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RESEARCH PROBLEM STATEMENTS

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NOTE: The highest priority statements are marked in each Section with an asterisk

A. GENERAL DESIGN - L. A. Herr, Chairman

A2A02 Geometric Design - G. M. Nairn, Jr.

PROBLEM NO. 1

I. NAME OF PROBLEM - Additional Through Lanes at Intersections

II. THE PROBLEM - A highway usually has much higher traffic capacity between intersections than it does at signalized at-grade intersections. To utilize the highway capacity between intersection, additional lanes can be provided at intersections. These additional lanes are usually designed for turning movements. However, there are certain situations that may require additional through lanes. There is need for a determination of length of the additional lane, both in advance of and beyond the intersections, to permit safe and efficient flow of through traffic. This determination must be recognized as a separate problem, and not associated with an auxiliary lane as derived in the highway capacity manual. The most uncertain part of the design is what length of lane is required beyond the intersection to provide a satisfactory traffic merge when the added lane is ended.

III. OBJECTIVES - To make field studies and collect and analyze operational data over a sufficient range of lane lengths and traffic volumes to determine:

A. The required length of extra through lane (including taper requirements) beyond the intersection.

B. The required length of extra through lane (including taper) needed in advance of the intersection.

C. The refinements of the above lane length as they are affected by design speed, profile grade and percent of trucks.

D. The differences, if any, between high volume (peak hour) and low volume (off peak) design requirements.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 22, 51, 52 and 53 have been scanned in preparing this statement.

B. Suggested key words are: geometric, design, intersection design, capacity, safety, traffic merge, truck factor.

C. Many studies have been made of traffic capacity at intersections but none to directly apply to this problem.

D. A reprint of "Public Roads" for the August, 1967 and October, 1967 issues provides a theoretical method of determining length requirements of widened intersection approaches in, Part 3 - Special Conditions, but research is needed to verify the suggested design is satisfactory.

V. URGENCY - This project warrants an immediate and high priority because existing highways can be provided with increased capacity at relatively minor cost if the designer is sure this design is safe and efficient.

PROBLEM NO. 2*

I. NAME OF PROBLEM - Arterial Street Widths

II. THE PROBLEM - The impact of the nationwide program of constructing freeway facilities through and adjacent to urban areas has pointed up the need to provide adequate distributor streets to feed and receive the high volume of traffic involved. Also, in the smaller communities that do not have freeways or expressways, the arterial street system is relatively even more important because they must perform the dual function of carrying the majority of the traffic and also serve in developing a desirable land-use pattern. Determination of the number of moving lanes for a particular arterial street is only the first step in establishing the proper curb-to-curb street width. Other consideration will involve lane width, and possible provision for left turn lanes and parking. Still another consideration is whether or not to provide an emergency stopping lane (breakdown lane) so that a stalled or disabled vehicle will not block a through lane. These considerations are quite variable and often argumentative. There is a need for the establishment of warrants on which to base the design of these facilities.

III. OBJECTIVES - Development of a standard evaluation procedure that will permit planners and designers to determine the most satisfactory street cross section for any given set of conditions. The procedure should be an orderly, vigorously defensible, step-by-step consideration of such factors as traffic volume, turning volumes, property values, lane use (present and projected), intensity of adjacent development, anticipated posted speed limit, and importance of arterial street.

IV. CURRENT ACTIVITIES -

A. Highway research in areas 15, 22, 53, and 84 have been scanned in preparing this statement.

B. Suggested key words are: arterial streets, geometric design, land use, traffic volume, emergency stopping lane.

C. Some related studies have been made in accident analysis, economics, urban land use, etc., but nothing was found that answers the objective stated above.

V. URGENCY - This project is deserving of a high priority as the movement of traffic in our urban areas is a nationwide problem. An accepted evaluation procedure as called for in this objective would be of tremendous value to urban planners and design personnel.

PROBLEM NO. 3

I. NAME OF PROBLEM - Minimum Ramp Pavement Width Required

II. THE PROBLEM - Present ramp design practiced nationally is extremely variable. The traveled way varies from 12 feet to 18 feet and the total pavement width (including the paved shoulders) varies from a minimum of 19 feet to a maximum of 30 feet. Also, it is a regrettable fact that highway costs are continuously increasing. Although one major concern of highway design engineers is cost, it should not be considered instead of safety and good engineering principles, but in conjunction with them. Presently there seems to be no data available addressing the problem of excessive and inconsistent ramp widths.

