Avg:		1077.4	Avg:	935.0
			Std Dev:		16.562			Std Dev:		32.424	Std Dev:	14.226
C	OF2	0	1	95	905.0	HF1	0	1	95	1660.0		1282.5
				96	931.0				96	1518.0		1224.5
				97	946.0				97	1510.0		1228.0
				98	976.0				98	1512.0		1244.0
				99	956.0				99	1560.0		1258.0
			Avg:		942.8			Avg:		1552.0	Avg:	1247.4
			Std Dev:		26.715			Std Dev:		63.734	Std Dev:	23.752
	OF2	0	2	95	931.0	HF1	0	2	95	1691.0		1311.0
				96	900.0				96	1488.0		1194.0
				97	888.0				97	1609.0		1248.5
				98	975.0				98	1783.0		1379.0
				99	978.0				99	1406.0		1192.0
			Avg:		934.4			Avg:		1595.4	Avg:	1264.9
			Std Dev:		41.525			Std Dev:		151.596	Std Dev:	80.241
	OF2	90	1	95	989.0	HF1	90	1	95	794.0		891.5
				96	1012.0				96	796.0		904.0
				97	1060.0				97	884.0		972.0
				98	1154.0				98	834.0		994.0
				99	1106.0				99	805.0		955.5
			Avg:		1064.2			Avg:		822.6	Avg:	943.4
			Std Dev:		67.470			Std Dev:		37.866	Std Dev:	44.076
	OF2	90	2	95	1042.0	HF1	90	2	95	845.0		943.5
				96	1137.0				96	841.0		989.0
				97	1084.0				97	811.0		947.5
				98	1037.0				98	814.0		925.5
				99	1029.0				99	802.0		915.5
			Avg:		1065.8			Avg:		822.6	Avg:	944.2
			Std Dev:		45.141			Std Dev:		19.191	Std Dev:	28.248

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	3130.0	HF2	0	1	95	1523.0		2326.5
				96	3110.0				96	1430.0		2270.0
				97	3059.0				97	1470.0		2264.5
				98	3020.0				98	1396.0		2208.0
				99	3300.0				99	1451.0		2375.5
				Avg:	3123.8				Avg:	1454.0	Avg:	2288.9
				Std Dev:	107.528				Std Dev:	47.344	Std Dev:	64.052
	OF1	0	2	95	2764.0	HF2	0	2	95	1538.0		2151.0
				96	2690.0				96	1510.0		2100.0
				97	2626.0				97	1466.0		2046.0
				98	2815.0				98	1503.0		2159.0
				99	2789.0				99	1545.0		2167.0
				Avg:	2736.8				Avg:	1512.4	Avg:	2124.6
				Std Dev:	77.535				Std Dev:	31.485	Std Dev:	51.140
	OF1	90	1	95	943.0	HF2	90	1	95	1214.0		1078.5
				96	910.0				96	1198.0		1054.0
				97	956.0				97	1206.0		1081.0
				98	903.0				98	1213.0		1058.0
				99	901.0				99	1220.0		1060.5
				Avg:	922.6				Avg:	1210.2	Avg:	1066.4
				Std Dev:	25.205				Std Dev:	8.438	Std Dev:	12.437
	OF1	90	2	95	840.0	HF2	90	2	95	1059.0		949.5
				96	926.0				96	1109.0		1017.5
				97	889.0				97	1080.0		984.5
				98	920.0				98	1066.0		993.0
				99	887.0				99	1259.0		1073.0
				Avg:	892.4				Avg:	1114.6	Avg:	1003.5
				Std Dev:	34.195				Std Dev:	82.966	Std Dev:	45.863
C	OF2	0	1	95	956.0	HF1	0	1	95	1486.0		1221.0
				96	936.0				96	1285.0		1110.5
				97	943.0				97	1334.0		1138.5
				98	945.0				98	2535.0		1740.0
				99	942.0				99	1465.0		1203.5
				Avg:	944.4				Avg:	1621.0	Avg:	1282.7
				Std Dev:	7.301				Std Dev:	517.982	Std Dev:	259.639
	OF2	0	2	95	864.0	HF1	0	2	95	2532.0		1698.0
				96	865.0				96	2569.0		1717.0
				97	868.0				97	2653.0		1760.5
				98	869.0				98	3353.0		2111.0
				99	853.0				99	2788.0		1820.5
				Avg:	863.8				Avg:	2779.0	Avg:	1821.4
				Std Dev:	6.380				Std Dev:	335.612	Std Dev:	168.601
	OF2	90	1	95	1071.0	HF1	90	1	95	1070.0		1070.5
				96	1053.0				96	1036.0		1044.5
				97	1090.0				97	1088.0		1089.0
				98	1083.0				98	1031.0		1057.0
				99	1105.0				99	1095.0		1100.0
				Avg:	1080.4				Avg:	1064.0	Avg:	1072.2
				Std Dev:	19.642				Std Dev:	29.351	Std Dev:	22.673
	OF2	90	2	95	1196.0	HF1	90	2	95	986.0		1091.0
				96	1163.0				96	957.0		1060.0
				97	1209.0				97	985.0		1097.0
				98	1142.0				98	959.0		1050.5
				99	1201.0				99	984.0		1092.5
				Avg:	1182.2				Avg:	974.2	Avg:	1078.2
				Std Dev:	28.490				Std Dev:	14.822	Std Dev:	21.332

Annex 10

NCHRP 1-28A Project

Diametral Test Results

Mr Total

12.5 mm
6 inch Dia.

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	703.0	HF2	0	1	95	464.0		583.5
				96	695.0				96	445.0		570.0
				97	714.0				97	419.0		566.5
				98	643.0				98	414.0		528.5
				99	695.0				99	452.0		573.5
			Avg:		690.0			Avg:		438.8	Avg:	564.4
			Std Dev:		27.404			Std Dev:		21.534	Std Dev:	21.049
	OF1	0	2	95	729.0	HF2	0	2	95	440.0		584.5
				96	713.0				96	458.0		585.5
				97	671.0				97	423.0		547.0
				98	641.0				98	407.0		524.0
				99	702.0				99	432.0		567.0
			Avg:		691.2			Avg:		432.0	Avg:	561.6
			Std Dev:		35.174			Std Dev:		19.013	Std Dev:	26.228
	OF1	90	1	95	920.0	HF2	90	1	95	504.0		712.0
				96	822.0				96	574.0		698.0
				97	774.0				97	503.0		638.5
				98	736.0				98	525.0		630.5
				99	753.0				99	534.0		643.5
			Avg:		801.0			Avg:		528.0	Avg:	664.5
			Std Dev:		73.926			Std Dev:		28.991	Std Dev:	37.588
	OF1	90	2	95	744.0	HF2	90	2	95	527.0		635.5
				96	760.0				96	518.0		639.0
				97	758.0				97	534.0		646.0
				98	809.0				98	499.0		654.0
				99	769.0				99	484.0		626.5
			Avg:		768.0			Avg:		512.4	Avg:	640.2
			Std Dev:		24.607			Std Dev:		20.599	Std Dev:	10.432
A	OF2	0	1	95	445.0	HF1	0	1	95	586.0		515.5
				96	428.0				96	615.0		521.5
				97	415.0				97	602.0		508.5
				98	426.0				98	577.0		501.5
				99	431.0				99	596.0		513.5
			Avg:		429.0			Avg:		595.2	Avg:	512.1
			Std Dev:		10.794			Std Dev:		14.618	Std Dev:	7.537
	OF2	0	2	95	461.0	HF1	0	2	95	635.0		548.0
				96	443.0				96	650.0		546.5
				97	444.0				97	626.0		535.0
				98	425.0				98	622.0		523.5
				99	453.0				99	585.0		519.0
			Avg:		445.2			Avg:		623.6	Avg:	534.4
			Std Dev:		13.461			Std Dev:		24.110	Std Dev:	13.112
	OF2	90	1	95	522.0	HF1	90	1	95	819.0		670.5
				96	507.0				96	837.0		672.0
				97	559.0				97	815.0		687.0
				98	572.0				98	750.0		661.0
				99	517.0				99	750.0		633.5
			Avg:		535.4			Avg:		794.2	Avg:	664.8
			Std Dev:		28.378			Std Dev:		41.191	Std Dev:	19.820
	OF2	90	2	95	591.0	HF1	90	2	95	676.0		633.5
				96	520.0				96	696.0		608.0
				97	508.0				97	690.0		599.0
				98	559.0				98	719.0		639.0
				99	501.0				99	789.0		645.0
			Avg:		535.8			Avg:		714.0	Avg:	624.9
			Std Dev:		38.141			Std Dev:		44.705	Std Dev:	20.206

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	566.0	HF2	0	1	95	626.0		596.0
				96	607.0				96	661.0		634.0
				97	577.0				97	656.0		616.5
				98	567.0				98	631.0		599.0
				99	601.0				99	660.0		630.5
			Avg:		583.6			Avg:		646.8	Avg:	615.2
			Std Dev:		19.230			Std Dev:		16.903	Std Dev:	17.466
	OF1	0	2	95	589.0	HF2	0	2	95	696.0		642.5
				96	582.0				96	672.0		627.0
				97	594.0				97	715.0		654.5
				98	596.0				98	682.0		639.0
				99	572.0				99	691.0		631.5
			Avg:		586.6			Avg:		691.2	Avg:	638.9
			Std Dev:		9.788			Std Dev:		16.146	Std Dev:	10.638
	OF1	90	1	95	650.0	HF2	90	1	95	638.0		644.0
				96	648.0				96	619.0		633.5
				97	656.0				97	665.0		660.5
				98	604.0				98	581.0		592.5
				99	595.0				99	604.0		599.5
			Avg:		630.6			Avg:		621.4	Avg:	626.0
			Std Dev:		28.719			Std Dev:		32.083	Std Dev:	29.133
	OF1	90	2	95	619.0	HF2	90	2	95	647.0		633.0
				96	615.0				96	651.0		633.0
				97	625.0				97	639.0		632.0
				98	637.0				98	641.0		639.0
				99	609.0				99	620.0		614.5
			Avg:		621.0			Avg:		639.6	Avg:	630.3
			Std Dev:		10.677			Std Dev:		11.950	Std Dev:	9.257
A	OF2	0	1	95	718.0	HF1	0	1	95	602.0		660.0
				96	701.0				96	597.0		649.0
				97	664.0				97	592.0		628.0
				98	635.0				98	584.0		609.5
				99	709.0				99	602.0		655.5
			Avg:		685.4			Avg:		595.4	Avg:	640.4
			Std Dev:		34.861			Std Dev:		7.603	Std Dev:	21.182
	OF2	0	2	95	758.0	HF1	0	2	95	631.0		694.5
				96	717.0				96	608.0		662.5
				97	709.0				97	623.0		666.0
				98	768.0				98	628.0		698.0
				99	725.0				99	620.0		672.5
			Avg:		735.4			Avg:		622.0	Avg:	678.7
			Std Dev:		26.063			Std Dev:		8.916	Std Dev:	16.464
	OF2	90	1	95	627.0	HF1	90	1	95	634.0		630.5
				96	649.0				96	680.0		664.5
				97	628.0				97	655.0		641.5
				98	620.0				98	615.0		617.5
				99	631.0				99	668.0		649.5
			Avg:		631.0			Avg:		650.4	Avg:	640.7
			Std Dev:		10.840			Std Dev:		26.121	Std Dev:	17.936
	OF2	90	2	95	627.0	HF1	90	2	95	647.0		637.0
				96	650.0				96	665.0		657.5
				97	651.0				97	649.0		650.0
				98	623.0				98	633.0		628.0
				99	656.0				99	677.0		666.5
			Avg:		641.4			Avg:		654.2	Avg:	647.8
			Std Dev:		15.209			Std Dev:		17.065	Std Dev:	15.470

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	650.0	HF2	0	1	95	755.0		702.5
				96	645.0				96	747.0		696.0
				97	637.0				97	738.0		687.5
				98	636.0				98	731.0		683.5
				99	638.0				99	767.0		702.5
				Avg:	641.2				Avg:	747.6	Avg:	694.4
				Std Dev:	6.058				Std Dev:	14.135	Std Dev:	8.663
	OF1	0	2	95	620.0	HF2	0	2	95	771.0		695.5
				96	618.0				96	739.0		678.5
				97	592.0				97	751.0		671.5
				98	620.0				98	737.0		678.5
				99	612.0				99	760.0		686.0
				Avg:	612.4				Avg:	751.6	Avg:	682.0
				Std Dev:	11.866				Std Dev:	14.311	Std Dev:	9.124
	OF1	90	1	95	643.0	HF2	90	1	95	851.0		747.0
				96	620.0				96	834.0		727.0
				97	609.0				97	839.0		724.0
				98	606.0				98	843.0		724.5
				99	612.0				99	827.0		719.5
				Avg:	618.0				Avg:	838.8	Avg:	728.4
				Std Dev:	14.916				Std Dev:	9.066	Std Dev:	10.744
	OF1	90	2	95	567.0	HF2	90	2	95	920.0		743.5
				96	562.0				96	911.0		736.5
				97	550.0				97	860.0		705.0
				98	533.0				98	856.0		694.5
				99	576.0				99	897.0		736.5
				Avg:	557.6				Avg:	888.8	Avg:	723.2
				Std Dev:	16.652				Std Dev:	29.321	Std Dev:	21.913
A	OF2	0	1	95	535.0	HF1	0	1	95	839.0		687.0
				96	534.0				96	869.0		701.5
				97	553.0				97	863.0		708.0
				98	549.0				98	842.0		695.5
				99	539.0				99	848.0		693.5
				Avg:	542.0				Avg:	852.2	Avg:	697.1
				Std Dev:	8.544				Std Dev:	13.180	Std Dev:	7.995
	OF2	0	2	95	552.0	HF1	0	2	95	887.0		719.5
				96	560.0				96	899.0		729.5
				97	551.0				97	872.0		711.5
				98	558.0				98	922.0		740.0
				99	557.0				99	926.0		741.5
				Avg:	555.6				Avg:	901.2	Avg:	728.4
				Std Dev:	3.912				Std Dev:	22.950	Std Dev:	12.963
	OF2	90	1	95	663.0	HF1	90	1	95	676.0		669.5
				96	650.0				96	696.0		673.0
				97	654.0				97	678.0		666.0
				98	687.0				98	673.0		680.0
				99	651.0				99	678.0		664.5
				Avg:	661.0				Avg:	680.2	Avg:	670.6
				Std Dev:	15.411				Std Dev:	9.066	Std Dev:	6.199
	OF2	90	2	95	699.0	HF1	90	2	95	722.0		710.5
				96	696.0				96	697.0		696.5
				97	670.0				97	690.0		680.0
				98	686.0				98	724.0		705.0
				99	662.0				99	709.0		685.5
				Avg:	682.6				Avg:	708.4	Avg:	695.5
				Std Dev:	16.149				Std Dev:	14.977	Std Dev:	12.811

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	681.0	HF2	0	1	95	798.0		739.5
				96	686.0				96	843.0		764.5
				97	632.0				97	1002.0		817.0
				98	600.0				98	918.0		759.0
				99	692.0				99	886.0		789.0
				Avg:	658.2				Avg:	889.4	Avg:	773.8
				Std Dev:	40.339				Std Dev:	77.484	Std Dev:	29.914
	OF1	0	2	95	636.0	HF2	0	2	95	1048.0		842.0
				96	644.0				96	989.0		816.5
				97	622.0				97	916.0		769.0
				98	692.0				98	982.0		837.0
				99	661.0				99	885.0		773.0
				Avg:	651.0				Avg:	964.0	Avg:	807.5
				Std Dev:	26.907				Std Dev:	64.323	Std Dev:	34.691
	OF1	90	1	95	749.0	HF2	90	1	95	839.0		794.0
				96	705.0				96	829.0		767.0
				97	629.0				97	814.0		721.5
				98	587.0				98	734.0		660.5
				99	709.0				99	758.0		733.5
				Avg:	675.8				Avg:	794.8	Avg:	735.3
				Std Dev:	65.933				Std Dev:	46.214	Std Dev:	50.595
	OF1	90	2	95	590.0	HF2	90	2	95	783.0		686.5
				96	583.0				96	847.0		715.0
				97	547.0				97	743.0		645.0
				98	588.0				98	693.0		640.5
				99	658.0				99	881.0		769.5
				Avg:	593.2				Avg:	789.4	Avg:	691.3
				Std Dev:	40.233				Std Dev:	76.150	Std Dev:	53.442
B	OF2	0	1	95	782.0	HF1	0	1	95	724.0		753.0
				96	643.0				96	741.0		692.0
				97	717.0				97	718.0		717.5
				98	753.0				98	757.0		755.0
				99	744.0				99	655.0		699.5
				Avg:	727.8				Avg:	719.0	Avg:	723.4
				Std Dev:	52.780				Std Dev:	38.891	Std Dev:	29.439
	OF2	0	2	95	691.0	HF1	0	2	95	763.0		727.0
				96	724.0				96	668.0		696.0
				97	814.0				97	708.0		761.0
				98	764.0				98	701.0		732.5
				99	707.0				99	760.0		733.5
				Avg:	740.0				Avg:	720.0	Avg:	730.0
				Std Dev:	49.492				Std Dev:	40.798	Std Dev:	23.154
	OF2	90	1	95	844.0	HF1	90	1	95	554.0		699.0
				96	705.0				96	529.0		617.0
				97	781.0				97	539.0		660.0
				98	753.0				98	575.0		664.0
				99	729.0				99	611.0		670.0
				Avg:	762.4				Avg:	561.6	Avg:	662.0
				Std Dev:	53.626				Std Dev:	32.601	Std Dev:	29.436
	OF2	90	2	95	816.0	HF1	90	2	95	678.0		747.0
				96	741.0				96	705.0		723.0
				97	856.0				97	649.0		752.5
				98	836.0				98	639.0		737.5
				99	745.0				99	579.0		662.0
				Avg:	798.8				Avg:	650.0	Avg:	724.4
				Std Dev:	52.884				Std Dev:	47.360	Std Dev:	36.632

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Total

<u>Mr Analysis</u>

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	636.0	HF2	0	1	95	943.0		789.5
				96	616.0				96	883.0		749.5
				97	625.0				97	888.0		756.5
				98	621.0				98	923.0		772.0
				99	632.0				99	890.0		761.0
			Avg:		626.0			Avg:		905.4	Avg:	765.7
			Std Dev:		8.093			Std Dev:		26.293	Std Dev:	15.615
	OF1	0	2	95	584.0	HF2	0	2	95	870.0		727.0
				96	628.0				96	913.0		770.5
				97	580.0				97	876.0		728.0
				98	602.0				98	891.0		746.5
				99	608.0				99	899.0		753.5
			Avg:		600.4			Avg:		889.8	Avg:	745.1
			Std Dev:		19.411			Std Dev:		17.370	Std Dev:	18.287
	OF1	90	1	95	634.0	HF2	90	1	95	506.0		570.0
				96	580.0				96	512.0		546.0
				97	564.0				97	490.0		527.0
				98	592.0				98	524.0		558.0
				99	574.0				99	522.0		548.0
			Avg:		588.8			Avg:		510.8	Avg:	549.8
			Std Dev:		27.225			Std Dev:		13.755	Std Dev:	15.912
	OF1	90	2	95	621.0	HF2	90	2	95	509.0		565.0
				96	633.0				96	541.0		587.0
				97	614.0				97	508.0		561.0
				98	574.0				98	495.0		534.5
				99	573.0				99	489.0		531.0
			Avg:		603.0			Avg:		508.4	Avg:	555.7
			Std Dev:		27.776			Std Dev:		20.120	Std Dev:	23.205
B	OF2	0	1	95	553.0	HF1	0	1	95	603.0		578.0
				96	542.0				96	576.0		559.0
				97	579.0				97	608.0		593.5
				98	549.0				98	621.0		585.0
				99	562.0				99	591.0		576.5
			Avg:		557.0			Avg:		599.8	Avg:	578.4
			Std Dev:		14.265			Std Dev:		17.108	Std Dev:	12.764
	OF2	0	2	95	736.0	HF1	0	2	95	637.0		687.5
				96	699.0				96	625.0		662.0
				97	688.0				97	606.0		647.0
				98	718.0				98	585.0		651.5
				99	718.0				99	618.0		668.0
			Avg:		712.2			Avg:		614.2	Avg:	663.2
			Std Dev:		19.318			Std Dev:		19.817	Std Dev:	15.924
	OF2	90	1	95	553.0	HF1	90	1	95	603.0		578.0
				96	542.0				96	576.0		559.0
				97	579.0				97	608.0		593.5
				98	549.0				98	621.0		585.0
				99	562.0				99	591.0		576.5
			Avg:		557.0			Avg:		599.8	Avg:	578.4
			Std Dev:		14.265			Std Dev:		17.108	Std Dev:	12.764
	OF2	90	2	95	738.0	HF1	90	2	95	637.0		687.5
				96	699.0				96	625.0		662.0
				97	688.0				97	606.0		647.0
				98	718.0				98	585.0		651.5
				99	718.0				99	618.0		668.0
			Avg:		712.2			Avg:		614.2	Avg:	663.2
			Std Dev:		19.318			Std Dev:		19.817	Std Dev:	15.924

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	649.0	HF2	0	1	95	727.0		688.0
				96	644.0				96	693.0		668.5
				97	657.0				97	671.0		664.0
				98	643.0				98	684.0		663.5
				99	642.0				99	679.0		660.5
				Avg:	647.0				Avg:	690.8	Avg:	668.9
				Std Dev:	6.205				Std Dev:	21.753	Std Dev:	11.053
	OF1	0	2	95	656.0	HF2	0	2	95	677.0		666.5
				96	651.0				96	690.0		670.5
				97	646.0				97	659.0		652.5
				98	646.0				98	677.0		661.5
				99	642.0				99	689.0		665.5
				Avg:	648.2				Avg:	678.4	Avg:	663.3
				Std Dev:	5.404				Std Dev:	12.522	Std Dev:	6.834
	OF1	90	1	95	651.0	HF2	90	1	95	729.0		690.0
				96	651.0				96	734.0		692.5
				97	640.0				97	720.0		680.0
				98	654.0				98	690.0		672.0
				99	665.0				99	731.0		698.0
				Avg:	652.2				Avg:	720.8	Avg:	686.5
				Std Dev:	8.927				Std Dev:	17.992	Std Dev:	10.404
	OF1	90	2	95	657.0	HF2	90	2	95	654.0		655.5
				96	685.0				96	702.0		693.5
				97	662.0				97	656.0		659.0
				98	650.0				98	672.0		661.0
				99	619.0				99	660.0		639.5
				Avg:	654.6				Avg:	668.8	Avg:	661.7
				Std Dev:	23.839				Std Dev:	19.829	Std Dev:	19.687
B	OF2	0	1	95	635.0	HF1	0	1	95	698.0		666.5
				96	658.0				96	706.0		682.0
				97	609.0				97	683.0		646.0
				98	583.0				98	677.0		630.0
				99	636.0				99	708.0		672.0
				Avg:	624.2				Avg:	694.4	Avg:	659.3
				Std Dev:	28.839				Std Dev:	13.831	Std Dev:	20.999
	OF2	0	2	95	641.0	HF1	0	2	95	690.0		665.5
				96	610.0				96	681.0		645.5
				97	620.0				97	685.0		652.5
				98	647.0				98	687.0		667.0
				99	597.0				99	668.0		632.5
				Avg:	623.0				Avg:	682.2	Avg:	652.6
				Std Dev:	20.940				Std Dev:	8.585	Std Dev:	14.389
	OF2	90	1	95	671.0	HF1	90	1	95	674.0		672.5
				96	682.0				96	673.0		677.5
				97	690.0				97	661.0		675.5
				98	685.0				98	678.0		681.5
				99	668.0				99	640.0		654.0
				Avg:	679.2				Avg:	665.2	Avg:	672.2
				Std Dev:	9.365				Std Dev:	15.450	Std Dev:	10.686
	OF2	90	2	95	675.0	HF1	90	2	95	654.0		664.5
				96	687.0				96	646.0		666.5
				97	650.0				97	626.0		638.0
				98	686.0				98	649.0		667.5
				99	677.0				99	620.0		648.5
				Avg:	675.0				Avg:	639.0	Avg:	657.0
				Std Dev:	14.950				Std Dev:	15.033	Std Dev:	13.134

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Total

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	606.0	HF2	0	1	95	500.0		553.0
				96	609.0				96	475.0		542.0
				97	572.0				97	478.0		525.0
				98	557.0				98	474.0		515.5
				99	577.0				99	507.0		542.0
				Avg:	584.2				Avg:	486.8	Avg:	535.5
				Std Dev:	22.532				Std Dev:	15.515	Std Dev:	15.008
	OF1	0	2	95	626.0	HF2	0	2	95	466.0		546.0
				96	582.0				96	479.0		530.5
				97	575.0				97	523.0		549.0
				98	585.0				98	486.0		535.5
				99	583.0				99	482.0		532.5
				Avg:	590.2				Avg:	487.2	Avg:	538.7
				Std Dev:	20.364				Std Dev:	21.371	Std Dev:	8.296
	OF1	90	1	95	699.0	HF2	90	1	95	859.0		779.0
				96	660.0				96	748.0		704.0
				97	699.0				97	755.0		727.0
				98	692.0				98	769.0		730.5
				99	781.0				99	746.0		763.5
				Avg:	706.2				Avg:	775.4	Avg:	740.8
				Std Dev:	44.819				Std Dev:	47.595	Std Dev:	30.105
	OF1	90	2	95	800.0	HF2	90	2	95	816.0		808.0
				96	798.0				96	767.0		782.5
				97	817.0				97	770.0		793.5
				98	847.0				98	839.0		843.0
				99	791.0				99	815.0		803.0
				Avg:	810.6				Avg:	801.4	Avg:	806.0
				Std Dev:	22.479				Std Dev:	31.548	Std Dev:	22.861
C	OF2	0	1	95	504.0	HF1	0	1	95	571.0		537.5
				96	541.0				96	587.0		564.0
				97	535.0				97	605.0		570.0
				98	547.0				98	592.0		569.5
				99	588.0				99	595.0		591.5
				Avg:	543.0				Avg:	590.0	Avg:	566.5
				Std Dev:	30.125				Std Dev:	12.490	Std Dev:	19.323
	OF2	0	2	95	454.0	HF1	0	2	95	528.0		491.0
				96	479.0				96	575.0		527.0
				97	544.0				97	606.0		575.0
				98	503.0				98	589.0		546.0
				99	492.0				99	556.0		524.0
				Avg:	494.4				Avg:	570.8	Avg:	532.6
				Std Dev:	33.201				Std Dev:	30.161	Std Dev:	30.876
	OF2	90	1	95	705.0	HF1	90	1	95	854.0		779.5
				96	600.0				96	750.0		675.0
				97	593.0				97	795.0		694.0
				98	631.0				98	811.0		721.0
				99	641.0				99	1030.0		835.5
				Avg:	634.0				Avg:	848.0	Avg:	741.0
				Std Dev:	44.542				Std Dev:	108.331	Std Dev:	65.912
	OF2	90	2	95	622.0	HF1	90	2	95	1068.0		845.0
				96	547.0				96	1063.0		805.0
				97	621.0				97	1002.0		811.5
				98	612.0				98	890.0		751.0
				99	551.0				99	798.0		674.5
				Avg:	590.6				Avg:	964.2	Avg:	777.4
				Std Dev:	38.201				Std Dev:	117.359	Std Dev:	66.670

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Total

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	667.0	HF2	0	1	95	767.0		717.0
				96	671.0				96	730.0		700.5
				97	671.0				97	737.0		704.0
				98	642.0				98	753.0		697.5
				99	660.0				99	725.0		692.5
				Avg:	662.2				Avg:	742.4	Avg:	702.3
				Std Dev:	12.153				Std Dev:	17.344	Std Dev:	9.237
	OF1	0	2	95	669.0	HF2	0	2	95	770.0		719.5
				96	671.0				96	773.0		722.0
				97	671.0				97	799.0		735.0
				98	655.0				98	742.0		698.5
				99	708.0				99	756.0		732.0
				Avg:	674.8				Avg:	768.0	Avg:	721.4
				Std Dev:	19.728				Std Dev:	21.272	Std Dev:	14.367
	OF1	90	1	95	482.0	HF2	90	1	95	561.0		521.5
				96	486.0				96	559.0		522.5
				97	474.0				97	555.0		514.5
				98	464.0				98	550.0		507.0
				99	503.0				99	570.0		536.5
				Avg:	481.8				Avg:	559.0	Avg:	520.4
				Std Dev:	14.533				Std Dev:	7.450	Std Dev:	10.945
	OF1	90	2	95	486.0	HF2	90	2	95	530.0		508.0
				96	496.0				96	565.0		530.5
				97	473.0				97	538.0		505.5
				98	471.0				98	542.0		506.5
				99	494.0				99	559.0		526.5
				Avg:	484.0				Avg:	546.8	Avg:	515.4
				Std Dev:	11.597				Std Dev:	14.687	Std Dev:	12.075
C	OF2	0	1	95	683.0	HF1	0	1	95	574.0		628.5
				96	716.0				96	614.0		665.0
				97	731.0				97	607.0		669.0
				98	688.0				98	592.0		640.0
				99	718.0				99	601.0		659.5
				Avg:	707.2				Avg:	597.6	Avg:	652.4
				Std Dev:	20.705				Std Dev:	15.469	Std Dev:	17.390
	OF2	0	2	95	717.0	HF1	0	2	95	628.0		672.5
				96	735.0				96	646.0		690.5
				97	724.0				97	630.0		677.0
				98	710.0				98	631.0		670.5
				99	744.0				99	649.0		696.5
				Avg:	726.0				Avg:	636.8	Avg:	681.4
				Std Dev:	13.657				Std Dev:	9.884	Std Dev:	11.491
	OF2	90	1	95	604.0	HF1	90	1	95	439.0		521.5
				96	584.0				96	484.0		534.0
				97	626.0				97	479.0		552.5
				98	569.0				98	448.0		508.5
				99	625.0				99	483.0		554.0
				Avg:	601.6				Avg:	466.6	Avg:	534.1
				Std Dev:	25.106				Std Dev:	21.408	Std Dev:	19.677
	OF2	90	2	95	621.0	HF1	90	2	95	469.0		545.0
				96	574.0				96	461.0		517.5
				97	632.0				97	468.0		550.0
				98	558.0				98	458.0		508.0
				99	598.0				99	478.0		538.0
				Avg:	596.6				Avg:	466.8	Avg:	531.7
				Std Dev:	31.029				Std Dev:	7.791	Std Dev:	18.130

Mix Type= 12.5mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Total

Mr Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	578.0	HF2	0	1	95	754.0		666.0
				96	575.0				96	748.0		661.5
				97	562.0				97	753.0		657.5
				98	576.0				98	742.0		659.0
				99	582.0				99	721.0		651.5
			Avg:		574.6			Avg:		743.6	Avg:	659.1
			Std Dev:		7.537			Std Dev:		13.502	Std Dev:	5.332
	OF1	0	2	95	592.0	HF2	0	2	95	715.0		653.5
				96	596.0				96	715.0		655.5
				97	566.0				97	683.0		624.5
				98	593.0				98	739.0		666.0
				99	593.0				99	739.0		666.0
			Avg:		588.0			Avg:		718.2	Avg:	653.1
			Std Dev:		12.390			Std Dev:		23.048	Std Dev:	17.005
	OF1	90	1	95	589.0	HF2	90	1	95	618.0		603.5
				96	606.0				96	612.0		609.0
				97	590.0				97	604.0		597.0
				98	596.0				98	609.0		602.5
				99	591.0				99	617.0		604.0
			Avg:		594.4			Avg:		612.0	Avg:	603.2
			Std Dev:		7.021			Std Dev:		5.788	Std Dev:	4.281
	OF1	90	2	95	673.0	HF2	90	2	95	620.0		646.5
				96	649.0				96	607.0		628.0
				97	641.0				97	598.0		619.5
				98	668.0				98	608.0		638.0
				99	631.0				99	606.0		618.5
			Avg:		652.4			Avg:		607.8	Avg:	630.1
			Std Dev:		17.799			Std Dev:		7.887	Std Dev:	12.070
C	OF2	0	1	95	763.0	HF1	0	1	95	638.0		700.5
				96	763.0				96	634.0		698.5
				97	758.0				97	605.0		681.5
				98	769.0				98	614.0		691.5
				99	767.0				99	638.0		702.5
			Avg:		764.0			Avg:		625.8	Avg:	694.9
			Std Dev:		4.243			Std Dev:		15.304	Std Dev:	8.562
	OF2	0	2	95	744.0	HF1	0	2	95	686.0		715.0
				96	737.0				96	681.0		709.0
				97	723.0				97	676.0		699.5
				98	683.0				98	653.0		668.0
				99	729.0				99	698.0		713.5
			Avg:		723.2			Avg:		678.8	Avg:	701.0
			Std Dev:		23.837			Std Dev:		16.574	Std Dev:	19.413
	OF2	90	1	95	505.0	HF1	90	1	95	723.0		614.0
				96	505.0				96	736.0		620.5
				97	508.0				97	742.0		625.0
				98	493.0				98	705.0		599.0
				99	483.0				99	717.0		600.0
			Avg:		498.8			Avg:		724.6	Avg:	611.7
			Std Dev:		10.545			Std Dev:		14.809	Std Dev:	11.809
	OF2	90	2	95	495.0	HF1	90	2	95	780.0		637.5
				96	488.0				96	775.0		631.5
				97	484.0				97	728.0		606.0
				98	499.0				98	721.0		610.0
				99	496.0				99	752.0		624.0
			Avg:		492.4			Avg:		751.2	Avg:	621.8
			Std Dev:		6.189			Std Dev:		26.678	Std Dev:	13.549

Annex 11

NCHRP 1-28A Project

Diametral Test Results

Mr Total

19.0 mm
6 inch Dia.

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	311.0	HF2	0	1	95	1529.0		920.0
				96	325.0				96	1105.0		715.0
				97	320.0				97	1187.0		753.5
				98	305.0				98	1340.0		822.5
				99	312.0				99	1233.0		772.5
			Avg:		314.6			Avg:		1278.8	Avg:	796.7
			Std Dev:		7.893			Std Dev:		163.613	Std Dev:	79.050
	OF1	0	2	95	353.0	HF2	0	2	95	1145.0		749.0
				96	345.0				96	1364.0		854.5
				97	354.0				97	928.0		641.0
				98	354.0				98	1218.0		786.0
				99	348.0				99	1443.0		895.5
			Avg:		350.8			Avg:		1219.6	Avg:	785.2
			Std Dev:		4.087			Std Dev:		200.846	Std Dev:	98.835
	OF1	90	1	95	627.0	HF2	90	1	95	711.0		669.0
				96	657.0				96	785.0		721.0
				97	578.0				97	829.0		703.5
				98	540.0				98	726.0		633.0
				99	597.0				99	854.0		725.5
			Avg:		599.8			Avg:		781.0	Avg:	690.4
			Std Dev:		44.919			Std Dev:		62.398	Std Dev:	39.028
	OF1	90	2	95	595.0	HF2	90	2	95	890.0		742.5
				96	537.0				96	626.0		581.5
				97	615.0				97	734.0		674.5
				98	629.0				98	796.0		712.5
				99	656.0				99	646.0		651.0
			Avg:		606.4			Avg:		738.4	Avg:	672.4
			Std Dev:		44.697			Std Dev:		108.962	Std Dev:	61.740
A	OF2	0	1	95	1307.0	HF1	0	1	95	368.0		837.5
				96	1008.0				96	357.0		682.5
				97	1160.0				97	347.0		753.5
				98	1335.0				98	350.0		842.5
				99	963.0				99	346.0		654.5
			Avg:		1154.6			Avg:		353.6	Avg:	754.1
			Std Dev:		168.820			Std Dev:		9.127	Std Dev:	86.338
	OF2	0	2	95	1534.0	HF1	0	2	95	372.0		953.0
				96	982.0				96	381.0		681.5
				97	1404.0				97	355.0		879.5
				98	1210.0				98	351.0		780.5
				99	1010.0				99	378.0		694.0
			Avg:		1228.0			Avg:		367.4	Avg:	797.7
			Std Dev:		241.338			Std Dev:		13.612	Std Dev:	117.645
	OF2	90	1	95	703.0	HF1	90	1	95	535.0		619.0
				96	660.0				96	564.0		612.0
				97	741.0				97	603.0		672.0
				98	722.0				98	596.0		659.0
				99	719.0				99	596.0		657.5
			Avg:		709.0			Avg:		578.8	Avg:	643.9
			Std Dev:		30.537			Std Dev:		28.787	Std Dev:	26.647
	OF2	90	2	95	752.0	HF1	90	2	95	610.0		681.0
				96	705.0				96	653.0		679.0
				97	729.0				97	626.0		677.5
				98	665.0				98	592.0		628.5
				99	716.0				99	616.0		666.0
			Avg:		713.4			Avg:		619.4	Avg:	666.4
			Std Dev:		32.223			Std Dev:		22.490	Std Dev:	21.976

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	755.0	HF2	0	1	95	630.0		692.5
				96	778.0				96	626.0		702.0
				97	786.0				97	646.0		716.0
				98	784.0				98	633.0		708.5
				99	812.0				99	650.0		731.0
				Avg:	783.0				Avg:	637.0	Avg:	710.0
				Std Dev:	20.372				Std Dev:	10.440	Std Dev:	14.573
	OF1	0	2	95	679.0	HF2	0	2	95	582.0		630.5
				96	686.0				96	577.0		632.5
				97	711.0				97	593.0		652.0
				98	672.0				98	591.0		631.5
				99	683.0				99	584.0		633.5
				Avg:	686.6				Avg:	585.4	Avg:	636.0
				Std Dev:	14.843				Std Dev:	6.580	Std Dev:	9.014
	OF1	90	1	95	749.0	HF2	90	1	95	743.0		746.0
				96	721.0				96	755.0		738.0
				97	723.0				97	725.0		724.0
				98	695.0				98	747.0		721.0
				99	777.0				99	769.0		773.0
				Avg:	733.0				Avg:	747.8	Avg:	740.4
				Std Dev:	31.145				Std Dev:	16.162	Std Dev:	20.888
	OF1	90	2	95	776.0	HF2	90	2	95	711.0		743.5
				96	738.0				96	712.0		725.0
				97	751.0				97	713.0		732.0
				98	744.0				98	749.0		746.5
				99	760.0				99	761.0		760.5
				Avg:	753.8				Avg:	729.2	Avg:	741.5
				Std Dev:	14.873				Std Dev:	23.942	Std Dev:	13.716
A	OF2	0	1	95	698.0	HF1	0	1	95	588.0		643.0
				96	704.0				96	572.0		638.0
				97	687.0				97	598.0		642.5
				98	638.0				98	559.0		598.5
				99	656.0				99	591.0		623.5
				Avg:	676.6				Avg:	581.6	Avg:	629.1
				Std Dev:	28.422				Std Dev:	15.821	Std Dev:	18.839
	OF2	0	2	95	712.0	HF1	0	2	95	608.0		660.0
				96	653.0				96	626.0		639.5
				97	644.0				97	610.0		627.0
				98	660.0				98	624.0		642.0
				99	633.0				99	617.0		625.0
				Avg:	660.4				Avg:	617.0	Avg:	638.7
				Std Dev:	30.566				Std Dev:	8.062	Std Dev:	14.052
	OF2	90	1	95	725.0	HF1	90	1	95	724.0		724.5
				96	719.0				96	708.0		713.5
				97	784.0				97	736.0		760.0
				98	777.0				98	722.0		749.5
				99	774.0				99	732.0		753.0
				Avg:	755.8				Avg:	724.4	Avg:	740.1
				Std Dev:	31.140				Std Dev:	10.807	Std Dev:	20.011
	OF2	90	2	95	735.0	HF1	90	2	95	728.0		731.5
				96	758.0				96	719.0		738.5
				97	770.0				97	703.0		736.5
				98	781.0				98	748.0		764.5
				99	797.0				99	713.0		755.0
				Avg:	768.2				Avg:	722.2	Avg:	745.2
				Std Dev:	23.467				Std Dev:	17.050	Std Dev:	13.936

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

<u>*Mr Analysis*</u>

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	513.0	HF2	0	1	95	597.0		555.0
				96	520.0				96	607.0		563.5
				97	507.0				97	586.0		546.5
				98	518.0				98	589.0		553.5
				99	520.0				99	587.0		553.5
				Avg:	515.6				Avg:	593.2	Avg:	554.4
				Std Dev:	5.595				Std Dev:	8.843	Std Dev:	6.066
	OF1	0	2	95	563.0	HF2	0	2	95	578.0		570.5
				96	565.0				96	561.0		563.0
				97	555.0				97	579.0		567.0
				98	563.0				98	564.0		563.5
				99	558.0				99	584.0		571.0
				Avg:	560.8				Avg:	573.2	Avg:	567.0
				Std Dev:	4.147				Std Dev:	10.085	Std Dev:	3.758
	OF1	90	1	95	622.0	HF2	90	1	95	730.0		676.0
				96	626.0				96	743.0		684.5
				97	632.0				97	745.0		688.5
				98	612.0				98	753.0		682.5
				99	627.0				99	753.0		690.0
				Avg:	623.8				Avg:	744.8	Avg:	684.3
				Std Dev:	7.497				Std Dev:	9.445	Std Dev:	5.529
	OF1	90	2	95	619.0	HF2	90	2	95	744.0		681.5
				96	615.0				96	727.0		671.0
				97	627.0				97	742.0		684.5
				98	628.0				98	733.0		680.5
				99	626.0				99	747.0		686.5
				Avg:	623.0				Avg:	738.6	Avg:	680.8
				Std Dev:	5.701				Std Dev:	8.325	Std Dev:	5.975
A	OF2	0	1	95	728.0	HF1	0	1	95	533.0		630.5
				96	720.0				96	548.0		634.0
				97	752.0				97	547.0		649.5
				98	733.0				98	539.0		636.0
				99	723.0				99	548.0		635.5
				Avg:	731.2				Avg:	543.0	Avg:	637.1
				Std Dev:	12.637				Std Dev:	6.745	Std Dev:	7.258
	OF2	0	2	95	684.0	HF1	0	2	95	528.0		606.0
				96	694.0				96	522.0		608.0
				97	683.0				97	521.0		602.0
				98	716.0				98	533.0		624.5
				99	720.0				99	539.0		629.5
				Avg:	699.4				Avg:	528.6	Avg:	614.0
				Std Dev:	17.573				Std Dev:	7.570	Std Dev:	12.191
	OF2	90	1	95	692.0	HF1	90	1	95	571.0		631.5
				96	667.0				96	564.0		615.5
				97	700.0				97	573.0		636.5
				98	687.0				98	570.0		628.5
				99	688.0				99	571.0		629.5
				Avg:	686.8				Avg:	569.8	Avg:	628.3
				Std Dev:	12.194				Std Dev:	3.421	Std Dev:	7.791
	OF2	90	2	95	636.0	HF1	90	2	95	609.0		622.5
				96	622.0				96	612.0		617.0
				97	650.0				97	619.0		634.5
				98	633.0				98	621.0		627.0
				99	648.0				99	629.0		638.5
				Avg:	637.8				Avg:	618.0	Avg:	627.9
				Std Dev:	11.498				Std Dev:	7.874	Std Dev:	8.728

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	923.0	HF2	0	1	95	570.0		746.5
				96	1022.0				96	703.0		862.5
				97	995.0				97	622.0		808.5
				98	1010.0				98	468.0		739.0
				99	945.0				99	536.0		740.5
			Avg:		979.0			Avg:		579.8	Avg:	779.4
			Std Dev:		42.889			Std Dev:		88.703	Std Dev:	54.727
	OF1	0	2	95	989.0	HF2	0	2	95	493.0		741.0
				96	913.0				96	603.0		758.0
				97	945.0				97	672.0		808.5
				98	924.0				98	620.0		772.0
				99	915.0				99	531.0		723.0
			Avg:		937.2			Avg:		583.8	Avg:	760.5
			Std Dev:		31.610			Std Dev:		71.573	Std Dev:	32.515
	OF1	90	1	95	1111.0	HF2	90	1	95	594.0		852.5
				96	974.0				96	831.0		902.5
				97	1147.0				97	865.0		1006.0
				98	1146.0				98	631.0		888.5
				99	1131.0				99	563.0		847.0
			Avg:		1101.8			Avg:		696.8	Avg:	899.3
			Std Dev:		72.916			Std Dev:		140.624	Std Dev:	64.104
	OF1	90	2	95	955.0	HF2	90	2	95	687.0		821.0
				96	1028.0				96	615.0		821.5
				97	1064.0				97	673.0		868.5
				98	1184.0				98	867.0		1025.5
				99	1094.0				99	738.0		916.0
			Avg:		1065.0			Avg:		716.0	Avg:	890.5
			Std Dev:		84.368			Std Dev:		95.100	Std Dev:	85.074
B	OF2	0	1	95	560.0	HF1	0	1	95	931.0		745.5
				96	725.0				96	963.0		844.0
				97	895.0				97	1075.0		985.0
				98	628.0				98	1056.0		842.0
				99	553.0				99	943.0		748.0
			Avg:		672.2			Avg:		993.6	Avg:	832.9
			Std Dev:		142.459			Std Dev:		66.961	Std Dev:	97.708
	OF2	0	2	95	633.0	HF1	0	2	95	936.0		784.5
				96	895.0				96	917.0		906.0
				97	682.0				97	846.0		764.0
				98	584.0				98	775.0		679.5
				99	785.0				99	906.0		845.5
			Avg:		715.8			Avg:		876.0	Avg:	795.9
			Std Dev:		124.771			Std Dev:		65.731	Std Dev:	85.555
	OF2	90	1	95	695.0	HF1	90	1	95	1122.0		908.5
				96	721.0				96	1095.0		908.0
				97	655.0				97	1153.0		904.0
				98	984.0				98	1095.0		1039.5
				99	523.0				99	1107.0		815.0
			Avg:		715.6			Avg:		1114.4	Avg:	915.0
			Std Dev:		168.270			Std Dev:		24.265	Std Dev:	80.176
	OF2	90	2	95	542.0	HF1	90	2	95	1330.0		936.0
				96	732.0				96	1498.0		1115.0
				97	651.0				97	1258.0		954.5
				98	576.0				98	1425.0		1000.5
				99	1014.0				99	1139.0		1076.5
			Avg:		703.0			Avg:		1330.0	Avg:	1016.5
			Std Dev:		188.624			Std Dev:		140.458	Std Dev:	77.270

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	937.0	HF2	0	1	95	748.0		842.5
				96	963.0				96	742.0		852.5
				97	968.0				97	764.0		866.0
				98	925.0				98	751.0		838.0
				99	963.0				99	752.0		857.5
				Avg:	951.2				Avg:	751.4	Avg:	851.3
				Std Dev:	19.032				Std Dev:	8.050	Std Dev:	11.295
	OF1	0	2	95	924.0	HF2	0	2	95	720.0		822.0
				96	944.0				96	732.0		838.0
				97	938.0				97	762.0		850.0
				98	916.0				98	746.0		831.0
				99	922.0				99	733.0		827.5
				Avg:	928.8				Avg:	738.6	Avg:	833.7
				Std Dev:	11.713				Std Dev:	15.994	Std Dev:	10.803
	OF1	90	1	95	964.0	HF2	90	1	95	508.0		736.0
				96	1005.0				96	504.0		754.5
				97	980.0				97	510.0		745.0
				98	959.0				98	508.0		733.5
				99	972.0				99	503.0		737.5
				Avg:	976.0				Avg:	506.6	Avg:	741.3
				Std Dev:	18.069				Std Dev:	2.966	Std Dev:	8.534
	OF1	90	2	95	901.0	HF2	90	2	95	509.0		705.0
				96	932.0				96	508.0		720.0
				97	990.0				97	500.0		745.0
				98	991.0				98	511.0		751.0
				99	946.0				99	523.0		734.5
				Avg:	952.0				Avg:	510.2	Avg:	731.1
				Std Dev:	38.736				Std Dev:	8.289	Std Dev:	18.743
B	OF2	0	1	95	590.0	HF1	0	1	95	1109.0		849.5
				96	608.0				96	1141.0		874.5
				97	621.0				97	1163.0		892.0
				98	625.0				98	1129.0		877.0
				99	603.0				99	1178.0		890.5
				Avg:	609.4				Avg:	1144.0	Avg:	876.7
				Std Dev:	14.117				Std Dev:	27.276	Std Dev:	17.098
	OF2	0	2	95	599.0	HF1	0	2	95	1088.0		843.5
				96	587.0				96	1058.0		822.5
				97	579.0				97	1073.0		826.0
				98	594.0				98	1065.0		829.5
				99	589.0				99	1112.0		850.5
				Avg:	589.6				Avg:	1079.2	Avg:	834.4
				Std Dev:	7.537				Std Dev:	21.464	Std Dev:	12.023
	OF2	90	1	95	476.0	HF1	90	1	95	985.0		730.5
				96	476.0				96	997.0		736.5
				97	474.0				97	1036.0		755.0
				98	494.0				98	985.0		739.5
				99	497.0				99	1028.0		762.5
				Avg:	483.4				Avg:	1006.2	Avg:	744.8
				Std Dev:	11.127				Std Dev:	24.222	Std Dev:	13.405
	OF2	90	2	95	480.0	HF1	90	2	95	1048.0		764.0
				96	483.0				96	995.0		739.0
				97	500.0				97	1083.0		791.5
				98	487.0				98	1072.0		779.5
				99	481.0				99	1043.0		762.0
				Avg:	486.2				Avg:	1048.2	Avg:	767.2
				Std Dev:	8.167				Std Dev:	34.040	Std Dev:	19.839

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	644.0	HF2	0	1	95	644.0		644.0
				96	586.0				96	656.0		621.0
				97	601.0				97	663.0		632.0
				98	558.0				98	662.0		610.0
				99	627.0				99	657.0		642.0
				Avg:	603.2				Avg:	656.4	Avg:	629.8
				Std Dev:	33.819				Std Dev:	7.570	Std Dev:	14.360
	OF1	0	2	95	629.0	HF2	0	2	95	646.0		637.5
				96	616.0				96	627.0		621.5
				97	632.0				97	662.0		647.0
				98	636.0				98	663.0		649.5
				99	622.0				99	638.0		630.0
				Avg:	627.0				Avg:	647.2	Avg:	637.1
				Std Dev:	8.000				Std Dev:	15.515	Std Dev:	11.680
	OF1	90	1	95	543.0	HF2	90	1	95	519.0		531.0
				96	546.0				96	527.0		536.5
				97	551.0				97	529.0		540.0
				98	548.0				98	533.0		540.5
				99	544.0				99	515.0		529.5
				Avg:	546.4				Avg:	524.6	Avg:	535.5
				Std Dev:	3.209				Std Dev:	7.403	Std Dev:	5.062
	OF1	90	2	95	625.0	HF2	90	2	95	541.0		583.0
				96	615.0				96	543.0		579.0
				97	606.0				97	544.0		575.0
				98	513.0				98	538.0		525.5
				99	604.0				99	546.0		575.0
				Avg:	592.6				Avg:	542.4	Avg:	567.5
				Std Dev:	45.269				Std Dev:	3.050	Std Dev:	23.712
B	OF2	0	1	95	728.0	HF1	0	1	95	533.0		630.5
				96	720.0				96	548.0		634.0
				97	752.0				97	547.0		649.5
				98	733.0				98	539.0		636.0
				99	723.0				99	548.0		635.5
				Avg:	731.2				Avg:	543.0	Avg:	637.1
				Std Dev:	12.637				Std Dev:	6.745	Std Dev:	7.258
	OF2	0	2	95	715.0	HF1	0	2	95	766.0		740.5
				96	696.0				96	769.0		732.5
				97	736.0				97	785.0		760.5
				98	735.0				98	791.0		763.0
				99	737.0				99	777.0		757.0
				Avg:	723.8				Avg:	777.6	Avg:	750.7
				Std Dev:	18.019				Std Dev:	10.526	Std Dev:	13.438
	OF2	90	1	95	515.0	HF1	90	1	95	752.0		633.5
				96	527.0				96	775.0		651.0
				97	516.0				97	773.0		644.5
				98	524.0				98	777.0		650.5
				99	518.0				99	782.0		650.0
				Avg:	520.0				Avg:	771.8	Avg:	645.9
				Std Dev:	5.244				Std Dev:	11.563	Std Dev:	7.411
	OF2	90	2	95	513.0	HF1	90	2	95	767.0		640.0
				96	520.0				96	764.0		642.0
				97	516.0				97	767.0		641.5
				98	531.0				98	784.0		657.5
				99	528.0				99	774.0		651.0
				Avg:	521.6				Avg:	771.2	Avg:	646.4
				Std Dev:	7.701				Std Dev:	8.044	Std Dev:	7.561

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	549.0	HF2	0	1	95	347.0		448.0
				96	580.0				96	316.0		448.0
				97	553.0				97	378.0		465.5
				98	576.0				98	328.0		452.0
				99	528.0				99	332.0		430.0
			Avg:		557.2			Avg:		340.2	Avg:	448.7
			Std Dev:		21.277			Std Dev:		23.858	Std Dev:	12.687
	OF1	0	2	95	477.0	HF2	0	2	95	318.0		397.5
				96	510.0				96	318.0		414.0
				97	519.0				97	373.0		446.0
				98	526.0				98	308.0		417.0
				99	535.0				99	367.0		451.0
			Avg:		513.4			Avg:		336.8	Avg:	425.1
			Std Dev:		22.323			Std Dev:		30.655	Std Dev:	22.684
	OF1	90	1	95	475.0	HF2	90	1	95	395.0		435.0
				96	475.0				96	457.0		466.0
				97	464.0				97	506.0		485.0
				98	478.0				98	401.0		439.5
				99	467.0				99	494.0		480.5
			Avg:		471.8			Avg:		450.6	Avg:	461.2
			Std Dev:		5.975			Std Dev:		51.345	Std Dev:	23.018
	OF1	90	2	95	492.0	HF2	90	2	95	513.0		502.5
				96	484.0				96	436.0		460.0
				97	473.0				97	412.0		442.5
				98	476.0				98	522.0		499.0
				99	513.0				99	434.0		473.5
			Avg:		487.6			Avg:		463.4	Avg:	475.5
			Std Dev:		16.009			Std Dev:		50.377	Std Dev:	25.566
C	OF2	0	1	95	419.0	HF1	0	1	95	663.0		541.0
				96	385.0				96	641.0		513.0
				97	503.0				97	734.0		618.5
				98	458.0				98	753.0		605.5
				99	383.0				99	753.0		568.0
			Avg:		429.6			Avg:		708.8	Avg:	569.2
			Std Dev:		51.155			Std Dev:		53.002	Std Dev:	43.884
	OF2	0	2	95	491.0	HF1	0	2	95	657.0		574.0
				96	414.0				96	720.0		567.0
				97	408.0				97	661.0		534.5
				98	539.0				98	767.0		653.0
				99	456.0				99	724.0		590.0
			Avg:		461.6			Avg:		705.8	Avg:	583.7
			Std Dev:		54.830			Std Dev:		46.548	Std Dev:	43.692
	OF2	90	1	95	459.0	HF1	90	1	95	557.0		508.0
				96	507.0				96	585.0		546.0
				97	420.0				97	554.0		487.0
				98	401.0				98	552.0		476.5
				99	484.0				99	526.0		505.0
			Avg:		454.2			Avg:		554.8	Avg:	504.5
			Std Dev:		43.871			Std Dev:		20.945	Std Dev:	26.575
	OF2	90	2	95	578.0	HF1	90	2	95	429.0		503.5
				96	954.0				96	415.0		684.5
				97	757.0				97	422.0		589.5
				98	812.0				98	434.0		623.0
				99	1176.0				99	442.0		809.0
			Avg:		855.4			Avg:		428.4	Avg:	641.9
			Std Dev:		224.176			Std Dev:		10.455	Std Dev:	114.012

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	514.0	HF2	0	1	95	578.0		546.0
				96	512.0				96	571.0		541.5
				97	506.0				97	559.0		532.5
				98	498.0				98	548.0		523.0
				99	505.0				99	582.0		543.5
			Avg:		507.0			Avg:		567.6	Avg:	537.3
			Std Dev:		6.325			Std Dev:		14.011	Std Dev:	9.478
	OF1	0	2	95	559.0	HF2	0	2	95	561.0		560.0
				96	540.0				96	556.0		548.0
				97	542.0				97	562.0		552.0
				98	542.0				98	560.0		551.0
				99	556.0				99	590.0		573.0
			Avg:		547.8			Avg:		565.8	Avg:	556.8
			Std Dev:		8.955			Std Dev:		13.719	Std Dev:	10.085
	OF1	90	1	95	565.0	HF2	90	1	95	633.0		599.0
				96	552.0				96	627.0		589.5
				97	550.0				97	606.0		578.0
				98	558.0				98	619.0		588.5
				99	563.0				99	620.0		591.5
			Avg:		557.6			Avg:		621.0	Avg:	589.3
			Std Dev:		6.580			Std Dev:		10.124	Std Dev:	7.538
	OF1	90	2	95	562.0	HF2	90	2	95	583.0		572.5
				96	538.0				96	589.0		563.5
				97	559.0				97	621.0		590.0
				98	561.0				98	595.0		578.0
				99	563.0				99	594.0		578.5
			Avg:		556.6			Avg:		596.4	Avg:	576.5
			Std Dev:		10.502			Std Dev:		14.553	Std Dev:	9.663
C	OF2	0	1	95	511.0	HF1	0	1	95	552.0		531.5
				96	539.0				96	569.0		554.0
				97	539.0				97	557.0		548.0
				98	522.0				98	558.0		540.0
				99	529.0				99	577.0		553.0
			Avg:		528.0			Avg:		562.6	Avg:	545.3
			Std Dev:		11.916			Std Dev:		10.164	Std Dev:	9.497
	OF2	0	2	95	544.0	HF1	0	2	95	584.0		564.0
				96	548.0				96	578.0		563.0
				97	567.0				97	607.0		587.0
				98	541.0				98	599.0		570.0
				99	560.0				99	573.0		566.5
			Avg:		552.0			Avg:		588.2	Avg:	570.1
			Std Dev:		11.068			Std Dev:		14.342	Std Dev:	9.826
	OF2	90	1	95	546.0	HF1	90	1	95	565.0		555.5
				96	554.0				96	558.0		556.0
				97	537.0				97	577.0		557.0
				98	552.0				98	578.0		565.0
				99	559.0				99	568.0		563.5
			Avg:		549.6			Avg:		569.2	Avg:	559.4
			Std Dev:		8.444			Std Dev:		8.408	Std Dev:	4.492
	OF2	90	2	95	539.0	HF1	90	2	95	581.0		560.0
				96	527.0				96	578.0		552.5
				97	531.0				97	587.0		559.0
				98	549.0				98	575.0		562.0
				99	553.0				99	572.0		562.5
			Avg:		539.8			Avg:		578.6	Avg:	559.2
			Std Dev:		11.189			Std Dev:		5.771	Std Dev:	4.009

Mix Type= 19.0 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	523.0	HF2	0	1	95	517.0		520.0
				96	517.0				96	519.0		518.0
				97	536.0				97	511.0		523.5
				98	525.0				98	515.0		520.0
				99	529.0				99	515.0		522.0
				Avg:	526.0				Avg:	515.4	Avg:	520.7
				Std Dev:	7.071				Std Dev:	2.966	Std Dev:	2.110
	OF1	0	2	95	539.0	HF2	0	2	95	538.0		538.5
				96	527.0				96	541.0		534.0
				97	554.0				97	540.0		547.0
				98	536.0				98	550.0		543.0
				99	524.0				99	548.0		536.0
				Avg:	536.0				Avg:	543.4	Avg:	539.7
				Std Dev:	11.811				Std Dev:	5.273	Std Dev:	5.287
	OF1	90	1	95	443.0	HF2	90	1	95	507.0		475.0
				96	428.0				96	479.0		453.5
				97	447.0				97	495.0		471.0
				98	470.0				98	510.0		490.0
				99	477.0				99	521.0		499.0
				Avg:	453.0				Avg:	502.4	Avg:	477.7
				Std Dev:	20.162				Std Dev:	16.025	Std Dev:	17.627
	OF1	90	2	95	489.0	HF2	90	2	95	525.0		507.0
				96	509.0				96	513.0		511.0
				97	502.0				97	526.0		514.0
				98	503.0				98	535.0		519.0
				99	490.0				99	709.0		599.5
				Avg:	498.6				Avg:	561.6	Avg:	530.1
				Std Dev:	8.735				Std Dev:	82.770	Std Dev:	39.042
C	OF2	0	1	95	467.0	HF1	0	1	95	562.0		514.5
				96	489.0				96	584.0		536.5
				97	468.0				97	553.0		510.5
				98	479.0				98	569.0		524.0
				99	474.0				99	572.0		523.0
				Avg:	475.4				Avg:	568.0	Avg:	521.7
				Std Dev:	9.017				Std Dev:	11.554	Std Dev:	10.041
	OF2	0	2	95	526.0	HF1	0	2	95	613.0		569.5
				96	499.0				96	599.0		549.0
				97	508.0				97	602.0		555.0
				98	501.0				98	613.0		557.0
				99	515.0				99	610.0		562.5
				Avg:	509.8				Avg:	607.4	Avg:	558.6
				Std Dev:	11.032				Std Dev:	6.504	Std Dev:	7.773
	OF2	90	1	95	554.0	HF1	90	1	95	666.0		610.0
				96	556.0				96	652.0		604.0
				97	570.0				97	674.0		622.0
				98	545.0				98	656.0		600.5
				99	556.0				99	665.0		610.5
				Avg:	556.2				Avg:	662.6	Avg:	609.4
				Std Dev:	8.955				Std Dev:	8.706	Std Dev:	8.196
	OF2	90	2	95	543.0	HF1	90	2	95	614.0		578.5
				96	554.0				96	627.0		590.5
				97	548.0				97	638.0		593.0
				98	522.0				98	592.0		557.0
				99	562.0				99	667.0		614.5
				Avg:	545.8				Avg:	627.6	Avg:	586.7
				Std Dev:	15.073				Std Dev:	27.898	Std Dev:	21.073

Annex 12

NCHRP 1-28A Project

Diametral Test Results

Mr Total

37.5 mm
6 inch Dia.

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	738.0	HF2	0	1	95	1110.0		924.0
				96	767.0				96	791.0		779.0
				97	803.0				97	1042.0		922.5
				98	750.0				98	1118.0		934.0
				99	831.0				99	766.0		798.5
				Avg:	777.8				Avg:	965.4	Avg:	871.6
				Std Dev:	38.532				Std Dev:	173.378	Std Dev:	76.073
	OF1	0	2	95	834.0	HF2	0	2	95	849.0		841.5
				96	819.0				96	1088.0		953.5
				97	856.0				97	796.0		826.0
				98	826.0				98	788.0		807.0
				99	878.0				99	1098.0		988.0
				Avg:	842.6				Avg:	923.8	Avg:	883.2
				Std Dev:	24.183				Std Dev:	156.266	Std Dev:	81.765
	OF1	90	1	95	745.0	HF2	90	1	95	652.0		698.5
				96	782.0				96	586.0		684.0
				97	816.0				97	559.0		687.5
				98	712.0				98	660.0		686.0
				99	802.0				99	527.0		664.5
				Avg:	771.4				Avg:	596.8	Avg:	684.1
				Std Dev:	42.612				Std Dev:	58.006	Std Dev:	12.316
	OF1	90	2	95	696.0	HF2	90	2	95	619.0		657.5
				96	736.0				96	519.0		627.5
				97	697.0				97	621.0		659.0
				98	814.0				98	598.0		706.0
				99	810.0				99	532.0		671.0
				Avg:	750.6				Avg:	577.8	Avg:	664.2
				Std Dev:	58.342				Std Dev:	48.803	Std Dev:	28.339
A	OF2	0	1	95	692.0	HF1	0	1	95	1219.0		955.5
				96	980.0				96	1300.0		1140.0
				97	782.0				97	1112.0		947.0
				98	696.0				98	1288.0		992.0
				99	933.0				99	1131.0		1032.0
				Avg:	816.6				Avg:	1210.0	Avg:	1013.3
				Std Dev:	133.712				Std Dev:	86.761	Std Dev:	78.410
	OF2	0	2	95	684.0	HF1	0	2	95	1349.0		1016.5
				96	589.0				96	1295.0		942.0
				97	769.0				97	1162.0		965.5
				98	599.0				98	1360.0		979.5
				99	680.0				99	1171.0		925.5
				Avg:	664.2				Avg:	1267.4	Avg:	965.8
				Std Dev:	73.367				Std Dev:	95.390	Std Dev:	35.174
	OF2	90	1	95	561.0	HF1	90	1	95	816.0		688.5
				96	483.0				96	925.0		704.0
				97	606.0				97	889.0		747.5
				98	564.0				98	819.0		691.5
				99	482.0				99	1019.0		750.5
				Avg:	539.2				Avg:	893.6	Avg:	716.4
				Std Dev:	54.733				Std Dev:	84.142	Std Dev:	30.341
	OF2	90	2	95	520.0	HF1	90	2	95	840.0		680.0
				96	466.0				96	854.0		660.0
				97	568.0				97	777.0		672.5
				98	517.0				98	949.0		733.0
				99	468.0				99	828.0		648.0
				Avg:	507.8				Avg:	849.6	Avg:	678.7
				Std Dev:	42.393				Std Dev:	62.708	Std Dev:	32.714

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	830.0	HF2	0	1	95	1014.0		922.0
				96	818.0				96	992.0		905.0
				97	823.0				97	1049.0		936.0
				98	869.0				98	1070.0		969.5
				99	836.0				99	1034.0		935.0
			Avg:		835.2			Avg:		1031.8	Avg:	933.5
			Std Dev:		20.092			Std Dev:		30.252	Std Dev:	23.712
	OF1	0	2	95	843.0	HF2	0	2	95	1018.0		930.5
				96	847.0				96	1068.0		957.5
				97	823.0				97	1008.0		915.5
				98	820.0				98	1048.0		934.0
				99	817.0				99	1050.0		933.5
			Avg:		830.0			Avg:		1038.4	Avg:	934.2
			Std Dev:		13.928			Std Dev:		24.714	Std Dev:	15.057
	OF1	90	1	95	587.0	HF2	90	1	95	799.0		693.0
				96	569.0				96	768.0		668.5
				97	596.0				97	817.0		706.5
				98	597.0				98	796.0		696.5
				99	585.0				99	799.0		692.0
			Avg:		586.8			Avg:		795.8	Avg:	691.3
			Std Dev:		11.278			Std Dev:		17.627	Std Dev:	13.976
	OF1	90	2	95	559.0	HF2	90	2	95	779.0		669.0
				96	554.0				96	828.0		691.0
				97	587.0				97	821.0		704.0
				98	565.0				98	835.0		700.0
				99	584.0				99	830.0		707.0
			Avg:		569.8			Avg:		818.6	Avg:	694.2
			Std Dev:		14.890			Std Dev:		22.700	Std Dev:	15.320
A	OF2	0	1	95	753.0	HF1	0	1	95	845.0		799.0
				96	762.0				96	850.0		806.0
				97	768.0				97	850.0		809.0
				98	762.0				98	850.0		806.0
				99	726.0				99	853.0		789.5
			Avg:		754.2			Avg:		849.6	Avg:	801.9
			Std Dev:		16.649			Std Dev:		2.881	Std Dev:	7.845
	OF2	0	2	95	661.0	HF1	0	2	95	857.0		759.0
				96	686.0				96	871.0		778.5
				97	711.0				97	858.0		784.5
				98	745.0				98	870.0		807.5
				99	719.0				99	887.0		803.0
			Avg:		704.4			Avg:		868.6	Avg:	786.5
			Std Dev:		32.122			Std Dev:		12.178	Std Dev:	19.605
	OF2	90	1	95	789.0	HF1	90	1	95	582.0		685.5
				96	742.0				96	583.0		662.5
				97	796.0				97	602.0		699.0
				98	783.0				98	607.0		695.0
				99	777.0				99	579.0		678.0
			Avg:		777.4			Avg:		590.6	Avg:	684.0
			Std Dev:		21.007			Std Dev:		12.896	Std Dev:	14.547
	OF2	90	2	95	768.0	HF1	90	2	95	598.0		683.0
				96	730.0				96	606.0		668.0
				97	757.0				97	619.0		688.0
				98	771.0				98	586.0		678.5
				99	798.0				99	620.0		709.0
			Avg:		764.8			Avg:		605.8	Avg:	685.3
			Std Dev:		24.611			Std Dev:		14.394	Std Dev:	15.164

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
A	OF1	0	1	95	867.0	HF2	0	1	95	749.0		808.0
				96	882.0				96	772.0		827.0
				97	873.0				97	818.0		845.5
				98	877.0				98	795.0		836.0
				99	901.0				99	780.0		840.5
				Avg:	880.0				Avg:	782.8	Avg:	831.4
				Std Dev:	12.961				Std Dev:	25.762	Std Dev:	14.745
	OF1	0	2	95	897.0	HF2	0	2	95	823.0		860.0
				96	894.0				96	811.0		852.5
				97	907.0				97	827.0		867.0
				98	912.0				98	849.0		880.5
				99	918.0				99	846.0		882.0
				Avg:	905.6				Avg:	831.2	Avg:	868.4
				Std Dev:	10.065				Std Dev:	16.037	Std Dev:	12.813
	OF1	90	1	95	773.0	HF2	90	1	95	629.0		701.0
				96	776.0				96	633.0		704.5
				97	778.0				97	629.0		703.5
				98	786.0				98	624.0		705.0
				99	788.0				99	650.0		719.0
				Avg:	780.2				Avg:	633.0	Avg:	706.6
				Std Dev:	6.496				Std Dev:	10.025	Std Dev:	7.101
	OF1	90	2	95	1196.0	HF2	90	2	95	851.0		1023.5
				96	1240.0				96	826.0		1033.0
				97	1185.0				97	831.0		1008.0
				98	1227.0				98	846.0		1036.5
				99	1229.0				99	868.0		1048.5
				Avg:	1215.4				Avg:	844.4	Avg:	1029.9
				Std Dev:	23.586				Std Dev:	16.742	Std Dev:	15.163
A	OF2	0	1	95	931.0	HF1	0	1	95	740.0		835.5
				96	884.0				96	740.0		812.0
				97	958.0				97	772.0		865.0
				98	937.0				98	752.0		844.5
				99	910.0				99	767.0		838.5
				Avg:	924.0				Avg:	754.2	Avg:	839.1
				Std Dev:	28.151				Std Dev:	14.906	Std Dev:	19.024
	OF2	0	2	95	879.0	HF1	0	2	95	767.0		823.0
				96	916.0				96	776.0		846.0
				97	868.0				97	784.0		826.0
				98	891.0				98	773.0		832.0
				99	933.0				99	785.0		859.0
				Avg:	897.4				Avg:	777.0	Avg:	837.2
				Std Dev:	26.726				Std Dev:	7.583	Std Dev:	15.057
	OF2	90	1	95	903.0	HF1	90	1	95	1062.0		982.5
				96	913.0				96	1030.0		971.5
				97	879.0				97	1068.0		973.5
				98	939.0				98	1016.0		977.5
				99	910.0				99	1058.0		984.0
				Avg:	908.8				Avg:	1046.8	Avg:	977.8
				Std Dev:	21.522				Std Dev:	22.565	Std Dev:	5.450
	OF2	90	2	95	948.0	HF1	90	2	95	904.0		926.0
				96	1018.0				96	898.0		958.0
				97	984.0				97	905.0		944.5
				98	961.0				98	873.0		917.0
				99	976.0				99	903.0		939.5
				Avg:	977.4				Avg:	896.6	Avg:	937.0
				Std Dev:	26.586				Std Dev:	13.465	Std Dev:	16.004

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	477.0	HF2	0	1	95	1138.0		807.5
				96	485.0				96	1396.0		940.5
				97	502.0				97	1689.0		1095.5
				98	442.0				98	1057.0		749.5
				99	512.0				99	1747.0		1129.5
				Avg:	483.6				Avg:	1405.4	Avg:	944.5
				Std Dev:	27.024				Std Dev:	312.287	Std Dev:	168.698
	OF1	0	2	95	470.0	HF2	0	2	95	1603.0		1036.5
				96	462.0				96	1845.0		1153.5
				97	480.0				97	1094.0		787.0
				98	462.0				98	2027.0		1244.5
				99	438.0				99	1184.0		811.0
				Avg:	462.4				Avg:	1550.6	Avg:	1006.5
				Std Dev:	15.518				Std Dev:	405.972	Std Dev:	203.441
	OF1	90	1	95	329.0	HF2	90	1	95	572.0		450.5
				96	321.0				96	513.0		417.0
				97	339.0				97	504.0		421.5
				98	341.0				98	611.0		476.0
				99	323.0				99	489.0		406.0
				Avg:	330.6				Avg:	537.8	Avg:	434.2
				Std Dev:	9.099				Std Dev:	51.640	Std Dev:	28.571
	OF1	90	2	95	323.0	HF2	90	2	95	470.0		396.5
				96	327.0				96	466.0		396.5
				97	323.0				97	538.0		430.5
				98	329.0				98	444.0		386.5
				99	326.0				99	527.0		426.5
				Avg:	325.6				Avg:	489.0	Avg:	407.3
				Std Dev:	2.608				Std Dev:	41.110	Std Dev:	19.829
B	OF2	0	1	95	994.0	HF1	0	1	95	607.0		800.5
				96	1458.0				96	628.0		1043.0
				97	947.0				97	612.0		779.5
				98	1228.0				98	610.0		919.0
				99	1348.0				99	619.0		983.5
				Avg:	1195.0				Avg:	615.2	Avg:	905.1
				Std Dev:	221.118				Std Dev:	8.408	Std Dev:	114.097
	OF2	0	2	95	1627.0	HF1	0	2	95	626.0		1126.5
				96	1053.0				96	617.0		835.0
				97	1738.0				97	574.0		1156.0
				98	1116.0				98	586.0		851.0
				99	1276.0				99	649.0		962.5
				Avg:	1362.0				Avg:	610.4	Avg:	986.2
				Std Dev:	306.184				Std Dev:	30.402	Std Dev:	150.182
	OF2	90	1	95	464.0	HF1	90	1	95	502.0		483.0
				96	405.0				96	508.0		456.5
				97	457.0				97	502.0		479.5
				98	454.0				98	501.0		477.5
				99	454.0				99	542.0		498.0
				Avg:	446.8				Avg:	511.0	Avg:	478.9
				Std Dev:	23.721				Std Dev:	17.550	Std Dev:	14.880
	OF2	90	2	95	441.0	HF1	90	2	95	468.0		454.5
				96	514.0				96	481.0		497.5
				97	469.0				97	498.0		483.5
				98	489.0				98	514.0		501.5
				99	486.0				99	466.0		476.0
				Avg:	479.8				Avg:	485.4	Avg:	482.6
				Std Dev:	26.994				Std Dev:	20.465	Std Dev:	18.796

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
B	OF1	0	1	95	973.0	HF2	0	1	95	1304.0		1138.5
				96	1032.0				96	1168.0		1100.0
				97	982.0				97	1224.0		1103.0
				98	996.0				98	1375.0		1185.5
				99	1031.0				99	1101.0		1066.0
			Avg:		1002.8			Avg:		1234.4	Avg:	1118.6
			Std Dev:		27.454			Std Dev:		108.311	Std Dev:	45.353
	OF1	0	2	95	992.0	HF2	0	2	95	1112.0		1052.0
				96	1021.0				96	1190.0		1105.5
				97	1012.0				97	1045.0		1028.5
				98	1041.0				98	1115.0		1078.0
				99	1026.0				99	1176.0		1101.0
			Avg:		1018.4			Avg:		1127.6	Avg:	1073.0
			Std Dev:		18.119			Std Dev:		58.011	Std Dev:	32.736
	OF1	90	1	95	967.0	HF2	90	1	95	905.0		936.0
				96	1071.0				96	1033.0		1052.0
				97	994.0				97	926.0		960.0
				98	1003.0				98	959.0		981.0
				99	1017.0				99	1015.0		1016.0
			Avg:		1010.4			Avg:		967.6	Avg:	989.0
			Std Dev:		38.481			Std Dev:		55.334	Std Dev:	45.858
	OF1	90	2	95	998.0	HF2	90	2	95	1011.0		1004.5
				96	1554.0				96	594.0		1074.0
				97	1342.0				97	651.0		996.5
				98	1408.0				98	600.0		1004.0
				99	1484.0				99	620.0		1052.0
			Avg:		1357.2			Avg:		695.2	Avg:	1026.2
			Std Dev:		216.012			Std Dev:		177.935	Std Dev:	34.628
B	OF2	0	1	95	645.0	HF1	0	1	95	931.0		788.0
				96	649.0				96	917.0		783.0
				97	653.0				97	915.0		784.0
				98	628.0				98	945.0		786.5
				99	656.0				99	944.0		800.0
			Avg:		646.2			Avg:		930.4	Avg:	788.3
			Std Dev:		10.986			Std Dev:		14.276	Std Dev:	6.834
	OF2	0	2	95	655.0	HF1	0	2	95	835.0		745.0
				96	602.0				96	813.0		707.5
				97	638.0				97	849.0		743.5
				98	636.0				98	834.0		735.0
				99	633.0				99	823.0		728.0
			Avg:		632.8			Avg:		830.8	Avg:	731.8
			Std Dev:		19.228			Std Dev:		13.572	Std Dev:	15.218
	OF2	90	1	95	366.0	HF1	90	1	95	1401.0		883.5
				96	369.0				96	1484.0		926.5
				97	364.0				97	1464.0		914.0
				98	362.0				98	1498.0		930.0
				99	377.0				99	1387.0		882.0
			Avg:		367.6			Avg:		1446.8	Avg:	907.2
			Std Dev:		5.857			Std Dev:		49.937	Std Dev:	23.105
	OF2	90	2	95	377.0	HF1	90	2	95	1498.0		937.5
				96	373.0				96	1498.0		935.5
				97	380.0				97	1629.0		1004.5
				98	367.0				98	1621.0		994.0
				99	376.0				99	1557.0		966.5
			Avg:		374.6			Avg:		1560.6	Avg:	967.6
			Std Dev:		4.930			Std Dev:		63.595	Std Dev:	31.608

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Mr Avg (Ksi)
B	OF1	0	1	95	1036.0	HF2	0	1	95	737.0	886.5
				96	1058.0				96	708.0	883.0
				97	1062.0				97	734.0	898.0
				98	1053.0				98	732.0	892.5
				99	1057.0				99	733.0	895.0
				Avg:	1053.2				Avg:	728.8	Avg: 891.0
				Std Dev:	10.134				Std Dev:	11.777	Std Dev: 6.154
	OF1	0	2	95	1047.0	HF2	0	2	95	729.0	888.0
				96	1040.0				96	720.0	880.0
				97	1073.0				97	719.0	896.0
				98	1050.0				98	748.0	899.0
				99	1069.0				99	742.0	905.5
				Avg:	1055.8				Avg:	731.6	Avg: 893.7
				Std Dev:	14.412				Std Dev:	13.012	Std Dev: 9.910
	OF1	90	1	95	4074.0	HF2	90	1	95	452.0	2263.0
				96	3711.0				96	455.0	2083.0
				97	3845.0				97	460.0	2152.5
				98	3612.0				98	473.0	2042.5
				99	3762.0				99	463.0	2112.5
				Avg:	3800.8				Avg:	460.6	Avg: 2130.7
				Std Dev:	174.504				Std Dev:	8.142	Std Dev: 84.209
	OF1	90	2	95	2607.0	HF2	90	2	95	414.0	1510.5
				96	2446.0				96	421.0	1433.5
				97	2879.0				97	419.0	1649.0
				98	2396.0				98	424.0	1410.0
				99	2675.0				99	427.0	1551.0
				Avg:	2600.6				Avg:	421.0	Avg: 1510.8
				Std Dev:	192.902				Std Dev:	4.950	Std Dev: 95.983
B	OF2	0	1	95	610.0	HF1	0	1	95	1238.0	924.0
				96	588.0				96	1252.0	920.0
				97	604.0				97	1224.0	914.0
				98	604.0				98	1249.0	926.5
				99	599.0				99	1196.0	897.5
				Avg:	601.0				Avg:	1231.8	Avg: 916.4
				Std Dev:	8.246				Std Dev:	22.830	Std Dev: 11.573
	OF2	0	2	95	587.0	HF1	0	2	95	1168.0	877.5
				96	600.0				96	1197.0	898.5
				97	609.0				97	1192.0	900.5
				98	606.0				98	1197.0	901.5
				99	590.0				99	1178.0	884.0
				Avg:	598.4				Avg:	1186.4	Avg: 892.4
				Std Dev:	9.659				Std Dev:	12.896	Std Dev: 10.934
	OF2	90	1	95	798.0	HF1	90	1	95	960.0	879.0
				96	829.0				96	932.0	880.5
				97	811.0				97	923.0	867.0
				98	807.0				98	977.0	892.0
				99	765.0				99	924.0	844.5
				Avg:	802.0				Avg:	943.2	Avg: 872.6
				Std Dev:	23.558				Std Dev:	24.118	Std Dev: 18.033
	OF2	90	2	95	728.0	HF1	90	2	95	895.0	811.5
				96	727.0				96	941.0	834.0
				97	719.0				97	932.0	825.5
				98	786.0				98	904.0	845.0
				99	699.0				99	990.0	844.5
				Avg:	731.8				Avg:	932.4	Avg: 832.1
				Std Dev:	32.461				Std Dev:	37.407	Std Dev: 14.069

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 1.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	693.0	HF2	0	1	95	482.0		587.5
				96	687.0				96	496.0		591.5
				97	682.0				97	573.0		627.5
				98	708.0				98	522.0		615.0
				99	729.0				99	484.0		606.5
			Avg:		699.8			Avg:		511.4	Avg:	605.6
			Std Dev:		19.018			Std Dev:		37.945	Std Dev:	16.547
	OF1	0	2	95	723.0	HF2	0	2	95	566.0		644.5
				96	686.0				96	549.0		617.5
				97	702.0				97	532.0		617.0
				98	752.0				98	532.0		642.0
				99	721.0				99	564.0		642.5
			Avg:		716.8			Avg:		548.6	Avg:	632.7
			Std Dev:		24.813			Std Dev:		16.517	Std Dev:	14.136
	OF1	90	1	95	752.0	HF2	90	1	95	1459.0		1105.5
				96	855.0				96	1114.0		984.5
				97	794.0				97	1314.0		1054.0
				98	890.0				98	1322.0		1106.0
				99	701.0				99	1379.0		1040.0
			Avg:		798.4			Avg:		1317.6	Avg:	1058.0
			Std Dev:		76.245			Std Dev:		127.720	Std Dev:	50.751
	OF1	90	2	95	864.0	HF2	90	2	95	990.0		927.0
				96	945.0				96	1497.0		1221.0
				97	957.0				97	1346.0		1151.5
				98	825.0				98	1182.0		1003.5
				99	1072.0				99	1325.0		1198.5
			Avg:		932.6			Avg:		1268.0	Avg:	1100.3
			Std Dev:		95.479			Std Dev:		191.347	Std Dev:	128.682
C	OF2	0	1	95	417.0	HF1	0	1	95	720.0		568.5
				96	477.0				96	822.0		649.5
				97	493.0				97	795.0		644.0
				98	450.0				98	807.0		628.5
				99	468.0				99	801.0		634.5
			Avg:		461.0			Avg:		789.0	Avg:	625.0
			Std Dev:		29.095			Std Dev:		39.856	Std Dev:	32.619
	OF2	0	2	95	527.0	HF1	0	2	95	776.0		651.5
				96	508.0				96	847.0		677.5
				97	442.0				97	771.0		606.5
				98	483.0				98	874.0		678.5
				99	499.0				99	820.0		659.5
			Avg:		491.8			Avg:		817.6	Avg:	654.7
			Std Dev:		32.058			Std Dev:		44.590	Std Dev:	29.338
	OF2	90	1	95	1332.0	HF1	90	1	95	504.0		918.0
				96	2154.0				96	516.0		1335.0
				97	2682.0				97	527.0		1604.5
				98	1543.0				98	509.0		1026.0
				99	2168.0				99	491.0		1329.5
			Avg:		1975.8			Avg:		509.4	Avg:	1242.6
			Std Dev:		540.650			Std Dev:		13.428	Std Dev:	273.561
	OF2	90	2	95	3034.0	HF1	90	2	95	519.0		1776.5
				96	2089.0				96	537.0		1313.0
				97	1838.0				97	526.0		1182.0
				98	2923.0				98	515.0		1719.0
				99	2408.0				99	546.0		1477.0
			Avg:		2458.4			Avg:		528.6	Avg:	1493.5
			Std Dev:		517.460			Std Dev:		12.818	Std Dev:	255.355

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 3.0 in.
Instant

<u>Mr Analysis</u>

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*Mr(Ksi)*		*Mr Avg (Ksi)*
C	OF1	0	1	95	528.0	HF2	0	1	95	1254.0		891.0
				96	530.0				96	1397.0		963.5
				97	546.0				97	1260.0		903.0
				98	536.0				98	1325.0		930.5
				99	542.0				99	1209.0		875.5
			Avg:		536.4			Avg:		1289.0	Avg:	912.7
			Std Dev:		7.668			Std Dev:		73.188	Std Dev:	34.808
	OF1	0	2	95	548.0	HF2	0	2	95	1168.0		858.0
				96	537.0				96	1173.0		855.0
				97	565.0				97	1186.0		875.5
				98	567.0				98	1304.0		935.5
				99	545.0				99	1214.0		879.5
			Avg:		552.4			Avg:		1209.0	Avg:	880.7
			Std Dev:		13.069			Std Dev:		56.027	Std Dev:	32.432
	OF1	90	1	95	1050.0	HF2	90	1	95	650.0		850.0
				96	1099.0				96	637.0		868.0
				97	1179.0				97	637.0		908.0
				98	1065.0				98	652.0		858.5
				99	1013.0				99	631.0		822.0
			Avg:		1081.2			Avg:		641.4	Avg:	861.3
			Std Dev:		62.787			Std Dev:		9.127	Std Dev:	31.248
	OF1	90	2	95	1134.0	HF2	90	2	95	635.0		884.5
				96	1125.0				96	639.0		882.0
				97	1148.0				97	648.0		898.0
				98	1140.0				98	653.0		896.5
				99	1083.0				99	642.0		862.5
			Avg:		1126.0			Avg:		643.4	Avg:	884.7
			Std Dev:		25.466			Std Dev:		7.162	Std Dev:	14.285
C	OF2	0	1	95	918.0	HF1	0	1	95	626.0		772.0
				96	810.0				96	634.0		722.0
				97	886.0				97	603.0		744.5
				98	873.0				98	628.0		750.5
				99	808.0				99	624.0		716.0
			Avg:		859.0			Avg:		623.0	Avg:	741.0
			Std Dev:		48.497			Std Dev:		11.790	Std Dev:	22.636
	OF2	0	2	95	935.0	HF1	0	2	95	610.0		772.5
				96	1004.0				96	602.0		803.0
				97	831.0				97	609.0		720.0
				98	909.0				98	596.0		752.5
				99	872.0				99	605.0		738.5
			Avg:		910.2			Avg:		604.4	Avg:	757.3
			Std Dev:		65.473			Std Dev:		5.683	Std Dev:	31.966
	OF2	90	1	95	514.0	HF1	90	1	95	1535.0		1024.5
				96	506.0				96	1438.0		972.0
				97	525.0				97	1488.0		1006.5
				98	540.0				98	1679.0		1109.5
				99	524.0				99	1522.0		1023.0
			Avg:		521.8			Avg:		1532.4	Avg:	1027.1
			Std Dev:		12.814			Std Dev:		90.124	Std Dev:	50.680
	OF2	90	2	95	495.0	HF1	90	2	95	1800.0		1147.5
				96	518.0				96	1720.0		1119.0
				97	520.0				97	1773.0		1146.5
				98	498.0				98	1767.0		1132.5
				99	522.0				99	1711.0		1116.5
			Avg:		510.6			Avg:		1754.2	Avg:	1132.4
			Std Dev:		12.992			Std Dev:		37.586	Std Dev:	14.656

Mix Type= 37.5 mm
Diam.= 6.00 in.
Gage Length= 4.5 in.
Instant

Mr Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)	Hidden Face	Rotation Effect	Repeat	Cycle	Mr(Ksi)		Mr Avg (Ksi)
C	OF1	0	1	95	675.0	HF2	0	1	95	1050.0		862.5
				96	687.0				96	1056.0		871.5
				97	692.0				97	1098.0		895.0
				98	693.0				98	1117.0		905.0
				99	689.0				99	1112.0		900.5
			Avg:		687.2			Avg:		1086.6	Avg:	886.9
			Std Dev:		7.225			Std Dev:		31.525	Std Dev:	18.780
	OF1	0	2	95	686.0	HF2	0	2	95	1077.0		881.5
				96	689.0				96	1066.0		877.5
				97	702.0				97	1089.0		895.5
				98	694.0				98	1138.0		916.0
				99	699.0				99	1132.0		915.5
			Avg:		694.0			Avg:		1100.4	Avg:	897.2
			Std Dev:		6.671			Std Dev:		32.685	Std Dev:	18.206
	OF1	90	1	95	773.0	HF2	90	1	95	629.0		701.0
				96	776.0				96	633.0		704.5
				97	778.0				97	629.0		703.5
				98	786.0				98	624.0		705.0
				99	788.0				99	650.0		719.0
			Avg:		780.2			Avg:		633.0	Avg:	706.6
			Std Dev:		6.496			Std Dev:		10.025	Std Dev:	7.101
	OF1	90	2	95	836.0	HF2	90	2	95	627.0		731.5
				96	843.0				96	621.0		732.0
				97	837.0				97	654.0		745.5
				98	860.0				98	633.0		746.5
				99	850.0				99	636.0		743.0
			Avg:		845.2			Avg:		634.2	Avg:	739.7
			Std Dev:		9.985			Std Dev:		12.478	Std Dev:	7.371
C	OF2	0	1	95	1101.0	HF1	0	1	95	816.0		958.5
				96	1051.0				96	824.0		937.5
				97	1160.0				97	840.0		1000.0
				98	1058.0				98	816.0		937.0
				99	1127.0				99	838.0		982.5
			Avg:		1099.4			Avg:		826.8	Avg:	963.1
			Std Dev:		46.079			Std Dev:		11.628	Std Dev:	27.820
	OF2	0	2	95	1091.0	HF1	0	2	95	817.0		954.0
				96	1076.0				96	825.0		950.5
				97	1099.0				97	828.0		963.5
				98	1070.0				98	792.0		931.0
				99	1059.0				99	822.0		940.5
			Avg:		1079.0			Avg:		816.8	Avg:	947.9
			Std Dev:		16.078			Std Dev:		14.446	Std Dev:	12.527
	OF2	90	1	95	550.0	HF1	90	1	95	1060.0		805.0
				96	541.0				96	1079.0		810.0
				97	568.0				97	1102.0		835.0
				98	566.0				98	1118.0		842.0
				99	568.0				99	1064.0		816.0
			Avg:		558.6			Avg:		1084.6	Avg:	821.6
			Std Dev:		12.402			Std Dev:		24.896	Std Dev:	16.103
	OF2	90	2	95	544.0	HF1	90	2	95	1005.0		774.5
				96	554.0				96	1043.0		798.5
				97	547.0				97	1044.0		795.5
				98	553.0				98	1016.0		784.5
				99	540.0				99	1032.0		786.0
			Avg:		547.6			Avg:		1028.0	Avg:	787.8
			Std Dev:		5.941			Std Dev:		17.103	Std Dev:	9.550

Annex 13

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Instantaneous

12.5 mm
4 inch Dia.