In view of this, there appears to be a need to determine, by a study on a national level, a required minimum ramp pavement width. This minimum width should allow a safe and efficient flow of traffic exiting and entering a major roadway.

The study should consider such factors as (1) pavement width - curvature relationships, (2) comparison of accident data on wide ramps versus narrow ramps, (3) frequency of stalled vehicles on ramps, (4) sound traffic engineering principles and construction economics, (5) the drivers expectability and capability regarding narrower ramps, (6) a clearer interpretation of Table VII-7 (Design Widths of Pavements for Turning Roadways), Page 338 of the 1965 edition of A Policy on Geometric Design of Rural Highways, and (7) paved shoulders on one or both sides.

III. OBJECTIVES -

To determine whether or not any problems would occur with horizontal or vertical alignment.

To determine what percent savings could be realized by using a minimum width ramp.

To determine why a wide ramp is necessary for one-way travel when the majority of the roads are two-way with 12 feet or less lane widths and only a four inch center line separating opposing vehicles. Also, many of these roads have posted speed limits that are the same as interstate highways.

To make field studies and collect and analyze operational data from narrow ramp locations.

To determine the necessity of providing for passing a stalled vehicle on a one-way ramp; or a comparison of paved shoulders versus grass shoulders for passing stalled vehicles.

To determine from a traffic operation, safety, and an economical viewpoint a minimum ramp width within AASHTO requirements that could be used by all states.

To determine how the narrower width ramps would affect the level of service of the ramp proper.

To determine whether or not normal operational features will be diminished.

Uniformity in ramp pavement width from state to state.

To determine whether or not necessary maintenance would be significant.

To determine what effect, if any, a narrower ramp would have on the ramp proper design speed.

IV. CURRENT ACTIVITIES - None

V. URGENCY - The urgency in this problem is a matter of economics. The urgency lies in the fact that the time required for meaningful and productive research into this problem will be lengthy.

A2A03 Hydrology, Hydraulics & Water Quality - S. V. Fox

Research Problem Statements for this committee are listed in TRB Circular 207 dated June 1979. Names of problems are as follows:

HYDROLOGY

1 Generalized Flood-Frequency Estimates for Urban Drainage Areas

2 Mixed Population Flood-Frequency Analyses Techniques

3 Flood-Frequency Characteristics from Channel Size

4 The Economics of Flood Data-Collection and Culvert Design

5 Flood-Frequency Predictions for Bridge and Culvert Design

6 Criteria for the Analysis of Unusual Events in Annual Flood Peak Series

HYDRAULICS

1 Hydraulics of Bridge Waterways

2 Two-Dimensional Finite-Element Hydraulic Modeling of Bridge Crossings

3 Long Span Culvert Hydraulics

4 Effect of Very Heavy Sediment Loads on Flow Characteristics

5 Methods for Preventing Bridge Damage Caused by Floating Debris

6 Effects of Instream Mining on Channel Stability

7 Behavior of Supercritical Sediment-Transporting Flow

8 Flow Over Embankments and Guidelines for Embankment Protection

9 Design of Large Detention Basins and Appurtenances

10 Scour at Bridges

11 Implementing Improved Inlet Technology for Culverts

12 Guidelines for the Use of Gabions

13 A Rational Approach to Hydraulic Designs for Highway Encroachments on Flood Plains

14 Test and Evaluation of Inverted Siphons for Sanitary, Combined and/or Storm Sewers

15 River Training Works as Related to Highways

16 Erosion Resistance of New Grasses Used in Highway Drainage Channels

17 Energy Dissipation at Culvert Outlets and Storm Drain Outlets

18 Test and Evaluation of Expressway Drainage Design

19 Spur Dikes at Bridge Abutments

WATER QUALITY

1 Effectiveness of Temporary Erosion Control Methods

2 Tolerable Temporary Variances in Water Quality Standards Related to Total Suspended Solids and Turbidity as Caused by Transportation Construction Projects