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
A	OF1	0	1	95	0.450	HF2	0	1	95	0.700		0.575
				96	0.580				96	0.390		0.485
				97	0.430				97	0.670		0.550
				98	0.460				98	0.490		0.475
				99	0.430				99	0.790		0.610
				Avg:	0.470				Avg:	0.608	Avg:	0.539
				Std Dev:	0.063				Std Dev:	0.163	Std Dev:	0.058
	OF1	0	2	95	0.460	HF2	0	2	95	0.680		0.570
				96	0.340				96	0.860		0.600
				97	0.590				97	0.550		0.570
				98	0.480				98	0.540		0.510
				99	0.390				99	0.380		0.385
				Avg:	0.452				Avg:	0.602	Avg:	0.527
				Std Dev:	0.095				Std Dev:	0.179	Std Dev:	0.086
	OF1	90	1	95	0.450	HF2	90	1	95	0.220		0.335
				96	0.440				96	0.140		0.290
				97	0.530				97	0.100		0.315
				98	0.430				98	0.220		0.325
				99	0.360				99	0.070		0.215
				Avg:	0.442				Avg:	0.150	Avg:	0.296
				Std Dev:	0.061				Std Dev:	0.069	Std Dev:	0.048
	OF1	90	2	95	0.420	HF2	90	2	95	0.110		0.265
				96	0.500				96	0.140		0.320
				97	0.430				97	0.200		0.315
				98	0.480				98	0.230		0.355
				99	0.490				99	0.140		0.315
				Avg:	0.464				Avg:	0.164	Avg:	0.314
				Std Dev:	0.036				Std Dev:	0.049	Std Dev:	0.032
A	OF2	0	1	95	0.540	HF1	0	1	95	0.430		0.485
				96	0.840				96	0.450		0.645
				97	0.670				97	0.370		0.520
				98	0.990				98	0.410		0.700
				99	0.880				99	0.450		0.665
				Avg:	0.784				Avg:	0.422	Avg:	0.603
				Std Dev:	0.178				Std Dev:	0.033	Std Dev:	0.095
	OF2	0	2	95	0.470	HF1	0	2	95	0.380		0.425
				96	0.630				96	0.360		0.495
				97	0.880				97	0.440		0.660
				98	0.880				98	0.480		0.680
				99	0.780				99	0.490		0.635
				Avg:	0.728				Avg:	0.430	Avg:	0.579
				Std Dev:	0.177				Std Dev:	0.058	Std Dev:	0.113
	OF2	90	1	95	0.270	HF1	90	1	95	0.430		0.350
				96	0.130				96	0.350		0.240
				97	0.140				97	0.240		0.190
				98	0.310				98	0.360		0.335
				99	0.360				99	0.410		0.385
				Avg:	0.242				Avg:	0.358	Avg:	0.300
				Std Dev:	0.103				Std Dev:	0.074	Std Dev:	0.082
	OF2	90	2	95	0.140	HF1	90	2	95	0.460		0.300
				96	0.240				96	0.420		0.330
				97	0.180				97	0.420		0.300
				98	0.220				98	0.510		0.365
				99	0.190				99	0.370		0.280
				Avg:	0.194				Avg:	0.436	Avg:	0.315
				Std Dev:	0.038				Std Dev:	0.052	Std Dev:	0.033

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.380	HF2	0	1	95	0.600		0.490
				96	0.410				96	0.600		0.505
				97	0.360				97	0.570		0.465
				98	0.380				98	0.660		0.520
				99	0.440				99	0.500		0.470
			Avg:		0.394			Avg:		0.586	Avg:	0.490
			Std Dev:		0.031			Std Dev:		0.058	Std Dev:	0.023
	OF1	0	2	95	0.450	HF2	0	2	95	0.720		0.585
				96	0.440				96	0.670		0.555
				97	0.420				97	0.710		0.565
				98	0.370				98	0.700		0.535
				99	0.390				99	0.810		0.600
			Avg:		0.414			Avg:		0.722	Avg:	0.568
			Std Dev:		0.034			Std Dev:		0.053	Std Dev:	0.025
	OF1	90	1	95	0.410	HF2	90	1	95	0.270		0.340
				96	0.450				96	0.300		0.375
				97	0.430				97	0.340		0.385
				98	0.410				98	0.360		0.385
				99	0.440				99	0.430		0.435
			Avg:		0.428			Avg:		0.340	Avg:	0.384
			Std Dev:		0.018			Std Dev:		0.061	Std Dev:	0.034
	OF1	90	2	95	0.540	HF2	90	2	95	0.440		0.490
				96	0.450				96	0.470		0.460
				97	0.480				97	0.380		0.430
				98	0.480				98	0.480		0.480
				99	0.440				99	0.470		0.455
			Avg:		0.478			Avg:		0.448	Avg:	0.463
			Std Dev:		0.039			Std Dev:		0.041	Std Dev:	0.023
A	OF2	0	1	95	0.570	HF1	0	1	95	0.550		0.560
				96	0.480				96	0.370		0.425
				97	0.550				97	0.380		0.465
				98	0.500				98	0.470		0.485
				99	0.550				99	0.450		0.500
			Avg:		0.530			Avg:		0.444	Avg:	0.467
			Std Dev:		0.038			Std Dev:		0.073	Std Dev:	0.050
	OF2	0	2	95	0.650	HF1	0	2	95	0.380		0.515
				96	0.660				96	0.530		0.595
				97	0.610				97	0.560		0.585
				98	0.550				98	0.400		0.475
				99	0.620				99	0.410		0.515
			Avg:		0.618			Avg:		0.456	Avg:	0.537
			Std Dev:		0.043			Std Dev:		0.083	Std Dev:	0.051
	OF2	90	1	95	0.400	HF1	90	1	95	0.480		0.440
				96	0.420				96	0.440		0.430
				97	0.350				97	0.430		0.390
				98	0.460				98	0.420		0.440
				99	0.480				99	0.390		0.435
			Avg:		0.422			Avg:		0.432	Avg:	0.427
			Std Dev:		0.051			Std Dev:		0.033	Std Dev:	0.021
	OF2	90	2	95	0.390	HF1	90	2	95	0.490		0.440
				96	0.220				96	0.530		0.375
				97	0.370				97	0.670		0.520
				98	0.490				98	0.730		0.610
				99	0.400				99	0.490		0.445
			Avg:		0.374			Avg:		0.582	Avg:	0.478
			Std Dev:		0.098			Std Dev:		0.111	Std Dev:	0.090

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.570	HF2	0	1	95	0.590		0.580
				96	0.570				96	0.610		0.590
				97	0.580				97	0.550		0.565
				98	0.590				98	0.630		0.610
				99	0.570				99	0.630		0.600
			Avg:		0.576			Avg:		0.602	Avg:	0.589
			Std Dev:		0.009			Std Dev:		0.033	Std Dev:	0.017
	OF1	0	2	95	0.510	HF2	0	2	95	0.650		0.580
				96	0.490				96	0.680		0.585
				97	0.480				97	0.590		0.535
				98	0.520				98	0.640		0.580
				99	0.400				99	0.650		0.525
			Avg:		0.480			Avg:		0.642	Avg:	0.561
			Std Dev:		0.047			Std Dev:		0.033	Std Dev:	0.029
	OF1	90	1	95	0.330	HF2	90	1	95	0.390		0.360
				96	0.370				96	0.530		0.450
				97	0.350				97	0.490		0.420
				98	0.390				98	0.400		0.395
				99	0.410				99	0.450		0.430
			Avg:		0.370			Avg:		0.452	Avg:	0.411
			Std Dev:		0.032			Std Dev:		0.059	Std Dev:	0.035
	OF1	90	2	95	0.440	HF2	90	2	95	0.450		0.445
				96	0.440				96	0.500		0.470
				97	0.440				97	0.470		0.455
				98	0.410				98	0.550		0.480
				99	0.430				99	0.490		0.460
			Avg:		0.432			Avg:		0.492	Avg:	0.462
			Std Dev:		0.013			Std Dev:		0.038	Std Dev:	0.014
A	OF2	0	1	95	0.710	HF1	0	1	95	0.560		0.635
				96	0.700				96	0.430		0.565
				97	0.570				97	0.380		0.475
				98	0.660				98	0.460		0.560
				99	0.640				99	0.460		0.550
			Avg:		0.656			Avg:		0.458	Avg:	0.557
			Std Dev:		0.056			Std Dev:		0.066	Std Dev:	0.057
	OF2	0	2	95	0.670	HF1	0	2	95	0.420		0.545
				96	0.740				96	0.520		0.630
				97	0.790				97	0.550		0.670
				98	0.740				98	0.630		0.685
				99	0.660				99	0.610		0.635
			Avg:		0.720			Avg:		0.546	Avg:	0.633
			Std Dev:		0.054			Std Dev:		0.083	Std Dev:	0.054
	OF2	90	1	95	0.500	HF1	90	1	95	0.550		0.525
				96	0.350				96	0.460		0.405
				97	0.490				97	0.530		0.510
				98	0.420				98	0.550		0.485
				99	0.570				99	0.500		0.535
			Avg:		0.466			Avg:		0.518	Avg:	0.492
			Std Dev:		0.084			Std Dev:		0.038	Std Dev:	0.052
	OF2	90	2	95	0.560	HF1	90	2	95	0.520		0.540
				96	0.480				96	0.570		0.525
				97	0.530				97	0.540		0.535
				98	0.360				98	0.530		0.445
				99	0.480				99	0.570		0.525
			Avg:		0.482			Avg:		0.546	Avg:	0.514
			Std Dev:		0.076			Std Dev:		0.023	Std Dev:	0.039

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.370	HF2	0	1	95	0.110		0.240
				96	0.460				96	0.180		0.320
				97	0.510				97	0.010		0.260
				98	0.480				98	0.190		0.335
				99	0.660				99	0.030		0.345
			Avg:		0.496			Avg:		0.104	Avg:	0.300
			Std Dev:		0.105			Std Dev:		0.083	Std Dev:	0.047
	OF1	0	2	95	0.440	HF2	0	2	95	0.060		0.250
				96	0.500				96	0.060		0.280
				97	0.280				97	0.070		0.175
				98	0.300				98	0.130		0.215
				99	0.380				99	0.100		0.240
			Avg:		0.380			Avg:		0.084	Avg:	0.232
			Std Dev:		0.093			Std Dev:		0.030	Std Dev:	0.039
	OF1	90	1	95	0.240	HF2	90	1	95	1.170		0.705
				96	0.120				96	0.700		0.410
				97	0.150				97	1.800		0.975
				98	0.260				98	0.940		0.600
				99	0.300				99	1.120		0.710
			Avg:		0.214			Avg:		1.146	Avg:	0.680
			Std Dev:		0.076			Std Dev:		0.409	Std Dev:	0.205
	OF1	90	2	95	0.190	HF2	90	2	95	1.020		0.605
				96	0.110				96	1.170		0.640
				97	0.150				97	0.970		0.560
				98	0.090				98	0.840		0.465
				99	0.150				99	1.120		0.635
			Avg:		0.138			Avg:		1.024	Avg:	0.581
			Std Dev:		0.039			Std Dev:		0.130	Std Dev:	0.072
B	OF2	0	1	95	0.060	HF1	0	1	95	0.590		0.325
				96	0.140				96	0.510		0.325
				97	0.060				97	0.410		0.235
				98	0.130				98	0.440		0.285
				99	0.080				99	0.320		0.200
			Avg:		0.094			Avg:		0.454	Avg:	0.274
			Std Dev:		0.038			Std Dev:		0.102	Std Dev:	0.055
	OF2	0	2	95	0.120	HF1	0	2	95	0.360		0.240
				96	0.160				96	0.280		0.220
				97	0.180				97	0.460		0.320
				98	0.260				98	0.480		0.370
				99	0.050				99	0.340		0.195
			Avg:		0.154			Avg:		0.384	Avg:	0.269
			Std Dev:		0.077			Std Dev:		0.084	Std Dev:	0.073
	OF2	90	1	95	0.690	HF1	90	1	95	0.140		0.415
				96	0.830				96	0.160		0.495
				97	1.100				97	0.220		0.660
				98	0.770				98	0.280		0.525
				99	0.670				99	0.180		0.425
			Avg:		0.812			Avg:		0.196	Avg:	0.504
			Std Dev:		0.173			Std Dev:		0.055	Std Dev:	0.099
	OF2	90	2	95	0.490	HF1	90	2	95	0.110		0.300
				96	0.790				96	0.160		0.475
				97	1.200				97	0.260		0.730
				98	0.700				98	0.170		0.435
				99	0.810				99	0.210		0.510
			Avg:		0.798			Avg:		0.182	Avg:	0.490
			Std Dev:		0.258			Std Dev:		0.056	Std Dev:	0.156

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.450	HF2	0	1	95	0.480		0.465
				96	0.390				96	0.570		0.480
				97	0.460				97	0.480		0.470
				98	0.450				98	0.420		0.435
				99	0.440				99	0.480		0.460
				Avg:	0.438				Avg:	0.486	Avg:	0.462
				Std Dev:	0.028				Std Dev:	0.054	Std Dev:	0.017
	OF1	0	2	95	0.440	HF2	0	2	95	0.560		0.500
				96	0.400				96	0.340		0.370
				97	0.410				97	0.460		0.435
				98	0.450				98	0.600		0.525
				99	0.430				99	0.550		0.490
				Avg:	0.426				Avg:	0.502	Avg:	0.464
				Std Dev:	0.021				Std Dev:	0.104	Std Dev:	0.062
	OF1	90	1	95	0.430	HF2	90	1	95	0.410		0.420
				96	0.420				96	0.500		0.460
				97	0.400				97	0.560		0.480
				98	0.420				98	0.360		0.390
				99	0.400				99	0.290		0.345
				Avg:	0.414				Avg:	0.424	Avg:	0.419
				Std Dev:	0.013				Std Dev:	0.108	Std Dev:	0.054
	OF1	90	2	95	0.450	HF2	90	2	95	0.510		0.480
				96	0.420				96	0.490		0.455
				97	0.430				97	0.460		0.445
				98	0.420				98	0.370		0.395
				99	0.420				99	0.370		0.395
				Avg:	0.428				Avg:	0.440	Avg:	0.434
				Std Dev:	0.013				Std Dev:	0.066	Std Dev:	0.038
B	OF2	0	1	95	0.590	HF1	0	1	95	0.380		0.485
				96	0.630				96	0.320		0.475
				97	0.490				97	0.380		0.435
				98	0.510				98	0.390		0.450
				99	0.420				99	0.350		0.385
				Avg:	0.528				Avg:	0.364	Avg:	0.446
				Std Dev:	0.083				Std Dev:	0.029	Std Dev:	0.039
	OF2	0	2	95	0.490	HF1	0	2	95	0.460		0.475
				96	0.460				96	0.440		0.450
				97	0.410				97	0.400		0.405
				98	0.500				98	0.430		0.465
				99	0.650				99	0.450		0.550
				Avg:	0.502				Avg:	0.436	Avg:	0.469
				Std Dev:	0.090				Std Dev:	0.023	Std Dev:	0.053
	OF2	90	1	95	0.490	HF1	90	1	95	0.420		0.455
				96	0.440				96	0.470		0.455
				97	0.430				97	0.450		0.440
				98	0.430				98	0.430		0.430
				99	0.340				99	0.460		0.400
				Avg:	0.426				Avg:	0.446	Avg:	0.436
				Std Dev:	0.054				Std Dev:	0.021	Std Dev:	0.023
	OF2	90	2	95	0.300	HF1	90	2	95	0.400		0.350
				96	0.390				96	0.390		0.390
				97	0.430				97	0.440		0.435
				98	0.450				98	0.440		0.445
				99	0.510				99	0.420		0.465
				Avg:	0.416				Avg:	0.418	Avg:	0.417
				Std Dev:	0.078				Std Dev:	0.023	Std Dev:	0.046

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.350	HF2	0	1	95	0.600		0.475
				96	0.410				96	0.520		0.465
				97	0.450				97	0.520		0.485
				98	0.320				98	0.580		0.450
				99	0.400				99	0.510		0.455
			Avg:		0.386			Avg:		0.546	Avg:	0.466
			Std Dev:		0.051			Std Dev:		0.041	Std Dev:	0.014
	OF1	0	2	95	0.410	HF2	0	2	95	0.520		0.465
				96	0.370				96	0.540		0.455
				97	0.340				97	0.590		0.465
				98	0.380				98	0.570		0.475
				99	0.420				99	0.590		0.505
			Avg:		0.384			Avg:		0.562	Avg:	0.473
			Std Dev:		0.032			Std Dev:		0.031	Std Dev:	0.019
	OF1	90	1	95	0.540	HF2	90	1	95	0.460		0.500
				96	0.450				96	0.430		0.440
				97	0.480				97	0.350		0.415
				98	0.490				98	0.410		0.450
				99	0.520				99	0.470		0.495
			Avg:		0.496			Avg:		0.424	Avg:	0.460
			Std Dev:		0.035			Std Dev:		0.048	Std Dev:	0.037
	OF1	90	2	95	0.490	HF2	90	2	95	0.450		0.470
				96	0.510				96	0.500		0.505
				97	0.530				97	0.390		0.460
				98	0.570				98	0.460		0.515
				99	0.510				99	0.470		0.490
			Avg:		0.522			Avg:		0.454	Avg:	0.488
			Std Dev:		0.030			Std Dev:		0.040	Std Dev:	0.023
B	OF2	0	1	95	0.480	HF1	0	1	95	0.420		0.450
				96	0.480				96	0.340		0.410
				97	0.480				97	0.440		0.460
				98	0.490				98	0.390		0.440
				99	0.460				99	0.430		0.445
			Avg:		0.478			Avg:		0.404	Avg:	0.441
			Std Dev:		0.011			Std Dev:		0.040	Std Dev:	0.019
	OF2	0	2	95	0.500	HF1	0	2	95	0.440		0.470
				96	0.490				96	0.410		0.450
				97	0.460				97	0.430		0.445
				98	0.470				98	0.490		0.480
				99	0.510				99	0.410		0.460
			Avg:		0.486			Avg:		0.436	Avg:	0.461
			Std Dev:		0.021			Std Dev:		0.033	Std Dev:	0.014
	OF2	90	1	95	0.450	HF1	90	1	95	0.420		0.435
				96	0.530				96	0.400		0.465
				97	0.470				97	0.440		0.455
				98	0.500				98	0.440		0.470
				99	0.510				99	0.440		0.475
			Avg:		0.492			Avg:		0.428	Avg:	0.460
			Std Dev:		0.032			Std Dev:		0.018	Std Dev:	0.016
	OF2	90	2	95	0.520	HF1	90	2	95	0.520		0.520
				96	0.550				96	0.470		0.510
				97	0.520				97	0.430		0.475
				98	0.500				98	0.510		0.505
				99	0.510				99	0.410		0.460
			Avg:		0.520			Avg:		0.468	Avg:	0.494
			Std Dev:		0.019			Std Dev:		0.048	Std Dev:	0.025

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.210	HF2	0	1	95	0.310		0.260
				96	0.140				96	0.270		0.205
				97	0.170				97	0.310		0.240
				98	0.200				98	0.300		0.250
				99	0.190				99	0.390		0.290
			Avg:		0.182			Avg:		0.316	Avg:	0.249
			Std Dev:		0.028			Std Dev:		0.044	Std Dev:	0.031
	OF1	0	2	95	0.260	HF2	0	2	95	0.200		0.230
				96	0.210				96	0.390		0.300
				97	0.340				97	0.340		0.340
				98	0.290				98	0.240		0.265
				99	0.250				99	0.320		0.285
			Avg:		0.270			Avg:		0.298	Avg:	0.284
			Std Dev:		0.048			Std Dev:		0.077	Std Dev:	0.041
	OF1	90	1	95	0.810	HF2	90	1	95	0.910		0.860
				96	0.890				96	0.880		0.885
				97	1.020				97	0.880		0.950
				98	0.970				98	0.840		0.905
				99	1.170				99	0.760		0.965
			Avg:		0.972			Avg:		0.854	Avg:	0.913
			Std Dev:		0.136			Std Dev:		0.058	Std Dev:	0.044
	OF1	90	2	95	1.250	HF2	90	2	95	1.050		1.150
				96	1.230				96	0.900		1.065
				97	1.390				97	0.930		1.160
				98	1.070				98	0.960		1.015
				99	1.350				99	1.020		1.185
			Avg:		1.258			Avg:		0.972	Avg:	1.115
			Std Dev:		0.125			Std Dev:		0.062	Std Dev:	0.072
C	OF2	0	1	95	0.050	HF1	0	1	95	0.030		0.040
				96	0.100				96	0.110		0.105
				97	0.150				97	0.040		0.095
				98	0.030				98	0.020		0.025
				99	0.050				99	0.110		0.080
			Avg:		0.076			Avg:		0.062	Avg:	0.069
			Std Dev:		0.049			Std Dev:		0.044	Std Dev:	0.035
	OF2	0	2	95	0.040	HF1	0	2	95	0.250		0.145
				96	0.060				96	0.280		0.170
				97	0.120				97	0.220		0.170
				98	0.080				98	0.290		0.185
				99	0.080				99	0.240		0.160
			Avg:		0.076			Avg:		0.256	Avg:	0.166
			Std Dev:		0.030			Std Dev:		0.029	Std Dev:	0.015
	OF2	90	1	95	1.010	HF1	90	1	95	1.500		1.255
				96	0.920				96	1.490		1.205
				97	1.190				97	1.410		1.300
				98	0.780				98	1.430		1.105
				99	0.940				99	1.470		1.205
			Avg:		0.968			Avg:		1.460	Avg:	1.214
			Std Dev:		0.150			Std Dev:		0.039	Std Dev:	0.073
	OF2	90	2	95	0.870	HF1	90	2	95	1.420		1.145
				96	0.710				96	1.640		1.175
				97	0.760				97	1.330		1.045
				98	1.060				98	1.460		1.260
				99	0.930				99	1.280		1.105
			Avg:		0.866			Avg:		1.426	Avg:	1.146
			Std Dev:		0.139			Std Dev:		0.139	Std Dev:	0.080

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.360	HF2	0	1	95	0.970		0.665
				96	0.310				96	0.800		0.555
				97	0.300				97	0.630		0.465
				98	0.370				98	0.650		0.510
				99	0.300				99	0.680		0.490
			Avg:		0.328			Avg:		0.746	Avg:	0.537
			Std Dev:		0.034			Std Dev:		0.142	Std Dev:	0.079
	OF1	0	2	95	0.310	HF2	0	2	95	0.690		0.500
				96	0.390				96	0.680		0.535
				97	0.340				97	0.700		0.520
				98	0.320				98	0.680		0.500
				99	0.340				99	0.780		0.560
			Avg:		0.340			Avg:		0.706	Avg:	0.523
			Std Dev:		0.031			Std Dev:		0.042	Std Dev:	0.025
	OF1	90	1	95	0.300	HF2	90	1	95	0.060		0.180
				96	0.260				96	0.080		0.170
				97	0.270				97	0.060		0.165
				98	0.290				98	0.050		0.170
				99	0.290				99	0.080		0.185
			Avg:		0.282			Avg:		0.066	Avg:	0.174
			Std Dev:		0.016			Std Dev:		0.013	Std Dev:	0.008
	OF1	90	2	95	0.290	HF2	90	2	95	0.030		0.160
				96	0.260				96	0.050		0.155
				97	0.300				97	0.040		0.170
				98	0.290				98	0.050		0.170
				99	0.290				99	0.090		0.190
			Avg:		0.286			Avg:		0.052	Avg:	0.169
			Std Dev:		0.015			Std Dev:		0.023	Std Dev:	0.013
C	OF2	0	1	95	0.550	HF1	0	1	95	0.470		0.510
				96	0.560				96	0.490		0.525
				97	0.570				97	0.410		0.490
				98	0.480				98	0.410		0.445
				99	0.490				99	0.480		0.485
			Avg:		0.530			Avg:		0.452	Avg:	0.491
			Std Dev:		0.042			Std Dev:		0.039	Std Dev:	0.030
	OF2	0	2	95	0.540	HF1	0	2	95	0.460		0.500
				96	0.530				96	0.410		0.470
				97	0.550				97	0.380		0.465
				98	0.570				98	0.410		0.490
				99	0.570				99	0.480		0.525
			Avg:		0.552			Avg:		0.428	Avg:	0.490
			Std Dev:		0.018			Std Dev:		0.041	Std Dev:	0.024
	OF2	90	1	95	0.170	HF1	90	1	95	0.320		0.245
				96	0.160				96	0.250		0.205
				97	0.080				97	0.240		0.160
				98	0.110				98	0.290		0.200
				99	0.160				99	0.280		0.220
			Avg:		0.136			Avg:		0.276	Avg:	0.206
			Std Dev:		0.039			Std Dev:		0.032	Std Dev:	0.031
	OF2	90	2	95	0.030	HF1	90	2	95	0.310		0.170
				96	0.020				96	0.260		0.140
				97	0.030				97	0.270		0.150
				98	0.070				98	0.300		0.185
				99	0.040				99	0.270		0.155
			Avg:		0.038			Avg:		0.282	Avg:	0.160
			Std Dev:		0.019			Std Dev:		0.022	Std Dev:	0.018

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.550	HF2	0	1	95	0.620		0.585
				96	0.590				96	0.680		0.635
				97	0.650				97	0.660		0.655
				98	0.710				98	0.670		0.690
				99	0.550				99	0.730		0.640
			Avg:		0.610			Avg:		0.672	Avg:	0.641
			Std Dev:		0.069			Std Dev:		0.040	Std Dev:	0.038
	OF1	0	2	95	0.510	HF2	0	2	95	0.600		0.555
				96	0.640				96	0.690		0.665
				97	0.590				97	0.670		0.630
				98	0.550				98	0.750		0.650
				99	0.550				99	0.650		0.600
			Avg:		0.568			Avg:		0.672	Avg:	0.620
			Std Dev:		0.049			Std Dev:		0.055	Std Dev:	0.044
	OF1	90	1	95	0.630	HF2	90	1	95	0.670		0.650
				96	0.660				96	0.830		0.745
				97	0.650				97	0.870		0.760
				98	0.630				98	0.730		0.680
				99	1.090				99	0.790		0.940
			Avg:		0.732			Avg:		0.778	Avg:	0.755
			Std Dev:		0.201			Std Dev:		0.079	Std Dev:	0.113
	OF1	90	2	95	0.750	HF2	90	2	95	0.820		0.785
				96	0.740				96	0.960		0.850
				97	0.780				97	0.870		0.825
				98	0.740				98	0.860		0.800
				99	0.760				99	0.880		0.820
			Avg:		0.754			Avg:		0.878	Avg:	0.816
			Std Dev:		0.017			Std Dev:		0.051	Std Dev:	0.025
C	OF2	0	1	95	0.470	HF1	0	1	95	0.650		0.560
				96	0.420				96	0.620		0.520
				97	0.440				97	0.600		0.520
				98	0.430				98	0.640		0.535
				99	0.430				99	0.610		0.520
			Avg:		0.438			Avg:		0.624	Avg:	0.531
			Std Dev:		0.019			Std Dev:		0.021	Std Dev:	0.017
	OF2	0	2	95	0.510	HF1	0	2	95	0.620		0.565
				96	0.490				96	0.640		0.565
				97	0.560				97	0.650		0.605
				98	0.560				98	0.570		0.565
				99	0.510				99	0.590		0.550
			Avg:		0.526			Avg:		0.614	Avg:	0.570
			Std Dev:		0.032			Std Dev:		0.034	Std Dev:	0.021
	OF2	90	1	95	0.830	HF1	90	1	95	0.860		0.845
				96	0.850				96	0.830		0.840
				97	0.720				97	0.780		0.750
				98	0.870				98	0.750		0.810
				99	0.910				99	0.840		0.875
			Avg:		0.836			Avg:		0.812	Avg:	0.824
			Std Dev:		0.071			Std Dev:		0.045	Std Dev:	0.047
	OF2	90	2	95	0.840	HF1	90	2	95	0.910		0.875
				96	0.890				96	0.750		0.820
				97	0.720				97	0.790		0.755
				98	0.740				98	0.810		0.775
				99	0.770				99	0.770		0.770
			Avg:		0.792			Avg:		0.806	Avg:	0.799
			Std Dev:		0.071			Std Dev:		0.062	Std Dev:	0.049

Annex 14

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Instantaneous

19.0 mm
4 inch Dia.

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	1.360	HF2	0	1	95	0.180		0.770
				96	1.390				96	0.170		0.780
				97	1.410				97	0.280		0.845
				98	1.640				98	0.250		0.945
				99	1.520				99	0.220		0.870
			Avg:		1.464			Avg:		0.220	Avg:	0.842
			Std Dev:		0.115			Std Dev:		0.046	Std Dev:	0.071
	OF1	0	2	95	1.860	HF2	0	2	95	0.270		1.065
				96	1.850				96	0.290		1.070
				97	1.740				97	0.250		0.995
				98	2.550				98	0.180		1.365
				99	2.510				99	0.220		1.365
			Avg:		2.102			Avg:		0.242	Avg:	1.172
			Std Dev:		0.394			Std Dev:		0.043	Std Dev:	0.179
	OF1	90	1	95	0.040	HF2	90	1	95	0.910		0.475
				96	0.010				96	0.810		0.410
				97	0.010				97	0.930		0.470
				98	0.020				98	0.790		0.405
				99	0.040				99	0.810		0.425
			Avg:		0.024			Avg:		0.850	Avg:	0.437
			Std Dev:		0.015			Std Dev:		0.065	Std Dev:	0.033
	OF1	90	2	95	0.100	HF2	90	2	95	1.030		0.565
				96	0.030				96	0.880		0.455
				97	0.010				97	0.890		0.450
				98	0.030				98	1.260		0.645
				99	0.120				99	0.800		0.460
			Avg:		0.058			Avg:		0.972	Avg:	0.515
			Std Dev:		0.049			Std Dev:		0.181	Std Dev:	0.087
A	OF2	0	1	95	0.230	HF1	0	1	95	1.100		0.665
				96	0.310				96	1.570		0.940
				97	0.400				97	1.530		0.965
				98	0.290				98	1.480		0.885
				99	0.210				99	1.440		0.825
			Avg:		0.288			Avg:		1.424	Avg:	0.856
			Std Dev:		0.075			Std Dev:		0.188	Std Dev:	0.120
	OF2	0	2	95	0.260	HF1	0	2	95	2.290		1.275
				96	0.300				96	1.860		1.080
				97	0.340				97	2.000		1.170
				98	0.280				98	2.060		1.170
				99	0.300				99	1.850		1.075
			Avg:		0.296			Avg:		2.012	Avg:	1.154
			Std Dev:		0.030			Std Dev:		0.180	Std Dev:	0.082
	OF2	90	1	95	0.740	HF1	90	1	95	0.070		0.405
				96	0.920				96	0.060		0.490
				97	0.810				97	0.080		0.445
				98	0.850				98	0.030		0.440
				99	0.860				99	0.080		0.470
			Avg:		0.836			Avg:		0.064	Avg:	0.450
			Std Dev:		0.067			Std Dev:		0.021	Std Dev:	0.032
	OF2	90	2	95	1.020	HF1	90	2	95	0.010		0.515
				96	0.810				96	0.040		0.425
				97	0.980				97	0.010		0.495
				98	1.040				98	0.070		0.555
				99	1.070				99	0.080		0.575
			Avg:		0.984			Avg:		0.042	Avg:	0.513
			Std Dev:		0.103			Std Dev:		0.033	Std Dev:	0.058

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.340	HF2	0	1	95	0.280		0.310
				96	0.450				96	0.400		0.425
				97	0.380				97	0.430		0.405
				98	0.380				98	0.500		0.440
				99	0.350				99	0.550		0.450
			Avg:		0.380			Avg:		0.432	Avg:	0.406
			Std Dev:		0.043			Std Dev:		0.103	Std Dev:	0.056
	OF1	0	2	95	0.360	HF2	0	2	95	0.440		0.400
				96	0.400				96	0.510		0.455
				97	0.390				97	0.540		0.465
				98	0.390				98	0.490		0.440
				99	0.410				99	0.430		0.420
			Avg:		0.390			Avg:		0.482	Avg:	0.436
			Std Dev:		0.019			Std Dev:		0.047	Std Dev:	0.026
	OF1	90	1	95	0.710	HF2	90	1	95	0.590		0.650
				96	0.740				96	0.510		0.625
				97	0.760				97	0.530		0.645
				98	0.760				98	0.520		0.640
				99	0.790				99	0.420		0.605
			Avg:		0.752			Avg:		0.514	Avg:	0.633
			Std Dev:		0.029			Std Dev:		0.061	Std Dev:	0.018
	OF1	90	2	95	0.780	HF2	90	2	95	0.350		0.565
				96	0.920				96	0.330		0.625
				97	0.790				97	0.330		0.560
				98	0.830				98	0.320		0.575
				99	0.860				99	0.280		0.570
			Avg:		0.836			Avg:		0.322	Avg:	0.579
			Std Dev:		0.057			Std Dev:		0.026	Std Dev:	0.026
A	OF2	0	1	95	0.340	HF1	0	1	95	0.350		0.345
				96	0.370				96	0.320		0.345
				97	0.410				97	0.360		0.385
				98	0.560				98	0.400		0.480
				99	0.490				99	0.410		0.450
			Avg:		0.434			Avg:		0.368	Avg:	0.401
			Std Dev:		0.090			Std Dev:		0.037	Std Dev:	0.062
	OF2	0	2	95	0.490	HF1	0	2	95	0.350		0.420
				96	0.360				96	0.370		0.365
				97	0.380				97	0.380		0.380
				98	0.350				98	0.370		0.360
				99	0.310				99	0.400		0.355
			Avg:		0.378			Avg:		0.374	Avg:	0.376
			Std Dev:		0.068			Std Dev:		0.018	Std Dev:	0.026
	OF2	90	1	95	0.570	HF1	90	1	95	0.720		0.645
				96	0.550				96	0.780		0.665
				97	0.420				97	0.690		0.555
				98	0.400				98	0.700		0.550
				99	0.420				99	0.880		0.650
			Avg:		0.472			Avg:		0.754	Avg:	0.613
			Std Dev:		0.081			Std Dev:		0.079	Std Dev:	0.056
	OF2	90	2	95	0.440	HF1	90	2	95	0.860		0.650
				96	0.440				96	0.760		0.600
				97	0.570				97	0.900		0.735
				98	0.600				98	0.860		0.730
				99	0.630				99	0.950		0.790
			Avg:		0.536			Avg:		0.866	Avg:	0.701
			Std Dev:		0.090			Std Dev:		0.070	Std Dev:	0.075

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	1.210	HF2	0	1	95	0.570		0.890
				96	1.120				96	0.580		0.850
				97	1.020				97	0.530		0.775
				98	1.250				98	0.440		0.845
				99	1.120				99	0.480		0.800
			Avg:		1.144			Avg:		0.520	Avg:	0.832
			Std Dev:		0.090			Std Dev:		0.060	Std Dev:	0.045
	OF1	0	2	95	0.980	HF2	0	2	95	0.490		0.735
				96	1.160				96	0.460		0.820
				97	1.190				97	0.450		0.820
				98	1.170				98	0.440		0.805
				99	1.030				99	0.520		0.775
			Avg:		1.110			Avg:		0.472	Avg:	0.791
			Std Dev:		0.098			Std Dev:		0.033	Std Dev:	0.036
	OF1	90	1	95	0.590	HF2	90	1	95	0.390		0.490
				96	0.640				96	0.290		0.465
				97	0.650				97	0.280		0.465
				98	0.600				98	0.220		0.410
				99	0.660				99	0.260		0.460
			Avg:		0.628			Avg:		0.288	Avg:	0.458
			Std Dev:		0.031			Std Dev:		0.063	Std Dev:	0.029
	OF1	90	2	95	0.640	HF2	90	2	95	0.270		0.455
				96	0.690				96	0.350		0.520
				97	0.610				97	0.390		0.500
				98	0.690				98	0.350		0.520
				99	0.700				99	0.310		0.505
			Avg:		0.666			Avg:		0.334	Avg:	0.500
			Std Dev:		0.039			Std Dev:		0.046	Std Dev:	0.027
A	OF2	0	1	95	0.620	HF1	0	1	95	0.710		0.665
				96	0.590				96	0.660		0.625
				97	0.570				97	0.720		0.645
				98	0.460				98	0.730		0.595
				99	0.480				99	0.700		0.590
			Avg:		0.544			Avg:		0.704	Avg:	0.624
			Std Dev:		0.070			Std Dev:		0.027	Std Dev:	0.032
	OF2	0	2	95	0.490	HF1	0	2	95	0.760		0.625
				96	0.540				96	0.720		0.630
				97	0.430				97	0.670		0.550
				98	0.390				98	0.750		0.570
				99	0.470				99	0.700		0.585
			Avg:		0.464			Avg:		0.720	Avg:	0.592
			Std Dev:		0.057			Std Dev:		0.037	Std Dev:	0.035
	OF2	90	1	95	0.240	HF1	90	1	95	0.670		0.455
				96	0.290				96	0.700		0.495
				97	0.290				97	0.730		0.510
				98	0.320				98	0.800		0.560
				99	0.350				99	0.730		0.540
			Avg:		0.298			Avg:		0.726	Avg:	0.512
			Std Dev:		0.041			Std Dev:		0.048	Std Dev:	0.041
	OF2	90	2	95	0.270	HF1	90	2	95	0.730		0.500
				96	0.320				96	0.720		0.520
				97	0.260				97	0.670		0.465
				98	0.300				98	0.750		0.525
				99	0.360				99	0.700		0.530
			Avg:		0.302			Avg:		0.714	Avg:	0.508
			Std Dev:		0.040			Std Dev:		0.030	Std Dev:	0.027

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	1.230	HF2	0	1	95	1.030		1.130
				96	0.610				96	0.670		0.640
				97	0.870				97	1.090		0.980
				98	0.620				98	0.790		0.705
				99	0.710				99	0.800		0.755
				Avg:	0.808				Avg:	0.876	Avg:	0.842
				Std Dev:	0.258				Std Dev:	0.177	Std Dev:	0.206
	OF1	0	2	95	0.560	HF2	0	2	95	0.870		0.715
				96	0.440				96	0.960		0.700
				97	0.470				97	0.920		0.695
				98	0.700				98	1.340		1.020
				99	0.540				99	0.940		0.740
				Avg:	0.542				Avg:	1.006	Avg:	0.774
				Std Dev:	0.101				Std Dev:	0.190	Std Dev:	0.139
	OF1	90	1	95	0.220	HF2	90	1	95	0.670		0.445
				96	0.260				96	0.610		0.435
				97	0.270				97	0.660		0.465
				98	0.260				98	0.580		0.420
				99	0.210				99	0.480		0.345
				Avg:	0.244				Avg:	0.600	Avg:	0.422
				Std Dev:	0.027				Std Dev:	0.076	Std Dev:	0.046
	OF1	90	2	95	0.220	HF2	90	2	95	0.510		0.365
				96	0.250				96	0.680		0.465
				97	0.160				97	0.630		0.395
				98	0.240				98	0.590		0.415
				99	0.240				99	0.710		0.475
				Avg:	0.222				Avg:	0.624	Avg:	0.423
				Std Dev:	0.036				Std Dev:	0.079	Std Dev:	0.047
B	OF2	0	1	95	0.900	HF1	0	1	95	0.940		0.920
				96	0.820				96	0.670		0.745
				97	0.840				97	0.780		0.810
				98	0.990				98	0.690		0.840
				99	0.960				99	0.820		0.890
				Avg:	0.902				Avg:	0.780	Avg:	0.841
				Std Dev:	0.074				Std Dev:	0.109	Std Dev:	0.069
	OF2	0	2	95	0.860	HF1	0	2	95	0.700		0.780
				96	0.780				96	0.690		0.735
				97	0.920				97	0.670		0.795
				98	0.800				98	0.660		0.730
				99	0.680				99	0.590		0.635
				Avg:	0.808				Avg:	0.662	Avg:	0.735
				Std Dev:	0.090				Std Dev:	0.043	Std Dev:	0.063
	OF2	90	1	95	0.560	HF1	90	1	95	0.330		0.445
				96	0.480				96	0.300		0.390
				97	0.520				97	0.300		0.410
				98	0.570				98	0.260		0.415
				99	0.720				99	0.300		0.510
				Avg:	0.570				Avg:	0.298	Avg:	0.434
				Std Dev:	0.091				Std Dev:	0.025	Std Dev:	0.047
	OF2	90	2	95	0.540	HF1	90	2	95	0.340		0.440
				96	0.650				96	0.250		0.450
				97	0.420				97	0.210		0.315
				98	0.520				98	0.300		0.410
				99	0.470				99	0.180		0.325
				Avg:	0.520				Avg:	0.256	Avg:	0.388
				Std Dev:	0.086				Std Dev:	0.065	Std Dev:	0.064

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.180	HF2	0	1	95	0.210		0.195
				96	0.300				96	0.280		0.290
				97	0.300				97	0.280		0.290
				98	0.220				98	0.400		0.310
				99	0.170				99	0.380		0.275
				Avg:	0.234				Avg:	0.310	Avg:	0.272
				Std Dev:	0.063				Std Dev:	0.079	Std Dev:	0.045
	OF1	0	2	95	0.270	HF2	0	2	95	0.360		0.315
				96	0.260				96	0.380		0.320
				97	0.290				97	0.440		0.365
				98	0.260				98	0.390		0.325
				99	0.270				99	0.370		0.320
				Avg:	0.270				Avg:	0.388	Avg:	0.329
				Std Dev:	0.012				Std Dev:	0.031	Std Dev:	0.020
	OF1	90	1	95	0.590	HF2	90	1	95	0.310		0.450
				96	0.630				96	0.280		0.455
				97	0.640				97	0.300		0.470
				98	0.550				98	0.270		0.410
				99	0.650				99	0.220		0.435
				Avg:	0.612				Avg:	0.276	Avg:	0.444
				Std Dev:	0.041				Std Dev:	0.035	Std Dev:	0.023
	OF1	90	2	95	0.590	HF2	90	2	95	0.430		0.510
				96	0.670				96	0.420		0.545
				97	0.620				97	0.510		0.565
				98	0.590				98	0.550		0.570
				99	0.630				99	0.490		0.560
				Avg:	0.620				Avg:	0.480	Avg:	0.550
				Std Dev:	0.033				Std Dev:	0.055	Std Dev:	0.024
B	OF2	0	1	95	0.360	HF1	0	1	95	0.200		0.280
				96	0.470				96	0.210		0.340
				97	0.460				97	0.190		0.325
				98	0.390				98	0.200		0.295
				99	0.300				99	0.210		0.255
				Avg:	0.396				Avg:	0.202	Avg:	0.299
				Std Dev:	0.071				Std Dev:	0.008	Std Dev:	0.034
	OF2	0	2	95	0.440	HF1	0	2	95	0.260		0.350
				96	0.500				96	0.230		0.365
				97	0.340				97	0.130		0.235
				98	0.300				98	0.200		0.250
				99	0.250				99	0.240		0.245
				Avg:	0.366				Avg:	0.212	Avg:	0.289
				Std Dev:	0.102				Std Dev:	0.051	Std Dev:	0.063
	OF2	90	1	95	0.490	HF1	90	1	95	0.590		0.540
				96	0.470				96	0.640		0.555
				97	0.430				97	0.680		0.555
				98	0.600				98	0.640		0.620
				99	0.470				99	0.570		0.520
				Avg:	0.492				Avg:	0.624	Avg:	0.558
				Std Dev:	0.064				Std Dev:	0.044	Std Dev:	0.038
	OF2	90	2	95	0.360	HF1	90	2	95	0.650		0.505
				96	0.450				96	0.620		0.535
				97	0.450				97	0.610		0.530
				98	0.520				98	0.600		0.560
				99	0.560				99	0.640		0.600
				Avg:	0.468				Avg:	0.624	Avg:	0.546
				Std Dev:	0.077				Std Dev:	0.021	Std Dev:	0.036

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.660	HF2	0	1	95	0.160		0.410
				96	0.690				96	0.170		0.430
				97	0.720				97	0.200		0.460
				98	0.620				98	0.130		0.375
				99	0.570				99	0.130		0.350
			Avg:		0.652			Avg:		0.158	Avg:	0.405
			Std Dev:		0.059			Std Dev:		0.029	Std Dev:	0.044
	OF1	0	2	95	0.740	HF2	0	2	95	0.230		0.485
				96	0.700				96	0.270		0.485
				97	0.760				97	0.220		0.490
				98	0.780				98	0.190		0.485
				99	0.770				99	0.230		0.500
			Avg:		0.750			Avg:		0.228	Avg:	0.489
			Std Dev:		0.032			Std Dev:		0.029	Std Dev:	0.007
	OF1	90	1	95	0.680	HF2	90	1	95	0.610		0.645
				96	0.780				96	0.610		0.695
				97	0.780				97	0.570		0.675
				98	0.810				98	0.630		0.720
				99	0.740				99	0.640		0.690
			Avg:		0.758			Avg:		0.612	Avg:	0.685
			Std Dev:		0.050			Std Dev:		0.027	Std Dev:	0.028
	OF1	90	2	95	1.040	HF2	90	2	95	0.660		0.850
				96	0.830				96	0.690		0.760
				97	0.820				97	0.660		0.740
				98	0.900				98	0.620		0.760
				99	0.760				99	0.550		0.655
			Avg:		0.870			Avg:		0.636	Avg:	0.753
			Std Dev:		0.107			Std Dev:		0.054	Std Dev:	0.069
B	OF2	0	1	95	0.510	HF1	0	1	95	0.320		0.415
				96	0.460				96	0.320		0.390
				97	0.540				97	0.310		0.425
				98	0.520				98	0.360		0.440
				99	0.440				99	0.300		0.370
			Avg:		0.494			Avg:		0.322	Avg:	0.408
			Std Dev:		0.042			Std Dev:		0.023	Std Dev:	0.028
	OF2	0	2	95	0.590	HF1	0	2	95	0.390		0.490
				96	0.490				96	0.360		0.425
				97	0.570				97	0.370		0.470
				98	0.600				98	0.390		0.495
				99	0.560				99	0.420		0.490
			Avg:		0.562			Avg:		0.386	Avg:	0.474
			Std Dev:		0.043			Std Dev:		0.023	Std Dev:	0.029
	OF2	90	1	95	0.480	HF1	90	1	95	0.330		0.405
				96	0.450				96	0.390		0.420
				97	0.490				97	0.330		0.410
				98	0.450				98	0.340		0.395
				99	0.480				99	0.380		0.430
			Avg:		0.470			Avg:		0.354	Avg:	0.412
			Std Dev:		0.019			Std Dev:		0.029	Std Dev:	0.014
	OF2	90	2	95	0.520	HF1	90	2	95	0.320		0.420
				96	0.600				96	0.360		0.480
				97	0.630				97	0.310		0.470
				98	0.550				98	0.370		0.460
				99	0.600				99	0.370		0.485
			Avg:		0.580			Avg:		0.346	Avg:	0.463
			Std Dev:		0.044			Std Dev:		0.029	Std Dev:	0.026

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.390	HF2	0	1	95	0.410		0.400
				96	0.460				96	0.470		0.465
				97	0.320				97	0.460		0.390
				98	0.380				98	0.510		0.445
				99	0.440				99	0.500		0.470
				Avg:	0.398				Avg:	0.470	Avg:	0.434
				Std Dev:	0.055				Std Dev:	0.039	Std Dev:	0.037
	OF1	0	2	95	0.560	HF2	0	2	95	0.490		0.525
				96	0.390				96	0.470		0.430
				97	0.490				97	0.460		0.475
				98	0.330				98	0.420		0.375
				99	0.330				99	0.340		0.335
				Avg:	0.420				Avg:	0.436	Avg:	0.428
				Std Dev:	0.102				Std Dev:	0.059	Std Dev:	0.076
	OF1	90	1	95	0.070	HF2	90	1	95	0.630		0.350
				96	0.100				96	0.650		0.375
				97	0.120				97	0.800		0.460
				98	0.160				98	0.640		0.400
				99	0.100				99	0.420		0.260
				Avg:	0.110				Avg:	0.628	Avg:	0.369
				Std Dev:	0.033				Std Dev:	0.136	Std Dev:	0.073
	OF1	90	2	95	0.150	HF2	90	2	95	0.690		0.420
				96	0.080				96	0.730		0.405
				97	0.080				97	0.850		0.465
				98	0.080				98	0.480		0.280
				99	0.100				99	0.570		0.335
				Avg:	0.098				Avg:	0.664	Avg:	0.381
				Std Dev:	0.030				Std Dev:	0.143	Std Dev:	0.073
C	OF2	0	1	95	0.510	HF1	0	1	95	0.590		0.550
				96	0.630				96	0.740		0.685
				97	0.450				97	0.500		0.475
				98	0.500				98	0.600		0.550
				99	0.610				99	0.560		0.585
				Avg:	0.540				Avg:	0.598	Avg:	0.569
				Std Dev:	0.077				Std Dev:	0.088	Std Dev:	0.076
	OF2	0	2	95	0.430	HF1	0	2	95	0.380		0.405
				96	0.590				96	0.510		0.550
				97	0.520				97	0.470		0.495
				98	0.670				98	0.670		0.670
				99	0.500				99	0.380		0.440
				Avg:	0.542				Avg:	0.482	Avg:	0.512
				Std Dev:	0.091				Std Dev:	0.119	Std Dev:	0.104
	OF2	90	1	95	0.680	HF1	90	1	95	0.100		0.390
				96	0.590				96	0.140		0.365
				97	0.610				97	0.070		0.340
				98	0.590				98	0.130		0.360
				99	0.650				99	0.040		0.345
				Avg:	0.624				Avg:	0.096	Avg:	0.360
				Std Dev:	0.040				Std Dev:	0.042	Std Dev:	0.020
	OF2	90	2	95	0.540	HF1	90	2	95	0.080		0.310
				96	0.550				96	0.060		0.305
				97	0.650				97	0.110		0.380
				98	0.490				98	0.080		0.285
				99	0.710				99	0.120		0.415
				Avg:	0.588				Avg:	0.090	Avg:	0.339
				Std Dev:	0.090				Std Dev:	0.024	Std Dev:	0.056

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.770	HF2	0	1	95	0.400		0.585
				96	0.730				96	0.450		0.590
				97	0.630				97	0.460		0.545
				98	0.740				98	0.490		0.615
				99	0.760				99	0.560		0.660
			Avg:		0.726			Avg:		0.472	Avg:	0.599
			Std Dev:		0.056			Std Dev:		0.059	Std Dev:	0.042
	OF1	0	2	95	0.750	HF2	0	2	95	0.540		0.645
				96	0.720				96	0.560		0.640
				97	0.840				97	0.590		0.715
				98	0.850				98	0.590		0.720
				99	0.750				99	0.470		0.610
			Avg:		0.782			Avg:		0.550	Avg:	0.666
			Std Dev:		0.059			Std Dev:		0.049	Std Dev:	0.049
	OF1	90	1	95	0.300	HF2	90	1	95	0.290		0.295
				96	0.280				96	0.330		0.305
				97	0.300				97	0.340		0.320
				98	0.240				98	0.310		0.275
				99	0.260				99	0.380		0.320
			Avg:		0.276			Avg:		0.330	Avg:	0.303
			Std Dev:		0.026			Std Dev:		0.034	Std Dev:	0.019
	OF1	90	2	95	0.310	HF2	90	2	95	0.370		0.340
				96	0.300				96	0.310		0.305
				97	0.280				97	0.250		0.265
				98	0.320				98	0.300		0.310
				99	0.290				99	0.250		0.270
			Avg:		0.300			Avg:		0.296	Avg:	0.298
			Std Dev:		0.016			Std Dev:		0.050	Std Dev:	0.031
C	OF2	0	1	95	0.520	HF1	0	1	95	0.580		0.550
				96	0.450				96	0.570		0.510
				97	0.450				97	0.670		0.560
				98	0.390				98	0.590		0.490
				99	0.490				99	0.690		0.590
			Avg:		0.460			Avg:		0.620	Avg:	0.540
			Std Dev:		0.049			Std Dev:		0.056	Std Dev:	0.040
	OF2	0	2	95	0.640	HF1	0	2	95	0.660		0.650
				96	0.510				96	0.630		0.570
				97	0.500				97	0.750		0.625
				98	0.380				98	0.540		0.460
				99	0.380				99	0.580		0.480
			Avg:		0.482			Avg:		0.632	Avg:	0.557
			Std Dev:		0.108			Std Dev:		0.080	Std Dev:	0.085
	OF2	90	1	95	0.430	HF1	90	1	95	0.330		0.380
				96	0.340				96	0.250		0.295
				97	0.290				97	0.300		0.295
				98	0.270				98	0.310		0.290
				99	0.310				99	0.260		0.285
			Avg:		0.328			Avg:		0.290	Avg:	0.309
			Std Dev:		0.063			Std Dev:		0.034	Std Dev:	0.040
	OF2	90	2	95	0.260	HF1	90	2	95	0.250		0.255
				96	0.380				96	0.330		0.355
				97	0.360				97	0.310		0.335
				98	0.420				98	0.310		0.365
				99	0.540				99	0.330		0.435
			Avg:		0.392			Avg:		0.306	Avg:	0.349
			Std Dev:		0.102			Std Dev:		0.033	Std Dev:	0.065

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.740	HF2	0	1	95	0.160		0.450
				96	0.660				96	0.180		0.420
				97	0.610				97	0.150		0.380
				98	0.510				98	0.130		0.320
				99	0.640				99	0.190		0.415
			Avg:		0.632			Avg:		0.162	Avg:	0.397
			Std Dev:		0.083			Std Dev:		0.024	Std Dev:	0.050
	OF1	0	2	95	0.640	HF2	0	2	95	0.240		0.440
				96	0.880				96	0.200		0.540
				97	0.590				97	0.210		0.400
				98	0.590				98	0.250		0.420
				99	0.510				99	0.180		0.345
			Avg:		0.642			Avg:		0.216	Avg:	0.429
			Std Dev:		0.141			Std Dev:		0.029	Std Dev:	0.071
	OF1	90	1	95	0.360	HF2	90	1	95	0.940		0.650
				96	0.410				96	0.830		0.620
				97	0.330				97	0.890		0.610
				98	0.350				98	0.980		0.665
				99	0.350				99	0.880		0.615
			Avg:		0.300			Avg:		0.904	Avg:	0.632
			Std Dev:		0.030			Std Dev:		0.058	Std Dev:	0.024
	OF1	90	2	95	0.370	HF2	90	2	95	0.850		0.610
				96	0.380				96	1.050		0.715
				97	0.340				97	0.850		0.595
				98	0.360				98	0.760		0.560
				99	0.330				99	1.020		0.675
			Avg:		0.356			Avg:		0.906	Avg:	0.631
			Std Dev:		0.021			Std Dev:		0.124	Std Dev:	0.063
C	OF2	0	1	95	0.130	HF1	0	1	95	0.540		0.335
				96	0.190				96	0.570		0.380
				97	0.190				97	0.530		0.360
				98	0.130				98	0.510		0.320
				99	0.100				99	0.430		0.265
			Avg:		0.148			Avg:		0.516	Avg:	0.332
			Std Dev:		0.040			Std Dev:		0.053	Std Dev:	0.044
	OF2	0	2	95	0.150	HF1	0	2	95	0.570		0.360
				96	0.180				96	0.560		0.370
				97	0.130				97	0.540		0.335
				98	0.190				98	0.640		0.415
				99	0.210				99	0.580		0.395
			Avg:		0.172			Avg:		0.578	Avg:	0.375
			Std Dev:		0.032			Std Dev:		0.038	Std Dev:	0.031
	OF2	90	1	95	0.720	HF1	90	1	95	0.650		0.685
				96	0.780				96	0.570		0.675
				97	0.720				97	0.610		0.665
				98	0.710				98	0.670		0.690
				99	0.760				99	0.650		0.705
			Avg:		0.738			Avg:		0.630	Avg:	0.684
			Std Dev:		0.030			Std Dev:		0.040	Std Dev:	0.015
	OF2	90	2	95	0.620	HF1	90	2	95	0.600		0.610
				96	0.790				96	0.780		0.785
				97	0.770				97	0.590		0.680
				98	0.650				98	0.550		0.600
				99	0.720				99	0.750		0.735
			Avg:		0.710			Avg:		0.654	Avg:	0.682
			Std Dev:		0.074			Std Dev:		0.104	Std Dev:	0.080

Annex 15

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Instantaneous

37.5 mm
4 inch Dia.

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.830	HF2	0	1	95	1.450		1.140
				96	1.120				96	1.520		1.320
				97	0.990				97	1.570		1.280
				98	0.950				98	1.290		1.120
				99	1.120				99	1.470		1.295
				Avg:	1.002				Avg:	1.460	Avg:	1.231
				Std Dev:	0.123				Std Dev:	0.106	Std Dev:	0.094
	OF1	0	2	95	1.260	HF2	0	2	95	1.300		1.280
				96	1.320				96	1.480		1.400
				97	1.040				97	1.430		1.235
				98	1.590				98	1.340		1.465
				99	1.170				99	1.450		1.310
				Avg:	1.276				Avg:	1.400	Avg:	1.338
				Std Dev:	0.205				Std Dev:	0.076	Std Dev:	0.093
	OF1	90	1	95	0.790	HF2	90	1	95	0.150		0.470
				96	0.830				96	0.040		0.435
				97	0.660				97	0.070		0.365
				98	0.810				98	0.040		0.425
				99	0.820				99	0.030		0.425
				Avg:	0.782				Avg:	0.066	Avg:	0.424
				Std Dev:	0.070				Std Dev:	0.049	Std Dev:	0.038
	OF1	90	2	95	1.190	HF2	90	2	95	0.020		0.605
				96	0.990				96	0.020		0.505
				97	1.140				97	0.010		0.575
				98	1.300				98	0.060		0.680
				99	1.040				99	0.030		0.535
				Avg:	1.132				Avg:	0.028	Avg:	0.580
				Std Dev:	0.123				Std Dev:	0.019	Std Dev:	0.068
A	OF2	0	1	95	1.090	HF1	0	1	95	0.800		0.945
				96	0.920				96	0.860		0.890
				97	1.560				97	0.930		1.245
				98	1.370				98	0.840		1.105
				99	1.370				99	0.820		1.095
				Avg:	1.262				Avg:	0.850	Avg:	1.056
				Std Dev:	0.254				Std Dev:	0.050	Std Dev:	0.141
	OF2	0	2	95	1.260	HF1	0	2	95	1.130		1.195
				96	1.410				96	1.310		1.360
				97	1.590				97	1.100		1.345
				98	1.420				98	1.280		1.350
				99	1.420				99	1.020		1.220
				Avg:	1.420				Avg:	1.168	Avg:	1.294
				Std Dev:	0.117				Std Dev:	0.123	Std Dev:	0.080
	OF2	90	1	95	0.040	HF1	90	1	95	0.890		0.465
				96	0.020				96	0.860		0.440
				97	0.090				97	0.770		0.430
				98	0.010				98	0.940		0.475
				99	0.010				99	0.890		0.450
				Avg:	0.034				Avg:	0.870	Avg:	0.452
				Std Dev:	0.034				Std Dev:	0.063	Std Dev:	0.018
	OF2	90	2	95	0.100	HF1	90	2	95	0.910		0.505
				96	0.040				96	1.060		0.550
				97	0.010				97	0.850		0.430
				98	0.040				98	0.860		0.450
				99	0.010				99	0.860		0.435
				Avg:	0.040				Avg:	0.908	Avg:	0.474
				Std Dev:	0.037				Std Dev:	0.088	Std Dev:	0.052

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.400	HF2	0	1	95	2.460		1.430
				96	0.390				96	2.090		1.240
				97	0.330				97	3.110		1.720
				98	0.310				98	2.720		1.515
				99	0.350				99	2.490		1.420
			Avg:		0.356			Avg:		2.574	Avg:	1.465
			Std Dev:		0.038			Std Dev:		0.375	Std Dev:	0.174
	OF1	0	2	95	0.350	HF2	0	2	95	1.500		0.925
				96	0.420				96	1.470		0.945
				97	0.450				97	1.530		0.990
				98	0.440				98	1.270		0.855
				99	0.390				99	1.120		0.755
			Avg:		0.410			Avg:		1.378	Avg:	0.894
			Std Dev:		0.041			Std Dev:		0.177	Std Dev:	0.092
	OF1	90	1	95	1.400	HF2	90	1	95	0.200		0.800
				96	1.250				96	0.240		0.745
				97	1.250				97	0.200		0.725
				98	1.210				98	0.160		0.685
				99	1.340				99	0.190		0.765
			Avg:		1.290			Avg:		0.198	Avg:	0.744
			Std Dev:		0.078			Std Dev:		0.029	Std Dev:	0.043
	OF1	90	2	95	1.120	HF2	90	2	95	0.270		0.695
				96	1.100				96	0.250		0.675
				97	1.090				97	0.290		0.690
				98	1.150				98	0.310		0.730
				99	1.070				99	0.310		0.690
			Avg:		1.106			Avg:		0.286	Avg:	0.696
			Std Dev:		0.030			Std Dev:		0.026	Std Dev:	0.020
A	OF2	0	1	95	0.930	HF1	0	1	95	0.220		0.575
				96	1.050				96	0.240		0.645
				97	1.190				97	0.230		0.710
				98	1.330				98	0.230		0.780
				99	1.290				99	0.230		0.760
			Avg:		1.158			Avg:		0.230	Avg:	0.694
			Std Dev:		0.167			Std Dev:		0.007	Std Dev:	0.085
	OF2	0	2	95	1.310	HF1	0	2	95	0.280		0.795
				96	1.650				96	0.320		0.985
				97	2.060				97	0.280		1.170
				98	1.900				98	0.250		1.075
				99	2.190				99	0.300		1.245
			Avg:		1.822			Avg:		0.286	Avg:	1.054
			Std Dev:		0.350			Std Dev:		0.026	Std Dev:	0.175
	OF2	90	1	95	0.020	HF1	90	1	95	0.940		0.480
				96	0.060				96	0.980		0.520
				97	0.110				97	0.970		0.540
				98	0.080				98	0.930		0.505
				99	0.030				99	0.920		0.475
			Avg:		0.060			Avg:		0.948	Avg:	0.504
			Std Dev:		0.037			Std Dev:		0.026	Std Dev:	0.027
	OF2	90	2	95	0.090	HF1	90	2	95	1.070		0.580
				96	0.110				96	1.110		0.610
				97	0.190				97	1.200		0.695
				98	0.120				98	1.150		0.635
				99	0.170				99	1.180		0.675
			Avg:		0.136			Avg:		1.142	Avg:	0.639
			Std Dev:		0.042			Std Dev:		0.053	Std Dev:	0.047

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.790	HF2	0	1	95	1.110		0.950
				96	0.890				96	1.150		1.020
				97	0.850				97	1.140		0.995
				98	0.870				98	1.080		0.975
				99	0.820				99	0.830		0.825
			Avg:		0.844			Avg:		1.062	Avg:	0.953
			Std Dev:		0.040			Std Dev:		0.133	Std Dev:	0.076
	OF1	0	2	95	0.970	HF2	0	2	95	0.810		0.890
				96	0.950				96	0.860		0.905
				97	1.010				97	0.960		0.985
				98	0.940				98	0.870		0.905
				99	1.030				99	1.020		1.025
			Avg:		0.980			Avg:		0.904	Avg:	0.942
			Std Dev:		0.039			Std Dev:		0.084	Std Dev:	0.060
	OF1	90	1	95	2.090	HF2	90	1	95	0.050		1.070
				96	2.100				96	0.050		1.075
				97	2.220				97	0.040		1.130
				98	2.020				98	0.090		1.055
				99	2.220				99	0.100		1.160
			Avg:		2.130			Avg:		0.066	Avg:	1.098
			Std Dev:		0.088			Std Dev:		0.027	Std Dev:	0.045
	OF1	90	2	95	2.240	HF2	90	2	95	0.010		1.125
				96	2.300				96	0.050		1.175
				97	2.270				97	0.020		1.145
				98	2.270				98	0.060		1.165
				99	2.420				99	0.050		1.235
			Avg:		2.300			Avg:		0.038	Avg:	1.169
			Std Dev:		0.070			Std Dev:		0.022	Std Dev:	0.042
A	OF2	0	1	95	4.520	HF1	0	1	95	0.870		2.695
				96	1.330				96	0.830		1.080
				97	1.280				97	0.860		1.070
				98	1.300				98	0.830		1.065
				99	1.310				99	0.810		1.060
			Avg:		1.948			Avg:		0.840	Avg:	1.394
			Std Dev:		1.438			Std Dev:		0.024	Std Dev:	0.727
	OF2	0	2	95	1.270	HF1	0	2	95	0.910		1.090
				96	1.230				96	0.850		1.040
				97	1.160				97	0.870		1.015
				98	1.260				98	0.920		1.090
				99	1.220				99	0.810		1.015
			Avg:		1.228			Avg:		0.872	Avg:	1.050
			Std Dev:		0.043			Std Dev:		0.045	Std Dev:	0.038
	OF2	90	1	95	0.030	HF1	90	1	95	1.400		0.715
				96	0.010				96	1.510		0.760
				97	0.010				97	1.480		0.745
				98	0.010				98	1.420		0.715
				99	0.010				99	1.410		0.710
			Avg:		0.014			Avg:		1.444	Avg:	0.729
			Std Dev:		0.009			Std Dev:		0.048	Std Dev:	0.022
	OF2	90	2	95	0.030	HF1	90	2	95	1.210		0.620
				96	0.040				96	1.240		0.640
				97	0.050				97	1.300		0.675
				98	0.030				98	1.230		0.630
				99	0.060				99	1.190		0.625
			Avg:		0.042			Avg:		1.234	Avg:	0.638
			Std Dev:		0.013			Std Dev:		0.042	Std Dev:	0.022

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.450	HF2	0	1	95	0.570		0.510
				96	0.500				96	0.580		0.540
				97	0.630				97	0.470		0.550
				98	0.670				98	0.650		0.660
				99	0.570				99	0.630		0.600
			Avg:		0.564			Avg:		0.580	Avg:	0.572
			Std Dev:		0.090			Std Dev:		0.070	Std Dev:	0.059
	OF1	0	2	95	0.580	HF2	0	2	95	0.810		0.695
				96	0.530				96	0.820		0.675
				97	0.620				97	0.680		0.650
				98	0.560				98	0.790		0.675
				99	0.580				99	0.510		0.545
			Avg:		0.574			Avg:		0.722	Avg:	0.648
			Std Dev:		0.033			Std Dev:		0.131	Std Dev:	0.060
	OF1	90	1	95	1.230	HF2	90	1	95	2.260		1.745
				96	2.500				96	1.520		2.010
				97	3.360				97	1.440		2.400
				98	1.500				98	1.420		1.460
				99	1.170				99	0.710		0.940
			Avg:		1.952			Avg:		1.470	Avg:	1.711
			Std Dev:		0.951			Std Dev:		0.549	Std Dev:	0.553
	OF1	90	2	95	1.310	HF2	90	2	95	1.170		1.240
				96	1.770				96	1.060		1.415
				97	2.010				97	1.470		1.740
				98	2.370				98	2.530		2.450
				99	1.900				99	1.890		1.895
			Avg:		1.872			Avg:		1.624	Avg:	1.748
			Std Dev:		0.365			Std Dev:		0.600	Std Dev:	0.470
B	OF2	0	1	95	0.470	HF1	0	1	95	0.430		0.450
				96	0.540				96	0.570		0.555
				97	0.830				97	0.580		0.705
				98	0.730				98	0.510		0.620
				99	0.700				99	0.430		0.565
			Avg:		0.654			Avg:		0.504	Avg:	0.579
			Std Dev:		0.146			Std Dev:		0.073	Std Dev:	0.094
	OF2	0	2	95	0.600	HF1	0	2	95	0.680		0.640
				96	0.550				96	0.610		0.580
				97	0.650				97	0.740		0.695
				98	0.810				98	0.560		0.685
				99	1.100				99	0.730		0.915
			Avg:		0.742			Avg:		0.664	Avg:	0.703
			Std Dev:		0.223			Std Dev:		0.078	Std Dev:	0.127
	OF2	90	1	95	1.170	HF1	90	1	95	2.160		1.665
				96	1.280				96	1.750		1.515
				97	2.590				97	1.670		2.130
				98	0.780				98	0.860		0.820
				99	0.600				99	1.540		1.070
			Avg:		1.284			Avg:		1.596	Avg:	1.440
			Std Dev:		0.781			Std Dev:		0.472	Std Dev:	0.513
	OF2	90	2	95	0.920	HF1	90	2	95	2.290		1.605
				96	1.060				96	2.010		1.535
				97	1.780				97	1.850		1.815
				98	0.740				98	2.240		1.490
				99	1.370				99	2.350		1.860
			Avg:		1.174			Avg:		2.148	Avg:	1.661
			Std Dev:		0.410			Std Dev:		0.211	Std Dev:	0.167

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.510	HF2	0	1	95	0.390		0.450
				96	0.560				96	0.460		0.510
				97	0.510				97	0.500		0.505
				98	0.340				98	0.370		0.355
				99	0.440				99	0.430		0.435
			Avg:		0.472			Avg:		0.430	Avg:	0.451
			Std Dev:		0.085			Std Dev:		0.052	Std Dev:	0.063
	OF1	0	2	95	0.500	HF2	0	2	95	0.550		0.525
				96	0.430				96	0.560		0.495
				97	0.460				97	0.550		0.505
				98	0.540				98	0.500		0.520
				99	0.510				99	0.550		0.530
			Avg:		0.488			Avg:		0.542	Avg:	0.515
			Std Dev:		0.043			Std Dev:		0.024	Std Dev:	0.015
	OF1	90	1	95	0.500	HF2	90	1	95	0.270		0.385
				96	0.510				96	0.220		0.365
				97	0.500				97	0.200		0.350
				98	0.450				98	0.240		0.345
				99	0.490				99	0.230		0.360
			Avg:		0.490			Avg:		0.232	Avg:	0.361
			Std Dev:		0.023			Std Dev:		0.026	Std Dev:	0.016
	OF1	90	2	95	0.450	HF2	90	2	95	0.140		0.295
				96	0.520				96	0.070		0.295
				97	0.540				97	0.130		0.335
				98	0.450				98	0.190		0.320
				99	0.440				99	0.150		0.295
			Avg:		0.480			Avg:		0.136	Avg:	0.308
			Std Dev:		0.046			Std Dev:		0.043	Std Dev:	0.019
B	OF2	0	1	95	0.460	HF1	0	1	95	0.660		0.560
				96	0.390				96	0.540		0.465
				97	0.340				97	0.520		0.430
				98	0.340				98	0.550		0.445
				99	0.440				99	0.510		0.475
			Avg:		0.394			Avg:		0.556	Avg:	0.475
			Std Dev:		0.055			Std Dev:		0.060	Std Dev:	0.051
	OF2	0	2	95	0.730	HF1	0	2	95	0.600		0.665
				96	0.840				96	0.560		0.700
				97	0.670				97	0.510		0.590
				98	0.460				98	0.600		0.530
				99	0.580				99	0.680		0.630
			Avg:		0.656			Avg:		0.590	Avg:	0.623
			Std Dev:		0.145			Std Dev:		0.062	Std Dev:	0.066
	OF2	90	1	95	0.150	HF1	90	1	95	0.810		0.480
				96	0.070				96	0.960		0.515
				97	0.090				97	1.130		0.610
				98	0.080				98	1.090		0.585
				99	0.040				99	0.900		0.470
			Avg:		0.086			Avg:		0.978	Avg:	0.532
			Std Dev:		0.040			Std Dev:		0.133	Std Dev:	0.063
	OF2	90	2	95	0.250	HF1	90	2	95	0.930		0.590
				96	0.310				96	0.690		0.500
				97	0.240				97	0.880		0.560
				98	0.250				98	0.820		0.535
				99	0.260				99	0.950		0.605
			Avg:		0.262			Avg:		0.854	Avg:	0.558
			Std Dev:		0.028			Std Dev:		0.105	Std Dev:	0.042

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.360	HF2	0	1	95	0.370		0.365
				96	0.270				96	0.340		0.305
				97	0.290				97	0.370		0.330
				98	0.280				98	0.400		0.340
				99	0.290				99	0.460		0.375
			Avg:		0.298			Avg:		0.388	Avg:	0.343
			Std Dev:		0.036			Std Dev:		0.045	Std Dev:	0.028
	OF1	0	2	95	0.220	HF2	0	2	95	0.370		0.295
				96	0.240				96	0.390		0.315
				97	0.230				97	0.420		0.325
				98	0.280				98	0.430		0.355
				99	0.290				99	0.460		0.375
			Avg:		0.252			Avg:		0.414	Avg:	0.333
			Std Dev:		0.031			Std Dev:		0.035	Std Dev:	0.032
	OF1	90	1	95	0.360	HF2	90	1	95	0.500		0.430
				96	0.320				96	0.440		0.380
				97	0.350				97	0.590		0.470
				98	0.370				98	0.690		0.530
				99	0.420				99	0.670		0.545
			Avg:		0.364			Avg:		0.578	Avg:	0.471
			Std Dev:		0.036			Std Dev:		0.108	Std Dev:	0.069
	OF1	90	2	95	0.390	HF2	90	2	95	0.560		0.475
				96	0.380				96	0.600		0.490
				97	0.380				97	0.620		0.500
				98	0.410				98	0.850		0.630
				99	0.360				99	0.800		0.580
			Avg:		0.384			Avg:		0.686	Avg:	0.535
			Std Dev:		0.018			Std Dev:		0.130	Std Dev:	0.067
B	OF2	0	1	95	0.450	HF1	0	1	95	0.270		0.360
				96	0.480				96	0.210		0.345
				97	0.340				97	0.210		0.275
				98	0.310				98	0.240		0.275
				99	0.310				99	0.200		0.255
			Avg:		0.378			Avg:		0.226	Avg:	0.302
			Std Dev:		0.081			Std Dev:		0.029	Std Dev:	0.047
	OF2	0	2	95	0.220	HF1	0	2	95	0.300		0.260
				96	0.260				96	0.370		0.315
				97	0.140				97	0.350		0.245
				98	0.320				98	0.360		0.340
				99	0.400				99	0.400		0.400
			Avg:		0.268			Avg:		0.356	Avg:	0.312
			Std Dev:		0.099			Std Dev:		0.036	Std Dev:	0.063
	OF2	90	1	95	0.500	HF1	90	1	95	0.380		0.440
				96	0.380				96	0.290		0.335
				97	0.390				97	0.370		0.380
				98	0.500				98	0.400		0.450
				99	0.510				99	0.400		0.455
			Avg:		0.456			Avg:		0.368	Avg:	0.412
			Std Dev:		0.065			Std Dev:		0.045	Std Dev:	0.053
	OF2	90	2	95	0.540	HF1	90	2	95	0.300		0.420
				96	0.680				96	0.310		0.495
				97	0.630				97	0.350		0.490
				98	0.520				98	0.350		0.435
				99	0.580				99	0.310		0.445
			Avg:		0.590			Avg:		0.324	Avg:	0.457
			Std Dev:		0.066			Std Dev:		0.024	Std Dev:	0.034

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.640	HF2	0	1	95	0.730		0.685
				96	1.670				96	0.720		1.195
				97	1.670				97	0.840		1.255
				98	0.990				98	0.450		0.720
				99	1.440				99	0.470		0.955
			Avg:		1.282			Avg:		0.642	Avg:	0.962
			Std Dev:		0.454			Std Dev:		0.173	Std Dev:	0.262
	OF1	0	2	95	0.550	HF2	0	2	95	0.890		0.720
				96	0.050				96	0.650		0.350
				97	1.640				97	0.830		1.235
				98	5.980				98	0.820		3.400
				99	2.570				99	0.920		1.745
			Avg:		2.158			Avg:		0.822	Avg:	1.490
			Std Dev:		2.349			Std Dev:		0.105	Std Dev:	1.191
	OF1	90	1	95	0.170	HF2	90	1	95	0.380		0.275
				96	0.170				96	0.240		0.205
				97	0.190				97	0.110		0.150
				98	0.170				98	0.200		0.185
				99	0.180				99	0.090		0.135
			Avg:		0.176			Avg:		0.204	Avg:	0.190
			Std Dev:		0.009			Std Dev:		0.116	Std Dev:	0.055
	OF1	90	2	95	0.150	HF2	90	2	95	0.220		0.185
				96	0.160				96	0.300		0.230
				97	0.170				97	0.190		0.180
				98	0.210				98	0.240		0.225
				99	0.160				99	0.260		0.210
			Avg:		0.170			Avg:		0.242	Avg:	0.206
			Std Dev:		0.023			Std Dev:		0.041	Std Dev:	0.023
C	OF2	0	1	95	0.910	HF1	0	1	95	0.990		0.950
				96	0.925				96	0.870		0.898
				97	0.790				97	0.760		0.775
				98	0.600				98	0.910		0.755
				99	0.760				99	1.110		0.935
			Avg:		0.797			Avg:		0.928	Avg:	0.863
			Std Dev:		0.132			Std Dev:		0.131	Std Dev:	0.091
	OF2	0	2	95	0.600	HF1	0	2	95	1.290		0.945
				96	1.030				96	0.760		0.895
				97	1.110				97	1.000		1.055
				98	0.850				98	0.890		0.870
				99	0.650				99	0.930		0.790
			Avg:		0.848			Avg:		0.974	Avg:	0.911
			Std Dev:		0.225			Std Dev:		0.197	Std Dev:	0.098
	OF2	90	1	95	0.250	HF1	90	1	95	0.150		0.200
				96	0.200				96	0.120		0.160
				97	0.130				97	0.130		0.130
				98	0.110				98	0.150		0.130
				99	0.370				99	0.160		0.265
			Avg:		0.212			Avg:		0.142	Avg:	0.177
			Std Dev:		0.104			Std Dev:		0.016	Std Dev:	0.057
	OF2	90	2	95	0.190	HF1	90	2	95	0.180		0.185
				96	0.370				96	0.150		0.260
				97	0.300				97	0.130		0.215
				98	0.180				98	0.170		0.175
				99	0.110				99	0.140		0.125
			Avg:		0.230			Avg:		0.154	Avg:	0.192
			Std Dev:		0.104			Std Dev:		0.021	Std Dev:	0.050

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Instant

<u>Poissons Ratio Analysis</u>

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	1.770	HF2	0	1	95	0.790		1.280
				96	1.920				96	0.720		1.320
				97	1.820				97	0.640		1.230
				98	1.670				98	0.720		1.195
				99	1.540				99	0.530		1.035
			Avg:		1.744			Avg:		0.680	Avg:	1.212
			Std Dev:		0.145			Std Dev:		0.099	Std Dev:	0.110
	OF1	0	2	95	2.020	HF2	0	2	95	0.650		1.335
				96	1.980				96	0.630		1.305
				97	1.660				97	0.570		1.115
				98	1.980				98	0.620		1.300
				99	2.310				99	0.500		1.405
			Avg:		1.990			Avg:		0.594	Avg:	1.292
			Std Dev:		0.230			Std Dev:		0.060	Std Dev:	0.107
	OF1	90	1	95	0.250	HF2	90	1	95	0.810		0.530
				96	0.240				96	0.860		0.550
				97	0.210				97	0.950		0.580
				98	0.240				98	0.970		0.605
				99	0.180				99	0.760		0.470
			Avg:		0.224			Avg:		0.870	Avg:	0.547
			Std Dev:		0.029			Std Dev:		0.090	Std Dev:	0.052
	OF1	90	2	95	0.280	HF2	90	2	95	0.850		0.565
				96	0.250				96	0.760		0.505
				97	0.190				97	0.760		0.475
				98	0.210				98	0.670		0.440
				99	0.300				99	0.650		0.475
			Avg:		0.246			Avg:		0.738	Avg:	0.492
			Std Dev:		0.046			Std Dev:		0.080	Std Dev:	0.047
C	OF2	0	1	95	0.460	HF1	0	1	95	1.340		0.900
				96	0.440				96	1.300		0.870
				97	0.610				97	1.290		0.950
				98	0.620				98	1.130		0.875
				99	0.760				99	1.500		1.130
			Avg:		0.578			Avg:		1.312	Avg:	0.945
			Std Dev:		0.131			Std Dev:		0.132	Std Dev:	0.108
	OF2	0	2	95	0.640	HF1	0	2	95	1.240		0.940
				96	0.420				96	1.050		0.735
				97	0.350				97	1.300		0.825
				98	0.340				98	1.280		0.810
				99	0.420				99	0.980		0.700
			Avg:		0.434			Avg:		1.170	Avg:	0.802
			Std Dev:		0.121			Std Dev:		0.145	Std Dev:	0.093
	OF2	90	1	95	0.810	HF1	90	1	95	0.440		0.625
				96	0.750				96	0.510		0.630
				97	0.750				97	0.520		0.635
				98	0.830				98	0.420		0.625
				99	0.960				99	0.490		0.725
			Avg:		0.820			Avg:		0.476	Avg:	0.648
			Std Dev:		0.086			Std Dev:		0.044	Std Dev:	0.043
	OF2	90	2	95	0.830	HF1	90	2	95	0.490		0.660
				96	0.900				96	0.450		0.675
				97	1.030				97	0.530		0.780
				98	1.120				98	0.470		0.795
				99	1.160				99	0.430		0.795
			Avg:		1.008			Avg:		0.474	Avg:	0.741
			Std Dev:		0.141			Std Dev:		0.038	Std Dev:	0.068

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	1.200	HF2	0	1	95	0.640		0.920
				96	1.530				96	0.710		1.120
				97	1.290				97	0.680		0.985
				98	1.370				98	0.430		0.900
				99	1.730				99	0.580		1.155
			Avg:		1.424			Avg:		0.608	Avg:	1.016
			Std Dev:		0.210			Std Dev:		0.111	Std Dev:	0.116
	OF1	0	2	95	1.480	HF2	0	2	95	0.730		1.105
				96	1.330				96	0.690		1.010
				97	1.360				97	0.610		0.985
				98	1.430				98	0.530		0.980
				99	1.310				99	0.630		0.970
			Avg:		1.382			Avg:		0.638	Avg:	1.010
			Std Dev:		0.071			Std Dev:		0.077	Std Dev:	0.055
	OF1	90	1	95	0.250	HF2	90	1	95	0.690		0.470
				96	0.260				96	0.600		0.430
				97	0.250				97	0.600		0.425
				98	0.240				98	0.660		0.450
				99	0.250				99	0.840		0.545
			Avg:		0.250			Avg:		0.678	Avg:	0.464
			Std Dev:		0.007			Std Dev:		0.099	Std Dev:	0.049
	OF1	90	2	95	0.280	HF2	90	2	95	0.570		0.425
				96	0.320				96	0.680		0.500
				97	0.310				97	0.640		0.475
				98	0.340				98	0.700		0.520
				99	0.300				99	0.620		0.460
			Avg:		0.310			Avg:		0.642	Avg:	0.476
			Std Dev:		0.022			Std Dev:		0.051	Std Dev:	0.037
C	OF2	0	1	95	0.710	HF1	0	1	95	0.590		0.650
				96	0.690				96	0.440		0.565
				97	0.770				97	0.710		0.740
				98	0.840				98	1.210		1.025
				99	0.710				99	0.510		0.610
			Avg:		0.744			Avg:		0.692	Avg:	0.718
			Std Dev:		0.061			Std Dev:		0.306	Std Dev:	0.183
	OF2	0	2	95	0.750	HF1	0	2	95	0.770		0.760
				96	0.740				96	1.050		0.895
				97	0.880				97	1.760		1.320
				98	0.760				98	1.330		1.045
				99	0.710				99	1.160		0.935
			Avg:		0.768			Avg:		1.214	Avg:	0.991
			Std Dev:		0.065			Std Dev:		0.367	Std Dev:	0.210
	OF2	90	1	95	0.600	HF1	90	1	95	0.430		0.515
				96	0.590				96	0.420		0.505
				97	0.690				97	0.390		0.540
				98	0.670				98	0.370		0.520
				99	0.550				99	0.450		0.500
			Avg:		0.620			Avg:		0.412	Avg:	0.516
			Std Dev:		0.058			Std Dev:		0.032	Std Dev:	0.016
	OF2	90	2	95	0.590	HF1	90	2	95	0.360		0.475
				96	0.590				96	0.400		0.495
				97	0.760				97	0.420		0.590
				98	0.730				98	0.400		0.565
				99	0.730				99	0.450		0.590
			Avg:		0.680			Avg:		0.406	Avg:	0.543
			Std Dev:		0.083			Std Dev:		0.033	Std Dev:	0.054

Annex 16

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Instantaneous

12.5 mm
6 inch Dia.

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 1.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.320	HF2	0	1	95	0.290		0.305
				96	0.440				96	0.250		0.345
				97	0.530				97	0.330		0.430
				98	0.380				98	0.320		0.350
				99	0.380				99	0.240		0.310
			Avg:		0.410			Avg:		0.286	Avg:	0.348
			Std Dev:		0.079			Std Dev:		0.040	Std Dev:	0.050
	OF1	0	2	95	0.440	HF2	0	2	95	0.290		0.365
				96	0.460				96	0.270		0.365
				97	0.460				97	0.330		0.395
				98	0.380				98	0.380		0.380
				99	0.620				99	0.320		0.470
			Avg:		0.472			Avg:		0.318	Avg:	0.395
			Std Dev:		0.089			Std Dev:		0.042	Std Dev:	0.044
	OF1	90	1	95	0.570	HF2	90	1	95	0.480		0.525
				96	0.490				96	0.620		0.555
				97	0.450				97	0.580		0.515
				98	0.410				98	0.680		0.545
				99	0.520				99	0.500		0.510
			Avg:		0.488			Avg:		0.572	Avg:	0.530
			Std Dev:		0.062			Std Dev:		0.083	Std Dev:	0.019
	OF1	90	2	95	0.500	HF2	90	2	95	0.590		0.545
				96	0.580				96	0.620		0.600
				97	0.580				97	0.420		0.500
				98	0.610				98	0.480		0.545
				99	0.460				99	0.140		0.300
			Avg:		0.546			Avg:		0.450	Avg:	0.498
			Std Dev:		0.063			Std Dev:		0.191	Std Dev:	0.116
A	OF2	0	1	95	0.250	HF1	0	1	95	0.400		0.325
				96	0.240				96	0.350		0.295
				97	0.350				97	0.280		0.315
				98	0.330				98	0.320		0.325
				99	0.190				99	0.320		0.255
			Avg:		0.272			Avg:		0.334	Avg:	0.303
			Std Dev:		0.066			Std Dev:		0.044	Std Dev:	0.029
	OF2	0	2	95	0.250	HF1	0	2	95	0.470		0.360
				96	0.370				96	0.450		0.410
				97	0.340				97	0.420		0.380
				98	0.260				98	0.460		0.360
				99	0.390				99	0.360		0.375
			Avg:		0.322			Avg:		0.432	Avg:	0.377
			Std Dev:		0.064			Std Dev:		0.044	Std Dev:	0.020
	OF2	90	1	95	0.440	HF1	90	1	95	0.760		0.600
				96	0.460				96	0.770		0.615
				97	0.530				97	0.750		0.640
				98	0.560				98	0.540		0.550
				99	0.630				99	0.580		0.605
			Avg:		0.524			Avg:		0.680	Avg:	0.602
			Std Dev:		0.077			Std Dev:		0.111	Std Dev:	0.033
	OF2	90	2	95	0.430	HF1	90	2	95	0.580		0.505
				96	0.420				96	0.530		0.475
				97	0.580				97	0.600		0.590
				98	0.550				98	0.730		0.640
				99	0.350				99	0.760		0.555
			Avg:		0.466			Avg:		0.640	Avg:	0.553
			Std Dev:		0.096			Std Dev:		0.100	Std Dev:	0.066

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.330	HF2	0	1	95	0.470		0.400
				96	0.440				96	0.530		0.485
				97	0.300				97	0.470		0.385
				98	0.380				98	0.570		0.475
				99	0.420				99	0.530		0.475
				Avg:	0.374				Avg:	0.514	Avg:	0.444
				Std Dev:	0.059				Std Dev:	0.043	Std Dev:	0.047
	OF1	0	2	95	0.410	HF2	0	2	95	0.610		0.510
				96	0.240				96	0.440		0.340
				97	0.400				97	0.550		0.475
				98	0.400				98	0.540		0.470
				99	0.300				99	0.550		0.425
				Avg:	0.350				Avg:	0.538	Avg:	0.444
				Std Dev:	0.076				Std Dev:	0.061	Std Dev:	0.066
	OF1	90	1	95	0.450	HF2	90	1	95	0.470		0.460
				96	0.430				96	0.430		0.430
				97	0.460				97	0.450		0.455
				98	0.420				98	0.460		0.440
				99	0.390				99	0.400		0.395
				Avg:	0.430				Avg:	0.442	Avg:	0.436
				Std Dev:	0.027				Std Dev:	0.028	Std Dev:	0.026
	OF1	90	2	95	0.400	HF2	90	2	95	0.530		0.465
				96	0.400				96	0.500		0.450
				97	0.450				97	0.490		0.470
				98	0.430				98	0.490		0.460
				99	0.430				99	0.480		0.455
				Avg:	0.422				Avg:	0.498	Avg:	0.460
				Std Dev:	0.022				Std Dev:	0.019	Std Dev:	0.008
A	OF2	0	1	95	0.590	HF1	0	1	95	0.390		0.490
				96	0.550				96	0.380		0.465
				97	0.540				97	0.450		0.495
				98	0.480				98	0.310		0.395
				99	0.480				99	0.340		0.410
				Avg:	0.528				Avg:	0.374	Avg:	0.451
				Std Dev:	0.048				Std Dev:	0.053	Std Dev:	0.046
	OF2	0	2	95	0.510	HF1	0	2	95	0.360		0.435
				96	0.560				96	0.370		0.465
				97	0.490				97	0.430		0.460
				98	0.620				98	0.390		0.505
				99	0.620				99	0.430		0.525
				Avg:	0.560				Avg:	0.396	Avg:	0.478
				Std Dev:	0.060				Std Dev:	0.033	Std Dev:	0.036
	OF2	90	1	95	0.510	HF1	90	1	95	0.440		0.475
				96	0.490				96	0.440		0.465
				97	0.460				97	0.450		0.455
				98	0.510				98	0.440		0.475
				99	0.430				99	0.430		0.430
				Avg:	0.480				Avg:	0.440	Avg:	0.460
				Std Dev:	0.035				Std Dev:	0.007	Std Dev:	0.019
	OF2	90	2	95	0.420	HF1	90	2	95	0.470		0.445
				96	0.450				96	0.440		0.445
				97	0.390				97	0.420		0.405
				98	0.420				98	0.440		0.430
				99	0.520				99	0.490		0.505
				Avg:	0.440				Avg:	0.452	Avg:	0.446
				Std Dev:	0.049				Std Dev:	0.028	Std Dev:	0.037

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 4.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.380	HF2	0	1	95	0.390		0.385
				96	0.470				96	0.340		0.405
				97	0.460				97	0.360		0.410
				98	0.480				98	0.310		0.395
				99	0.360				99	0.410		0.385
				Avg:	0.430				Avg:	0.362	Avg:	0.396
				Std Dev:	0.056				Std Dev:	0.040	Std Dev:	0.011
	OF1	0	2	95	0.400	HF2	0	2	95	0.320		0.360
				96	0.350				96	0.290		0.320
				97	0.370				97	0.360		0.365
				98	0.420				98	0.280		0.350
				99	0.360				99	0.350		0.355
				Avg:	0.380				Avg:	0.320	Avg:	0.350
				Std Dev:	0.029				Std Dev:	0.035	Std Dev:	0.018
	OF1	90	1	95	0.470	HF2	90	1	95	0.490		0.480
				96	0.460				96	0.610		0.535
				97	0.480				97	0.520		0.500
				98	0.430				98	0.470		0.450
				99	0.440				99	0.510		0.475
				Avg:	0.456				Avg:	0.520	Avg:	0.488
				Std Dev:	0.021				Std Dev:	0.054	Std Dev:	0.032
	OF1	90	2	95	0.460	HF2	90	2	95	0.680		0.570
				96	0.410				96	0.670		0.540
				97	0.440				97	0.580		0.510
				98	0.450				98	0.600		0.525
				99	0.430				99	0.610		0.520
				Avg:	0.438				Avg:	0.628	Avg:	0.533
				Std Dev:	0.019				Std Dev:	0.044	Std Dev:	0.023
A	OF2	0	1	95	0.330	HF1	0	1	95	0.520		0.425
				96	0.350				96	0.500		0.425
				97	0.330				97	0.560		0.445
				98	0.360				98	0.460		0.410
				99	0.340				99	0.450		0.395
				Avg:	0.342				Avg:	0.498	Avg:	0.420
				Std Dev:	0.013				Std Dev:	0.045	Std Dev:	0.019
	OF2	0	2	95	0.270	HF1	0	2	95	0.430		0.350
				96	0.370				96	0.540		0.455
				97	0.370				97	0.600		0.485
				98	0.330				98	0.630		0.480
				99	0.340				99	0.560		0.450
				Avg:	0.336				Avg:	0.552	Avg:	0.444
				Std Dev:	0.041				Std Dev:	0.077	Std Dev:	0.055
	OF2	90	1	95	0.510	HF1	90	1	95	0.420		0.465
				96	0.550				96	0.410		0.480
				97	0.620				97	0.430		0.525
				98	0.630				98	0.400		0.515
				99	0.580				99	0.420		0.500
				Avg:	0.578				Avg:	0.416	Avg:	0.497
				Std Dev:	0.050				Std Dev:	0.011	Std Dev:	0.025
	OF2	90	2	95	0.660	HF1	90	2	95	0.440		0.550
				96	0.700				96	0.410		0.555
				97	0.690				97	0.420		0.555
				98	0.620				98	0.430		0.525
				99	0.520				99	0.420		0.470
				Avg:	0.638				Avg:	0.424	Avg:	0.531
				Std Dev:	0.073				Std Dev:	0.011	Std Dev:	0.036

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 1.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.860	HF2	0	1	95	0.500		0.680
				96	0.870				96	0.690		0.780
				97	0.580				97	0.630		0.605
				98	0.400				98	0.780		0.590
				99	0.800				99	0.830		0.815
				Avg:	0.702				Avg:	0.686	Avg:	0.694
				Std Dev:	0.205				Std Dev:	0.130	Std Dev:	0.101
	OF1	0	2	95	0.480	HF2	0	2	95	0.760		0.620
				96	0.830				96	0.660		0.745
				97	0.750				97	0.810		0.780
				98	0.780				98	0.520		0.650
				99	0.550				99	0.790		0.670
				Avg:	0.678				Avg:	0.708	Avg:	0.693
				Std Dev:	0.154				Std Dev:	0.120	Std Dev:	0.067
	OF1	90	1	95	0.620	HF2	90	1	95	0.250		0.435
				96	0.520				96	0.530		0.525
				97	0.510				97	0.660		0.585
				98	0.420				98	0.230		0.325
				99	0.660				99	0.380		0.520
				Avg:	0.546				Avg:	0.410	Avg:	0.478
				Std Dev:	0.095				Std Dev:	0.184	Std Dev:	0.101
	OF1	90	2	95	0.430	HF2	90	2	95	0.140		0.285
				96	0.440				96	0.390		0.415
				97	0.350				97	0.140		0.245
				98	0.340				98	0.240		0.290
				99	0.530				99	0.410		0.470
				Avg:	0.418				Avg:	0.264	Avg:	0.341
				Std Dev:	0.077				Std Dev:	0.131	Std Dev:	0.096
B	OF2	0	1	95	0.670	HF1	0	1	95	0.800		0.735
				96	0.550				96	0.930		0.740
				97	0.570				97	0.840		0.705
				98	0.430				98	0.840		0.635
				99	0.630				99	0.350		0.490
				Avg:	0.570				Avg:	0.752	Avg:	0.661
				Std Dev:	0.092				Std Dev:	0.230	Std Dev:	0.104
	OF2	0	2	95	0.450	HF1	0	2	95	0.640		0.545
				96	0.480				96	0.440		0.460
				97	0.580				97	0.460		0.520
				98	0.730				98	0.620		0.675
				99	0.610				99	0.890		0.750
				Avg:	0.570				Avg:	0.610	Avg:	0.590
				Std Dev:	0.112				Std Dev:	0.181	Std Dev:	0.119
	OF2	90	1	95	0.440	HF1	90	1	95	0.330		0.385
				96	0.630				96	0.380		0.505
				97	0.580				97	0.470		0.525
				98	0.390				98	0.590		0.490
				99	0.490				99	0.590		0.540
				Avg:	0.506				Avg:	0.472	Avg:	0.489
				Std Dev:	0.099				Std Dev:	0.119	Std Dev:	0.061
	OF2	90	2	95	0.360	HF1	90	2	95	0.650		0.505
				96	0.360				96	0.730		0.545
				97	0.480				97	0.510		0.495
				98	0.480				98	0.480		0.480
				99	0.500				99	0.450		0.475
				Avg:	0.436				Avg:	0.564	Avg:	0.500
				Std Dev:	0.070				Std Dev:	0.120	Std Dev:	0.028

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.510	HF2	0	1	95	0.500		0.505
				96	0.410				96	0.460		0.435
				97	0.500				97	0.470		0.485
				98	0.470				98	0.410		0.440
				99	0.500				99	0.430		0.465
			Avg:		0.478			Avg:		0.454	Avg:	0.466
			Std Dev:		0.041			Std Dev:		0.035	Std Dev:	0.030
	OF1	0	2	95	0.500	HF2	0	2	95	0.520		0.510
				96	0.530				96	0.480		0.505
				97	0.420				97	0.510		0.465
				98	0.490				98	0.410		0.450
				99	0.500				99	0.420		0.460
			Avg:		0.488			Avg:		0.468	Avg:	0.478
			Std Dev:		0.041			Std Dev:		0.051	Std Dev:	0.028
	OF1	90	1	95	0.440	HF2	90	1	95	0.050		0.245
				96	0.410				96	0.050		0.230
				97	0.410				97	0.090		0.250
				98	0.380				98	0.020		0.200
				99	0.400				99	0.070		0.235
			Avg:		0.408			Avg:		0.056	Avg:	0.232
			Std Dev:		0.022			Std Dev:		0.026	Std Dev:	0.020
	OF1	90	2	95	0.460	HF2	90	2	95	0.050		0.255
				96	0.420				96	0.100		0.260
				97	0.440				97	0.130		0.285
				98	0.390				98	0.070		0.230
				99	0.430				99	0.070		0.250
			Avg:		0.428			Avg:		0.084	Avg:	0.256
			Std Dev:		0.026			Std Dev:		0.031	Std Dev:	0.020
B	OF2	0	1	95	0.060	HF1	0	1	95	0.370		0.215
				96	0.090				96	0.390		0.240
				97	0.090				97	0.380		0.235
				98	0.020				98	0.420		0.220
				99	0.090				99	0.380		0.235
			Avg:		0.070			Avg:		0.388	Avg:	0.229
			Std Dev:		0.031			Std Dev:		0.019	Std Dev:	0.011
	OF2	0	2	95	0.420	HF1	0	2	95	0.620		0.520
				96	0.420				96	0.520		0.470
				97	0.420				97	0.570		0.495
				98	0.460				98	0.390		0.425
				99	0.490				99	0.520		0.505
			Avg:		0.442			Avg:		0.524	Avg:	0.483
			Std Dev:		0.032			Std Dev:		0.086	Std Dev:	0.037
	OF2	90	1	95	0.060	HF1	90	1	95	0.370		0.215
				96	0.090				96	0.390		0.240
				97	0.090				97	0.380		0.235
				98	0.020				98	0.420		0.220
				99	0.090				99	0.380		0.235
			Avg:		0.070			Avg:		0.388	Avg:	0.229
			Std Dev:		0.031			Std Dev:		0.019	Std Dev:	0.011
	OF2	90	2	95	0.420	HF1	90	2	95	0.620		0.520
				96	0.420				96	0.520		0.470
				97	0.420				97	0.570		0.495
				98	0.460				98	0.390		0.425
				99	0.490				99	0.520		0.505
			Avg:		0.442			Avg:		0.524	Avg:	0.483
			Std Dev:		0.032			Std Dev:		0.086	Std Dev:	0.037

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 4.50 in
Instant

Polssons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.560	HF2	0	1	95	0.420		0.490
				96	0.560				96	0.410		0.485
				97	0.610				97	0.390		0.500
				98	0.590				98	0.470		0.530
				99	0.540				99	0.380		0.460
			Avg:		0.572			Avg:		0.414	Avg:	0.493
			Std Dev:		0.028			Std Dev:		0.035	Std Dev:	0.025
	OF1	0	2	95	0.580	HF2	0	2	95	0.410		0.495
				96	0.570				96	0.390		0.480
				97	0.560				97	0.370		0.465
				98	0.520				98	0.390		0.455
				99	0.610				99	0.400		0.505
			Avg:		0.568			Avg:		0.392	Avg:	0.480
			Std Dev:		0.033			Std Dev:		0.015	Std Dev:	0.021
	OF1	90	1	95	0.510	HF2	90	1	95	0.490		0.500
				96	0.500				96	0.560		0.530
				97	0.510				97	0.460		0.485
				98	0.520				98	0.370		0.445
				99	0.490				99	0.450		0.470
			Avg:		0.506			Avg:		0.466	Avg:	0.486
			Std Dev:		0.011			Std Dev:		0.069	Std Dev:	0.032
	OF1	90	2	95	0.580	HF2	90	2	95	0.490		0.535
				96	0.530				96	0.380		0.455
				97	0.530				97	0.380		0.455
				98	0.510				98	0.490		0.500
				99	0.530				99	0.470		0.500
			Avg:		0.536			Avg:		0.442	Avg:	0.489
			Std Dev:		0.026			Std Dev:		0.057	Std Dev:	0.034
B	OF2	0	1	95	0.450	HF1	0	1	95	0.520		0.485
				96	0.460				96	0.520		0.490
				97	0.400				97	0.560		0.480
				98	0.440				98	0.570		0.505
				99	0.430				99	0.490		0.460
			Avg:		0.436			Avg:		0.532	Avg:	0.484
			Std Dev:		0.023			Std Dev:		0.033	Std Dev:	0.016
	OF2	0	2	95	0.440	HF1	0	2	95	0.510		0.475
				96	0.360				96	0.530		0.445
				97	0.470				97	0.540		0.505
				98	0.410				98	0.460		0.435
				99	0.380				99	0.550		0.465
			Avg:		0.412			Avg:		0.518	Avg:	0.465
			Std Dev:		0.044			Std Dev:		0.036	Std Dev:	0.027
	OF2	90	1	95	0.440	HF1	90	1	95	0.470		0.455
				96	0.470				96	0.480		0.475
				97	0.450				97	0.440		0.445
				98	0.470				98	0.460		0.465
				99	0.510				99	0.430		0.470
			Avg:		0.468			Avg:		0.456	Avg:	0.462
			Std Dev:		0.027			Std Dev:		0.021	Std Dev:	0.012
	OF2	90	2	95	0.440	HF1	90	2	95	0.490		0.465
				96	0.500				96	0.500		0.500
				97	0.440				97	0.470		0.455
				98	0.510				98	0.480		0.495
				99	0.430				99	0.450		0.440
			Avg:		0.464			Avg:		0.478	Avg:	0.471
			Std Dev:		0.038			Std Dev:		0.019	Std Dev:	0.026

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 1.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.210	HF2	0	1	95	0.140		0.175
				96	0.200				96	0.240		0.220
				97	0.120				97	0.210		0.165
				98	0.140				98	0.150		0.145
				99	0.030				99	0.240		0.135
			Avg:		0.140			Avg:		0.196	Avg:	0.168
			Std Dev:		0.072			Std Dev:		0.048	Std Dev:	0.033
	OF1	0	2	95	0.220	HF2	0	2	95	0.120		0.170
				96	0.240				96	0.270		0.255
				97	0.150				97	0.220		0.185
				98	0.040				98	0.170		0.105
				99	0.010				99	0.180		0.095
			Avg:		0.132			Avg:		0.192	Avg:	0.162
			Std Dev:		0.104			Std Dev:		0.056	Std Dev:	0.065
	OF1	90	1	95	0.630	HF2	90	1	95	0.590		0.610
				96	0.520				96	0.640		0.580
				97	0.610				97	0.880		0.745
				98	0.740				98	0.780		0.760
				99	0.950				99	0.690		0.820
			Avg:		0.690			Avg:		0.716	Avg:	0.703
			Std Dev:		0.165			Std Dev:		0.115	Std Dev:	0.103
	OF1	90	2	95	0.860	HF2	90	2	95	0.950		0.905
				96	0.910				96	0.650		0.780
				97	0.990				97	0.730		0.860
				98	0.940				98	0.890		0.915
				99	0.690				99	0.770		0.730
			Avg:		0.878			Avg:		0.798	Avg:	0.838
			Std Dev:		0.115			Std Dev:		0.121	Std Dev:	0.081
C	OF2	0	1	95	0.310	HF1	0	1	95	0.140		0.225
				96	0.230				96	0.170		0.200
				97	0.270				97	0.190		0.230
				98	0.400				98	0.280		0.340
				99	0.210				99	0.210		0.210
			Avg:		0.284			Avg:		0.198	Avg:	0.241
			Std Dev:		0.075			Std Dev:		0.053	Std Dev:	0.057
	OF2	0	2	95	0.160	HF1	0	2	95	0.140		0.150
				96	0.190				96	0.150		0.170
				97	0.250				97	0.170		0.210
				98	0.210				98	0.200		0.205
				99	0.360				99	0.140		0.250
			Avg:		0.234			Avg:		0.160	Avg:	0.197
			Std Dev:		0.078			Std Dev:		0.025	Std Dev:	0.039
	OF2	90	1	95	0.510	HF1	90	1	95	0.800		0.655
				96	0.440				96	0.470		0.455
				97	0.750				97	0.570		0.660
				98	0.780				98	0.690		0.735
				99	0.670				99	1.310		0.990
			Avg:		0.630			Avg:		0.768	Avg:	0.699
			Std Dev:		0.149			Std Dev:		0.327	Std Dev:	0.193
	OF2	90	2	95	0.510	HF1	90	2	95	1.130		0.820
				96	0.610				96	1.640		1.125
				97	0.640				97	1.270		0.955
				98	0.500				98	0.820		0.660
				99	0.530				99	0.590		0.560
			Avg:		0.558			Avg:		1.090	Avg:	0.824
			Std Dev:		0.063			Std Dev:		0.406	Std Dev:	0.226

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 3.00 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.480	HF2	0	1	95	0.490		0.485
				96	0.460				96	0.500		0.480
				97	0.540				97	0.680		0.610
				98	0.480				98	0.600		0.540
				99	0.500				99	0.480		0.490
			Avg:		0.492				Avg:	0.550	Avg:	0.521
			Std Dev:		0.030				Std Dev:	0.087	Std Dev:	0.055
	OF1	0	2	95	0.490	HF2	0	2	95	0.580		0.535
				96	0.470				96	0.700		0.585
				97	0.470				97	0.710		0.590
				98	0.400				98	0.480		0.440
				99	0.470				99	0.560		0.515
			Avg:		0.460				Avg:	0.606	Avg:	0.533
			Std Dev:		0.035				Std Dev:	0.098	Std Dev:	0.061
	OF1	90	1	95	0.140	HF2	90	1	95	0.260		0.200
				96	0.150				96	0.320		0.235
				97	0.150				97	0.400		0.275
				98	0.160				98	0.290		0.225
				99	0.170				99	0.310		0.240
			Avg:		0.154				Avg:	0.316	Avg:	0.235
			Std Dev:		0.011				Std Dev:	0.052	Std Dev:	0.027
	OF1	90	2	95	0.150	HF2	90	2	95	0.230		0.190
				96	0.140				96	0.210		0.175
				97	0.150				97	0.270		0.210
				98	0.160				98	0.290		0.225
				99	0.160				99	0.180		0.170
			Avg:		0.152				Avg:	0.236	Avg:	0.194
			Std Dev:		0.008				Std Dev:	0.044	Std Dev:	0.023
C	OF2	0	1	95	0.480	HF1	0	1	95	0.320		0.400
				96	0.650				96	0.480		0.565
				97	0.600				97	0.480		0.540
				98	0.500				98	0.340		0.420
				99	0.600				99	0.480		0.540
			Avg:		0.566				Avg:	0.420	Avg:	0.493
			Std Dev:		0.073				Std Dev:	0.082	Std Dev:	0.077
	OF2	0	2	95	0.660	HF1	0	2	95	0.570		0.615
				96	0.520				96	0.480		0.500
				97	0.540				97	0.420		0.480
				98	0.570				98	0.570		0.570
				99	0.590				99	0.480		0.535
			Avg:		0.576				Avg:	0.504	Avg:	0.540
			Std Dev:		0.054				Std Dev:	0.065	Std Dev:	0.054
	OF2	90	1	95	0.270	HF1	90	1	95	0.190		0.230
				96	0.240				96	0.220		0.230
				97	0.300				97	0.230		0.265
				98	0.250				98	0.190		0.220
				99	0.260				99	0.220		0.240
			Avg:		0.264				Avg:	0.210	Avg:	0.237
			Std Dev:		0.023				Std Dev:	0.019	Std Dev:	0.017
	OF2	90	2	95	0.280	HF1	90	2	95	0.210		0.245
				96	0.220				96	0.170		0.195
				97	0.310				97	0.180		0.245
				98	0.190				98	0.190		0.190
				99	0.240				99	0.230		0.235
			Avg:		0.248				Avg:	0.196	Avg:	0.222
			Std Dev:		0.048				Std Dev:	0.024	Std Dev:	0.027

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 4.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.470	HF2	0	1	95	0.450		0.460
				96	0.470				96	0.580		0.525
				97	0.510				97	0.550		0.530
				98	0.560				98	0.530		0.545
				99	0.520				99	0.430		0.475
			Avg:		0.506			Avg:		0.508	Avg:	0.507
			Std Dev:		0.038			Std Dev:		0.065	Std Dev:	0.037
	OF1	0	2	95	0.530	HF2	0	2	95	0.590		0.560
				96	0.520				96	0.460		0.490
				97	0.500				97	0.540		0.520
				98	0.490				98	0.570		0.530
				99	0.540				99	0.550		0.545
			Avg:		0.516			Avg:		0.542	Avg:	0.529
			Std Dev:		0.021			Std Dev:		0.050	Std Dev:	0.027
	OF1	90	1	95	0.330	HF2	90	1	95	0.420		0.375
				96	0.380				96	0.420		0.400
				97	0.370				97	0.470		0.420
				98	0.370				98	0.450		0.410
				99	0.370				99	0.540		0.455
			Avg:		0.364			Avg:		0.460	Avg:	0.412
			Std Dev:		0.019			Std Dev:		0.049	Std Dev:	0.029
	OF1	90	2	95	0.420	HF2	90	2	95	0.490		0.455
				96	0.410				96	0.460		0.435
				97	0.440				97	0.440		0.440
				98	0.430				98	0.480		0.455
				99	0.350				99	0.480		0.415
			Avg:		0.410			Avg:		0.470	Avg:	0.440
			Std Dev:		0.035			Std Dev:		0.020	Std Dev:	0.017
C	OF2	0	1	95	0.450	HF1	0	1	95	0.450		0.450
				96	0.510				96	0.450		0.480
				97	0.510				97	0.470		0.490
				98	0.520				98	0.460		0.490
				99	0.510				99	0.490		0.500
			Avg:		0.500			Avg:		0.464	Avg:	0.482
			Std Dev:		0.028			Std Dev:		0.017	Std Dev:	0.019
	OF2	0	2	95	0.570	HF1	0	2	95	0.560		0.565
				96	0.560				96	0.590		0.575
				97	0.560				97	0.660		0.610
				98	0.530				98	0.620		0.575
				99	0.550				99	0.610		0.580
			Avg:		0.554			Avg:		0.608	Avg:	0.581
			Std Dev:		0.015			Std Dev:		0.037	Std Dev:	0.017
	OF2	90	1	95	0.520	HF1	90	1	95	0.360		0.440
				96	0.510				96	0.340		0.425
				97	0.460				97	0.340		0.400
				98	0.420				98	0.330		0.375
				99	0.500				99	0.390		0.445
			Avg:		0.482			Avg:		0.352	Avg:	0.417
			Std Dev:		0.041			Std Dev:		0.024	Std Dev:	0.029
	OF2	90	2	95	0.460	HF1	90	2	95	0.340		0.400
				96	0.490				96	0.360		0.425
				97	0.530				97	0.370		0.450
				98	0.560				98	0.420		0.490
				99	0.500				99	0.360		0.430
			Avg:		0.508			Avg:		0.370	Avg:	0.439
			Std Dev:		0.038			Std Dev:		0.030	Std Dev:	0.034

Annex 17

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Instantaneous

19.0 mm
6 inch Dia.

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.200	HF2	0	1	95	0.720		0.460
				96	0.270				96	1.030		0.650
				97	0.190				97	0.950		0.570
				98	0.160				98	0.800		0.480
				99	0.190				99	1.670		0.930
			Avg:		0.202			Avg:		1.034	Avg:	0.618
			Std Dev:		0.041			Std Dev:		0.376	Std Dev:	0.190
	OF1	0	2	95	0.250	HF2	0	2	95	0.960		0.605
				96	0.240				96	0.780		0.510
				97	0.280				97	0.610		0.445
				98	0.250				98	1.120		0.685
				99	0.290				99	0.720		0.505
			Avg:		0.262			Avg:		0.838	Avg:	0.550
			Std Dev:		0.022			Std Dev:		0.202	Std Dev:	0.095
	OF1	90	1	95	0.960	HF2	90	1	95	0.010		0.485
				96	1.000				96	0.110		0.555
				97	0.710				97	0.060		0.385
				98	0.600				98	0.010		0.305
				99	0.730				99	0.220		0.475
			Avg:		0.800			Avg:		0.082	Avg:	0.441
			Std Dev:		0.172			Std Dev:		0.088	Std Dev:	0.097
	OF1	90	2	95	0.850	HF2	90	2	95	0.100		0.475
				96	0.580				96	0.090		0.335
				97	0.740				97	0.030		0.385
				98	0.800				98	0.120		0.460
				99	0.900				99	0.120		0.510
			Avg:		0.774			Avg:		0.092	Avg:	0.433
			Std Dev:		0.124			Std Dev:		0.037	Std Dev:	0.071
A	OF2	0	1	95	0.390	HF1	0	1	95	0.300		0.345
				96	0.570				96	0.340		0.455
				97	0.890				97	0.210		0.550
				98	0.330				98	0.250		0.290
				99	0.530				99	0.170		0.350
			Avg:		0.542			Avg:		0.254	Avg:	0.398
			Std Dev:		0.218			Std Dev:		0.068	Std Dev:	0.104
	OF2	0	2	95	0.570	HF1	0	2	95	0.350		0.460
				96	0.510				96	0.340		0.425
				97	0.890				97	0.220		0.555
				98	0.350				98	0.190		0.270
				99	0.900				99	0.330		0.615
			Avg:		0.644			Avg:		0.286	Avg:	0.465
			Std Dev:		0.243			Std Dev:		0.075	Std Dev:	0.133
	OF2	90	1	95	0.080	HF1	90	1	95	0.630		0.355
				96	0.090				96	0.730		0.410
				97	0.130				97	0.820		0.475
				98	0.150				98	0.880		0.515
				99	0.130				99	0.840		0.485
			Avg:		0.116			Avg:		0.780	Avg:	0.448
			Std Dev:		0.030			Std Dev:		0.100	Std Dev:	0.065
	OF2	90	2	95	0.020	HF1	90	2	95	0.820		0.420
				96	0.050				96	0.960		0.505
				97	0.040				97	0.930		0.485
				98	0.020				98	0.780		0.400
				99	0.010				99	0.930		0.470
			Avg:		0.028			Avg:		0.884	Avg:	0.456
			Std Dev:		0.016			Std Dev:		0.079	Std Dev:	0.044

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.410	HF2	0	1	95	0.270		0.340
				96	0.460				96	0.240		0.350
				97	0.360				97	0.230		0.295
				98	0.340				98	0.200		0.270
				99	0.370				99	0.290		0.330
				Avg:	0.388				Avg:	0.246	Avg:	0.317
				Std Dev:	0.048				Std Dev:	0.035	Std Dev:	0.033
	OF1	0	2	95	0.320	HF2	0	2	95	0.310		0.315
				96	0.430				96	0.250		0.340
				97	0.320				97	0.210		0.265
				98	0.270				98	0.290		0.280
				99	0.300				99	0.320		0.310
				Avg:	0.328				Avg:	0.276	Avg:	0.302
				Std Dev:	0.061				Std Dev:	0.046	Std Dev:	0.030
	OF1	90	1	95	0.580	HF2	90	1	95	0.310		0.445
				96	0.540				96	0.400		0.470
				97	0.540				97	0.260		0.400
				98	0.520				98	0.230		0.375
				99	0.630				99	0.260		0.445
				Avg:	0.562				Avg:	0.292	Avg:	0.427
				Std Dev:	0.044				Std Dev:	0.067	Std Dev:	0.039
	OF1	90	2	95	0.720	HF2	90	2	95	0.290		0.505
				96	0.520				96	0.290		0.405
				97	0.610				97	0.270		0.440
				98	0.600				98	0.280		0.440
				99	0.580				99	0.170		0.375
				Avg:	0.606				Avg:	0.260	Avg:	0.433
				Std Dev:	0.073				Std Dev:	0.051	Std Dev:	0.049
A	OF2	0	1	95	0.300	HF1	0	1	95	0.300		0.300
				96	0.360				96	0.300		0.330
				97	0.270				97	0.380		0.325
				98	0.220				98	0.330		0.275
				99	0.200				99	0.320		0.260
				Avg:	0.270				Avg:	0.326	Avg:	0.298
				Std Dev:	0.064				Std Dev:	0.033	Std Dev:	0.031
	OF2	0	2	95	0.310	HF1	0	2	95	0.390		0.350
				96	0.220				96	0.320		0.270
				97	0.270				97	0.320		0.295
				98	0.290				98	0.380		0.335
				99	0.250				99	0.400		0.325
				Avg:	0.268				Avg:	0.362	Avg:	0.315
				Std Dev:	0.035				Std Dev:	0.039	Std Dev:	0.032
	OF2	90	1	95	0.270	HF1	90	1	95	0.580		0.425
				96	0.360				96	0.510		0.435
				97	0.410				97	0.610		0.510
				98	0.380				98	0.530		0.455
				99	0.290				99	0.570		0.430
				Avg:	0.342				Avg:	0.560	Avg:	0.451
				Std Dev:	0.060				Std Dev:	0.040	Std Dev:	0.035
	OF2	90	2	95	0.270	HF1	90	2	95	0.610		0.440
				96	0.580				96	0.520		0.550
				97	0.430				97	0.550		0.490
				98	0.310				98	0.580		0.445
				99	0.380				99	0.520		0.450
				Avg:	0.394				Avg:	0.556	Avg:	0.475
				Std Dev:	0.121				Std Dev:	0.039	Std Dev:	0.046

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 4.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.270	HF2	0	1	95	0.130		0.200
				96	0.250				96	0.080		0.165
				97	0.200				97	0.070		0.135
				98	0.270				98	0.120		0.195
				99	0.260				99	0.030		0.145
			Avg:		0.250			Avg:		0.086	Avg:	0.168
			Std Dev:		0.029			Std Dev:		0.040	Std Dev:	0.029
	OF1	0	2	95	0.270	HF2	0	2	95	0.090		0.180
				96	0.250				96	0.080		0.165
				97	0.210				97	0.080		0.145
				98	0.190				98	0.030		0.110
				99	0.210				99	0.110		0.160
			Avg:		0.226			Avg:		0.078	Avg:	0.152
			Std Dev:		0.033			Std Dev:		0.029	Std Dev:	0.027
	OF1	90	1	95	0.620	HF2	90	1	95	0.320		0.470
				96	0.610				96	0.320		0.465
				97	0.590				97	0.410		0.500
				98	0.650				98	0.320		0.485
				99	0.620				99	0.420		0.520
			Avg:		0.618			Avg:		0.358	Avg:	0.488
			Std Dev:		0.022			Std Dev:		0.052	Std Dev:	0.023
	OF1	90	2	95	0.650	HF2	90	2	95	0.320		0.485
				96	0.630				96	0.250		0.440
				97	0.680				97	0.300		0.490
				98	0.650				98	0.280		0.465
				99	0.640				99	0.380		0.510
			Avg:		0.650			Avg:		0.306	Avg:	0.478
			Std Dev:		0.019			Std Dev:		0.049	Std Dev:	0.027
A	OF2	0	1	95	0.030	HF1	0	1	95	0.290		0.160
				96	0.050				96	0.280		0.165
				97	0.010				97	0.320		0.165
				98	0.020				98	0.300		0.160
				99	0.010				99	0.290		0.150
			Avg:		0.024			Avg:		0.296	Avg:	0.160
			Std Dev:		0.017			Std Dev:		0.015	Std Dev:	0.006
	OF2	0	2	95	0.010	HF1	0	2	95	0.350		0.180
				96	0.010				96	0.330		0.170
				97	0.020				97	0.320		0.170
				98	0.060				98	0.350		0.205
				99	0.040				99	0.350		0.195
			Avg:		0.028			Avg:		0.340	Avg:	0.184
			Std Dev:		0.022			Std Dev:		0.014	Std Dev:	0.016
	OF2	90	1	95	0.260	HF1	90	1	95	0.510		0.385
				96	0.270				96	0.490		0.380
				97	0.290				97	0.510		0.400
				98	0.300				98	0.530		0.415
				99	0.290				99	0.510		0.400
			Avg:		0.282			Avg:		0.510	Avg:	0.396
			Std Dev:		0.016			Std Dev:		0.014	Std Dev:	0.014
	OF2	90	2	95	0.280	HF1	90	2	95	0.560		0.420
				96	0.260				96	0.530		0.395
				97	0.270				97	0.570		0.420
				98	0.310				98	0.600		0.455
				99	0.320				99	0.580		0.450
			Avg:		0.288			Avg:		0.568	Avg:	0.428
			Std Dev:		0.026			Std Dev:		0.026	Std Dev:	0.025

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.590	HF2	0	1	95	0.760		0.675
				96	0.590				96	0.450		0.520
				97	0.590				97	0.410		0.500
				98	0.780				98	0.410		0.595
				99	0.500				99	0.990		0.745
				Avg:	0.610				Avg:	0.604	Avg:	0.607
				Std Dev:	0.103				Std Dev:	0.261	Std Dev:	0.103
	OF1	0	2	95	0.610	HF2	0	2	95	0.630		0.620
				96	0.440				96	0.910		0.675
				97	0.600				97	0.590		0.595
				98	0.520				98	0.330		0.425
				99	0.470				99	0.610		0.540
				Avg:	0.528				Avg:	0.614	Avg:	0.571
				Std Dev:	0.076				Std Dev:	0.206	Std Dev:	0.095
	OF1	90	1	95	0.400	HF2	90	1	95	0.790		0.595
				96	0.230				96	0.970		0.600
				97	0.380				97	0.280		0.330
				98	0.390				98	0.470		0.430
				99	0.340				99	0.640		0.490
				Avg:	0.348				Avg:	0.630	Avg:	0.489
				Std Dev:	0.070				Std Dev:	0.269	Std Dev:	0.114
	OF1	90	2	95	0.310	HF2	90	2	95	0.120		0.215
				96	0.440				96	0.680		0.560
				97	0.450				97	0.770		0.610
				98	0.560				98	0.520		0.540
				99	0.580				99	0.310		0.445
				Avg:	0.468				Avg:	0.480	Avg:	0.474
				Std Dev:	0.108				Std Dev:	0.267	Std Dev:	0.157
B	OF2	0	1	95	0.590	HF1	0	1	95	0.520		0.555
				96	0.850				96	0.460		0.655
				97	0.480				97	0.820		0.650
				98	0.230				98	0.380		0.305
				99	0.700				99	0.460		0.580
				Avg:	0.570				Avg:	0.528	Avg:	0.549
				Std Dev:	0.234				Std Dev:	0.171	Std Dev:	0.143
	OF2	0	2	95	0.890	HF1	0	2	95	0.590		0.740
				96	0.640				96	0.590		0.615
				97	0.230				97	0.320		0.275
				98	0.680				98	0.280		0.480
				99	1.070				99	0.550		0.810
				Avg:	0.702				Avg:	0.466	Avg:	0.584
				Std Dev:	0.315				Std Dev:	0.153	Std Dev:	0.214
	OF2	90	1	95	0.560	HF1	90	1	95	0.540		0.550
				96	0.140				96	0.570		0.355
				97	0.890				97	0.730		0.810
				98	0.400				98	0.620		0.510
				99	0.130				99	0.590		0.360
				Avg:	0.424				Avg:	0.610	Avg:	0.517
				Std Dev:	0.318				Std Dev:	0.073	Std Dev:	0.186
	OF2	90	2	95	0.380	HF1	90	2	95	0.790		0.585
				96	0.640				96	1.030		0.835
				97	0.150				97	0.820		0.485
				98	0.630				98	0.940		0.785
				99	0.440				99	0.500		0.470
				Avg:	0.448				Avg:	0.816	Avg:	0.632
				Std Dev:	0.202				Std Dev:	0.201	Std Dev:	0.169

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.570	HF2	0	1	95	0.570		0.570
				96	0.540				96	0.630		0.585
				97	0.510				97	0.610		0.560
				98	0.510				98	0.680		0.595
				99	0.540				99	0.680		0.610
			Avg:		0.534			Avg:		0.634	Avg:	0.584
			Std Dev:		0.025			Std Dev:		0.047	Std Dev:	0.020
	OF1	0	2	95	0.520	HF2	0	2	95	0.580		0.550
				96	0.610				96	0.640		0.625
				97	0.450				97	0.530		0.490
				98	0.510				98	0.570		0.540
				99	0.530				99	0.550		0.540
			Avg:		0.524			Avg:		0.574	Avg:	0.549
			Std Dev:		0.057			Std Dev:		0.042	Std Dev:	0.049
	OF1	90	1	95	0.470	HF2	90	1	95	0.330		0.400
				96	0.560				96	0.330		0.445
				97	0.530				97	0.360		0.445
				98	0.510				98	0.330		0.420
				99	0.550				99	0.290		0.420
			Avg:		0.524			Avg:		0.328	Avg:	0.426
			Std Dev:		0.036			Std Dev:		0.025	Std Dev:	0.019
	OF1	90	2	95	0.470	HF2	90	2	95	0.310		0.390
				96	0.470				96	0.310		0.390
				97	0.520				97	0.330		0.425
				98	0.490				98	0.330		0.410
				99	0.460				99	0.340		0.400
			Avg:		0.482			Avg:		0.324	Avg:	0.403
			Std Dev:		0.024			Std Dev:		0.013	Std Dev:	0.015
B	OF2	0	1	95	0.540	HF1	0	1	95	0.590		0.565
				96	0.580				96	0.590		0.585
				97	0.580				97	0.540		0.560
				98	0.540				98	0.560		0.550
				99	0.540				99	0.630		0.585
			Avg:		0.556			Avg:		0.582	Avg:	0.569
			Std Dev:		0.022			Std Dev:		0.034	Std Dev:	0.016
	OF2	0	2	95	0.630	HF1	0	2	95	0.640		0.635
				96	0.600				96	0.690		0.645
				97	0.570				97	0.630		0.600
				98	0.660				98	0.620		0.640
				99	0.650				99	0.700		0.675
			Avg:		0.622			Avg:		0.656	Avg:	0.639
			Std Dev:		0.037			Std Dev:		0.036	Std Dev:	0.027
	OF2	90	1	95	0.340	HF1	90	1	95	0.430		0.385
				96	0.360				96	0.450		0.405
				97	0.320				97	0.560		0.440
				98	0.380				98	0.480		0.430
				99	0.340				99	0.510		0.425
			Avg:		0.348			Avg:		0.486	Avg:	0.417
			Std Dev:		0.023			Std Dev:		0.051	Std Dev:	0.022
	OF2	90	2	95	0.340	HF1	90	2	95	0.570		0.455
				96	0.290				96	0.440		0.365
				97	0.310				97	0.630		0.470
				98	0.290				98	0.520		0.405
				99	0.270				99	0.570		0.420
			Avg:		0.300			Avg:		0.546	Avg:	0.423
			Std Dev:		0.026			Std Dev:		0.071	Std Dev:	0.042

Mix Type=	19.0 mm	
Diam.=	6.00 in	
Gage Length=	4.50 in	
Instant		

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.610	HF2	0	1	95	0.580		0.595
				96	0.550				96	0.660		0.605
				97	0.650				97	0.570		0.610
				98	0.470				98	0.650		0.560
				99	0.440				99	0.610		0.525
			Avg:		0.544			Avg:		0.614	Avg:	0.579
			Std Dev:		0.089			Std Dev:		0.040	Std Dev:	0.036
	OF1	0	2	95	0.500	HF2	0	2	95	0.680		0.590
				96	0.470				96	0.530		0.500
				97	0.510				97	0.690		0.600
				98	0.510				98	0.660		0.585
				99	0.510				99	0.610		0.560
			Avg:		0.500			Avg:		0.634	Avg:	0.567
			Std Dev:		0.017			Std Dev:		0.066	Std Dev:	0.040
	OF1	90	1	95	0.350	HF2	90	1	95	0.370		0.360
				96	0.380				96	0.430		0.405
				97	0.400				97	0.460		0.430
				98	0.320				98	0.400		0.360
				99	0.330				99	0.380		0.355
			Avg:		0.356			Avg:		0.408	Avg:	0.382
			Std Dev:		0.034			Std Dev:		0.037	Std Dev:	0.034
	OF1	90	2	95	0.430	HF2	90	2	95	0.410		0.420
				96	0.390				96	0.480		0.435
				97	0.380				97	0.410		0.395
				98	0.390				98	0.410		0.400
				99	0.380				99	0.380		0.380
			Avg:		0.394			Avg:		0.418	Avg:	0.406
			Std Dev:		0.021			Std Dev:		0.037	Std Dev:	0.022
B	OF2	0	1	95	0.030	HF1	0	1	95	0.290		0.160
				96	0.050				96	0.280		0.165
				97	0.010				97	0.320		0.165
				98	0.020				98	0.300		0.160
				99	0.010				99	0.290		0.150
			Avg:		0.024			Avg:		0.296	Avg:	0.160
			Std Dev:		0.017			Std Dev:		0.015	Std Dev:	0.006
	OF2	0	2	95	0.690	HF1	0	2	95	0.500		0.595
				96	0.660				96	0.590		0.625
				97	0.720				97	0.530		0.625
				98	0.700				98	0.520		0.610
				99	0.720				99	0.540		0.630
			Avg:		0.698			Avg:		0.536	Avg:	0.617
			Std Dev:		0.025			Std Dev:		0.034	Std Dev:	0.014
	OF2	90	1	95	0.380	HF1	90	1	95	0.420		0.400
				96	0.340				96	0.470		0.405
				97	0.360				97	0.500		0.430
				98	0.360				98	0.470		0.415
				99	0.370				99	0.450		0.410
			Avg:		0.362			Avg:		0.462	Avg:	0.412
			Std Dev:		0.015			Std Dev:		0.029	Std Dev:	0.012
	OF2	90	2	95	0.370	HF1	90	2	95	0.450		0.410
				96	0.400				96	0.430		0.415
				97	0.430				97	0.480		0.455
				98	0.380				98	0.460		0.420
				99	0.390				99	0.500		0.445
			Avg:		0.394			Avg:		0.464	Avg:	0.429
			Std Dev:		0.023			Std Dev:		0.027	Std Dev:	0.020

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 1.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.480	HF2	0	1	95	0.220		0.350
				96	0.660				96	0.360		0.510
				97	0.540				97	0.360		0.450
				98	0.460				98	0.210		0.335
				99	0.470				99	0.400		0.435
			Avg:		0.522			Avg:		0.310	Avg:	0.416
			Std Dev:		0.083			Std Dev:		0.088	Std Dev:	0.073
	OF1	0	2	95	0.400	HF2	0	2	95	0.250		0.325
				96	0.490				96	0.320		0.405
				97	0.560				97	0.240		0.400
				98	0.510				98	0.370		0.440
				99	0.570				99	0.370		0.470
			Avg:		0.506			Avg:		0.310	Avg:	0.408
			Std Dev:		0.068			Std Dev:		0.063	Std Dev:	0.054
	OF1	90	1	95	0.420	HF2	90	1	95	0.290		0.355
				96	0.400				96	0.530		0.465
				97	0.280				97	0.260		0.270
				98	0.370				98	0.300		0.335
				99	0.380				99	0.480		0.430
			Avg:		0.370			Avg:		0.372	Avg:	0.371
			Std Dev:		0.054			Std Dev:		0.124	Std Dev:	0.078
	OF1	90	2	95	0.380	HF2	90	2	95	0.380		0.380
				96	0.360				96	0.300		0.330
				97	0.310				97	0.530		0.420
				98	0.320				98	0.400		0.360
				99	0.410				99	0.280		0.345
			Avg:		0.356			Avg:		0.378	Avg:	0.367
			Std Dev:		0.042			Std Dev:		0.099	Std Dev:	0.035
C	OF2	0	1	95	0.180	HF1	0	1	95	0.700		0.440
				96	0.340				96	0.380		0.360
				97	0.450				97	0.550		0.500
				98	0.180				98	0.770		0.475
				99	0.250				99	0.750		0.500
			Avg:		0.280			Avg:		0.630	Avg:	0.455
			Std Dev:		0.116			Std Dev:		0.164	Std Dev:	0.059
	OF2	0	2	95	0.220	HF1	0	2	95	0.580		0.400
				96	0.170				96	0.590		0.380
				97	0.420				97	0.470		0.445
				98	0.450				98	0.760		0.605
				99	0.150				99	0.760		0.455
			Avg:		0.282			Avg:		0.632	Avg:	0.457
			Std Dev:		0.142			Std Dev:		0.126	Std Dev:	0.088
	OF2	90	1	95	0.600	HF1	90	1	95	0.350		0.475
				96	0.350				96	0.470		0.410
				97	0.210				97	0.380		0.295
				98	0.400				98	0.360		0.380
				99	0.470				99	0.240		0.355
			Avg:		0.406			Avg:		0.360	Avg:	0.383
			Std Dev:		0.144			Std Dev:		0.082	Std Dev:	0.067
	OF2	90	2	95	1.200	HF1	90	2	95	0.570		0.885
				96	1.450				96	0.580		1.015
				97	2.100				97	0.510		1.305
				98	1.060				98	0.520		0.790
				99	1.170				99	0.660		0.915
			Avg:		1.396			Avg:		0.568	Avg:	0.982
			Std Dev:		0.419			Std Dev:		0.060	Std Dev:	0.198

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 3.00 in
Instant

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
C	OF1	0	1	95	0.400	HF2	0	1	95	0.330		0.365
				96	0.430				96	0.220		0.325
				97	0.370				97	0.230		0.300
				98	0.340				98	0.230		0.285
				99	0.370				99	0.280		0.325
				Avg:	0.382				Avg:	0.258	Avg:	0.320
				Std Dev:	0.034				Std Dev:	0.047	Std Dev:	0.030
	OF1	0	2	95	0.500	HF2	0	2	95	0.240		0.370
				96	0.430				96	0.240		0.335
				97	0.390				97	0.250		0.320
				98	0.440				98	0.340		0.390
				99	0.430				99	0.260		0.345
				Avg:	0.438				Avg:	0.266	Avg:	0.352
				Std Dev:	0.040				Std Dev:	0.042	Std Dev:	0.028
	OF1	90	1	95	0.390	HF2	90	1	95	0.490		0.440
				96	0.440				96	0.460		0.450
				97	0.380				97	0.450		0.415
				98	0.370				98	0.520		0.445
				99	0.370				99	0.430		0.400
				Avg:	0.390				Avg:	0.470	Avg:	0.430
				Std Dev:	0.029				Std Dev:	0.035	Std Dev:	0.022
	OF1	90	2	95	0.440	HF2	90	2	95	0.450		0.445
				96	0.330				96	0.500		0.415
				97	0.370				97	0.390		0.380
				98	0.440				98	0.430		0.435
				99	0.410				99	0.470		0.440
				Avg:	0.398				Avg:	0.448	Avg:	0.423
				Std Dev:	0.048				Std Dev:	0.041	Std Dev:	0.027
C	OF2	0	1	95	0.220	HF1	0	1	95	0.410		0.315
				96	0.310				96	0.440		0.375
				97	0.260				97	0.400		0.330
				98	0.260				98	0.410		0.335
				99	0.290				99	0.490		0.390
				Avg:	0.268				Avg:	0.430	Avg:	0.349
				Std Dev:	0.034				Std Dev:	0.037	Std Dev:	0.032
	OF2	0	2	95	0.300	HF1	0	2	95	0.420		0.360
				96	0.310				96	0.430		0.370
				97	0.240				97	0.470		0.355
				98	0.240				98	0.450		0.345
				99	0.300				99	0.380		0.340
				Avg:	0.278				Avg:	0.430	Avg:	0.354
				Std Dev:	0.035				Std Dev:	0.034	Std Dev:	0.012
	OF2	90	1	95	0.400	HF1	90	1	95	0.390		0.395
				96	0.390				96	0.360		0.375
				97	0.390				97	0.390		0.390
				98	0.440				98	0.430		0.435
				99	0.370				99	0.390		0.380
				Avg:	0.398				Avg:	0.392	Avg:	0.395
				Std Dev:	0.026				Std Dev:	0.025	Std Dev:	0.024
	OF2	90	2	95	0.370	HF1	90	2	95	0.410		0.390
				96	0.400				96	0.440		0.420
				97	0.420				97	0.430		0.425
				98	0.410				98	0.410		0.410
				99	0.400				99	0.400		0.400
				Avg:	0.400				Avg:	0.418	Avg:	0.409
				Std Dev:	0.019				Std Dev:	0.016	Std Dev:	0.014

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.430	HF2	0	1	95	0.250		0.340
				96	0.430				96	0.270		0.350
				97	0.480				97	0.200		0.340
				98	0.440				98	0.220		0.330
				99	0.500				99	0.270		0.385
			Avg:		0.456			Avg:		0.242	Avg:	0.349
			Std Dev:		0.032			Std Dev:		0.031	Std Dev:	0.021
	OF1	0	2	95	0.560	HF2	0	2	95	0.290		0.425
				96	0.600				96	0.320		0.460
				97	0.570				97	0.240		0.405
				98	0.520				98	0.300		0.410
				99	0.540				99	0.320		0.430
			Avg:		0.558			Avg:		0.294	Avg:	0.426
			Std Dev:		0.030			Std Dev:		0.033	Std Dev:	0.022
	OF1	90	1	95	0.420	HF2	90	1	95	0.420		0.420
				96	0.440				96	0.460		0.450
				97	0.420				97	0.430		0.425
				98	0.450				98	0.440		0.445
				99	0.460				99	0.420		0.440
			Avg:		0.438			Avg:		0.434	Avg:	0.436
			Std Dev:		0.018			Std Dev:		0.017	Std Dev:	0.013
	OF1	90	2	95	0.470	HF2	90	2	95	0.470		0.470
				96	0.490				96	0.480		0.485
				97	0.510				97	0.490		0.500
				98	0.490				98	0.570		0.530
				99	0.460				99	0.520		0.490
			Avg:		0.484			Avg:		0.506	Avg:	0.495
			Std Dev:		0.019			Std Dev:		0.040	Std Dev:	0.022
C	OF2	0	1	95	0.210	HF1	0	1	95	0.510		0.360
				96	0.220				96	0.530		0.375
				97	0.190				97	0.460		0.325
				98	0.230				98	0.490		0.360
				99	0.180				99	0.500		0.340
			Avg:		0.206			Avg:		0.498	Avg:	0.352
			Std Dev:		0.021			Std Dev:		0.026	Std Dev:	0.020
	OF2	0	2	95	0.310	HF1	0	2	95	0.600		0.455
				96	0.270				96	0.590		0.430
				97	0.300				97	0.520		0.410
				98	0.260				98	0.610		0.435
				99	0.380				99	0.550		0.465
			Avg:		0.304			Avg:		0.574	Avg:	0.439
			Std Dev:		0.047			Std Dev:		0.038	Std Dev:	0.022
	OF2	90	1	95	0.520	HF1	90	1	95	0.580		0.550
				96	0.610				96	0.510		0.560
				97	0.560				97	0.570		0.565
				98	0.550				98	0.560		0.555
				99	0.500				99	0.530		0.515
			Avg:		0.548			Avg:		0.550	Avg:	0.549
			Std Dev:		0.042			Std Dev:		0.029	Std Dev:	0.020
	OF2	90	2	95	0.530	HF1	90	2	95	0.530		0.530
				96	0.550				96	0.570		0.560
				97	0.540				97	0.560		0.550
				98	0.580				98	0.580		0.580
				99	0.550				99	0.590		0.570
			Avg:		0.550			Avg:		0.566	Avg:	0.558
			Std Dev:		0.019			Std Dev:		0.023	Std Dev:	0.019

Annex 18

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Instantaneous

37.5 mm
6 inch Dia.

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.440	HF2	0	1	95	0.520		0.480
				96	0.420				96	0.720		0.570
				97	0.660				97	1.290		0.975
				98	0.460				98	0.570		0.515
				99	0.740				99	0.680		0.710
			Avg:		0.544			Avg:		0.756	Avg:	0.650
			Std Dev:		0.146			Std Dev:		0.309	Std Dev:	0.202
	OF1	0	2	95	0.580	HF2	0	2	95	1.050		0.815
				96	0.520				96	0.680		0.600
				97	0.720				97	0.640		0.680
				98	0.550				98	0.820		0.685
				99	0.710				99	0.660		0.685
			Avg:		0.616			Avg:		0.770	Avg:	0.693
			Std Dev:		0.093			Std Dev:		0.172	Std Dev:	0.077
	OF1	90	1	95	0.340	HF2	90	1	95	0.030		0.185
				96	0.310				96	0.030		0.170
				97	0.390				97	0.100		0.245
				98	0.310				98	0.110		0.210
				99	0.390				99	0.010		0.200
			Avg:		0.348			Avg:		0.056	Avg:	0.202
			Std Dev:		0.040			Std Dev:		0.046	Std Dev:	0.028
	OF1	90	2	95	0.270	HF2	90	2	95	0.110		0.190
				96	0.440				96	0.130		0.285
				97	0.370				97	0.210		0.290
				98	0.400				98	0.040		0.220
				99	0.530				99	0.170		0.350
			Avg:		0.402			Avg:		0.132	Avg:	0.267
			Std Dev:		0.095			Std Dev:		0.064	Std Dev:	0.063
A	OF2	0	1	95	0.900	HF1	0	1	95	0.950		0.925
				96	0.700				96	1.120		0.910
				97	0.580				97	0.590		0.585
				98	0.720				98	1.120		0.920
				99	0.600				99	0.670		0.635
			Avg:		0.700			Avg:		0.890	Avg:	0.795
			Std Dev:		0.127			Std Dev:		0.249	Std Dev:	0.170
	OF2	0	2	95	0.560	HF1	0	2	95	1.380		0.970
				96	0.700				96	0.670		0.685
				97	0.600				97	0.610		0.605
				98	0.570				98	0.970		0.770
				99	1.050				99	0.660		0.855
			Avg:		0.696			Avg:		0.858	Avg:	0.777
			Std Dev:		0.205			Std Dev:		0.324	Std Dev:	0.143
	OF2	90	1	95	0.100	HF1	90	1	95	0.370		0.235
				96	0.140				96	0.470		0.305
				97	0.180				97	0.480		0.330
				98	0.150				98	0.310		0.230
				99	0.170				99	0.660		0.415
			Avg:		0.148			Avg:		0.458	Avg:	0.303
			Std Dev:		0.031			Std Dev:		0.133	Std Dev:	0.076
	OF2	90	2	95	0.050	HF1	90	2	95	0.480		0.265
				96	0.180				96	0.470		0.325
				97	0.260				97	0.360		0.310
				98	0.030				98	0.590		0.310
				99	0.180				99	0.400		0.290
			Avg:		0.140			Avg:		0.460	Avg:	0.300
			Std Dev:		0.097			Std Dev:		0.088	Std Dev:	0.023

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.450	HF2	0	1	95	0.530		0.490
				96	0.390				96	0.330		0.360
				97	0.410				97	0.460		0.435
				98	0.460				98	0.530		0.495
				99	0.470				99	0.330		0.400
			Avg:		0.436			Avg:		0.436	Avg:	0.436
			Std Dev:		0.034			Std Dev:		0.101	Std Dev:	0.058
	OF1	0	2	95	0.440	HF2	0	2	95	0.430		0.435
				96	0.460				96	0.400		0.430
				97	0.440				97	0.440		0.440
				98	0.410				98	0.490		0.450
				99	0.360				99	0.430		0.395
			Avg:		0.422			Avg:		0.438	Avg:	0.430
			Std Dev:		0.039			Std Dev:		0.033	Std Dev:	0.021
	OF1	90	1	95	0.090	HF2	90	1	95	0.230		0.160
				96	0.090				96	0.080		0.085
				97	0.080				97	0.060		0.070
				98	0.080				98	0.150		0.115
				99	0.030				99	0.180		0.105
			Avg:		0.074			Avg:		0.140	Avg:	0.107
			Std Dev:		0.025			Std Dev:		0.070	Std Dev:	0.034
	OF1	90	2	95	0.050	HF2	90	2	95	0.110		0.080
				96	0.030				96	0.070		0.050
				97	0.070				97	0.090		0.080
				98	0.050				98	0.190		0.120
				99	0.030				99	0.170		0.100
			Avg:		0.046			Avg:		0.126	Avg:	0.086
			Std Dev:		0.017			Std Dev:		0.052	Std Dev:	0.026
A	OF2	0	1	95	0.340	HF1	0	1	95	0.430		0.385
				96	0.330				96	0.470		0.400
				97	0.340				97	0.430		0.385
				98	0.330				98	0.420		0.375
				99	0.280				99	0.440		0.360
			Avg:		0.324			Avg:		0.438	Avg:	0.381
			Std Dev:		0.025			Std Dev:		0.019	Std Dev:	0.015
	OF2	0	2	95	0.370	HF1	0	2	95	0.510		0.440
				96	0.430				96	0.550		0.490
				97	0.470				97	0.460		0.465
				98	0.420				98	0.400		0.410
				99	0.360				99	0.480		0.420
			Avg:		0.410			Avg:		0.480	Avg:	0.445
			Std Dev:		0.045			Std Dev:		0.056	Std Dev:	0.033
	OF2	90	1	95	0.190	HF1	90	1	95	0.330		0.260
				96	0.200				96	0.330		0.265
				97	0.160				97	0.320		0.240
				98	0.100				98	0.320		0.210
				99	0.110				99	0.300		0.205
			Avg:		0.152			Avg:		0.320	Avg:	0.236
			Std Dev:		0.045			Std Dev:		0.012	Std Dev:	0.028
	OF2	90	2	95	0.180	HF1	90	2	95	0.370		0.275
				96	0.160				96	0.330		0.245
				97	0.220				97	0.360		0.290
				98	0.220				98	0.240		0.230
				99	0.210				99	0.350		0.280
			Avg:		0.198			Avg:		0.330	Avg:	0.264
			Std Dev:		0.027			Std Dev:		0.052	Std Dev:	0.025

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 4.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.420	HF2	0	1	95	0.410		0.415
				96	0.540				96	0.510		0.525
				97	0.500				97	0.510		0.505
				98	0.390				98	0.490		0.440
				99	0.450				99	0.470		0.460
			Avg:		0.460			Avg:		0.478	Avg:	0.469
			Std Dev:		0.060			Std Dev:		0.041	Std Dev:	0.045
	OF1	0	2	95	0.470	HF2	0	2	95	0.450		0.460
				96	0.550				96	0.470		0.510
				97	0.480				97	0.510		0.495
				98	0.440				98	0.480		0.460
				99	0.490				99	0.960		0.725
			Avg:		0.486			Avg:		0.574	Avg:	0.530
			Std Dev:		0.040			Std Dev:		0.217	Std Dev:	0.111
	OF1	90	1	95	0.260	HF2	90	1	95	0.160		0.210
				96	0.240				96	0.160		0.200
				97	0.230				97	0.200		0.215
				98	0.270				98	0.210		0.240
				99	0.230				99	0.200		0.215
			Avg:		0.246			Avg:		0.186	Avg:	0.216
			Std Dev:		0.018			Std Dev:		0.024	Std Dev:	0.015
	OF1	90	2	95	0.610	HF2	90	2	95	0.490		0.550
				96	0.590				96	0.380		0.485
				97	0.520				97	0.380		0.450
				98	0.580				98	0.420		0.500
				99	0.620				99	0.530		0.575
			Avg:		0.584			Avg:		0.440	Avg:	0.512
			Std Dev:		0.039			Std Dev:		0.067	Std Dev:	0.050
A	OF2	0	1	95	0.460	HF1	0	1	95	0.340		0.400
				96	0.440				96	0.340		0.390
				97	0.600				97	0.460		0.530
				98	0.480				98	0.400		0.440
				99	0.420				99	0.460		0.440
			Avg:		0.480			Avg:		0.400	Avg:	0.440
			Std Dev:		0.071			Std Dev:		0.060	Std Dev:	0.055
	OF2	0	2	95	0.500	HF1	0	2	95	0.450		0.475
				96	0.520				96	0.380		0.450
				97	0.450				97	0.480		0.465
				98	0.570				98	0.410		0.490
				99	0.530				99	0.460		0.495
			Avg:		0.514			Avg:		0.436	Avg:	0.475
			Std Dev:		0.044			Std Dev:		0.040	Std Dev:	0.018
	OF2	90	1	95	0.610	HF1	90	1	95	0.550		0.580
				96	0.660				96	0.530		0.595
				97	0.570				97	0.580		0.575
				98	0.530				98	0.500		0.515
				99	0.620				99	0.550		0.585
			Avg:		0.598			Avg:		0.542	Avg:	0.570
			Std Dev:		0.050			Std Dev:		0.029	Std Dev:	0.032
	OF2	90	2	95	0.610	HF1	90	2	95	0.560		0.585
				96	0.550				96	0.560		0.555
				97	0.570				97	0.560		0.565
				98	0.630				98	0.500		0.565
				99	0.590				99	0.580		0.585
			Avg:		0.590			Avg:		0.552	Avg:	0.571
			Std Dev:		0.032			Std Dev:		0.030	Std Dev:	0.013

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.770	HF2	0	1	95	1.030		0.900
				96	0.750				96	1.840		1.295
				97	0.820				97	0.990		0.905
				98	0.560				98	1.120		0.840
				99	0.830				99	1.720		1.275
			Avg:		0.746			Avg:		1.340	Avg:	1.043
			Std Dev:		0.109			Std Dev:		0.407	Std Dev:	0.223
	OF1	0	2	95	0.770	HF2	0	2	95	2.000		1.385
				96	0.710				96	1.060		0.885
				97	0.780				97	1.330		1.055
				98	0.720				98	1.990		1.355
				99	0.580				99	0.630		0.605
			Avg:		0.712			Avg:		1.402	Avg:	1.057
			Std Dev:		0.080			Std Dev:		0.596	Std Dev:	0.328
	OF1	90	1	95	0.080	HF2	90	1	95	0.250		0.165
				96	0.040				96	0.080		0.060
				97	0.130				97	0.290		0.210
				98	0.080				98	0.150		0.115
				99	0.060				99	0.220		0.140
			Avg:		0.078			Avg:		0.198	Avg:	0.138
			Std Dev:		0.033			Std Dev:		0.083	Std Dev:	0.056
	OF1	90	2	95	0.050	HF2	90	2	95	0.100		0.075
				96	0.110				96	0.200		0.155
				97	0.080				97	0.180		0.130
				98	0.040				98	0.090		0.065
				99	0.080				99	0.280		0.180
			Avg:		0.072			Avg:		0.170	Avg:	0.121
			Std Dev:		0.028			Std Dev:		0.078	Std Dev:	0.050
B	OF2	0	1	95	1.310	HF1	0	1	95	0.660		0.985
				96	1.340				96	0.860		1.100
				97	0.900				97	0.710		0.805
				98	1.560				98	0.830		1.195
				99	1.040				99	0.770		0.905
			Avg:		1.230			Avg:		0.766	Avg:	0.998
			Std Dev:		0.261			Std Dev:		0.083	Std Dev:	0.154
	OF2	0	2	95	1.320	HF1	0	2	95	0.940		1.130
				96	1.170				96	0.860		1.015
				97	2.030				97	0.690		1.360
				98	0.730				98	0.790		0.760
				99	2.090				99	0.920		1.505
			Avg:		1.468			Avg:		0.840	Avg:	1.154
			Std Dev:		0.583			Std Dev:		0.102	Std Dev:	0.292
	OF2	90	1	95	0.210	HF1	90	1	95	0.200		0.205
				96	0.040				96	0.220		0.130
				97	0.220				97	0.100		0.160
				98	0.050				98	0.130		0.090
				99	0.260				99	0.240		0.250
			Avg:		0.156			Avg:		0.178	Avg:	0.167
			Std Dev:		0.103			Std Dev:		0.060	Std Dev:	0.063
	OF2	90	2	95	0.080	HF1	90	2	95	0.080		0.080
				96	0.240				96	0.100		0.170
				97	0.040				97	0.130		0.085
				98	0.200				98	0.190		0.195
				99	0.050				99	0.050		0.050
			Avg:		0.122			Avg:		0.110	Avg:	0.116
			Std Dev:		0.092			Std Dev:		0.053	Std Dev:	0.063

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.870	HF2	0	1	95	0.800		0.835
				96	1.200				96	0.710		0.955
				97	0.980				97	0.850		0.915
				98	0.960				98	0.930		0.945
				99	1.190				99	0.590		0.890
			Avg:		1.040			Avg:		0.776	Avg:	0.908
			Std Dev:		0.147			Std Dev:		0.131	Std Dev:	0.048
	OF1	0	2	95	0.900	HF2	0	2	95	0.850		0.875
				96	1.130				96	0.790		0.960
				97	0.920				97	0.570		0.745
				98	1.040				98	0.880		0.960
				99	1.170				99	0.670		0.920
			Avg:		1.032			Avg:		0.752	Avg:	0.892
			Std Dev:		0.121			Std Dev:		0.130	Std Dev:	0.089
	OF1	90	1	95	0.460	HF2	90	1	95	0.350		0.405
				96	0.650				96	0.460		0.555
				97	0.500				97	0.290		0.395
				98	0.560				98	0.380		0.470
				99	0.570				99	0.210		0.390
			Avg:		0.548			Avg:		0.338	Avg:	0.443
			Std Dev:		0.073			Std Dev:		0.094	Std Dev:	0.070
	OF1	90	2	95	0.980	HF2	90	2	95	0.610		0.795
				96	1.010				96	0.280		0.645
				97	0.690				97	0.270		0.480
				98	0.780				98	0.280		0.530
				99	0.760				99	0.320		0.540
			Avg:		0.844			Avg:		0.352	Avg:	0.598
			Std Dev:		0.142			Std Dev:		0.145	Std Dev:	0.125
B	OF2	0	1	95	0.420	HF1	0	1	95	0.730		0.575
				96	0.520				96	0.680		0.600
				97	0.460				97	0.620		0.540
				98	0.490				98	0.740		0.615
				99	0.460				99	0.820		0.640
			Avg:		0.470			Avg:		0.718	Avg:	0.594
			Std Dev:		0.037			Std Dev:		0.074	Std Dev:	0.038
	OF2	0	2	95	0.410	HF1	0	2	95	0.640		0.525
				96	0.420				96	0.600		0.510
				97	0.500				97	0.760		0.630
				98	0.440				98	0.670		0.555
				99	0.430				99	0.600		0.515
			Avg:		0.440			Avg:		0.654	Avg:	0.547
			Std Dev:		0.035			Std Dev:		0.066	Std Dev:	0.050
	OF2	90	1	95	0.150	HF1	90	1	95	0.950		0.550
				96	0.110				96	1.060		0.585
				97	0.140				97	1.010		0.575
				98	0.160				98	1.010		0.585
				99	0.110				99	0.860		0.485
			Avg:		0.134			Avg:		0.978	Avg:	0.556
			Std Dev:		0.023			Std Dev:		0.077	Std Dev:	0.042
	OF2	90	2	95	0.110	HF1	90	2	95	1.010		0.560
				96	0.210				96	1.110		0.660
				97	0.100				97	1.070		0.585
				98	0.150				98	1.030		0.590
				99	0.120				99	1.120		0.620
			Avg:		0.138			Avg:		1.068	Avg:	0.603
			Std Dev:		0.044			Std Dev:		0.048	Std Dev:	0.038

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.210	HF2	0	1	95	0.210		0.210
				96	0.240				96	0.180		0.210
				97	0.180				97	0.210		0.195
				98	0.270				98	0.180		0.225
				99	0.270				99	0.230		0.250
			Avg:		0.234			Avg:		0.202	Avg:	0.218
			Std Dev:		0.039			Std Dev:		0.022	Std Dev:	0.021
	OF1	0	2	95	0.280	HF2	0	2	95	0.220		0.250
				96	0.240				96	0.260		0.250
				97	0.310				97	0.250		0.280
				98	0.260				98	0.280		0.270
				99	0.300				99	0.230		0.265
			Avg:		0.278			Avg:		0.248	Avg:	0.263
			Std Dev:		0.029			Std Dev:		0.024	Std Dev:	0.013
	OF1	90	1	95	1.400	HF2	90	1	95	0.280		0.840
				96	1.270				96	0.290		0.780
				97	1.390				97	0.370		0.880
				98	1.310				98	0.310		0.810
				99	1.250				99	0.280		0.765
			Avg:		1.324			Avg:		0.306	Avg:	0.815
			Std Dev:		0.068			Std Dev:		0.038	Std Dev:	0.046
	OF1	90	2	95	0.970	HF2	90	2	95	0.290		0.630
				96	0.840				96	0.240		0.540
				97	1.000				97	0.300		0.650
				98	0.950				98	0.320		0.635
				99	0.980				99	0.250		0.615
			Avg:		0.948			Avg:		0.280	Avg:	0.614
			Std Dev:		0.063			Std Dev:		0.034	Std Dev:	0.043
B	OF2	0	1	95	0.350	HF1	0	1	95	0.310		0.330
				96	0.290				96	0.440		0.365
				97	0.280				97	0.260		0.270
				98	0.310				98	0.390		0.350
				99	0.300				99	0.300		0.300
			Avg:		0.306			Avg:		0.340	Avg:	0.323
			Std Dev:		0.027			Std Dev:		0.073	Std Dev:	0.038
	OF2	0	2	95	0.240	HF1	0	2	95	0.400		0.320
				96	0.280				96	0.330		0.305
				97	0.330				97	0.410		0.370
				98	0.260				98	0.290		0.275
				99	0.320				99	0.300		0.310
			Avg:		0.286			Avg:		0.346	Avg:	0.316
			Std Dev:		0.038			Std Dev:		0.056	Std Dev:	0.035
	OF2	90	1	95	0.740	HF1	90	1	95	0.140		0.440
				96	0.650				96	0.170		0.410
				97	0.920				97	0.160		0.540
				98	0.820				98	0.140		0.480
				99	0.680				99	0.170		0.425
			Avg:		0.762			Avg:		0.156	Avg:	0.459
			Std Dev:		0.110			Std Dev:		0.015	Std Dev:	0.052
	OF2	90	2	95	0.700	HF1	90	2	95	0.240		0.470
				96	0.540				96	0.180		0.360
				97	0.670				97	0.190		0.430
				98	0.750				98	0.190		0.470
				99	0.670				99	0.190		0.430
			Avg:		0.666			Avg:		0.198	Avg:	0.432
			Std Dev:		0.078			Std Dev:		0.024	Std Dev:	0.045

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 1.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.560	HF2	0	1	95	0.030		0.295
				96	0.570				96	0.060		0.315
				97	0.550				97	0.030		0.290
				98	0.770				98	0.030		0.400
				99	0.680				99	0.010		0.345
				Avg:	0.626				Avg:	0.032	Avg:	0.329
				Std Dev:	0.096				Std Dev:	0.018	Std Dev:	0.045
	OF1	0	2	95	0.580	HF2	0	2	95	0.080		0.330
				96	0.520				96	0.100		0.310
				97	0.450				97	0.060		0.255
				98	0.750				98	0.100		0.425
				99	0.580				99	0.100		0.340
				Avg:	0.576				Avg:	0.088	Avg:	0.332
				Std Dev:	0.111				Std Dev:	0.018	Std Dev:	0.062
	OF1	90	1	95	0.060	HF2	90	1	95	1.050		0.555
				96	0.180				96	0.630		0.405
				97	0.080				97	2.250		1.165
				98	0.210				98	1.210		0.710
				99	0.230				99	0.830		0.530
				Avg:	0.152				Avg:	1.194	Avg:	0.673
				Std Dev:	0.077				Std Dev:	0.630	Std Dev:	0.296
	OF1	90	2	95	0.250	HF2	90	2	95	0.670		0.460
				96	0.190				96	1.720		0.955
				97	0.240				97	1.170		0.705
				98	0.080				98	0.880		0.480
				99	0.350				99	1.850		1.100
				Avg:	0.222				Avg:	1.258	Avg:	0.740
				Std Dev:	0.098				Std Dev:	0.515	Std Dev:	0.284
C	OF2	0	1	95	0.070	HF1	0	1	95	0.380		0.225
				96	0.090				96	0.560		0.325
				97	0.080				97	0.500		0.290
				98	0.030				98	0.430		0.230
				99	0.050				99	0.460		0.255
				Avg:	0.064				Avg:	0.466	Avg:	0.265
				Std Dev:	0.024				Std Dev:	0.068	Std Dev:	0.042
	OF2	0	2	95	0.100	HF1	0	2	95	0.520		0.310
				96	0.020				96	0.660		0.340
				97	0.010				97	0.490		0.250
				98	0.070				98	0.780		0.425
				99	0.050				99	0.520		0.285
				Avg:	0.050				Avg:	0.594	Avg:	0.322
				Std Dev:	0.037				Std Dev:	0.123	Std Dev:	0.066
	OF2	90	1	95	1.330	HF1	90	1	95	0.010		0.670
				96	2.410				96	0.020		1.215
				97	1.410				97	0.030		0.720
				98	1.340				98	0.060		0.700
				99	2.120				99	0.010		1.065
				Avg:	1.722				Avg:	0.026	Avg:	0.874
				Std Dev:	0.507				Std Dev:	0.021	Std Dev:	0.249
	OF2	90	2	95	2.020	HF1	90	2	95	0.010		1.015
				96	1.060				96	0.030		0.545
				97	2.840				97	0.020		1.430
				98	1.730				98	0.010		0.870
				99	1.290				99	0.100		0.695
				Avg:	1.788				Avg:	0.034	Avg:	0.911
				Std Dev:	0.697				Std Dev:	0.038	Std Dev:	0.340

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 3.00 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.130	HF2	0	1	95	0.590		0.360
				96	0.080				96	0.590		0.335
				97	0.150				97	0.660		0.405
				98	0.070				98	0.690		0.380
				99	0.130				99	0.620		0.375
			Avg:		0.112			Avg:		0.630	Avg:	0.371
			Std Dev:		0.035			Std Dev:		0.044	Std Dev:	0.026
	OF1	0	2	95	0.120	HF2	0	2	95	0.490		0.305
				96	0.080				96	0.510		0.295
				97	0.120				97	0.530		0.325
				98	0.110				98	0.550		0.330
				99	0.100				99	0.680		0.390
			Avg:		0.106			Avg:		0.552	Avg:	0.329
			Std Dev:		0.017			Std Dev:		0.075	Std Dev:	0.037
	OF1	90	1	95	0.620	HF2	90	1	95	0.050		0.335
				96	0.660				96	0.070		0.365
				97	0.710				97	0.040		0.375
				98	0.650				98	0.180		0.415
				99	0.500				99	0.060		0.280
			Avg:		0.628			Avg:		0.080	Avg:	0.354
			Std Dev:		0.079			Std Dev:		0.057	Std Dev:	0.050
	OF1	90	2	95	0.660	HF2	90	2	95	0.020		0.340
				96	0.650				96	0.140		0.395
				97	0.660				97	0.090		0.375
				98	0.680				98	0.180		0.430
				99	0.600				99	0.130		0.365
			Avg:		0.650			Avg:		0.112	Avg:	0.381
			Std Dev:		0.030			Std Dev:		0.061	Std Dev:	0.034
C	OF2	0	1	95	0.420	HF1	0	1	95	0.100		0.260
				96	0.260				96	0.150		0.205
				97	0.490				97	0.120		0.305
				98	0.410				98	0.180		0.295
				99	0.300				99	0.050		0.175
			Avg:		0.376			Avg:		0.120	Avg:	0.248
			Std Dev:		0.094			Std Dev:		0.049	Std Dev:	0.057
	OF2	0	2	95	0.490	HF1	0	2	95	0.120		0.305
				96	0.470				96	0.130		0.300
				97	0.340				97	0.060		0.200
				98	0.490				98	0.130		0.310
				99	0.370				99	0.140		0.255
			Avg:		0.432			Avg:		0.116	Avg:	0.274
			Std Dev:		0.072			Std Dev:		0.032	Std Dev:	0.047
	OF2	90	1	95	0.140	HF1	90	1	95	0.680		0.410
				96	0.060				96	0.640		0.350
				97	0.250				97	0.600		0.425
				98	0.090				98	0.800		0.445
				99	0.070				99	0.710		0.390
			Avg:		0.122			Avg:		0.686	Avg:	0.404
			Std Dev:		0.078			Std Dev:		0.076	Std Dev:	0.036
	OF2	90	2	95	0.100	HF1	90	2	95	0.850		0.475
				96	0.060				96	0.680		0.370
				97	0.120				97	0.770		0.445
				98	0.070				98	0.800		0.435
				99	0.030				99	0.740		0.385
			Avg:		0.076			Avg:		0.768	Avg:	0.422
			Std Dev:		0.035			Std Dev:		0.064	Std Dev:	0.044

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Instant

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.450	HF2	0	1	95	0.360		0.405
				96	0.500				96	0.490		0.495
				97	0.500				97	0.600		0.550
				98	0.500				98	0.580		0.540
				99	0.470				99	0.440		0.455
			Avg:		0.484			Avg:		0.494	Avg:	0.489
			Std Dev:		0.023			Std Dev:		0.099	Std Dev:	0.060
	OF1	0	2	95	0.470	HF2	0	2	95	0.410		0.440
				96	0.450				96	0.450		0.450
				97	0.410				97	0.540		0.475
				98	0.420				98	0.500		0.460
				99	0.470				99	0.490		0.480
			Avg:		0.444			Avg:		0.478	Avg:	0.461
			Std Dev:		0.028			Std Dev:		0.050	Std Dev:	0.017
	OF1	90	1	95	0.260	HF2	90	1	95	0.160		0.210
				96	0.240				96	0.160		0.200
				97	0.230				97	0.200		0.215
				98	0.270				98	0.210		0.240
				99	0.230				99	0.200		0.215
			Avg:		0.246			Avg:		0.186	Avg:	0.216
			Std Dev:		0.018			Std Dev:		0.024	Std Dev:	0.015
	OF1	90	2	95	0.330	HF2	90	2	95	0.150		0.240
				96	0.290				96	0.220		0.255
				97	0.330				97	0.160		0.245
				98	0.360				98	0.230		0.295
				99	0.290				99	0.140		0.215
			Avg:		0.320			Avg:		0.180	Avg:	0.250
			Std Dev:		0.030			Std Dev:		0.042	Std Dev:	0.029
C	OF2	0	1	95	0.450	HF1	0	1	95	0.430		0.440
				96	0.370				96	0.390		0.380
				97	0.470				97	0.420		0.445
				98	0.430				98	0.370		0.400
				99	0.490				99	0.440		0.465
			Avg:		0.442			Avg:		0.410	Avg:	0.426
			Std Dev:		0.046			Std Dev:		0.029	Std Dev:	0.035
	OF2	0	2	95	0.500	HF1	0	2	95	0.440		0.470
				96	0.470				96	0.470		0.470
				97	0.470				97	0.480		0.475
				98	0.460				98	0.450		0.455
				99	0.400				99	0.500		0.450
			Avg:		0.460			Avg:		0.468	Avg:	0.464
			Std Dev:		0.037			Std Dev:		0.024	Std Dev:	0.011
	OF2	90	1	95	0.110	HF1	90	1	95	0.480		0.295
				96	0.100				96	0.540		0.320
				97	0.140				97	0.540		0.340
				98	0.150				98	0.570		0.360
				99	0.130				99	0.530		0.330
			Avg:		0.126			Avg:		0.532	Avg:	0.329
			Std Dev:		0.021			Std Dev:		0.033	Std Dev:	0.024
	OF2	90	2	95	0.170	HF1	90	2	95	0.500		0.335
				96	0.140				96	0.510		0.325
				97	0.150				97	0.540		0.345
				98	0.090				98	0.480		0.285
				99	0.140				99	0.530		0.335
			Avg:		0.138			Avg:		0.512	Avg:	0.325
			Std Dev:		0.029			Std Dev:		0.024	Std Dev:	0.023

Annex 19

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Total

12.5 mm
4 inch Dia.

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
A	OF1	0	1	95	0.550	HF2	0	1	95	0.740		0.645
				96	0.560				96	0.410		0.485
				97	0.430				97	0.570		0.500
				98	0.530				98	0.470		0.500
				99	0.530				99	0.720		0.625
				Avg:	0.520				Avg:	0.582	Avg:	0.551
				Std Dev:	0.052				Std Dev:	0.147	Std Dev:	0.077
	OF1	0	2	95	0.490	HF2	0	2	95	0.640		0.565
				96	0.450				96	0.700		0.575
				97	0.620				97	0.650		0.635
				98	0.490				98	0.730		0.610
				99	0.470				99	0.550		0.510
				Avg:	0.504				Avg:	0.654	Avg:	0.579
				Std Dev:	0.067				Std Dev:	0.069	Std Dev:	0.048
	OF1	90	1	95	0.410	HF2	90	1	95	0.210		0.310
				96	0.440				96	0.220		0.330
				97	0.450				97	0.120		0.285
				98	0.380				98	0.170		0.275
				99	0.350				99	0.070		0.210
				Avg:	0.406				Avg:	0.158	Avg:	0.282
				Std Dev:	0.042				Std Dev:	0.063	Std Dev:	0.046
	OF1	90	2	95	0.380	HF2	90	2	95	0.170		0.275
				96	0.480				96	0.180		0.330
				97	0.400				97	0.100		0.250
				98	0.380				98	0.160		0.270
				99	0.450				99	0.130		0.290
				Avg:	0.418				Avg:	0.148	Avg:	0.283
				Std Dev:	0.045				Std Dev:	0.033	Std Dev:	0.030
A	OF2	0	1	95	0.640	HF1	0	1	95	0.450		0.545
				96	0.850				96	0.490		0.670
				97	0.590				97	0.480		0.535
				98	0.780				98	0.460		0.620
				99	0.890				99	0.510		0.700
				Avg:	0.750				Avg:	0.478	Avg:	0.614
				Std Dev:	0.131				Std Dev:	0.024	Std Dev:	0.073
	OF2	0	2	95	0.620	HF1	0	2	95	0.400		0.510
				96	0.720				96	0.470		0.595
				97	0.680				97	0.520		0.600
				98	0.680				98	0.500		0.590
				99	0.760				99	0.540		0.650
				Avg:	0.692				Avg:	0.486	Avg:	0.589
				Std Dev:	0.052				Std Dev:	0.055	Std Dev:	0.050
	OF2	90	1	95	0.290	HF1	90	1	95	0.350		0.320
				96	0.190				96	0.310		0.250
				97	0.140				97	0.240		0.190
				98	0.190				98	0.320		0.255
				99	0.270				99	0.350		0.310
				Avg:	0.216				Avg:	0.314	Avg:	0.265
				Std Dev:	0.062				Std Dev:	0.045	Std Dev:	0.052
	OF2	90	2	95	0.190	HF1	90	2	95	0.430		0.310
				96	0.240				96	0.380		0.310
				97	0.200				97	0.380		0.290
				98	0.250				98	0.480		0.365
				99	0.160				99	0.360		0.260
				Avg:	0.208				Avg:	0.406	Avg:	0.307
				Std Dev:	0.037				Std Dev:	0.049	Std Dev:	0.038

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.380	HF2	0	1	95	0.590		0.485
				96	0.430				96	0.590		0.510
				97	0.370				97	0.580		0.475
				98	0.420				98	0.620		0.520
				99	0.440				99	0.490		0.465
			Avg:		0.408			Avg:		0.574	Avg:	0.491
			Std Dev:		0.031			Std Dev:		0.049	Std Dev:	0.023
	OF1	0	2	95	0.420	HF2	0	2	95	0.600		0.510
				96	0.440				96	0.600		0.520
				97	0.450				97	0.610		0.530
				98	0.400				98	0.590		0.495
				99	0.440				99	0.640		0.540
			Avg:		0.430			Avg:		0.608	Avg:	0.519
			Std Dev:		0.020			Std Dev:		0.019	Std Dev:	0.017
	OF1	90	1	95	0.330	HF2	90	1	95	0.180		0.255
				96	0.360				96	0.220		0.290
				97	0.360				97	0.240		0.300
				98	0.380				98	0.240		0.310
				99	0.380				99	0.250		0.315
			Avg:		0.362			Avg:		0.226	Avg:	0.294
			Std Dev:		0.020			Std Dev:		0.028	Std Dev:	0.024
	OF1	90	2	95	0.520	HF2	90	2	95	0.350		0.435
				96	0.450				96	0.370		0.410
				97	0.480				97	0.330		0.405
				98	0.480				98	0.420		0.450
				99	0.470				99	0.410		0.440
			Avg:		0.480			Avg:		0.376	Avg:	0.428
			Std Dev:		0.025			Std Dev:		0.038	Std Dev:	0.020
A	OF2	0	1	95	0.550	HF1	0	1	95	0.460		0.505
				96	0.520				96	0.330		0.425
				97	0.600				97	0.390		0.495
				98	0.530				98	0.470		0.500
				99	0.540				99	0.380		0.460
			Avg:		0.548			Avg:		0.406	Avg:	0.477
			Std Dev:		0.031			Std Dev:		0.059	Std Dev:	0.034
	OF2	0	2	95	0.660	HF1	0	2	95	0.480		0.570
				96	0.660				96	0.540		0.600
				97	0.700				97	0.530		0.615
				98	0.700				98	0.430		0.565
				99	0.760				99	0.490		0.625
			Avg:		0.696			Avg:		0.494	Avg:	0.595
			Std Dev:		0.041			Std Dev:		0.044	Std Dev:	0.027
	OF2	90	1	95	0.350	HF1	90	1	95	0.440		0.395
				96	0.370				96	0.420		0.395
				97	0.320				97	0.420		0.370
				98	0.390				98	0.460		0.425
				99	0.400				99	0.350		0.375
			Avg:		0.366			Avg:		0.418	Avg:	0.392
			Std Dev:		0.032			Std Dev:		0.041	Std Dev:	0.022
	OF2	90	2	95	0.460	HF1	90	2	95	0.470		0.465
				96	0.310				96	0.450		0.380
				97	0.320				97	0.370		0.345
				98	0.360				98	0.500		0.430
				99	0.360				99	0.550		0.455
			Avg:		0.362			Avg:		0.468	Avg:	0.415
			Std Dev:		0.059			Std Dev:		0.066	Std Dev:	0.051

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.00 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.540	HF2	0	1	95	0.610		0.575
				96	0.550				96	0.610		0.580
				97	0.520				97	0.560		0.540
				98	0.560				98	0.640		0.600
				99	0.530				99	0.650		0.590
				Avg:	0.540				Avg:	0.614	Avg:	0.577
				Std Dev:	0.016				Std Dev:	0.035	Std Dev:	0.023
	OF1	0	2	95	0.500	HF2	0	2	95	0.710		0.605
				96	0.480				96	0.670		0.575
				97	0.480				97	0.630		0.555
				98	0.470				98	0.660		0.565
				99	0.430				99	0.660		0.545
				Avg:	0.472				Avg:	0.666	Avg:	0.569
				Std Dev:	0.026				Std Dev:	0.029	Std Dev:	0.023
	OF1	90	1	95	0.300	HF2	90	1	95	0.380		0.340
				96	0.340				96	0.430		0.385
				97	0.330				97	0.380		0.355
				98	0.370				98	0.330		0.350
				99	0.360				99	0.400		0.380
				Avg:	0.340				Avg:	0.384	Avg:	0.362
				Std Dev:	0.027				Std Dev:	0.036	Std Dev:	0.020
	OF1	90	2	95	0.450	HF2	90	2	95	0.440		0.445
				96	0.420				96	0.430		0.425
				97	0.450				97	0.410		0.430
				98	0.410				98	0.440		0.425
				99	0.440				99	0.450		0.445
				Avg:	0.434				Avg:	0.434	Avg:	0.434
				Std Dev:	0.018				Std Dev:	0.015	Std Dev:	0.010
A	OF2	0	1	95	0.610	HF1	0	1	95	0.450		0.530
				96	0.610				96	0.400		0.505
				97	0.540				97	0.300		0.420
				98	0.600				98	0.390		0.495
				99	0.650				99	0.410		0.530
				Avg:	0.602				Avg:	0.390	Avg:	0.496
				Std Dev:	0.040				Std Dev:	0.055	Std Dev:	0.045
	OF2	0	2	95	0.720	HF1	0	2	95	0.410		0.565
				96	0.730				96	0.490		0.610
				97	0.770				97	0.540		0.655
				98	0.710				98	0.560		0.635
				99	0.660				99	0.560		0.610
				Avg:	0.718				Avg:	0.512	Avg:	0.615
				Std Dev:	0.040				Std Dev:	0.064	Std Dev:	0.034
	OF2	90	1	95	0.530	HF1	90	1	95	0.550		0.540
				96	0.440				96	0.520		0.480
				97	0.520				97	0.580		0.550
				98	0.410				98	0.580		0.495
				99	0.490				99	0.530		0.510
				Avg:	0.478				Avg:	0.552	Avg:	0.515
				Std Dev:	0.052				Std Dev:	0.028	Std Dev:	0.030
	OF2	90	2	95	0.560	HF1	90	2	95	0.560		0.560
				96	0.520				96	0.580		0.550
				97	0.550				97	0.560		0.555
				98	0.450				98	0.560		0.505
				99	0.510				99	0.590		0.550
				Avg:	0.518				Avg:	0.570	Avg:	0.544
				Std Dev:	0.043				Std Dev:	0.014	Std Dev:	0.022

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle		u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle		u-Ratio		U-Ratio (Avg)
B	OF1	0	1		95	0.470	HF2	0	1		95	0.180		0.325
					96	0.540					96	0.190		0.365
					97	0.510					97	0.070		0.290
					98	0.480					98	0.160		0.320
					99	0.570					99	0.060		0.315
				Avg:		0.514				Avg:		0.132	Avg:	0.323
				Std Dev:		0.042				Std Dev:		0.062	Std Dev:	0.027
	OF1	0	2		95	0.370	HF2	0	2		95	0.050		0.210
					96	0.500					96	0.050		0.275
					97	0.310					97	0.090		0.200
					98	0.390					98	0.140		0.265
					99	0.490					99	0.160		0.325
				Avg:		0.412				Avg:		0.098	Avg:	0.255
				Std Dev:		0.081				Std Dev:		0.051	Std Dev:	0.051
	OF1	90	1		95	0.290	HF2	90	1		95	1.340		0.815
					96	0.210					96	0.810		0.510
					97	0.200					97	1.370		0.785
					98	0.270					98	0.810		0.540
					99	0.280					99	1.030		0.655
				Avg:		0.250				Avg:		1.072	Avg:	0.661
				Std Dev:		0.042				Std Dev:		0.274	Std Dev:	0.138
	OF1	90	2		95	0.230	HF2	90	2		95	0.910		0.570
					96	0.160					96	1.240		0.700
					97	0.230					97	1.050		0.640
					98	0.170					98	0.990		0.580
					99	0.240					99	1.320		0.780
				Avg:		0.206				Avg:		1.102	Avg:	0.654
				Std Dev:		0.038				Std Dev:		0.172	Std Dev:	0.088
B	OF2	0	1		95	0.120	HF1	0	1		95	0.480		0.300
					96	0.160					96	0.440		0.300
					97	0.060					97	0.420		0.240
					98	0.190					98	0.500		0.345
					99	0.100					99	0.400		0.250
				Avg:		0.126				Avg:		0.448	Avg:	0.287
				Std Dev:		0.051				Std Dev:		0.041	Std Dev:	0.043
	OF2	0	2		95	0.090	HF1	0	2		95	0.410		0.250
					96	0.160					96	0.320		0.240
					97	0.170					97	0.400		0.285
					98	0.270					98	0.440		0.355
					99	0.070					99	0.400		0.235
				Avg:		0.152				Avg:		0.394	Avg:	0.273
				Std Dev:		0.079				Std Dev:		0.044	Std Dev:	0.050
	OF2	90	1		95	0.790	HF1	90	1		95	0.170		0.480
					96	0.880					96	0.200		0.540
					97	0.910					97	0.240		0.575
					98	0.780					98	0.220		0.500
					99	0.770					99	0.170		0.470
				Avg:		0.826				Avg:		0.200	Avg:	0.513
				Std Dev:		0.064				Std Dev:		0.031	Std Dev:	0.044
	OF2	90	2		95	0.720	HF1	90	2		95	0.140		0.430
					96	0.800					96	0.180		0.490
					97	0.940					97	0.240		0.590
					98	0.720					98	0.160		0.440
					99	0.910					99	0.200		0.555
				Avg:		0.818				Avg:		0.184	Avg:	0.501
				Std Dev:		0.104				Std Dev:		0.038	Std Dev:	0.070

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.430	HF2	0	1	95	0.510		0.470
				96	0.410				96	0.530		0.470
				97	0.460				97	0.470		0.465
				98	0.440				98	0.550		0.495
				99	0.470				99	0.530		0.500
			Avg:		0.442			Avg:		0.518	Avg:	0.480
			Std Dev:		0.024			Std Dev:		0.030	Std Dev:	0.016
	OF1	0	2	95	0.470	HF2	0	2	95	0.520		0.495
				96	0.370				96	0.490		0.430
				97	0.430				97	0.540		0.485
				98	0.420				98	0.510		0.465
				99	0.480				99	0.510		0.495
			Avg:		0.434			Avg:		0.514	Avg:	0.474
			Std Dev:		0.044			Std Dev:		0.018	Std Dev:	0.027
	OF1	90	1	95	0.450	HF2	90	1	95	0.470		0.460
				96	0.410				96	0.450		0.430
				97	0.410				97	0.440		0.425
				98	0.390				98	0.360		0.375
				99	0.400				99	0.390		0.395
			Avg:		0.412			Avg:		0.422	Avg:	0.417
			Std Dev:		0.023			Std Dev:		0.045	Std Dev:	0.033
	OF1	90	2	95	0.470	HF2	90	2	95	0.510		0.490
				96	0.410				96	0.410		0.410
				97	0.450				97	0.430		0.440
				98	0.410				98	0.470		0.440
				99	0.440				99	0.450		0.445
			Avg:		0.436			Avg:		0.454	Avg:	0.445
			Std Dev:		0.026			Std Dev:		0.038	Std Dev:	0.029
B	OF2	0	1	95	0.530	HF1	0	1	95	0.330		0.430
				96	0.530				96	0.360		0.445
				97	0.400				97	0.310		0.355
				98	0.480				98	0.410		0.445
				99	0.510				99	0.340		0.425
			Avg:		0.490			Avg:		0.350	Avg:	0.420
			Std Dev:		0.054			Std Dev:		0.038	Std Dev:	0.037
	OF2	0	2	95	0.510	HF1	0	2	95	0.480		0.495
				96	0.580				96	0.450		0.515
				97	0.530				97	0.410		0.470
				98	0.610				98	0.490		0.550
				99	0.600				99	0.400		0.500
			Avg:		0.566			Avg:		0.446	Avg:	0.506
			Std Dev:		0.044			Std Dev:		0.040	Std Dev:	0.029
	OF2	90	1	95	0.390	HF1	90	1	95	0.410		0.400
				96	0.380				96	0.420		0.400
				97	0.340				97	0.410		0.375
				98	0.450				98	0.410		0.430
				99	0.420				99	0.410		0.415
			Avg:		0.396			Avg:		0.412	Avg:	0.404
			Std Dev:		0.042			Std Dev:		0.004	Std Dev:	0.020
	OF2	90	2	95	0.420	HF1	90	2	95	0.360		0.390
				96	0.390				96	0.350		0.370
				97	0.400				97	0.430		0.415
				98	0.380				98	0.400		0.390
				99	0.340				99	0.390		0.365
			Avg:		0.386			Avg:		0.386	Avg:	0.386
			Std Dev:		0.030			Std Dev:		0.032	Std Dev:	0.020

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.340	HF2	0	1	95	0.560		0.450
				96	0.410				96	0.520		0.465
				97	0.400				97	0.530		0.465
				98	0.310				98	0.560		0.435
				99	0.400				99	0.510		0.455
			Avg:		0.372			Avg:		0.536	Avg:	0.454
			Std Dev:		0.044			Std Dev:		0.023	Std Dev:	0.012
	OF1	0	2	95	0.370	HF2	0	2	95	0.580		0.475
				96	0.370				96	0.550		0.460
				97	0.320				97	0.560		0.440
				98	0.400				98	0.600		0.500
				99	0.400				99	0.620		0.510
			Avg:		0.372			Avg:		0.582	Avg:	0.477
			Std Dev:		0.033			Std Dev:		0.029	Std Dev:	0.029
	OF1	90	1	95	0.430	HF2	90	1	95	0.330		0.380
				96	0.380				96	0.380		0.380
				97	0.410				97	0.330		0.370
				98	0.410				98	0.370		0.390
				99	0.420				99	0.350		0.385
			Avg:		0.410			Avg:		0.352	Avg:	0.381
			Std Dev:		0.019			Std Dev:		0.023	Std Dev:	0.007
	OF1	90	2	95	0.450	HF2	90	2	95	0.410		0.430
				96	0.460				96	0.400		0.430
				97	0.490				97	0.420		0.455
				98	0.510				98	0.450		0.480
				99	0.480				99	0.410		0.445
			Avg:		0.478			Avg:		0.418	Avg:	0.448
			Std Dev:		0.024			Std Dev:		0.019	Std Dev:	0.021
B	OF2	0	1	95	0.420	HF1	0	1	95	0.380		0.400
				96	0.410				96	0.330		0.370
				97	0.450				97	0.400		0.425
				98	0.450				98	0.380		0.415
				99	0.420				99	0.400		0.410
			Avg:		0.430			Avg:		0.378	Avg:	0.404
			Std Dev:		0.019			Std Dev:		0.029	Std Dev:	0.021
	OF2	0	2	95	0.550	HF1	0	2	95	0.470		0.510
				96	0.550				96	0.450		0.500
				97	0.530				97	0.470		0.500
				98	0.520				98	0.500		0.510
				99	0.550				99	0.430		0.490
			Avg:		0.540			Avg:		0.464	Avg:	0.502
			Std Dev:		0.014			Std Dev:		0.026	Std Dev:	0.008
	OF2	90	1	95	0.320	HF1	90	1	95	0.340		0.330
				96	0.380				96	0.340		0.360
				97	0.360				97	0.370		0.365
				98	0.390				98	0.410		0.400
				99	0.430				99	0.370		0.400
			Avg:		0.376			Avg:		0.366	Avg:	0.371
			Std Dev:		0.040			Std Dev:		0.029	Std Dev:	0.030
	OF2	90	2	95	0.400	HF1	90	2	95	0.450		0.425
				96	0.460				96	0.450		0.455
				97	0.410				97	0.370		0.390
				98	0.390				98	0.430		0.410
				99	0.450				99	0.380		0.415
			Avg:		0.422			Avg:		0.416	Avg:	0.419
			Std Dev:		0.031			Std Dev:		0.038	Std Dev:	0.024

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.210	HF2	0	1	95	0.290		0.250
				96	0.190				96	0.280		0.235
				97	0.180				97	0.310		0.245
				98	0.180				98	0.290		0.235
				99	0.180				99	0.330		0.255
			Avg:		0.188			Avg:		0.300	Avg:	0.244
			Std Dev:		0.013			Std Dev:		0.020	Std Dev:	0.009
	OF1	0	2	95	0.240	HF2	0	2	95	0.260		0.250
				96	0.250				96	0.330		0.290
				97	0.370				97	0.320		0.345
				98	0.340				98	0.270		0.305
				99	0.290				99	0.330		0.310
			Avg:		0.298			Avg:		0.302	Avg:	0.300
			Std Dev:		0.056			Std Dev:		0.034	Std Dev:	0.034
	OF1	90	1	95	0.770	HF2	90	1	95	0.980		0.875
				96	0.760				96	0.980		0.870
				97	0.840				97	0.990		0.915
				98	0.780				98	0.890		0.835
				99	0.920				99	0.790		0.855
			Avg:		0.814			Avg:		0.926	Avg:	0.870
			Std Dev:		0.067			Std Dev:		0.086	Std Dev:	0.030
	OF1	90	2	95	1.290	HF2	90	2	95	1.050		1.170
				96	1.200				96	0.920		1.060
				97	1.310				97	0.980		1.145
				98	1.050				98	0.900		0.975
				99	1.230				99	0.900		1.065
			Avg:		1.216			Avg:		0.950	Avg:	1.083
			Std Dev:		0.103			Std Dev:		0.065	Std Dev:	0.077
C	OF2	0	1	95	0.030	HF1	0	1	95	0.020		0.025
				96	0.110				96	0.110		0.110
				97	0.090				97	0.040		0.065
				98	0.020				98	0.010		0.015
				99	0.020				99	0.090		0.055
			Avg:		0.054			Avg:		0.054	Avg:	0.054
			Std Dev:		0.043			Std Dev:		0.044	Std Dev:	0.037
	OF2	0	2	95	0.020	HF1	0	2	95	0.270		0.145
				96	0.030				96	0.300		0.165
				97	0.090				97	0.260		0.175
				98	0.060				98	0.300		0.180
				99	0.050				99	0.260		0.155
			Avg:		0.050			Avg:		0.278	Avg:	0.164
			Std Dev:		0.027			Std Dev:		0.020	Std Dev:	0.014
	OF2	90	1	95	0.970	HF1	90	1	95	1.450		1.210
				96	1.000				96	1.500		1.250
				97	1.170				97	1.470		1.320
				98	0.870				98	1.380		1.125
				99	0.970				99	1.470		1.220
			Avg:		0.996			Avg:		1.454	Avg:	1.225
			Std Dev:		0.109			Std Dev:		0.045	Std Dev:	0.071
	OF2	90	2	95	0.920	HF1	90	2	95	1.480		1.200
				96	0.790				96	1.650		1.220
				97	0.850				97	1.370		1.110
				98	1.070				98	1.500		1.285
				99	0.890				99	1.370		1.130
			Avg:		0.904			Avg:		1.474	Avg:	1.189
			Std Dev:		0.105			Std Dev:		0.115	Std Dev:	0.071

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.400	HF2	0	1	95	0.640		0.520
				96	0.370				96	0.660		0.515
				97	0.290				97	0.570		0.430
				98	0.370				98	0.560		0.465
				99	0.380				99	0.670		0.525
			Avg:		0.362			Avg:		0.620	Avg:	0.491
			Std Dev:		0.042			Std Dev:		0.051	Std Dev:	0.042
	OF1	0	2	95	0.360	HF2	0	2	95	0.770		0.565
				96	0.370				96	0.750		0.560
				97	0.360				97	0.670		0.515
				98	0.400				98	0.700		0.550
				99	0.370				99	0.750		0.560
			Avg:		0.372			Avg:		0.728	Avg:	0.550
			Std Dev:		0.016			Std Dev:		0.041	Std Dev:	0.020
	OF1	90	1	95	0.270	HF2	90	1	95	0.050		0.160
				96	0.250				96	0.060		0.155
				97	0.270				97	0.070		0.170
				98	0.260				98	0.030		0.145
				99	0.260				99	0.010		0.135
			Avg:		0.262			Avg:		0.044	Avg:	0.153
			Std Dev:		0.008			Std Dev:		0.024	Std Dev:	0.014
	OF1	90	2	95	0.290	HF2	90	2	95	0.040		0.165
				96	0.270				96	0.070		0.170
				97	0.290				97	0.090		0.190
				98	0.280				98	0.070		0.175
				99	0.280				99	0.040		0.160
			Avg:		0.282			Avg:		0.062	Avg:	0.172
			Std Dev:		0.008			Std Dev:		0.022	Std Dev:	0.012
C	OF2	0	1	95	0.460	HF1	0	1	95	0.420		0.440
				96	0.460				96	0.480		0.470
				97	0.520				97	0.480		0.500
				98	0.490				98	0.410		0.450
				99	0.470				99	0.430		0.450
			Avg:		0.480			Avg:		0.444	Avg:	0.462
			Std Dev:		0.025			Std Dev:		0.034	Std Dev:	0.024
	OF2	0	2	95	0.590	HF1	0	2	95	0.520		0.555
				96	0.620				96	0.440		0.530
				97	0.580				97	0.370		0.475
				98	0.560				98	0.410		0.485
				99	0.580				99	0.520		0.550
			Avg:		0.586			Avg:		0.452	Avg:	0.519
			Std Dev:		0.022			Std Dev:		0.067	Std Dev:	0.037
	OF2	90	1	95	0.100	HF1	90	1	95	0.300		0.200
				96	0.140				96	0.260		0.200
				97	0.090				97	0.230		0.160
				98	0.070				98	0.260		0.165
				99	0.070				99	0.260		0.165
			Avg:		0.094			Avg:		0.262	Avg:	0.178
			Std Dev:		0.029			Std Dev:		0.025	Std Dev:	0.020
	OF2	90	2	95	0.130	HF1	90	2	95	0.300		0.215
				96	0.120				96	0.240		0.180
				97	0.070				97	0.250		0.160
				98	0.100				98	0.290		0.195
				99	0.120				99	0.260		0.190
			Avg:		0.108			Avg:		0.268	Avg:	0.188
			Std Dev:		0.024			Std Dev:		0.028	Std Dev:	0.020

Mix Type= 12.5mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.540	HF2	0	1	95	0.590		0.565
				96	0.560				96	0.650		0.605
				97	0.580				97	0.610		0.595
				98	0.680				98	0.670		0.675
				99	0.540				99	0.680		0.610
			Avg:		0.580			Avg:		0.640	Avg:	0.610
			Std Dev:		0.058			Std Dev:		0.039	Std Dev:	0.040
	OF1	0	2	95	0.540	HF2	0	2	95	0.630		0.585
				96	0.640				96	0.690		0.665
				97	0.600				97	0.700		0.650
				98	0.560				98	0.730		0.645
				99	0.550				99	0.690		0.620
			Avg:		0.578			Avg:		0.688	Avg:	0.633
			Std Dev:		0.041			Std Dev:		0.036	Std Dev:	0.031
	OF1	90	1	95	0.550	HF2	90	1	95	0.600		0.575
				96	0.580				96	0.710		0.645
				97	0.490				97	0.570		0.530
				98	0.480				98	0.590		0.535
				99	0.910				99	0.660		0.785
			Avg:		0.602			Avg:		0.626	Avg:	0.614
			Std Dev:		0.177			Std Dev:		0.058	Std Dev:	0.106
	OF1	90	2	95	0.720	HF2	90	2	95	0.760		0.740
				96	0.700				96	0.750		0.725
				97	0.680				97	0.770		0.725
				98	0.710				98	0.760		0.735
				99	0.700				99	0.700		0.700
			Avg:		0.702			Avg:		0.748	Avg:	0.725
			Std Dev:		0.015			Std Dev:		0.028	Std Dev:	0.015
C	OF2	0	1	95	0.390	HF1	0	1	95	0.540		0.465
				96	0.410				96	0.520		0.465
				97	0.390				97	0.510		0.450
				98	0.370				98	0.510		0.440
				99	0.410				99	0.540		0.475
			Avg:		0.394			Avg:		0.524	Avg:	0.459
			Std Dev:		0.017			Std Dev:		0.015	Std Dev:	0.014
	OF2	0	2	95	0.520	HF1	0	2	95	0.540		0.530
				96	0.540				96	0.620		0.580
				97	0.540				97	0.580		0.560
				98	0.550				98	0.590		0.570
				99	0.550				99	0.550		0.550
			Avg:		0.540			Avg:		0.576	Avg:	0.558
			Std Dev:		0.012			Std Dev:		0.032	Std Dev:	0.019
	OF2	90	1	95	0.700	HF1	90	1	95	0.770		0.735
				96	0.770				96	0.750		0.760
				97	0.790				97	0.740		0.765
				98	0.760				98	0.720		0.740
				99	0.800				99	0.800		0.800
			Avg:		0.764			Avg:		0.756	Avg:	0.760
			Std Dev:		0.039			Std Dev:		0.030	Std Dev:	0.026
	OF2	90	2	95	0.750	HF1	90	2	95	0.830		0.790
				96	0.820				96	0.740		0.780
				97	0.700				97	0.710		0.705
				98	0.710				98	0.750		0.730
				99	0.800				99	0.760		0.780
			Avg:		0.756			Avg:		0.758	Avg:	0.757
			Std Dev:		0.053			Std Dev:		0.044	Std Dev:	0.037

Annex 20

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Total

19.0 mm
4 inch Dia.

Mix Type=	19.0 mm
Diam.=	4.00 in
Gage Length=	1.0 in
Total	

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
A	OF1	0	1	95	1.440	HF2	0	1	95	0.260		0.850
				96	1.200				96	0.190		0.695
				97	1.560				97	0.280		0.920
				98	1.330				98	0.250		0.790
				99	1.570				99	0.190		0.880
				Avg:	1.420				Avg:	0.234	Avg:	0.827
				Std Dev:	0.157				Std Dev:	0.042	Std Dev:	0.086
	OF1	0	2	95	1.990	HF2	0	2	95	0.300		1.145
				96	1.580				96	0.240		0.910
				97	2.010				97	0.250		1.130
				98	1.880				98	0.220		1.050
				99	2.330				99	0.250		1.290
				Avg:	1.958				Avg:	0.252	Avg:	1.105
				Std Dev:	0.270				Std Dev:	0.029	Std Dev:	0.139
	OF1	90	1	95	0.060	HF2	90	1	95	0.670		0.365
				96	0.070				96	0.900		0.485
				97	0.060				97	0.640		0.350
				98	0.060				98	0.940		0.500
				99	0.100				99	0.640		0.370
				Avg:	0.070				Avg:	0.758	Avg:	0.414
				Std Dev:	0.017				Std Dev:	0.149	Std Dev:	0.072
	OF1	90	2	95	0.100	HF2	90	2	95	0.780		0.440
				96	0.070				96	0.880		0.475
				97	0.060				97	0.920		0.490
				98	0.070				98	0.990		0.530
				99	0.100				99	1.030		0.565
				Avg:	0.080				Avg:	0.920	Avg:	0.500
				Std Dev:	0.019				Std Dev:	0.098	Std Dev:	0.049
A	OF2	0	1	95	0.270	HF1	0	1	95	1.050		0.660
				96	0.290				96	1.710		1.000
				97	0.440				97	1.410		0.925
				98	0.260				98	1.440		0.850
				99	0.320				99	1.490		0.905
				Avg:	0.316				Avg:	1.420	Avg:	0.868
				Std Dev:	0.073				Std Dev:	0.238	Std Dev:	0.128
	OF2	0	2	95	0.260	HF1	0	2	95	1.940		1.100
				96	0.360				96	2.020		1.190
				97	0.350				97	1.500		0.925
				98	0.220				98	2.020		1.120
				99	0.280				99	1.530		0.905
				Avg:	0.294				Avg:	1.802	Avg:	1.048
				Std Dev:	0.060				Std Dev:	0.264	Std Dev:	0.126
	OF2	90	1	95	0.760	HF1	90	1	95	0.110		0.435
				96	0.680				96	0.080		0.380
				97	0.920				97	0.100		0.510
				98	0.590				98	0.090		0.340
				99	0.900				99	0.100		0.500
				Avg:	0.770				Avg:	0.096	Avg:	0.433
				Std Dev:	0.141				Std Dev:	0.011	Std Dev:	0.074
	OF2	90	2	95	0.840	HF1	90	2	95	0.020		0.430
				96	1.040				96	0.070		0.555
				97	0.750				97	0.070		0.410
				98	1.060				98	0.080		0.570
				99	0.920				99	0.010		0.465
				Avg:	0.922				Avg:	0.050	Avg:	0.486
				Std Dev:	0.132				Std Dev:	0.032	Std Dev:	0.073

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.300	HF2	0	1	95	0.360		0.330
				96	0.460				96	0.450		0.455
				97	0.360				97	0.460		0.410
				98	0.370				98	0.410		0.390
				99	0.380				99	0.420		0.400
				Avg:	0.374				Avg:	0.420	Avg:	0.397
				Std Dev:	0.057				Std Dev:	0.039	Std Dev:	0.045
	OF1	0	2	95	0.440	HF2	0	2	95	0.460		0.450
				96	0.370				96	0.420		0.395
				97	0.400				97	0.410		0.405
				98	0.400				98	0.390		0.395
				99	0.390				99	0.320		0.355
				Avg:	0.400				Avg:	0.400	Avg:	0.400
				Std Dev:	0.025				Std Dev:	0.051	Std Dev:	0.034
	OF1	90	1	95	0.610	HF2	90	1	95	0.470		0.540
				96	0.560				96	0.390		0.475
				97	0.600				97	0.320		0.460
				98	0.600				98	0.380		0.490
				99	0.580				99	0.310		0.445
				Avg:	0.590				Avg:	0.374	Avg:	0.482
				Std Dev:	0.020				Std Dev:	0.064	Std Dev:	0.037
	OF1	90	2	95	0.690	HF2	90	2	95	0.380		0.535
				96	0.760				96	0.330		0.545
				97	0.750				97	0.400		0.575
				98	0.710				98	0.420		0.565
				99	0.750				99	0.360		0.555
				Avg:	0.732				Avg:	0.378	Avg:	0.555
				Std Dev:	0.030				Std Dev:	0.035	Std Dev:	0.016
A	OF2	0	1	95	0.360	HF1	0	1	95	0.320		0.340
				96	0.380				96	0.340		0.360
				97	0.340				97	0.270		0.305
				98	0.390				98	0.390		0.390
				99	0.330				99	0.380		0.355
				Avg:	0.360				Avg:	0.340	Avg:	0.350
				Std Dev:	0.025				Std Dev:	0.046	Std Dev:	0.031
	OF2	0	2	95	0.350	HF1	0	2	95	0.410		0.380
				96	0.270				96	0.340		0.305
				97	0.330				97	0.420		0.375
				98	0.410				98	0.400		0.405
				99	0.350				99	0.380		0.365
				Avg:	0.342				Avg:	0.390	Avg:	0.366
				Std Dev:	0.050				Std Dev:	0.032	Std Dev:	0.037
	OF2	90	1	95	0.380	HF1	90	1	95	0.520		0.450
				96	0.360				96	0.650		0.505
				97	0.370				97	0.550		0.460
				98	0.330				98	0.540		0.435
				99	0.440				99	0.730		0.585
				Avg:	0.376				Avg:	0.598	Avg:	0.487
				Std Dev:	0.040				Std Dev:	0.089	Std Dev:	0.061
	OF2	90	2	95	0.600	HF1	90	2	95	0.780		0.690
				96	0.470				96	0.650		0.560
				97	0.610				97	0.790		0.700
				98	0.580				98	0.730		0.655
				99	0.480				99	0.780		0.630
				Avg:	0.548				Avg:	0.746	Avg:	0.647
				Std Dev:	0.068				Std Dev:	0.059	Std Dev:	0.056

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	1.130	HF2	0	1	95	0.500		0.815
				96	1.060				96	0.470		0.765
				97	1.060				97	0.470		0.765
				98	1.090				98	0.440		0.765
				99	1.150				99	0.510		0.830
			Avg:		1.098			Avg:		0.478	Avg:	0.788
			Std Dev:		0.041			Std Dev:		0.028	Std Dev:	0.032
	OF1	0	2	95	1.040	HF2	0	2	95	0.470		0.755
				96	1.030				96	0.480		0.755
				97	1.160				97	0.470		0.815
				98	1.130				98	0.480		0.805
				99	1.000				99	0.460		0.730
			Avg:		1.072			Avg:		0.472	Avg:	0.772
			Std Dev:		0.069			Std Dev:		0.008	Std Dev:	0.036
	OF1	90	1	95	0.510	HF2	90	1	95	0.260		0.385
				96	0.520				96	0.220		0.370
				97	0.560				97	0.200		0.380
				98	0.550				98	0.240		0.395
				99	0.560				99	0.230		0.395
			Avg:		0.540			Avg:		0.230	Avg:	0.385
			Std Dev:		0.023			Std Dev:		0.022	Std Dev:	0.011
	OF1	90	2	95	0.600	HF2	90	2	95	0.300		0.450
				96	0.620				96	0.290		0.455
				97	0.630				97	0.320		0.475
				98	0.610				98	0.290		0.450
				99	0.650				99	0.250		0.450
			Avg:		0.622			Avg:		0.290	Avg:	0.456
			Std Dev:		0.019			Std Dev:		0.025	Std Dev:	0.011
A	OF2	0	1	95	0.450	HF1	0	1	95	0.600		0.525
				96	0.430				96	0.620		0.525
				97	0.400				97	0.560		0.480
				98	0.390				98	0.690		0.540
				99	0.440				99	0.600		0.520
			Avg:		0.422			Avg:		0.614	Avg:	0.518
			Std Dev:		0.026			Std Dev:		0.048	Std Dev:	0.023
	OF2	0	2	95	0.430	HF1	0	2	95	0.700		0.565
				96	0.440				96	0.740		0.590
				97	0.390				97	0.660		0.525
				98	0.390				98	0.690		0.540
				99	0.490				99	0.690		0.590
			Avg:		0.428			Avg:		0.696	Avg:	0.562
			Std Dev:		0.041			Std Dev:		0.029	Std Dev:	0.029
	OF2	90	1	95	0.190	HF1	90	1	95	0.600		0.395
				96	0.250				96	0.650		0.450
				97	0.290				97	0.680		0.485
				98	0.220				98	0.720		0.470
				99	0.290				99	0.690		0.490
			Avg:		0.248			Avg:		0.668	Avg:	0.458
			Std Dev:		0.044			Std Dev:		0.045	Std Dev:	0.039
	OF2	90	2	95	0.280	HF1	90	2	95	0.710		0.495
				96	0.270				96	0.690		0.480
				97	0.290				97	0.680		0.485
				98	0.300				98	0.700		0.500
				99	0.300				99	0.690		0.495
			Avg:		0.288			Avg:		0.694	Avg:	0.491
			Std Dev:		0.013			Std Dev:		0.011	Std Dev:	0.008

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	1.110	HF2	0	1	95	1.030		1.070
				96	0.620				96	0.730		0.675
				97	0.950				97	0.990		0.970
				98	0.740				98	1.020		0.880
				99	0.590				99	0.850		0.720
			Avg:		0.802			Avg:		0.924	Avg:	0.863
			Std Dev:		0.223			Std Dev:		0.130	Std Dev:	0.166
	OF1	0	2	95	0.530	HF2	0	2	95	0.850		0.690
				96	0.610				96	0.940		0.775
				97	0.550				97	0.860		0.705
				98	0.640				98	0.920		0.780
				99	0.640				99	1.050		0.845
			Avg:		0.594			Avg:		0.924	Avg:	0.759
			Std Dev:		0.051			Std Dev:		0.080	Std Dev:	0.063
	OF1	90	1	95	0.180	HF2	90	1	95	0.470		0.325
				96	0.260				96	0.680		0.470
				97	0.190				97	0.600		0.395
				98	0.230				98	0.490		0.360
				99	0.210				99	0.550		0.380
			Avg:		0.214			Avg:		0.558	Avg:	0.386
			Std Dev:		0.032			Std Dev:		0.085	Std Dev:	0.054
	OF1	90	2	95	0.180	HF2	90	2	95	0.470		0.325
				96	0.220				96	0.550		0.385
				97	0.180				97	0.640		0.410
				98	0.180				98	0.490		0.335
				99	0.210				99	0.550		0.380
			Avg:		0.194			Avg:		0.540	Avg:	0.367
			Std Dev:		0.019			Std Dev:		0.066	Std Dev:	0.036
B	OF2	0	1	95	0.980	HF1	0	1	95	1.080		1.030
				96	1.070				96	0.720		0.895
				97	0.890				97	0.760		0.825
				98	0.950				98	1.050		1.000
				99	1.090				99	1.030		1.060
			Avg:		0.996			Avg:		0.928	Avg:	0.962
			Std Dev:		0.084			Std Dev:		0.173	Std Dev:	0.099
	OF2	0	2	95	0.870	HF1	0	2	95	0.700		0.785
				96	0.830				96	0.700		0.765
				97	0.830				97	0.720		0.775
				98	1.000				98	0.780		0.890
				99	0.840				99	0.560		0.700
			Avg:		0.874			Avg:		0.692	Avg:	0.783
			Std Dev:		0.072			Std Dev:		0.081	Std Dev:	0.068
	OF2	90	1	95	0.560	HF1	90	1	95	0.280		0.420
				96	0.420				96	0.260		0.340
				97	0.550				97	0.320		0.435
				98	0.500				98	0.240		0.370
				99	0.510				99	0.270		0.390
			Avg:		0.508			Avg:		0.274	Avg:	0.391
			Std Dev:		0.055			Std Dev:		0.030	Std Dev:	0.038
	OF2	90	2	95	0.400	HF1	90	2	95	0.300		0.350
				96	0.610				96	0.290		0.450
				97	0.410				97	0.180		0.295
				98	0.430				98	0.270		0.350
				99	0.480				99	0.210		0.345
			Avg:		0.466			Avg:		0.250	Avg:	0.358
			Std Dev:		0.086			Std Dev:		0.052	Std Dev:	0.056

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.140	HF2	0	1	95	0.190		0.165
				96	0.220				96	0.190		0.205
				97	0.230				97	0.170		0.200
				98	0.200				98	0.250		0.225
				99	0.210				99	0.250		0.230
				Avg:	0.200				Avg:	0.210	Avg:	0.205
				Std Dev:	0.035				Std Dev:	0.037	Std Dev:	0.026
	OF1	0	2	95	0.220	HF2	0	2	95	0.270		0.245
				96	0.200				96	0.300		0.250
				97	0.220				97	0.370		0.295
				98	0.230				98	0.340		0.285
				99	0.260				99	0.380		0.320
				Avg:	0.226				Avg:	0.332	Avg:	0.279
				Std Dev:	0.022				Std Dev:	0.047	Std Dev:	0.032
	OF1	90	1	95	0.600	HF2	90	1	95	0.290		0.445
				96	0.580				96	0.250		0.415
				97	0.590				97	0.250		0.420
				98	0.610				98	0.350		0.480
				99	0.630				99	0.330		0.480
				Avg:	0.602				Avg:	0.294	Avg:	0.448
				Std Dev:	0.019				Std Dev:	0.046	Std Dev:	0.031
	OF1	90	2	95	0.660	HF2	90	2	95	0.500		0.580
				96	0.670				96	0.480		0.575
				97	0.610				97	0.420		0.515
				98	0.650				98	0.450		0.550
				99	0.640				99	0.430		0.535
				Avg:	0.646				Avg:	0.456	Avg:	0.551
				Std Dev:	0.023				Std Dev:	0.034	Std Dev:	0.027
B	OF2	0	1	95	0.220	HF1	0	1	95	0.170		0.195
				96	0.210				96	0.140		0.175
				97	0.220				97	0.180		0.200
				98	0.220				98	0.200		0.210
				99	0.140				99	0.150		0.145
				Avg:	0.202				Avg:	0.168	Avg:	0.185
				Std Dev:	0.035				Std Dev:	0.024	Std Dev:	0.026
	OF2	0	2	95	0.250	HF1	0	2	95	0.180		0.215
				96	0.270				96	0.190		0.230
				97	0.260				97	0.160		0.210
				98	0.280				98	0.150		0.215
				99	0.230				99	0.180		0.205
				Avg:	0.258				Avg:	0.172	Avg:	0.215
				Std Dev:	0.019				Std Dev:	0.016	Std Dev:	0.009
	OF2	90	1	95	0.330	HF1	90	1	95	0.520		0.425
				96	0.300				96	0.500		0.400
				97	0.180				97	0.530		0.355
				98	0.290				98	0.560		0.425
				99	0.270				99	0.480		0.375
				Avg:	0.274				Avg:	0.518	Avg:	0.396
				Std Dev:	0.057				Std Dev:	0.030	Std Dev:	0.031
	OF2	90	2	95	0.450	HF1	90	2	95	0.610		0.530
				96	0.380				96	0.630		0.505
				97	0.390				97	0.640		0.515
				98	0.420				98	0.600		0.510
				99	0.340				99	0.620		0.480
				Avg:	0.396				Avg:	0.620	Avg:	0.508
				Std Dev:	0.042				Std Dev:	0.016	Std Dev:	0.018

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.670	HF2	0	1	95	0.200		0.435
				96	0.670				96	0.210		0.440
				97	0.710				97	0.270		0.490
				98	0.640				98	0.250		0.445
				99	0.600				99	0.200		0.400
				Avg:	0.658				Avg:	0.226	Avg:	0.442
				Std Dev:	0.041				Std Dev:	0.032	Std Dev:	0.032
	OF1	0	2	95	0.730	HF2	0	2	95	0.240		0.485
				96	0.710				96	0.270		0.490
				97	0.740				97	0.310		0.525
				98	0.800				98	0.290		0.545
				99	0.780				99	0.240		0.510
				Avg:	0.752				Avg:	0.270	Avg:	0.511
				Std Dev:	0.037				Std Dev:	0.031	Std Dev:	0.025
	OF1	90	1	95	0.590	HF2	90	1	95	0.600		0.595
				96	0.690				96	0.610		0.650
				97	0.650				97	0.530		0.590
				98	0.760				98	0.540		0.650
				99	0.710				99	0.560		0.635
				Avg:	0.680				Avg:	0.568	Avg:	0.624
				Std Dev:	0.064				Std Dev:	0.036	Std Dev:	0.029
	OF1	90	2	95	0.840	HF2	90	2	95	0.560		0.700
				96	0.790				96	0.630		0.710
				97	0.800				97	0.680		0.740
				98	0.820				98	0.620		0.720
				99	0.690				99	0.520		0.605
				Avg:	0.788				Avg:	0.602	Avg:	0.695
				Std Dev:	0.058				Std Dev:	0.063	Std Dev:	0.052
B	OF2	0	1	95	0.500	HF1	0	1	95	0.260		0.380
				96	0.450				96	0.300		0.375
				97	0.480				97	0.260		0.370
				98	0.430				98	0.330		0.380
				99	0.460				99	0.270		0.365
				Avg:	0.464				Avg:	0.284	Avg:	0.374
				Std Dev:	0.027				Std Dev:	0.030	Std Dev:	0.007
	OF2	0	2	95	0.620	HF1	0	2	95	0.420		0.520
				96	0.520				96	0.310		0.415
				97	0.530				97	0.380		0.455
				98	0.570				98	0.380		0.475
				99	0.540				99	0.370		0.455
				Avg:	0.556				Avg:	0.372	Avg:	0.464
				Std Dev:	0.040				Std Dev:	0.040	Std Dev:	0.038
	OF2	90	1	95	0.470	HF1	90	1	95	0.320		0.395
				96	0.450				96	0.380		0.415
				97	0.520				97	0.350		0.435
				98	0.550				98	0.340		0.445
				99	0.550				99	0.360		0.455
				Avg:	0.508				Avg:	0.350	Avg:	0.429
				Std Dev:	0.046				Std Dev:	0.022	Std Dev:	0.024
	OF2	90	2	95	0.510	HF1	90	2	95	0.300		0.405
				96	0.580				96	0.350		0.465
				97	0.610				97	0.340		0.475
				98	0.560				98	0.360		0.460
				99	0.600				99	0.340		0.470
				Avg:	0.572				Avg:	0.338	Avg:	0.455
				Std Dev:	0.040				Std Dev:	0.023	Std Dev:	0.029

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.340	HF2	0	1	95	0.500		0.420
				96	0.390				96	0.470		0.430
				97	0.460				97	0.520		0.490
				98	0.330				98	0.540		0.435
				99	0.450				99	0.400		0.425
			Avg:		0.394			Avg:		0.486	Avg:	0.440
			Std Dev:		0.060			Std Dev:		0.055	Std Dev:	0.029
	OF1	0	2	95	0.480	HF2	0	2	95	0.460		0.470
				96	0.390				96	0.570		0.480
				97	0.390				97	0.470		0.430
				98	0.420				98	0.460		0.440
				99	0.330				99	0.430		0.380
			Avg:		0.402			Avg:		0.478	Avg:	0.440
			Std Dev:		0.054			Std Dev:		0.054	Std Dev:	0.039
	OF1	90	1	95	0.010	HF2	90	1	95	0.700		0.355
				96	0.010				96	0.820		0.415
				97	0.020				97	0.780		0.400
				98	0.080				98	0.700		0.390
				99	0.020				99	0.580		0.300
			Avg:		0.028			Avg:		0.716	Avg:	0.372
			Std Dev:		0.029			Std Dev:		0.092	Std Dev:	0.046
	OF1	90	2	95	0.080	HF2	90	2	95	0.900		0.490
				96	0.010				96	0.680		0.345
				97	0.060				97	0.800		0.430
				98	0.020				98	0.650		0.335
				99	0.010				99	0.540		0.275
			Avg:		0.036			Avg:		0.714	Avg:	0.375
			Std Dev:		0.032			Std Dev:		0.139	Std Dev:	0.085
C	OF2	0	1	95	0.550	HF1	0	1	95	0.510		0.530
				96	0.510				96	0.730		0.620
				97	0.570				97	0.570		0.570
				98	0.470				98	0.570		0.520
				99	0.670				99	0.680		0.675
			Avg:		0.554			Avg:		0.612	Avg:	0.583
			Std Dev:		0.075			Std Dev:		0.090	Std Dev:	0.065
	OF2	0	2	95	0.530	HF1	0	2	95	0.360		0.445
				96	0.540				96	0.680		0.610
				97	0.540				97	0.530		0.535
				98	0.570				98	0.640		0.605
				99	0.650				99	0.570		0.610
			Avg:		0.566			Avg:		0.556	Avg:	0.561
			Std Dev:		0.049			Std Dev:		0.124	Std Dev:	0.072
	OF2	90	1	95	0.670	HF1	90	1	95	0.040		0.355
				96	0.680				96	0.050		0.365
				97	0.570				97	0.030		0.300
				98	0.870				98	0.050		0.460
				99	0.580				99	0.010		0.295
			Avg:		0.674			Avg:		0.036	Avg:	0.355
			Std Dev:		0.121			Std Dev:		0.017	Std Dev:	0.067
	OF2	90	2	95	0.650	HF1	90	2	95	0.060		0.355
				96	0.540				96	0.010		0.275
				97	0.630				97	0.050		0.340
				98	0.690				98	0.040		0.365
				99	0.620				99	0.080		0.350
			Avg:		0.626			Avg:		0.048	Avg:	0.337
			Std Dev:		0.055			Std Dev:		0.026	Std Dev:	0.036

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
C	OF1	0	1	95	0.720	HF2	0	1	95	0.490		0.605
				96	0.610				96	0.570		0.590
				97	0.570				97	0.560		0.565
				98	0.710				98	0.590		0.650
				99	0.650				99	0.580		0.615
				Avg:	0.652				Avg:	0.558	Avg:	0.605
				Std Dev:	0.064				Std Dev:	0.040	Std Dev:	0.031
	OF1	0	2	95	0.650	HF2	0	2	95	0.510		0.580
				96	0.740				96	0.480		0.610
				97	0.790				97	0.480		0.635
				98	0.710				98	0.470		0.590
				99	0.790				99	0.420		0.605
				Avg:	0.736				Avg:	0.472	Avg:	0.604
				Std Dev:	0.059				Std Dev:	0.033	Std Dev:	0.021
	OF1	90	1	95	0.220	HF2	90	1	95	0.380		0.300
				96	0.210				96	0.410		0.310
				97	0.230				97	0.450		0.340
				98	0.190				98	0.370		0.280
				99	0.210				99	0.400		0.305
				Avg:	0.212				Avg:	0.402	Avg:	0.307
				Std Dev:	0.015				Std Dev:	0.031	Std Dev:	0.022
	OF1	90	2	95	0.260	HF2	90	2	95	0.350		0.305
				96	0.250				96	0.370		0.310
				97	0.220				97	0.310		0.265
				98	0.270				98	0.400		0.335
				99	0.230				99	0.400		0.315
				Avg:	0.246				Avg:	0.366	Avg:	0.306
				Std Dev:	0.021				Std Dev:	0.038	Std Dev:	0.026
C	OF2	0	1	95	0.490	HF1	0	1	95	0.550		0.520
				96	0.480				96	0.560		0.520
				97	0.480				97	0.550		0.515
				98	0.490				98	0.560		0.525
				99	0.570				99	0.560		0.565
				Avg:	0.502				Avg:	0.556	Avg:	0.529
				Std Dev:	0.038				Std Dev:	0.005	Std Dev:	0.020
	OF2	0	2	95	0.490	HF1	0	2	95	0.660		0.575
				96	0.440				96	0.540		0.490
				97	0.460				97	0.700		0.580
				98	0.450				98	0.570		0.510
				99	0.470				99	0.520		0.495
				Avg:	0.462				Avg:	0.598	Avg:	0.530
				Std Dev:	0.019				Std Dev:	0.078	Std Dev:	0.044
	OF2	90	1	95	0.310	HF1	90	1	95	0.250		0.280
				96	0.360				96	0.160		0.260
				97	0.280				97	0.210		0.245
				98	0.370				98	0.240		0.305
				99	0.400				99	0.170		0.285
				Avg:	0.344				Avg:	0.206	Avg:	0.275
				Std Dev:	0.048				Std Dev:	0.040	Std Dev:	0.023
	OF2	90	2	95	0.380	HF1	90	2	95	0.210		0.295
				96	0.440				96	0.300		0.370
				97	0.480				97	0.270		0.375
				98	0.380				98	0.270		0.325
				99	0.470				99	0.310		0.390
				Avg:	0.430				Avg:	0.272	Avg:	0.351
				Std Dev:	0.048				Std Dev:	0.039	Std Dev:	0.040

Mix Type= 19.0 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.680	HF2	0	1	95	0.180		0.430
				96	0.650				96	0.240		0.445
				97	0.580				97	0.220		0.400
				98	0.510				98	0.160		0.335
				99	0.650				99	0.220		0.435
			Avg:		0.614			Avg:		0.204	Avg:	0.409
			Std Dev:		0.069			Std Dev:		0.033	Std Dev:	0.045
	OF1	0	2	95	0.790	HF2	0	2	95	0.320		0.555
				96	0.640				96	0.250		0.445
				97	0.590				97	0.220		0.405
				98	0.550				98	0.300		0.425
				99	0.720				99	0.280		0.500
			Avg:		0.658			Avg:		0.274	Avg:	0.466
			Std Dev:		0.097			Std Dev:		0.040	Std Dev:	0.061
	OF1	90	1	95	0.320	HF2	90	1	95	0.880		0.600
				96	0.360				96	0.890		0.625
				97	0.300				97	0.730		0.515
				98	0.330				98	0.810		0.570
				99	0.320				99	0.840		0.580
			Avg:		0.326			Avg:		0.830	Avg:	0.578
			Std Dev:		0.022			Std Dev:		0.064	Std Dev:	0.041
	OF1	90	2	95	0.350	HF2	90	2	95	0.750		0.550
				96	0.350				96	0.830		0.590
				97	0.320				97	0.920		0.620
				98	0.350				98	0.690		0.520
				99	0.320				99	0.820		0.570
			Avg:		0.338			Avg:		0.802	Avg:	0.570
			Std Dev:		0.016			Std Dev:		0.087	Std Dev:	0.038
C	OF2	0	1	95	0.210	HF1	0	1	95	0.520		0.365
				96	0.180				96	0.490		0.335
				97	0.240				97	0.480		0.360
				98	0.270				98	0.470		0.370
				99	0.180				99	0.410		0.295
			Avg:		0.216			Avg:		0.474	Avg:	0.345
			Std Dev:		0.039			Std Dev:		0.040	Std Dev:	0.031
	OF2	0	2	95	0.180	HF1	0	2	95	0.550		0.365
				96	0.240				96	0.520		0.380
				97	0.230				97	0.550		0.390
				98	0.230				98	0.550		0.390
				99	0.190				99	0.520		0.355
			Avg:		0.214			Avg:		0.538	Avg:	0.376
			Std Dev:		0.027			Std Dev:		0.016	Std Dev:	0.016
	OF2	90	1	95	0.610	HF1	90	1	95	0.560		0.585
				96	0.670				96	0.510		0.590
				97	0.710				97	0.540		0.625
				98	0.620				98	0.600		0.610
				99	0.590				99	0.540		0.565
			Avg:		0.640			Avg:		0.550	Avg:	0.595
			Std Dev:		0.049			Std Dev:		0.033	Std Dev:	0.023
	OF2	90	2	95	0.630	HF1	90	2	95	0.560		0.595
				96	0.660				96	0.670		0.665
				97	0.780				97	0.570		0.675
				98	0.670				98	0.540		0.605
				99	0.640				99	0.660		0.650
			Avg:		0.676			Avg:		0.600	Avg:	0.638
			Std Dev:		0.060			Std Dev:		0.060	Std Dev:	0.036

Annex 21

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Total

37.5 mm
4 inch Dia.

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.880	HF2	0	1	95	1.510		1.195
				96	1.370				96	1.360		1.365
				97	1.090				97	1.780		1.435
				98	0.960				98	1.330		1.145
				99	1.290				99	1.710		1.500
			Avg:		1.118			Avg:		1.538	Avg:	1.328
			Std Dev:		0.209			Std Dev:		0.202	Std Dev:	0.153
	OF1	0	2	95	1.450	HF2	0	2	95	1.360		1.405
				96	1.250				96	1.800		1.525
				97	1.130				97	1.490		1.310
				98	1.430				98	1.680		1.555
				99	1.170				99	1.570		1.370
			Avg:		1.286			Avg:		1.580	Avg:	1.433
			Std Dev:		0.147			Std Dev:		0.170	Std Dev:	0.104
	OF1	90	1	95	0.680	HF2	90	1	95	0.110		0.395
				96	0.690				96	0.110		0.400
				97	0.670				97	0.070		0.370
				98	0.680				98	0.140		0.410
				99	0.700				99	0.020		0.360
			Avg:		0.684			Avg:		0.090	Avg:	0.387
			Std Dev:		0.011			Std Dev:		0.046	Std Dev:	0.021
	OF1	90	2	95	1.160	HF2	90	2	95	0.060		0.620
				96	0.940				96	0.050		0.495
				97	1.150				97	0.030		0.590
				98	1.100				98	0.030		0.565
				99	0.990				99	0.060		0.525
			Avg:		1.072			Avg:		0.046	Avg:	0.559
			Std Dev:		0.103			Std Dev:		0.015	Std Dev:	0.050
A	OF2	0	1	95	1.440	HF1	0	1	95	0.930		1.185
				96	1.140				96	0.850		0.995
				97	1.680				97	1.050		1.365
				98	1.530				98	0.800		1.165
				99	1.510				99	0.940		1.225
			Avg:		1.460			Avg:		0.914	Avg:	1.187
			Std Dev:		0.199			Std Dev:		0.096	Std Dev:	0.133
	OF2	0	2	95	1.620	HF1	0	2	95	1.170		1.395
				96	1.400				96	1.220		1.310
				97	1.920				97	1.140		1.530
				98	1.440				98	1.270		1.355
				99	1.870				99	1.120		1.495
			Avg:		1.650			Avg:		1.184	Avg:	1.417
			Std Dev:		0.239			Std Dev:		0.061	Std Dev:	0.093
	OF2	90	1	95	0.080	HF1	90	1	95	0.710		0.395
				96	0.040				96	0.740		0.390
				97	0.080				97	0.670		0.375
				98	0.090				98	0.820		0.455
				99	0.060				99	0.790		0.425
			Avg:		0.070			Avg:		0.746	Avg:	0.408
			Std Dev:		0.020			Std Dev:		0.060	Std Dev:	0.032
	OF2	90	2	95	0.060	HF1	90	2	95	0.900		0.480
				96	0.070				96	0.990		0.530
				97	0.020				97	0.880		0.450
				98	0.080				98	0.840		0.460
				99	0.050				99	0.910		0.480
			Avg:		0.056			Avg:		0.904	Avg:	0.480
			Std Dev:		0.023			Std Dev:		0.055	Std Dev:	0.031

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.370	HF2	0	1	95	2.200		1.285
				96	0.320				96	1.410		0.865
				97	0.310				97	1.530		0.920
				98	0.330				98	1.440		0.885
				99	0.340				99	1.570		0.955
			Avg:		0.334			Avg:		1.630	Avg:	0.982
			Std Dev:		0.023			Std Dev:		0.325	Std Dev:	0.173
	OF1	0	2	95	0.370	HF2	0	2	95	1.150		0.760
				96	0.370				96	1.110		0.740
				97	0.410				97	1.100		0.755
				98	0.470				98	1.400		0.935
				99	0.390				99	1.350		0.870
			Avg:		0.402			Avg:		1.222	Avg:	0.812
			Std Dev:		0.041			Std Dev:		0.142	Std Dev:	0.086
	OF1	90	1	95	1.530	HF2	90	1	95	0.260		0.895
				96	1.460				96	0.340		0.900
				97	1.430				97	0.400		0.915
				98	1.340				98	0.350		0.845
				99	1.440				99	0.320		0.880
			Avg:		1.440			Avg:		0.334	Avg:	0.887
			Std Dev:		0.068			Std Dev:		0.051	Std Dev:	0.027
	OF1	90	2	95	1.250	HF2	90	2	95	0.270		0.760
				96	1.190				96	0.220		0.705
				97	1.180				97	0.200		0.690
				98	1.290				98	0.240		0.765
				99	1.220				99	0.310		0.765
			Avg:		1.226			Avg:		0.248	Avg:	0.737
			Std Dev:		0.045			Std Dev:		0.043	Std Dev:	0.037
A	OF2	0	1	95	1.300	HF1	0	1	95	0.150		0.725
				96	1.340				96	0.180		0.760
				97	1.540				97	0.200		0.870
				98	1.770				98	0.180		0.975
				99	1.440				99	0.160		0.800
			Avg:		1.478			Avg:		0.174	Avg:	0.826
			Std Dev:		0.188			Std Dev:		0.019	Std Dev:	0.099
	OF2	0	2	95	1.670	HF1	0	2	95	0.240		0.955
				96	1.700				96	0.270		0.985
				97	1.800				97	0.290		1.045
				98	1.770				98	0.260		1.015
				99	1.640				99	0.250		0.945
			Avg:		1.716			Avg:		0.262	Avg:	0.989
			Std Dev:		0.067			Std Dev:		0.019	Std Dev:	0.042
	OF2	90	1	95	0.090	HF1	90	1	95	0.860		0.475
				96	0.080				96	0.850		0.465
				97	0.110				97	0.900		0.505
				98	0.190				98	0.900		0.545
				99	0.150				99	0.840		0.495
			Avg:		0.124			Avg:		0.870	Avg:	0.497
			Std Dev:		0.046			Std Dev:		0.028	Std Dev:	0.031
	OF2	90	2	95	0.210	HF1	90	2	95	1.160		0.685
				96	0.190				96	1.250		0.720
				97	0.250				97	1.350		0.800
				98	0.250				98	1.250		0.750
				99	0.200				99	1.250		0.725
			Avg:		0.220			Avg:		1.252	Avg:	0.736
			Std Dev:		0.028			Std Dev:		0.067	Std Dev:	0.043

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.00 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.740	HF2	0	1	95	1.020		0.880
				96	0.780				96	0.980		0.880
				97	0.770				97	0.960		0.865
				98	0.800				98	1.180		0.990
				99	0.690				99	0.950		0.820
			Avg:		0.756			Avg:		1.018	Avg:	0.887
			Std Dev:		0.043			Std Dev:		0.094	Std Dev:	0.063
	OF1	0	2	95	1.020	HF2	0	2	95	1.010		1.015
				96	0.900				96	1.040		0.970
				97	1.040				97	1.080		1.060
				98	0.920				98	1.020		0.970
				99	0.980				99	1.050		1.015
			Avg:		0.972			Avg:		1.040	Avg:	1.006
			Std Dev:		0.061			Std Dev:		0.027	Std Dev:	0.038
	OF1	90	1	95	1.660	HF2	90	1	95	0.070		0.865
				96	1.620				96	0.012		0.816
				97	1.760				97	0.060		0.910
				98	1.600				98	0.070		0.835
				99	1.700				99	0.110		0.905
			Avg:		1.668			Avg:		0.064	Avg:	0.866
			Std Dev:		0.064			Std Dev:		0.035	Std Dev:	0.042
	OF1	90	2	95	1.980	HF2	90	2	95	0.010		0.995
				96	1.970				96	0.060		1.015
				97	1.990				97	0.030		1.010
				98	1.990				98	0.010		1.000
				99	1.980				99	0.050		1.015
			Avg:		1.982			Avg:		0.032	Avg:	1.007
			Std Dev:		0.008			Std Dev:		0.023	Std Dev:	0.009
A	OF2	0	1	95	1.260	HF1	0	1	95	0.900		1.080
				96	1.260				96	0.800		1.030
				97	1.180				97	0.800		0.990
				98	1.400				98	0.880		1.140
				99	1.370				99	0.820		1.095
			Avg:		1.294			Avg:		0.840	Avg:	1.067
			Std Dev:		0.090			Std Dev:		0.047	Std Dev:	0.058
	OF2	0	2	95	1.170	HF1	0	2	95	0.900		1.035
				96	1.130				96	0.920		1.025
				97	1.060				97	0.880		0.970
				98	1.050				98	0.910		0.980
				99	1.140				99	0.910		1.025
			Avg:		1.110			Avg:		0.904	Avg:	1.007
			Std Dev:		0.052			Std Dev:		0.015	Std Dev:	0.030
	OF2	90	1	95	0.010	HF1	90	1	95	1.120		0.565
				96	0.010				96	1.150		0.580
				97	0.030				97	1.190		0.610
				98	0.020				98	1.150		0.585
				99	0.020				99	1.100		0.560
			Avg:		0.018			Avg:		1.142	Avg:	0.580
			Std Dev:		0.008			Std Dev:		0.034	Std Dev:	0.020
	OF2	90	2	95	0.010	HF1	90	2	95	1.210		0.610
				96	0.020				96	1.150		0.585
				97	0.040				97	1.250		0.645
				98	0.010				98	1.210		0.610
				99	0.010				99	1.150		0.580
			Avg:		0.018			Avg:		1.194	Avg:	0.606
			Std Dev:		0.013			Std Dev:		0.043	Std Dev:	0.026

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.490	HF2	0	1	95	0.440		0.465
				96	0.440				96	0.520		0.480
				97	0.510				97	0.250		0.380
				98	0.640				98	0.360		0.500
				99	0.610				99	0.470		0.540
			Avg:		0.538			Avg:		0.408	Avg:	0.473
			Std Dev:		0.084			Std Dev:		0.106	Std Dev:	0.059
	OF1	0	2	95	0.650	HF2	0	2	95	0.460		0.555
				96	0.570				96	0.670		0.620
				97	0.520				97	0.430		0.475
				98	0.580				98	0.450		0.515
				99	0.650				99	0.410		0.530
			Avg:		0.594			Avg:		0.484	Avg:	0.539
			Std Dev:		0.056			Std Dev:		0.106	Std Dev:	0.054
	OF1	90	1	95	1.620	HF2	90	1	95	0.440		1.030
				96	1.960				96	0.520		1.240
				97	2.430				97	0.250		1.340
				98	2.620				98	0.360		1.490
				99	1.550				99	0.470		1.010
			Avg:		2.036			Avg:		0.408	Avg:	1.222
			Std Dev:		0.477			Std Dev:		0.106	Std Dev:	0.205
	OF1	90	2	95	1.510	HF2	90	2	95	0.460		0.985
				96	1.560				96	0.670		1.115
				97	2.020				97	0.430		1.225
				98	3.100				98	0.450		1.775
				99	1.870				99	0.410		1.140
			Avg:		2.012			Avg:		0.484	Avg:	1.248
			Std Dev:		0.644			Std Dev:		0.106	Std Dev:	0.307
B	OF2	0	1	95	0.410	HF1	0	1	95	0.420		0.415
				96	0.460				96	0.460		0.460
				97	0.570				97	0.570		0.570
				98	0.650				98	0.570		0.610
				99	0.690				99	0.380		0.535
			Avg:		0.556			Avg:		0.480	Avg:	0.518
			Std Dev:		0.120			Std Dev:		0.087	Std Dev:	0.080
	OF2	0	2	95	0.400	HF1	0	2	95	0.700		0.550
				96	0.340				96	0.640		0.490
				97	0.410				97	0.650		0.530
				98	0.350				98	0.540		0.445
				99	0.810				99	0.800		0.805
			Avg:		0.462			Avg:		0.666	Avg:	0.564
			Std Dev:		0.197			Std Dev:		0.095	Std Dev:	0.141
	OF2	90	1	95	1.560	HF1	90	1	95	1.950		1.755
				96	1.470				96	2.350		1.910
				97	4.220				97	3.150		3.685
				98	3.240				98	1.050		2.145
				99	0.950				99	1.450		1.200
			Avg:		2.288			Avg:		1.990	Avg:	2.139
			Std Dev:		1.381			Std Dev:		0.814	Std Dev:	0.932
	OF2	90	2	95	1.060	HF1	90	2	95	1.870		1.465
				96	1.070				96	2.950		2.010
				97	1.420				97	2.860		2.140
				98	1.170				98	2.190		1.680
				99	1.270				99	2.160		1.715
			Avg:		1.198			Avg:		2.406	Avg:	1.802
			Std Dev:		0.151			Std Dev:		0.473	Std Dev:	0.271

Mix Type=	37.5 mm
Diam.=	4.00 in
Gage Length=	2.0 in
Total	

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.480	HF2	0	1	95	0.540		0.510
				96	0.590				96	0.560		0.575
				97	0.610				97	0.700		0.655
				98	0.430				98	0.630		0.530
				99	0.400				99	0.680		0.540
			Avg:		0.502			Avg:		0.622	Avg:	0.562
			Std Dev:		0.094			Std Dev:		0.071	Std Dev:	0.057
	OF1	0	2	95	0.660	HF2	0	2	95	0.830		0.745
				96	0.550				96	0.890		0.720
				97	0.470				97	0.780		0.625
				98	0.590				98	0.680		0.635
				99	0.660				99	0.750		0.705
			Avg:		0.586			Avg:		0.766	Avg:	0.686
			Std Dev:		0.080			Std Dev:		0.080	Std Dev:	0.053
	OF1	90	1	95	0.420	HF2	90	1	95	0.150		0.285
				96	0.380				96	0.140		0.260
				97	0.350				97	0.060		0.205
				98	0.360				98	0.100		0.230
				99	0.430				99	0.180		0.305
			Avg:		0.388			Avg:		0.126	Avg:	0.257
			Std Dev:		0.036			Std Dev:		0.047	Std Dev:	0.040
	OF1	90	2	95	0.420	HF2	90	2	95	0.350		0.385
				96	0.420				96	0.250		0.335
				97	0.420				97	0.220		0.320
				98	0.420				98	0.300		0.360
				99	0.400				99	0.330		0.365
			Avg:		0.416			Avg:		0.290	Avg:	0.353
			Std Dev:		0.009			Std Dev:		0.054	Std Dev:	0.026
B	OF2	0	1	95	0.540	HF1	0	1	95	0.700		0.620
				96	0.640				96	0.740		0.690
				97	0.590				97	0.550		0.570
				98	0.580				98	0.520		0.550
				99	0.620				99	0.650		0.635
			Avg:		0.594			Avg:		0.632	Avg:	0.613
			Std Dev:		0.038			Std Dev:		0.095	Std Dev:	0.055
	OF2	0	2	95	0.570	HF1	0	2	95	0.590		0.580
				96	0.610				96	0.710		0.660
				97	0.620				97	0.690		0.655
				98	0.490				98	0.610		0.550
				99	0.590				99	0.560		0.575
			Avg:		0.576			Avg:		0.632	Avg:	0.604
			Std Dev:		0.052			Std Dev:		0.065	Std Dev:	0.050
	OF2	90	1	95	0.150	HF1	90	1	95	0.840		0.495
				96	0.110				96	0.800		0.455
				97	0.090				97	0.930		0.510
				98	0.100				98	1.100		0.600
				99	0.170				99	0.880		0.525
			Avg:		0.124			Avg:		0.910	Avg:	0.517
			Std Dev:		0.034			Std Dev:		0.117	Std Dev:	0.053
	OF2	90	2	95	0.150	HF1	90	2	95	0.770		0.460
				96	0.210				96	0.730		0.470
				97	0.210				97	0.820		0.515
				98	0.160				98	0.690		0.425
				99	0.120				99	0.800		0.460
			Avg:		0.170			Avg:		0.762	Avg:	0.466
			Std Dev:		0.039			Std Dev:		0.053	Std Dev:	0.032

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.350	HF2	0	1	95	0.410		0.380
				96	0.310				96	0.440		0.375
				97	0.260				97	0.450		0.355
				98	0.310				98	0.450		0.380
				99	0.300				99	0.460		0.380
			Avg:		0.306			Avg:		0.442	Avg:	0.374
			Std Dev:		0.032			Std Dev:		0.019	Std Dev:	0.011
	OF1	0	2	95	0.220	HF2	0	2	95	0.480		0.350
				96	0.270				96	0.450		0.360
				97	0.280				97	0.440		0.360
				98	0.260				98	0.390		0.325
				99	0.330				99	0.460		0.395
			Avg:		0.272			Avg:		0.444	Avg:	0.358
			Std Dev:		0.040			Std Dev:		0.034	Std Dev:	0.025
	OF1	90	1	95	0.290	HF2	90	1	95	0.490		0.390
				96	0.240				96	0.510		0.375
				97	0.270				97	0.500		0.385
				98	0.300				98	0.600		0.450
				99	0.310				99	0.480		0.395
			Avg:		0.282			Avg:		0.516	Avg:	0.399
			Std Dev:		0.028			Std Dev:		0.048	Std Dev:	0.029
	OF1	90	2	95	0.310	HF2	90	2	95	0.580		0.445
				96	0.330				96	0.740		0.535
				97	0.330				97	0.650		0.490
				98	0.360				98	0.690		0.525
				99	0.340				99	0.740		0.540
			Avg:		0.334			Avg:		0.680	Avg:	0.507
			Std Dev:		0.018			Std Dev:		0.067	Std Dev:	0.040
B	OF2	0	1	95	0.350	HF1	0	1	95	0.220		0.285
				96	0.100				96	0.220		0.160
				97	0.690				97	0.140		0.415
				98	0.320				98	0.190		0.255
				99	0.350				99	0.210		0.280
			Avg:		0.362			Avg:		0.196	Avg:	0.279
			Std Dev:		0.211			Std Dev:		0.034	Std Dev:	0.091
	OF2	0	2	95	0.240	HF1	0	2	95	0.330		0.285
				96	0.330				96	0.330		0.330
				97	0.370				97	0.400		0.385
				98	0.350				98	0.340		0.345
				99	0.370				99	0.380		0.375
			Avg:		0.332			Avg:		0.356	Avg:	0.344
			Std Dev:		0.054			Std Dev:		0.032	Std Dev:	0.040
	OF2	90	1	95	0.390	HF1	90	1	95	0.290		0.340
				96	0.420				96	0.230		0.325
				97	0.370				97	0.260		0.315
				98	0.510				98	0.290		0.400
				99	0.530				99	0.310		0.420
			Avg:		0.444			Avg:		0.276	Avg:	0.360
			Std Dev:		0.072			Std Dev:		0.031	Std Dev:	0.047
	OF2	90	2	95	0.520	HF1	90	2	95	0.240		0.380
				96	0.550				96	0.240		0.395
				97	0.600				97	0.280		0.440
				98	0.450				98	0.270		0.360
				99	0.500				99	0.280		0.390
			Avg:		0.524			Avg:		0.262	Avg:	0.393
			Std Dev:		0.056			Std Dev:		0.020	Std Dev:	0.029

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 1.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.850	HF2	0	1	95	0.850		0.850
				96	0.470				96	0.730		0.600
				97	1.290				97	0.720		1.005
				98	0.860				98	0.630		0.745
				99	0.710				99	0.510		0.610
			Avg:		0.836			Avg:		0.688	Avg:	0.762
			Std Dev:		0.299			Std Dev:		0.127	Std Dev:	0.171
	OF1	0	2	95	0.680	HF2	0	2	95	1.120		0.900
				96	0.570				96	0.710		0.640
				97	2.280				97	0.940		1.610
				98	1.290				98	1.080		1.185
				99	1.440				99	0.810		1.125
			Avg:		1.252			Avg:		0.932	Avg:	1.092
			Std Dev:		0.687			Std Dev:		0.174	Std Dev:	0.360
	OF1	90	1	95	0.200	HF2	90	1	95	0.210		0.205
				96	0.220				96	0.250		0.235
				97	0.220				97	0.050		0.135
				98	0.180				98	0.200		0.190
				99	0.210				99	0.200		0.205
			Avg:		0.206			Avg:		0.182	Avg:	0.194
			Std Dev:		0.017			Std Dev:		0.077	Std Dev:	0.037
	OF1	90	2	95	0.190	HF2	90	2	95	0.130		0.160
				96	0.180				96	0.190		0.185
				97	0.180				97	0.220		0.200
				98	0.210				98	0.140		0.175
				99	0.180				99	0.220		0.200
			Avg:		0.188			Avg:		0.180	Avg:	0.184
			Std Dev:		0.013			Std Dev:		0.043	Std Dev:	0.017
C	OF2	0	1	95	0.730	HF1	0	1	95	0.670		0.700
				96	0.680				96	0.700		0.690
				97	0.750				97	0.670		0.710
				98	0.530				98	0.630		0.580
				99	0.660				99	0.640		0.650
			Avg:		0.670			Avg:		0.662	Avg:	0.666
			Std Dev:		0.086			Std Dev:		0.028	Std Dev:	0.053
	OF2	0	2	95	0.560	HF1	0	2	95	0.920		0.740
				96	0.920				96	0.710		0.815
				97	1.280				97	0.890		1.085
				98	1.110				98	0.710		0.910
				99	0.670				99	0.580		0.625
			Avg:		0.908			Avg:		0.762	Avg:	0.835
			Std Dev:		0.299			Std Dev:		0.141	Std Dev:	0.174
	OF2	90	1	95	0.230	HF1	90	1	95	0.170		0.200
				96	0.190				96	0.140		0.165
				97	0.120				97	0.160		0.140
				98	0.020				98	0.180		0.100
				99	0.210				99	0.180		0.195
			Avg:		0.154			Avg:		0.166	Avg:	0.160
			Std Dev:		0.086			Std Dev:		0.017	Std Dev:	0.041
	OF2	90	2	95	0.060	HF1	90	2	95	0.190		0.125
				96	0.200				96	0.160		0.180
				97	0.250				97	0.130		0.190
				98	0.180				98	0.170		0.175
				99	0.070				99	0.160		0.115
			Avg:		0.152			Avg:		0.162	Avg:	0.157
			Std Dev:		0.083			Std Dev:		0.022	Std Dev:	0.034

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 2.0 in
Total

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
C	OF1	0	1	95	1.810	HF2	0	1	95	0.660		1.235
				96	1.860				96	0.610		1.235
				97	2.000				97	0.570		1.285
				98	1.950				98	0.680		1.315
				99	1.770				99	0.600		1.185
			Avg:		1.878			Avg:		0.624	Avg:	1.251
			Std Dev:		0.096			Std Dev:		0.045	Std Dev:	0.050
	OF1	0	2	95	2.210	HF2	0	2	95	0.570		1.390
				96	2.340				96	0.600		1.470
				97	1.940				97	0.620		1.280
				98	2.090				98	0.650		1.370
				99	2.050				99	0.580		1.315
			Avg:		2.126			Avg:		0.604	Avg:	1.365
			Std Dev:		0.154			Std Dev:		0.032	Std Dev:	0.073
	OF1	90	1	95	0.200	HF2	90	1	95	0.780		0.490
				96	0.190				96	0.710		0.450
				97	0.200				97	0.690		0.445
				98	0.220				98	0.770		0.495
				99	0.160				99	0.680		0.420
			Avg:		0.194			Avg:		0.726	Avg:	0.460
			Std Dev:		0.022			Std Dev:		0.046	Std Dev:	0.032
	OF1	90	2	95	0.230	HF2	90	2	95	0.590		0.410
				96	0.240				96	0.600		0.420
				97	0.200				97	0.700		0.450
				98	0.200				98	0.660		0.430
				99	0.240				99	0.590		0.415
			Avg:		0.222			Avg:		0.628	Avg:	0.425
			Std Dev:		0.020			Std Dev:		0.050	Std Dev:	0.016
C	OF2	0	1	95	0.490	HF1	0	1	95	1.250		0.870
				96	0.530				96	1.020		0.775
				97	0.620				97	1.070		0.845
				98	0.570				98	1.110		0.840
				99	0.550				99	1.020		0.785
			Avg:		0.552			Avg:		1.094	Avg:	0.823
			Std Dev:		0.048			Std Dev:		0.095	Std Dev:	0.041
	OF2	0	2	95	0.450	HF1	0	2	95	1.290		0.870
				96	0.410				96	0.980		0.695
				97	0.390				97	1.150		0.770
				98	0.510				98	1.360		0.935
				99	0.560				99	0.870		0.715
			Avg:		0.464			Avg:		1.130	Avg:	0.797
			Std Dev:		0.071			Std Dev:		0.206	Std Dev:	0.103
	OF2	90	1	95	0.850	HF1	90	1	95	0.420		0.635
				96	0.830				96	0.440		0.635
				97	0.900				97	0.500		0.700
				98	1.050				98	0.420		0.735
				99	0.940				99	0.430		0.685
			Avg:		0.914			Avg:		0.442	Avg:	0.678
			Std Dev:		0.087			Std Dev:		0.033	Std Dev:	0.043
	OF2	90	2	95	1.040	HF1	90	2	95	0.500		0.770
				96	1.160				96	0.430		0.795
				97	1.030				97	0.490		0.760
				98	0.990				98	0.490		0.740
				99	0.990				99	0.440		0.715
			Avg:		1.042			Avg:		0.470	Avg:	0.756
			Std Dev:		0.070			Std Dev:		0.032	Std Dev:	0.030

Mix Type= 37.5 mm
Diam.= 4.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	1.610	HF2	0	1	95	0.630		1.120
				96	1.500				96	0.580		1.040
				97	1.560				97	0.590		1.075
				98	1.410				98	0.490		0.950
				99	1.890				99	0.620		1.255
			Avg:		1.594			Avg:		0.582	Avg:	1.088
			Std Dev:		0.181			Std Dev:		0.055	Std Dev:	0.112
	OF1	0	2	95	1.390	HF2	0	2	95	0.670		1.030
				96	1.560				96	0.620		1.090
				97	1.270				97	0.560		0.915
				98	1.610				98	0.570		1.090
				99	1.280				99	0.720		1.000
			Avg:		1.422			Avg:		0.628	Avg:	1.025
			Std Dev:		0.157			Std Dev:		0.068	Std Dev:	0.073
	OF1	90	1	95	0.210	HF2	90	1	95	0.490		0.350
				96	0.210				96	0.490		0.350
				97	0.220				97	0.490		0.355
				98	0.210				98	0.570		0.390
				99	0.210				99	0.560		0.385
			Avg:		0.212			Avg:		0.520	Avg:	0.366
			Std Dev:		0.004			Std Dev:		0.041	Std Dev:	0.020
	OF1	90	2	95	0.260	HF2	90	2	95	0.600		0.430
				96	0.300				96	0.600		0.450
				97	0.280				97	0.580		0.430
				98	0.320				98	0.550		0.435
				99	0.290				99	0.610		0.450
			Avg:		0.290			Avg:		0.588	Avg:	0.439
			Std Dev:		0.022			Std Dev:		0.024	Std Dev:	0.010
C	OF2	0	1	95	0.770	HF1	0	1	95	1.070		0.920
				96	0.720				96	1.020		0.870
				97	0.760				97	1.060		0.910
				98	0.780				98	1.080		0.930
				99	0.750				99	1.050		0.900
			Avg:		0.756			Avg:		1.056	Avg:	0.906
			Std Dev:		0.023			Std Dev:		0.023	Std Dev:	0.023
	OF2	0	2	95	0.800	HF1	0	2	95	0.700		0.750
				96	0.820				96	0.670		0.745
				97	0.830				97	0.960		0.895
				98	0.810				98	0.820		0.815
				99	0.780				99	0.860		0.820
			Avg:		0.808			Avg:		0.802	Avg:	0.805
			Std Dev:		0.019			Std Dev:		0.119	Std Dev:	0.061
	OF2	90	1	95	0.590	HF1	90	1	95	0.420		0.505
				96	0.480				96	0.380		0.430
				97	0.570				97	0.370		0.470
				98	0.520				98	0.340		0.430
				99	0.540				99	0.410		0.475
			Avg:		0.540			Avg:		0.384	Avg:	0.462
			Std Dev:		0.043			Std Dev:		0.032	Std Dev:	0.032
	OF2	90	2	95	0.680	HF1	90	2	95	0.390		0.535
				96	0.620				96	0.390		0.505
				97	0.770				97	0.410		0.590
				98	0.610				98	0.380		0.495
				99	0.710				99	0.460		0.585
			Avg:		0.678			Avg:		0.406	Avg:	0.542
			Std Dev:		0.066			Std Dev:		0.032	Std Dev:	0.044

Annex 22

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Total

12.5 mm
6 inch Dia.

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 1.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.380	HF2	0	1	95	0.350		0.365
				96	0.420				96	0.300		0.360
				97	0.450				97	0.250		0.350
				98	0.290				98	0.310		0.300
				99	0.340				99	0.320		0.330
			Avg:		0.376			Avg:		0.306	Avg:	0.341
			Std Dev:		0.063			Std Dev:		0.036	Std Dev:	0.027
	OF1	0	2	95	0.430	HF2	0	2	95	0.270		0.350
				96	0.470				96	0.350		0.410
				97	0.430				97	0.300		0.365
				98	0.280				98	0.300		0.290
				99	0.440				99	0.350		0.395
			Avg:		0.410			Avg:		0.314	Avg:	0.362
			Std Dev:		0.074			Std Dev:		0.035	Std Dev:	0.047
	OF1	90	1	95	0.640	HF2	90	1	95	0.470		0.555
				96	0.540				96	0.660		0.600
				97	0.460				97	0.460		0.460
				98	0.380				98	0.530		0.455
				99	0.430				99	0.570		0.500
			Avg:		0.490			Avg:		0.538	Avg:	0.514
			Std Dev:		0.102			Std Dev:		0.082	Std Dev:	0.063
	OF1	90	2	95	0.520	HF2	90	2	95	0.600		0.560
				96	0.530				96	0.530		0.530
				97	0.550				97	0.590		0.570
				98	0.680				98	0.560		0.620
				99	0.530				99	0.420		0.475
			Avg:		0.562			Avg:		0.540	Avg:	0.551
			Std Dev:		0.067			Std Dev:		0.072	Std Dev:	0.053
A	OF2	0	1	95	0.310	HF1	0	1	95	0.290		0.300
				96	0.280				96	0.340		0.310
				97	0.260				97	0.320		0.290
				98	0.320				98	0.270		0.295
				99	0.240				99	0.260		0.250
			Avg:		0.282			Avg:		0.296	Avg:	0.289
			Std Dev:		0.033			Std Dev:		0.034	Std Dev:	0.023
	OF2	0	2	95	0.310	HF1	0	2	95	0.380		0.345
				96	0.320				96	0.440		0.380
				97	0.330				97	0.440		0.385
				98	0.300				98	0.420		0.360
				99	0.310				99	0.250		0.280
			Avg:		0.314			Avg:		0.386	Avg:	0.350
			Std Dev:		0.011			Std Dev:		0.080	Std Dev:	0.042
	OF2	90	1	95	0.430	HF1	90	1	95	0.650		0.540
				96	0.380				96	0.670		0.525
				97	0.540				97	0.720		0.630
				98	0.610				98	0.600		0.605
				99	0.400				99	0.560		0.480
			Avg:		0.472			Avg:		0.640	Avg:	0.556
			Std Dev:		0.099			Std Dev:		0.062	Std Dev:	0.061
	OF2	90	2	95	0.530	HF1	90	2	95	0.540		0.535
				96	0.410				96	0.590		0.500
				97	0.420				97	0.620		0.520
				98	0.570				98	0.690		0.630
				99	0.340				99	0.700		0.520
			Avg:		0.454			Avg:		0.628	Avg:	0.541
			Std Dev:		0.094			Std Dev:		0.068	Std Dev:	0.051

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.340	HF2	0	1	95	0.460		0.400
				96	0.410				96	0.550		0.480
				97	0.300				97	0.450		0.375
				98	0.380				98	0.570		0.475
				99	0.390				99	0.540		0.465
			Avg:		0.364			Avg:		0.514	Avg:	0.439
			Std Dev:		0.044			Std Dev:		0.055	Std Dev:	0.048
	OF1	0	2	95	0.370	HF2	0	2	95	0.590		0.480
				96	0.270				96	0.450		0.360
				97	0.380				97	0.600		0.490
				98	0.360				98	0.490		0.425
				99	0.310				99	0.580		0.445
			Avg:		0.338			Avg:		0.542	Avg:	0.440
			Std Dev:		0.047			Std Dev:		0.068	Std Dev:	0.052
	OF1	90	1	95	0.440	HF2	90	1	95	0.470		0.455
				96	0.450				96	0.410		0.430
				97	0.440				97	0.480		0.460
				98	0.430				98	0.420		0.425
				99	0.400				99	0.440		0.420
			Avg:		0.432			Avg:		0.444	Avg:	0.438
			Std Dev:		0.019			Std Dev:		0.030	Std Dev:	0.018
	OF1	90	2	95	0.430	HF2	90	2	95	0.480		0.455
				96	0.420				96	0.520		0.470
				97	0.450				97	0.450		0.450
				98	0.430				98	0.490		0.460
				99	0.430				99	0.460		0.445
			Avg:		0.432			Avg:		0.480	Avg:	0.456
			Std Dev:		0.011			Std Dev:		0.027	Std Dev:	0.010
A	OF2	0	1	95	0.590	HF1	0	1	95	0.360		0.475
				96	0.500				96	0.410		0.455
				97	0.560				97	0.430		0.495
				98	0.460				98	0.330		0.395
				99	0.500				99	0.380		0.440
			Avg:		0.522			Avg:		0.382	Avg:	0.452
			Std Dev:		0.052			Std Dev:		0.040	Std Dev:	0.038
	OF2	0	2	95	0.550	HF1	0	2	95	0.370		0.460
				96	0.510				96	0.380		0.445
				97	0.530				97	0.430		0.480
				98	0.590				98	0.370		0.480
				99	0.580				99	0.440		0.510
			Avg:		0.552			Avg:		0.398	Avg:	0.475
			Std Dev:		0.033			Std Dev:		0.034	Std Dev:	0.024
	OF2	90	1	95	0.490	HF1	90	1	95	0.430		0.460
				96	0.440				96	0.430		0.435
				97	0.480				97	0.440		0.460
				98	0.460				98	0.420		0.440
				99	0.440				99	0.430		0.435
			Avg:		0.462			Avg:		0.430	Avg:	0.446
			Std Dev:		0.023			Std Dev:		0.007	Std Dev:	0.013
	OF2	90	2	95	0.440	HF1	90	2	95	0.480		0.460
				96	0.410				96	0.440		0.425
				97	0.440				97	0.440		0.440
				98	0.410				98	0.440		0.425
				99	0.490				99	0.490		0.490
			Avg:		0.438			Avg:		0.458	Avg:	0.448
			Std Dev:		0.033			Std Dev:		0.025	Std Dev:	0.028

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 4.5 in
Total

Poissons Ratio Analysis

Specimen	*Observable Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*	*Hidden Face*	*Rotation Effect*	*Repeat*	*Cycle*	*u-Ratio*		*U-Ratio (Avg)*
A	OF1	0	1	95	0.440	HF2	0	1	95	0.370		0.405
				96	0.480				96	0.380		0.430
				97	0.480				97	0.320		0.400
				98	0.530				98	0.360		0.445
				99	0.420				99	0.370		0.395
			Avg:		0.470			Avg:		0.360	Avg:	0.415
			Std Dev:		0.042			Std Dev:		0.023	Std Dev:	0.022
	OF1	0	2	95	0.440	HF2	0	2	95	0.400		0.420
				96	0.410				96	0.290		0.350
				97	0.420				97	0.420		0.420
				98	0.440				98	0.300		0.370
				99	0.420				99	0.360		0.390
			Avg:		0.426			Avg:		0.354	Avg:	0.390
			Std Dev:		0.013			Std Dev:		0.058	Std Dev:	0.031
	OF1	90	1	95	0.470	HF2	90	1	95	0.530		0.500
				96	0.470				96	0.560		0.515
				97	0.480				97	0.550		0.515
				98	0.450				98	0.480		0.465
				99	0.460				99	0.500		0.480
			Avg:		0.466			Avg:		0.524	Avg:	0.495
			Std Dev:		0.011			Std Dev:		0.034	Std Dev:	0.022
	OF1	90	2	95	0.450	HF2	90	2	95	0.600		0.525
				96	0.420				96	0.570		0.495
				97	0.430				97	0.520		0.475
				98	0.450				98	0.570		0.510
				99	0.440				99	0.530		0.485
			Avg:		0.438			Avg:		0.558	Avg:	0.498
			Std Dev:		0.013			Std Dev:		0.033	Std Dev:	0.020
A	OF2	0	1	95	0.370	HF1	0	1	95	0.510		0.440
				96	0.310				96	0.510		0.410
				97	0.370				97	0.560		0.465
				98	0.370				98	0.470		0.420
				99	0.320				99	0.460		0.390
			Avg:		0.348			Avg:		0.502	Avg:	0.425
			Std Dev:		0.030			Std Dev:		0.040	Std Dev:	0.029
	OF2	0	2	95	0.320	HF1	0	2	95	0.440		0.380
				96	0.350				96	0.530		0.440
				97	0.380				97	0.530		0.455
				98	0.350				98	0.590		0.470
				99	0.350				99	0.520		0.435
			Avg:		0.350			Avg:		0.522	Avg:	0.436
			Std Dev:		0.021			Std Dev:		0.054	Std Dev:	0.034
	OF2	90	1	95	0.590	HF1	90	1	95	0.410		0.500
				96	0.540				96	0.410		0.475
				97	0.660				97	0.430		0.545
				98	0.640				98	0.390		0.515
				99	0.570				99	0.420		0.495
			Avg:		0.600			Avg:		0.412	Avg:	0.506
			Std Dev:		0.049			Std Dev:		0.015	Std Dev:	0.026
	OF2	90	2	95	0.600	HF1	90	2	95	0.430		0.515
				96	0.670				96	0.430		0.550
				97	0.610				97	0.440		0.525
				98	0.600				98	0.420		0.510
				99	0.510				99	0.420		0.465
			Avg:		0.598			Avg:		0.428	Avg:	0.513
			Std Dev:		0.057			Std Dev:		0.008	Std Dev:	0.031

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 1.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.780	HF2	0	1	95	0.450		0.615
				96	0.760				96	0.590		0.675
				97	0.640				97	0.830		0.735
				98	0.520				98	0.700		0.610
				99	0.730				99	0.570		0.650
			Avg:		0.686			Avg:		0.628	Avg:	0.657
			Std Dev:		0.107			Std Dev:		0.144	Std Dev:	0.051
	OF1	0	2	95	0.590	HF2	0	2	95	0.820		0.705
				96	0.580				96	0.720		0.650
				97	0.630				97	0.720		0.675
				98	0.820				98	0.760		0.790
				99	0.630				99	0.680		0.655
			Avg:		0.650			Avg:		0.740	Avg:	0.695
			Std Dev:		0.098			Std Dev:		0.053	Std Dev:	0.057
	OF1	90	1	95	0.620	HF2	90	1	95	0.520		0.570
				96	0.570				96	0.410		0.490
				97	0.500				97	0.420		0.460
				98	0.390				98	0.320		0.355
				99	0.600				99	0.380		0.490
			Avg:		0.536			Avg:		0.410	Avg:	0.473
			Std Dev:		0.093			Std Dev:		0.073	Std Dev:	0.078
	OF1	90	2	95	0.440	HF2	90	2	95	0.330		0.385
				96	0.420				96	0.420		0.420
				97	0.390				97	0.290		0.340
				98	0.410				98	0.230		0.320
				99	0.510				99	0.480		0.495
			Avg:		0.434			Avg:		0.350	Avg:	0.392
			Std Dev:		0.046			Std Dev:		0.100	Std Dev:	0.070
B	OF2	0	1	95	0.740	HF1	0	1	95	0.620		0.680
				96	0.460				96	0.740		0.600
				97	0.560				97	0.700		0.630
				98	0.640				98	0.800		0.720
				99	0.610				99	0.550		0.580
			Avg:		0.602			Avg:		0.682	Avg:	0.642
			Std Dev:		0.103			Std Dev:		0.099	Std Dev:	0.058
	OF2	0	2	95	0.480	HF1	0	2	95	0.710		0.595
				96	0.460				96	0.550		0.505
				97	0.690				97	0.620		0.655
				98	0.650				98	0.660		0.655
				99	0.490				99	0.730		0.610
			Avg:		0.554			Avg:		0.654	Avg:	0.604
			Std Dev:		0.107			Std Dev:		0.072	Std Dev:	0.061
	OF2	90	1	95	0.520	HF1	90	1	95	0.390		0.455
				96	0.390				96	0.410		0.400
				97	0.530				97	0.460		0.495
				98	0.470				98	0.520		0.495
				99	0.470				99	0.580		0.525
			Avg:		0.476			Avg:		0.472	Avg:	0.474
			Std Dev:		0.055			Std Dev:		0.079	Std Dev:	0.048
	OF2	90	2	95	0.430	HF1	90	2	95	0.590		0.510
				96	0.350				96	0.660		0.505
				97	0.580				97	0.610		0.595
				98	0.460				98	0.550		0.505
				99	0.320				99	0.450		0.385
			Avg:		0.428			Avg:		0.572	Avg:	0.500
			Std Dev:		0.102			Std Dev:		0.079	Std Dev:	0.075

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.480	HF2	0	1	95	0.540		0.510
				96	0.410				96	0.430		0.420
				97	0.510				97	0.530		0.520
				98	0.480				98	0.450		0.465
				99	0.470				99	0.440		0.455
			Avg:		0.470			Avg:		0.478	Avg:	0.474
			Std Dev:		0.037			Std Dev:		0.053	Std Dev:	0.041
	OF1	0	2	95	0.510	HF2	0	2	95	0.520		0.515
				96	0.530				96	0.570		0.550
				97	0.460				97	0.520		0.490
				98	0.490				98	0.460		0.475
				99	0.500				99	0.500		0.500
			Avg:		0.498			Avg:		0.514	Avg:	0.506
			Std Dev:		0.026			Std Dev:		0.040	Std Dev:	0.029
	OF1	90	1	95	0.490	HF2	90	1	95	0.020		0.255
				96	0.450				96	0.050		0.250
				97	0.440				97	0.030		0.235
				98	0.440				98	0.020		0.230
				99	0.430				99	0.050		0.240
			Avg:		0.450			Avg:		0.034	Avg:	0.242
			Std Dev:		0.023			Std Dev:		0.015	Std Dev:	0.010
	OF1	90	2	95	0.500	HF2	90	2	95	0.060		0.280
				96	0.460				96	0.070		0.265
				97	0.470				97	0.090		0.280
				98	0.440				98	0.040		0.240
				99	0.470				99	0.050		0.260
			Avg:		0.468			Avg:		0.062	Avg:	0.265
			Std Dev:		0.022			Std Dev:		0.019	Std Dev:	0.017
B	OF2	0	1	95	0.050	HF1	0	1	95	0.390		0.220
				96	0.070				96	0.380		0.225
				97	0.060				97	0.400		0.230
				98	0.010				98	0.430		0.220
				99	0.070				99	0.390		0.230
			Avg:		0.052			Avg:		0.398	Avg:	0.225
			Std Dev:		0.025			Std Dev:		0.019	Std Dev:	0.005
	OF2	0	2	95	0.470	HF1	0	2	95	0.600		0.535
				96	0.410				96	0.540		0.475
				97	0.480				97	0.580		0.530
				98	0.430				98	0.410		0.420
				99	0.530				99	0.570		0.550
			Avg:		0.464			Avg:		0.540	Avg:	0.502
			Std Dev:		0.047			Std Dev:		0.076	Std Dev:	0.054
	OF2	90	1	95	0.050	HF1	90	1	95	0.390		0.220
				96	0.070				96	0.380		0.225
				97	0.060				97	0.400		0.230
				98	0.010				98	0.430		0.220
				99	0.070				99	0.390		0.230
			Avg:		0.052			Avg:		0.398	Avg:	0.225
			Std Dev:		0.025			Std Dev:		0.019	Std Dev:	0.005
	OF2	90	2	95	0.470	HF1	90	2	95	0.600		0.535
				96	0.410				96	0.540		0.475
				97	0.480				97	0.580		0.530
				98	0.430				98	0.410		0.420
				99	0.430				99	0.570		0.500
			Avg:		0.444			Avg:		0.540	Avg:	0.492
			Std Dev:		0.030			Std Dev:		0.076	Std Dev:	0.047

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 4.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.520	HF2	0	1	95	0.450		0.485
				96	0.510				96	0.420		0.465
				97	0.540				97	0.370		0.455
				98	0.530				98	0.420		0.475
				99	0.520				99	0.410		0.465
			Avg:		0.524			Avg:		0.414	Avg:	0.469
			Std Dev:		0.011			Std Dev:		0.029	Std Dev:	0.011
	OF1	0	2	95	0.600	HF2	0	2	95	0.370		0.485
				96	0.600				96	0.440		0.520
				97	0.560				97	0.380		0.470
				98	0.520				98	0.380		0.450
				99	0.570				99	0.390		0.480
			Avg:		0.570			Avg:		0.392	Avg:	0.481
			Std Dev:		0.033			Std Dev:		0.028	Std Dev:	0.026
	OF1	90	1	95	0.460	HF2	90	1	95	0.400		0.430
				96	0.450				96	0.450		0.450
				97	0.480				97	0.440		0.460
				98	0.480				98	0.340		0.410
				99	0.450				99	0.400		0.425
			Avg:		0.464			Avg:		0.406	Avg:	0.435
			Std Dev:		0.015			Std Dev:		0.043	Std Dev:	0.020
	OF1	90	2	95	0.540	HF2	90	2	95	0.420		0.480
				96	0.520				96	0.380		0.450
				97	0.510				97	0.340		0.425
				98	0.510				98	0.440		0.475
				99	0.520				99	0.480		0.500
			Avg:		0.520			Avg:		0.412	Avg:	0.466
			Std Dev:		0.012			Std Dev:		0.054	Std Dev:	0.029
B	OF2	0	1	95	0.420	HF1	0	1	95	0.450		0.435
				96	0.460				96	0.420		0.440
				97	0.430				97	0.470		0.450
				98	0.380				98	0.490		0.435
				99	0.440				99	0.470		0.455
			Avg:		0.426			Avg:		0.460	Avg:	0.443
			Std Dev:		0.030			Std Dev:		0.026	Std Dev:	0.009
	OF2	0	2	95	0.460	HF1	0	2	95	0.460		0.460
				96	0.380				96	0.480		0.430
				97	0.420				97	0.490		0.455
				98	0.430				98	0.500		0.465
				99	0.430				99	0.540		0.485
			Avg:		0.424			Avg:		0.494	Avg:	0.459
			Std Dev:		0.029			Std Dev:		0.030	Std Dev:	0.020
	OF2	90	1	95	0.360	HF1	90	1	95	0.430		0.395
				96	0.380				96	0.430		0.405
				97	0.420				97	0.420		0.420
				98	0.430				98	0.440		0.435
				99	0.460				99	0.410		0.435
			Avg:		0.410			Avg:		0.426	Avg:	0.418
			Std Dev:		0.040			Std Dev:		0.011	Std Dev:	0.018
	OF2	90	2	95	0.390	HF1	90	2	95	0.500		0.445
				96	0.500				96	0.520		0.510
				97	0.430				97	0.490		0.460
				98	0.470				98	0.490		0.480
				99	0.490				99	0.480		0.485
			Avg:		0.456			Avg:		0.496	Avg:	0.476
			Std Dev:		0.046			Std Dev:		0.015	Std Dev:	0.025

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 1.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.160	HF2	0	1	95	0.180		0.170
				96	0.090				96	0.130		0.110
				97	0.060				97	0.190		0.125
				98	0.090				98	0.170		0.130
				99	0.050				99	0.180		0.115
			Avg:		0.090			Avg:		0.170	Avg:	0.130
			Std Dev:		0.043			Std Dev:		0.023	Std Dev:	0.024
	OF1	0	2	95	0.180	HF2	0	2	95	0.100		0.140
				96	0.130				96	0.170		0.150
				97	0.070				97	0.260		0.165
				98	0.070				98	0.180		0.125
				99	0.070				99	0.120		0.095
			Avg:		0.104			Avg:		0.166	Avg:	0.135
			Std Dev:		0.050			Std Dev:		0.062	Std Dev:	0.027
	OF1	90	1	95	0.690	HF2	90	1	95	0.850		0.770
				96	0.620				96	0.610		0.615
				97	0.690				97	0.690		0.690
				98	0.700				98	0.760		0.730
				99	0.850				99	0.670		0.760
			Avg:		0.710			Avg:		0.716	Avg:	0.713
			Std Dev:		0.085			Std Dev:		0.092	Std Dev:	0.063
	OF1	90	2	95	0.840	HF2	90	2	95	0.740		0.790
				96	0.840				96	0.690		0.765
				97	0.950				97	0.670		0.810
				98	0.980				98	0.900		0.940
				99	0.830				99	0.880		0.855
			Avg:		0.888			Avg:		0.776	Avg:	0.832
			Std Dev:		0.071			Std Dev:		0.107	Std Dev:	0.069
C	OF2	0	1	95	0.200	HF1	0	1	95	0.190		0.195
				96	0.260				96	0.180		0.220
				97	0.210				97	0.250		0.230
				98	0.310				98	0.240		0.275
				99	0.320				99	0.230		0.275
			Avg:		0.260			Avg:		0.218	Avg:	0.239
			Std Dev:		0.055			Std Dev:		0.031	Std Dev:	0.035
	OF2	0	2	95	0.190	HF1	0	2	95	0.130		0.160
				96	0.140				96	0.180		0.160
				97	0.230				97	0.230		0.230
				98	0.240				98	0.240		0.240
				99	0.230				99	0.150		0.190
			Avg:		0.206			Avg:		0.186	Avg:	0.196
			Std Dev:		0.042			Std Dev:		0.048	Std Dev:	0.038
	OF2	90	1	95	0.710	HF1	90	1	95	0.820		0.765
				96	0.510				96	0.610		0.560
				97	0.550				97	0.700		0.625
				98	0.760				98	0.720		0.740
				99	0.640				99	1.070		0.855
			Avg:		0.634			Avg:		0.784	Avg:	0.709
			Std Dev:		0.105			Std Dev:		0.176	Std Dev:	0.117
	OF2	90	2	95	0.630	HF1	90	2	95	1.170		0.900
				96	0.440				96	1.170		0.805
				97	0.660				97	1.140		0.900
				98	0.740				98	0.940		0.840
				99	0.490				99	0.750		0.620
			Avg:		0.592			Avg:		1.034	Avg:	0.813
			Std Dev:		0.124			Std Dev:		0.186	Std Dev:	0.115

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 3.00 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.560	HF2	0	1	95	0.570		0.565
				96	0.530				96	0.470		0.500
				97	0.570				97	0.550		0.560
				98	0.530				98	0.630		0.580
				99	0.530				99	0.500		0.515
				Avg:	0.544				Avg:	0.544	Avg:	0.544
				Std Dev:	0.019				Std Dev:	0.062	Std Dev:	0.035
	OF1	0	2	95	0.490	HF2	0	2	95	0.600		0.545
				96	0.480				96	0.640		0.560
				97	0.480				97	0.680		0.580
				98	0.420				98	0.540		0.480
				99	0.530				99	0.540		0.535
				Avg:	0.480				Avg:	0.600	Avg:	0.540
				Std Dev:	0.039				Std Dev:	0.062	Std Dev:	0.038
	OF1	90	1	95	0.160	HF2	90	1	95	0.350		0.255
				96	0.150				96	0.300		0.225
				97	0.160				97	0.350		0.255
				98	0.160				98	0.310		0.235
				99	0.170				99	0.270		0.220
				Avg:	0.160				Avg:	0.316	Avg:	0.238
				Std Dev:	0.007				Std Dev:	0.034	Std Dev:	0.016
	OF1	90	2	95	0.170	HF2	90	2	95	0.260		0.215
				96	0.160				96	0.280		0.220
				97	0.150				97	0.220		0.185
				98	0.150				98	0.290		0.220
				99	0.160				99	0.260		0.210
				Avg:	0.158				Avg:	0.262	Avg:	0.210
				Std Dev:	0.008				Std Dev:	0.027	Std Dev:	0.015
C	OF2	0	1	95	0.530	HF1	0	1	95	0.390		0.460
				96	0.550				96	0.510		0.530
				97	0.620				97	0.490		0.555
				98	0.480				98	0.441		0.461
				99	0.590				99	0.520		0.555
				Avg:	0.554				Avg:	0.470	Avg:	0.512
				Std Dev:	0.054				Std Dev:	0.054	Std Dev:	0.048
	OF2	0	2	95	0.620	HF1	0	2	95	0.560		0.590
				96	0.560				96	0.520		0.540
				97	0.530				97	0.480		0.505
				98	0.590				98	0.590		0.590
				99	0.570				99	0.550		0.560
				Avg:	0.574				Avg:	0.540	Avg:	0.557
				Std Dev:	0.034				Std Dev:	0.042	Std Dev:	0.036
	OF2	90	1	95	0.300	HF1	90	1	95	0.200		0.250
				96	0.240				96	0.230		0.235
				97	0.310				97	0.210		0.260
				98	0.230				98	0.210		0.220
				99	0.300				99	0.230		0.265
				Avg:	0.276				Avg:	0.216	Avg:	0.246
				Std Dev:	0.038				Std Dev:	0.013	Std Dev:	0.019
	OF2	90	2	95	0.350	HF1	90	2	95	0.220		0.285
				96	0.250				96	0.190		0.220
				97	0.340				97	0.210		0.275
				98	0.220				98	0.210		0.215
				99	0.300				99	0.240		0.270
				Avg:	0.292				Avg:	0.214	Avg:	0.253
				Std Dev:	0.056				Std Dev:	0.018	Std Dev:	0.033

Mix Type= 12.5mm
Diam.= 6.00 in
Gage Length= 4.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.490	HF2	0	1	95	0.520		0.505
				96	0.480				96	0.550		0.515
				97	0.480				97	0.560		0.520
				98	0.500				98	0.540		0.520
				99	0.490				99	0.480		0.485
			Avg:		0.488			Avg:		0.530	Avg:	0.509
			Std Dev:		0.008			Std Dev:		0.032	Std Dev:	0.015
	OF1	0	2	95	0.500	HF2	0	2	95	0.580		0.540
				96	0.510				96	0.540		0.525
				97	0.520				97	0.530		0.525
				98	0.490				98	0.590		0.540
				99	0.500				99	0.590		0.545
			Avg:		0.504			Avg:		0.566	Avg:	0.535
			Std Dev:		0.011			Std Dev:		0.029	Std Dev:	0.009
	OF1	90	1	95	0.300	HF2	90	1	95	0.390		0.345
				96	0.360				96	0.360		0.360
				97	0.350				97	0.400		0.375
				98	0.360				98	0.450		0.405
				99	0.370				99	0.490		0.430
			Avg:		0.348			Avg:		0.418	Avg:	0.383
			Std Dev:		0.028			Std Dev:		0.052	Std Dev:	0.034
	OF1	90	2	95	0.410	HF2	90	2	95	0.440		0.425
				96	0.400				96	0.440		0.420
				97	0.410				97	0.430		0.420
				98	0.420				98	0.520		0.470
				99	0.370				99	0.480		0.425
			Avg:		0.402			Avg:		0.462	Avg:	0.432
			Std Dev:		0.019			Std Dev:		0.038	Std Dev:	0.021
C	OF2	0	1	95	0.410	HF1	0	1	95	0.450		0.430
				96	0.410				96	0.440		0.425
				97	0.440				97	0.420		0.430
				98	0.460				98	0.400		0.430
				99	0.420				99	0.430		0.425
			Avg:		0.428			Avg:		0.428	Avg:	0.428
			Std Dev:		0.022			Std Dev:		0.019	Std Dev:	0.003
	OF2	0	2	95	0.570	HF1	0	2	95	0.570		0.570
				96	0.550				96	0.570		0.560
				97	0.570				97	0.610		0.590
				98	0.550				98	0.580		0.565
				99	0.490				99	0.590		0.540
			Avg:		0.546			Avg:		0.584	Avg:	0.565
			Std Dev:		0.033			Std Dev:		0.017	Std Dev:	0.018
	OF2	90	1	95	0.500	HF1	90	1	95	0.290		0.395
				96	0.480				96	0.280		0.380
				97	0.460				97	0.290		0.375
				98	0.430				98	0.280		0.355
				99	0.450				99	0.310		0.380
			Avg:		0.464			Avg:		0.290	Avg:	0.377
			Std Dev:		0.027			Std Dev:		0.012	Std Dev:	0.014
	OF2	90	2	95	0.510	HF1	90	2	95	0.390		0.450
				96	0.520				96	0.390		0.455
				97	0.510				97	0.370		0.440
				98	0.540				98	0.340		0.440
				99	0.540				99	0.370		0.455
			Avg:		0.524			Avg:		0.372	Avg:	0.448
			Std Dev:		0.015			Std Dev:		0.020	Std Dev:	0.008

Annex 23

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Total

19.0 mm
6 inch Dia.

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.200	HF2	0	1	95	1.210		0.705
				96	0.250				96	0.650		0.450
				97	0.200				97	0.830		0.515
				98	0.180				98	1.130		0.655
				99	0.180				99	0.850		0.515
			Avg:		0.202			Avg:		0.934	Avg:	0.568
			Std Dev:		0.029			Std Dev:		0.231	Std Dev:	0.107
	OF1	0	2	95	0.250	HF2	0	2	95	0.870		0.560
				96	0.260				96	1.100		0.680
				97	0.290				97	0.480		0.385
				98	0.270				98	1.040		0.655
				99	0.300				99	1.170		0.735
			Avg:		0.274			Avg:		0.932	Avg:	0.603
			Std Dev:		0.021			Std Dev:		0.276	Std Dev:	0.137
	OF1	90	1	95	0.880	HF2	90	1	95	0.040		0.460
				96	0.880				96	0.010		0.445
				97	0.720				97	0.190		0.455
				98	0.610				98	0.070		0.340
				99	0.730				99	0.080		0.405
			Avg:		0.764			Avg:		0.078	Avg:	0.421
			Std Dev:		0.116			Std Dev:		0.068	Std Dev:	0.050
	OF1	90	2	95	0.790	HF2	90	2	95	0.230		0.510
				96	0.600				96	0.050		0.325
				97	0.770				97	0.070		0.420
				98	0.830				98	0.110		0.470
				99	0.900				99	0.050		0.475
			Avg:		0.778			Avg:		0.102	Avg:	0.440
			Std Dev:		0.111			Std Dev:		0.076	Std Dev:	0.072
A	OF2	0	1	95	0.890	HF1	0	1	95	0.310		0.600
				96	0.240				96	0.310		0.275
				97	0.540				97	0.230		0.385
				98	0.720				98	0.250		0.485
				99	0.180				99	0.220		0.200
			Avg:		0.514			Avg:		0.264	Avg:	0.389
			Std Dev:		0.305			Std Dev:		0.043	Std Dev:	0.160
	OF2	0	2	95	1.010	HF1	0	2	95	0.340		0.675
				96	0.270				96	0.330		0.300
				97	0.740				97	0.240		0.490
				98	0.610				98	0.240		0.425
				99	0.360				99	0.330		0.345
			Avg:		0.598			Avg:		0.296	Avg:	0.447
			Std Dev:		0.298			Std Dev:		0.051	Std Dev:	0.147
	OF2	90	1	95	0.020	HF1	90	1	95	0.640		0.330
				96	0.100				96	0.720		0.410
				97	0.030				97	0.830		0.430
				98	0.060				98	0.830		0.445
				99	0.070				99	0.830		0.450
			Avg:		0.056			Avg:		0.770	Avg:	0.413
			Std Dev:		0.032			Std Dev:		0.087	Std Dev:	0.049
	OF2	90	2	95	0.010	HF1	90	2	95	0.860		0.435
				96	0.020				96	0.950		0.485
				97	0.050				97	0.910		0.480
				98	0.080				98	0.840		0.460
				99	0.070				99	0.900		0.485
			Avg:		0.046			Avg:		0.892	Avg:	0.469
			Std Dev:		0.030			Std Dev:		0.043	Std Dev:	0.022

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.350	HF2	0	1	95	0.290		0.320
				96	0.360				96	0.270		0.315
				97	0.330				97	0.290		0.310
				98	0.340				98	0.240		0.290
				99	0.380				99	0.270		0.325
				Avg:	0.352				Avg:	0.272	Avg:	0.312
				Std Dev:	0.019				Std Dev:	0.020	Std Dev:	0.014
	OF1	0	2	95	0.340	HF2	0	2	95	0.320		0.330
				96	0.370				96	0.270		0.320
				97	0.300				97	0.250		0.275
				98	0.340				98	0.300		0.320
				99	0.360				99	0.290		0.325
				Avg:	0.342				Avg:	0.286	Avg:	0.314
				Std Dev:	0.027				Std Dev:	0.027	Std Dev:	0.022
	OF1	90	1	95	0.610	HF2	90	1	95	0.300		0.455
				96	0.540				96	0.320		0.430
				97	0.560				97	0.230		0.395
				98	0.520				98	0.270		0.395
				99	0.640				99	0.340		0.490
				Avg:	0.574				Avg:	0.292	Avg:	0.433
				Std Dev:	0.050				Std Dev:	0.043	Std Dev:	0.041
	OF1	90	2	95	0.570	HF2	90	2	95	0.290		0.430
				96	0.550				96	0.300		0.425
				97	0.630				97	0.290		0.460
				98	0.620				98	0.340		0.480
				99	0.590				99	0.300		0.445
				Avg:	0.592				Avg:	0.304	Avg:	0.448
				Std Dev:	0.033				Std Dev:	0.021	Std Dev:	0.023
A	OF2	0	1	95	0.320	HF1	0	1	95	0.310		0.315
				96	0.350				96	0.340		0.345
				97	0.270				97	0.380		0.325
				98	0.210				98	0.310		0.260
				99	0.220				99	0.330		0.275
				Avg:	0.274				Avg:	0.334	Avg:	0.304
				Std Dev:	0.061				Std Dev:	0.029	Std Dev:	0.035
	OF2	0	2	95	0.340	HF1	0	2	95	0.360		0.350
				96	0.270				96	0.330		0.300
				97	0.260				97	0.360		0.310
				98	0.250				98	0.370		0.310
				99	0.210				99	0.380		0.295
				Avg:	0.266				Avg:	0.360	Avg:	0.313
				Std Dev:	0.047				Std Dev:	0.019	Std Dev:	0.022
	OF2	90	1	95	0.260	HF1	90	1	95	0.580		0.420
				96	0.260				96	0.550		0.405
				97	0.370				97	0.560		0.465
				98	0.370				98	0.520		0.445
				99	0.350				99	0.580		0.465
				Avg:	0.322				Avg:	0.558	Avg:	0.440
				Std Dev:	0.057				Std Dev:	0.025	Std Dev:	0.027
	OF2	90	2	95	0.270	HF1	90	2	95	0.610		0.440
				96	0.480				96	0.560		0.520
				97	0.330				97	0.510		0.420
				98	0.360				98	0.600		0.480
				99	0.470				99	0.540		0.505
				Avg:	0.382				Avg:	0.564	Avg:	0.473
				Std Dev:	0.091				Std Dev:	0.042	Std Dev:	0.042

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 4.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.280	HF2	0	1	95	0.070		0.175
				96	0.260				96	0.100		0.180
				97	0.230				97	0.050		0.140
				98	0.290				98	0.090		0.190
				99	0.280				99	0.070		0.175
				Avg:	0.268				Avg:	0.076	Avg:	0.172
				Std Dev:	0.024				Std Dev:	0.019	Std Dev:	0.019
	OF1	0	2	95	0.290	HF2	0	2	95	0.100		0.195
				96	0.290				96	0.040		0.165
				97	0.240				97	0.110		0.175
				98	0.240				98	0.050		0.145
				99	0.250				99	0.080		0.165
				Avg:	0.262				Avg:	0.076	Avg:	0.169
				Std Dev:	0.026				Std Dev:	0.030	Std Dev:	0.018
	OF1	90	1	95	0.610	HF2	90	1	95	0.320		0.465
				96	0.600				96	0.340		0.470
				97	0.590				97	0.340		0.465
				98	0.620				98	0.330		0.475
				99	0.600				99	0.360		0.480
				Avg:	0.604				Avg:	0.338	Avg:	0.471
				Std Dev:	0.011				Std Dev:	0.015	Std Dev:	0.007
	OF1	90	2	95	0.650	HF2	90	2	95	0.360		0.505
				96	0.640				96	0.250		0.445
				97	0.660				97	0.310		0.485
				98	0.640				98	0.300		0.470
				99	0.640				99	0.350		0.495
				Avg:	0.646				Avg:	0.314	Avg:	0.480
				Std Dev:	0.009				Std Dev:	0.044	Std Dev:	0.023
A	OF2	0	1	95	0.030	HF1	0	1	95	0.280		0.155
				96	0.050				96	0.290		0.170
				97	0.040				97	0.300		0.170
				98	0.010				98	0.280		0.145
				99	0.050				99	0.280		0.165
				Avg:	0.036				Avg:	0.286	Avg:	0.161
				Std Dev:	0.017				Std Dev:	0.009	Std Dev:	0.011
	OF2	0	2	95	0.010	HF1	0	2	95	0.380		0.195
				96	0.030				96	0.350		0.190
				97	0.020				97	0.350		0.185
				98	0.020				98	0.380		0.200
				99	0.020				99	0.370		0.195
				Avg:	0.020				Avg:	0.366	Avg:	0.193
				Std Dev:	0.007				Std Dev:	0.015	Std Dev:	0.006
	OF2	90	1	95	0.250	HF1	90	1	95	0.470		0.360
				96	0.210				96	0.460		0.335
				97	0.290				97	0.480		0.385
				98	0.240				98	0.490		0.365
				99	0.290				99	0.470		0.380
				Avg:	0.256				Avg:	0.474	Avg:	0.365
				Std Dev:	0.034				Std Dev:	0.011	Std Dev:	0.020
	OF2	90	2	95	0.270	HF1	90	2	95	0.540		0.405
				96	0.240				96	0.530		0.385
				97	0.280				97	0.560		0.420
				98	0.260				98	0.560		0.410
				99	0.320				99	0.560		0.440
				Avg:	0.274				Avg:	0.550	Avg:	0.412
				Std Dev:	0.030				Std Dev:	0.014	Std Dev:	0.020

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.490	HF2	0	1	95	0.630		0.560
				96	0.540				96	0.880		0.710
				97	0.490				97	0.620		0.555
				98	0.580				98	0.280		0.430
				99	0.450				99	0.540		0.495
				Avg:	0.510				Avg:	0.590	Avg:	0.550
				Std Dev:	0.050				Std Dev:	0.215	Std Dev:	0.104
	OF1	0	2	95	0.510	HF2	0	2	95	0.360		0.435
				96	0.400				96	0.590		0.495
				97	0.520				97	0.910		0.715
				98	0.530				98	0.680		0.605
				99	0.450				99	0.440		0.445
				Avg:	0.482				Avg:	0.596	Avg:	0.539
				Std Dev:	0.055				Std Dev:	0.215	Std Dev:	0.119
	OF1	90	1	95	0.480	HF2	90	1	95	0.330		0.405
				96	0.330				96	0.930		0.630
				97	0.470				97	0.910		0.690
				98	0.430				98	0.450		0.440
				99	0.450				99	0.300		0.375
				Avg:	0.432				Avg:	0.584	Avg:	0.508
				Std Dev:	0.060				Std Dev:	0.312	Std Dev:	0.142
	OF1	90	2	95	0.440	HF2	90	2	95	0.560		0.500
				96	0.490				96	0.370		0.430
				97	0.570				97	0.480		0.525
				98	0.710				98	0.940		0.825
				99	0.660				99	0.680		0.670
				Avg:	0.574				Avg:	0.606	Avg:	0.590
				Std Dev:	0.113				Std Dev:	0.218	Std Dev:	0.158
B	OF2	0	1	95	0.270	HF1	0	1	95	0.500		0.385
				96	0.620				96	0.510		0.565
				97	1.080				97	0.670		0.875
				98	0.400				98	0.580		0.490
				99	0.260				99	0.470		0.365
				Avg:	0.526				Avg:	0.546	Avg:	0.536
				Std Dev:	0.342				Std Dev:	0.080	Std Dev:	0.206
	OF2	0	2	95	0.440	HF1	0	2	95	0.520		0.480
				96	1.080				96	0.510		0.795
				97	0.530				97	0.340		0.435
				98	0.290				98	0.320		0.305
				99	0.770				99	0.450		0.610
				Avg:	0.622				Avg:	0.428	Avg:	0.525
				Std Dev:	0.310				Std Dev:	0.094	Std Dev:	0.186
	OF2	90	1	95	0.440	HF1	90	1	95	0.620		0.530
				96	0.470				96	0.630		0.550
				97	0.330				97	0.723		0.527
				98	1.020				98	0.630		0.825
				99	0.050				99	0.690		0.370
				Avg:	0.462				Avg:	0.659	Avg:	0.560
				Std Dev:	0.353				Std Dev:	0.045	Std Dev:	0.165
	OF2	90	2	95	0.280	HF1	90	2	95	0.930		0.605
				96	0.640				96	1.130		0.885
				97	0.490				97	0.940		0.715
				98	0.250				98	1.020		0.635
				99	1.110				99	0.640		0.875
				Avg:	0.554				Avg:	0.932	Avg:	0.743
				Std Dev:	0.349				Std Dev:	0.182	Std Dev:	0.131

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.540	HF2	0	1	95	0.620		0.580
				96	0.510				96	0.600		0.555
				97	0.570				97	0.590		0.580
				98	0.470				98	0.590		0.530
				99	0.550				99	0.580		0.565
				Avg:	0.528				Avg:	0.596	Avg:	0.562
				Std Dev:	0.039				Std Dev:	0.015	Std Dev:	0.021
	OF1	0	2	95	0.510	HF2	0	2	95	0.570		0.540
				96	0.590				96	0.600		0.595
				97	0.510				97	0.580		0.545
				98	0.490				98	0.620		0.555
				99	0.520				99	0.580		0.550
				Avg:	0.524				Avg:	0.590	Avg:	0.557
				Std Dev:	0.038				Std Dev:	0.020	Std Dev:	0.022
	OF1	90	1	95	0.490	HF2	90	1	95	0.290		0.390
				96	0.560				96	0.280		0.420
				97	0.550				97	0.310		0.430
				98	0.520				98	0.320		0.420
				99	0.520				99	0.290		0.405
				Avg:	0.528				Avg:	0.298	Avg:	0.413
				Std Dev:	0.028				Std Dev:	0.016	Std Dev:	0.016
	OF1	90	2	95	0.470	HF2	90	2	95	0.320		0.395
				96	0.470				96	0.290		0.380
				97	0.550				97	0.300		0.425
				98	0.570				98	0.320		0.445
				99	0.500				99	0.350		0.425
				Avg:	0.512				Avg:	0.316	Avg:	0.414
				Std Dev:	0.046				Std Dev:	0.023	Std Dev:	0.026
B	OF2	0	1	95	0.580	HF1	0	1	95	0.600		0.590
				96	0.620				96	0.630		0.625
				97	0.640				97	0.610		0.625
				98	0.630				98	0.590		0.610
				99	0.610				99	0.650		0.630
				Avg:	0.616				Avg:	0.616	Avg:	0.616
				Std Dev:	0.023				Std Dev:	0.024	Std Dev:	0.016
	OF2	0	2	95	0.590	HF1	0	2	95	0.600		0.595
				96	0.560				96	0.630		0.595
				97	0.510				97	0.580		0.545
				98	0.580				98	0.580		0.580
				99	0.570				99	0.670		0.620
				Avg:	0.562				Avg:	0.612	Avg:	0.587
				Std Dev:	0.031				Std Dev:	0.038	Std Dev:	0.028
	OF2	90	1	95	0.300	HF1	90	1	95	0.500		0.400
				96	0.320				96	0.500		0.410
				97	0.310				97	0.600		0.455
				98	0.360				98	0.500		0.430
				99	0.330				99	0.550		0.440
				Avg:	0.324				Avg:	0.530	Avg:	0.427
				Std Dev:	0.023				Std Dev:	0.045	Std Dev:	0.022
	OF2	90	2	95	0.350	HF1	90	2	95	0.630		0.490
				96	0.032				96	0.450		0.241
				97	0.340				97	0.620		0.480
				98	0.310				98	0.550		0.430
				99	0.270				99	0.540		0.405
				Avg:	0.260				Avg:	0.558	Avg:	0.409
				Std Dev:	0.131				Std Dev:	0.073	Std Dev:	0.100

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.550	HF2	0	1	95	0.600		0.575
				96	0.470				96	0.630		0.550
				97	0.490				97	0.640		0.565
				98	0.410				98	0.630		0.520
				99	0.500				99	0.660		0.580
			Avg:		0.484			Avg:		0.632	Avg:	0.558
			Std Dev:		0.051			Std Dev:		0.022	Std Dev:	0.024
	OF1	0	2	95	0.510	HF2	0	2	95	0.670		0.590
				96	0.490				96	0.570		0.530
				97	0.510				97	0.640		0.575
				98	0.510				98	0.690		0.600
				99	0.520				99	0.600		0.560
			Avg:		0.508			Avg:		0.634	Avg:	0.571
			Std Dev:		0.011			Std Dev:		0.049	Std Dev:	0.027
	OF1	90	1	95	0.330	HF2	90	1	95	0.380		0.355
				96	0.350				96	0.440		0.395
				97	0.340				97	0.420		0.380
				98	0.310				98	0.440		0.375
				99	0.330				99	0.370		0.350
			Avg:		0.332			Avg:		0.410	Avg:	0.371
			Std Dev:		0.015			Std Dev:		0.033	Std Dev:	0.019
	OF1	90	2	95	0.440	HF2	90	2	95	0.440		0.440
				96	0.410				96	0.480		0.445
				97	0.400				97	0.460		0.430
				98	0.400				98	0.420		0.410
				99	0.390				99	0.430		0.410
			Avg:		0.408			Avg:		0.446	Avg:	0.427
			Std Dev:		0.019			Std Dev:		0.024	Std Dev:	0.016
B	OF2	0	1	95	0.030	HF1	0	1	95	0.280		0.155
				96	0.050				96	0.290		0.170
				97	0.040				97	0.300		0.170
				98	0.010				98	0.280		0.145
				99	0.050				99	0.280		0.165
			Avg:		0.036			Avg:		0.286	Avg:	0.161
			Std Dev:		0.017			Std Dev:		0.009	Std Dev:	0.011
	OF2	0	2	95	0.740	HF1	0	2	95	0.540		0.640
				96	0.690				96	0.590		0.640
				97	0.770				97	0.570		0.670
				98	0.730				98	0.560		0.645
				99	0.760				99	0.550		0.655
			Avg:		0.738			Avg:		0.562	Avg:	0.650
			Std Dev:		0.031			Std Dev:		0.019	Std Dev:	0.013
	OF2	90	1	95	0.390	HF1	90	1	95	0.420		0.405
				96	0.340				96	0.440		0.390
				97	0.370				97	0.480		0.425
				98	0.380				98	0.470		0.425
				99	0.370				99	0.450		0.410
			Avg:		0.370			Avg:		0.452	Avg:	0.411
			Std Dev:		0.019			Std Dev:		0.024	Std Dev:	0.015
	OF2	90	2	95	0.380	HF1	90	2	95	0.460		0.420
				96	0.440				96	0.460		0.450
				97	0.430				97	0.490		0.460
				98	0.430				98	0.470		0.450
				99	0.390				99	0.490		0.440
			Avg:		0.414			Avg:		0.474	Avg:	0.444
			Std Dev:		0.027			Std Dev:		0.015	Std Dev:	0.015

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 1.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.510	HF2	0	1	95	0.360		0.435
				96	0.620				96	0.200		0.410
				97	0.510				97	0.490		0.500
				98	0.490				98	0.220		0.355
				99	0.480				99	0.290		0.385
			Avg:		0.522			Avg:		0.312	Avg:	0.417
			Std Dev:		0.056			Std Dev:		0.118	Std Dev:	0.055
	OF1	0	2	95	0.450	HF2	0	2	95	0.280		0.365
				96	0.510				96	0.250		0.380
				97	0.570				97	0.440		0.505
				98	0.550				98	0.230		0.390
				99	0.570				99	0.440		0.505
			Avg:		0.530			Avg:		0.328	Avg:	0.429
			Std Dev:		0.051			Std Dev:		0.104	Std Dev:	0.070
	OF1	90	1	95	0.370	HF2	90	1	95	0.180		0.275
				96	0.380				96	0.420		0.400
				97	0.290				97	0.490		0.390
				98	0.340				98	0.160		0.250
				99	0.340				99	0.490		0.415
			Avg:		0.344			Avg:		0.348	Avg:	0.346
			Std Dev:		0.035			Std Dev:		0.165	Std Dev:	0.077
	OF1	90	2	95	0.360	HF2	90	2	95	0.560		0.460
				96	0.340				96	0.330		0.335
				97	0.310				97	0.280		0.295
				98	0.320				98	0.580		0.450
				99	0.380				99	0.310		0.345
			Avg:		0.342			Avg:		0.412	Avg:	0.377
			Std Dev:		0.029			Std Dev:		0.145	Std Dev:	0.074
C	OF2	0	1	95	0.260	HF1	0	1	95	0.660		0.460
				96	0.170				96	0.510		0.340
				97	0.500				97	0.640		0.570
				98	0.410				98	0.800		0.605
				99	0.140				99	0.800		0.470
			Avg:		0.296			Avg:		0.682	Avg:	0.489
			Std Dev:		0.155			Std Dev:		0.122	Std Dev:	0.104
	OF2	0	2	95	0.480	HF1	0	2	95	0.600		0.540
				96	0.180				96	0.580		0.380
				97	0.220				97	0.540		0.380
				98	0.570				98	0.730		0.650
				99	0.320				99	0.690		0.505
			Avg:		0.354			Avg:		0.628	Avg:	0.491
			Std Dev:		0.167			Std Dev:		0.079	Std Dev:	0.115
	OF2	90	1	95	0.380	HF1	90	1	95	0.330		0.355
				96	0.570				96	0.400		0.485
				97	0.240				97	0.340		0.290
				98	0.160				98	0.330		0.245
				99	0.450				99	0.230		0.340
			Avg:		0.360			Avg:		0.326	Avg:	0.343
			Std Dev:		0.164			Std Dev:		0.061	Std Dev:	0.090
	OF2	90	2	95	0.300	HF1	90	2	95	0.570		0.435
				96	0.150				96	0.540		0.345
				97	0.370				97	0.540		0.455
				98	0.600				98	0.570		0.585
				99	0.200				99	0.630		0.415
			Avg:		0.324			Avg:		0.570	Avg:	0.447
			Std Dev:		0.176			Std Dev:		0.037	Std Dev:	0.088

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 3.00 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.390	HF2	0	1	95	0.330		0.360
				96	0.400				96	0.280		0.340
				97	0.360				97	0.260		0.310
				98	0.340				98	0.210		0.275
				99	0.360				99	0.290		0.325
			Avg:		0.370				Avg:	0.274	Avg:	0.322
			Std Dev:		0.024				Std Dev:	0.044	Std Dev:	0.032
	OF1	0	2	95	0.470	HF2	0	2	95	0.270		0.370
				96	0.410				96	0.260		0.335
				97	0.390				97	0.230		0.310
				98	0.420				98	0.300		0.360
				99	0.410				99	0.310		0.360
			Avg:		0.420				Avg:	0.274	Avg:	0.347
			Std Dev:		0.030				Std Dev:	0.032	Std Dev:	0.024
	OF1	90	1	95	0.350	HF2	90	1	95	0.470		0.410
				96	0.390				96	0.470		0.430
				97	0.350				97	0.380		0.365
				98	0.340				98	0.450		0.395
				99	0.360				99	0.450		0.405
			Avg:		0.358				Avg:	0.444	Avg:	0.401
			Std Dev:		0.019				Std Dev:	0.037	Std Dev:	0.024
	OF1	90	2	95	0.440	HF2	90	2	95	0.430		0.435
				96	0.360				96	0.460		0.410
				97	0.370				97	0.450		0.410
				98	0.440				98	0.430		0.435
				99	0.420				99	0.440		0.430
			Avg:		0.406				Avg:	0.442	Avg:	0.424
			Std Dev:		0.038				Std Dev:	0.013	Std Dev:	0.013
C	OF2	0	1	95	0.200	HF1	0	1	95	0.390		0.295
				96	0.280				96	0.430		0.355
				97	0.310				97	0.400		0.355
				98	0.260				98	0.400		0.330
				99	0.240				99	0.440		0.340
			Avg:		0.258				Avg:	0.412	Avg:	0.335
			Std Dev:		0.041				Std Dev:	0.022	Std Dev:	0.025
	OF2	0	2	95	0.230	HF1	0	2	95	0.400		0.315
				96	0.290				96	0.420		0.355
				97	0.300				97	0.450		0.375
				98	0.230				98	0.450		0.340
				99	0.250				99	0.370		0.310
			Avg:		0.260				Avg:	0.418	Avg:	0.339
			Std Dev:		0.033				Std Dev:	0.034	Std Dev:	0.027
	OF2	90	1	95	0.440	HF1	90	1	95	0.380		0.410
				96	0.410				96	0.350		0.380
				97	0.350				97	0.370		0.360
				98	0.420				98	0.400		0.410
				99	0.410				99	0.380		0.395
			Avg:		0.406				Avg:	0.376	Avg:	0.391
			Std Dev:		0.034				Std Dev:	0.018	Std Dev:	0.021
	OF2	90	2	95	0.440	HF1	90	2	95	0.420		0.430
				96	0.400				96	0.440		0.420
				97	0.400				97	0.440		0.420
				98	0.450				98	0.400		0.425
				99	0.450				99	0.410		0.430
			Avg:		0.428				Avg:	0.422	Avg:	0.425
			Std Dev:		0.026				Std Dev:	0.018	Std Dev:	0.005

Mix Type= 19.0 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.470	HF2	0	1	95	0.260		0.365
				96	0.470				96	0.310		0.390
				97	0.500				97	0.220		0.360
				98	0.480				98	0.280		0.380
				99	0.520				99	0.280		0.400
				Avg:	0.488				Avg:	0.270	Avg:	0.379
				Std Dev:	0.022				Std Dev:	0.033	Std Dev:	0.017
	OF1	0	2	95	0.580	HF2	0	2	95	0.330		0.455
				96	0.610				96	0.350		0.480
				97	0.590				97	0.300		0.445
				98	0.570				98	0.350		0.460
				99	0.570				99	0.370		0.470
				Avg:	0.584				Avg:	0.340	Avg:	0.462
				Std Dev:	0.017				Std Dev:	0.026	Std Dev:	0.014
	OF1	90	1	95	0.400	HF2	90	1	95	0.400		0.400
				96	0.430				96	0.400		0.415
				97	0.410				97	0.420		0.415
				98	0.410				98	0.360		0.385
				99	0.420				99	0.380		0.400
				Avg:	0.414				Avg:	0.302	Avg:	0.403
				Std Dev:	0.011				Std Dev:	0.023	Std Dev:	0.013
	OF1	90	2	95	0.470	HF2	90	2	95	0.460		0.465
				96	0.500				96	0.430		0.465
				97	0.510				97	0.480		0.495
				98	0.490				98	0.510		0.500
				99	0.480				99	0.490		0.485
				Avg:	0.490				Avg:	0.474	Avg:	0.482
				Std Dev:	0.016				Std Dev:	0.030	Std Dev:	0.016
C	OF2	0	1	95	0.260	HF1	0	1	95	0.520		0.390
				96	0.260				96	0.530		0.395
				97	0.260				97	0.490		0.375
				98	0.260				98	0.510		0.385
				99	0.260				99	0.530		0.395
				Avg:	0.260				Avg:	0.516	Avg:	0.388
				Std Dev:	0.000				Std Dev:	0.017	Std Dev:	0.008
	OF2	0	2	95	0.370	HF1	0	2	95	0.620		0.495
				96	0.370				96	0.650		0.510
				97	0.380				97	0.610		0.495
				98	0.350				98	0.650		0.500
				99	0.430				99	0.630		0.530
				Avg:	0.380				Avg:	0.632	Avg:	0.506
				Std Dev:	0.030				Std Dev:	0.018	Std Dev:	0.015
	OF2	90	1	95	0.480	HF1	90	1	95	0.490		0.485
				96	0.540				96	0.450		0.495
				97	0.490				97	0.470		0.480
				98	0.500				98	0.480		0.490
				99	0.430				99	0.450		0.440
				Avg:	0.488				Avg:	0.468	Avg:	0.478
				Std Dev:	0.040				Std Dev:	0.018	Std Dev:	0.022
	OF2	90	2	95	0.530	HF1	90	2	95	0.530		0.530
				96	0.560				96	0.550		0.555
				97	0.500				97	0.560		0.530
				98	0.590				98	0.590		0.590
				99	0.510				99	0.580		0.545
				Avg:	0.538				Avg:	0.562	Avg:	0.550
				Std Dev:	0.037				Std Dev:	0.024	Std Dev:	0.025

Annex 24

NCHRP 1-28A Project

Diametral Test Results

Poisson's Ratio Total

37.5 mm
6 inch Dia.

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.510	HF2	0	1	95	1.050		0.780
				96	0.500				96	0.460		0.480
				97	0.620				97	0.880		0.750
				98	0.540				98	1.000		0.770
				99	0.740				99	0.370		0.555
			Avg:		0.582			Avg:		0.752	Avg:	0.667
			Std Dev:		0.100			Std Dev:		0.315	Std Dev:	0.139
	OF1	0	2	95	0.600	HF2	0	2	95	0.550		0.575
				96	0.630				96	1.080		0.855
				97	0.660				97	0.480		0.570
				98	0.600				98	0.510		0.555
				99	0.740				99	1.030		0.885
			Avg:		0.646			Avg:		0.730	Avg:	0.688
			Std Dev:		0.058			Std Dev:		0.298	Std Dev:	0.167
	OF1	90	1	95	0.390	HF2	90	1	95	0.140		0.265
				96	0.350				96	0.020		0.185
				97	0.440				97	0.070		0.255
				98	0.330				98	0.210		0.270
				99	0.420				99	0.050		0.235
			Avg:		0.386			Avg:		0.098	Avg:	0.242
			Std Dev:		0.046			Std Dev:		0.077	Std Dev:	0.035
	OF1	90	2	95	0.320	HF2	90	2	95	0.210		0.265
				96	0.460				96	0.040		0.250
				97	0.440				97	0.230		0.335
				98	0.460				98	0.110		0.285
				99	0.570				99	0.010		0.290
			Avg:		0.450			Avg:		0.120	Avg:	0.285
			Std Dev:		0.089			Std Dev:		0.098	Std Dev:	0.032
A	OF2	0	1	95	0.460	HF1	0	1	95	0.800		0.630
				96	1.020				96	0.870		0.945
				97	0.560				97	0.520		0.540
				98	0.460				98	0.900		0.680
				99	0.950				99	0.620		0.785
			Avg:		0.690			Avg:		0.742	Avg:	0.716
			Std Dev:		0.273			Std Dev:		0.165	Std Dev:	0.156
	OF2	0	2	95	0.580	HF1	0	2	95	1.030		0.805
				96	0.500				96	0.770		0.635
				97	0.950				97	0.660		0.805
				98	0.530				98	0.920		0.725
				99	0.750				99	0.630		0.690
			Avg:		0.662			Avg:		0.802	Avg:	0.732
			Std Dev:		0.188			Std Dev:		0.171	Std Dev:	0.074
	OF2	90	1	95	0.090	HF1	90	1	95	0.480		0.285
				96	0.050				96	0.590		0.320
				97	0.200				97	0.550		0.375
				98	0.120				98	0.410		0.265
				99	0.020				99	0.690		0.355
			Avg:		0.096			Avg:		0.544	Avg:	0.320
			Std Dev:		0.069			Std Dev:		0.107	Std Dev:	0.046
	OF2	90	2	95	0.165	HF1	90	2	95	0.540		0.353
				96	0.030				96	0.550		0.290
				97	0.310				97	0.440		0.375
				98	0.120				98	0.700		0.410
				99	0.020				99	0.500		0.260
			Avg:		0.129			Avg:		0.546	Avg:	0.338
			Std Dev:		0.118			Std Dev:		0.096	Std Dev:	0.062

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.450	HF2	0	1	95	0.470		0.460
				96	0.400				96	0.380		0.390
				97	0.400				97	0.440		0.420
				98	0.480				98	0.480		0.480
				99	0.480				99	0.400		0.440
				Avg:	0.442				Avg:	0.434	Avg:	0.438
				Std Dev:	0.040				Std Dev:	0.043	Std Dev:	0.035
	OF1	0	2	95	0.450	HF2	0	2	95	0.390		0.420
				96	0.510				96	0.490		0.500
				97	0.440				97	0.410		0.425
				98	0.410				98	0.420		0.415
				99	0.390				99	0.460		0.425
				Avg:	0.440				Avg:	0.434	Avg:	0.437
				Std Dev:	0.046				Std Dev:	0.040	Std Dev:	0.035
	OF1	90	1	95	0.090	HF2	90	1	95	0.170		0.130
				96	0.050				96	0.040		0.045
				97	0.090				97	0.120		0.105
				98	0.100				98	0.130		0.115
				99	0.050				99	0.100		0.075
				Avg:	0.076				Avg:	0.112	Avg:	0.094
				Std Dev:	0.024				Std Dev:	0.048	Std Dev:	0.034
	OF1	90	2	95	0.060	HF2	90	2	95	0.060		0.060
				96	0.050				96	0.140		0.095
				97	0.090				97	0.110		0.100
				98	0.070				98	0.170		0.120
				99	0.060				99	0.140		0.100
				Avg:	0.066				Avg:	0.124	Avg:	0.095
				Std Dev:	0.015				Std Dev:	0.042	Std Dev:	0.022
A	OF2	0	1	95	0.330	HF1	0	1	95	0.440		0.385
				96	0.350				96	0.500		0.425
				97	0.360				97	0.460		0.410
				98	0.380				98	0.450		0.415
				99	0.280				99	0.470		0.375
				Avg:	0.340				Avg:	0.464	Avg:	0.402
				Std Dev:	0.038				Std Dev:	0.023	Std Dev:	0.021
	OF2	0	2	95	0.290	HF1	0	2	95	0.460		0.375
				96	0.330				96	0.530		0.430
				97	0.350				97	0.460		0.405
				98	0.370				98	0.450		0.410
				99	0.380				99	0.510		0.445
				Avg:	0.344				Avg:	0.482	Avg:	0.413
				Std Dev:	0.036				Std Dev:	0.036	Std Dev:	0.027
	OF2	90	1	95	0.150	HF1	90	1	95	0.300		0.225
				96	0.200				96	0.330		0.265
				97	0.210				97	0.310		0.260
				98	0.190				98	0.320		0.255
				99	0.210				99	0.310		0.260
				Avg:	0.192				Avg:	0.314	Avg:	0.253
				Std Dev:	0.025				Std Dev:	0.011	Std Dev:	0.016
	OF2	90	2	95	0.110	HF1	90	2	95	0.340		0.225
				96	0.090				96	0.320		0.205
				97	0.140				97	0.370		0.255
				98	0.180				98	0.270		0.225
				99	0.210				99	0.350		0.280
				Avg:	0.146				Avg:	0.330	Avg:	0.238
				Std Dev:	0.049				Std Dev:	0.038	Std Dev:	0.029

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 4.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
A	OF1	0	1	95	0.410	HF2	0	1	95	0.450		0.430
				96	0.490				96	0.490		0.490
				97	0.480				97	0.540		0.510
				98	0.420				98	0.550		0.485
				99	0.460				99	0.490		0.475
				Avg:	0.452				Avg:	0.504	Avg:	0.476
				Std Dev:	0.036				Std Dev:	0.041	Std Dev:	0.030
	OF1	0	2	95	0.430	HF2	0	2	95	0.500		0.465
				96	0.480				96	0.470		0.475
				97	0.460				97	0.490		0.475
				98	0.430				98	0.540		0.485
				99	0.520				99	0.530		0.525
				Avg:	0.464				Avg:	0.506	Avg:	0.485
				Std Dev:	0.038				Std Dev:	0.029	Std Dev:	0.023
	OF1	90	1	95	0.260	HF2	90	1	95	0.240		0.250
				96	0.260				96	0.240		0.250
				97	0.250				97	0.190		0.220
				98	0.280				98	0.210		0.245
				99	0.250				99	0.270		0.260
				Avg:	0.260				Avg:	0.230	Avg:	0.245
				Std Dev:	0.012				Std Dev:	0.031	Std Dev:	0.015
	OF1	90	2	95	0.580	HF2	90	2	95	0.490		0.535
				96	0.550				96	0.370		0.460
				97	0.520				97	0.410		0.465
				98	0.580				98	0.430		0.505
				99	0.600				99	0.440		0.520
				Avg:	0.566				Avg:	0.428	Avg:	0.497
				Std Dev:	0.031				Std Dev:	0.044	Std Dev:	0.033
A	OF2	0	1	95	0.510	HF1	0	1	95	0.320		0.415
				96	0.390				96	0.320		0.355
				97	0.540				97	0.400		0.470
				98	0.480				98	0.310		0.395
				99	0.450				99	0.390		0.420
				Avg:	0.474				Avg:	0.348	Avg:	0.411
				Std Dev:	0.058				Std Dev:	0.043	Std Dev:	0.042
	OF2	0	2	95	0.460	HF1	0	2	95	0.410		0.435
				96	0.550				96	0.390		0.470
				97	0.480				97	0.460		0.470
				98	0.510				98	0.380		0.445
				99	0.530				99	0.400		0.465
				Avg:	0.506				Avg:	0.408	Avg:	0.457
				Std Dev:	0.036				Std Dev:	0.031	Std Dev:	0.016
	OF2	90	1	95	0.570	HF1	90	1	95	0.520		0.545
				96	0.550				96	0.490		0.520
				97	0.510				97	0.540		0.525
				98	0.540				98	0.500		0.520
				99	0.530				99	0.530		0.530
				Avg:	0.540				Avg:	0.516	Avg:	0.528
				Std Dev:	0.022				Std Dev:	0.021	Std Dev:	0.010
	OF2	90	2	95	0.510	HF1	90	2	95	0.510		0.510
				96	0.580				96	0.540		0.560
				97	0.570				97	0.550		0.560
				98	0.540				98	0.520		0.530
				99	0.540				99	0.550		0.545
				Avg:	0.548				Avg:	0.534	Avg:	0.541
				Std Dev:	0.028				Std Dev:	0.018	Std Dev:	0.021

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 1.5 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.760	HF2	0	1	95	0.810		0.785
				96	0.810				96	1.280		1.045
				97	0.850				97	1.780		1.315
				98	0.640				98	0.730		0.685
				99	0.870				99	1.940		1.405
				Avg:	0.786				Avg:	1.308	Avg:	1.047
				Std Dev:	0.092				Std Dev:	0.549	Std Dev:	0.316
	OF1	0	2	95	0.820	HF2	0	2	95	1.620		1.220
				96	0.790				96	1.880		1.335
				97	0.890				97	0.800		0.845
				98	0.800				98	2.210		1.505
				99	0.700				99	0.960		0.830
				Avg:	0.800				Avg:	1.494	Avg:	1.147
				Std Dev:	0.068				Std Dev:	0.601	Std Dev:	0.300
	OF1	90	1	95	0.090	HF2	90	1	95	0.330		0.210
				96	0.060				96	0.210		0.135
				97	0.130				97	0.190		0.160
				98	0.100				98	0.400		0.250
				99	0.070				99	0.140		0.105
				Avg:	0.090				Avg:	0.254	Avg:	0.172
				Std Dev:	0.027				Std Dev:	0.107	Std Dev:	0.058
	OF1	90	2	95	0.060	HF2	90	2	95	0.230		0.145
				96	0.110				96	0.170		0.140
				97	0.090				97	0.400		0.245
				98	0.060				98	0.100		0.080
				99	0.110				99	0.340		0.225
				Avg:	0.086				Avg:	0.248	Avg:	0.167
				Std Dev:	0.025				Std Dev:	0.122	Std Dev:	0.068
B	OF2	0	1	95	0.790	HF1	0	1	95	0.750		0.770
				96	1.770				96	0.910		1.340
				97	0.780				97	0.790		0.785
				98	1.290				98	0.820		1.055
				99	1.410				99	0.800		1.105
				Avg:	1.208				Avg:	0.814	Avg:	1.011
				Std Dev:	0.425				Std Dev:	0.059	Std Dev:	0.239
	OF2	0	2	95	1.970	HF1	0	2	95	1.000		1.485
				96	0.870				96	0.900		0.885
				97	2.100				97	0.770		1.435
				98	1.050				98	0.870		0.960
				99	1.330				99	1.000		1.165
				Avg:	1.464				Avg:	0.908	Avg:	1.186
				Std Dev:	0.548				Std Dev:	0.097	Std Dev:	0.271
	OF2	90	1	95	0.320	HF1	90	1	95	0.190		0.255
				96	0.120				96	0.190		0.155
				97	0.240				97	0.110		0.175
				98	0.210				98	0.140		0.175
				99	0.220				99	0.230		0.225
				Avg:	0.222				Avg:	0.172	Avg:	0.197
				Std Dev:	0.072				Std Dev:	0.047	Std Dev:	0.041
	OF2	90	2	95	0.110	HF1	90	2	95	0.080		0.095
				96	0.310				96	0.110		0.210
				97	0.170				97	0.140		0.155
				98	0.200				98	0.170		0.185
				99	0.220				99	0.080		0.150
				Avg:	0.202				Avg:	0.116	Avg:	0.159
				Std Dev:	0.073				Std Dev:	0.039	Std Dev:	0.043

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 3.0 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.990	HF2	0	1	95	0.870		0.930
				96	1.200				96	0.820		1.010
				97	1.040				97	0.760		0.900
				98	1.010				98	1.030		1.020
				99	1.180				99	0.630		0.905
			Avg:		1.084			Avg:		0.822	Avg:	0.953
			Std Dev:		0.099			Std Dev:		0.147	Std Dev:	0.058
	OF1	0	2	95	1.030	HF2	0	2	95	0.740		0.885
				96	1.170				96	0.840		1.005
				97	1.050				97	0.720		0.885
				98	1.150				98	0.720		0.935
				99	1.230				99	0.830		1.030
			Avg:		1.126			Avg:		0.770	Avg:	0.948
			Std Dev:		0.084			Std Dev:		0.060	Std Dev:	0.067
	OF1	90	1	95	0.500	HF2	90	1	95	0.220		0.360
				96	0.610				96	0.300		0.455
				97	0.540				97	0.200		0.370
				98	0.570				98	0.320		0.445
				99	0.590				99	0.230		0.410
			Avg:		0.562			Avg:		0.254	Avg:	0.408
			Std Dev:		0.043			Std Dev:		0.053	Std Dev:	0.043
	OF1	90	2	95	1.060	HF2	90	2	95	0.590		0.825
				96	0.970				96	0.210		0.590
				97	0.780				97	0.270		0.525
				98	0.810				98	0.210		0.510
				99	0.880				99	0.290		0.585
			Avg:		0.900			Avg:		0.314	Avg:	0.607
			Std Dev:		0.116			Std Dev:		0.158	Std Dev:	0.127
B	OF2	0	1	95	0.450	HF1	0	1	95	0.720		0.585
				96	0.440				96	0.640		0.540
				97	0.510				97	0.620		0.565
				98	0.420				98	0.690		0.555
				99	0.440				99	0.730		0.585
			Avg:		0.452			Avg:		0.680	Avg:	0.566
			Std Dev:		0.034			Std Dev:		0.048	Std Dev:	0.019
	OF2	0	2	95	0.490	HF1	0	2	95	0.610		0.550
				96	0.440				96	0.640		0.540
				97	0.510				97	0.700		0.605
				98	0.480				98	0.610		0.545
				99	0.440				99	0.630		0.535
			Avg:		0.472			Avg:		0.638	Avg:	0.555
			Std Dev:		0.031			Std Dev:		0.037	Std Dev:	0.029
	OF2	90	1	95	0.100	HF1	90	1	95	1.110		0.605
				96	0.120				96	1.190		0.655
				97	0.110				97	1.170		0.640
				98	0.140				98	1.180		0.660
				99	0.120				99	1.040		0.580
			Avg:		0.118			Avg:		1.138	Avg:	0.628
			Std Dev:		0.015			Std Dev:		0.063	Std Dev:	0.034
	OF2	90	2	95	0.120	HF1	90	2	95	1.180		0.650
				96	0.150				96	1.210		0.680
				97	0.130				97	1.290		0.710
				98	0.100				98	1.240		0.670
				99	0.150				99	1.290		0.720
			Avg:		0.130			Avg:		1.242	Avg:	0.686
			Std Dev:		0.021			Std Dev:		0.049	Std Dev:	0.029

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
B	OF1	0	1	95	0.220	HF2	0	1	95	0.240		0.230
				96	0.270				96	0.180		0.225
				97	0.250				97	0.200		0.225
				98	0.300				98	0.210		0.255
				99	0.250				99	0.220		0.235
			Avg:		0.258			Avg:		0.210	Avg:	0.234
			Std Dev:		0.029			Std Dev:		0.022	Std Dev:	0.012
	OF1	0	2	95	0.320	HF2	0	2	95	0.190		0.255
				96	0.280				96	0.270		0.275
				97	0.330				97	0.210		0.270
				98	0.260				98	0.220		0.240
				99	0.330				99	0.250		0.290
			Avg:		0.304			Avg:		0.228	Avg:	0.266
			Std Dev:		0.032			Std Dev:		0.032	Std Dev:	0.019
	OF1	90	1	95	2.140	HF2	90	1	95	0.310		1.225
				96	1.900				96	0.320		1.110
				97	1.990				97	0.330		1.160
				98	1.800				98	0.340		1.070
				99	1.960				99	0.310		1.135
			Avg:		1.958			Avg:		0.322	Avg:	1.140
			Std Dev:		0.125			Std Dev:		0.013	Std Dev:	0.058
	OF1	90	2	95	1.300	HF2	90	2	95	0.280		0.790
				96	1.130				96	0.280		0.705
				97	1.400				97	0.280		0.840
				98	1.200				98	0.290		0.745
				99	1.350				99	0.290		0.820
			Avg:		1.276			Avg:		0.284	Avg:	0.780
			Std Dev:		0.110			Std Dev:		0.005	Std Dev:	0.055
B	OF2	0	1	95	0.350	HF1	0	1	95	0.360		0.355
				96	0.260				96	0.410		0.335
				97	0.330				97	0.270		0.300
				98	0.330				98	0.440		0.385
				99	0.280				99	0.310		0.295
			Avg:		0.310			Avg:		0.358	Avg:	0.334
			Std Dev:		0.038			Std Dev:		0.070	Std Dev:	0.038
	OF2	0	2	95	0.270	HF1	0	2	95	0.410		0.340
				96	0.250				96	0.320		0.285
				97	0.310				97	0.390		0.350
				98	0.290				98	0.340		0.315
				99	0.290				99	0.360		0.325
			Avg:		0.282			Avg:		0.364	Avg:	0.323
			Std Dev:		0.023			Std Dev:		0.036	Std Dev:	0.025
	OF2	90	1	95	0.730	HF1	90	1	95	0.180		0.455
				96	0.590				96	0.170		0.380
				97	0.780				97	0.180		0.480
				98	0.740				98	0.190		0.465
				99	0.620				99	0.130		0.375
			Avg:		0.692			Avg:		0.170	Avg:	0.431
			Std Dev:		0.082			Std Dev:		0.023	Std Dev:	0.050
	OF2	90	2	95	0.670	HF1	90	2	95	0.240		0.455
				96	0.530				96	0.230		0.380
				97	0.640				97	0.240		0.440
				98	0.720				98	0.190		0.455
				99	0.600				99	0.270		0.435
			Avg:		0.632			Avg:		0.234	Avg:	0.433
			Std Dev:		0.072			Std Dev:		0.029	Std Dev:	0.031

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 1.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.430	HF2	0	1	95	0.070		0.250
				96	0.460				96	0.050		0.255
				97	0.460				97	0.080		0.270
				98	0.540				98	0.090		0.315
				99	0.490				99	0.070		0.280
				Avg:	0.476				Avg:	0.072	Avg:	0.274
				Std Dev:	0.042				Std Dev:	0.015	Std Dev:	0.026
	OF1	0	2	95	0.460	HF2	0	2	95	0.120		0.290
				96	0.440				96	0.010		0.225
				97	0.450				97	0.010		0.230
				98	0.560				98	0.010		0.285
				99	0.420				99	0.150		0.285
				Avg:	0.466				Avg:	0.060	Avg:	0.263
				Std Dev:	0.055				Std Dev:	0.069	Std Dev:	0.033
	OF1	90	1	95	0.100	HF2	90	1	95	1.810		0.955
				96	0.220				96	1.020		0.620
				97	0.150				97	1.340		0.745
				98	0.220				98	1.270		0.745
				99	0.070				99	1.390		0.730
				Avg:	0.152				Avg:	1.366	Avg:	0.759
				Std Dev:	0.068				Std Dev:	0.286	Std Dev:	0.121
	OF1	90	2	95	0.200	HF2	90	2	95	0.690		0.445
				96	0.230				96	1.550		0.890
				97	0.220				97	2.000		1.110
				98	0.160				98	1.080		0.620
				99	0.400				99	1.230		0.815
				Avg:	0.242				Avg:	1.310	Avg:	0.776
				Std Dev:	0.092				Std Dev:	0.494	Std Dev:	0.255
C	OF2	0	1	95	0.140	HF1	0	1	95	0.350		0.245
				96	0.030				96	0.430		0.230
				97	0.010				97	0.330		0.170
				98	0.100				98	0.410		0.255
				99	0.050				99	0.390		0.220
				Avg:	0.066				Avg:	0.382	Avg:	0.224
				Std Dev:	0.053				Std Dev:	0.041	Std Dev:	0.033
	OF2	0	2	95	0.050	HF1	0	2	95	0.430		0.240
				96	0.030				96	0.570		0.300
				97	0.110				97	0.450		0.280
				98	0.020				98	0.590		0.305
				99	0.020				99	0.440		0.230
				Avg:	0.046				Avg:	0.496	Avg:	0.271
				Std Dev:	0.038				Std Dev:	0.077	Std Dev:	0.034
	OF2	90	1	95	0.820	HF1	90	1	95	0.010		0.415
				96	1.840				96	0.030		0.935
				97	2.430				97	0.040		1.235
				98	1.090				98	0.020		0.555
				99	1.790				99	0.010		0.900
				Avg:	1.594				Avg:	0.022	Avg:	0.808
				Std Dev:	0.642				Std Dev:	0.013	Std Dev:	0.326
	OF2	90	2	95	3.420	HF1	90	2	95	0.020		1.720
				96	1.650				96	0.060		0.855
				97	1.360				97	0.030		0.695
				98	2.610				98	0.010		1.310
				99	1.860				99	0.070		0.965
				Avg:	2.180				Avg:	0.038	Avg:	1.109
				Std Dev:	0.833				Std Dev:	0.026	Std Dev:	0.409

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 3.00 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.070	HF2	0	1	95	0.570		0.320
				96	0.090				96	0.610		0.350
				97	0.090				97	0.500		0.295
				98	0.080				98	0.560		0.320
				99	0.100				99	0.490		0.295
				Avg:	0.086				Avg:	0.546	Avg:	0.316
				Std Dev:	0.011				Std Dev:	0.050	Std Dev:	0.023
	OF1	0	2	95	0.090	HF2	0	2	95	0.470		0.280
				96	0.050				96	0.530		0.290
				97	0.090				97	0.490		0.290
				98	0.080				98	0.590		0.335
				99	0.050				99	0.540		0.295
				Avg:	0.072				Avg:	0.524	Avg:	0.298
				Std Dev:	0.020				Std Dev:	0.047	Std Dev:	0.021
	OF1	90	1	95	0.630	HF2	90	1	95	0.050		0.340
				96	0.700				96	0.050		0.375
				97	0.770				97	0.020		0.395
				98	0.710				98	0.180		0.445
				99	0.570				99	0.110		0.340
				Avg:	0.676				Avg:	0.082	Avg:	0.379
				Std Dev:	0.077				Std Dev:	0.064	Std Dev:	0.044
	OF1	90	2	95	0.760	HF2	90	2	95	0.060		0.410
				96	0.720				96	0.100		0.410
				97	0.790				97	0.120		0.455
				98	0.760				98	0.180		0.470
				99	0.650				99	0.130		0.390
				Avg:	0.736				Avg:	0.118	Avg:	0.427
				Std Dev:	0.054				Std Dev:	0.044	Std Dev:	0.034
C	OF2	0	1	95	0.470	HF1	0	1	95	0.110		0.290
				96	0.220				96	0.130		0.175
				97	0.380				97	0.060		0.220
				98	0.450				98	0.130		0.290
				99	0.270				99	0.050		0.160
				Avg:	0.358				Avg:	0.096	Avg:	0.227
				Std Dev:	0.110				Std Dev:	0.038	Std Dev:	0.062
	OF2	0	2	95	0.440	HF1	0	2	95	0.090		0.265
				96	0.520				96	0.100		0.310
				97	0.300				97	0.060		0.180
				98	0.410				98	0.100		0.255
				99	0.400				99	0.080		0.240
				Avg:	0.414				Avg:	0.086	Avg:	0.250
				Std Dev:	0.079				Std Dev:	0.017	Std Dev:	0.047
	OF2	90	1	95	0.120	HF1	90	1	95	0.760		0.440
				96	0.050				96	0.700		0.375
				97	0.200				97	0.730		0.465
				98	0.110				98	0.800		0.455
				99	0.080				99	0.680		0.380
				Avg:	0.112				Avg:	0.734	Avg:	0.423
				Std Dev:	0.056				Std Dev:	0.048	Std Dev:	0.043
	OF2	90	2	95	0.120	HF1	90	2	95	0.880		0.500
				96	0.130				96	0.730		0.430
				97	0.150				97	0.880		0.515
				98	0.100				98	0.860		0.480
				99	0.120				99	0.810		0.465
				Avg:	0.124				Avg:	0.832	Avg:	0.478
				Std Dev:	0.018				Std Dev:	0.064	Std Dev:	0.033

Mix Type= 37.5 mm
Diam.= 6.00 in
Gage Length= 4.50 in
Total

Poissons Ratio Analysis

Specimen	Observable Face	Rotation Effect	Repeat	Cycle	u-Ratio	Hidden Face	Rotation Effect	Repeat	Cycle	u-Ratio		U-Ratio (Avg)
C	OF1	0	1	95	0.430	HF2	0	1	95	0.420		0.425
				96	0.460				96	0.440		0.450
				97	0.460				97	0.490		0.475
				98	0.470				98	0.560		0.515
				99	0.470				99	0.530		0.500
			Avg:		0.458			Avg:		0.488	Avg:	0.473
			Std Dev:		0.016			Std Dev:		0.059	Std Dev:	0.037
	OF1	0	2	95	0.480	HF2	0	2	95	0.540		0.510
				96	0.470				96	0.480		0.475
				97	0.440				97	0.440		0.440
				98	0.460				98	0.490		0.475
				99	0.500				99	0.570		0.535
			Avg:		0.470			Avg:		0.504	Avg:	0.487
			Std Dev:		0.022			Std Dev:		0.051	Std Dev:	0.037
	OF1	90	1	95	0.260	HF2	90	1	95	0.240		0.250
				96	0.260				96	0.240		0.250
				97	0.250				97	0.190		0.220
				98	0.260				98	0.210		0.235
				99	0.250				99	0.270		0.260
			Avg:		0.256			Avg:		0.230	Avg:	0.243
			Std Dev:		0.005			Std Dev:		0.031	Std Dev:	0.016
	OF1	90	2	95	0.330	HF2	90	2	95	0.190		0.260
				96	0.300				96	0.220		0.260
				97	0.310				97	0.230		0.270
				98	0.350				98	0.210		0.280
				99	0.320				99	0.210		0.265
			Avg:		0.322			Avg:		0.212	Avg:	0.267
			Std Dev:		0.019			Std Dev:		0.015	Std Dev:	0.008
C	OF2	0	1	95	0.460	HF1	0	1	95	0.430		0.445
				96	0.350				96	0.400		0.375
				97	0.460				97	0.420		0.440
				98	0.400				98	0.370		0.385
				99	0.460				99	0.450		0.455
			Avg:		0.426			Avg:		0.414	Avg:	0.420
			Std Dev:		0.050			Std Dev:		0.030	Std Dev:	0.037
	OF2	0	2	95	0.520	HF1	0	2	95	0.470		0.495
				96	0.440				96	0.500		0.470
				97	0.490				97	0.480		0.485
				98	0.430				98	0.460		0.445
				99	0.460				99	0.500		0.480
			Avg:		0.468			Avg:		0.482	Avg:	0.475
			Std Dev:		0.037			Std Dev:		0.018	Std Dev:	0.019
	OF2	90	1	95	0.140	HF1	90	1	95	0.530		0.335
				96	0.090				96	0.600		0.345
				97	0.160				97	0.610		0.385
				98	0.140				98	0.610		0.375
				99	0.160				99	0.580		0.370
			Avg:		0.138			Avg:		0.586	Avg:	0.362
			Std Dev:		0.029			Std Dev:		0.034	Std Dev:	0.021
	OF2	90	2	95	0.140	HF1	90	2	95	0.560		0.350
				96	0.170				96	0.600		0.385
				97	0.130				97	0.610		0.370
				98	0.130				98	0.560		0.345
				99	0.130				99	0.590		0.360
			Avg:		0.140			Avg:		0.584	Avg:	0.362
			Std Dev:		0.017			Std Dev:		0.023	Std Dev:	0.016

APPENDIX B

NCHRP 1-28A Project

Summary of Component Variance Analysis

Annex 1

NCHRP 1-28A Project

Component Variance Analysis

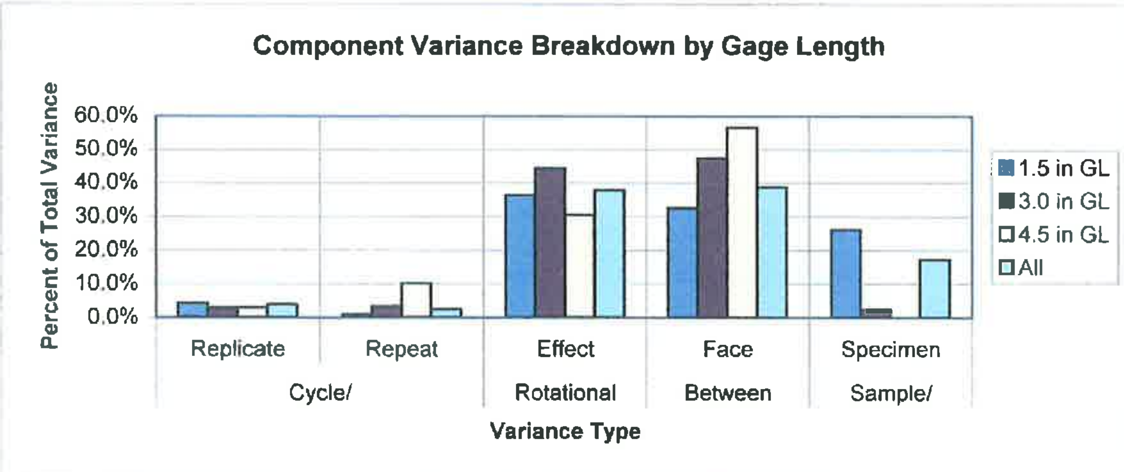
Mr Instantaneous

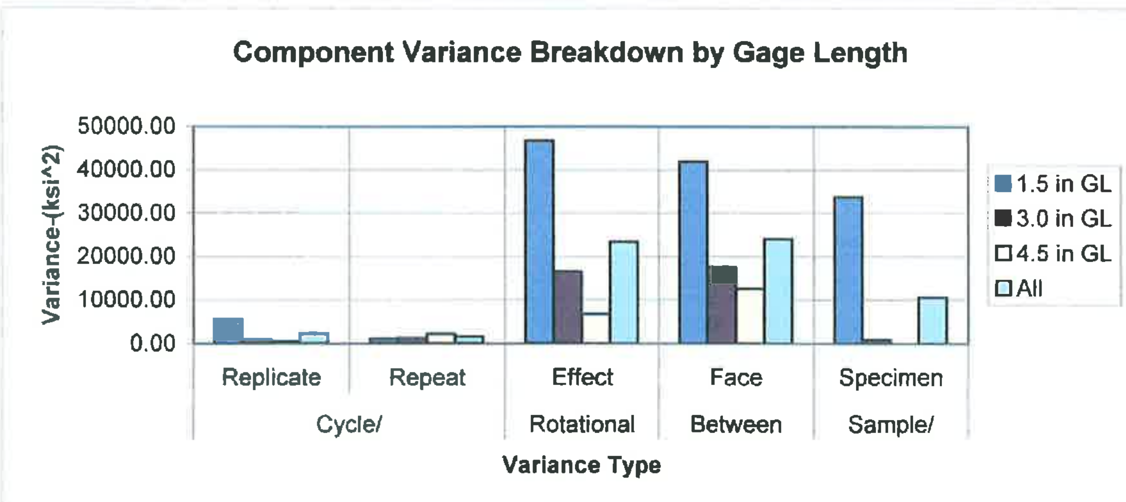
12.5 mm
4 inch Dia.

IMr12.5-4D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		5528.26	1150.5	46724.36	41880.2	33793.58	129076.937
1.0 in	Variance-%	4.3%	0.9%	36.2%	32.4%	26.2%	
		1017.62	1241.7	16435.44	17535.9	896.15	37126.854
2.0 in	Variance-%	2.7%	3.3%	44.3%	47.2%	2.4%	
		654.84	2228.5	6724.41	12520.3	0.00	22128.007
3.0 in	Variance-%	3.0%	10.1%	30.4%	56.6%	0.0%	
		2400.24	1540.2	23294.74	23978.8	10574.34	61788.362
All	Variance-%	3.9%	2.5%	37.7%	38.8%	17.1%	





Annex 2

NCHRP 1-28A Project

Component Variance Analysis

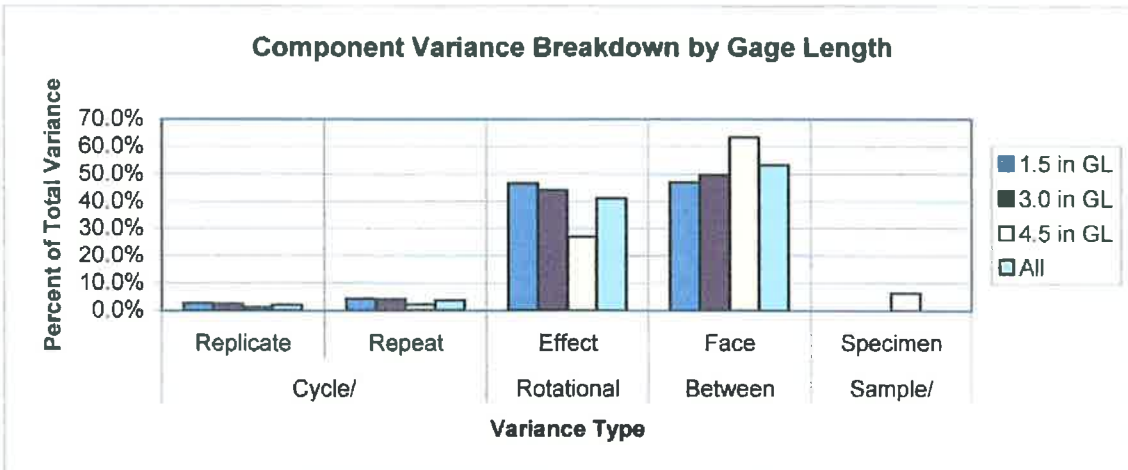
Mr Instantaneous

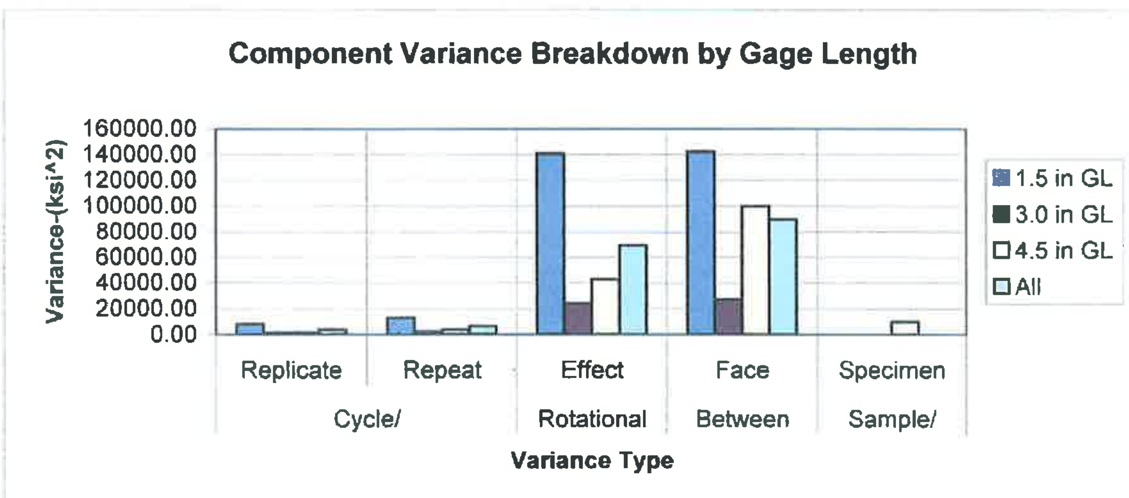
19.0 mm
4 inch Dia.

IMr19-4D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		7802.93	12887.1	140544.15	142168.9	0.00	303403.040
1.0 in	Variance-%	2.6%	4.2%	46.3%	46.9%	0.0%	
		1299.48	2205.0	24077.62	27064.8	0.00	54646.909
2.0 in	Variance-%	2.4%	4.0%	44.1%	49.5%	0.0%	
		1746.57	3559.5	42507.64	99771.3	9961.08	157546.055
3.0 in	Variance-%	1.1%	2.3%	27.0%	63.3%	6.3%	
		3616.33	6217.2	69043.14	89668.3	0.00	168544.975
All	Variance-%	2.1%	3.7%	41.0%	53.2%	0.0%	





Annex 3

NCHRP 1-28A Project

Component Variance Analysis

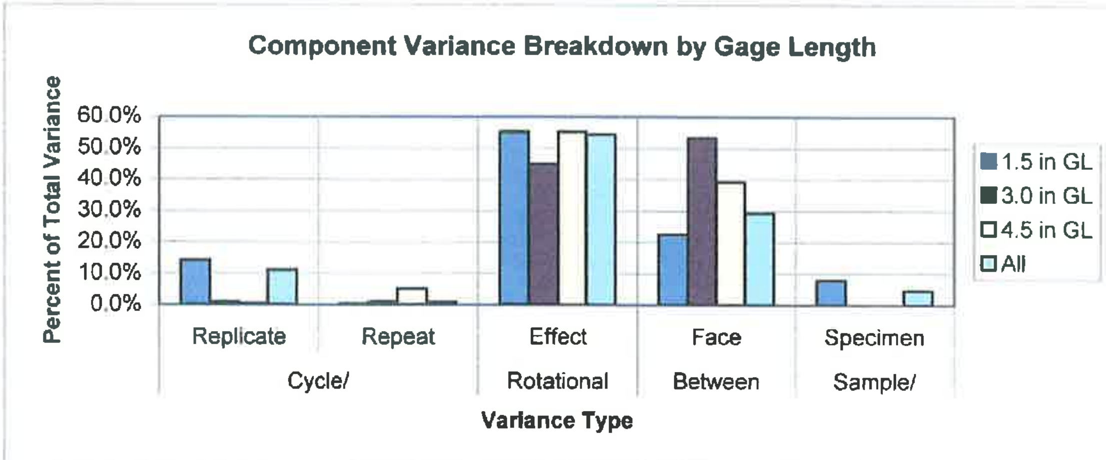
Mr Instantaneous

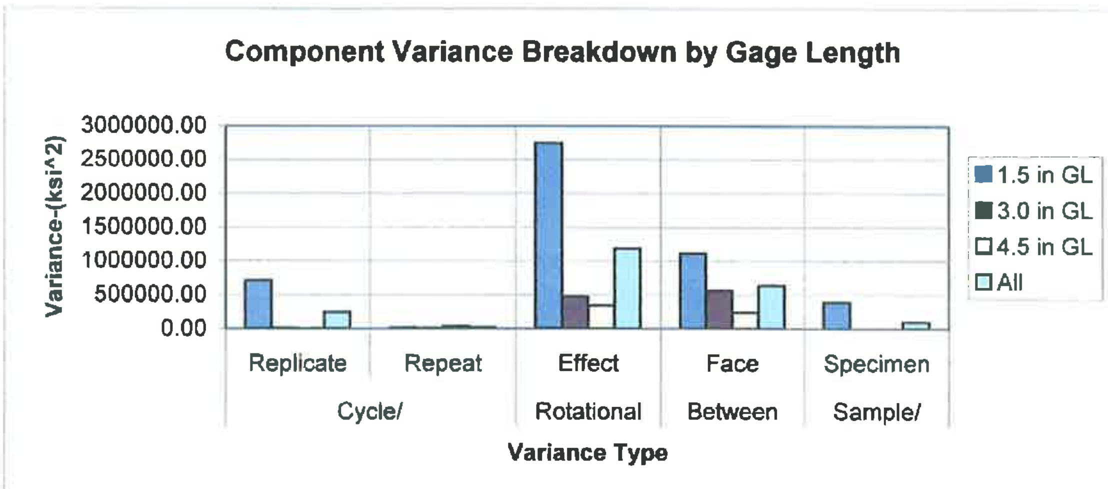
37.5 mm
4 inch Dia.

IMr37.5-4D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
1.0 in	Variance-%	705202.33 14.2%	19281.3 0.4%	2744854.12 55.2%	1108075.7 22.3%	392397.58 7.9%	4969811.004
2.0 in	Variance-%	9940.34 0.9%	9816.3 0.9%	469960.53 44.9%	556895.1 53.2%	0.00 0.0%	1046612.263
3.0 in	Variance-%	3617.77 0.6%	31311.0 5.1%	339667.84 55.2%	241055.2 39.2%	0.00 0.0%	615651.744
All	Variance-%	239586.81 11.0%	20136.2 0.9%	1184827.50 54.4%	635342.0 29.2%	98547.62 4.5%	2178440.099





Annex 4

NCHRP 1-28A Project

Component Variance Analysis

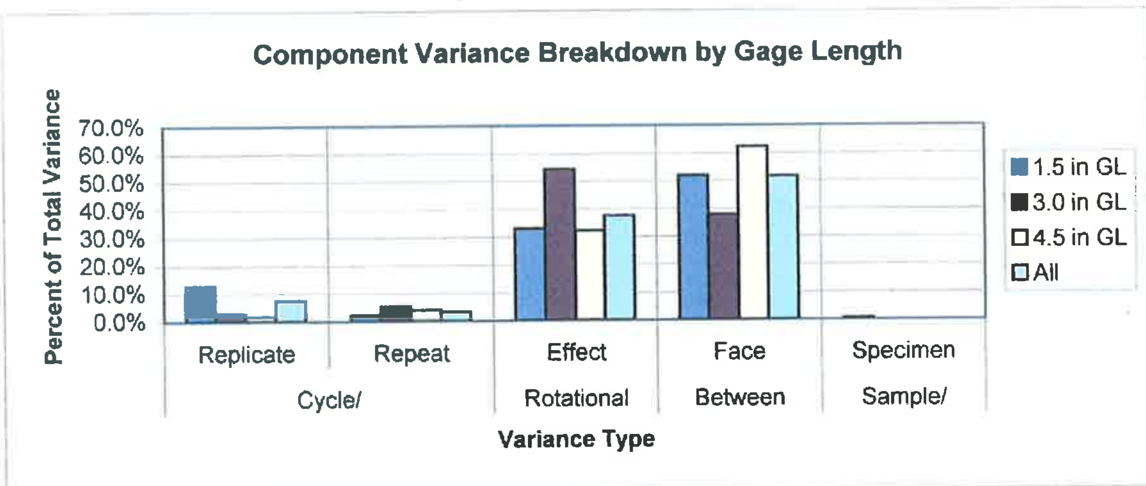
Mr Instantaneous

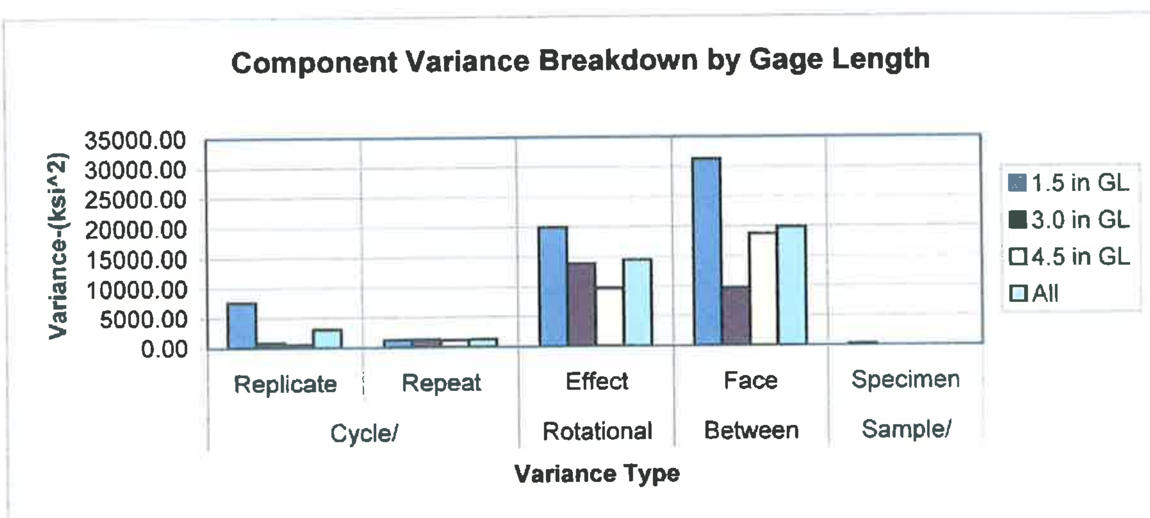
12.5 mm
6 inch Dia.

IMr12.5-6D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		7576.59	1242.7	19875.83	31235.1	286.47	60216.646
1.5 in	Variance-%	12.6%	2.1%	33.0%	51.9%	0.5%	
		729.70	1281.9	13805.72	9623.7	0.00	25441.054
3.0 in	Variance-%	2.9%	5.0%	54.3%	37.8%	0.0%	
		540.44	1127.3	9680.71	18743.2	0.00	30091.663
4.5 in	Variance-%	1.8%	3.7%	32.2%	62.3%	0.0%	
		2948.91	1217.3	14454.08	19867.3	0.00	38487.632
All	Variance-%	7.7%	3.2%	37.6%	51.6%	0.0%	





Annex 5

NCHRP 1-28A Project

Component Variance Analysis

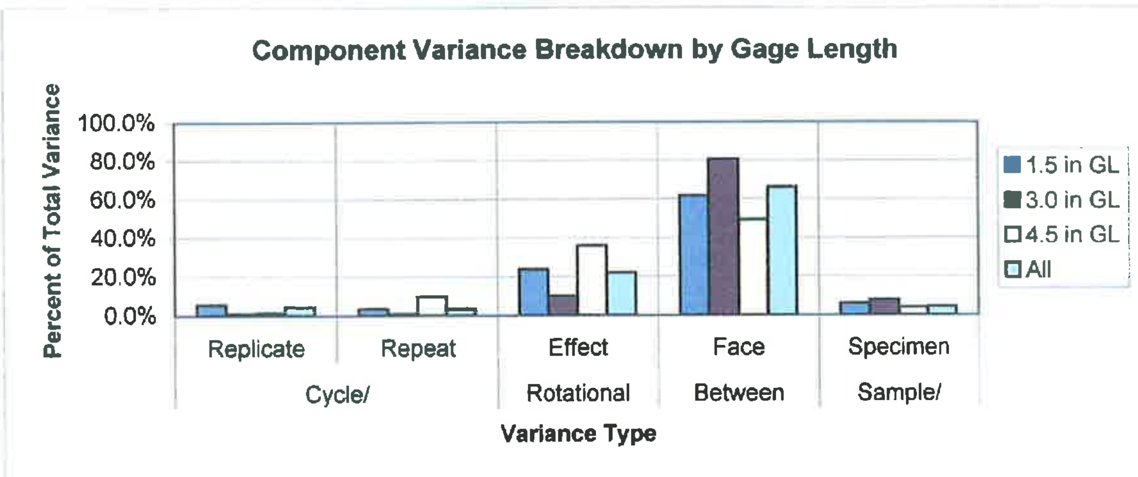
Mr Instantaneous

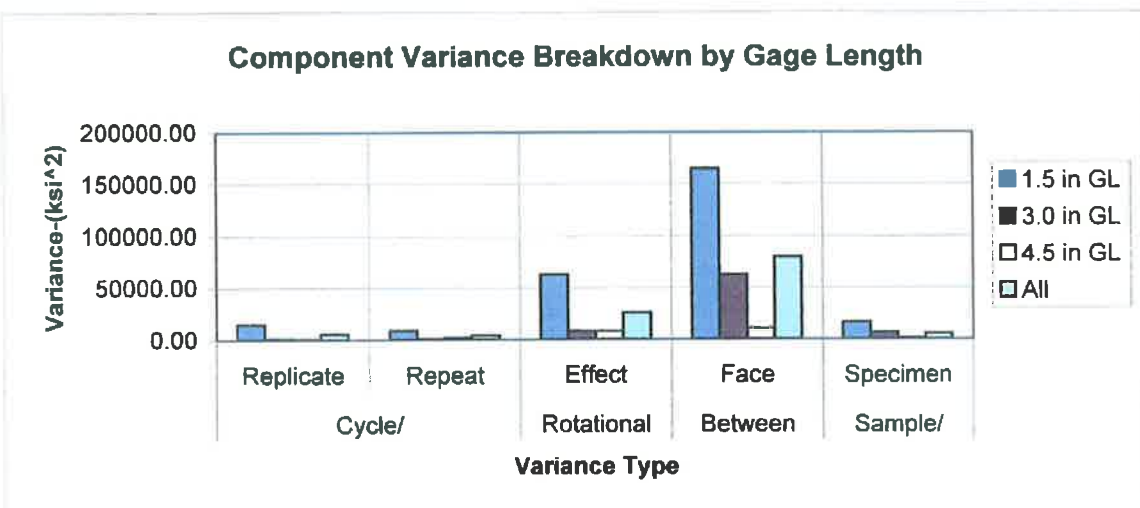
19.0 mm
6 inch Dia.

IMr19-6D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		14659.95	9039.1	62758.49	164833.2	16249.58	267540.283
1.5 in	Variance-%	5.5%	3.4%	23.5%	61.6%	6.1%	
		709.85	619.3	7741.53	62394.7	6080.98	77546.298
3.0 in	Variance-%	0.9%	0.8%	10.0%	80.5%	7.8%	
		314.25	2110.8	7867.55	10915.0	885.39	22092.993
4.5 in	Variance-%	1.4%	9.6%	35.6%	49.4%	4.0%	
		5228.01	3923.0	26122.52	79381.0	5275.58	119930.124
All	Variance-%	4.4%	3.3%	21.8%	66.2%	4.4%	





Annex 6

NCHRP 1-28A Project

Component Variance Analysis

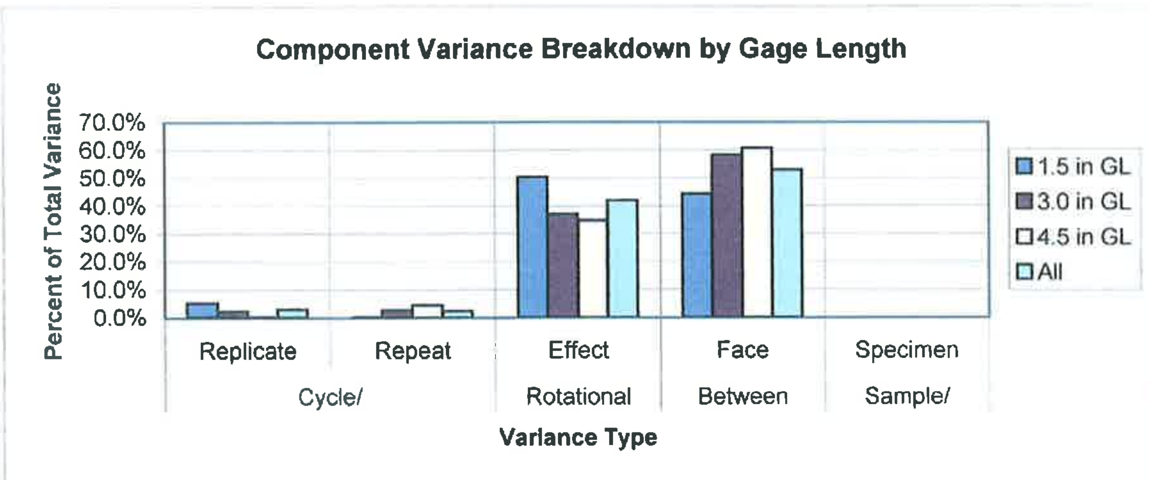
Mr Instantaneous

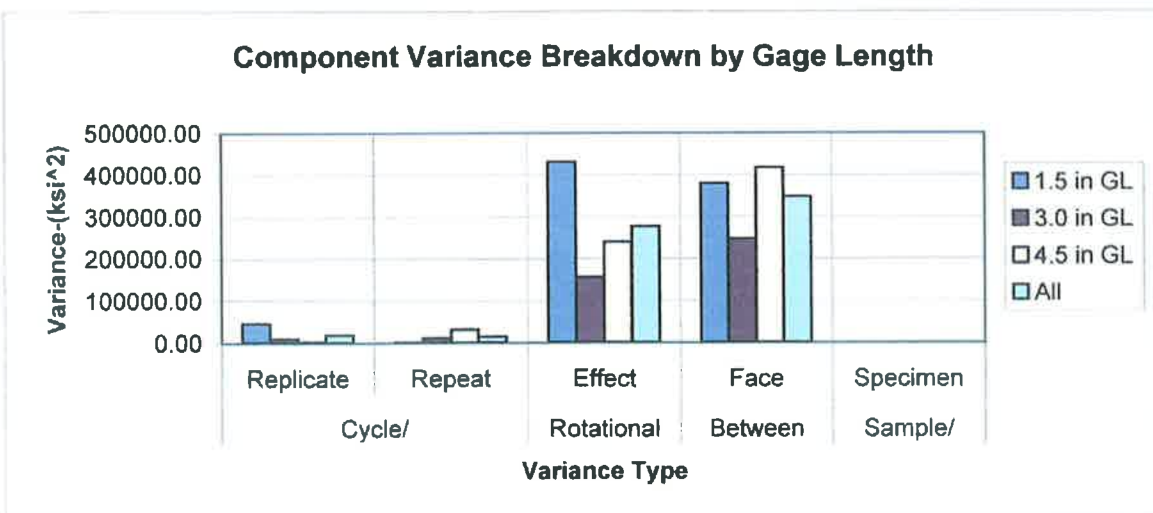
37.5 mm
6 inch Dia.

IMr37.5-6D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		45992.25	1640.3	430253.91	378310.0	0.00	856196.449
1.5 in	Variance-%	5.4%	0.2%	50.3%	44.2%	0.0%	
		9494.81	11545.6	156266.66	246720.9	0.00	424027.916
3.0 in	Variance-%	2.2%	2.7%	36.9%	58.2%	0.0%	
		1920.56	30901.1	238764.02	416406.4	0.00	687992.050
4.5 in	Variance-%	0.3%	4.5%	34.7%	60.5%	0.0%	
		19135.87	14695.6	275094.86	347145.8	0.00	656072.138
All	Variance-%	2.9%	2.2%	41.9%	52.9%	0.0%	





Annex 7

NCHRP 1-28A Project

Component Variance Analysis

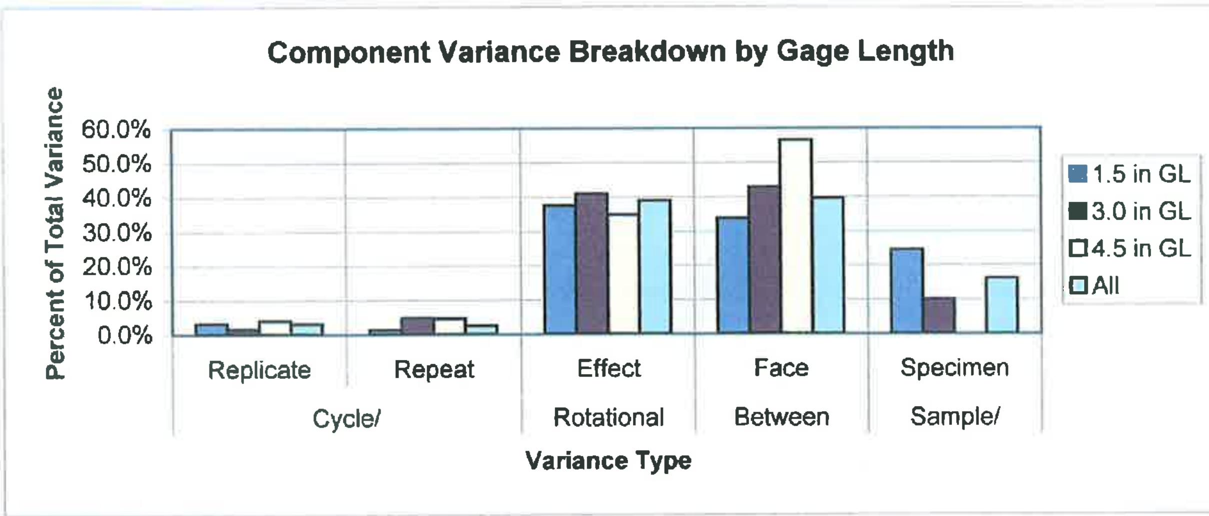
Mr Total

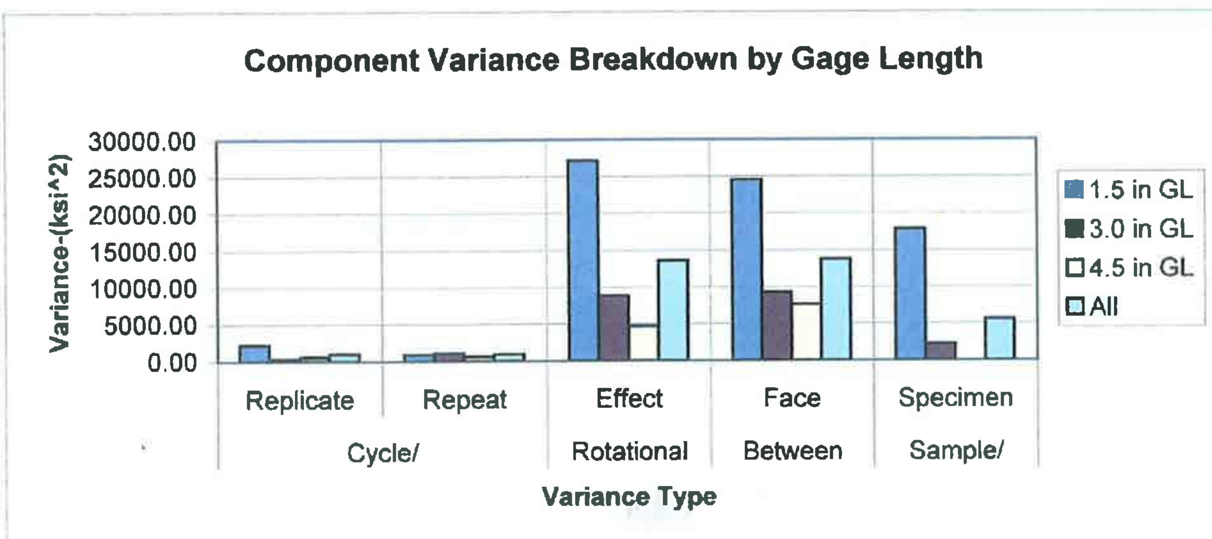
12.5 mm
4 inch Dia.

TMr12.5-4D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		2191.70	915.8	27165.70	24479.1	17779.48	72531.720
1.0 in	Variance-%	3.0%	1.3%	37.5%	33.7%	24.5%	
		321.90	1039.6	8804.89	9229.1	2177.92	21573.317
2.0 in	Variance-%	1.5%	4.8%	40.8%	42.8%	10.1%	
		537.13	618.9	4662.79	7563.4	0.00	13382.231
3.0 in	Variance-%	4.0%	4.6%	34.8%	56.5%	0.0%	
		1016.91	858.1	13544.46	13757.2	5593.69	34770.312
All	Variance-%	2.9%	2.5%	39.0%	39.6%	16.1%	





Annex 8

NCHRP 1-28A Project

Component Variance Analysis

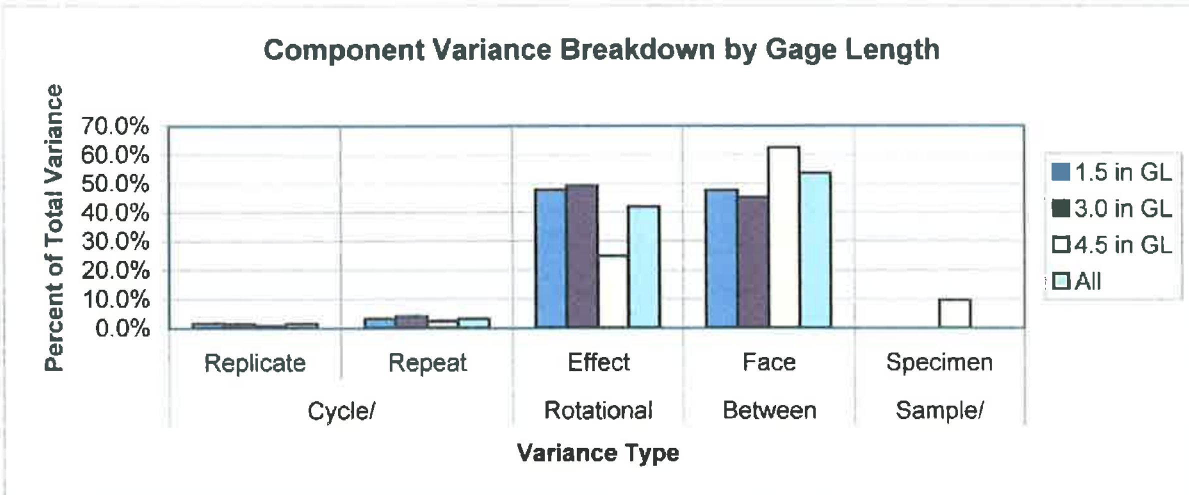
Mr Total

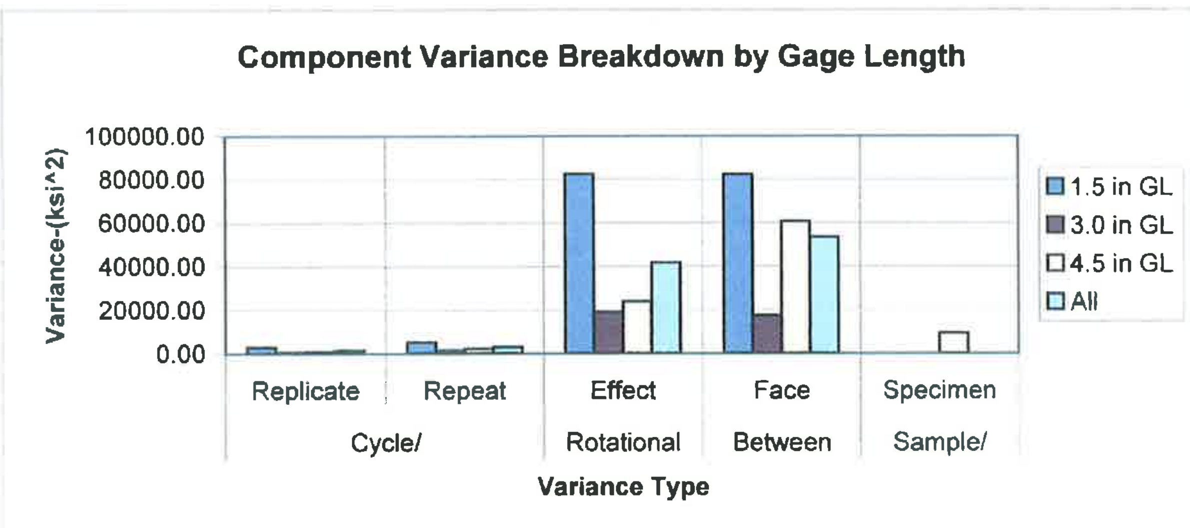
19.0 mm
4 inch Dia.

TMr19-4D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		2918.30	5233.8	82390.49	82202.1	0.00	172744.722
1.0 in	Variance-%	1.7%	3.0%	47.7%	47.6%	0.0%	
		620.48	1578.1	18959.75	17368.8	0.00	38527.176
2.0 in	Variance-%	1.6%	4.1%	49.2%	45.1%	0.0%	
		895.50	2269.5	23918.15	60546.8	9231.38	96861.292
3.0 in	Variance-%	0.9%	2.3%	24.7%	62.5%	9.5%	
		1478.09	3027.1	41756.13	53372.6	0.00	99633.936
All	Variance-%	1.5%	3.0%	41.9%	53.6%	0.0%	





Annex 9

NCHRP 1-28A Project

Component Variance Analysis

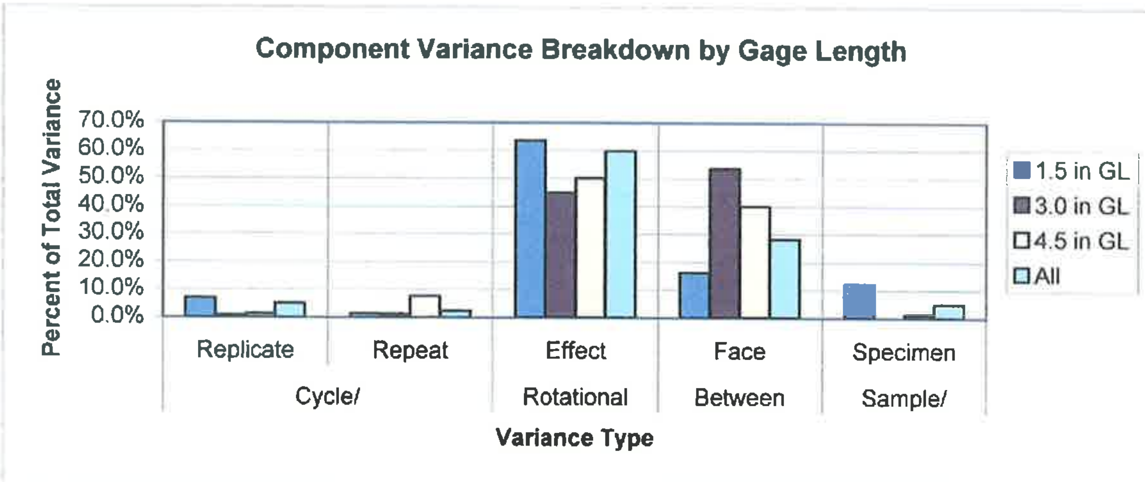
Mr Total

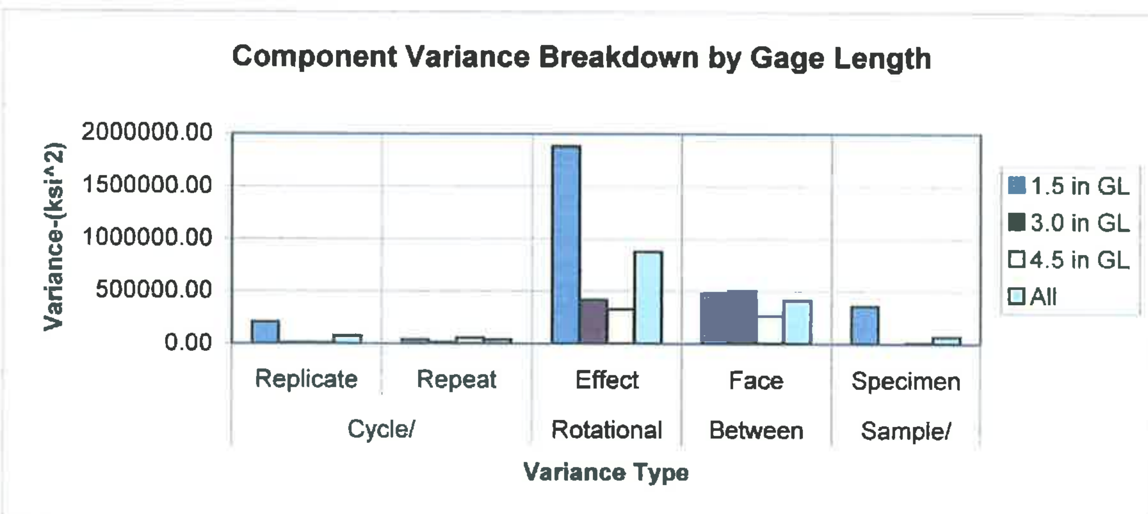
37.5 mm
4 inch Dia.

TMr37.5-4D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
1.0 in	Variance-%	203636.45 6.9%	37840.6 1.3%	1877338.51 63.5%	477693.0 16.2%	359034.69 12.1%	2955543.305
2.0 in	Variance-%	7246.08 0.8%	10471.2 1.1%	416594.28 44.7%	496799.7 53.4%	0.00 0.0%	931111.207
3.0 in	Variance-%	7286.54 1.1%	49674.2 7.6%	327735.59 50.0%	263098.9 40.1%	7985.89 1.2%	655781.158
All	Variance-%	72723.03 5.0%	32662.0 2.2%	873889.46 59.7%	412530.5 28.2%	71258.18 4.9%	1463063.211





Annex 10

NCHRP 1-28A Project

Component Variance Analysis

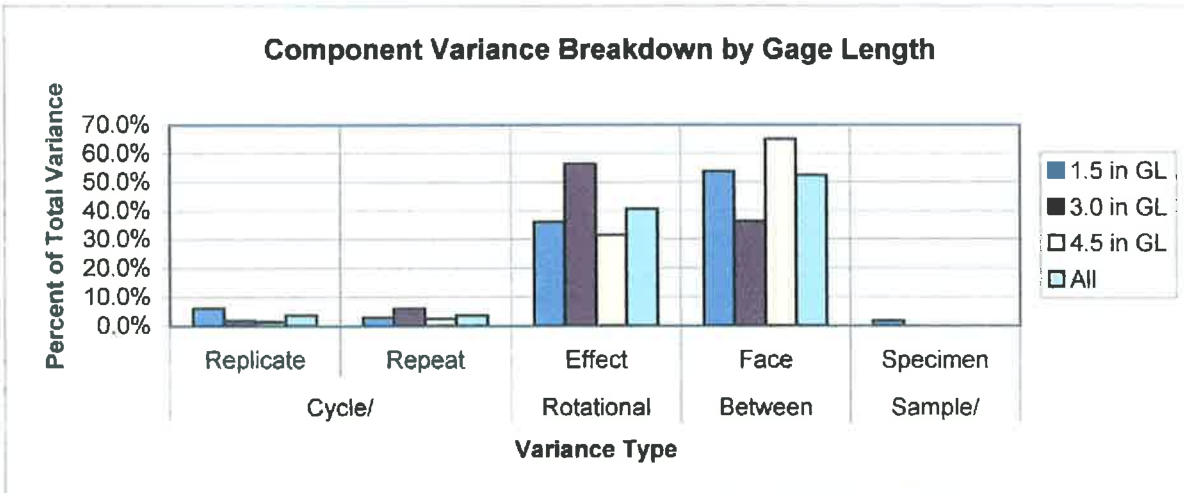
Mr Total

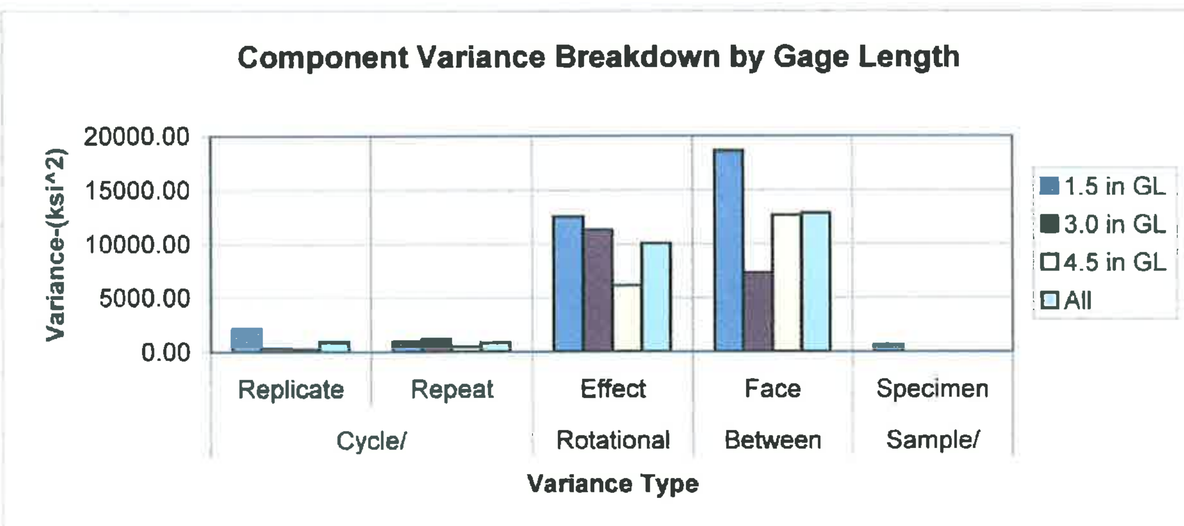
12.5 mm
6 inch Dia.

TMr12.5-6D

Variance Components-(ksi^2)

Gage Length		***Cycle/ Replicate***	***Repeat***	***Rotational Effect***	***Between Face***	***Sample/ Specimen***	***Total Variance***
		2091.71	941.4	12515.58	18638.9	608.36	34795.916
1.5 in	Variance-%	6.0%	2.7%	36.0%	53.6%	1.7%	
		364.89	1163.4	11272.01	7263.7	0.00	20064.041
3.0 in	Variance-%	1.8%	5.8%	56.2%	36.2%	0.0%	
		237.31	462.0	6125.62	12667.5	0.00	19492.464
4.5 in	Variance-%	1.2%	2.4%	31.4%	65.0%	0.0%	
		897.97	855.6	9971.07	12856.7	0.00	24581.353
All	Variance-%	3.7%	3.5%	40.6%	52.3%	0.0%	





Annex 11

NCHRP 1-28A Project

Component Variance Analysis

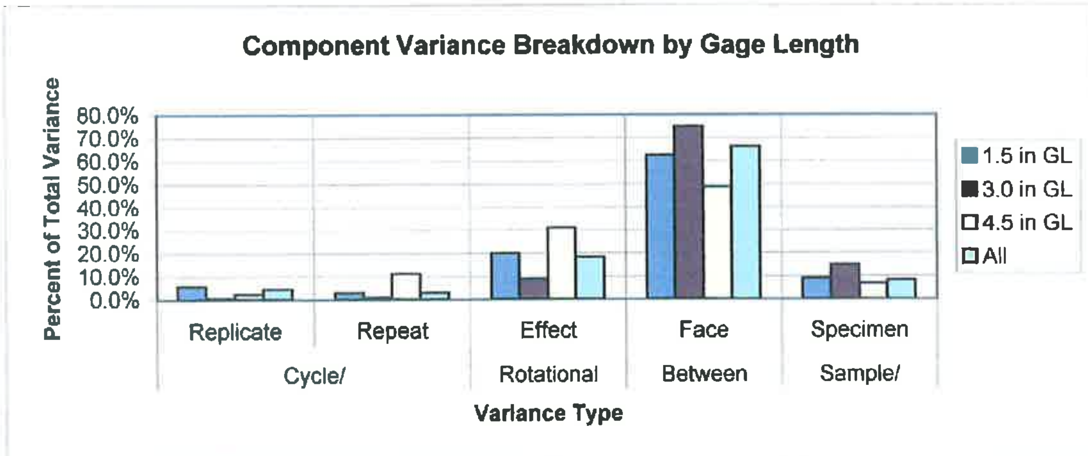
Mr Total

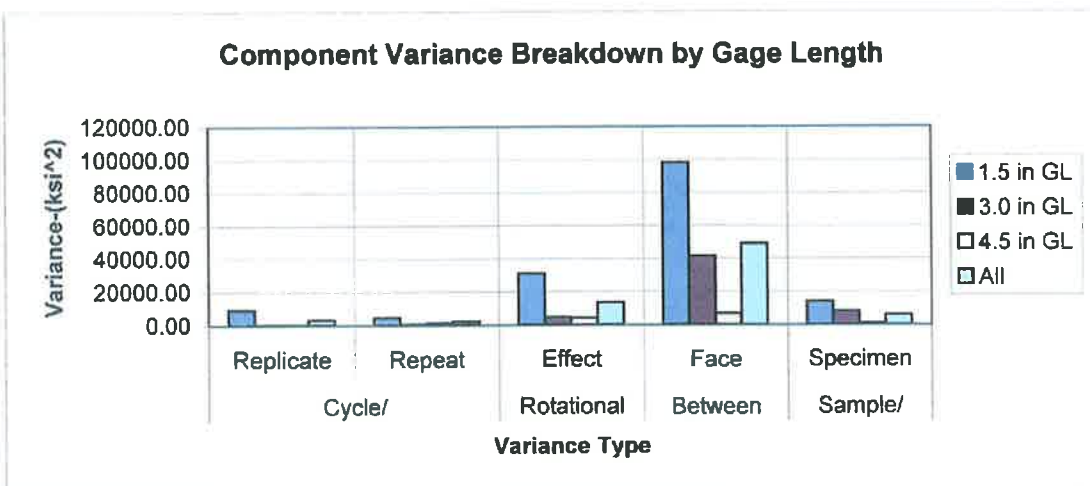
19.0 mm
6 inch Dia.

TMr19-6D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		9052.13	4724.9	31165.23	98260.8	14097.26	157300.241
1.5 in	Variance-%	5.8%	3.0%	19.8%	62.5%	9.0%	
		307.63	483.6	4835.37	41317.7	8207.85	55152.145
3.0 in	Variance-%	0.6%	0.9%	8.8%	74.9%	14.9%	
		320.51	1546.0	4276.55	6723.5	925.94	13792.572
4.5 in	Variance-%	2.3%	11.2%	31.0%	48.7%	6.7%	
		3226.76	2251.5	13425.71	48767.3	6041.95	73713.255
All	Variance-%	4.4%	3.1%	18.2%	66.2%	8.2%	





Annex 12

NCHRP 1-28A Project

Component Variance Analysis

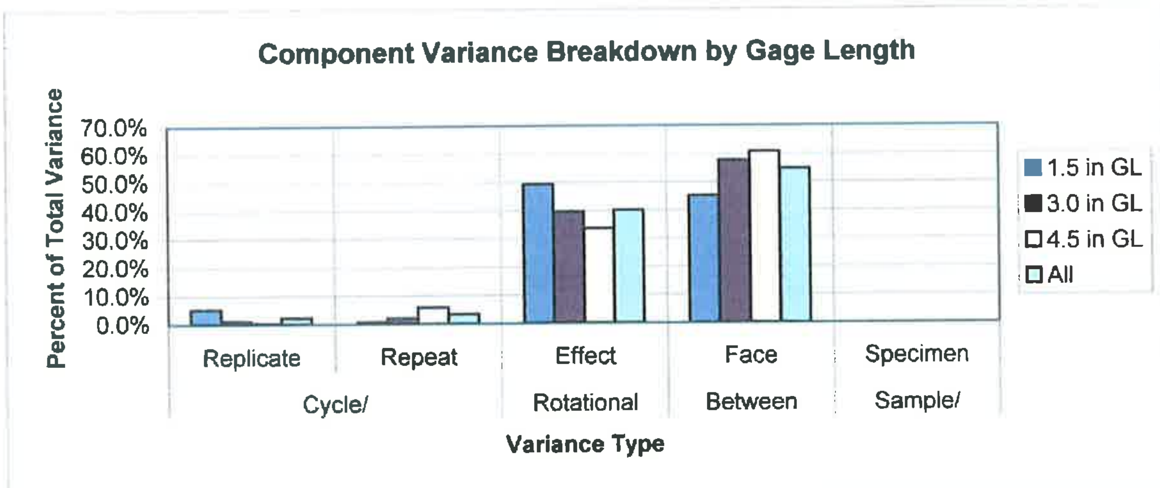
Mr Total

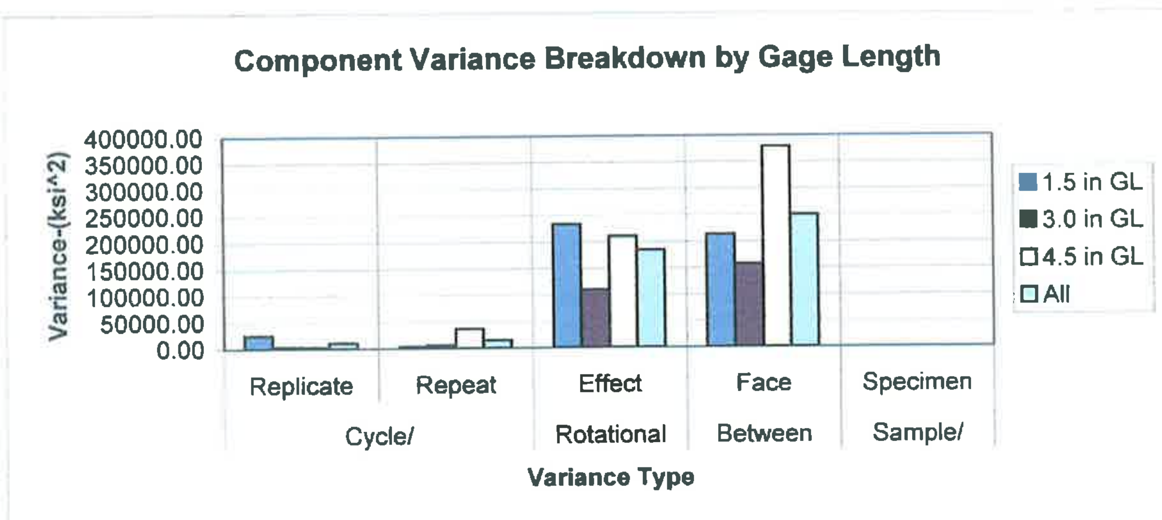
37.5 mm
6 inch Dia.

TMr37.5-6D

Variance Components-(ksi^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		24438.02	3406.7	231622.17	211977.9	0.00	471444.801
1.5 in	Variance-%	5.2%	0.7%	49.1%	45.0%	0.0%	
		2975.65	5544.7	108410.34	157180.3	0.00	274111.001
3.0 in	Variance-%	1.1%	2.0%	39.5%	57.3%	0.0%	
		1769.08	35558.4	209685.50	378944.7	0.00	625957.648
4.5 in	Variance-%	0.3%	5.7%	33.5%	60.5%	0.0%	
		9727.58	14836.6	183239.33	249367.6	0.00	457171.150
All	Variance-%	2.1%	3.2%	40.1%	54.5%	0.0%	





Annex 13

NCHRP 1-28A Project

Component Variance Analysis

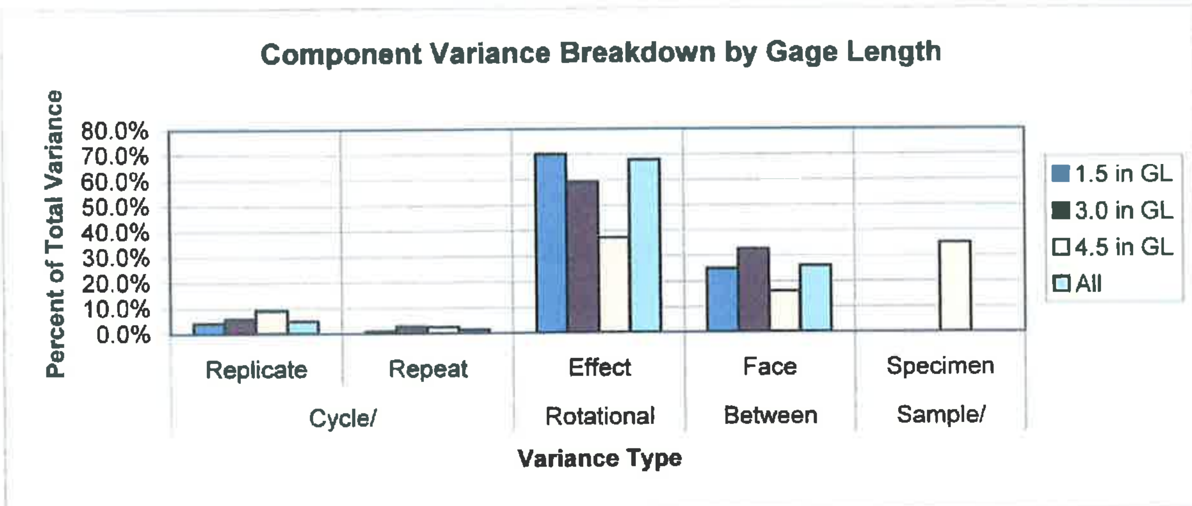
Poisson's Ratio Instantaneous

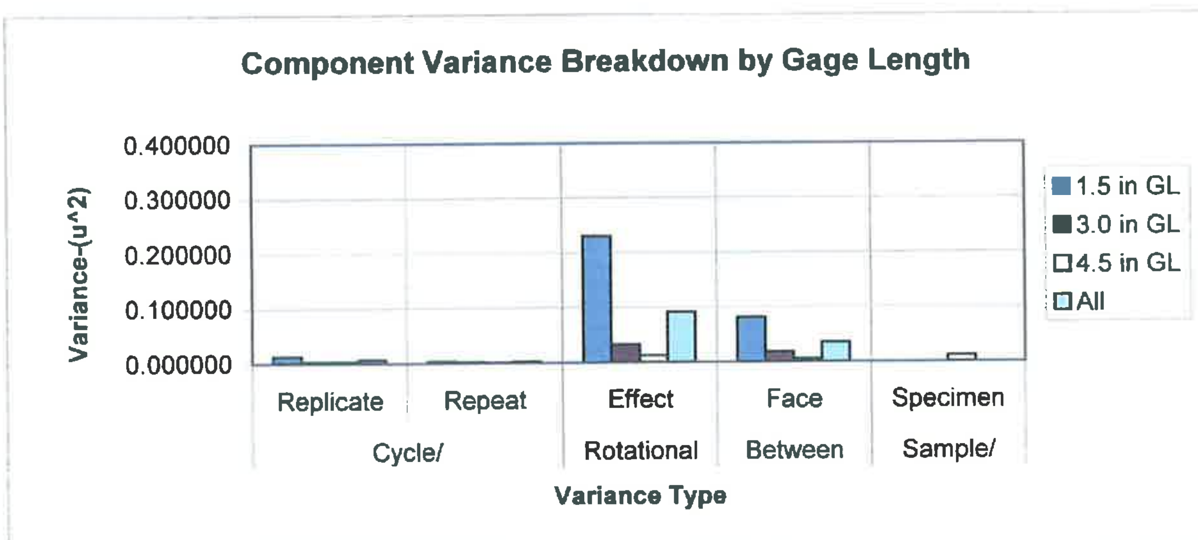
12.5 mm
4 inch Dia.

IPR12.5-4D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.013333	0.003239	0.229284	0.081750	0.000000	0.327605
1.0 in	Variance-%	4.1%	1.0%	70.0%	25.0%	0.0%	
		0.003083	0.001497	0.032315	0.017814	0.000000	0.054709
2.0 in	Variance-%	5.6%	2.7%	59.1%	32.6%	0.0%	
		0.002974	0.000861	0.012226	0.005245	0.011530	0.032836
3.0 in	Variance-%	9.1%	2.6%	37.2%	16.0%	35.1%	
		0.006463	0.001866	0.091275	0.034936	0.000000	0.134540
All	Variance-%	4.8%	1.4%	67.8%	26.0%	0.0%	





Annex 14

NCHRP 1-28A Project

Component Variance Analysis

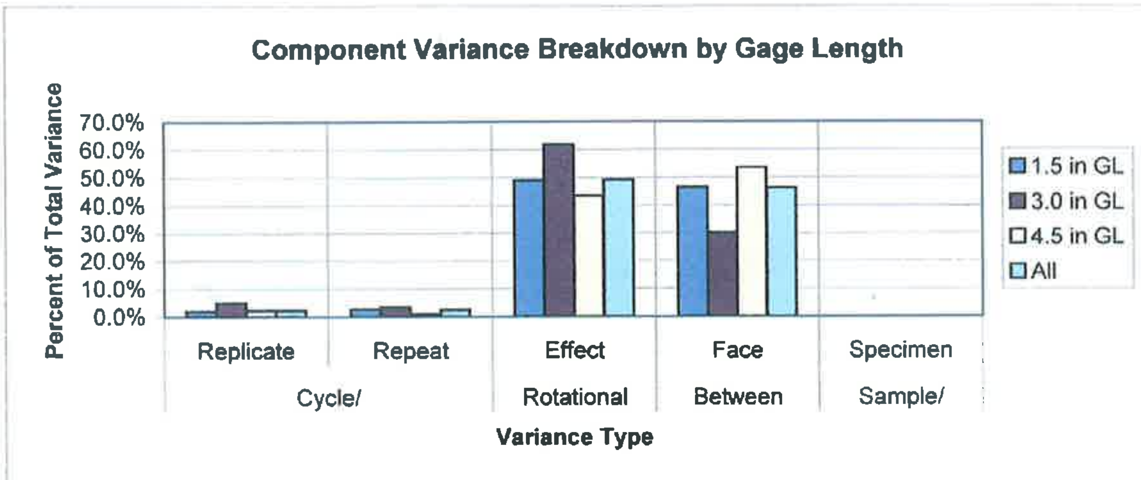
Poisson's Ratio Instantaneous

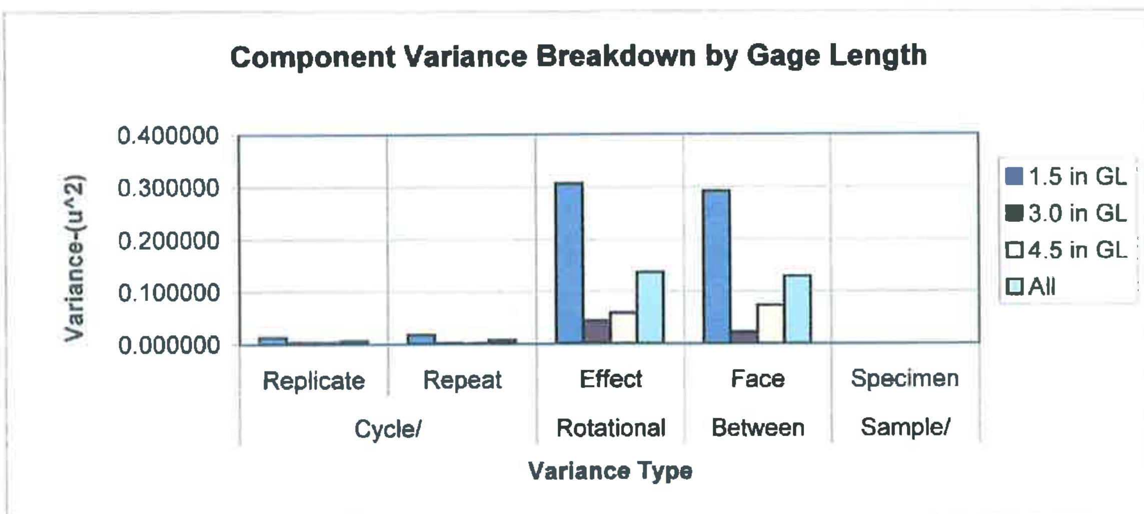
19.0 mm
4 inch Dia.

IPR19-4D

Variance Components-(u^2)

Gage Length		*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample/ Specimen*	*Total Variance*
		0.012836	0.017063	0.306112	0.290781	0.000000	0.626793
1.0 in	Variance-%	2.0%	2.7%	48.8%	46.4%	0.0%	
		0.003537	0.002270	0.043671	0.021285	0.000000	0.070764
2.0 in	Variance-%	5.0%	3.2%	61.7%	30.1%	0.0%	
		0.003205	0.001169	0.058593	0.072352	0.000000	0.135318
3.0 in	Variance-%	2.4%	0.9%	43.3%	53.5%	0.0%	
		0.006526	0.006834	0.136125	0.128139	0.000000	0.277625
All	Variance-%	2.4%	2.5%	49.0%	46.2%	0.0%	





Annex 15

NCHRP 1-28A Project

Component Variance Analysis

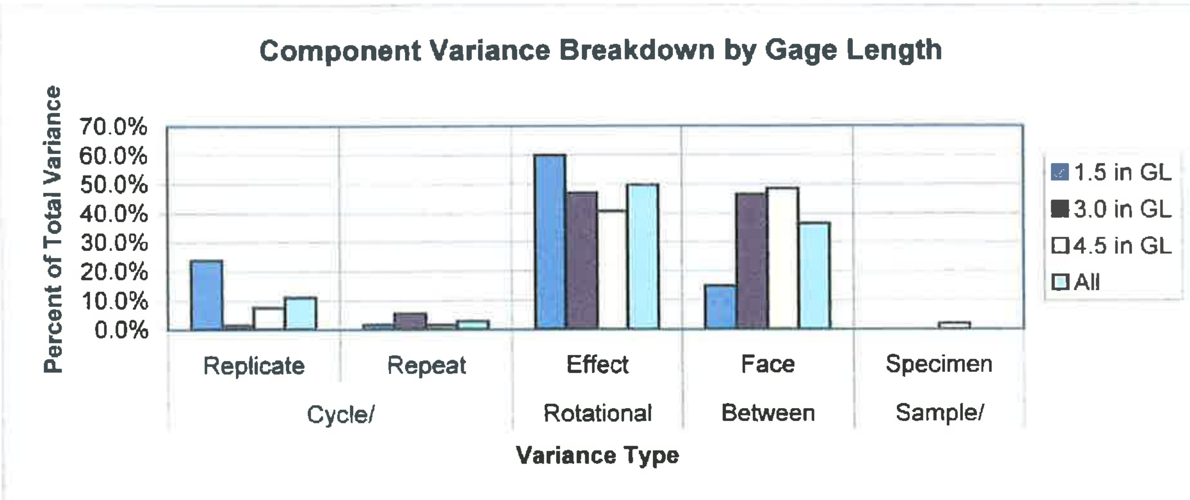
Poisson's Ratio Instantaneous

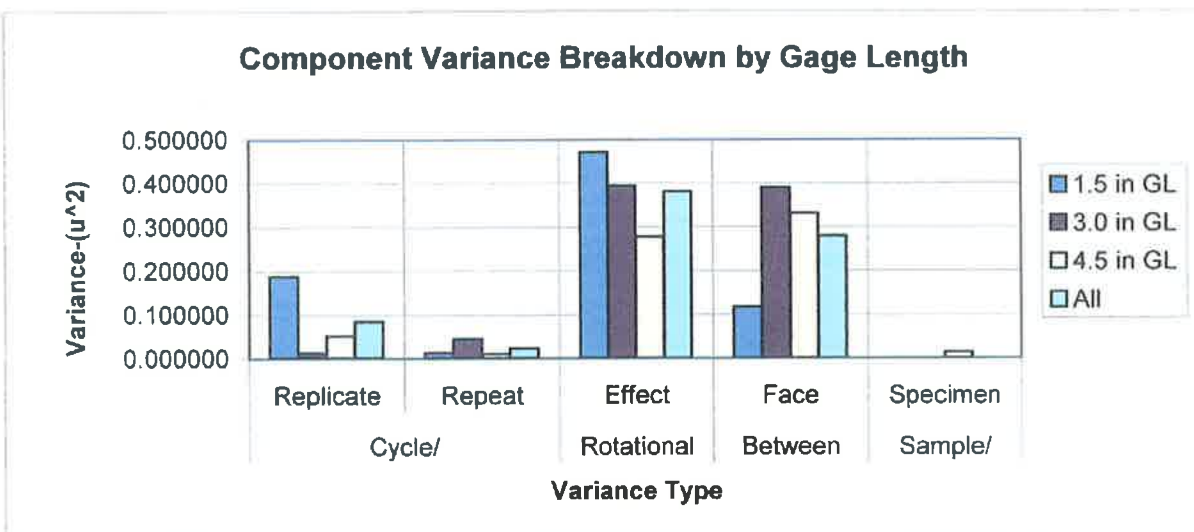
37.5 mm
4 inch Dia.

IPR37.5-4D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.187687	0.012598	0.470542	0.116771	0.000000	0.787599
1.0 in	Variance-%	23.8%	1.6%	59.7%	14.8%	0.0%	
		0.013077	0.044590	0.393280	0.389065	0.000000	0.840012
2.0 in	Variance-%	1.6%	5.3%	46.8%	46.3%	0.0%	
		0.052342	0.010341	0.277477	0.330792	0.013108	0.684059
3.0 in	Variance-%	7.7%	1.5%	40.6%	48.4%	1.9%	
		0.084369	0.022510	0.380433	0.278876	0.000000	0.766187
All	Variance-%	11.0%	2.9%	49.7%	36.4%	0.0%	





Annex 16

NCHRP 1-28A Project

Component Variance Analysis

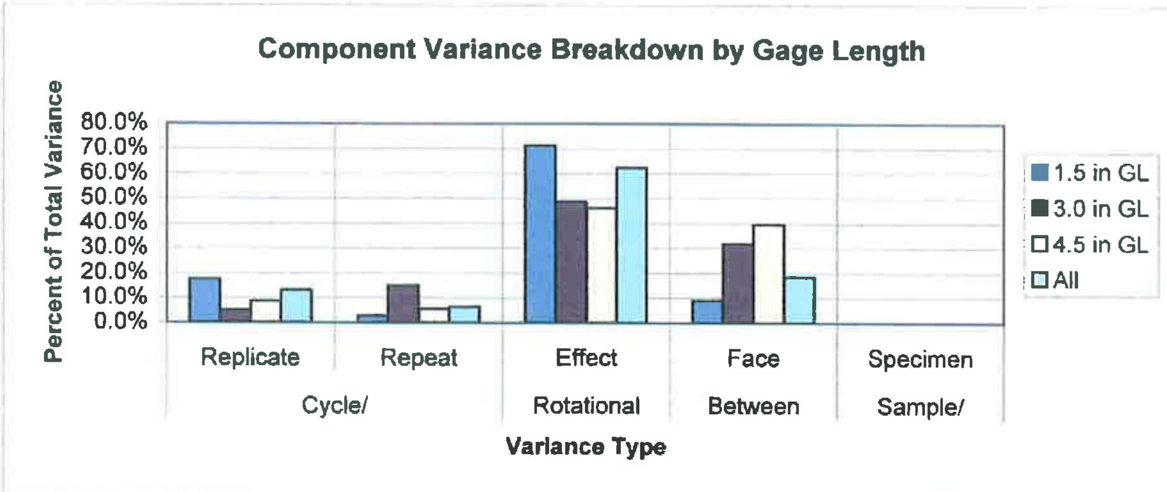
Poisson's Ratio Instantaneous

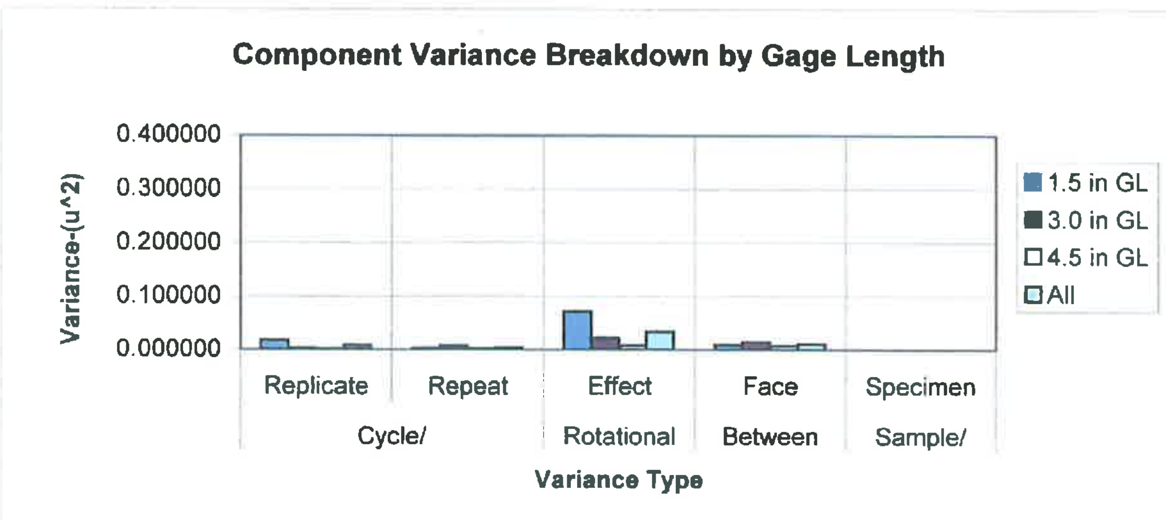
12.5 mm
6 inch Dia.

IPR12.5-6D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
1.5 in	Variance-%	0.017394 17.3%	0.002710 2.7%	0.071332 71.1%	0.008894 8.9%	0.000000 0.0%	0.100329
3.0 in	Variance-%	0.002251 5.0%	0.006775 14.9%	0.022029 48.5%	0.014383 31.7%	0.000000 0.0%	0.045438
4.5 in	Variance-%	0.001469 8.8%	0.000905 5.4%	0.007742 46.2%	0.006657 39.7%	0.000000 0.0%	0.016773
All	Variance-%	0.007038 13.0%	0.003464 6.4%	0.033701 62.2%	0.009978 18.4%	0.000000 0.0%	0.054180





Annex 17

NCHRP 1-28A Project

Component Variance Analysis

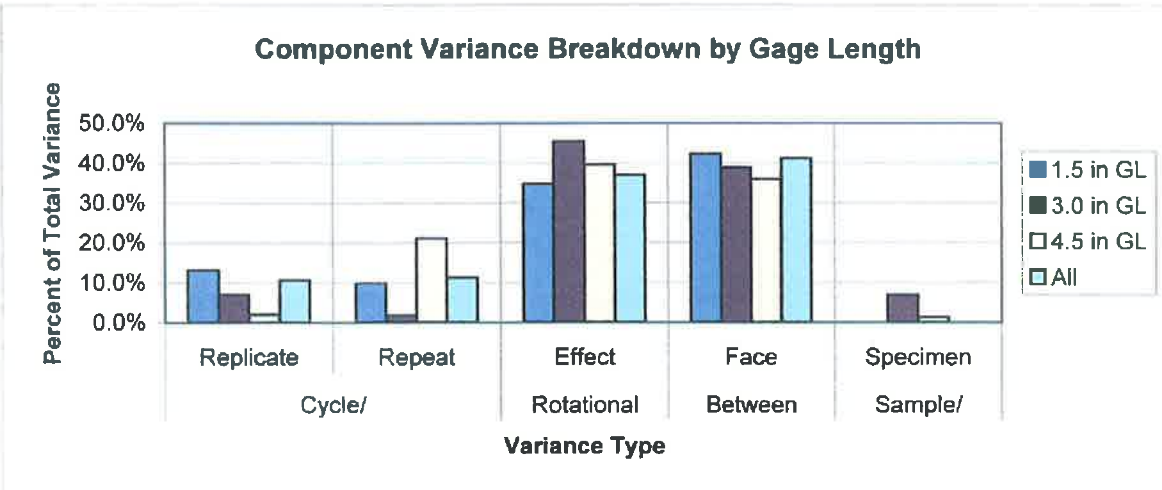
Poisson's Ratio Instantaneous

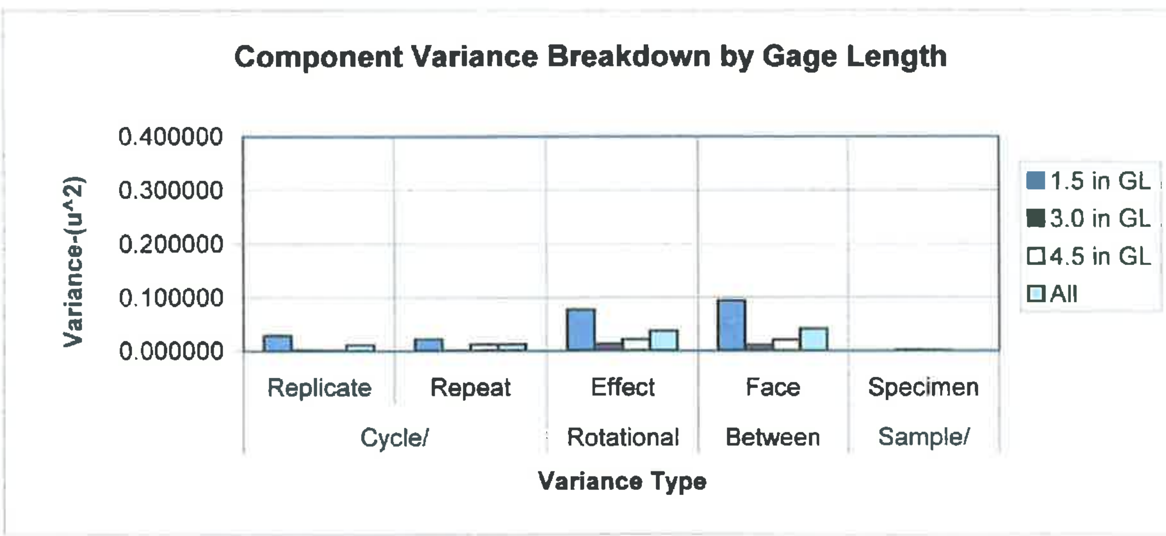
19.0 mm
6 inch Dia.

IPR19-6D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.028945	0.021878	0.077029	0.093768	0.000000	0.221619
1.5 in	Variance-%	13.1%	9.9%	34.8%	42.3%	0.0%	
		0.002002	0.000506	0.012976	0.011094	0.001989	0.028567
3.0 in	Variance-%	7.0%	1.8%	45.4%	38.8%	7.0%	
		0.001070	0.011562	0.021677	0.019635	0.000691	0.054635
4.5 in	Variance-%	2.0%	21.2%	39.7%	35.9%	1.3%	
		0.010672	0.011315	0.037227	0.041499	0.000000	0.100714
All	Variance-%	10.6%	11.2%	37.0%	41.2%	0.0%	





Annex 18

NCHRP 1-28A Project

Component Variance Analysis

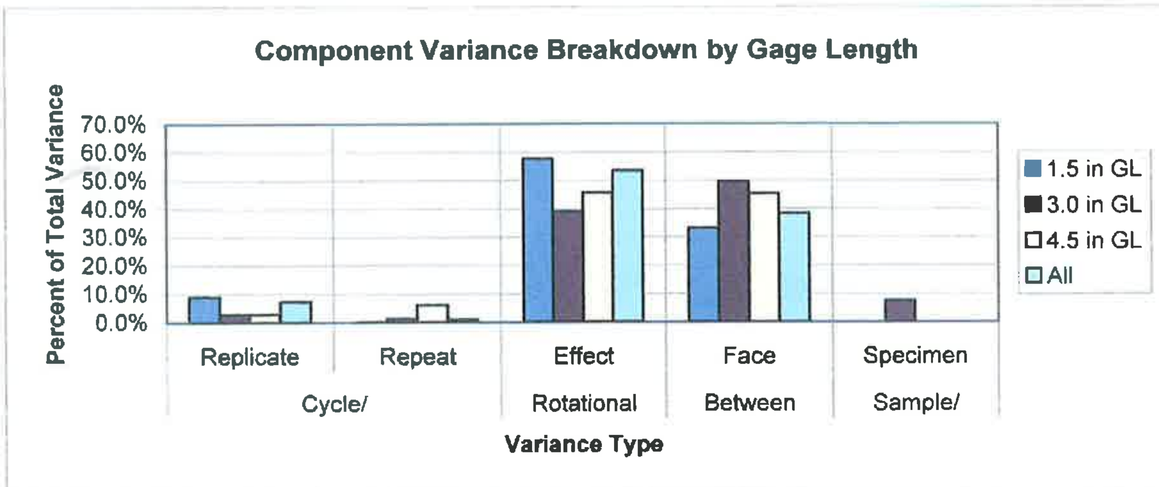
Poisson's Ratio Instantaneous

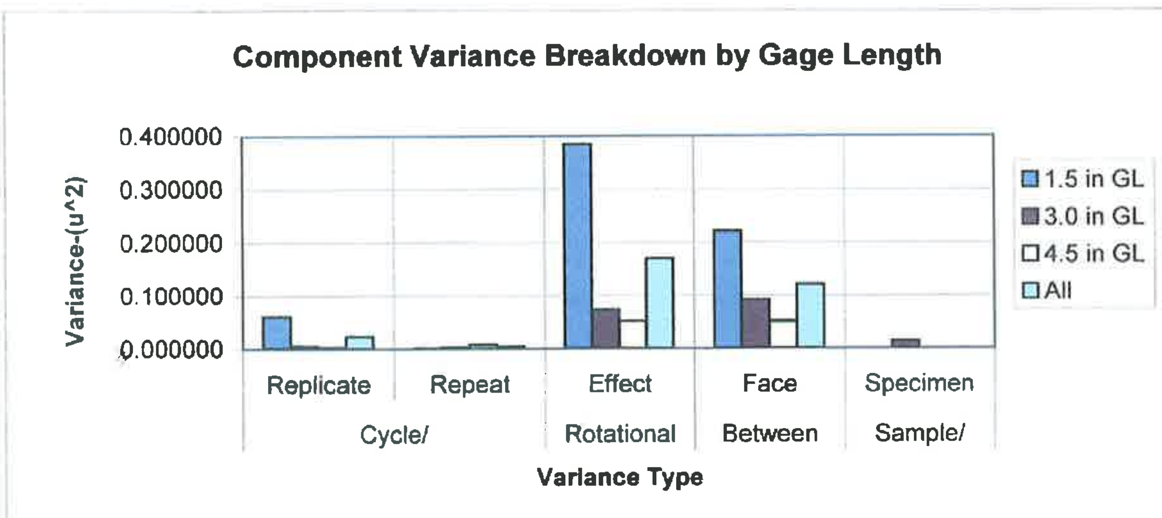
37.5 mm
6 inch Dia.

IPR37.5-6D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.060496	0.000580	0.383991	0.221212	0.000000	0.666280
1.5 in	Variance-%	9.1%	0.1%	57.6%	33.2%	0.0%	
		0.005025	0.002331	0.072487	0.091837	0.013923	0.185603
3.0 in	Variance-%	2.7%	1.3%	39.1%	49.5%	7.5%	
		0.003076	0.007036	0.050956	0.050641	0.000000	0.111710
4.5 in	Variance-%	2.8%	6.3%	45.6%	45.3%	0.0%	
		0.022866	0.003316	0.169145	0.121230	0.000000	0.316557
All	Variance-%	7.2%	1.0%	53.4%	38.3%	0.0%	





Annex 19

NCHRP 1-28A Project

Component Variance Analysis

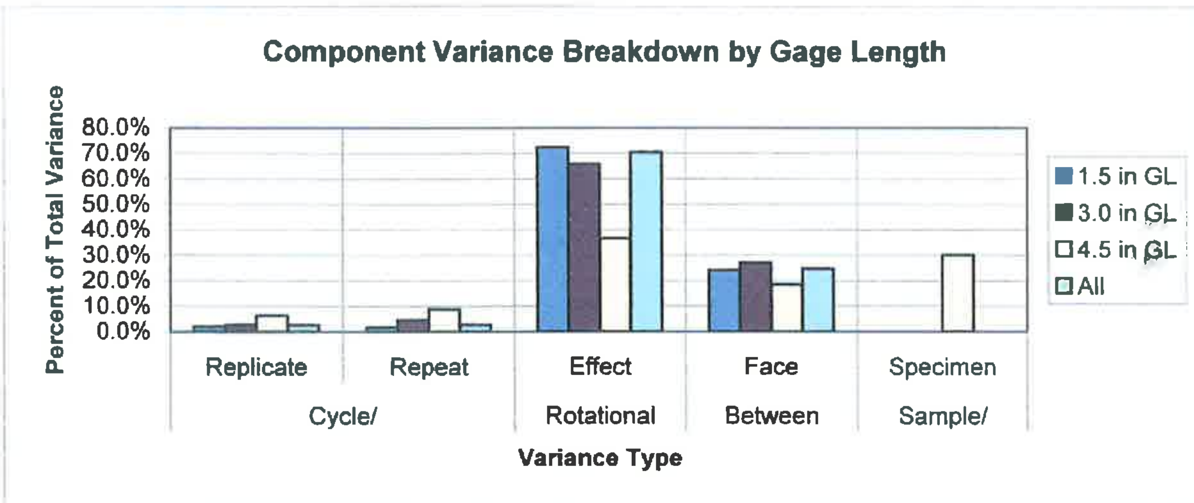
Poisson's Ratio Total

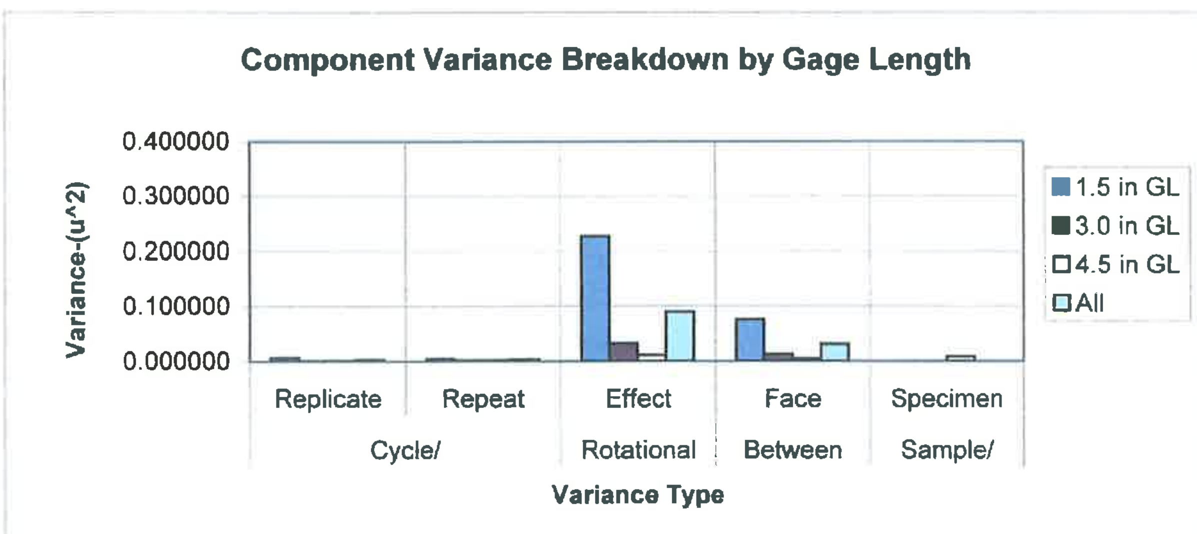
12.5 mm
4 inch Dia.

TPR12.5-4D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.006299	0.005071	0.226505	0.075645	0.000000	0.313520
1.0 in	Variance-%	2.0%	1.6%	72.2%	24.1%	0.0%	
		0.001320	0.002139	0.032098	0.013162	0.000000	0.048720
2.0 in	Variance-%	2.7%	4.4%	65.9%	27.0%	0.0%	
		0.001815	0.002521	0.010621	0.005315	0.008749	0.029022
3.0 in	Variance-%	6.3%	8.7%	36.6%	18.3%	30.1%	
		0.003145	0.003244	0.089742	0.031374	0.000000	0.127504
All	Variance-%	2.5%	2.5%	70.4%	24.6%	0.0%	





Annex 20

NCHRP 1-28A Project

Component Variance Analysis

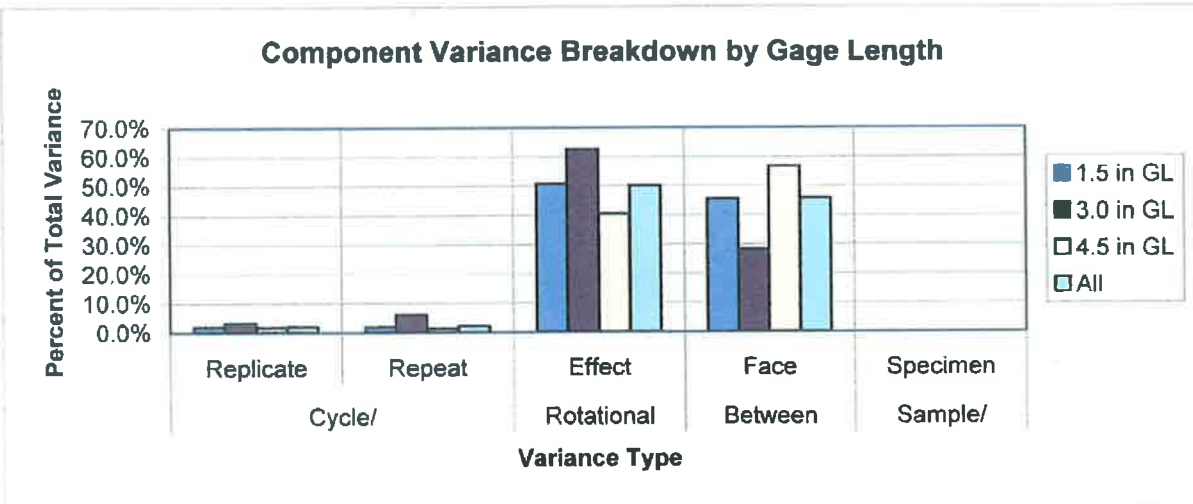
Poisson's Ratio Total

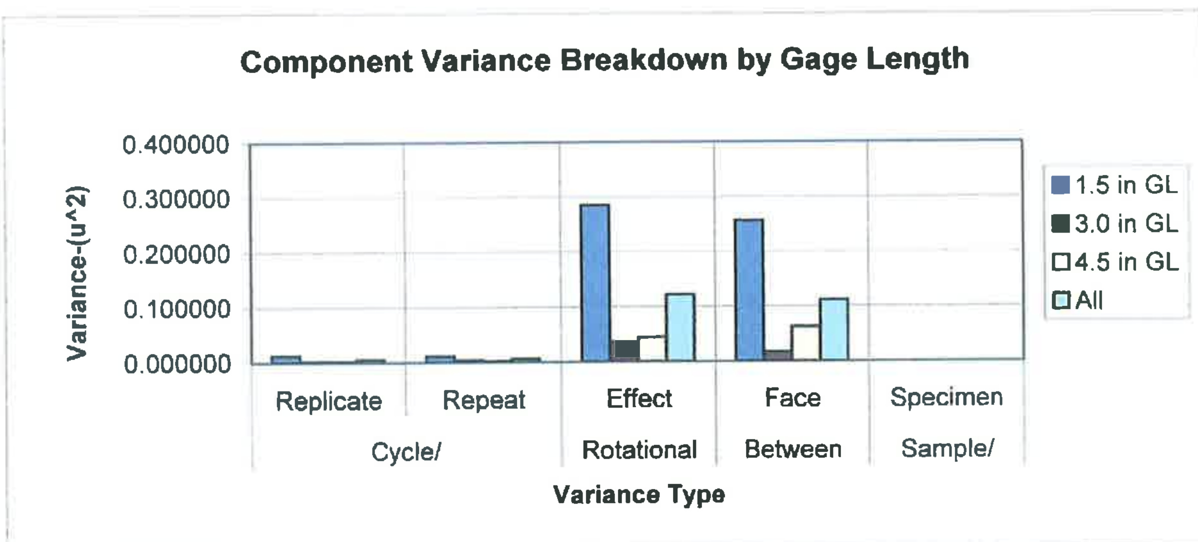
19.0 mm
4 inch Dia.

TPR19-4D

Variance Components-(u^2)

Gage Length		*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample/ Specimen*	*Total Variance*
1.0 in	Variance-%	0.011466 2.0%	0.010870 1.9%	0.284840 50.6%	0.256040 45.5%	0.000000 0.0%	0.563215
2.0 in	Variance-%	0.001791 3.2%	0.003424 6.1%	0.035168 62.4%	0.015946 28.3%	0.000000 0.0%	0.056329
3.0 in	Variance-%	0.001889 1.7%	0.001371 1.3%	0.043997 40.4%	0.061768 56.7%	0.000000 0.0%	0.109025
All	Variance-%	0.005048 2.1%	0.005221 2.2%	0.121335 50.0%	0.111251 45.8%	0.000000 0.0%	0.242856





Annex 21

NCHRP 1-28A Project

Component Variance Analysis

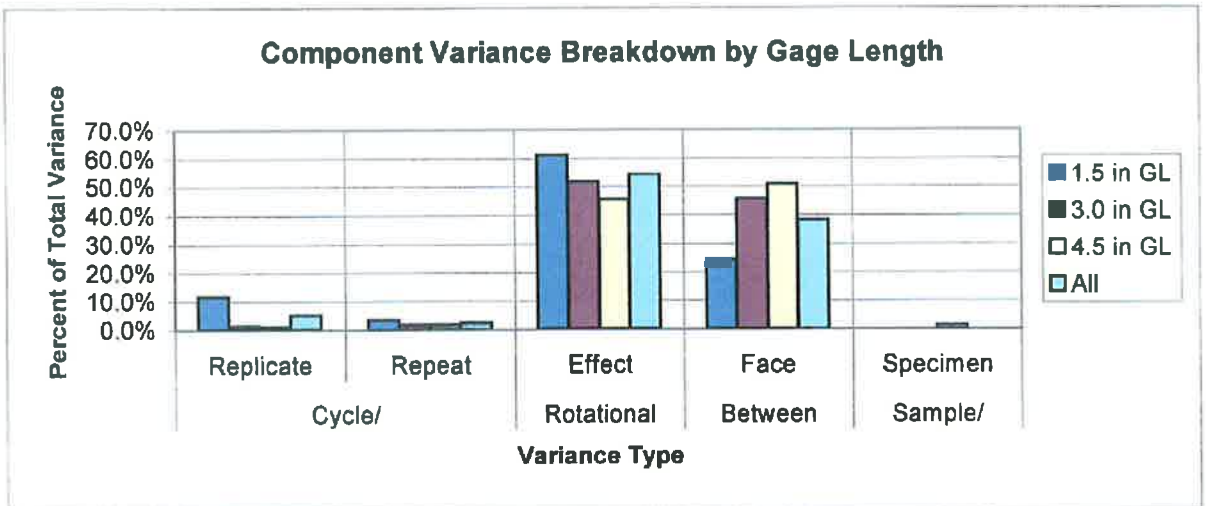
Poisson's Ratio Total

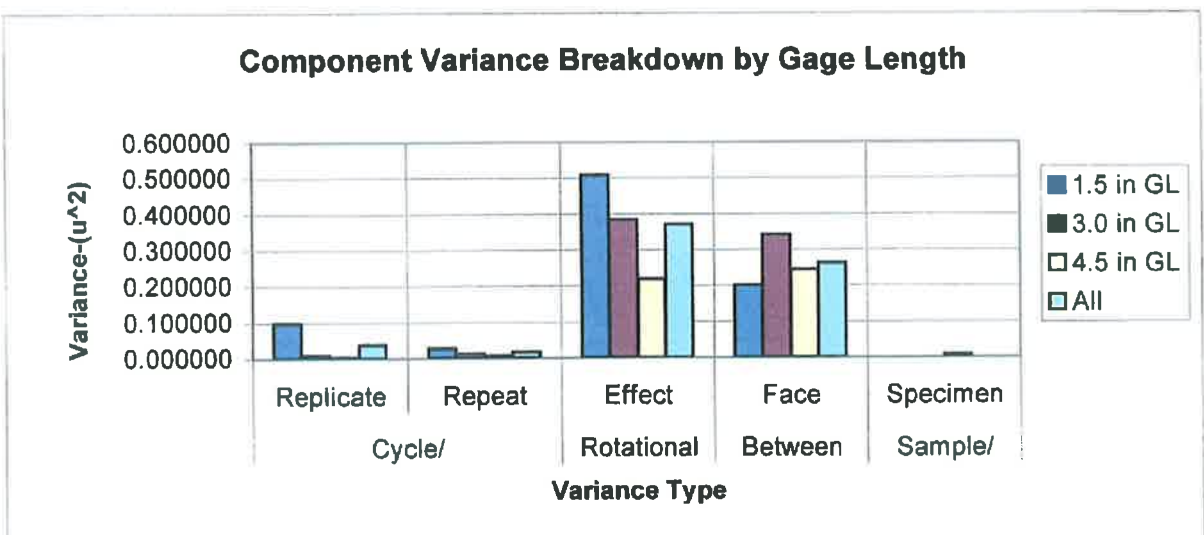
37.5 mm
4 inch Dia.

TPR37.5-4D

Variance Components-(u^2)

Gage Length		*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample/ Specimen*	*Total Variance*
		0.095788	0.026404	0.506977	0.200574	0.000000	0.829742
1.0 in	Variance-%	11.5%	3.2%	61.1%	24.2%	0.0%	
		0.007756	0.011795	0.382244	0.339484	0.000000	0.741279
2.0 in	Variance-%	1.0%	1.6%	51.6%	45.8%	0.0%	
		0.004188	0.007307	0.217716	0.243317	0.006700	0.479228
3.0 in	Variance-%	0.9%	1.5%	45.4%	50.8%	1.4%	
		0.035911	0.015168	0.368979	0.261125	0.000000	0.681183
All	Variance-%	5.3%	2.2%	54.2%	38.3%	0.0%	





Annex 22

NCHRP 1-28A Project

Component Variance Analysis

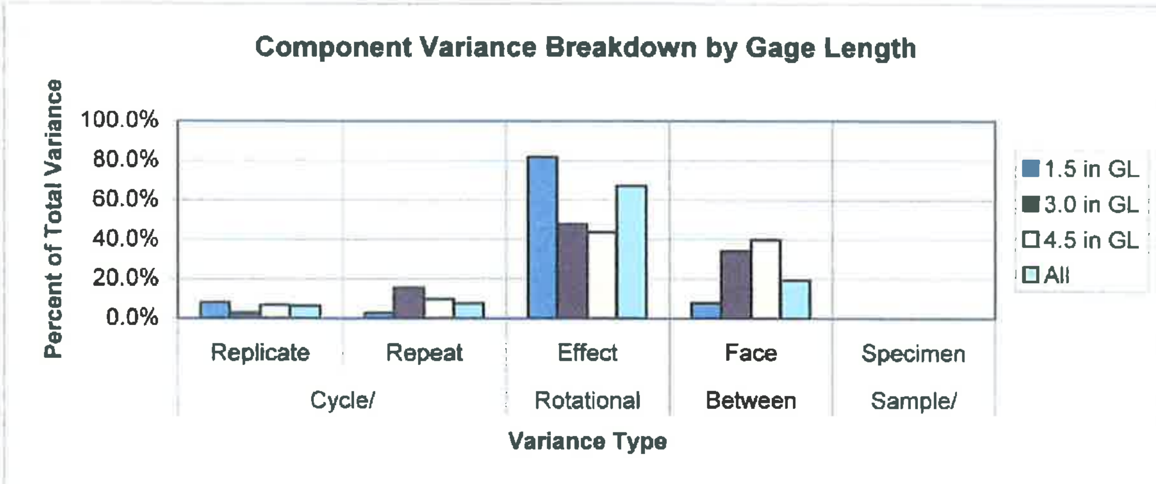
Poisson's Ratio Total

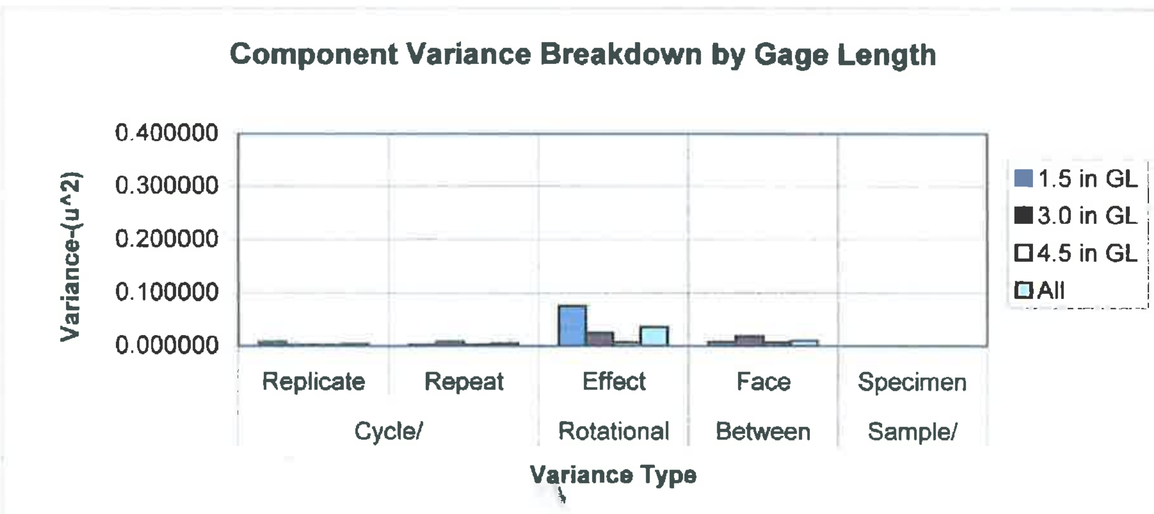
12.5 mm
6 inch Dia.

TPR12.5-6D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.007280	0.002389	0.073804	0.007011	0.000000	0.090484
1.5 in	Variance-%	8.0%	2.6%	81.6%	7.7%	0.0%	
		0.001515	0.007829	0.024306	0.017170	0.000000	0.050819
3.0 in	Variance-%	3.0%	15.4%	47.8%	33.8%	0.0%	
		0.000970	0.001419	0.006374	0.005817	0.000000	0.014579
4.5 in	Variance-%	6.7%	9.7%	43.7%	39.9%	0.0%	
		0.003255	0.003879	0.034828	0.009999	0.000000	0.051961
All	Variance-%	6.3%	7.5%	67.0%	19.2%	0.0%	





Annex 23

NCHRP 1-28A Project

Component Variance Analysis

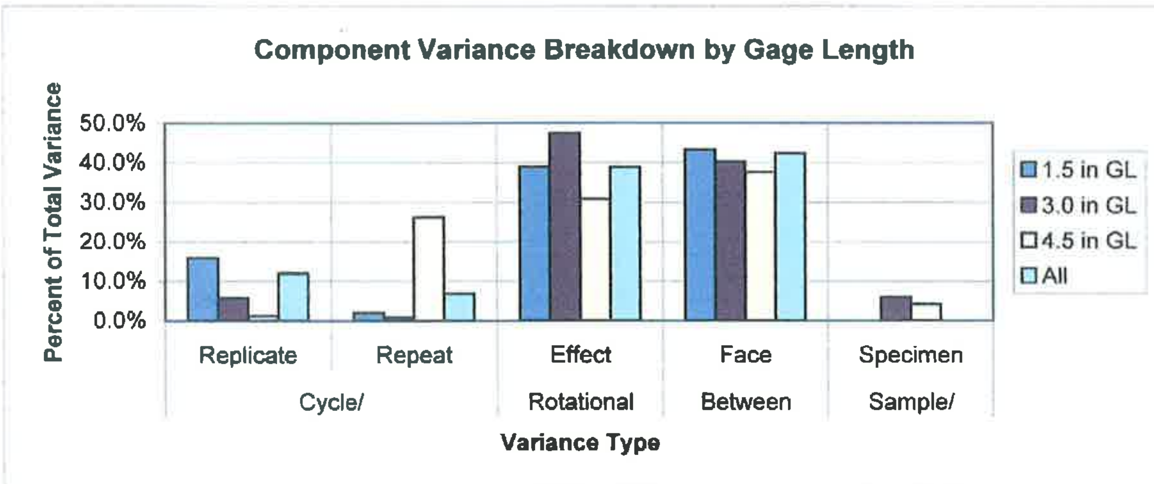
Poisson's Ratio Total

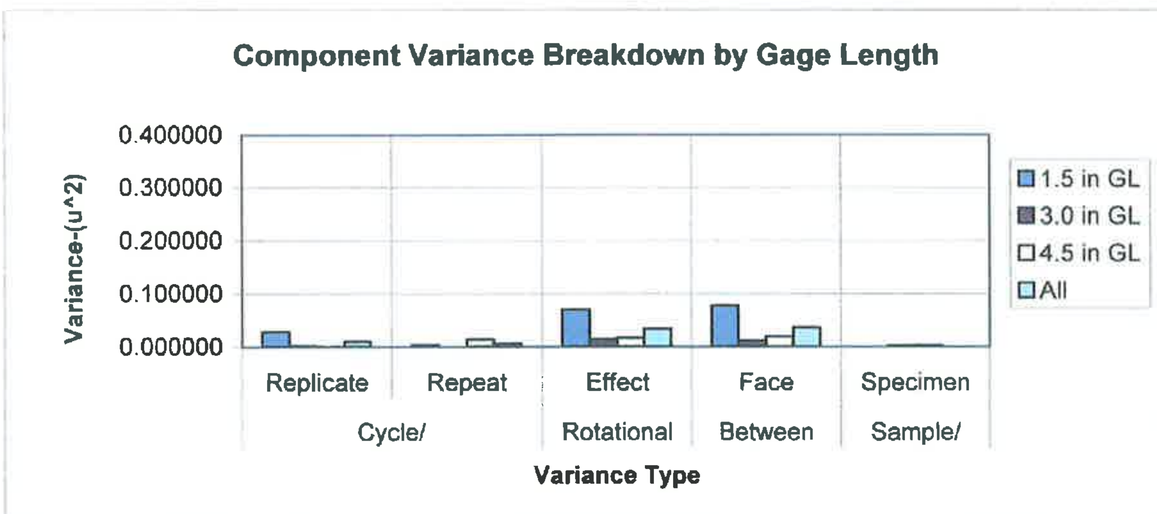
19.0 mm
6 inch Dia.

TPR19-6D

Variance Components-(u^2)

Gage Length		*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample/ Specimen*	*Total Variance*
		0.028142	0.003585	0.069314	0.076946	0.000000	0.177987
1.5 in	Variance-%	15.8%	2.0%	38.9%	43.2%	0.0%	
		0.001664	0.000234	0.013841	0.011762	0.001723	0.029225
3.0 in	Variance-%	5.7%	0.8%	47.4%	40.2%	5.9%	
		0.000606	0.013652	0.016025	0.019572	0.002170	0.052026
4.5 in	Variance-%	1.2%	26.2%	30.8%	37.6%	4.2%	
		0.010138	0.005624	0.033060	0.036093	0.000000	0.085115
All	Variance-%	11.9%	6.8%	38.8%	42.4%	0.0%	





Annex 24

NCHRP 1-28A Project

Component Variance Analysis

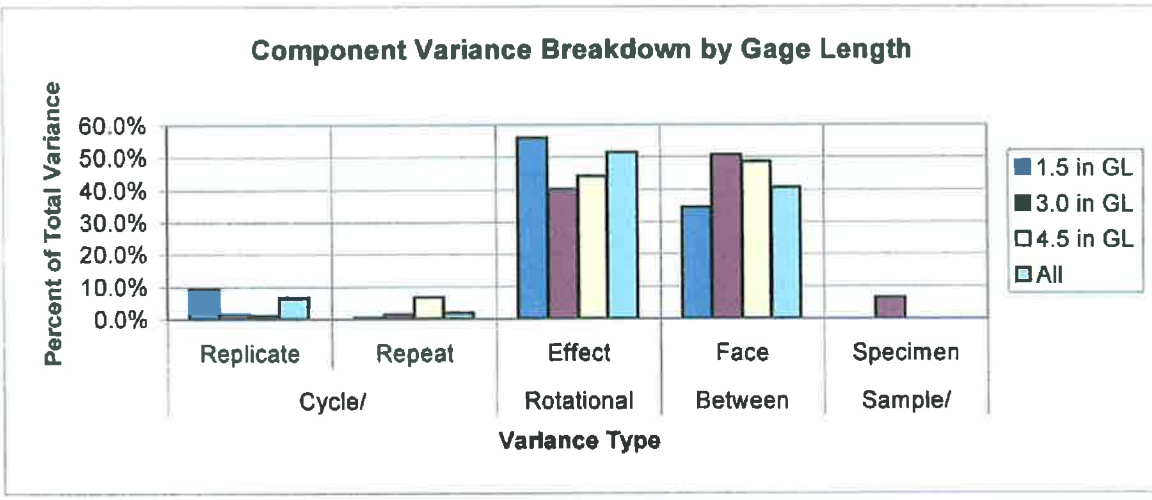
Poisson's Ratio Total

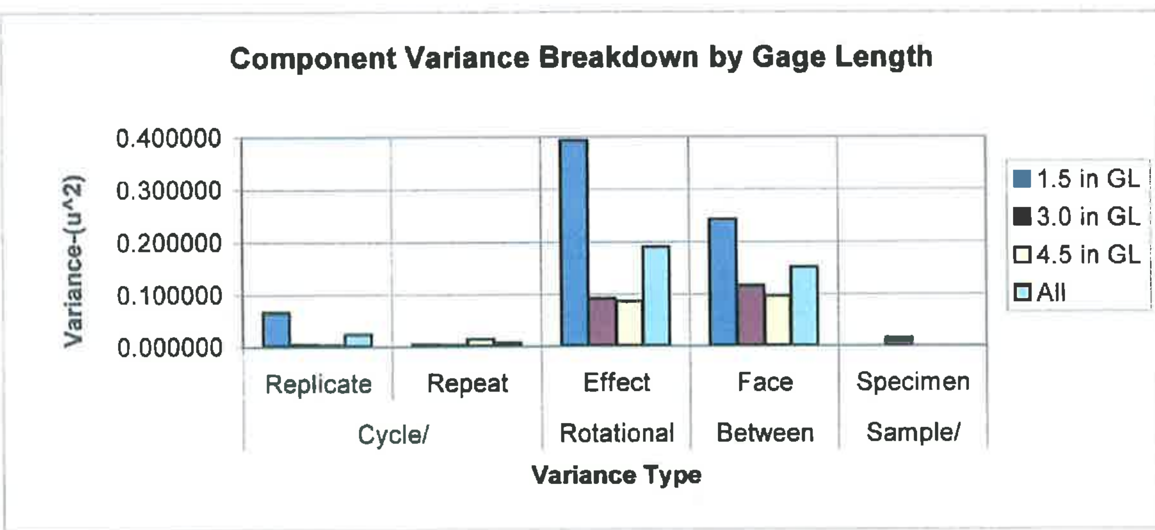
37.5 mm
6 inch Dia.

TPR37.5-6D

Variance Components-(u^2)

Gage Length		Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample/ Specimen	Total Variance
		0.064874	0.003148	0.392638	0.242342	0.000000	0.703002
1.5 in	Variance-%	9.2%	0.4%	55.9%	34.5%	0.0%	
		0.003526	0.002784	0.090787	0.114954	0.014656	0.226707
3.0 in	Variance-%	1.6%	1.2%	40.0%	50.7%	6.5%	
		0.001832	0.012776	0.086287	0.094903	0.000000	0.195798
4.5 in	Variance-%	0.9%	6.5%	44.1%	48.5%	0.0%	
		0.023411	0.006236	0.189904	0.150733	0.000000	0.370284
All	Variance-%	6.3%	1.7%	51.3%	40.7%	0.0%	





APPENDIX C

NCHRP 1-28A Project

Recommended Test Protocol

NCHRP 1-28A

Standard Test Method for Determining the Resilient Modulus of Bituminous Mixtures by Indirect Tension

1. SCOPE

1.1 General

This proposed protocol describes procedures for the determination of the resilient modulus of hot mix asphalt concrete (HMA), using repeated load indirect tensile test techniques. The procedure involves resilient modulus testing at 77°F.

1.2 Testing Prerequisites

Resilient modulus testing shall be conducted after system response has been verified by testing synthetic specimens, as outlined in section 8.1 of this protocol.

1.3 Sample Size

Resilient modulus testing shall be conducted on 6-inch diameter specimens that are 1.5 inches to 2.5 inches in thickness. The test specimens can be obtained from field coring or from a Gyratory compacted specimen. Depending upon the height of the Gyratory compacted specimen and the thickness of the test specimen, two or three specimens can be sawed from the Gyratory plug.

1.4 Pretest Tensile Strength

Prior to performing the resilient modulus test the indirect tensile strength shall be determined for one test specimen taken from the same layer and as close as possible to the location of the core specimen(s) to be tested for resilient modulus. For lab specimens, a sample having the same mix properties will be selected for indirect tensile strength testing. The indirect tensile strength test is performed as a basis for selecting the loading levels for the resilient modulus testing. Test shall be performed in accordance with attachment A of SHRP P07 protocol (November 1, 1992).

1.5 Definitions

The following definitions are used throughout this protocol:

(a) Layer – that part of the pavement produced with similar material and placed with similar equipment and techniques. The layer thickness can be equal to or less than the core thickness or length.

(b) Core – an intact cylindrical specimen of pavement materials which is removed from the pavement by drilling and sampling at the designated core location. A core may consist of, or include, one, two or more different layers.

(c) Test Specimen – that part of the layer which is used for, or in, the specified test. The thickness of the test specimen can be equal to or less than the layer thickness.

(d) Haversine Shaped Load Form - the required load pulse from the resilient modulus test. The load pulse is in the form $(1-\cos\theta)/2$ and the cyclic load is varied from the contact load ($P_{contact}$) to the maximum load (P_{max}), as shown in Figure C-1 (from SHRP P07 protocol).

(e) Maximum Applied Load (P_{max}) – the maximum total load applied to the sample, including the contact and cyclic (resilient) loads.

$$P_{max} = P_{contact} + P_{cyclic}$$

Contact Load ($P_{contact}$) – the vertical load placed on specimen to maintain a positive contact between the loading trip and the specimen. The contact load is four percent of the maximum load (0.04 P_{max}) and is not less than 5 lbs, but not more than 20 lbs.

(f) Cyclic Load (Resilient Vertical Load, P_{cyclic}) – load applied to a specimen, respectively, which is directly used to calculate resilient modulus.

$$P_{cyclic} = P_{max} + P_{contact}$$

(g) Instantaneous Resilient Modulus – determined from the deformation-time plots (both horizontal and vertical) as described herein.

To determine the instantaneous deformation values, it is recommended to perform regression in three portions of the deformation curve:

1. Linear regression in the straight portion of the unloading path.

2. Regression in the curved portion that connects the unloading path and the recovery portion to yield the following hyperbolic equation:

$$Y = a + b/X$$

Where
- Y = deformation value,
- X = time, and
- a, b = regression constants

3. Regression in the recovery portion between 40% and 90% (recommended range) of the rest period to yield a hyperbolic

equation. A tangent should be drawn to this hyperbola at the point correspondence to 55% (recommended point) of the rest period.

Two linear equations, one from the unloading path and other from the tangent of the hyperbola in the recovery period, shall be solved to determine the intersection. Then the point on the hyperbolic curve corresponding to the time coordinate of the intersection (for convenience, say point A) is selected to determine the instantaneous deformation by subtracting the deformation at the point A from the peak deformation.

(h) Total Resilient Modulus – determine from the deformation-time plots (both horizontal and vertical) by subtracting deformation obtained at the end of one load-unload cycle, as determined by taking the average of deformation values obtained for the time period between 85% completion to 95% completion of the rest period from the peak deformation values. This value includes both the instantaneous recoverable deformation and the time-dependent continuing recoverable deformation during the rest period portion of one cycle.

2. APPLICABLE DOCUMENTS

SHRP Protocol P07 Resilient Modulus for Asphalt Concrete (November 1, 1992)

3. SUMMARY OF METHOD

3.1 The repeated-load indirect tension resilient modulus test of asphalt concrete is conducted through repetitive applications of compressive loads in a haversine waveform. The compressive load is applied along a diametral plane of a cylindrical Asphalt Concrete specimen. The resulting horizontal and vertical deformations are measured. Values of resilient Poisson's ratio shall be calculated using recoverable vertical and horizontal deformations. The resilient modulus values are subsequently calculated using the calculated Poisson's ratio.

3.2 Two separate resilient modulus values are obtained. One, termed instantaneous resilient modulus, is calculated using the recoverable horizontal deformation that occurs during the unloading portion of one load-unload cycle. The other, termed total resilient modulus, is calculated using recoverable deformation which includes both the instantaneous recoverable and time-dependent continuing recoverable deformation during the unload or rest-period portion of one cycle.

3.3 For each resilient modulus test, the following general procedures must be followed:

(a) The tensile strength is determined on the test specimen at 77 ± 2°F using the procedure described in attachment A to SHRP P07 protocol. The value of tensile strength obtained from this procedure is used to determine the indirect tensile stress and corresponding compressive load to be respectively applied to the test specimens during the resilient modulus determination.

(b) The test specimen(s) are to be tested along two perpendicular diametral axes at test temperatures of 77 ± 2°F. A repetitive haversine load pulses of 0.1 second duration followed by a rest period of 0.9 seconds between load pulses are applied to the individual test specimens. The magnitude of the load pulse will be selected to produce a predefined indirect tensile stress on the specimen based on a percentage of the indirect tensile strength (see section 3.3(a) above).

(c) After completion of resilient modulus testing along the two perpendicular diametral planes, indirect tensile strength shall be performed in accordance with attachment A of the SHRP P07 protocol. This test is performed to determine the tensile strength of the specific specimen actually used in resilient modulus testing. For this specimen the loading axis shall be 90° to the second diametral axis used for modulus determination.

4. SIGNIFICANCE AND USE

Resilient modulus can be used in evaluation of materials quality and as input for pavement design, evaluation and analysis. With this method, the effects of temperature and load on resilient modulus can also be investigated.

5. APPARATUS

5.1 Testing Machine

The testing machine shall be a top loading, closed loop, electro-hydraulic testing machine with a function generator which is capable of applying a haversine shaped load pulse over a range of load durations, load levels, and rest periods.

5.2 Loading Device

The loading device should be capable of testing 6 inch diametral specimen with thickness up to 2.5 inches. The device should be compact enough to be used within the environmental chamber. It should have a fixed bottom loading plate and a moving upper loading plate. The movement of the upper plate should be guided by two columns, one on each side of the specimen and equidistance from the loading axis and the loading strips, to ensure it has minimal translational or rotational motion during loading of the specimen. The guide columns shall have a frictionless bearing surface that shall be kept well lubricated. The surface of the guide columns shall be frequently inspected for any grooves caused due to friction. Alignment of the device, within the loading system, shall be achieved so that such friction is limited to the minimum possible extent. The upper plate shall be rigid enough to prevent any deflections during loading. If heavyweight plates are used to achieve rigidity, the testing should be able to counteract all the weight, such that no more than 2 lbs. of load is transferred to the specimen when the load is not being applied. It is recommended that high strength material be used to achieve rigidity and keep the weight small. The loading strips shall preferably be perpendicular to the line connecting the two guide columns, so that visual alignment of the sample in the device is easier.

5.3 Temperature Control System

The temperature-control system should be capable of maintaining temperature control within 2°F (1.1°C), at a setting value of 77°F (25°C). The system shall include a temperature-controlled cabinet large enough to house the loading device, and a cabinet adequate to pre-condition at least three test specimens at a time prior to testing.

5.4 Measurement and Recording System

The measuring and recording system shall include sensors for measuring and simultaneously recording horizontal and vertical deformations and loads. The system shall be capable of recording horizontal and vertical deformations in the range of 0.000015 inch (0.00038 mm) of deformation. Load cells shall be accurately calibrated with a resolution of 2 lbs. or better.

5.4.1 Data Acquisition – The measuring or recording devices must provide real time deformation and load information and should be capable of monitoring readings on tests conducted to 1 Hz. Computer monitoring systems are recommended. The data acquisition system shall be capable of collecting 200 scans per second (a scan includes all deformation and load values at a given point of time). Capability to have real-time plots (simultaneous to the data collection by the computer monitoring system) shall also be provided to check the progress of the test. If strip chart recorders are used without computer monitoring systems, the plotting scale shall be adjusted such that there is a balance between the scale reduction required as a result of the pen reaction time and the scale amplification needed for purposes of accurate measurement of values from a plot.

Actual load values, and not the intended load values, shall be used for calculation purposes and so the data acquisition system shall also be capable of monitoring the load values continuously during testing.

5.4.2 Deformation Measurement – Both horizontal and vertical deformation shall be measured on the surface of the specimen by mounting LVDTs between gage points along the horizontal and vertical diameter. The gage length shall be half the diameter of the specimen (3 inch for 6 inch diameter specimen). It is required to have the two LVDTs, on each face of the specimen, one horizontal and one vertical resulting in a total of four LVDTs for deformation measurement. Extensometers, if used, should also be calibrated from time to time. The surfaces on which the knife edges of the extensometer assembly rests should be kept smooth and free of grooves.

5.4.3 Load Measurements – The repetitive loads shall be measured with an electronic load cell with a capacity adequate for the maximum required loading, and a sensitivity of 0.5% of the intended peak load.

During periods of resilient modulus testing, the load cell shall be monitored and checked once a month with a calibrated proving ring to assure that the load cell is operating properly. Additionally, the load cell shall be checked at any time that the QA/QC testing with in-house synthetic specimen (section 8.1) indicates a change in the system response or when there is a suspicion of a load cell problem.

5.5 Loading Strips

Steel loading strips, with concave sample contact surfaces, machined to the radius of curvature of a 6.000 ± 0.006 inch diameter specimen, are required to apply load to the test specimens. The contact area of the loading strip shall be ¾ inches wide. The outer edges of the curved surface shall be filed lightly to remove sharp edges that might cut the specimen during testing. Thin lines should be drawn along the length of the strip at its center, to help alignment. Also, appropriate marking should be made so as to center the specimens within the length of the strips. This could be either done by matching the center of specimen with a mark at the center of the strip or by positioning the specimen between two marks at the ends of the specimen thickness, or both.

5.6 Marking and Alignment Devices

A marking device shall be used to mark mutually perpendicular axes on the front and back faces of the specimen through the center. The axes shall be simultaneously marked on the front and back faces of the specimen to ensure that the axes on the front and the back lie in a single plane.

An alignment device shall be used to position and place horizontal and vertical LVDTs along the horizontal and vertical diameter of the specimen and hold it there, until the glue that holds the LVDTs cures. It shall be easily removable, without disturbing the LVDT (once the glue cures), and shall not be destructively mounted on the specimen. The device shall preferably have the capability to mount the LVDT at different gage lengths but mainly at a gage length of half the diameter of the specimen. The LVDT shall be as close to (but not touching) the surface of the specimen so as to minimize the bulging effect. To ensure uniform test results, a height of 0.2 inch is recommended. The axis of LVDT shall not be at a distance greater than 0.25 inch from the surface of the specimen.

6. TEST SPECIMEN

6.1 Core specimen - cores for test specimen preparation, which may contain one or more testable layers, must have smooth and uniform vertical (curved) surfaces, and must be no less than 5.85 inch or more than 6.15 inch in diameter. Cores which are obviously deformed or have any visible cracks must be rejected. Irregular top and bottom surfaces shall be trued up as necessary, and individual layer specimens obtained by cutting with a diamond saw using water or air as a coolant.

6.2 The test specimen designated for testing shall not be more than 2.5 inches in thickness. However, for base course or large-stone mixes the thickness shall not be greater than 3.5 inches. If a core specimen has more than one layer the layers shall be separated at the layer interface by sawing. Layers containing more than one lift of the same material as placed under contract specification, may be tested as a single specimen. Traffic direction shall be marked on each layer after cutting, to maintain the correct orientation. Layers too thin to test (less than 1.5 inch for 6 inch diameter specimen), as well as any thin surface treatments, shall be removed and discarded.

A test specimen shall consist of a single pavement material or layer greater than 1.5 inches in thickness. The desired thickness for testing is approximately 2.0 inches for a 6 inch diameter specimen. If the thickness of a particular AC layer scheduled for testing is one inch or more greater than the desired testing thickness, then the specimen to be used for testing shall be obtained from the middle of the AC layer is between 1.5 and 2.5 inches for a 6 inch diameter specimen, and has relatively smooth front and back faces then no sawing is required and the specimen for this layer may be tested as is.

6.3 Diametral Axis – Marking of the diametral axis to be tested shall be done using a suitable marking device as described in section 5.6. The axis shall be parallel to the traffic direction symbol (arrow) or "T" marked during the field coring operations. This diametral axis location can be rotated slightly, if necessary, to avoid contact of the loading strips with abnormally large aggregate particles or surface voids; or to avoid the mounting of the vertical LVDT over large surface voids. The second making will be perpendicular to the first marked diametral axis. These marking are required for mounting horizontal and vertical LVDTs.

6.4 The thickness (t) of each test specimen shall be measured to the nearest 0.01 inch (0.25 mm) prior to testing. The thickness shall be determined by averaging four measurements located at ¼ points around the sample perimeter, and ½ to 1 inch in from the specimen edge.

6.5 The diameter (D) of each test specimen shall be determined prior to testing to nearest 0.01 inch (0.25 mm) by averaging diametral measurements. Measure the diameter of the specimen at mid-height along (1) the axis parallel to the direction of traffic and (2) the axis perpendicular (90 degrees) to the axis measured in (1) above. The two measurements shall be averaged to determine the diameter of the test specimen.

7. PROCEDURE

7.1 General

For deformation measurement both in the horizontal and vertical direction, mount the gage points by gluing them to the test specimen. Wait until the gage points are properly set and the glue is dry. The asphalt cores are then placed in a controlled temperature cabinet/chamber and brought to the specified test temperature. Unless the core specimen temperature is monitored in some manner and the actual temperature known, the core samples shall remain in the cabinet/chamber for a minimum of 6 hours prior to testing at 77°F (25°C).

(a) Determine the tensile strength of the test specimens at 77° ± 2°F using the procedure described in Attachment A to SHRP Protocol P07.

(b) The test specimen(s) designated for resilient modulus testing shall be brought to the test temperature (77 ± 2°F) as specified in section 7.1.

(c) Attach the LVDTs on the two faces of the specimen. This consists of two horizontal and two vertical LVDTs. The electronic measuring system shall be adjusted and gains set as necessary for the four LVDTs. Prior to testing, zero the extensometers and the surface-mounted LVDTs. An initial negative offset might be necessary if high gain is being used and/or there is a possibility of exceeding the range of voltage otherwise.

7.2 Alignment and Specimen Seating

Position the test specimen so that the mid-thickness mark (cross mark for the two diamteral axis) on the test specimen is located in the line of action of the actuator shaft or alternately, ascertain that the specimen is centered exactly between end markings on loading strips. The diametral markings are then used to ensure that the specimen is aligned from top to bottom and front to back. The alignment of the front face of the specimen can be checked by ensuing that the diametral marking is centered on the top and bottom loading strips. With the use of a mirror, the back face can be similarly aligned.

The contact surface between the specimen and each loading strip is critical for proper test results. Any projections or depressions in the specimen to strip contact surface, which leave the strip in non-contact condition over a length of more than 0.75 inches after completion of load conditioning stage, shall be reason for rotating the test axis or rejecting the specimen. If no suitable replacement specimen is available, test shall be conducted on the available sample and the situation documented.

7.3 Preconditioning

Preconditioning and testing shall be conducted while the specimen is located in a temperature-controlled cabinet meeting the requirements of section 6.3.

7.3.1 Selection of applied loads for preconditioning and testing at the test temperature is based on the indirect tensile strength, determined as specified in Attachment A to the SHRP Protocol P07. Tensile stress levels of 15 percent of the tensile strength measured at 77°F are to be used in conducting the test at temperature of 77 ± 2°F. Specimen contact loads specified in section 1.5 (e) shall be maintained during testing.

7.3.2 The sequence of resilient modulus testing shall consist of initial testing along the first diametral axis (or along the traffic direction for the field cores) followed by rotating the specimen at 90 degree. It is important that the test specimen be maintained at 77°F. The computer-generated waveform shall be as closely matched as possible by adjusting the gains. The number of load applications to be applied for each rotation for preconditioning cycles is 100. However, the minimum number of load application for a given situation must be such that the resilient modulus deformations are stable (section 7.5.1). When, using more preconditioning cycles, the number of preconditioning cycles shall be recorded and the reason documented. Also, if specimen has to be realigned, or when precondition has to be stopped for any other reason, sufficient time should be given to the specimen for relaxation before resuming the test.

7.4 Horizontal and Vertical Deformation

Both the horizontal and vertical deformations shall be monitored during preconditioning. If total cumulative vertical deformations greater than 0.03 inch occur, the applied load shall be reduced to the minimum value possible and still retain adequate deformations for measurement purposes. If use of smaller load levels are not adequate for measurement purposes, discontinue preconditioning and generate 10 load pulses for resilient modulus determination, and so indicate on the test report.

7.5 Testing

At the end of preconditioning for each rotation, the resilient modulus shall be conducted as specified below.

7.5.1 Record measured deformation individually from the four deformation measuring devices and the load sensor as soon as preconditioning is over (the load pulses are to be applied continuously through preconditioning and data collection for resilient modulus). The response is only recorded (deformation and load) for the last 5 loading cycles of the total applied load pulses. One loading cycle consists of one load pulse and a subsequent rest period. The resilient modulus will be calculated and reported for each cycle using the equations in section 9 of this protocol.

7.5.2 After the specimen has been tested along the first diametral plane, rotate the specimen 90 degree and repeat section 7.3.2 through section 7.5.1 of this protocol.

7.5.3 After testing is completed for both the diametral axis, the specimen shall be brought to a test temperature of $77 \pm 2^{\circ}F$ and an indirect tensile strength test conducted on the test specimen as specified in Attachment A of SHRP P07.

7.6 Cumulative Deformation

The cumulative horizontal and vertical deformation shall be determined as per Attachment C of the SHRP P07 Protocol.

8. QUALITY ASSURANCE/QUALITY CONTROL

8.1 Prior to the start of resilient modulus testing each week, the laboratory testing personnel shall perform testing on one or more of in-house QA/QC synthetic specimens. The synthetic specimen should be selected for QA/QC to provide a response similar to the expected asphalt concrete specimen response at $77^{\circ}F$. Typically, materials such as Polyethylene may be used to verify the system response. The synthetic specimens shall be tested at a temperature of $77^{\circ}F$, at a load time of 0.1 second and a rest period of 0.9 second on both the axes at a load level expected for the AC samples.

However, QA/QC testing shall be done whenever alignment of the loading system may have changed.

The specimens shall be tested as follows:

8.1.1 The specimen shall be located in a temperature-controlled cabinet meeting the requirements of section 5.3 and at a temperature of $77^{\circ}F$. The applied loads for preconditioning and testing for the synthetic specimens are defined below.

8.1.2 The test specimen shall be preconditioned along the proper axis prior to testing by applying a minimum of 100 cycles of the specified haversine-shaped load pulse of 0.1 second duration with a rest period of 0.9 second. The computer generated wave form shall be matched as closely as possible by adjusting gains and preconditioning shall continue until both horizontal and vertical deformations are stable and appear to be uniform.

8.2 The results from the QA/QC testing shall be stored as a permanent record of the system response to obtain the system fingerprint. If all the synthetic specimens have not been tested for each set of 100 resilient modulus tests, QA/QC testing shall be performed on the remaining synthetic specimens in order to verify the system response.

9. CALCULATIONS

The following equations are intended for the calculation of either instantaneous or total values depending upon whether instantaneous or total deformation values are used. Consider horizontal deformation as positive and vertical deformation as negative. The load value is assumed to be positive.

9.1 Poisson's ratio:

Poisson's ratio shall be calculated from the vertical and horizontal deformation values by the use of the following equations:

$$\mu = \frac{-1.0695 - 0.2339\dfrac{\delta_v}{\delta_h}}{0.3074 + 0.7801\dfrac{\delta_v}{\delta_h}}$$

where:

μ = instantaneous or total Poisson's ratio,

δ_v = the recoverable vertical deformation measured over a gage length equal to three quarters of the diameter of the specimen, inches, and

δ_h = the recoverable horizontal deformation measured over the horizontal diameter of the specimen, inches.

It is expected that the Poisson's ratio is 0.25 – 0.45. When the calculated Poisson's ratio is outside the ranges defined above, the calculated values shall be reported and a visual inspection of the specimen should be made to study the deformation in shape and/or presence of cracks due to damage, and so reported.

The Poisson's ratio must be calculated for each set of LVDTs (horizontal and vertical). That is for the first diametral plane, two Poisson's ratio values are estimated. These are obtained from the two faces of the specimen. Another set of Poisson's ratio values are obtained after rotation, resulting in a total of four Poisson's ratio values for a single specimen.

9.2 Resilient modulus:

The resilient modulus can then be calculated from the Poisson's ratio, as obtained from section 9.1, and the recoverable horizontal deformation (instantaneous or total) according to the following equation.

$$M_R = \frac{P_{cyclic}}{\delta_h t}(0.2339 + 0.7801\mu)$$

where:

M_R	=	instantaneous or total resilient modulus, psi,
δ_h	=	recoverable horizontal deformation, inches,
P_{cyclic}	=	$P_{max} - P_{contact}$
	=	cyclic load applied to specimen, lbs.,
P_{max}	=	maximum applied load, lbs.
$P_{contact}$	=	contact load, lbs., and
μ	=	instantaneous or total Poisson's ratio.

For each horizontal deformation, corresponding Poisson's ratio value must be used, resulting in a total of four resilient modulus values for a single specimen.

9.3 Replicates:

The test procedure is applicable both for the laboratory compacted and field cores. In laboratory the test specimen are obtained from Gyratory compaction. From the compacted Gyratory plug with a height of 6 inches, three test specimens with a thickness equal to 1.5 inch can be obtained. It is recommended that both ends of the Gyratory plug be sawed 0.25 inch to obtain a smooth surface. This will result in three replicates from a given Gyratory plug. In case of field cores, three field samples are needed from a homogeneous section.

Three test samples will result in a total of twelve Poisson's ratio and resilient modulus values (4 values for each sample). It is important to report the individual values, average and the standard deviation of Poisson's ratio and the resilient modulus.

10. REPORT

10.1 The following general information shall be recorded:

10.1.1 Sample Identification.

10.1.2 Average thickness of the test specimen (t), to the nearest 0.01 inch (as per section 6.4)

10.1.3 Average diameter of the test specimen (D), to the nearest 0.01 inch (as per section 6.5)

10.1.4 Indirect tensile strength (initial), to the nearest psi.; from a comparable test specimen used to select the stress (or load) level for the testing.

10.1.5 Indirect tensile strength (final), to the nearest psi.; for the test specimen after the resilient modulus test has been completed.

10.1.6 Comments: The following (and additional, if so required) comments should be recorded, when relevant.

(a) If sawing was required for core specimens.

(b) If the specimen was skewed (either end of the specimen departed from perpendicularity to the axis by more than 0.5 degrees or 1/8 inch in 12 inches), as observed by placing the specimen on a level surface and measuring the departure from perpendicularity.

(c) If a "dummy" specimen was used to monitor the temperature. If not, the time specimen was maintained at the test temperature in the environmental chamber.

(d) If tests could not be completed due to damage/failure of test specimen.

(e) If the projections/depressions on the test surface were higher or deeper than 1/16 inch and the specimen was tested as no replacement specimen was available. Record the projections/depressions in such a case.

(f) If for core specimens, no traffic direction was marked, or if test was not performed on the marked axis due to some reason.

10.2 The following information shall be recorded:

10.2.1 Instantaneous Resilient Modulus:

(a) The vertical load levels (P_{cyclic})

(b) The contact load ($P_{contact}$) used over the last 5 loading cycles.

(c) Instantaneous recoverable horizontal and vertical deformations measured over the last five cycles.

(d) The calculated instantaneous Poisson's ratio (μ_i) over the last 5 loading cycles for each temperature.

(e) The calculated instantaneous resilient modulus (M_{ri}) over the last 5 loading cycles for each test temperature.

(f) The average and standard deviation of calculated instantaneous Poisson's ratio and instantaneous resilient modulus for all the replicates used for a given mix type.

10.2.2 Total Resilient Modulus:

(a) The vertical load levels (P_{cyclic})

(b) The contact load ($P_{contact}$) used over the last 5 loading cycles.

(c) Total recoverable horizontal and vertical deformations measured over the last five cycles.

(d) The calculated total Poisson's ratio (μ_t) over the last 5 loading cycles for each temperature.

(e) The calculated total resilient modulus (M_{rt}) over the last 5 loading cycles for each test temperature.

(f) The average and standard deviation of calculated total Poisson's ratio and instantaneous resilient modulus for all the replicates used for a given mix type.

10.2.3 Permanent Horizontal and Vertical Deformations:

(a) The number of preconditioning cycles used for each rotation.

(b) The cumulative permanent vertical deformation measured, including the preconditioning cumulative deformation and the resilient modulus testing cumulative deformation.

(c) The cumulative permanent horizontal deformation measured, including the preconditioning cumulative deformation and the resilient modulus testing cumulative deformation.

(d) The total number of load cycles conducted during the test. This includes the number of cycles for preconditioning and those cycles conducted for the determination of resilient modulus.

(e) The cumulative vertical deformation measured after preconditioning prior to initiation of resilient modulus testing.

(f) The cumulative horizontal deformation measured after preconditioning prior to initiation of resilient modulus testing.

(g) The cumulative permanent vertical deformation per load cycle.

(h) The cumulative permanent horizontal deformation per load cycle.

NCHRP Note:

Tables & figures for insertion at blank, numbered pages within report

Table 1.1: Experiment Design for Determining Sensitivity of Gage length to Aggregate and Specimen Size

Variables	Levels	Values
Nominal Maximum size	3	12.5, 19.0, 37.5 mm
Specimen Diameter	2	4-inch, 6-inch
Replicates	3	
Gage Length to Diameter Ratio	6	0.25, 0.5, 0.75 (4-inch dia.) 0.25, 0.5, 0.75 (6-inch dia.)
No. of Axis	2	Original & 90° Rotation
No. of samples to be failed for tensile strength deformation: 6 Total No. of Samples to be tested: 18 + 6 =24 Total No. of tests : 108 Specimen Diameter to Height ratio: 2 Temperature : 77° F		

Table 2.1 Integrated Stress Values of Hondros Equations for Different Gage Lengths on a 100 mm Diameter Specimen with 12.7 mm Loading Strip Width (11)

Gage Length in. (mm)	Numerical Integration Results			
	$\int_{-r}^{+r} \sigma_{yx}$	$\int_{-r}^{+r} \sigma_{xx}$	$\int_{-r}^{+r} \sigma_{xy}$	$\int_{-r}^{+r} \sigma_{yy}$
1.0 (25)	-8.9681	2.8707	3.0977	-9.7194
2.0 (50)	-15.5189	4.6525	6.1111	-21.2717
3.0 (75)	-18.9537	5.2889	8.5497	-38.4554
4.0 (100)	-19.8955	5.3679	-1.2651	-71.0635

TABLE 3.1 Correction Factors for Horizontal and Vertical Bulging in the Indirect Tension Specimen (1)

D = 4" or 6"	Poisson's Ratio ν	Diameter-to-Thickness Ratio (t/D)				
		0.167	0.333	0.500	0.625	0.750
C_{Bx}	0.20	0.9816	0.9638	0.9461	0.9358	0.9294
	0.35	0.9751	0.9518	0.9299	0.9179	0.9108
	0.45	0.9722	0.9466	0.9234	0.9111	0.9040
C_{By}	0.20	0.9886	0.9748	0.9677	0.9674	0.9688
	0.35	0.9808	0.9588	0.9479	0.9473	0.9493
	0.45	0.9759	0.9492	0.9364	0.9358	0.9380

TABLE 3.2 Correction Factors for Horizontal and Vertical Stress in the Indirect Tension Specimen (13)

D = 4" or 6"	Poisson's Ratio ν	Diameter to Thickness Ratio (t/D)				
		0.167	0.333	0.500	0.625	0.750
$C_{\sigma_{x_{CTR}}}$	0.20	0.9471	0.9773	1.0251	1.0696	1.1040
	0.35	0.9561	1.0007	1.0871	1.1682	1.2321
	0.45	0.9597	1.0087	1.1213	1.2307	1.3171
$C_{\sigma_{x_{CTR}}}$	0.20	-0.9648	-0.9754	-0.9743	-0.9693	-0.9611
	0.35	-0.9732	-0.9888	-0.9844	-0.9710	-0.9538
	0.45	-0.9788	-0.9971	-0.9864	-0.9646	-0.9395

TABLE 3.3 Percent Error in Moduli and Poisson's Ratios with Indirect Tension Test (13)

	Model Type*	Input ν	Deflections (*0.001in.)		Assume ν=0.35 (no vertical measurement)		Use H and V To Compute ν			
			H	V	E (ksi)	% Error	ν	% Error	E (ksi)	% Eror
Interior Measurements	1	0.20	.985	-2.02	271	+36	.203	+1.5	201	+0.5
		0.35	1.31	-2.15	204	+2.1	.357	+2.1	201	+0.5
		0.45	1.51	-2.23	177	-11	.456	+1.3	201	+0.5
	2	0.20	.985	-2.02	248	+24	.204	+2.1	195	-2.4
		0.35	1.31	-2.15	183	-8.3	.372	+6.3	189	-5.3
		0.45	1.51	-2.23	157	-21	.476	+5.8	186	-7.0
Exterior Measurements	3	0.20	2.03	-12.0	244	+22	.334	-4.5	238	+19
		0.35	2.84	-11.6	181	-9.6	.571	+27	245	+23
		0.45	3.21	-11.1	154	-23	.756	+68	256	+28
	4	0.20	1.80	-12.0	276	+38	2.65	+32	238	+19
		0.35	2.33	-11.6	213	+6.3	.447	+28	246	+23
		0.45	2.69	-11.1	185	-7.8	.591	+31	256	+28

* Model Type	Description
1	Interior measurements, 2-D plane stress solutions corrected for 3-D effects (corrections involve applying factors for bulging-induced measurement errors, conversion from 2-D to 3-D stress state at measurement location, and conversion from average strain across gage length to point strain at center of specimen.)
2	Interior measurements, 2-D plane stress assumptions used for analysis.
3	Exterior measurement H taken at specimen's edge
4	Exterior measurement H taken at center for specimen

Table 4.1 Comparison of Resilient Modulus Testing Protocols for Asphalt Concrete

Criteria	ASTM D4123-82	SHRP P07 (10/92)	AASHTO TP31-94	NCHRP 1-28	NCHRP 1-28A
Apparatus					
Testing Machine	Electro-hydraulic m/cs or other m/cs such as those using pneumatic devices	Top loading, closed loop Electro-hydraulic testing m/c capable of applying a haversine shaped load pulse	Top loading, closed loop, serve-hydraulic or servo-pneumatic capable of handling 22240 N (5000 Ibf)	Same as SHRP P07	Follow NCHRP 1-28
Loading device	NA		• Two vertical posts, rigid upper and lower platens • Fixed lower plate, upper moving plate • Clamped to testing frame to prevent movement relative to loading frame • Include counterbalance system	• Capable of testing 4 and 6 in, diameter specimens with thickness up to 4.5 in. • Must fit in temperature chamber. • Limit internal friction • Counteract all the weight such that no more than 2 Ibs. Transferred to the specimen	Follow NCHRP 1-28 (Will use modified SHRP LGD with spring counter weight)
Temperature Control System	Large enough to hold at least three specimens for 24h prior to testing		Large enough to house the load device	Include a cabinet large enough to house the loading device and a cabinet adequate to precondition at least three specimens prior to testing	Follow NCHRP 1-28 (Need Control Specification with temperature)
Deformation measurements	• By LVDTs or other suitable devices • Positive contact between the specimen and measuring device by spring loading or gluing attachments	• Vertical and horizontal deformation by spring loaded LVDTs. • Positive contact by using a spring loaded LVDT with half cylinder tips.	Same as SHRP P07	• Vertical: LVDT between gage points along vertical diameter. Gage length ¾ of diameter. • Horizontal: Extensometer (or comparable mountable device)	Will asses the accuracy of, on specimen vs. off specimen, deformation measurements as a function of aggregate size and specimen dimension

Quality Assurance / Quality Control	NA		NA	Load cell shall be checked: • With a proving ring • With in-house synthetic specimen	Follow NCHRP 1-28
Test Specimens					
Dimensions	Lab molded: Height of at least 2 in. and minimum diameter of 4 in. for aggregate up to 1 in. maximum size Height of at least 3 in. and minimum diameter of 6 in. for aggregate up to 1.5 in. maximum size Cores: Should have smooth parallel surface and conform to the dimension requirements for lab specimens.	No suggestions for lab molded Cores: as per section 6	Lab molded: Height of 38 mm (1.5 in.) min. 76 mm (3.0 in.) max. Diameter of 97.8 mm (3.85 in.) min to 105.4 mm (4.15 in.) max Cores: (addition to ASTM D4123) They shall be separated at the layer interface by sewing and testing separately.	• No less than 3.85 inch or more than 4.15 inch in diameter. • For course or large-stone mixes no less than 5.85 inch or more than 6.15 inch in diameter. • Desired thickness 2.5 in. for 4 in. dia. And 3.75 in. for 6 in. dia. • No more than 4 inch in thickness. For large-stone mixes no greater than 4.5 in. • Traffic direction shall be marked.	4 in. and 6 in. dia. Specimens will be molded and tested in the laboratory using 12.5, 19, 37.5 mm Maryland Superpave mix. Provisionally for lab procedure, thickness to max. aggregate diameter ratio of 4 is suggested.
Dimension Measurement	NA		• Thickness determined by averaging four measurements located at ¼ point around the sample, and ½ to 1 inch in from the edge. • Diameter measured at mid- height along the axis parallel to traffic and the axis perpendicular. Two measurements averaged.	Same as AASHTO TP 31-94	Follow NCHRP 1-28

Test Sequence	Testing to begin at the lowest temperature shortest load duration and smallest load. Subsequent testing on the specimen should provide progressively lower moduli	The sequence shall consist of an indirect tensile strength on similar specimen at 77 F, followed by resilient modulus testing at 41, 77 and 104 F and an indirect tensile at 77 F on the specimen.	Same as SHRP P07	Same as SHRP P07	Follow NCHRP 1-28
Temperature Recommended	41,77 (or ambient laboratory temperature), and 104 F	41, 77, and 104 F	Same as SHRP P07	Same as SHRP P07	Follow NCHRP 1-28 Will monitor sample deformation at higher temperature
Measurement of Indirect Tensile Strength	Destructive test on a specimen And the use of equation 8.3 in ASTM D4123	According to the procedure in attachment A to protocol P07 at 77+2 °F	• Destructive indirect test on one specimen at 25 °C • Specimen core from same area and layer for Resilient Modulus test • Calculation in accordance with section 9.3 of AASHTO TP31-94	Same as SHRP P07	Follow NCHRP 1-28
Recommended Load For Testing and Preconditioning	10 to 50% of indirect tensile strength	30%, 15%, and 5% of indirect tensile strength for test temperature of 41+2, 77+2, 104+2 °F respectively	Same as SHRP P07	30%, 15%, and 4% of indirect tensile strength for test temperature of 41+2, 77+2, 104+2 °F respectively	Provisionally Follow NCHRP 1-28 Need to reduce stress at higher temperature if strain exceeds 0.001
Seating Load	No specific recommendation	3%, 1.5%, and 0.5% of indirect tensile strength for test temperature of 41+2, 77+2, 104+2 °F respectively	10% of the load level, at each temperature	5%, 4%, and 4% of max load at 41, 77, and 104 °F respectively at 104 f not less than 5 Ibs, not more than 20 Ibs.	Provisionally Follow NCHRP 1-28 With modification to min. seating load (2 Ibs/in.)
Axes of Loading	Sample to be rotated 90° and repeat testing	Testing is to performed along single diametral axes	Same as SHRP P07	Same as SHRP P07	Will rotate the sample 90° once, reduce replicates from 3 to 2.
Wave Form	Haversine or suitable waveform	Haversine	Same as SHRP P07	Same as SHRP P07	Follow NCHRP 1-28

Loading Pattern	Load duration 0.1 to 0.4 Frequency of load: 0.33, 0.5 and 1 HZ suggested.	Load duration 0.1 sec. Rest period 0.9 sec	Same as SHRP P07	Same as SHRP P07	Will test over a range of loading time and dwell time
Preconditioning					
Period of Preconditioning	Until deformation is stable		Until acceptable vertical and horizontal deformation ratios are being measured	Until deformation is stable	Follow NCHRP 1-28
Expected load Repetition	A minimum of 50 to 200 cycles is typical	Expected ranges are 50-150, 50-150 and 20-50 at 41, 77, 104 °F respectively	Expected ranges are 50-100, 50-100, 20-50 at 5, 25, 40 °C respectively	Recommended numbers are 100, 100, 50 for 41, 77, and 104 °F, however, deformation must be stable	Follow NCHRP 1-28
Deformation Limits	0.001 inches	0.025 in at 41 °F 0.05 in at 77 and 104 °F	Same as SHRP P07	0.015 in. for 41 °F 0.03 in. for 77, and 104 °F	Need to express the limits in terms of strain or deformation per specimen dimensions
If Deformation Exceeds Limit	Reduce the test temperature, the applied load, or both	Reduce applied load to min. possible and retaining adequate deformation for measurement purposes, stop preconditioning and generate 10 load pulses for Mr determination and so indicate on test report	Reduce to min. possible and retain adequate deformation for measurement purposes, loads as low as 44 N (10 Ibs) and repetitions as few as 5, for loads between 44 and 110 N (10 to 25 Ibf)	Same as SHRP P07	Stop the test and discard the specimen. Select new specimen at reduced stress.
Number of Load Pulses to be Applied for Mr	Measure the average recoverable horizontal and vertical deformation over at least 3 cycles after the repeated resilient deformations are stable	Minimum of 30 load pulses to be applied. Four of the last five cycles used for resilient modulus calculations shall be within 15% of average	Same as SHRP P07	No specific number provided Four of the last five cycles used for resilient modulus calculations shall be within 15% of average Mr value	Follow NCHRP 1-28

Poisson's Ratio	Can be assumed or calculated 0.35 suggested to be reasonable at 77 °F	Shall be calculated. However, it shall lie between 0.1 and 0.5. if less than 0.1, 0.1 shall be assumed and if greater than 0.5, 0.5 shall be assumed.	Same as SHRP P07	Shall be calculated. Calculated values shall be in the range: 0.1 –0.3, 0.25-0.45 and 0.4-0.5 for 41, 77, and 104 °F. When in doubt about validity of the values calculated, values shall be reported and following values shall be assumed: 0.2, 0.35 and 0.5 for 41, 77, and 104 °F.	Will be decided later depending on the specific analysis to be used. (Considering visco-elastic strains)
Calculations	Elastic strains have been used in Poisson's ration and resilient modulus calculations.	Using the same principal in ASTM D4123 but new equations for calculation.	Same as ASTM D4123	Using the same principal in ASTM D4123 but new equation for calculations.	• Will take in to account the visco-elastic property of AC mixture in Poisson's ratio and Mr calculations. • Have to reexamine problem of bulging and non-uniform stress distribution using finite-element analysis.

Table 5.1 Maryland Aggregate Stockpile Data.

Test	Method	#10	Washed #10	#8	#7	#6	#57	#4
Gradation	AASHTO T27							
50.0 mm								100
37.5 mm						100		84.6
25.0 mm						90.0	100	37.2
19.0 mm					100	55.0	92.7	4.3
12.5 mm				100	90.4	6.0	44.1	1.2
9.5 mm		100	100	93.7	63.7	0.5	18.1	0.4
4.75 mm		93.3	92.2	18.6	12.5		3	
2.36 mm		62.9	59.1	3.2	2.7		1.1	
1.18 mm		39.1	31.7	1.3				
0.600 mm		26.7	17.4					
0.300 mm		19.4	9.5					
0.150 mm		15.2	5.2					
0.075 mm		12.4	3.7	1.2	1.1	0.5	0.8	0.4
Specific Gravity	AASHTO T84/T85							
Bulk		2.594	2.664	2.698	2.706	2.709	2.712	2.710
SSD		2.646	2.687	2.712	2.717	2.718	2.722	2.717
Apparent		2.735	2.729	2.736	2.736	2.729	2.740	2.729
Absorption, %		2.0	0.9	0.5	0.4	0.3	0.4	0.3
LA Abrasion, %	AASHTO T96			26	26		26	
Sodium Sulfate Soundness, %	AASHTO T104	1.2	1.2	0.1	0.1		0.1	
Fine Aggregate Angularity	AASHTO T304	45.5	45.6					
Sand Equivalent	AASHTO T176	89	92					
Fractured Faces, %	PTM 621	100	100	100	100	100	100	100
Flat and Elongated, %	ASTM D4791							
5:1				10.4	7.5		4.5	
3:1				20.2	20.8		17.5	

Table 5.2 AASHTO MP1 Grading

Condition	Test	Method *(24,26,27)*	Result
Unaged Asphalt			
	Specific Gravity at 25 °C	AASHTO T228	1.021
	Flash Point	AASHTO T48	294 °C
	Viscosity at 135 °C	ASTM D4402	0.420 Pa.s
	Viscosity at 165 °C	ASTM D4402	0.114 Pa.s
	G*/sinδ at 10 rad/sec, 64 °C	AASHTO TP5	1.260 kPa

Table 5.3 Mixing and Compaction Temperatures

Condition	Temperature, °C	
	Maximum	Minimum
Mixing	159	153
Compaction	147	142

Table 5.4. Preliminary Mixture Designs Supplied by MSHA

Property	12.5 mm Mix	19.0 mm Mix	37.5 mm Mix
N_{design}	96	109	126
AC Content, %	5.3	4.3	3.6
Air Voids, %	4.0	na	4.0
VMA, %	14.7	14.2	Na
VFA, %	74	72	Na
Filler/Asphalt Ratio	1.10	0.73	Na
G_{mm}	2.517	2.535	Na
Gradation			
50.0 mm			100
37.5 mm			98
25.0 mm		100	88
19.0 mm	100	96	77
12.5 mm	97	77	62
9.5 mm	88	61	55
4.75 mm	60	41	29
2.36 mm	37	26	16
1.18 mm	22	15	10
0.600 mm	14	11	7
0.300 mm	9	5	5
0.150 mm	7	4	4
0.075 mm	5.7	3.0	3.5
Blend Percentages			
#4			Na
#57		35	Na
#6			Na
#7	28	25	Na
#8	15		Na
#10	17	5	Na
Washed #10	40	35	Na

Table 5.5 12.5 mm Verification Results

Property	Trial 1 Actual	Estimated Optimum	Final
Asphalt Content	5.0	5.29	5.2
Air Voids	4.7	4.0	4.0
G_{mm}	2.501	2.493	2.488
VMA	15.3	15.2	15.5
VFA	69.2	74	74
Filler/Effective Asphalt Ratio	1.22	1.26	1.26

Table 5.6 19.0 mm Verification Results

Property	Trial 1 Actual	Estimated Optimum	Final
Asphalt Content	4.3	4.51	4.6
Air Voids	4.5	4.0	4.0
G_{mm}	2.531	2.523	2.523
VMA	14.1	14.0	14.1
VFA	68	71	72
Filler/Effective Asphalt Ratio	1.26	1.27	1.30

Table 5.7 Final 12.5 mm Design

Property	Design	Superpave Criteria
Gradation		
19.0 mm	100	
12.5 mm	97	
9.5 mm	87	
4.75 mm	58	
2.36 mm	35	
1.18 mm	21	
0.600 mm	13	
0.300 mm	9	
0.150 mm	8	
0.075 mm	6.1	
Asphalt Content, %	5.2	
G_{mm}	2.492	
G_{sb}	2.674	
Air Voids, %	4.0	4.0
VMA, %	15.5	>14.0
VFA, %	74	65-75
Filler/Effective Asphalt Ratio	1.26	0.6 – 1.2
% G_{mm} at $N_{initial}$	84.8	> 89.0
% G_{mm} at $N_{maximum}$	97.6	< 98
Coarse Aggregate Angularity	100/100	95/90
Fine Aggregate Angularity	46	> 45
Flat and Elongated	8.3	< 10
Sand Equivalent	91	> 45

Table 5.8 Final 19.0 mm Design

Property	Design	Superpave Criteria
Gradation		
25.0 mm	100	
19.0 mm	97	
12.5 mm	78	
9.5 mm	63	
4.75 mm	42	
2.36 mm	25	
1.18 mm	15	
0.600 mm	10	
0.300 mm	7	
0.150 mm	6	
0.075 mm	5.4	
Asphalt Content, %	4.6	
G_{mm}	2.523	
G_{sb}	2.692	
Air Voids, %	4.0	4.0
VMA, %	14.1	>13.0
VFA, %	72	65-75
Filler/Effective Asphalt Ratio	1.30	0.6 – 1.2
% G_{mm} at $N_{initial}$	84.2	> 89.0
% G_{mm} at $N_{maximum}$	97.7	< 98
Coarse Aggregate Angularity	100/100	95/90
Fine Aggregate Angularity	46	> 45
Flat and Elongated	6.3	< 10
Sand Equivalent	92	> 45

Table 5.9. Summary of Trial Blends for 37.5 mm Mixture.

Property	Trial 1	Trial 2	Trail 3	Trail 4	Trial 5
Gradation					
50.0 mm					
37.5 mm	94	95	97	91	93
25.0 mm	74	80	86	68	71
19.0 mm	57	66	28	50	52
12.5 mm	47	53	57	44	42
9.5 mm	43	47	51	41	39
4.75 mm	30	31	31	33	30
2.36 mm	19	19	19	22	20
1.18 mm	11	11	11	14	12
0.600 mm	7	7	7	10	8
0.300 mm	5	5	5	8	6
0.150 mm	4	4	4	7	5
0.075 mm	2.9	2.9	2.9	6.4	4.1
Asphalt Content, %	3.9	3.9	3.9	3.9	3.9
G_{mm}	2.561	2.532	2.549	2.556	2.549
Air Voids, %	5.6	4.9	6.6	3.7	4.0
VMA, %	13.4	12.8	14.4	11.8	12.4
VFA, %	58.3	61.5	53.7	69.1	67.6
Filler/Effective Asphalt Ratio	0.9	0.8	0.8	1.8	1.2
% G_{mm} at $N_{initial}$	82.3	82.3	81.4	84.0	83.7
% G_{mm} at $N_{maximum}$	94.4	95.1	93.4	98.3	98.0
Estimated AC	4.53	4.27	4.96	3.76	3.90
Estimated VMA	13.1	12.6	13.8	11.9	12.4
Estimated VFA	69.4	68.2	71.1	66.3	67.7
Estimated Dust Ratio	0.7	0.8	0.7	2.0	1.2

Table 5.10. Final 37.5 mm Design.

Property	Design	Superpave Criteria
Gradation		
50.0 mm	100	
37.5 mm	93	
25.0 mm	71	
19.0 mm	52	
12.5 mm	42	
9.5 mm	39	
4.75 mm	30	
2.36 mm	20	
1.18 mm	12	
0.600 mm	8	
0.300 mm	6	
0.150 mm	5	
0.075 mm	4.3	
Asphalt Content, %	3.9	
G_{mm}	2.549	
G_{sb}	2.684	
Air Voids, %	4.0	4.0
VMA, %	12.4	>11.0
VFA, %	68	65-75
Filler/Effective Asphalt Ratio	1.10	0.6 – 1.2
% G_{mm} at $N_{initial}$	83.7	> 89.0
% G_{mm} at $N_{maximum}$	98.0	< 98
Coarse Aggregate Angularity	100/100	95/90
Fine Aggregate Angularity	46	> 45
Flat and Elongated	3.7	< 10
Sand Equivalent	90	> 45

Table 5.11. Superpave Binder Characterization Tests.

Property	Method *(1)*	Conditions
Complex Modulus and Phase Angle	AASHTO TP5	15, 25, 35, 45, 60, 70, 80, 95, 105, and 115 °C 1, 10, 100 rad/sec
Brookfield Viscosity	AASHTO TP48	60, 80, 100, 121.1, 135, and 176.7 °C
Flexural Creep Stiffness and m-value	AASHTO TP1	Three temperatures, one above low temperature specification limit, two below
Fracture Stress and Strain	AASHTO TP3	Three temperatures used in flexural creep stiffness and m-value testing.

Table 5.12. Conventional Binder Characterization Tests.

Property	Method *(3)*	Conditions
Penetration	AASHTO T49	100 g, 5 sec, 15 and 25 °C
Softening Point	AASHTO T53	Measured temperature
Absolute Viscosity	AASHTO T202	60 °C
Kinematic Viscosity	AASHTO T201	135 °C

Table 5.13. Dynamic Shear Rheometer Data for Tank Condition.

					G*, Pa						
Freq, rad/sec	**1**	**1.59**	**2.51**	**3.98**	**6.31**	**10**	**15.9**	**25.1**	**39.8**	**63.1**	**100**
Temp, C											
15	1139000	1611000	2257000	3150000	4351000	5968000	8305000	11090000	14660000	19280000	24920000
25	113100	166700	244900	358600	519100	748800	1077000	1536000	2170000	3040000	4195000
35	16640	25100	37760	56320	83750	123700	185400	272400	398800	579600	836000
45	2846	4369	6711	10190	15280	21800	34970	52570	78660	116800	170500
60	251.1	394.5	620.5	972.5	1517	2360	3672	5657	8690	13310	20230
70	69.28	109.5	173.5	274.3	432	678.7	1074	1673	2600	4028	6202
80	22.35	36.31	56.9	89.27	141.6	223.9	354.4	556.5	875.5	1362	2460
95	5.11	8.27	12.75	20.35	32.28	51.14	80.99	127.6	202.3	319.7	501.9
105	2.447	3.963	6.049	9.578	15.21	24.05	37.84	59.94	94.70	149.8	235.9
115											

						Phase Angle, Degrees					
Freq, rad/sec	**1**	**1.59**	**2.51**	**3.98**	**6.31**	**10**	**15.9**	**25.1**	**39.8**	**63.1**	**100**
Temp, C											
15	69.02	67.49	65.75	64.23	62.25	60.13	59.77	57.75	55.45	53.31	51.36
25	76.19	75.27	74.23	73.36	72.05	70.85	69.73	68.33	66.82	65.32	63.68
35	80.93	80.18	79.51	78.59	77.79	77.00	75.87	75.06	74.27	73.29	72.31
45	85.67	85.00	84.32	83.55	82.89	82.18	80.61	79.69	79.03	78.42	77.84
60	88.51	88.28	87.70	87.30	86.72	86.01	85.52	84.77	84.13	83.70	83.15
70	89.43	89.28	89.15	88.89	88.58	88.16	87.57	86.96	86.44	85.89	85.50
80	90.92	89.89	89.38	89.54	89.38	89.11	88.93	90.03	88.22	87.89	87.36
95	87.66	91.39	89.46	89.43	89.73	89.63	89.56	89.77	89.72	89.50	89.29
105	88.15	87.95	89.61	89.45	89.59	89.61	89.84	89.71	89.79	89.73	89.68
115											

Table 5.14. Brookfield Viscosity Data.

Temperature, C	Tank condition Brookfield Viscosity, mPa.s
60	263000
80	20000
100	4120
121.1	880
135	383
176.7	69

Table 5.15. BBR Data.

	Temperature							
	-12 C		-18 C		-24 C		-30 C	
TANK CONDITION								
Time, s	S, MPa	m	S, MPa	M	S, MPa	M	S, MPa	m
8			496	0.238	1026	0.144	1439	0.085
15			423	0.272	929	0.176	1356	0.105
30			346	0.309	813	0.210	1251	0.127
60			276	0.346	694	0.245	1138	0.149
120			214	0.383	579	0.279	1018	0.171
240			162	0.420	472	0.314	898	0.193

Table 5.16. Conventional Binder Properties.

Property	Tank
Pen, 15°C, 1/10 mm	24
Pen, 25°C, 1/10 mm	69
Absolute Viscosity, 60°C, P	2503
Kinematic Viscosity, 135 °C, cSt	424
Softening Point, °C	48.5

Table 5.17. Parameters of ASTM VTS Equation.

Condition	A	VTS
Tank	10.9117206	-3.66286489

Table 7.1 Average Test Results of Study

Parameter	Mix-Diam	Gage Length (in)	Specimen Diameter	Avg	Overall Avg
Mri	12.5-4d	1		746.43	
		2		735.15	
		3		866.22	
			4		***782.602***
	12.5-6d	1.5		808.38	
		3		762.56	
		4.5		822.91	
			6		***797.952***
	19.0-4d	1		1033.91	
		2		903.57	
		3		1044.84	
			4		***994.106***
	19.0-6d	1.5		910.59	
		3		874.93	
		4.5		790.63	
			6		***858.718***
	37.5-4d	1		1898.53	
		2		1315.70	
		3		1302.71	
			4		***1505.648***
	37.5-6d	1.5		1079.65	
		3		1146.30	
		4.5		1191.30	
			6		***1139.085***

Parameter	Mix-Diam	Gage Length (in)	Specimen Diameter	Avg	Overall Avg
Mrt	12.5-4d	1		589.68	
		2		604.43	
		3		681.50	
			4		***625.199***
	12.5-6d	1.5		660.55	
		3		628.19	
		4.5		671.50	
			6		***653.413***
	19.0-4d	1		825.98	
		2		735.97	
		3		833.19	
			4		***798.379***
	19.0-6d	1.5		700.28	
		3		685.64	
		4.5		599.52	
			6		***661.811***
	37.5-4d	1		1550.61	
		2		1138.20	
		3		1130.85	
			4		***1273.220***
	37.5-6d	1.5		813.96	
		3		875.41	
		4.5		946.58	
			6		***878.649***

Table 7.1 Average Test Results of Study (Cont'd)

Parameter	Mix-Diam	Gage Length (in)	Specimen Diameter	Avg	Overall Avg
ui	12.5-4d	1		0.498	
		2		0.422	
		3		0.563	
			4		***0.495***
	12.5-6d	1.5		0.475	
		3		0.394	
		4.5		0.451	
			6		***0.440***
	19.0-4d	1		0.591	
		2		0.461	
		3		0.544	
			4		***0.532***
	19.0-6d	1.5		0.503	
		3		0.419	
		4.5		0.401	
			6		***0.441***
	37.5-4d	1		0.871	
		2		0.716	
		3		0.703	
			4		***0.764***
	37.5-6d	1.5		0.551	
		3		0.430	
		4.5		0.424	
			6		***0.468***

Parameter	Mix-Diam	Gage Length (in)	Specimen Diameter	Avg	Overall Avg
ut	12.5-4d	1		0.503	
		2		0.411	
		3		0.529	
			4		***0.481***
	12.5-6d	1.5		0.488	
		3		0.401	
		4.5		0.459	
			6		***0.449***
	19.0-4d	1		0.584	
		2		0.416	
		3		0.517	
			4		***0.505***
	19.0-6d	1.5		0.485	
		3		0.417	
		4.5		0.403	
			6		***0.435***
	37.5-4d	1		0.823	
		2		0.711	
		3		0.653	
			4		***0.729***
	37.5-6d	1.5		0.565	
		3		0.438	
		4.5		0.445	
			6		***0.483***

*Table 7.2 Best Estimate (True Means)**

Dnom Size	Specimen Diameter	Mri (ksi)	Mrt (ksi)	ui	ut
12.5 mm	6"	762.56	628.19	0.394	0.401
19.0 mm	6"	874.93	685.64	0.419	0.417
37.5 mm	6"	1146.30	875.41	0.430	0.438

*(*) Best Estimate based upon mean of 6" diameter specimens, using a 3.0" Gage Length*

Table 7.3 Tabular Summary of Total Variance Magnitudes by Mix Type and Specimen Diameter

Mix Type-Diameter Combination			*Total Variance (sigma ^2)*			
	Dnom(mm)	*Spec Diam (in)*	*Mri*	*Mrt*	*ui*	*ut*
12.5-4 d	12.5	4	61788	34770	0.135	0.128
19.0-4 d	19	4	168545	99634	0.278	0.243
37.5-4 d	37.5	4	2178440	1463063	0.766	0.681
12.5-6 d	12.5	6	38488	24581	0.054	0.052
19.0-6 d	19	6	119930	73713	0.101	0.085
37.5-6 d	37.5	6	656072	457171	0.317	0.370

Mix Type-Diameter Combination			*Ratio-Total Variance (Dnomi; dj/ 12.5 mm; 4" d))*			
	Dnom(mm)	*Spec Diam (in)*	*Mri*	*Mrt*	*ui*	*ut*
12.5-4 d	12.5	4	1.000	1.000	1.000	1.000
19.0-4 d	19	4	2.728	2.866	2.059	1.898
37.5-4 d	37.5	4	35.257	42.078	5.674	5.320
12.5-6 d	12.5	6	0.623	0.707	0.400	0.406
19.0-6 d	19	6	1.941	2.120	0.748	0.664
37.5-6 d	37.5	6	10.618	13.148	2.348	2.891

Mix Type-Diameter Combination			*Ratio-Total Variance (Dnomi; 6" d / Dnomi; 4" d))*			
	Dnom(mm)	*Spec Diam (in)*	*Mri*	*Mrt*	*ui*	*ut*
12.5-4 d	12.5	4	1.000	1.000	1.000	1.000
19.0-4 d	19	4	1.000	1.000	1.000	1.000
37.5-4 d	37.5	4	1.000	1.000	1.000	1.000
12.5-6 d	12.5	6	0.623	0.707	0.400	0.406
19.0-6 d	19	6	0.712	0.740	0.363	0.350
37.5-6 d	37.5	6	0.301	0.312	0.414	0.543

Table 7.4 Total Variance Summary by Mix Type and Gage Length (6" Diameter Specimens)

			Mri		*Mrt*		*ui*		*ut*	
Dnom(mm)	***Spec Diam (inches)***	***Gage Length (inches)***	***Total Variance***	***Var Ratio Gli / Gl=1.5"***	***Total Variance***	***Var Ratio Gli / Gl=1.5"***	***Total Variance***	***Var Ratio Gli / Gl=1.5"***	***Total Variance***	***Var Ratio Gli / Gl=1.5"***
12.5	6	1.5	60217	1.000	34796	1.000	0.10033	1.000	0.09048	1.000
		3.0	25442	0.423	20064	0.577	0.04544	0.453	0.05082	0.562
		4.5	30091	0.500	19493	0.560	0.01677	0.167	0.01458	0.161
19	6	1.5	267359	1.000	157300	1.000	0.22162	1.000	0.17799	1.000
		3.0	77546	0.290	55153	0.351	0.02857	0.129	0.02922	0.164
		4.5	22093	0.083	13794	0.088	0.05464	0.247	0.05203	0.292
37.5	6	1.5	856196	1.000	471487	1.000	0.66628	1.000	0.70300	1.000
		3.0	424028	0.495	274111	0.581	0.18560	0.279	0.22644	0.322
		4.5	687991	0.804	625958	1.328	0.11171	0.168	0.19580	0.279

[ ] ***Designates minimum Variance ratios***

Table 7.5 Summary of Component Variance Values (Instantaneous Modulus)

			Variance: Mri- Instantaneous Modulus (ksi ^2)					
Dnom(mm)	Spec Diam (in)	Gage Length (inches)	Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample / Specimen	Total Variance
12.5	4	1.0 in	5528	1151	46724	41880	33794	129077
		2.0 in	1018	1242	16435	17356	896	36947
		3.0 in	655	2229	6724	12520	0	22128
		All	2400	1540	23295	23979	10574	61788
19	4	1.0 in	7803	12887	140544	142169	0	303403
		2.0 in	1299	2205	24078	27065	0	54647
		3.0 in	1747	3560	42508	99771	9961	157547
		All	3616	6217	69043	89668	0	168544
37.5	4	1.0 in	705202	19281	2744854	1108075	392398	4969810
		2.0 in	9940	9816	469961	556895	0	1046612
		3.0 in	3618	31311	339668	241055	0	615652
		All	239587	20136	1184828	635342	98548	2178441
12.5	6	1.5 in	7577	1243	19876	31235	286	60217
		3.0 in	730	1282	13806	9624	0	25442
		4.5 in	540	1127	9681	18743	0	30091
		All	2949	1217	14454	19867	0	38487
19	6	1.5 in	14660	9039	62578	164833	16249	267359
		3.0 in	710	619	7741	62395	6081	77546
		4.5 in	314	2111	7868	10915	885	22093
		All	5228	3926	26123	79381	5276	119934
37.5	6	1.5 in	45992	1640	430254	378310	0	856196
		3.0 in	9495	11546	156267	246720	0	424028
		4.5 in	1920	30901	238764	416406	0	687991
		All	19135	14696	275095	347146	0	656072

Table 7.6 Summary of Component Variance Values (Total Modulus)

Dnom(mm)	Spec Diam (in)	Gage Length (inches)	Variance: Mrt- Total Modulus (ksi ^2) Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample / Specimen	Total Variance
12.5	4	1.0 in	2192	916	27166	24479	17779	72532
		2.0 in	322	1040	8805	9229	2178	21574
		3.0 in	537	619	4663	7563	0	13382
		All	1017	858	13545	13757	5594	34771
19	4	1.0 in	2918	5234	82390	82202	0	172744
		2.0 in	620	1578	18960	17369	0	38527
		3.0 in	896	2270	23918	60547	9231	96862
		All	1478	3027	41756	53373	0	99634
37.5	4	1.0 in	203636	37841	1877338	477693	359035	2955543
		2.0 in	7246	10471	416594	496800	0	931111
		3.0 in	7287	49674	327736	263099	7986	655782
		All	72723	32662	873889	412531	71258	1463063
12.5	6	1.5 in	2092	941	12516	18639	608	34796
		3.0 in	365	1163	11272	7264	0	20064
		4.5 in	237	462	6126	12668	0	19493
		All	898	856	9971	12857	0	24582
19	6	1.5 in	9052	4725	31165	98261	14097	157300
		3.0 in	308	484	4835	41318	8208	55153
		4.5 in	321	1546	4277	6724	926	13794
		All	3227	2252	13426	48767	6042	73714
37.5	6	1.5 in	24438	3407	231662	211980	0	471487
		3.0 in	2976	5545	108410	157180	0	274111
		4.5 in	1769	35558	209686	378945	0	625958
		All	9728	14837	183239	249377	0	457181

Table 7.7 Summary of Component Variance Values (Instantaneous Poisson's Ratio)

			Variance: ui- Instantaneous Poisson ratio					
Dnom(mm)	Spec Diam (in)	Gage Length (inches)	Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample / Specimen	Total Variance
12.5	4	1.0 in	0.01330	0.00320	0.22928	0.08175	0.00000	0.32753
		2.0 in	0.00308	0.00150	0.03230	0.01780	0.00000	0.05468
		3.0 in	0.00297	0.00086	0.01222	0.00525	0.01153	0.03283
		All	0.00646	0.00187	0.09128	0.03494	0.00000	0.13454
19	4	1.0 in	0.01284	0.01706	0.30611	0.29078	0.00000	0.62679
		2.0 in	0.00354	0.00227	0.04367	0.02129	0.00000	0.07076
		3.0 in	0.00321	0.00117	0.05859	0.07235	0.00000	0.13532
		All	0.00653	0.00683	0.13613	0.12814	0.00000	0.27762
37.5	4	1.0 in	0.18769	0.01260	0.47052	0.11677	0.00000	0.78758
		2.0 in	0.01308	0.04459	0.39328	0.38907	0.00000	0.84001
		3.0 in	0.05234	0.01034	0.27748	0.33079	0.01311	0.68406
		All	0.08437	0.02251	0.38043	0.27888	0.00000	0.76619
12.5	6	1.5 in	0.01739	0.00271	0.07133	0.00889	0.00000	0.10033
		3.0 in	0.00225	0.00678	0.02203	0.01438	0.00000	0.04544
		4.5 in	0.00147	0.00091	0.00774	0.00666	0.00000	0.01677
		All	0.00704	0.00346	0.03370	0.00998	0.00000	0.05418
19	6	1.5 in	0.02895	0.02188	0.07703	0.09377	0.00000	0.22162
		3.0 in	0.00200	0.00051	0.01298	0.01109	0.00199	0.02857
		4.5 in	0.00107	0.01156	0.02168	0.01964	0.00069	0.05464
		All	0.01067	0.01132	0.03723	0.04150	0.00000	0.10071
37.5	6	1.5 in	0.06050	0.00058	0.38399	0.22121	0.00000	0.66628
		3.0 in	0.00503	0.00233	0.07249	0.09184	0.01392	0.18560
		4.5 in	0.00308	0.00704	0.05096	0.05064	0.00000	0.11171
		All	0.02287	0.00332	0.16915	0.12123	0.00000	0.31656

Table 7.8 Summary of Component Variance Values (Total Poisson's Ratio)

			Variance: ut - Total Poisson Ratio					
Dnom(mm)	*Spec Diam (in)*	*Gage Length (inches)*	*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample / Specimen*	*Total Variance*
12.5	4	1.0 in	0.00630	0.00507	0.22651	0.07565	0.00000	0.31352
		2.0 in	0.00132	0.00214	0.03210	0.01316	0.00000	0.04872
		3.0 in	0.00182	0.00252	0.01062	0.00532	0.00875	0.02902
		All	0.00315	0.00324	0.08974	0.03137	0.00000	0.12751
19	4	1.0 in	0.01147	0.01087	0.28484	0.25604	0.00000	0.56322
		2.0 in	0.00179	0.00342	0.03517	0.01595	0.00000	0.05633
		3.0 in	0.00189	0.00137	0.04400	0.06177	0.00000	0.10903
		All	0.00505	0.00522	0.12134	0.11125	0.00000	0.24286
37.5	4	1.0 in	0.09579	0.02640	0.50698	0.20057	0.00000	0.82974
		2.0 in	0.00776	0.01180	0.38224	0.33948	0.00000	0.74128
		3.0 in	0.00419	0.00731	0.21772	0.24332	0.00670	0.47923
		All	0.03591	0.01517	0.36898	0.26113	0.00000	0.68118
12.5	6	1.5 in	0.00728	0.00239	0.07380	0.00701	0.00000	0.09048
		3.0 in	0.00152	0.00783	0.02431	0.01717	0.00000	0.05082
		4.5 in	0.00097	0.00142	0.00637	0.00582	0.00000	0.01458
		All	0.00326	0.00388	0.03483	0.01000	0.00000	0.05196
19	6	1.5 in	0.02814	0.00359	0.06931	0.07695	0.00000	0.17799
		3.0 in	0.00166	0.00023	0.01384	0.01176	0.00172	0.02922
		4.5 in	0.00061	0.01365	0.01603	0.01957	0.00217	0.05203
		All	0.01014	0.00582	0.03306	0.03609	0.00000	0.08512
37.5	6	1.5 in	0.06487	0.00315	0.39264	0.24234	0.00000	0.70300
		3.0 in	0.00326	0.00278	0.09079	0.11495	0.01466	0.22644
		4.5 in	0.00183	0.01278	0.08629	0.09490	0.00000	0.19580
		All	0.02341	0.00624	0.18990	0.15073	0.00000	0.37028

Table 7.9 Summary of Component Variance Values as Function of Percent Total Variance (Instantaneous Modulus)

Dnom(mm)	Spec Diam (in)	Gage Length (inches)	Percent Variance: Mri- Instantaneous Modulus Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample / Specimen	Total Variance
12.5	4	1.0 in	4.3%	0.9%	36.2%	32.4%	26.2%	100.0%
		2.0 in	2.8%	3.4%	44.5%	47.0%	2.4%	100.0%
		3.0 in	3.0%	10.1%	30.4%	56.6%	0.0%	100.0%
		All	3.9%	2.5%	37.7%	38.8%	17.1%	100.0%
19	4	1.0 in	2.6%	4.2%	46.3%	46.9%	0.0%	100.0%
		2.0 in	2.4%	4.0%	44.1%	49.5%	0.0%	100.0%
		3.0 in	1.1%	2.3%	27.0%	63.3%	6.3%	100.0%
		All	2.1%	3.7%	41.0%	53.2%	0.0%	100.0%
37.5	4	1.0 in	14.2%	0.4%	55.2%	22.3%	7.9%	100.0%
		2.0 in	0.9%	0.9%	44.9%	53.2%	0.0%	100.0%
		3.0 in	0.6%	5.1%	55.2%	39.2%	0.0%	100.0%
		All	11.0%	0.9%	54.4%	29.2%	4.5%	100.0%
			3.5%	*3.5%*	*42.6%*	*45.6%*	*4.8%*	*100.0%*
12.5	6	1.5 in	12.6%	2.1%	33.0%	51.9%	0.5%	100.0%
		3.0 in	2.9%	5.0%	54.3%	37.8%	0.0%	100.0%
		4.5 in	1.8%	3.7%	32.2%	62.3%	0.0%	100.0%
		All	7.7%	3.2%	37.6%	51.6%	0.0%	100.0%
19	6	1.5 in	5.5%	3.4%	23.4%	61.7%	6.1%	100.0%
		3.0 in	0.9%	0.8%	10.0%	80.5%	7.8%	100.0%
		4.5 in	1.4%	9.6%	35.6%	49.4%	4.0%	100.0%
		All	4.4%	3.3%	21.8%	66.2%	4.4%	100.0%
37.5	6	1.5 in	5.4%	0.2%	50.3%	44.2%	0.0%	100.0%
		3.0 in	2.2%	2.7%	36.9%	58.2%	0.0%	100.0%
		4.5 in	0.3%	4.5%	34.7%	60.5%	0.0%	100.0%
		All	2.9%	2.2%	41.9%	52.9%	0.0%	100.0%
			3.7%	*3.6%*	*34.5%*	*56.3%*	*2.0%*	*100.0%*

Table 7.10 Summary of Component Variance Values as Function of Percent Total Variance (Total Modulus)

			Percent Variance: Mrt- Total Modulus					
Dnom(mm)	*Spec Diam (in)*	*Gage Length (inches)*	*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample / Specimen*	*Total Variance*
12.5	4	1.0 in	3.0%	1.3%	37.5%	33.7%	24.5%	100.0%
		2.0 in	1.5%	4.8%	40.8%	42.8%	10.1%	100.0%
		3.0 in	4.0%	4.6%	34.8%	56.5%	0.0%	100.0%
		All	2.9%	2.5%	39.0%	39.6%	16.1%	100.0%
19	4	1.0 in	1.7%	3.0%	47.7%	47.6%	0.0%	100.0%
		2.0 in	1.6%	4.1%	49.2%	45.1%	0.0%	100.0%
		3.0 in	0.9%	2.3%	24.7%	62.5%	9.5%	100.0%
		All	1.5%	3.0%	41.9%	53.6%	0.0%	100.0%
37.5	4	1.0 in	6.9%	1.3%	63.5%	16.2%	12.1%	100.0%
		2.0 in	0.8%	1.1%	44.7%	53.4%	0.0%	100.0%
		3.0 in	1.1%	7.6%	50.0%	40.1%	1.2%	100.0%
		All	5.0%	2.2%	59.7%	28.2%	4.9%	100.0%
			2.4%	***3.4%***	***43.7%***	***44.2%***	***6.4%***	***100.0%***
12.5	6	1.5 in	6.0%	2.7%	36.0%	53.6%	1.7%	100.0%
		3.0 in	1.8%	5.8%	56.2%	36.2%	0.0%	100.0%
		4.5 in	1.2%	2.4%	31.4%	65.0%	0.0%	100.0%
		All	3.7%	3.5%	40.6%	52.3%	0.0%	100.0%
19	6	1.5 in	5.8%	3.0%	19.8%	62.5%	9.0%	100.0%
		3.0 in	0.6%	0.9%	8.8%	74.9%	14.9%	100.0%
		4.5 in	2.3%	11.2%	31.0%	48.7%	6.7%	100.0%
		All	4.4%	3.1%	18.2%	66.2%	8.2%	100.0%
37.5	6	1.5 in	5.2%	0.7%	49.1%	45.0%	0.0%	100.0%
		3.0 in	1.1%	2.0%	39.5%	57.3%	0.0%	100.0%
		4.5 in	0.3%	5.7%	33.5%	60.5%	0.0%	100.0%
		All	2.1%	3.2%	40.1%	54.5%	0.0%	100.0%
			2.7%	***3.8%***	***33.9%***	***56.0%***	***3.6%***	***100.0%***

Table 7.11 Summary of Component Variance Values as Function of Percent Total Variance (Instantaneous Poisson's Ratio)

			Percent Variance: ui- Instantaneous Poisson Ratio					
Dnom(mm)	*Spec Diam (in)*	*Gage Length (inches)*	*Cycle/ Replicate*	*Repeat*	*Rotational Effect*	*Between Face*	*Sample / Specimen*	*Total Variance*
12.5	4	1.0 in	4.1%	1.0%	70.0%	25.0%	0.0%	100.0%
		2.0 in	5.6%	2.7%	59.1%	32.6%	0.0%	100.0%
		3.0 in	9.0%	2.6%	37.2%	16.0%	35.1%	100.0%
		All	4.8%	1.4%	67.8%	26.0%	0.0%	100.0%
19	4	1.0 in	2.0%	2.7%	48.8%	46.4%	0.0%	100.0%
		2.0 in	5.0%	3.2%	61.7%	30.1%	0.0%	100.0%
		3.0 in	2.4%	0.9%	43.3%	53.5%	0.0%	100.0%
		All	2.4%	2.5%	49.0%	46.2%	0.0%	100.0%
37.5	4	1.0 in	23.8%	1.6%	59.7%	14.8%	0.0%	100.0%
		2.0 in	1.6%	5.3%	46.8%	46.3%	0.0%	100.0%
		3.0 in	7.7%	1.5%	40.6%	48.4%	1.9%	100.0%
		All	11.0%	2.9%	49.7%	36.4%	0.0%	100.0%
			6.8%	2.4%	51.9%	34.8%	4.1%	100.0%
12.5	6	1.5 in	17.3%	2.7%	71.1%	8.9%	0.0%	100.0%
		3.0 in	5.0%	14.9%	48.5%	31.7%	0.0%	100.0%
		4.5 in	8.8%	5.4%	46.2%	39.7%	0.0%	100.0%
		All	13.0%	6.4%	62.2%	18.4%	0.0%	100.0%
19	6	1.5 in	13.1%	9.9%	34.8%	42.3%	0.0%	100.0%
		3.0 in	7.0%	1.8%	45.4%	38.8%	7.0%	100.0%
		4.5 in	2.0%	21.2%	39.7%	35.9%	1.3%	100.0%
		All	10.6%	11.2%	37.0%	41.2%	0.0%	100.0%
37.5	6	1.5 in	9.1%	0.1%	57.6%	33.2%	0.0%	100.0%
		3.0 in	2.7%	1.3%	39.1%	49.5%	7.5%	100.0%
		4.5 in	2.8%	6.3%	45.6%	45.3%	0.0%	100.0%
		All	7.2%	1.0%	53.4%	38.3%	0.0%	100.0%
			7.5%	7.1%	47.5%	36.1%	1.7%	100.0%

Table 7.12 Summary of Component Variance Values as Function of Percent Total Variance (Total Poisson's Ratio)

			Percent Variance: ut - Total Poisson Ratio					
Dnom(mm)	Spec Diam (in)	Gage Length (inches)	Cycle/ Replicate	Repeat	Rotational Effect	Between Face	Sample / Specimen	Total Variance
12.5	4	1.0 in	2.0%	1.6%	72.2%	24.1%	0.0%	100.0%
		2.0 in	2.7%	4.4%	65.9%	27.0%	0.0%	100.0%
		3.0 in	6.3%	8.7%	36.6%	18.3%	30.1%	100.0%
		All	2.5%	2.5%	70.4%	24.6%	0.0%	100.0%
19	4	1.0 in	2.0%	1.9%	50.6%	45.5%	0.0%	100.0%
		2.0 in	3.2%	6.1%	62.4%	28.3%	0.0%	100.0%
		3.0 in	1.7%	1.3%	40.4%	56.7%	0.0%	100.0%
		All	2.1%	2.1%	50.0%	45.8%	0.0%	100.0%
37.5	4	1.0 in	11.5%	3.2%	61.1%	24.2%	0.0%	100.0%
		2.0 in	1.0%	1.6%	51.6%	45.8%	0.0%	100.0%
		3.0 in	0.9%	1.5%	45.4%	50.8%	1.4%	100.0%
		All	5.3%	2.2%	54.2%	38.3%	0.0%	100.0%
			3.5%	3.4%	54.0%	35.6%	3.5%	100.0%
12.5	6	1.5 in	8.0%	2.6%	81.6%	7.7%	0.0%	100.0%
		3.0 in	3.0%	15.4%	47.8%	33.8%	0.0%	100.0%
		4.5 in	6.7%	9.7%	43.7%	39.9%	0.0%	100.0%
		All	6.3%	7.5%	67.0%	19.2%	0.0%	100.0%
19	6	1.5 in	15.8%	2.0%	38.9%	43.2%	0.0%	100.0%
		3.0 in	5.7%	0.8%	47.4%	40.2%	5.9%	100.0%
		4.5 in	1.2%	26.2%	30.8%	37.6%	4.2%	100.0%
		All	11.9%	6.8%	38.8%	42.4%	0.0%	100.0%
37.5	6	1.5 in	9.2%	0.4%	55.9%	34.5%	0.0%	100.0%
		3.0 in	1.4%	1.2%	40.1%	50.8%	6.5%	100.0%
		4.5 in	0.9%	6.5%	44.1%	48.5%	0.0%	100.0%
		All	6.3%	1.7%	51.3%	40.7%	0.0%	100.0%
			5.8%	7.2%	47.8%	37.4%	1.8%	100.0%
		Overall Average %	4.5%	4.3%	44.5%	43.2%	3.5%	100.0%

Table 7.13 Percent of Total Variance by Component, Specimen Diameter and Test Parameter

Parameter	Specimen Diameter	Variance Components - Percentage of Total					Rotation + Bet Faces	Other Components
		Cycle	Repeat	Rotation	Bet Faces	Sample		
Mri	4" d	3.5	3.5	42.6	45.6	4.8	88.2	11.8
	6" d	3.7	3.6	34.5	56.3	2.0	90.8	9.2
Mrt	4" d	2.4	3.4	43.7	44.2	6.4	87.9	12.1
	6" d	2.7	3.8	33.9	56.0	3.6	89.9	10.1
	Avg Mr - 4"d	***3.0***	***3.5***	***43.2***	***44.9***	***5.6***	***88.1***	***12.0***
	Avg Mr - 6"d	***3.2***	***3.7***	***34.2***	***56.2***	***2.8***	***90.4***	***9.7***
ui	4" d	6.8	2.4	51.9	34.8	4.1	86.7	13.3
	6" d	7.5	7.1	47.5	36.1	1.7	83.6	16.4
ut	4" d	3.5	3.4	54.0	35.6	3.5	89.6	10.4
	6" d	5.8	7.2	47.8	37.4	1.8	85.2	14.8
	Avg u - 4"d	***5.2***	***2.9***	***53.0***	***35.2***	***3.8***	***88.2***	***11.9***
	Avg u - 6"d	***6.7***	***7.2***	***47.7***	***36.8***	***1.8***	***84.4***	***15.6***
	Overall Avg	*4.5*	*4.3*	*44.5*	*43.3*	*3.5*	*87.7*	*12.3*

Table 7.14 Best Estimate Values (Typical Means, Variances) by Mix Type and Test Parameter (6" Diameter and 3" gage Length)

Best Estimate Values (Typical Means, Variances) by Mix Type
(6" Diameter and Gage Length = 3.0")

Resilient Modulus Analysis (Instantaneous)

Nominal Dia (mm)	Avg (ksi)	Total Var (ksi^2)	Total Std Dev (ksi)	Cycle	Repeat	Rotation	Bet Faces	Specimen
	Percent Total Variance:			3%	4%	35%	55%	3%
12.5	763	38500	196.2	1155	1540	13475	21175	1155
19	875	119950	346.3	3599	4798	41983	65973	3599
37.5	1146	656070	810.0	19682	26243	229625	360839	19682

Poisson's Ratio Analysis (Instantaneous)

Nominal Dia (mm)	Avg	Total Var	Total Std Dev	Cycle	Repeat	Rotation	Bet Faces	Specimen
	Percent Total Variance:			3%	4%	35%	55%	3%
12.5	0.394	0.054	0.232	0.0016	0.0022	0.0189	0.0297	0.0016
19	0.419	0.101	0.318	0.0030	0.0040	0.0354	0.0556	0.0030
37.5	0.430	0.317	0.563	0.0095	0.0127	0.1110	0.1744	0.0095

Table 7.15 Estimated Means and Variances by Mix Type (Incorporates Filed Section Variance) (6" Diameter and 3" gage Length)

Estimated Means and Variances by Mix Type (Incorporates Field Section Variance)
(6" Diameter and Gage Length = 3.0")

Resilient Modulus Analysis (Instantaneous)

Nominal Dia (mm)	Avg (ksi)	Total Var (ksi^2)	Total Std Dev (ksi)	CV=15% Within Proj	Cycle	Repeat	Rotation	Bet Faces	Specimen
		Percent Total Variance:		15%	3%	4%	35%	55%	3%
12.5	763	38500	196.2	13099	1155	1540	13475	21175	1155
19	875	119950	346.3	17227	3599	4798	41983	65973	3599
37.5	1146	656070	810.0	29550	19682	26243	229625	360839	19682

Poisson's Ratio Analysis (Instantaneous)

Nominal Dia (mm)	Avg	Total Var	Total Std Dev	CV=20% Within Proj	Cycle	Repeat	Rotation	Bet Faces	Specimen
		Percent Total Variance:		20%	3%	4%	35%	55%	3%
12.5	0.394	0.054	0.232	0.0062	0.0016	0.0022	0.0189	0.0297	0.0016
19	0.419	0.101	0.318	0.0070	0.0030	0.0040	0.0354	0.0556	0.0030
37.5	0.430	0.317	0.563	0.0074	0.0095	0.0127	0.1110	0.1744	0.0095

Table 7.16 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Lab Prepared Specimens – Case 1)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Mri- Variance Cycle	Repeat	Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	30415	174.4		287	342	448
		nl: cycle	1											
		nj: repeat	1								LL:	476	421	315
		nk: rotation	1								UL:	1050	1105	1211
		nl: bet face:	1											
		nm: spec	1											
19	875			3599	4798	41983	65973	3599	94761	307.8		506	603	791
		nl: cycle	1											
		nj: repeat	1								LL:	369	272	84
		nk: rotation	1								UL:	1381	1478	1666
		nl: bet face:	1											
		nm: spec	1											
37.5	1146			19682	26243	229625	360839	19682	518295	719.9		1184	1411	1850
		nl: cycle	1											
		nj: repeat	1								LL:	-38	-265	-704
		nk: rotation	1								UL:	2330	2557	2996
		nl: bet face:	1											
		nm: spec	1											

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	ui- Variance Cycle	Repeat	Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0427	0.2065		0.3398	0.4048	0.5308
		nl: cycle	1											
		nj: repeat	1								LL:	0.0542	-0.0108	-0.1368
		nk: rotation	1								UL:	0.7338	0.7988	0.9248
		nl: bet face:	1											
		nm: spec	1											
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0798	0.2825		0.4647	0.5536	0.7260
		nl: cycle	1											
		nj: repeat	1								LL:	-0.0457	-0.1346	-0.3070
		nk: rotation	1								UL:	0.8837	0.9726	1.1450
		nl: bet face:	1											
		nm: spec	1											
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.2504	0.5004		0.8232	0.9808	1.2861
		nl: cycle	1											
		nj: repeat	1								LL:	-0.3932	-0.5508	-0.8561
		nk: rotation	1								UL:	1.2532	1.4108	1.7161
		nl: bet face:	1											
		nm: spec	1											

Table 7.17 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Lab Prepared Specimens – Case 2)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	8355	91.4		150	179	235
		nl: cycle	5											
		nj: repeat	1								LL:	613	584	528
		nk: rotation	2								UL:	913	942	998
		nl: bet face:	2											
		nm: spec	1											
19	875			3599	4798	41983	65973	3599	26029	161.3		265	316	415
		nl: cycle	5											
		nj: repeat	1								LL:	610	559	460
		nk: rotation	2								UL:	1140	1191	1290
		nl: bet face:	2											
		nm: spec	1											
37.5	1146			19682	26243	229625	360839	19682	142367	377.3		621	740	970
		nl: cycle	5											
		nj: repeat	1								LL:	525	406	176
		nk: rotation	2								UL:	1767	1886	2116
		nl: bet face:	2											
		nm: spec	1											

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0117	0.1082		0.1781	0.2122	0.2782
		nl: cycle	5											
		nj: repeat	1								LL:	0.2159	0.1818	0.1158
		nk: rotation	2								UL:	0.5721	0.6062	0.6722
		nl: bet face:	2											
		nm: spec	1											
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0219	0.1480		0.2435	0.2902	0.3805
		nl: cycle	5											
		nj: repeat	1								LL:	0.1755	0.1288	0.0385
		nk: rotation	2								UL:	0.6625	0.7092	0.7995
		nl: bet face:	2											
		nm: spec	1											
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0688	0.2623		0.4314	0.5141	0.6741
		nl: cycle	5											
		nj: repeat	1								LL:	-0.0014	-0.0841	-0.2441
		nk: rotation	2								UL:	0.8614	0.9441	1.1041
		nl: bet face:	2											
		nm: spec	1											

Table 7.18 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Lab Prepared Specimens – Case 3)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Mri- Variance Cycle	Repeat	Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	2785	52.8		87	103	136
		nl: cycle	5											
		nj: repeat	1								LL:	676	660	627
		nk: rotation	2								UL:	850	866	899
		nl: bet face:	2											
		nm: spec	3											
19	875			3599	4798	41983	65973	3599	8676	93.1		153	183	239
		nl: cycle	5											
		nj: repeat	1								LL:	722	692	636
		nk: rotation	2								UL:	1028	1058	1114
		nl: bet face:	2											
		nm: spec	3											
37.5	1146			19682	26243	229625	360839	19682	47456	217.8		358	427	560
		nl: cycle	5											
		nj: repeat	1								LL:	788	719	586
		nk: rotation	2								UL:	1504	1573	1706
		nl: bet face:	2											
		nm: spec	3											

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	ui- Variance Cycle	Repeat	Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0039	0.0625		0.1028	0.1225	0.1606
		nl: cycle	5											
		nj: repeat	1								LL:	0.2912	0.2715	0.2334
		nk: rotation	2								UL:	0.4968	0.5165	0.5546
		nl: bet face:	2											
		nm: spec	3											
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0073	0.0855		0.1406	0.1675	0.2197
		nl: cycle	5											
		nj: repeat	1								LL:	0.2784	0.2515	0.1993
		nk: rotation	2								UL:	0.5596	0.5865	0.6387
		nl: bet face:	2											
		nm: spec	3											
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0229	0.1514		0.2491	0.2968	0.3892
		nl: cycle	5											
		nj: repeat	1								LL:	0.1809	0.1332	0.0408
		nk: rotation	2								UL:	0.6791	0.7268	0.8192
		nl: bet face:	2											
		nm: spec	3											

Table 7.19 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Lab Prepared Specimens – Case 4)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	2780	52.7		87	103	136
		ni: cycle	10											
		nj: repeat	1								LL:	676	660	627
		nk: rotation	2								UL:	850	866	899
		nl: bet face:	2											
		nm: spec	3											
19	875			3599	4798	41983	65973	3599	8661	93.1		153	182	239
		ni: cycle	10											
		nj: repeat	1								LL:	722	693	636
		nk: rotation	2								UL:	1028	1057	1114
		nl: bet face:	2											
		nm: spec	3											
37.5	1146			19682	26243	229625	360839	19682	47374	217.7		358	427	559
		ni: cycle	10											
		nj: repeat	1								LL:	788	719	587
		nk: rotation	2								UL:	1504	1573	1705
		nl: bet face:	2											
		nm: spec	3											

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0039	0.0624		0.1027	0.1224	0.1605
		ni: cycle	10											
		nj: repeat	1								LL:	0.2913	0.2716	0.2335
		nk: rotation	2								UL:	0.4967	0.5164	0.5545
		nl: bet face:	2											
		nm: spec	3											
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0073	0.0854		0.1405	0.1674	0.2195
		ni: cycle	10											
		nj: repeat	1								LL:	0.2785	0.2516	0.1995
		nk: rotation	2								UL:	0.5595	0.5864	0.6385
		nl: bet face:	2											
		nm: spec	3											
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0229	0.1513		0.2489	0.2965	0.3888
		ni: cycle	10											
		nj: repeat	1								LL:	0.1811	0.1335	0.0412
		nk: rotation	2								UL:	0.6789	0.7265	0.8188
		nl: bet face:	2											
		nm: spec	3											

Table 7.20 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Lab Prepared Specimens – Case 5)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Mri- Variance Cycle	Repeat	Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	783			1155	1540	13475	21175	1155	1863	43.2		71	85	111
		nl: cycle	10											
		nj: repeat	2								LL:	692	678	652
		nk: rotation	2								UL:	834	848	874
		nl: bet face:	2											
		nm: spec	3											
19	875			3599	4798	41983	65973	3599	5805	76.2		125	149	196
		nl: cycle	10											
		nj: repeat	2								LL:	750	726	679
		nk: rotation	2								UL:	1000	1024	1071
		nl: bet face:	2											
		nm: spec	3											
37.5	1146			19682	26243	229625	360839	19682	31751	178.2		293	349	458
		nl: cycle	10											
		nj: repeat	2								LL:	853	797	688
		nk: rotation	2								UL:	1439	1495	1604
		nl: bet face:	2											
		nm: spec	3											

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	ui- Variance Cycle	Repeat	Rotation	Bet Faces	Specimen	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0026	0.0511		0.0841	0.1002	0.1314
		nl: cycle	10											
		nj: repeat	2								LL:	0.3099	0.2938	0.2626
		nk: rotation	2								UL:	0.4781	0.4942	0.5254
		nl: bet face:	2											
		nm: spec	3											
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0049	0.0699		0.1150	0.1370	0.1797
		nl: cycle	10											
		nj: repeat	2								LL:	0.3040	0.2820	0.2393
		nk: rotation	2								UL:	0.5340	0.5560	0.5987
		nl: bet face:	2											
		nm: spec	3											
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0153	0.1239		0.2038	0.2428	0.3183
		nl: cycle	10											
		nj: repeat	2								LL:	0.2262	0.1872	0.1117
		nk: rotation	2								UL:	0.6338	0.6728	0.7483
		nl: bet face:	2											
		nm: spec	3											

Table 7.21 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Field Core Specimens – Case 1)

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	13099	43514	208.6		343	409	536
		ni: cycle	1												
		nj: repeat	1									LL:	420	354	227
		nk: rotation	1									UL:	1106	1172	1299
		nl: bet face:	1												
		nm: spec	1												
		nn:Proj con	1												
19	875			3599	4798	41983	65973	3599	17227	111987	334.6		550	656	860
		ni: cycle	1												
		nj: repeat	1									LL:	325	219	15
		nk: rotation	1									UL:	1425	1531	1735
		nl: bet face:	1												
		nm: spec	1												
		nn:Proj con	1												
37.5	1146			19682	26243	229625	360839	19682	29550	547845	740.2		1218	1451	1902
		ni: cycle	1												
		nj: repeat	1									LL:	-72	-305	-756
		nk: rotation	1									UL:	2364	2597	3048
		nl: bet face:	1												
		nm: spec	1												
		nn:Proj con	1												

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0062	0.0489	0.2211		0.3637	0.4333	0.5681
		ni: cycle	1												
		nj: repeat	1									LL:	0.0303	-0.0393	-0.1741
		nk: rotation	1									UL:	0.7577	0.8273	0.9621
		nl: bet face:	1												
		nm: spec	1												
		nn:Proj con	1												
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0070	0.0868	0.2946		0.4847	0.5775	0.7572
		ni: cycle	1												
		nj: repeat	1									LL:	-0.0657	-0.1585	-0.3382
		nk: rotation	1									UL:	0.9037	0.9965	1.1762
		nl: bet face:	1												
		nm: spec	1												
		nn:Proj con	1												
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0074	0.2578	0.5078		0.8353	0.9952	1.3050
		ni: cycle	1												
		nj: repeat	1									LL:	-0.4053	-0.5652	-0.8750
		nk: rotation	1									UL:	1.2653	1.4252	1.7350
		nl: bet face:	1												
		nm: spec	1												
		nn:Proj con	1												

Table 7.22 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Field Core Specimens – Case 2)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	13099	21453	146.5		241	287	376
		ni: cycle	5												
		nj: repeat	1									LL:	522	476	387
		nk: rotation	2									UL:	1004	1050	1139
		nl: bet face:	2												
		nm: spec	1												
		nn:Proj con	1												
19	875			3599	4798	41983	65973	3599	17227	43256	208.0		342	408	535
		ni: cycle	5												
		nj: repeat	1									LL:	533	467	340
		nk: rotation	2									UL:	1217	1283	1410
		nl: bet face:	2												
		nm: spec	1												
		nn:Proj con	1												
37.5	1146			19682	26243	229625	360839	19682	29550	171917	414.6		682	813	1066
		ni: cycle	5												
		nj: repeat	1									LL:	464	333	80
		nk: rotation	2									UL:	1828	1959	2212
		nl: bet face:	2												
		nm: spec	1												
		nn:Proj con	1												

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0062	0.0179	0.1339		0.2203	0.2624	0.3441
		ni: cycle	5												
		nj: repeat	1									LL:	0.1737	0.1316	0.0499
		nk: rotation	2									UL:	0.6143	0.6564	0.7381
		nl: bet face:	2												
		nm: spec	1												
		nn:Proj con	1												
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0070	0.0289	0.1701		0.2798	0.3334	0.4372
		ni: cycle	5												
		nj: repeat	1									LL:	0.1392	0.0856	-0.0182
		nk: rotation	2									UL:	0.6988	0.7524	0.8562
		nl: bet face:	2												
		nm: spec	1												
		nn:Proj con	1												
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0074	0.0762	0.2760		0.4540	0.5410	0.7094
		ni: cycle	5												
		nj: repeat	1									LL:	-0.0240	-0.1110	-0.2794
		nk: rotation	2									UL:	0.8840	0.9710	1.1394
		nl: bet face:	2												
		nm: spec	1												
		nn:Proj con	1												

Table 7.23 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Field Core Specimens – Case 3)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	13099	5295	72.8		120	143	187
		ni: cycle	5												
		nj: repeat	1									LL:	643	620	576
		nk: rotation	2									UL:	883	906	950
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
19	875			3599	4798	41983	65973	3599	17227	8634	92.9		153	182	239
		ni: cycle	5												
		nj: repeat	1									LL:	722	693	636
		nk: rotation	2									UL:	1028	1057	1114
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
37.5	1146			19682	26243	229625	360839	19682	29550	25668	160.2		264	314	412
		ni: cycle	5												
		nj: repeat	1									LL:	882	832	734
		nk: rotation	2									UL:	1410	1460	1558
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0062	0.0034	0.0581		0.0955	0.1138	0.1492
		ni: cycle	5												
		nj: repeat	1									LL:	0.2985	0.2802	0.2448
		nk: rotation	2									UL:	0.4895	0.5078	0.5432
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0070	0.0048	0.0691		0.1137	0.1355	0.1776
		ni: cycle	5												
		nj: repeat	1									LL:	0.3053	0.2835	0.2414
		nk: rotation	2									UL:	0.5327	0.5545	0.5966
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0074	0.0101	0.1005		0.1654	0.1971	0.2584
		ni: cycle	5												
		nj: repeat	1									LL:	0.2646	0.2329	0.1716
		nk: rotation	2									UL:	0.5954	0.6271	0.6884
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												

Table 7.24 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Field Core Specimens – Case 4)

Confidence Interval Prediction

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	13099	5293	72.8		120	143	187
		ni: cycle	10												
		nj: repeat	1									LL:	643	620	576
		nk: rotation	2									UL:	883	906	950
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
19	875			3599	4798	41983	65973	3599	17227	8629	92.9		153	182	239
		ni: cycle	10												
		nj: repeat	1									LL:	722	693	636
		nk: rotation	2									UL:	1028	1057	1114
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
37.5	1146			19682	26243	229625	360839	19682	29550	25641	160.1		263	314	412
		ni: cycle	10												
		nj: repeat	1									LL:	883	832	734
		nk: rotation	2									UL:	1409	1460	1558
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0062	0.0034	0.0580		0.0955	0.1138	0.1492
		ni: cycle	10												
		nj: repeat	1									LL:	0.2985	0.2802	0.2448
		nk: rotation	2									UL:	0.4895	0.5078	0.5432
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0070	0.0048	0.0691		0.1136	0.1354	0.1775
		ni: cycle	10												
		nj: repeat	1									LL:	0.3054	0.2836	0.2415
		nk: rotation	2									UL:	0.5326	0.5544	0.5965
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0074	0.0101	0.1005		0.1653	0.1969	0.2582
		ni: cycle	10												
		nj: repeat	1									LL:	0.2647	0.2331	0.1718
		nk: rotation	2									UL:	0.5953	0.6269	0.6882
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	3												

Table 7.25 Summary of Confidence Level Values for Resilient Modulus and Poisson's Ratio (Field Core Specimens – Case 5)

Nominal Dia (mm)	Avg (ksi)	Levels	Number	Cycle	Repeat	Mri- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	763			1155	1540	13475	21175	1155	13099	2494	49.9		82	98	128
		ni: cycle	10												
		nj: repeat	2									LL:	681	665	635
		nk: rotation	2									UL:	845	861	891
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	6												
19	875			3599	4798	41983	65973	3599	17227	3839	62.0		102	121	159
		ni: cycle	10												
		nj: repeat	2									LL:	773	754	716
		nk: rotation	2									UL:	977	996	1034
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	6												
37.5	1146			19682	26243	229625	360839	19682	29550	10217	101.1		166	198	260
		ni: cycle	10												
		nj: repeat	2									LL:	980	948	886
		nk: rotation	2									UL:	1312	1344	1406
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	6												

Confidence Interval Prediction

Nominal Dia (mm)	Avg	Levels	Number	Cycle	Repeat	ui- Variance Rotation	Bet Faces	Specimen	Within Project	Total Variance	Total Std Dev		Plus - Minus Normal Deviate 90%	95%	99%
12.5	0.394			0.0016	0.0022	0.0189	0.0297	0.0016	0.0062	0.0015	0.0383		0.0631	0.0752	0.0986
		ni: cycle	10												
		nj: repeat	2									LL:	0.3309	0.3188	0.2954
		nk: rotation	2									UL:	0.4571	0.4692	0.4926
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	6												
19	0.419			0.0030	0.0040	0.0354	0.0556	0.0030	0.0070	0.0020	0.0446		0.0733	0.0873	0.1145
		ni: cycle	10												
		nj: repeat	2									LL:	0.3457	0.3317	0.3045
		nk: rotation	2									UL:	0.4923	0.5063	0.5335
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	6												
37.5	0.430			0.0095	0.0127	0.1110	0.1744	0.0095	0.0074	0.0038	0.0618		0.1013	0.1207	0.1582
		ni: cycle	10												
		nj: repeat	2									LL:	0.3287	0.3093	0.2718
		nk: rotation	2									UL:	0.5313	0.5507	0.5882
		nl: bet face:	2												
		nm: spec	3												
		nn:Proj con	6												

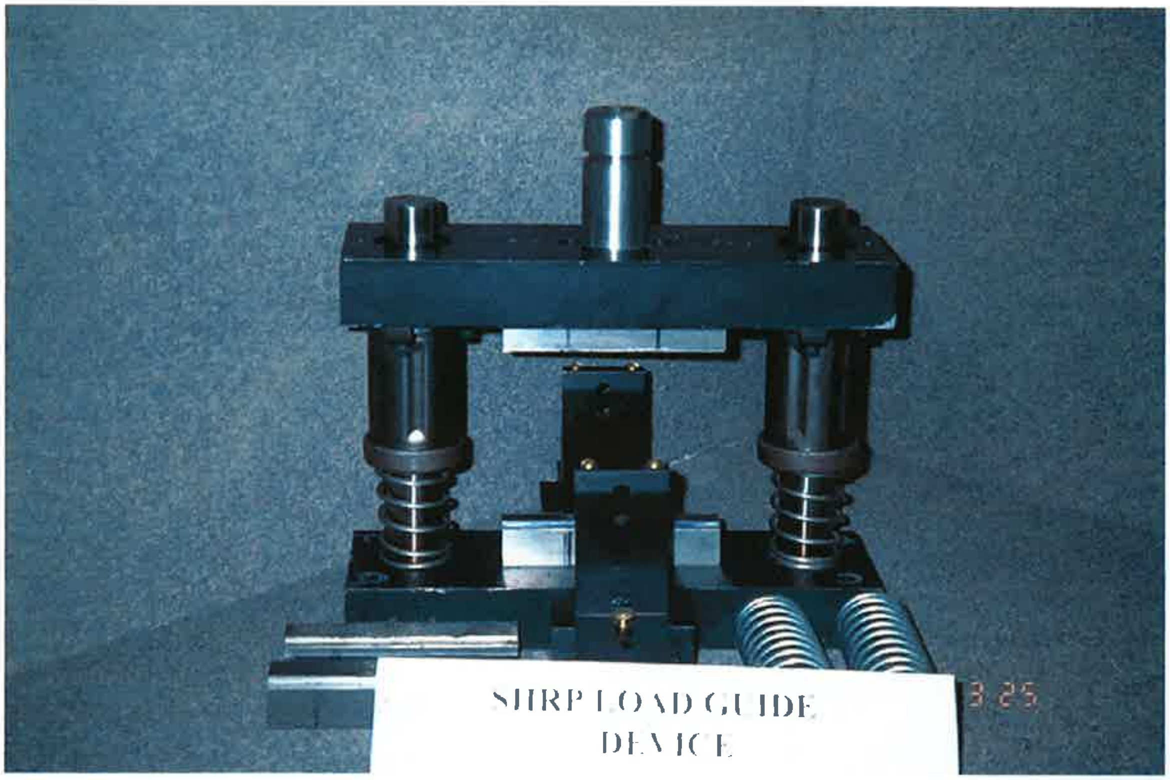


Figure 1.1 Modified SHRP Load Guide Device Used for NCHRP 1-28A

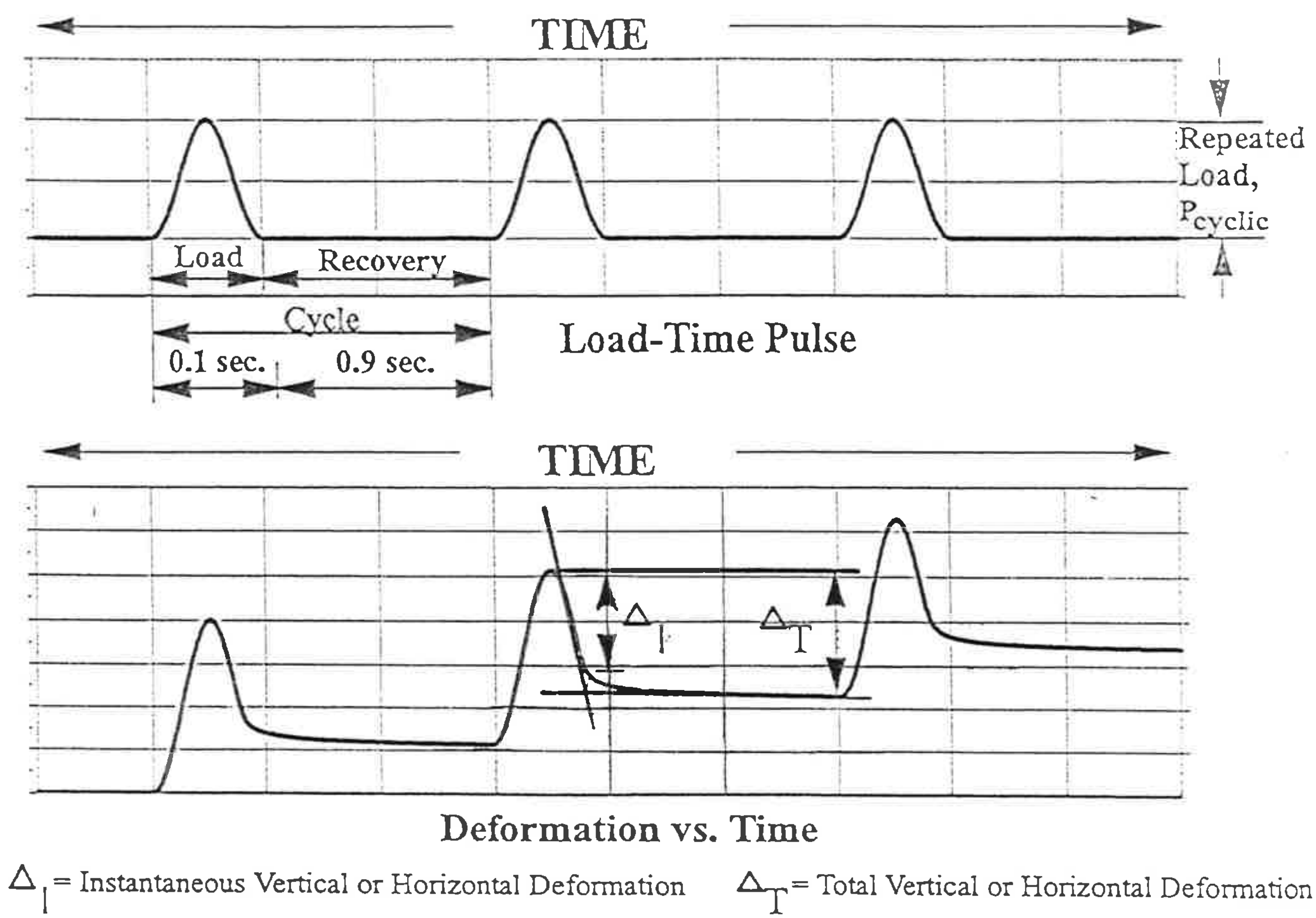


FIGURE 2.1 Typical Load and Deformation versus Time Relationship

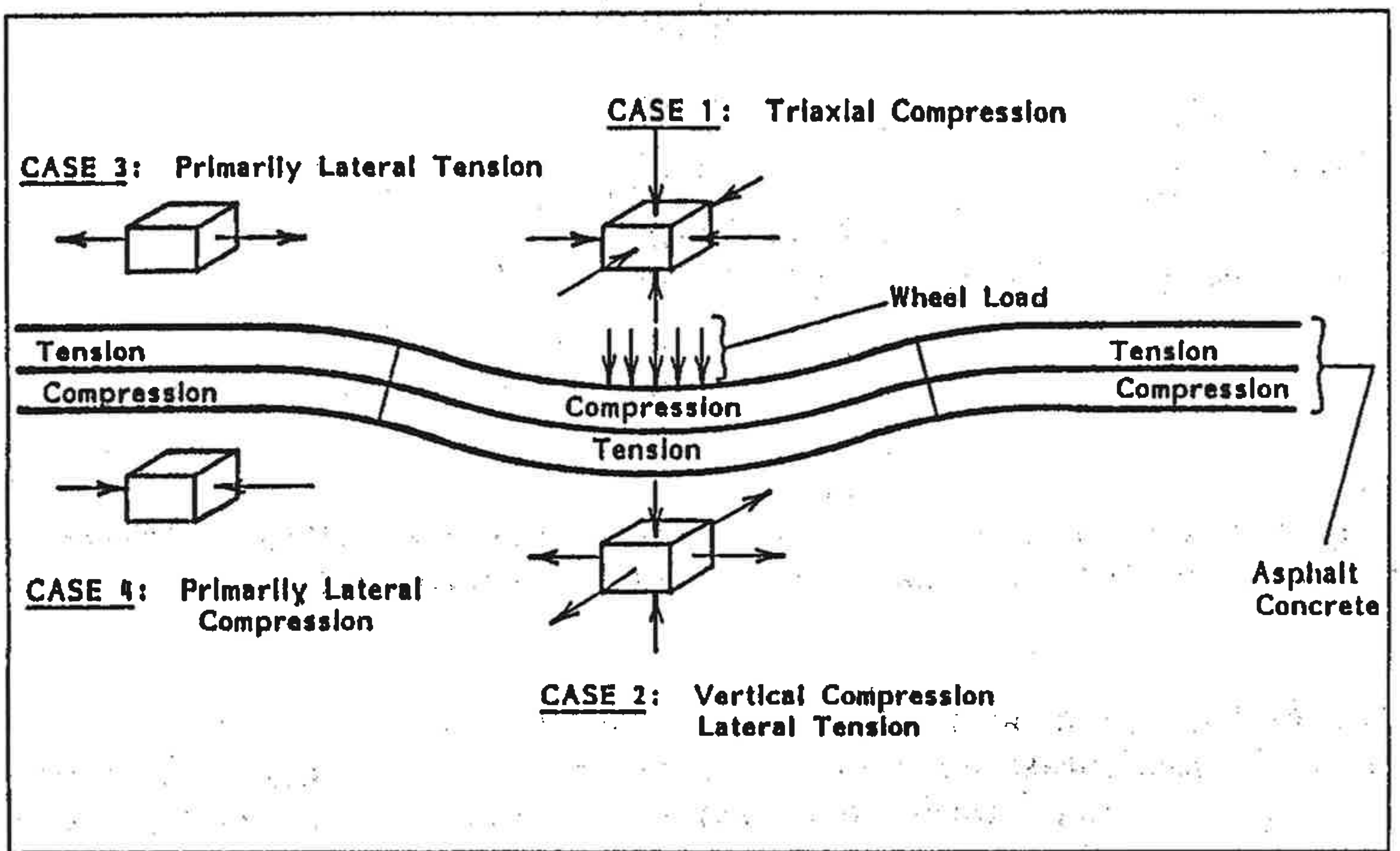


FIGURE 2.2 Typical Stress States in Asphalt Concrete Layer with Wheel Load Applied (2)

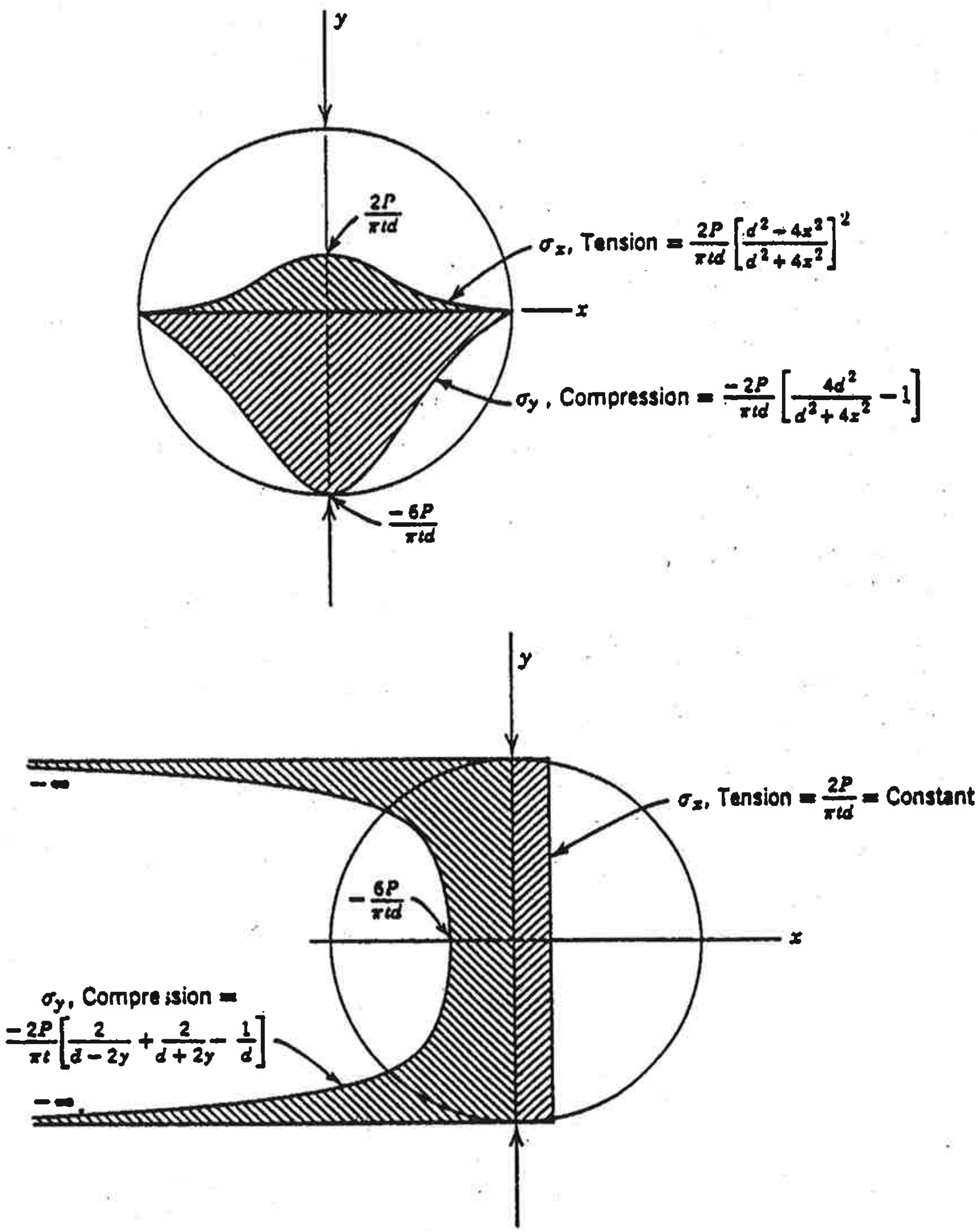


FIGURE 2.3 Theoretical Stress Distribution on Horizontal and Vertical Diameter Planes for Indirect Tensile Test (3)

(a) Schematic diagram

(b) Stress Distribution

(c) Integrated Stress

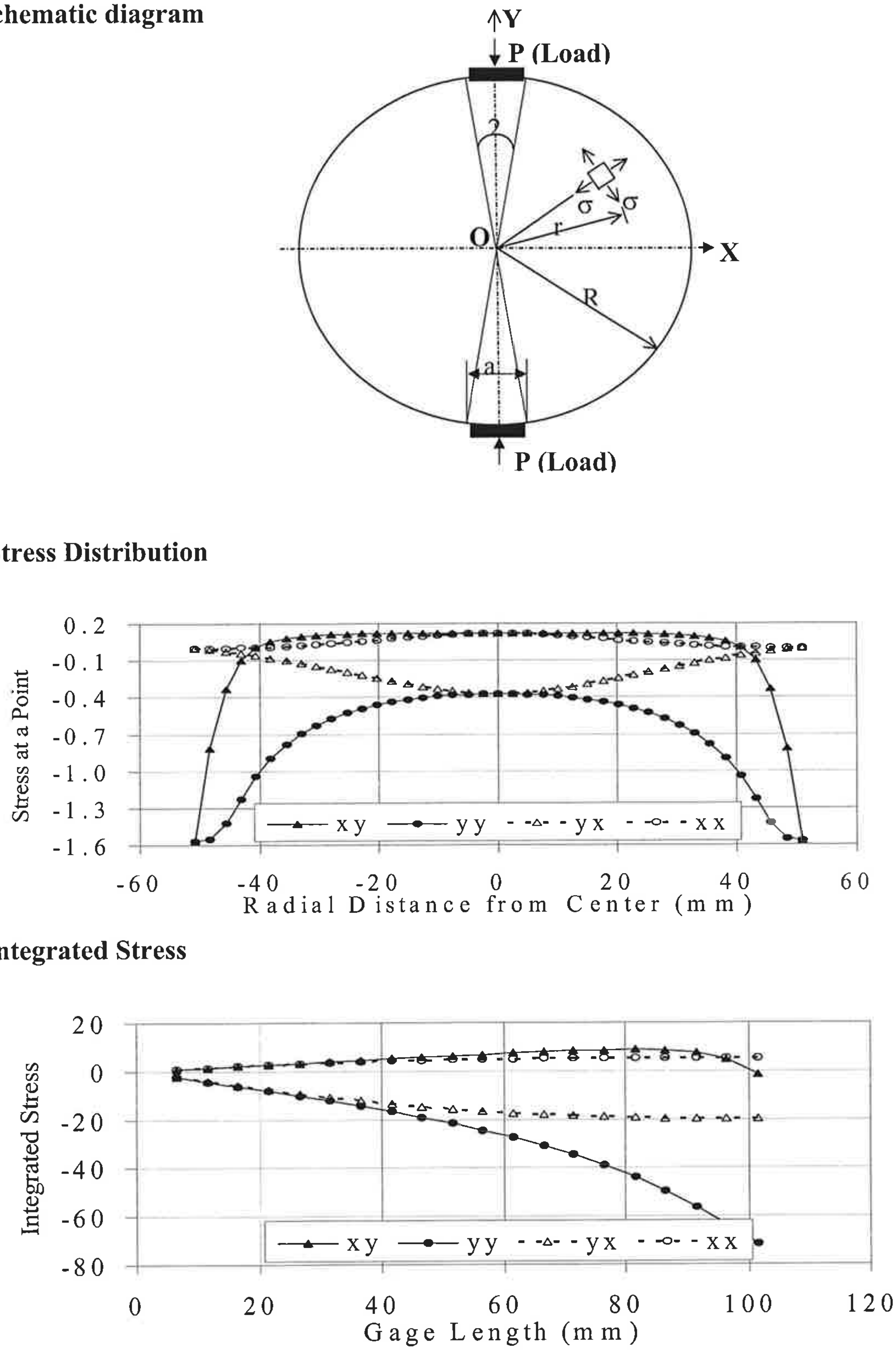
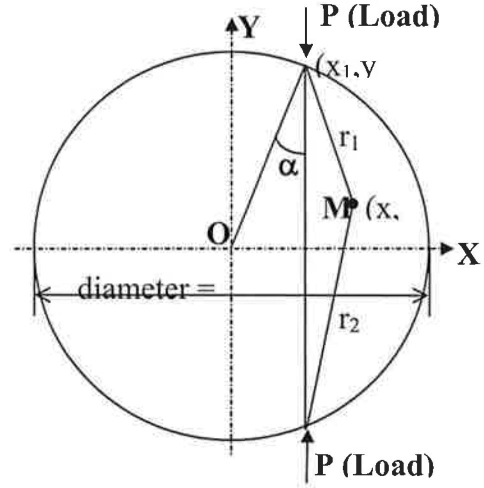
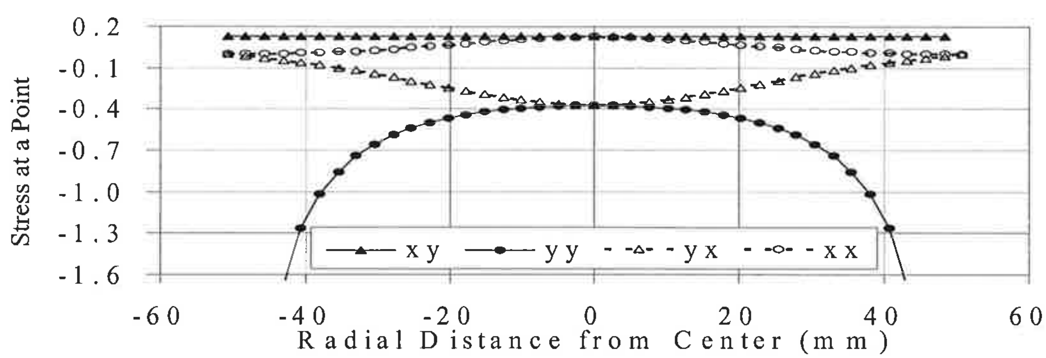


Figure 2.4 Representation of Hondros Solution (11)

(a) Schematic diagram



(b) Stress Distribution



(c) Integrated Stress

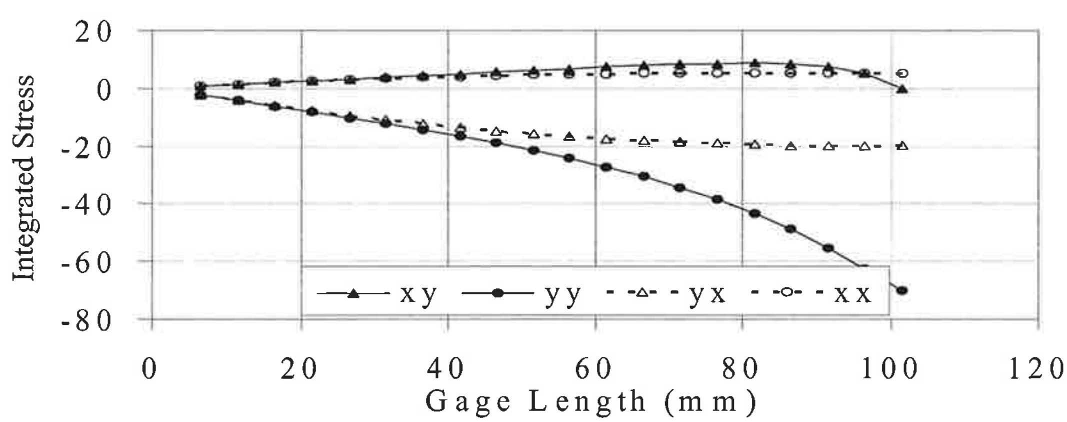
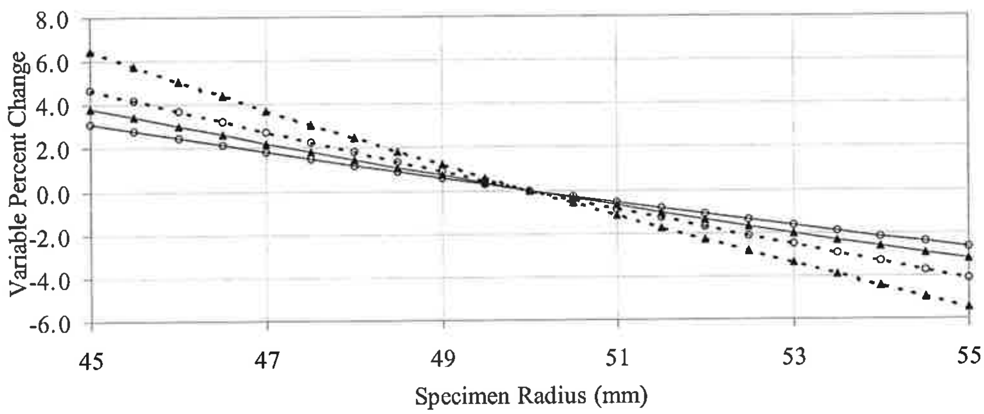


Figure 2.5 Representation of Frocht Solution (11)

(a) Sensitivity of Specimen Radius



(b) Sensitivity of Loading Strip Width

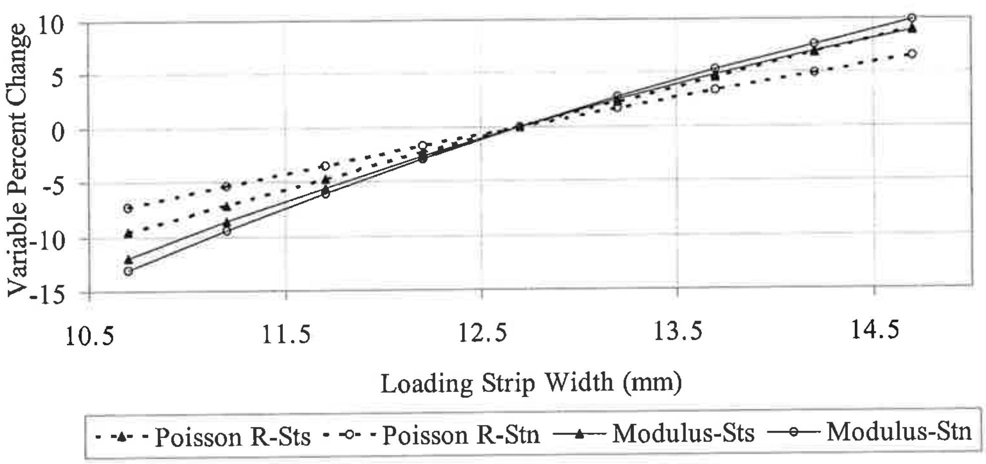


Figure 2.6 Percent Change in Poisson's Ratio and Elastic Modulus (11)

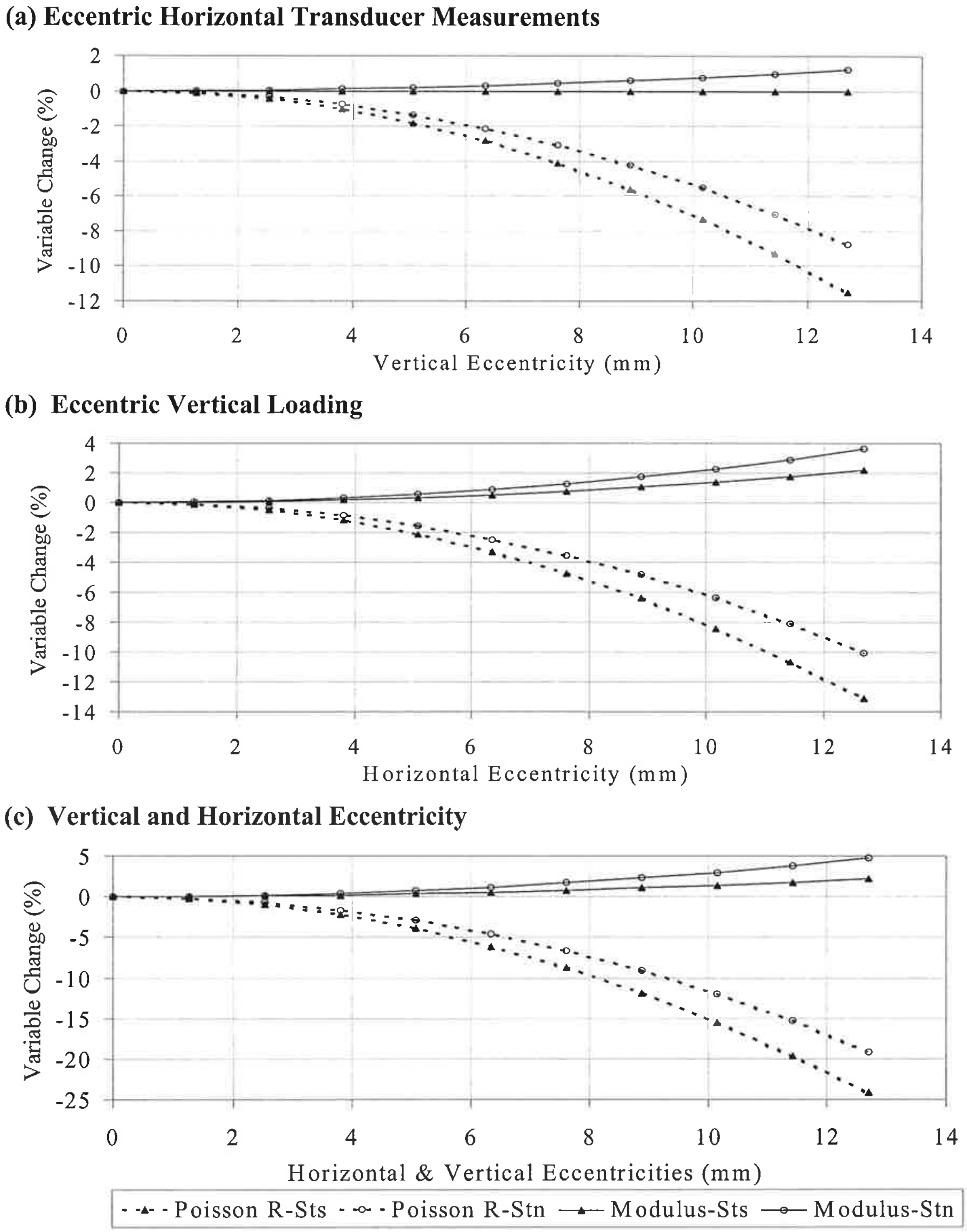


Figure 2.7 Sensitivity of Eccentricity in Vertical and Horizontal Measurements (11)

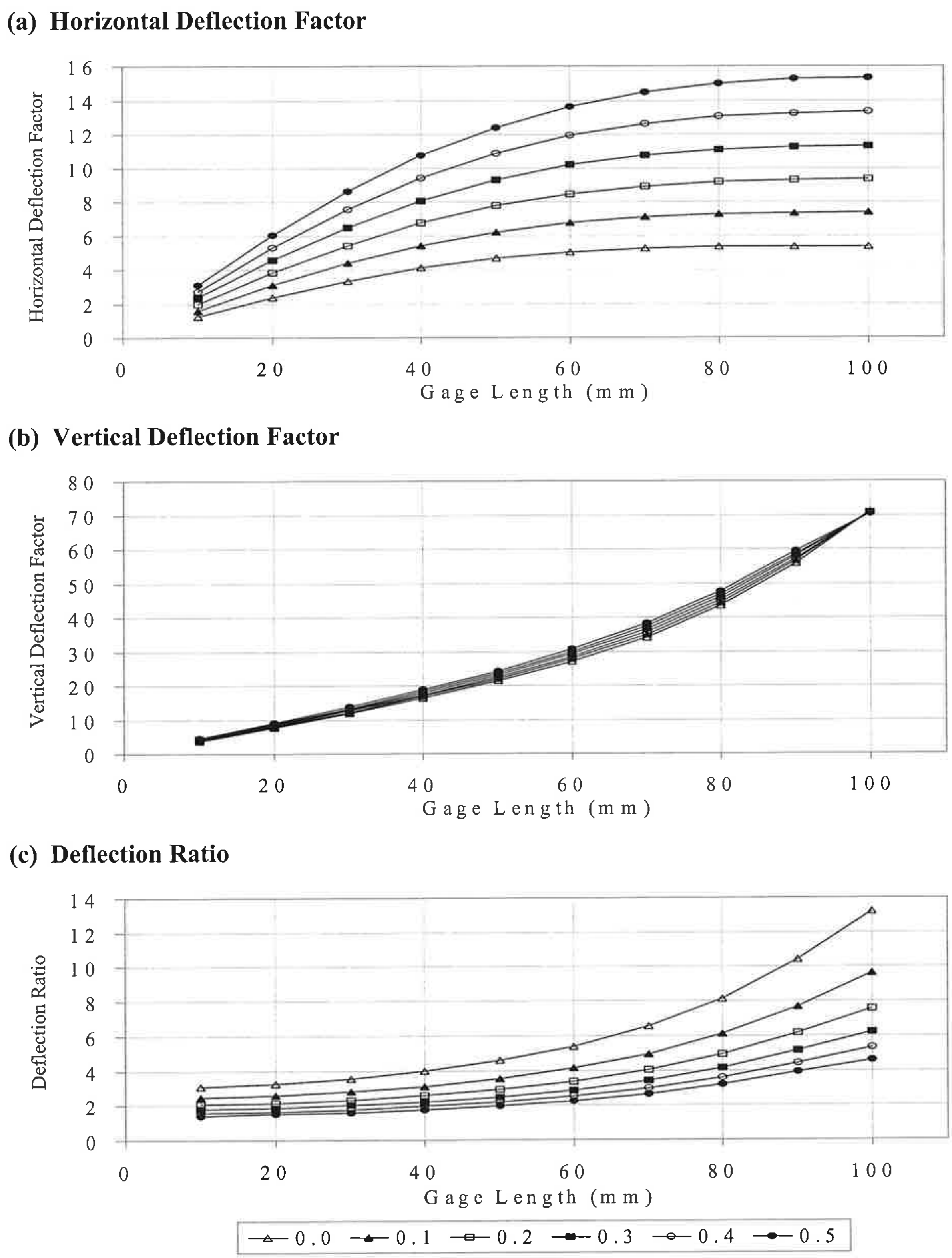


Figure 2.8 Prediction of Deflection Parameters as a Function of Gage Length and Poisson's Ratio (11)

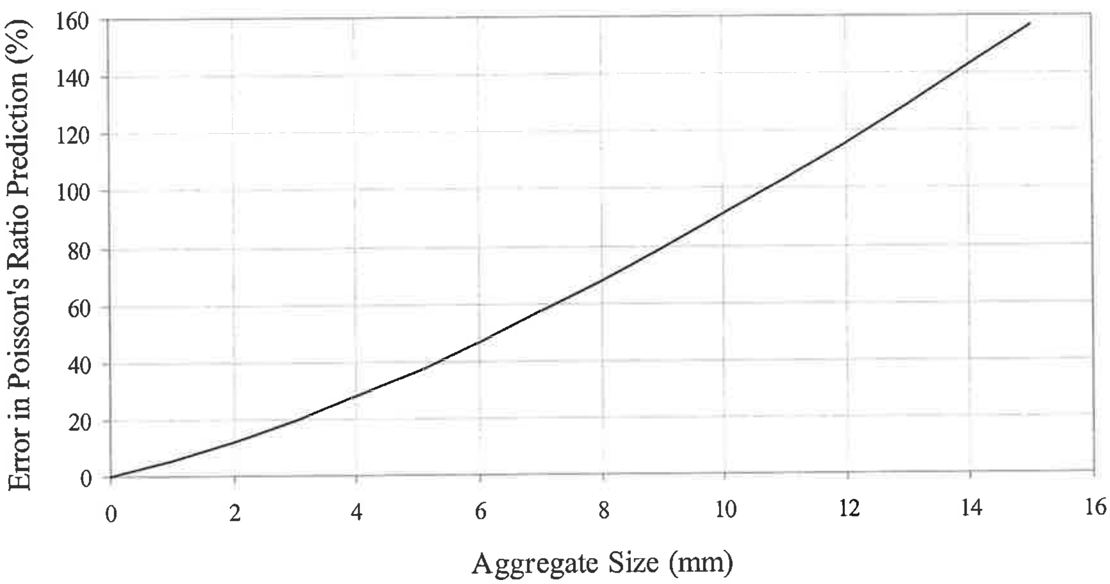


Figure 2.9 Error in Poisson's Ratio Prediction Due to the Presence of Relatively Incompressible Material under the Loading Strip (11)

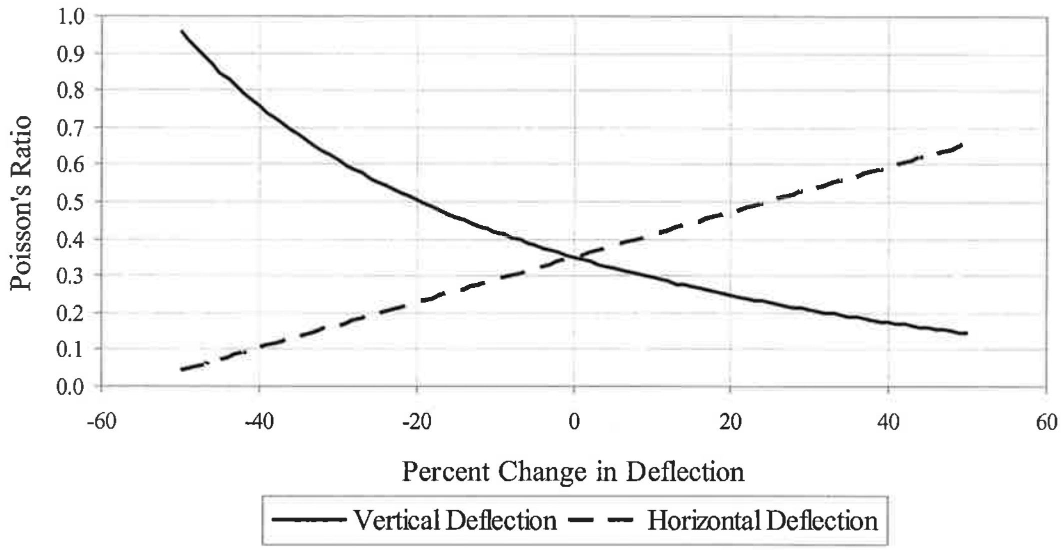


Figure 2.10 Change in Poisson's Ratio with the Measurement Error in Vertical and Horizontal Deflections (11)

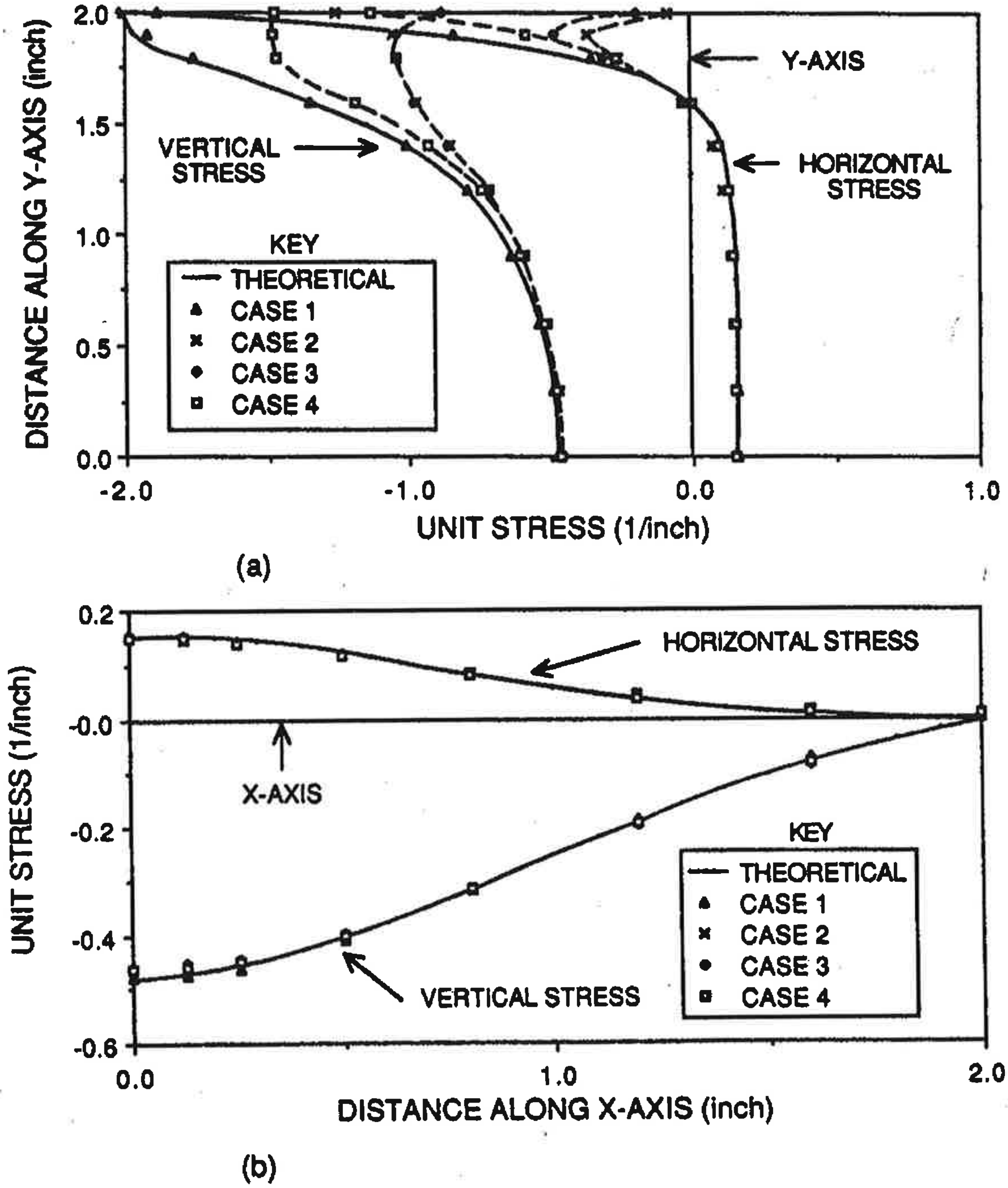


FIGURE 3.1 Comparison of Unit Stress Distributions: (a) along Vertical Axis; (b) along Horizontal Axis (14)

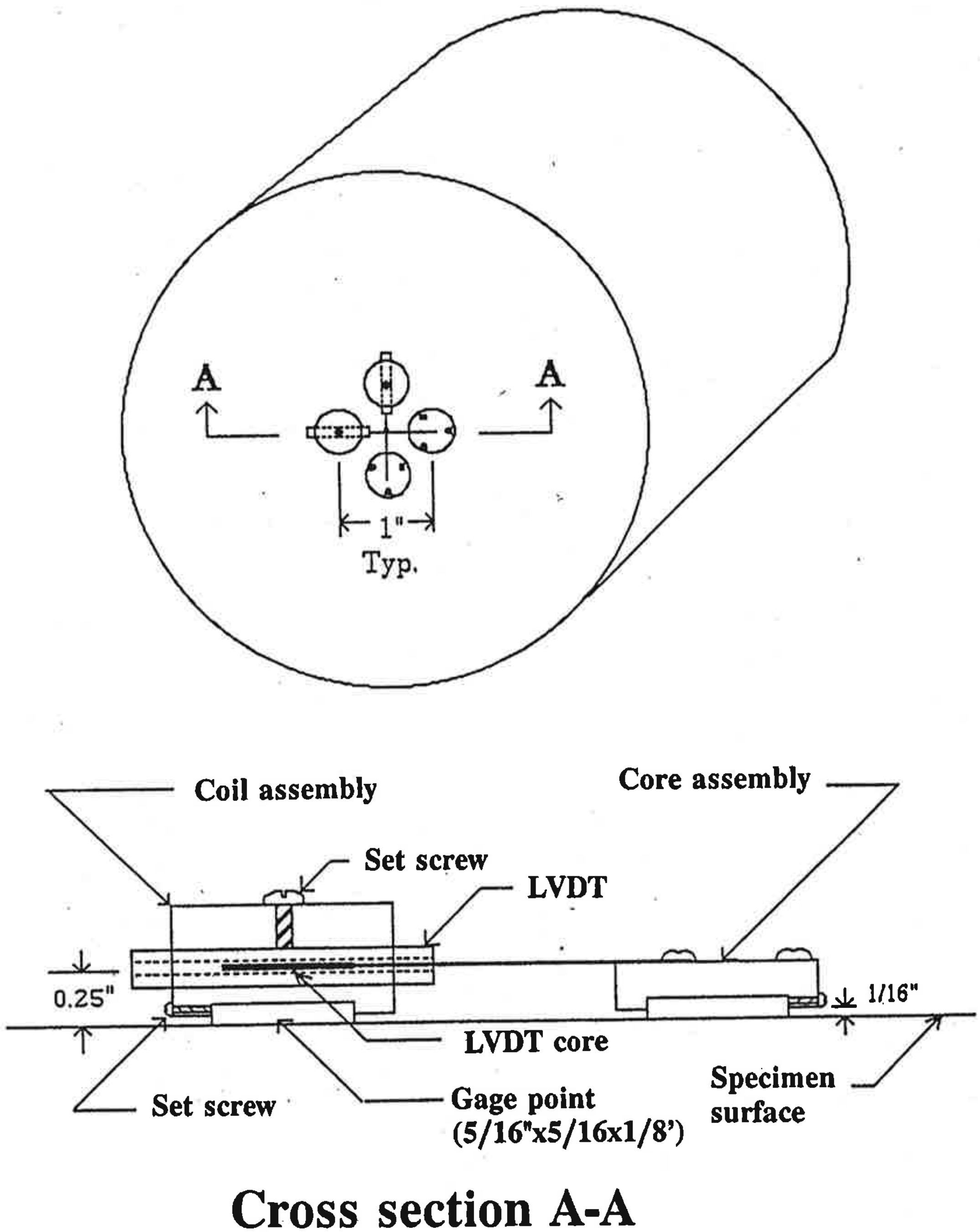
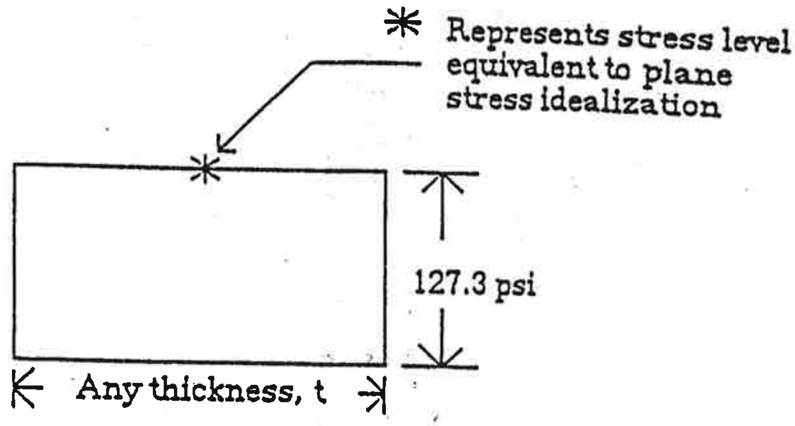
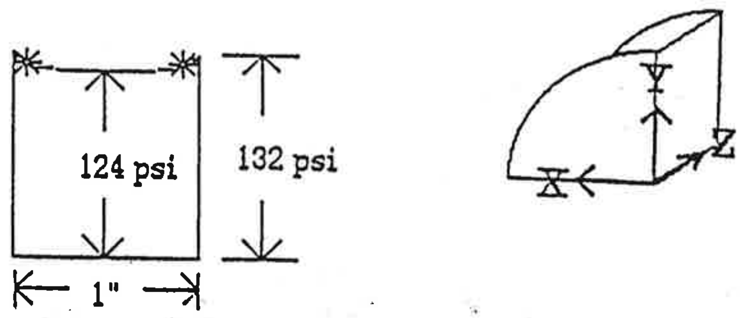


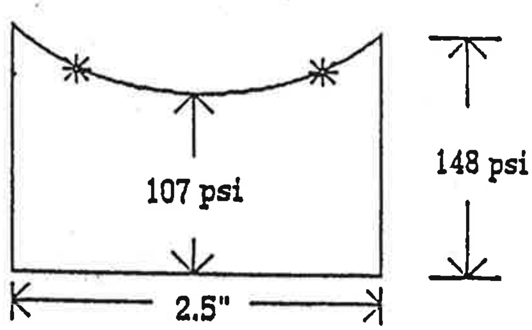
FIGURE 3.2: LVDT Mounting System for Indirect Tension Specimen (13)



(a) 2 - Dimensional Plane Stress idealization

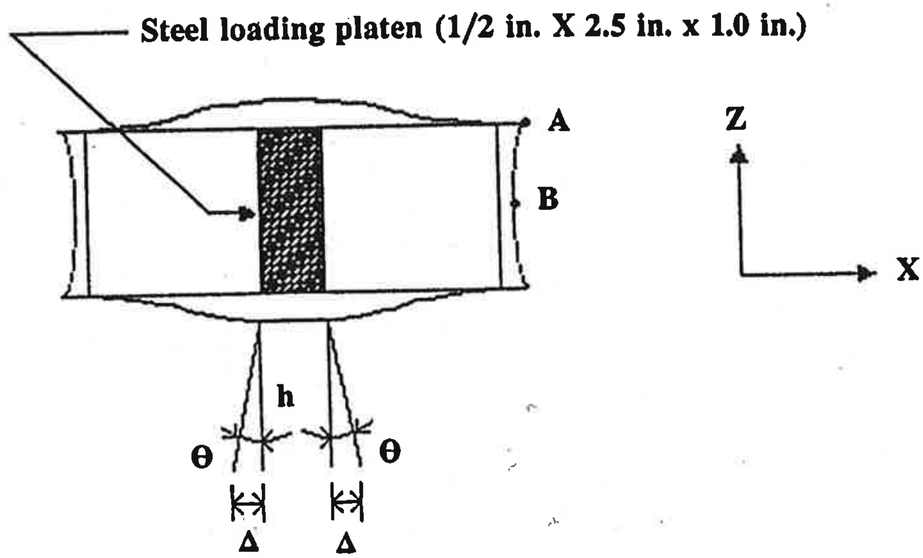


(b) 3 - Dimensional 1 in. Thick Specimen

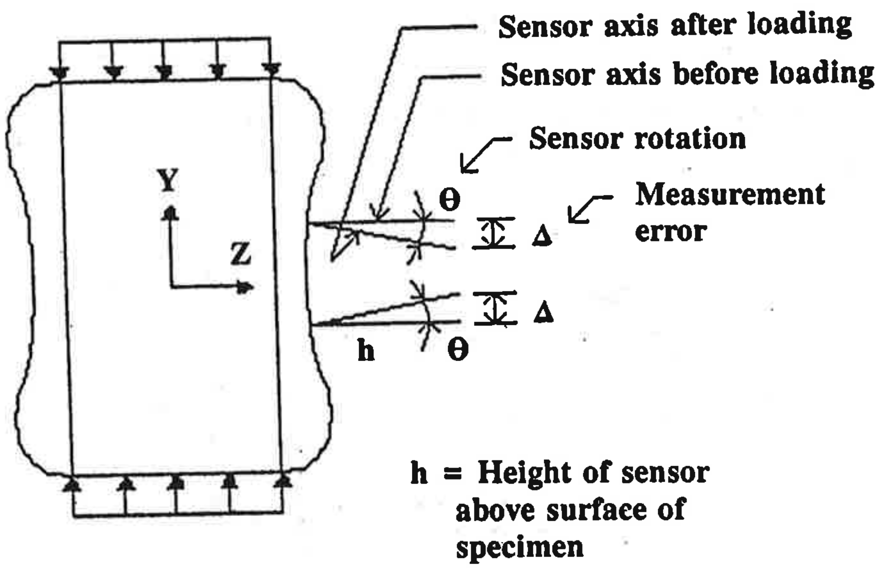


(c) 3 - Dimensional 2.5 in. Thick Specimen

FIGURE 3.3 Horizontal Tensile Stress Distribution Along the Z-axis (13)



(a) Plan View



(b) Side View

FIGURE 3.4 Surface Deformation of an Indirect Tension Specimen (13)

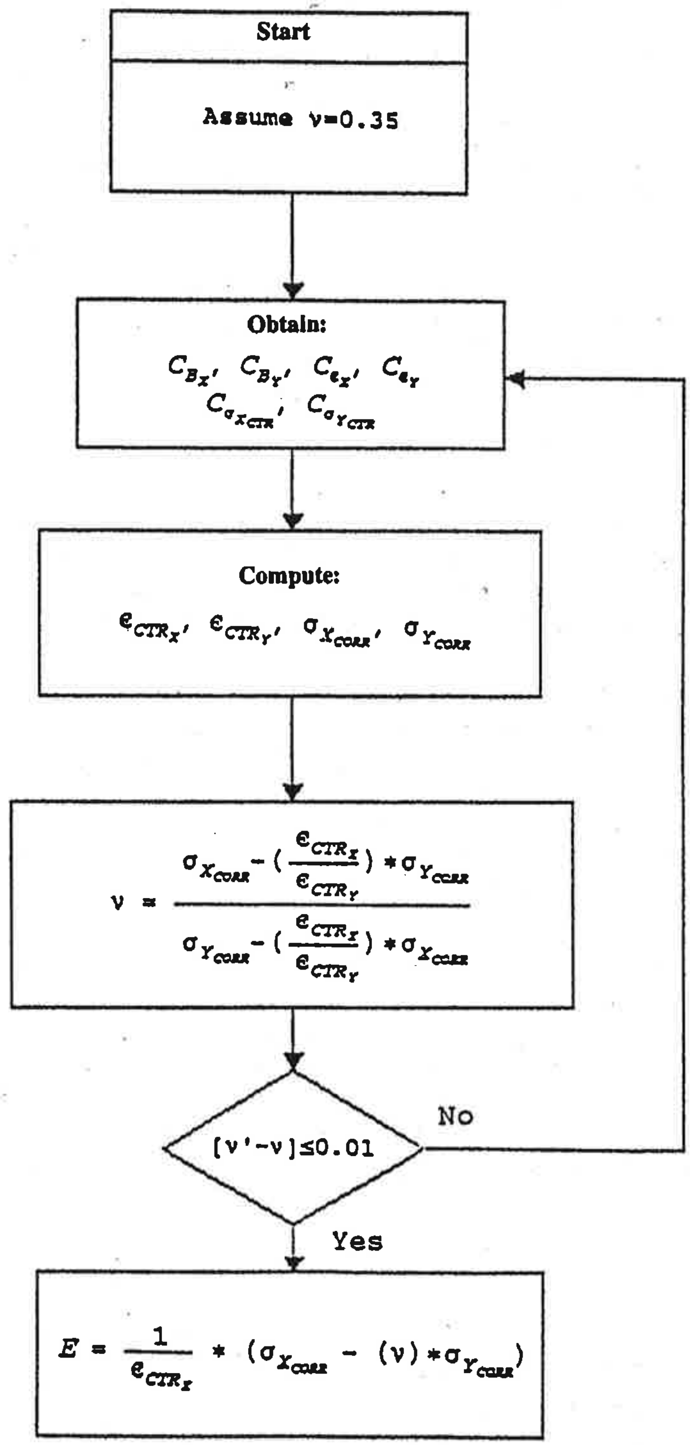


FIGURE 3.5 Iterative Method for Determining Poisson's Ratio in the Indirect Tension Test

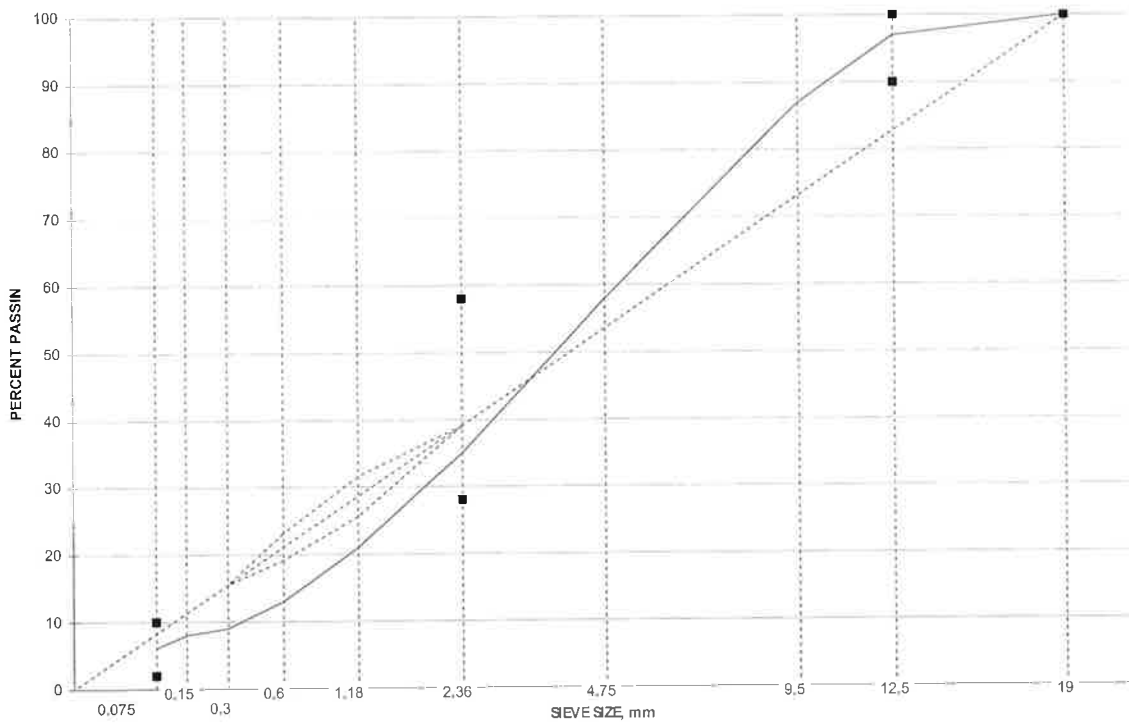


Figure 5.1 12.5 mm Gradation.

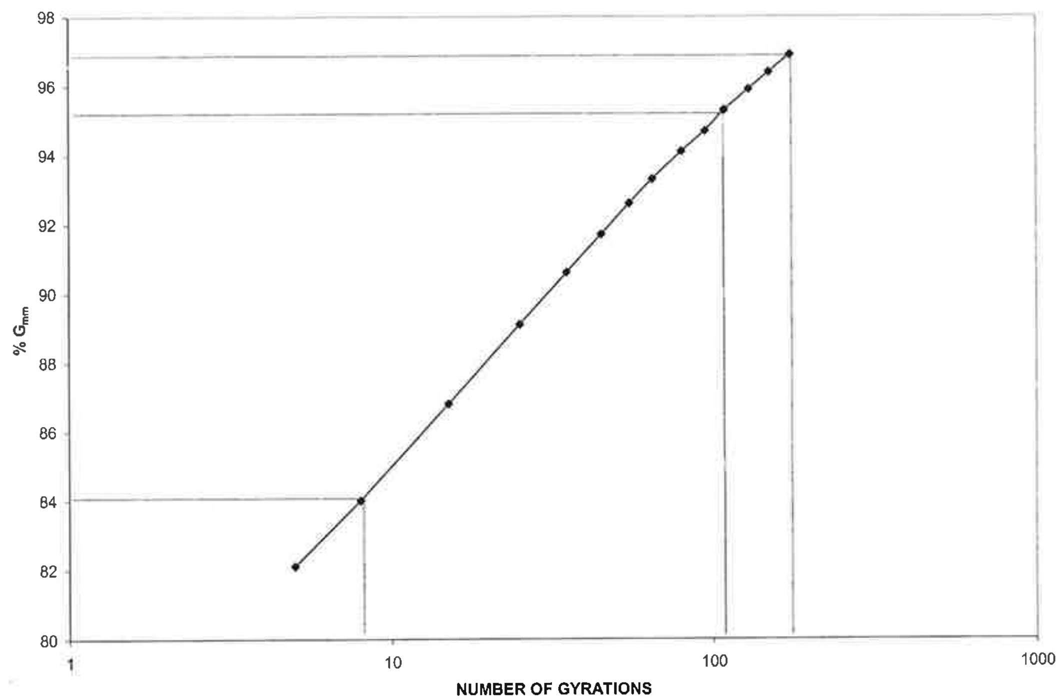


Figure 5.2 12.5 mm Trial Compaction Data.

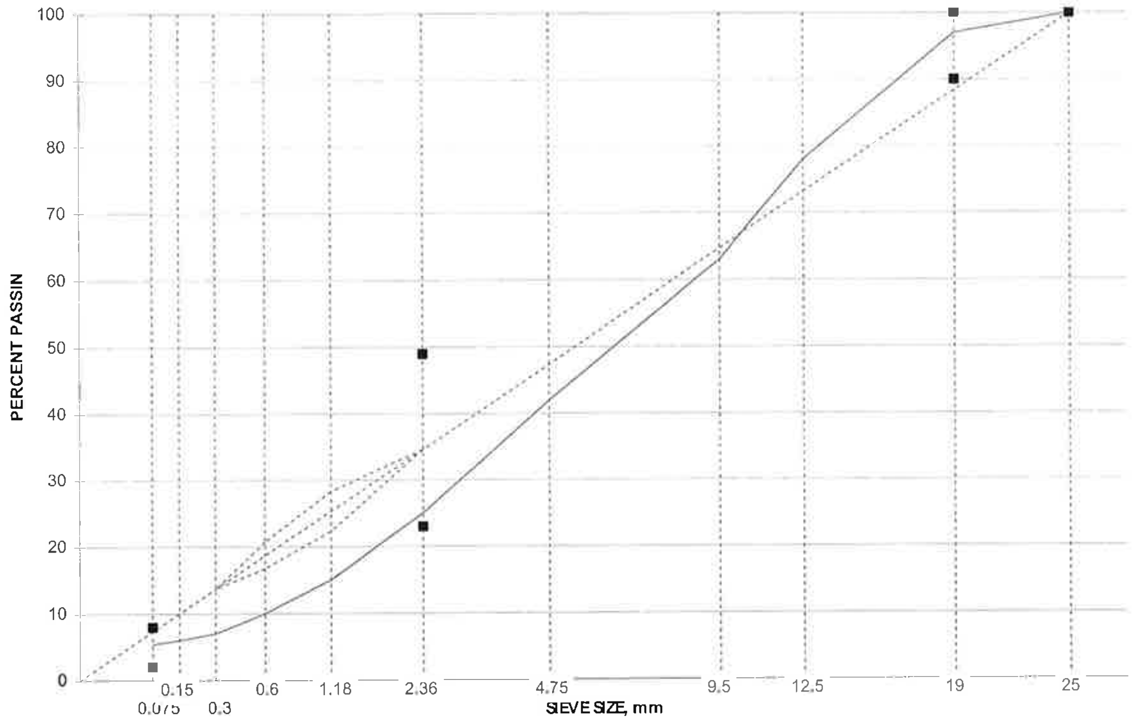


Figure 5.3. 19.0 mm Gradation.

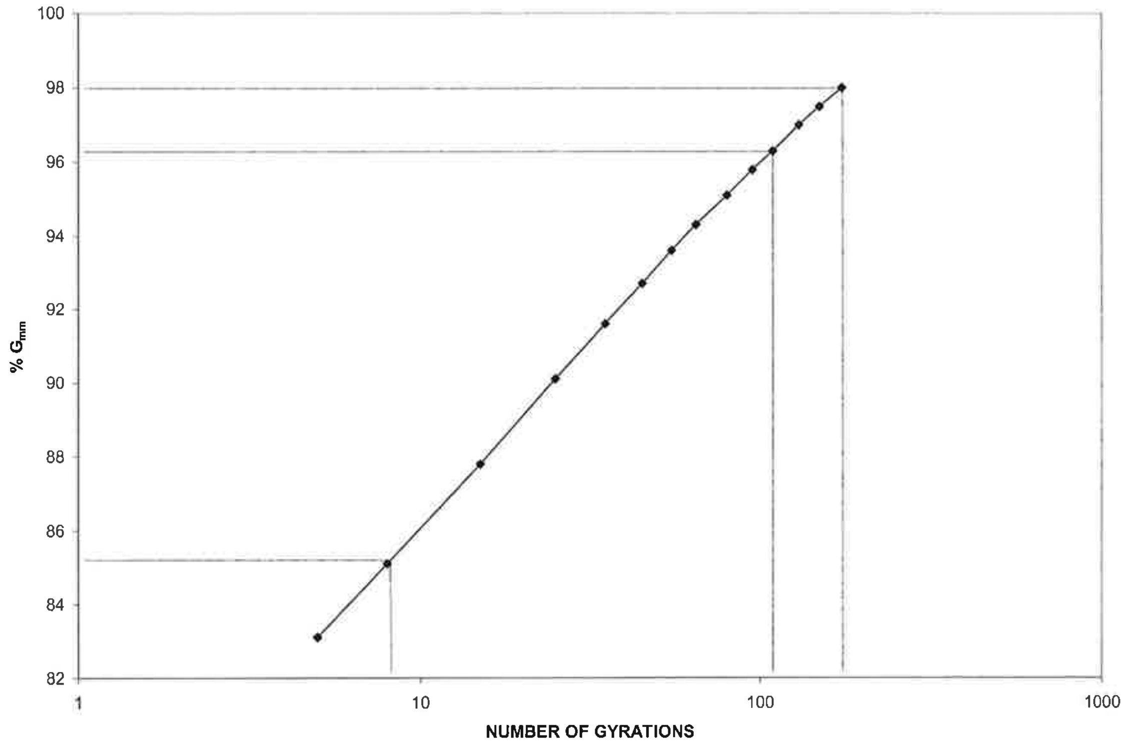


Figure 5.4. 19.0 mm Trial Compaction Data.

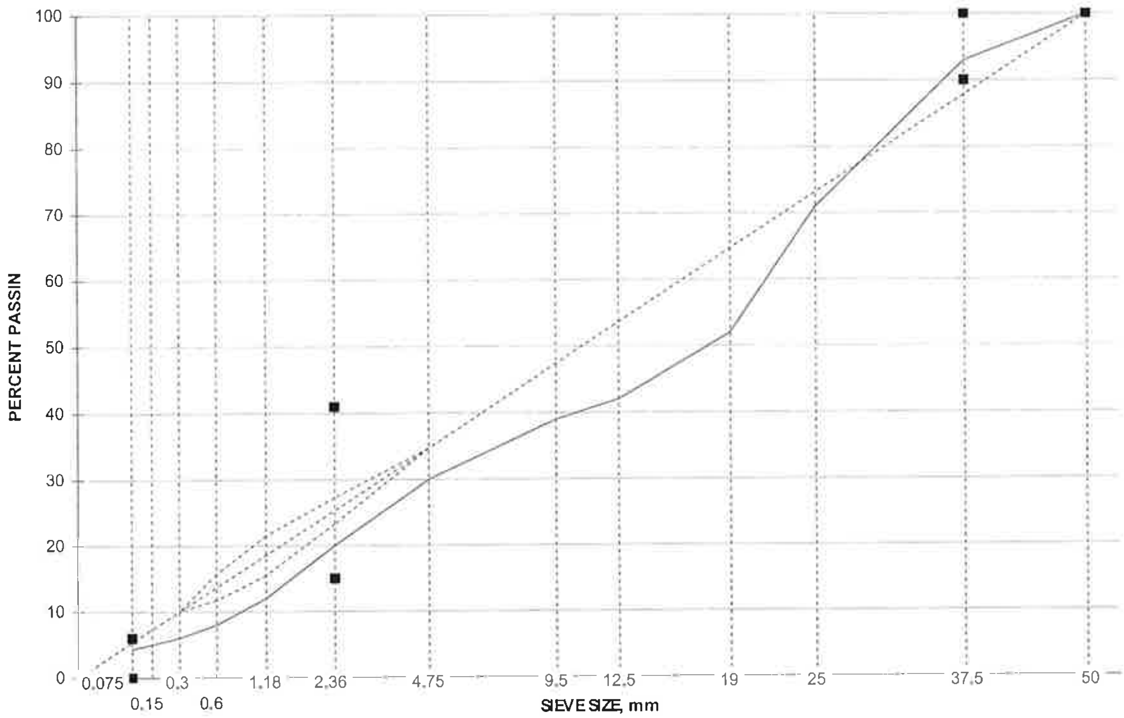


Figure 5.5. 37.5 mm Gradation.

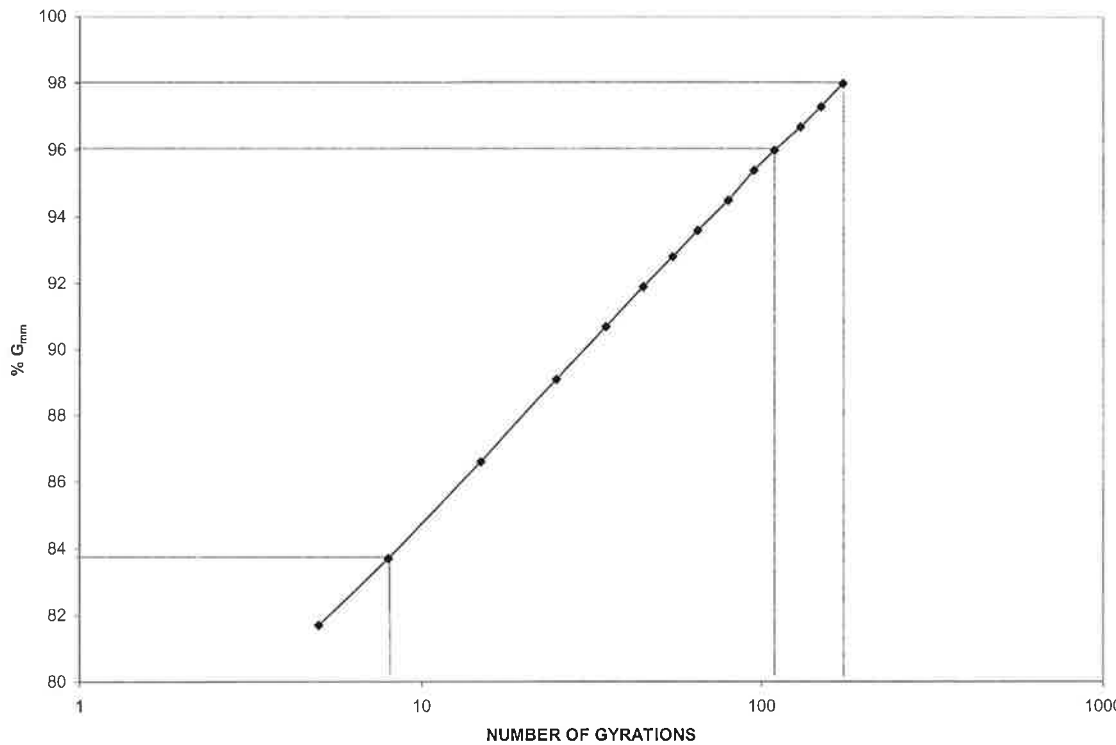


Figure 5.6. 37.5 mm Compaction Data.

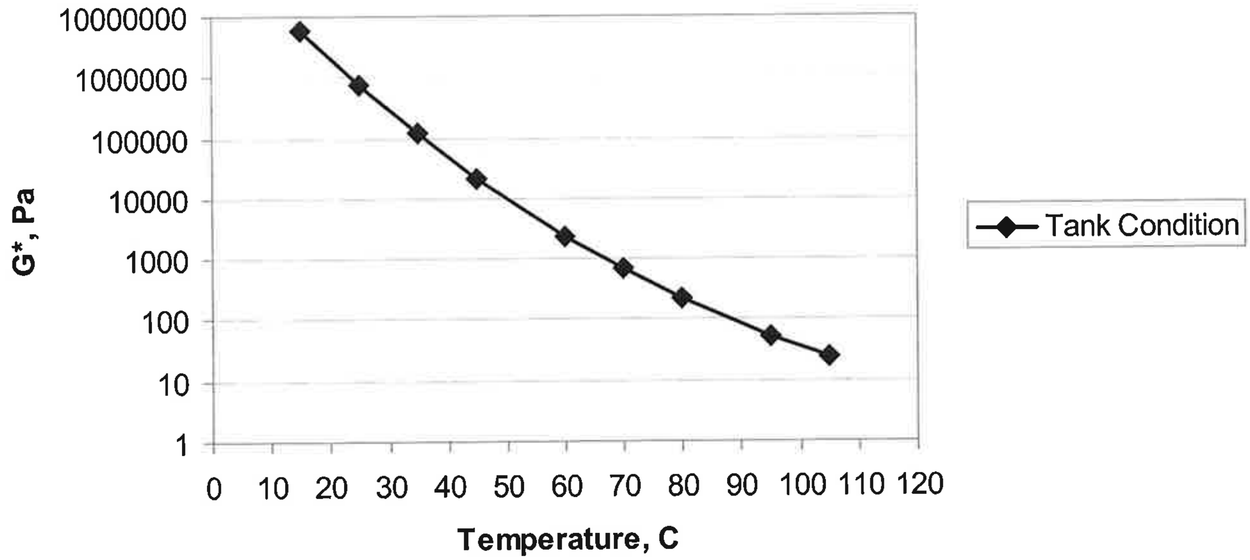


Figure 5.7. Isochronal Plot for G* at 10 rad/sec.

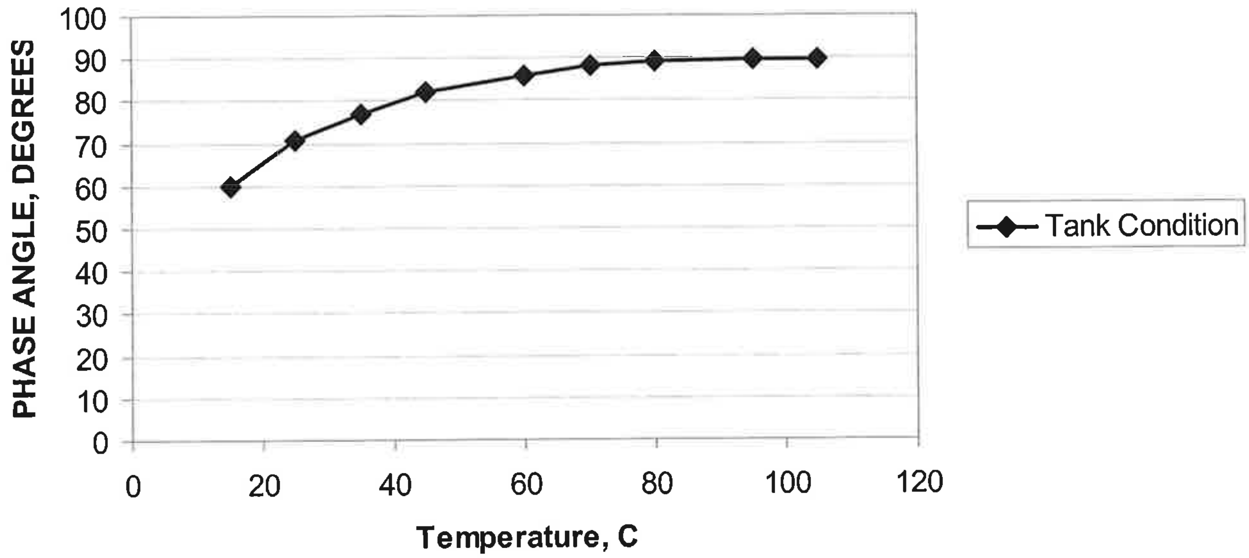


Figure 5.8. Isochronal Plot for Phase Angle at 10 rad/sec.

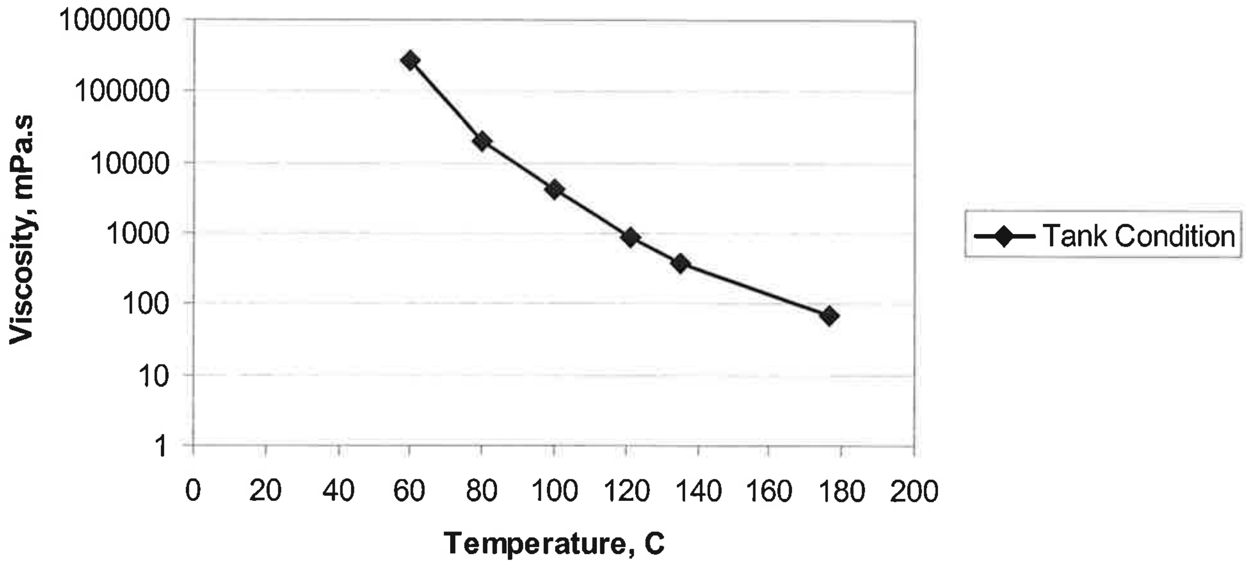


Figure 5.9. Brookfield Viscosity.

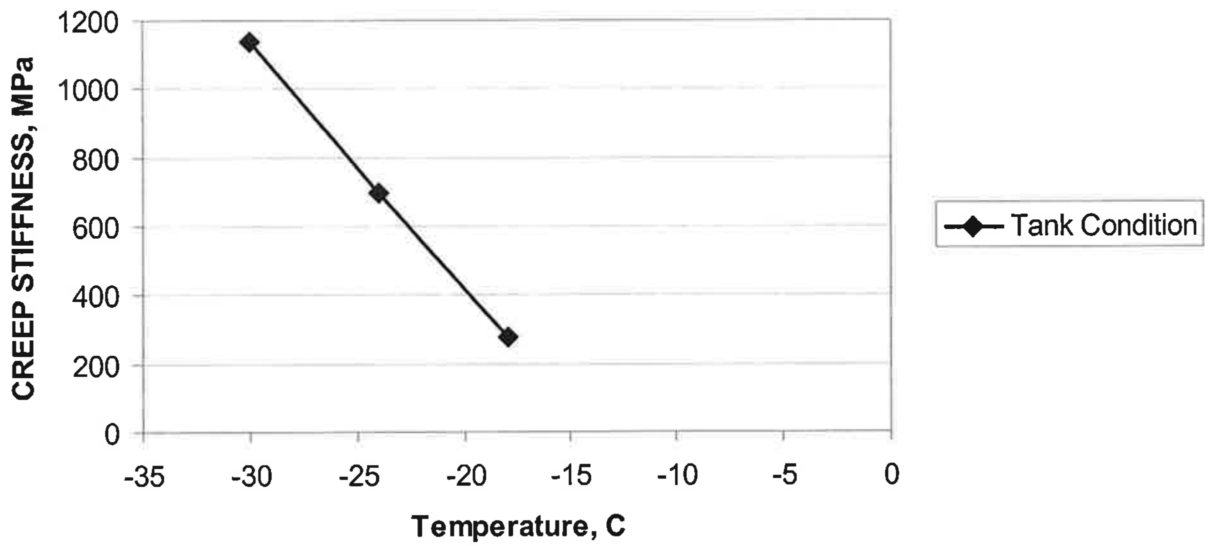


Figure 5.10. Flexural Stiffness Data for 60 sec Loading.

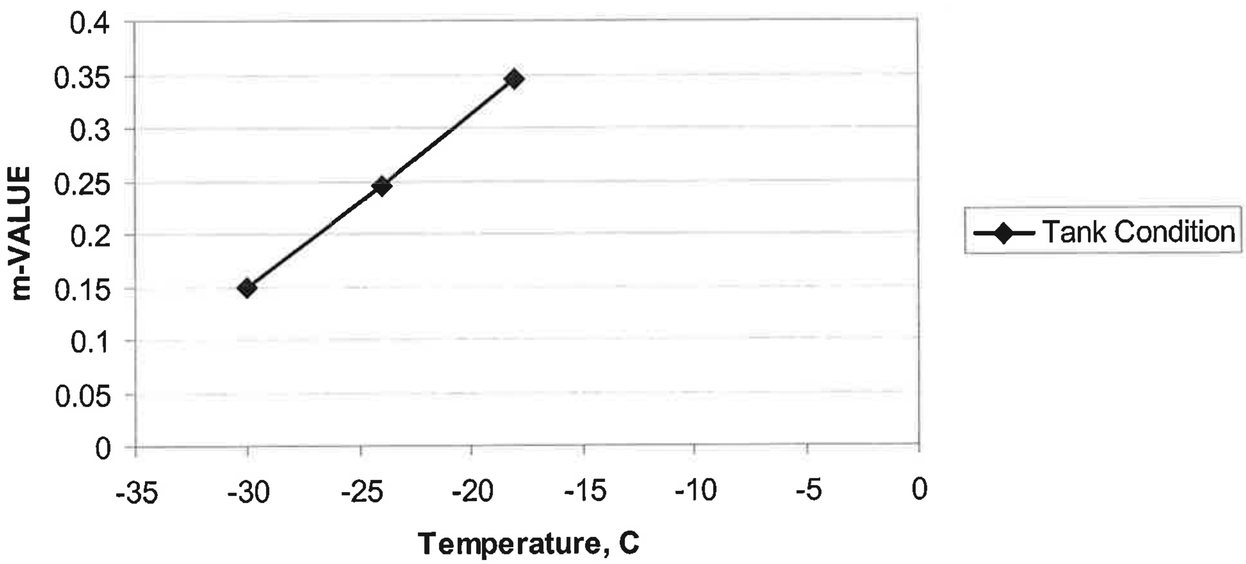
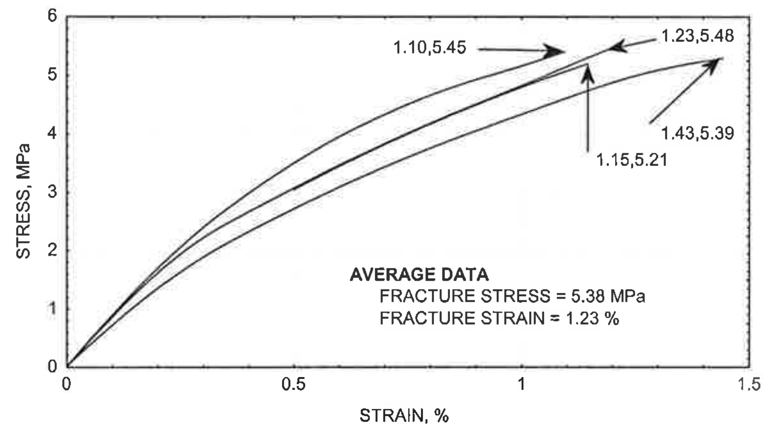
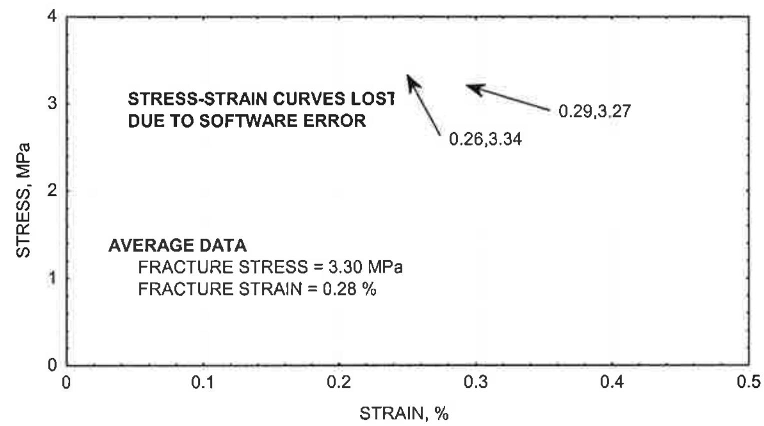


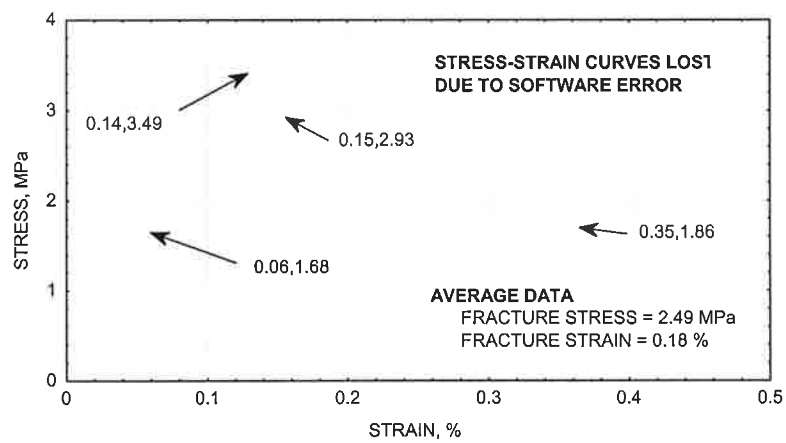
Figure 5.11. m-Value Data for 60 sec Loading.



a. Tests at –18 °C.



b. Tests at –24 °C.



c. Tests at –30 °C.

Figure 5.12. Direct Tension Stress Strain Curves for Tank Condition.

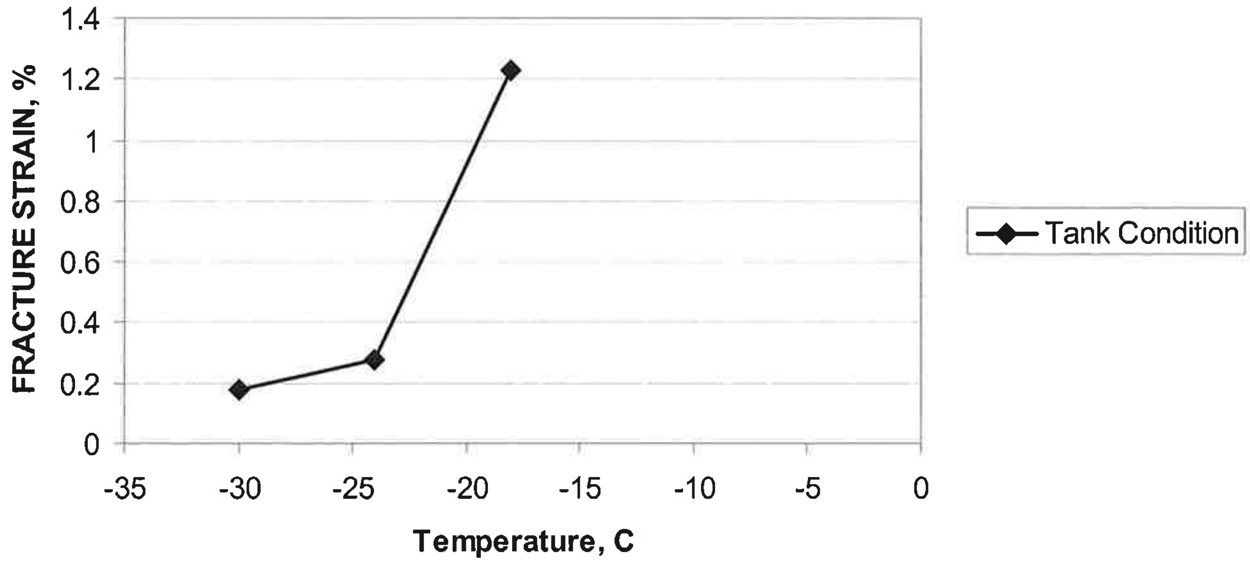


Figure 5.13. Low Temperature Fracture Strain.

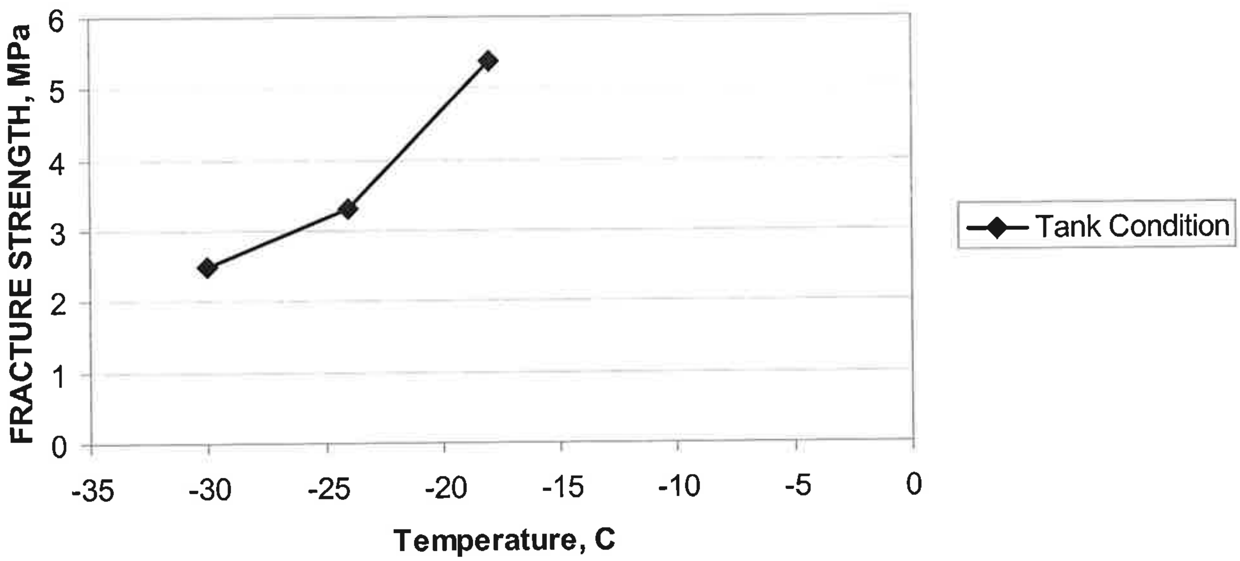


Figure 5.14. Low Temperature Fracture Strength Data.

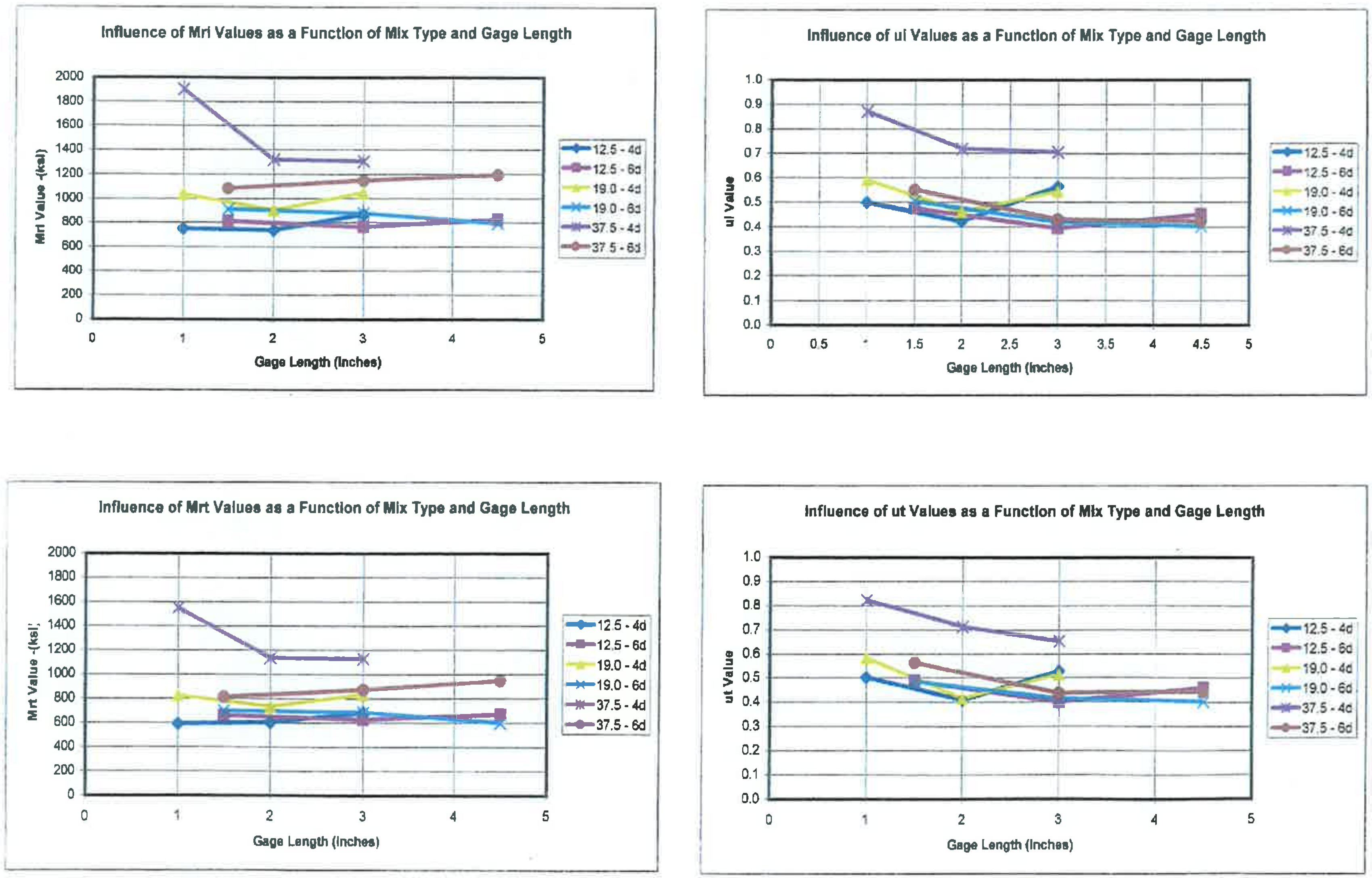


Figure 7.1 Average Test Results by Mix Type, Specimen Size and Gage Length

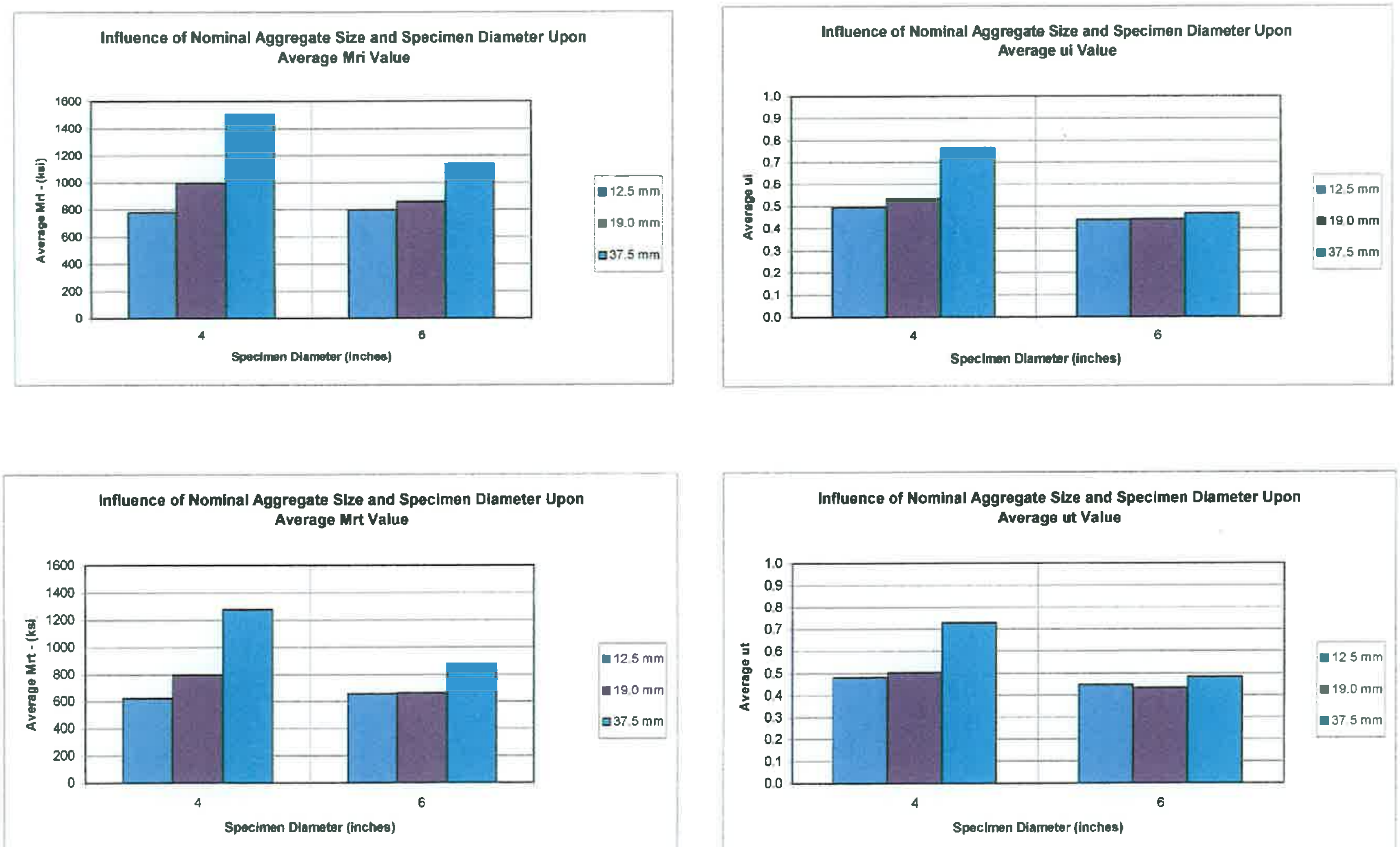
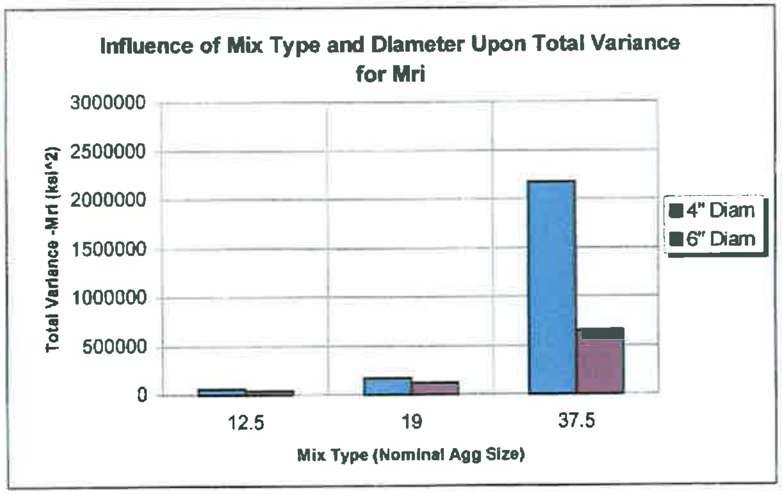
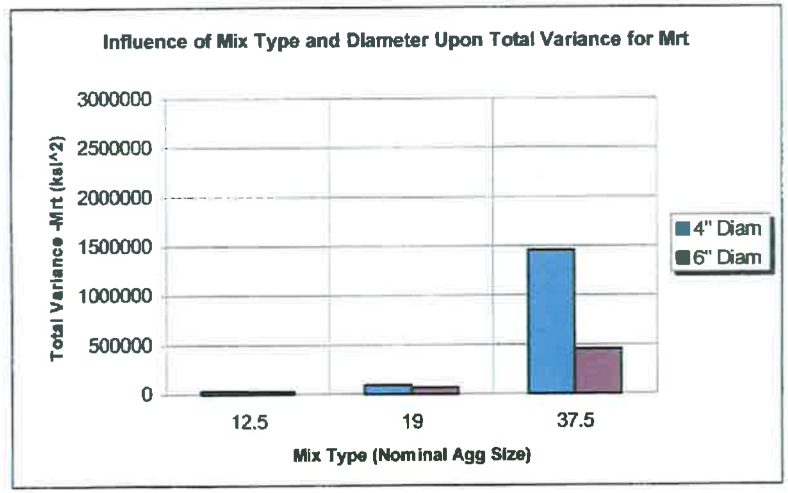
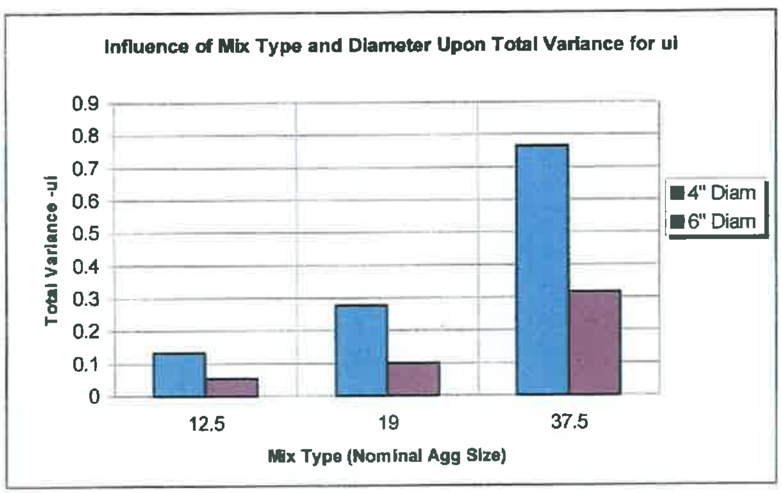


Figure 7.2 Influence of Mix Type and Specimen Diameter for Average Test Parameters







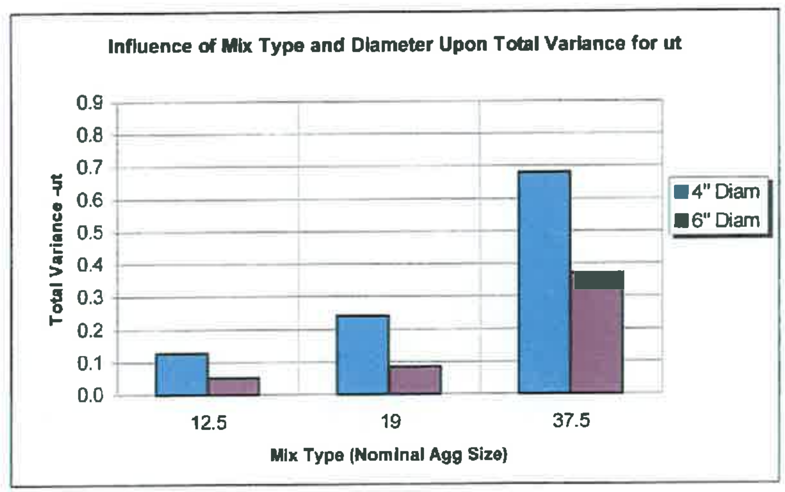


Figure 7.3 Influence of Mix Type and Specimen Diameter upon Total Variance

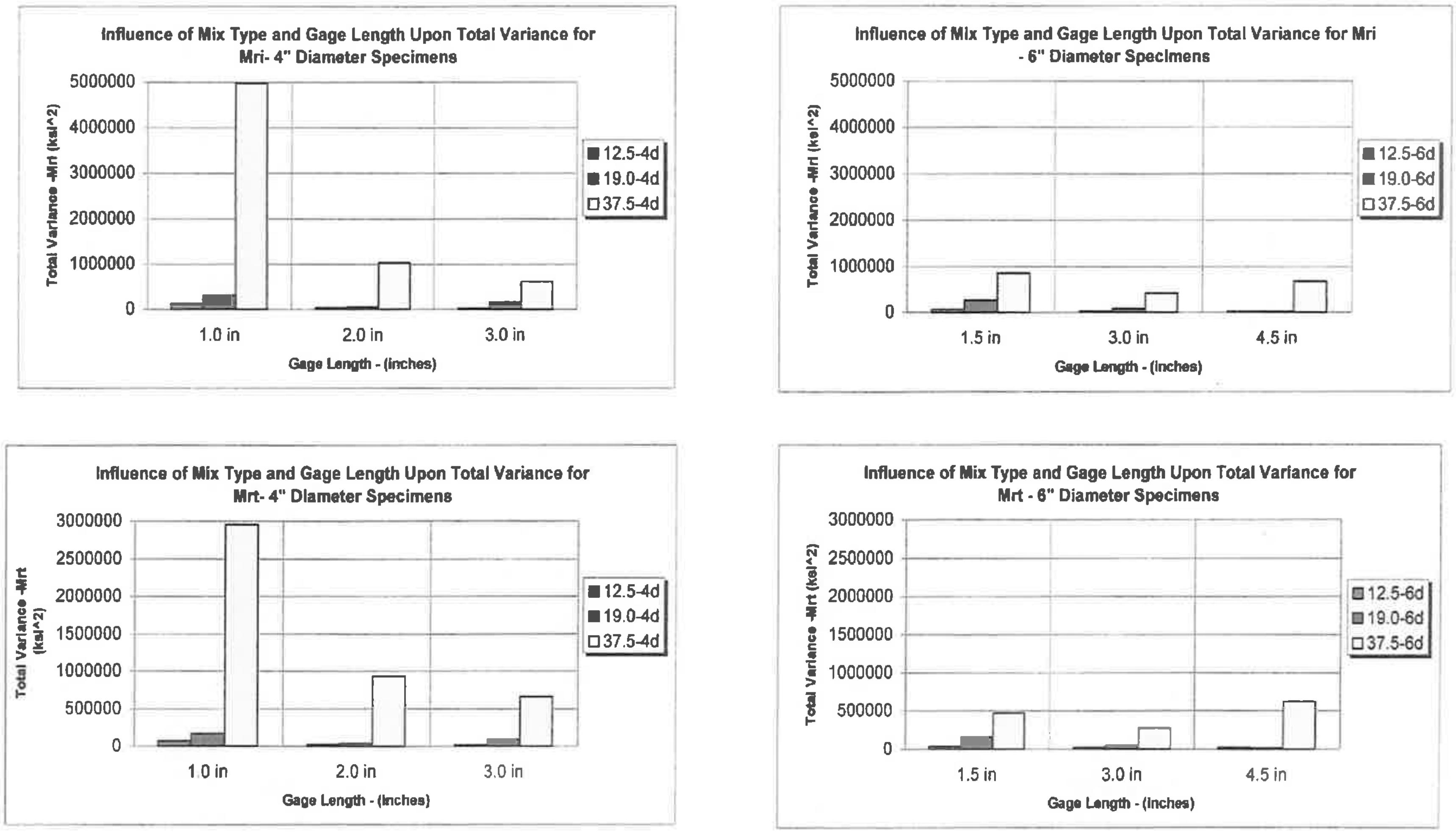
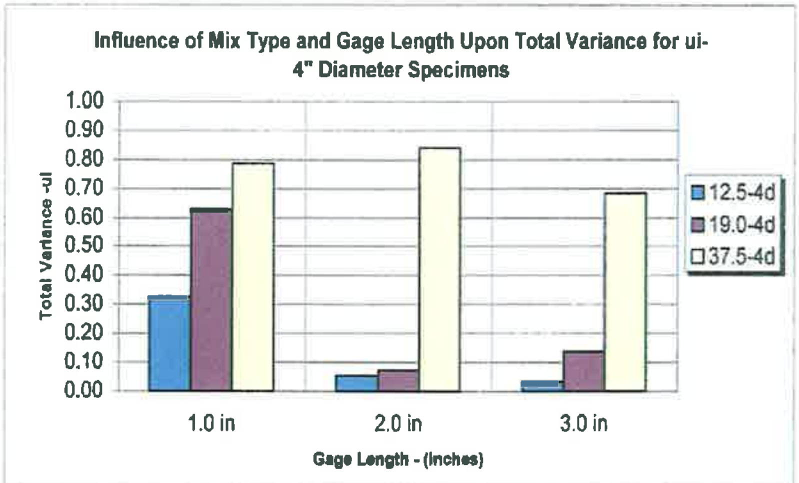
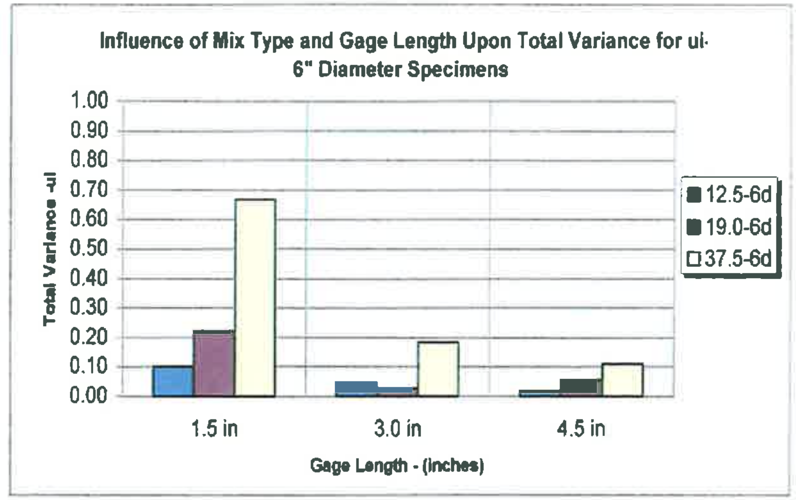
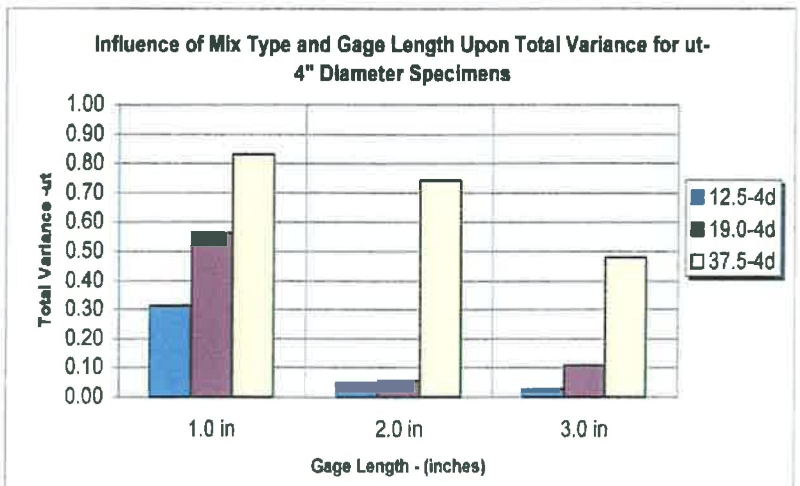


Figure 7.4 Influence of Mix Type and Gage Length upon Total Variance (Modulus) for 4 and 6 inch Diameter Specimens







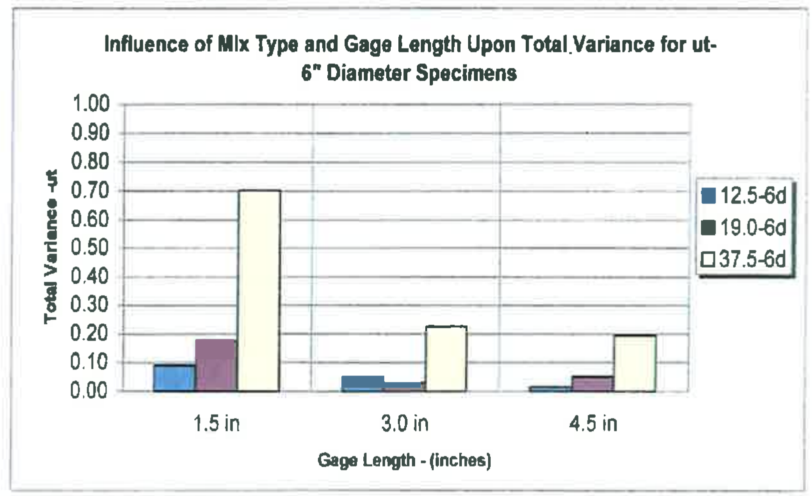


Figure 7.5 Influence of Mix Type and Gage Length upon Total Variance (Poisson's Ratio) for 4 and 6 inch Diameter Specimens

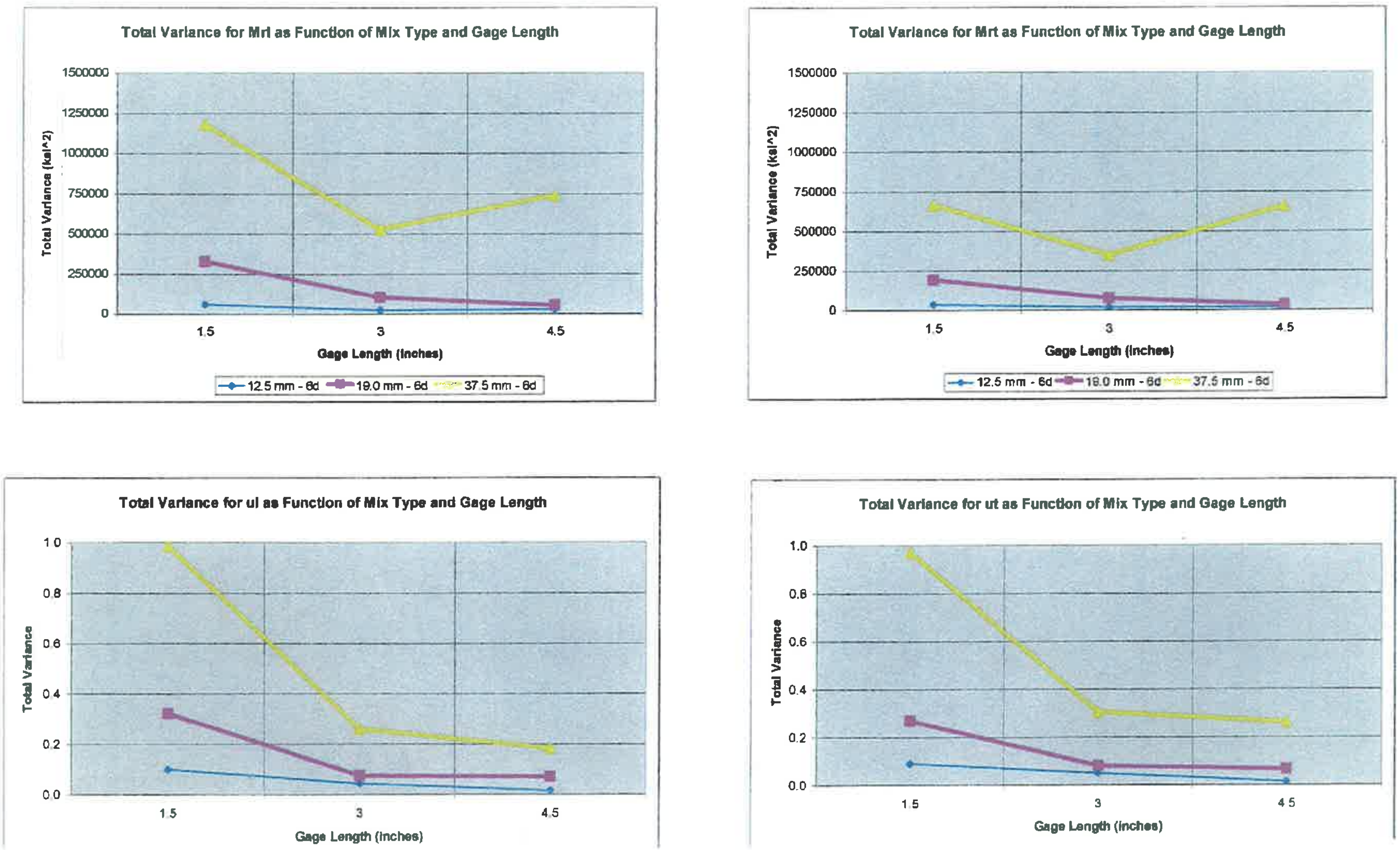


Figure 7.6 Total Variance as Function of Gage Length for Mix Types (6" Diameter Specimens)

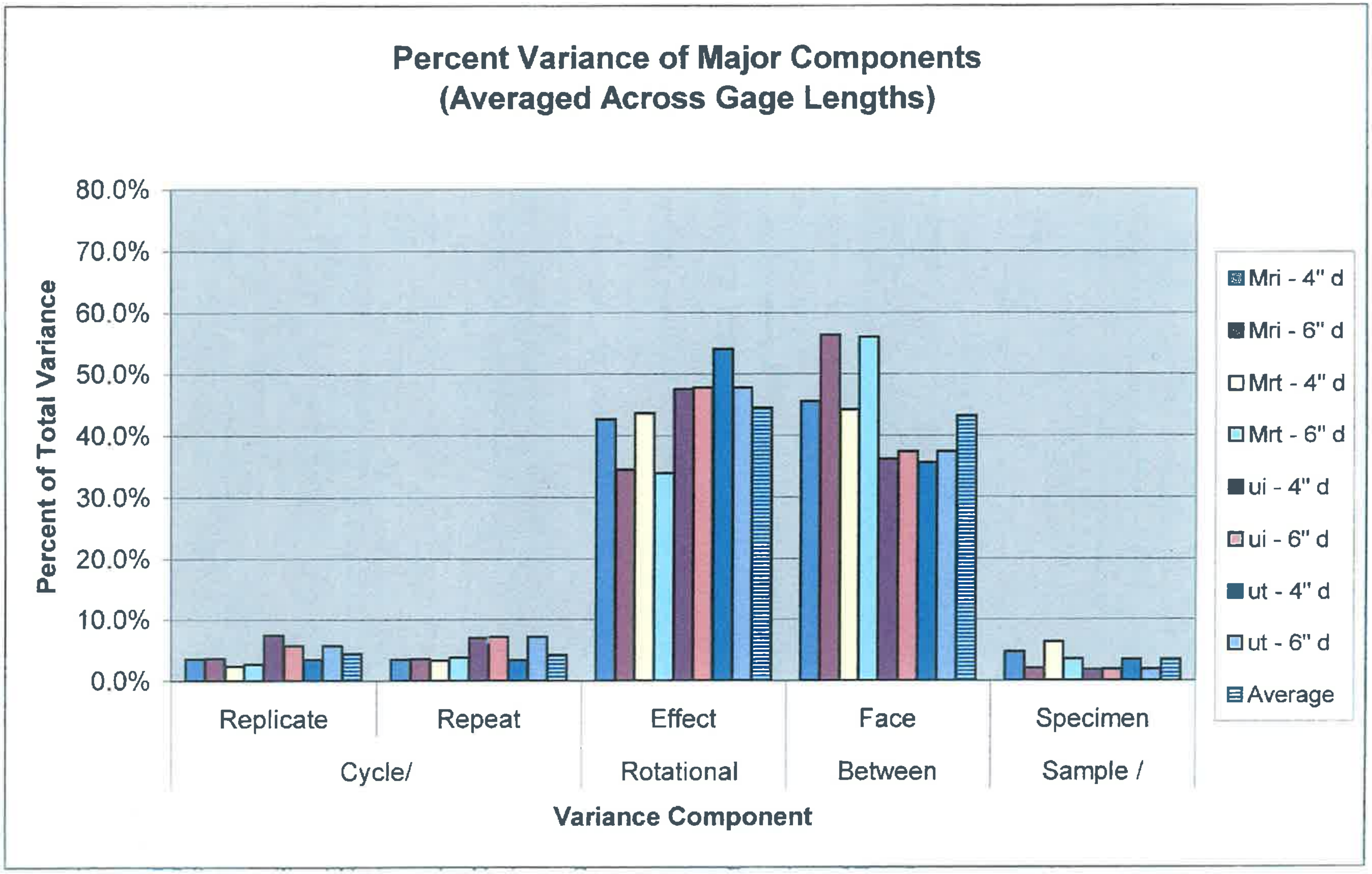


Figure 7.7 Percent Total Variance by Variance Component as Function of Test Parameter and Specimen Diameter

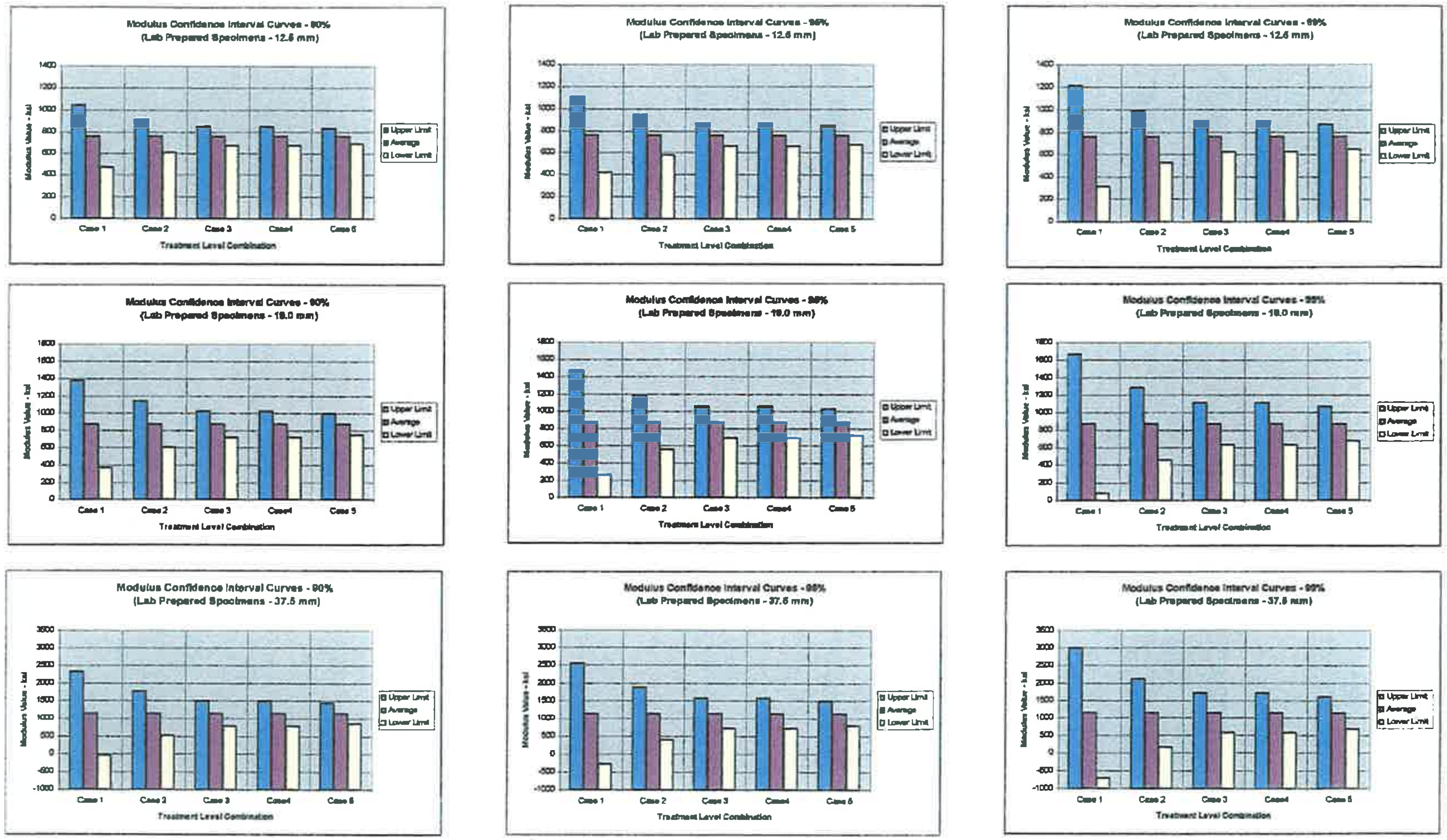


Figure 7.8 Modulus Confidence Interval Curves as Function of Probability, Mix Type and Treatment Level Combination (Lab Prepared Specimen)

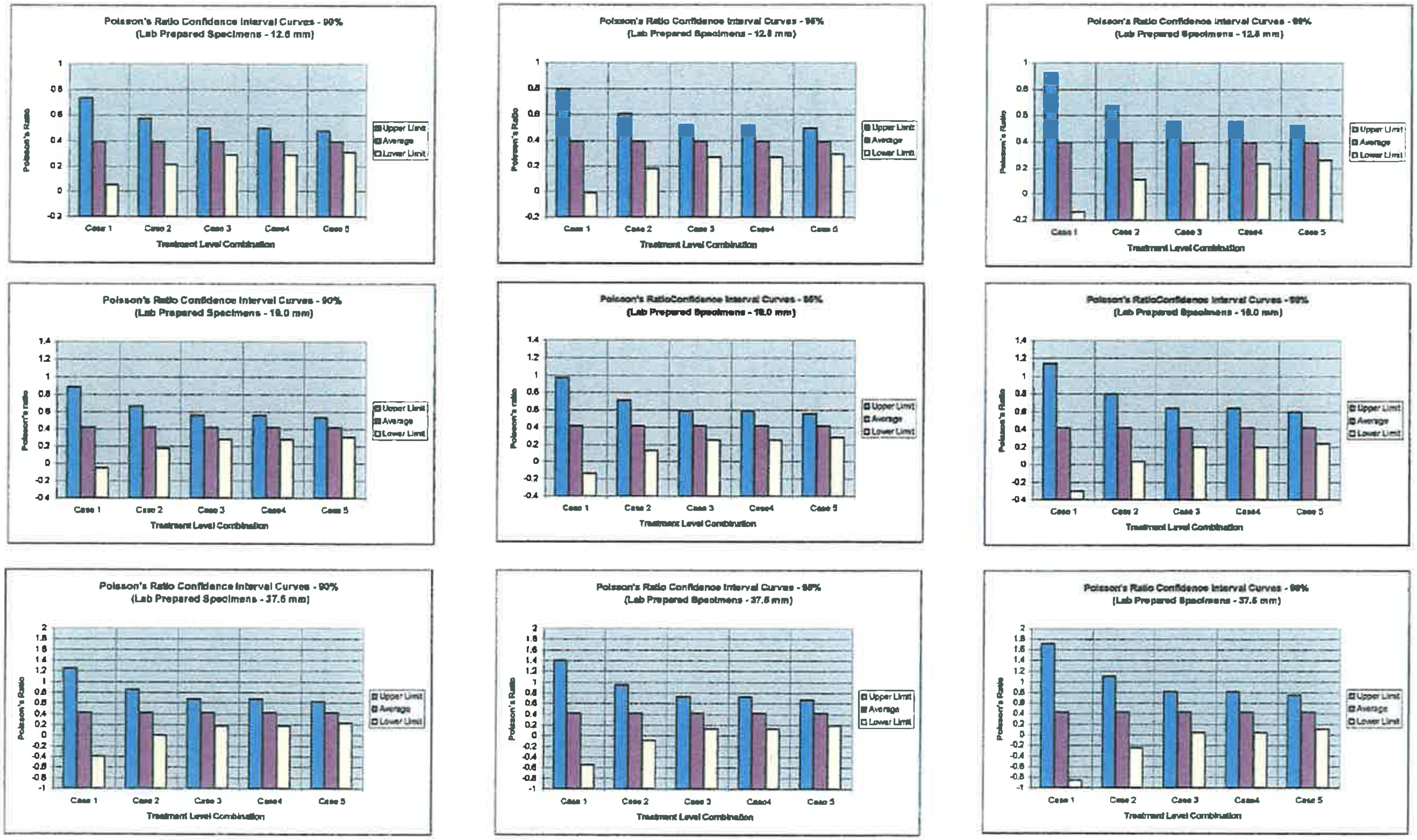


Figure 7.9 Poisson's Ratio Confidence Interval Curves as Function of Probability, Mix Type and Treatment Level Combination (Lab Prepared Specimen)

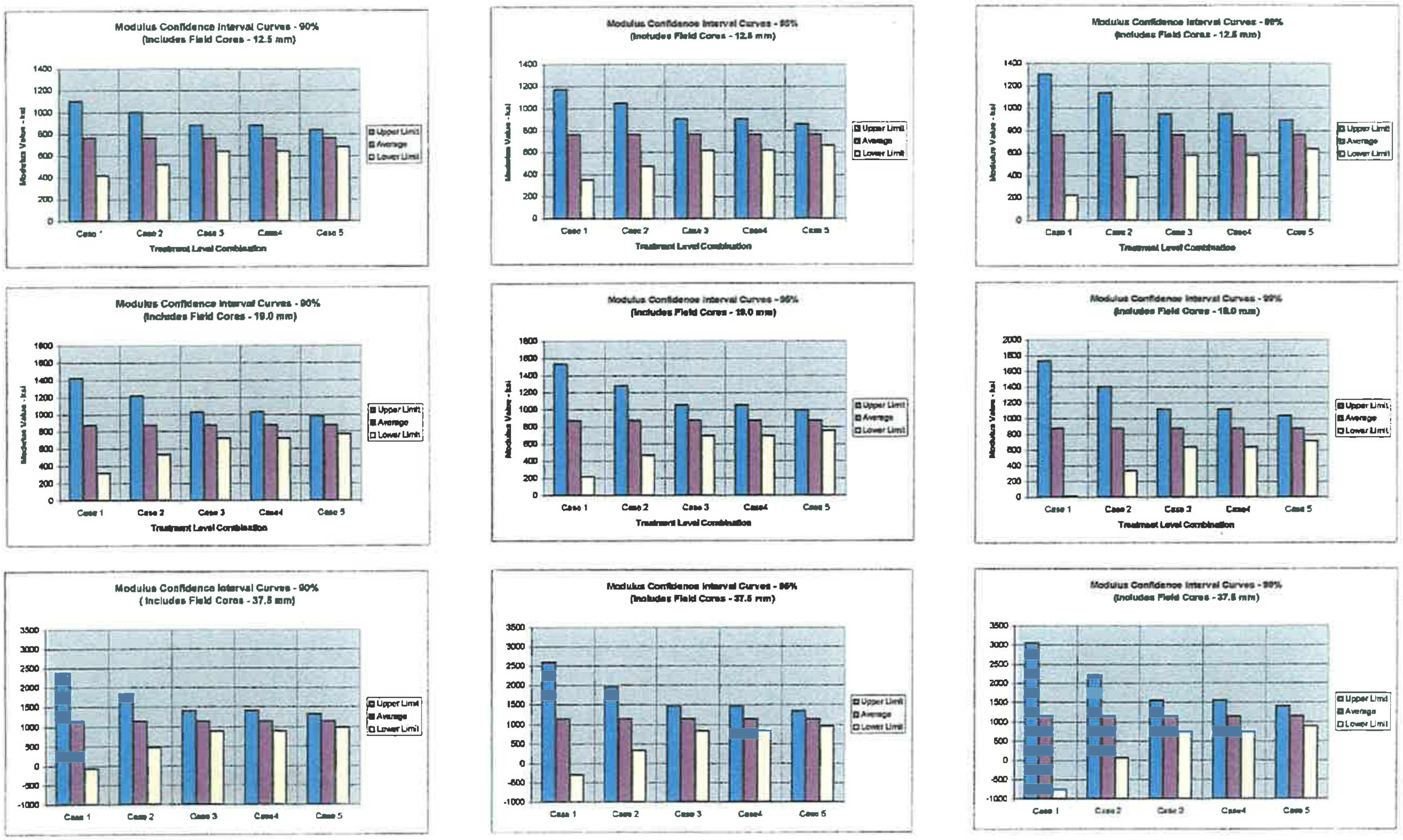


Figure 7.10 Modulus Confidence Interval Curves as Function of Probability, Mix Type and Treatment Level Combination (Field Core Specimen)

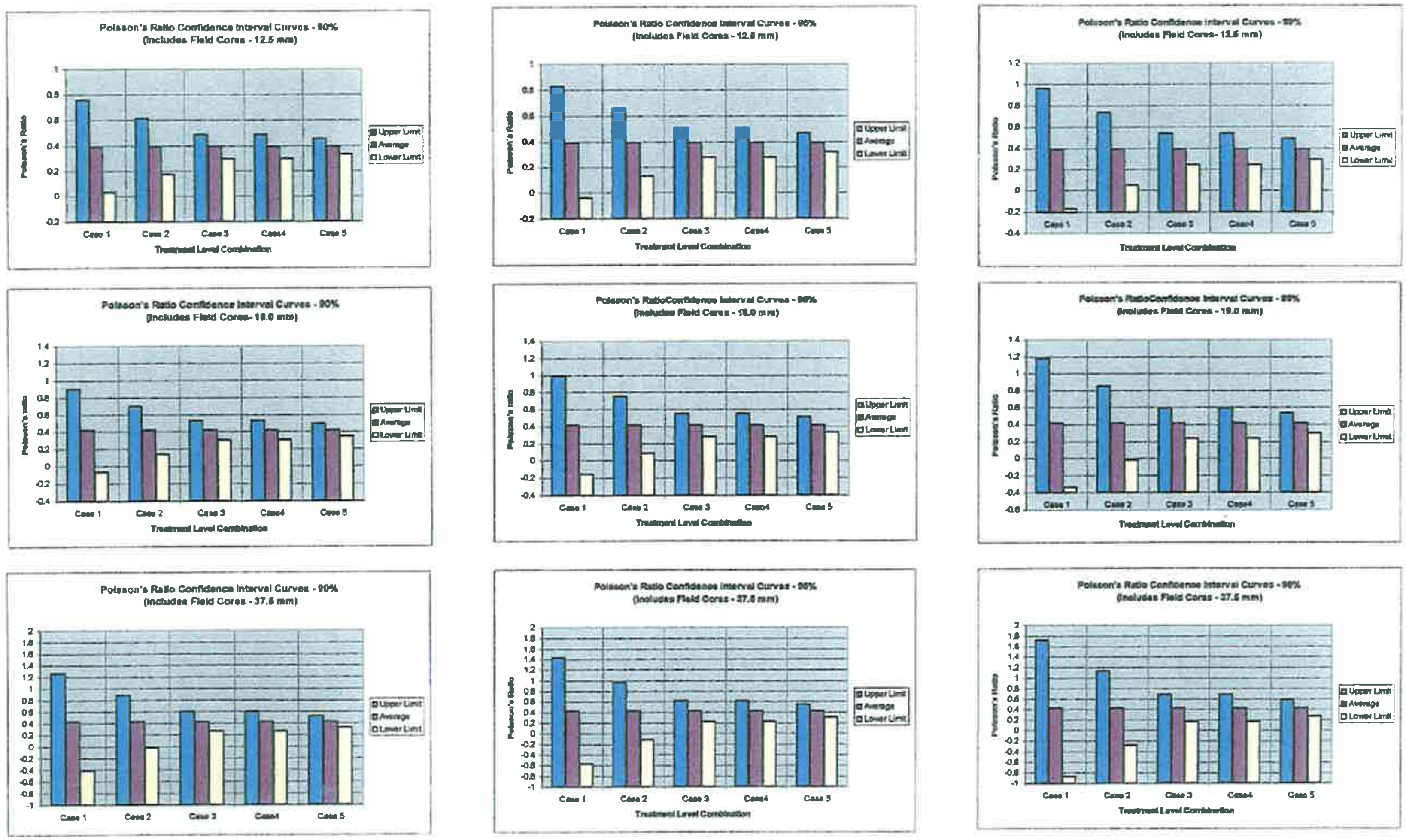
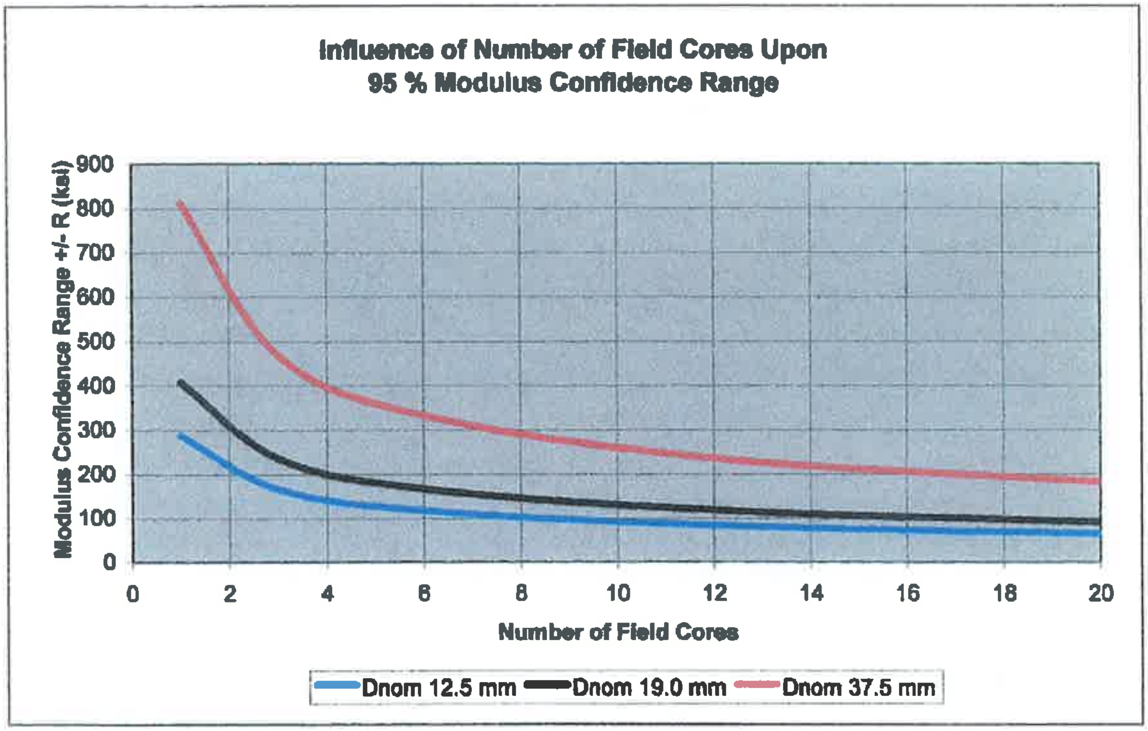


Figure 7.11 Modulus Confidence Interval Curves as Function of Probability, Mix Type and Treatment Level Combination (Field Core Specimen)



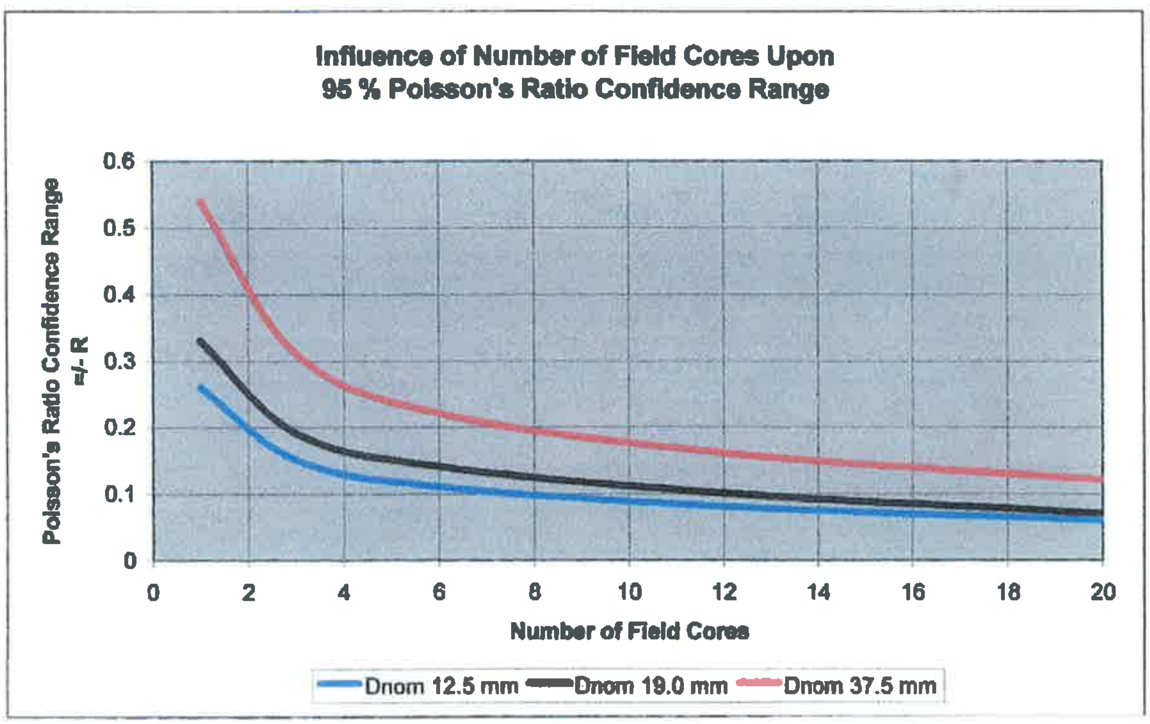


Figure 7.12 Influence of Number of Field Cores Upon 95% Confidence Range for Modulus and Poisson's Ratio