3 Natural Systems to Test Highway Runoff

4 Structural Methods for Removal of Constituents from Highway Runoff

5 Restoration of Wetlands as Mitigation for Adverse Impacts Resulting from the Construction of Transportation Facilities

6 Predictive Modeling of the Fate of Highway Runoff Pollutants

7 Methods of Upgrading Sewage Effluents

8 Evaluation of Septic Tank System Design

9 Design Criteria for Safety Rest Areas

10 Evaluation of Channel Alteration Design to Mitigate Damage to Fish and Wildlife Habitat

GENERAL PROBLEMS

1 Legalities of Highway Drainage Design

2 Hazardous and Toxic Materials Spills from Transportation Vehicles and Facilities

A2A07 Utilities - R. L. Williams

PROBLEM NO. 1

I. NAME OF PROBLEM - Reducing Delays, Damage, and Cost thru Improved Highway-Utility Coordination

II. THE PROBLEM - The coordination of utility relocation and adjustment work with highway construction projects is a national problem. Inter-

ference and delays have increased the cost of highway construction with many highway contractors filing requests for extensions of time and claims for additional monetary considerations. Damage to utility plant has been costly, caused interruptions of service to the public, and in some cases has resulted in injury or death to workman and others.

Some of the problems are due to: (1) ineffective leverage, cooperation, or liaison between highway, utility, and contractor personnel which results in the lack of specific responsibilities providing for the continuous follow-through for coordination of the work (2) ineffective or incomplete procedures or requirements; and (3) insufficient or misdirected legislation pertaining to prevention of damage to underground utilities.

III. OBJECTIVES - It is the objective of this problem statement that a comprehensive study be made to: (1) update Highway Research Board Special Report 77, An Analysis of Highway-Public Utility Liaison Practices; (2) classify the types of delays and damages that are occurring; (3) establish the causes of such incidences; (4) evaluate the effectiveness of legislation, pertaining to underground damage prevention; (5) determine the most effective liaison procedures and operational practices pertaining to relocation, adjustment and coordination of utility facilities on highway construction projects; and (6) make recommendations for implementation of the most effective legislation, organizational structures, procedures, and operational practices by highway departments and utilities.

IV. CURRENT ACTIVITIES - Current practices for the handling of the necessary utility relocation or adjustment work include, but are not limited to: (1) FHWA requirements on Federal Aid projects to have the necessary relocation work performed prior to advertisement of the project, or certification by the Highway Department that all necessary arrangements have been made to have adjustment work coordinated with the project construction in order to prevent delays, damage and added costs; (2) the Highway Department and utility agreeing to have the necessary work performed in some fashion, such as: (a) relocation of utilities by the utility owner or its contractor prior to construction (b) adjustment of utilities during construction or (c) inclusion of utility work in the highway project contract to be performed by the highway contractor; and (3) State legislation requiring excavators to call before they dig and requiring the utility to then mark the location of their existing facilities.

V. URGENCY - It is estimated that this project can be completed in 18 months at a cost of $100,000.

With the current emphasis and concern over spiraling costs, this project could result in the savings of millions of dollars, reduced damage and interruptions to utility service, and the savings of lives and reduction of injuries.

PROBLEM NO. 2

I. Utility Attachments to Highway Bridge Structures

II. THE PROBLEM - There is a great disparity, from state to state, with regard to how and what utility is allowed to utilize a bridge structure to cross a physical obstruction.

Utility lines must cross streams, highways, railroads and other physical obstructions during their normal practice of connecting source or supply to treatment or usage. Construction of these crossings usually involve disturbance to the stream or traffic flow and always involve considerable expense to the utility owner.

III. OBJECTIVES - The objectives of this study would be to:

1. Survey present installation practices on all types of highway bridges (freeway, limited access, primary secondary roads and city streets).

2. Survey to quantify experience as to the effects of existing utility attachments to bridges:

   a. Pipeline electrolysis

   b. Installation of hanger anchors

   c. Use of utility sleeves (conduit)

3. Correlate data obtained from viewpoints of highway agencies and utilities.

4. Make recommendations concerning design parameters attachment to high-

way bridge structures that could be utilized by the various bridge authorities.

IV. CURRENT ACTIVITIES - Some governmental agencies prohibit pipelines carrying certain hazardous materials on bridge structures. Some agencies prohibit utility access through bridge abutments or anchor attachment to the bridge structure.

V. URGENCY - It is estimated that this study could be completed in 24 months at a cost of $100,000.

With the current emphasis and concern over spiraling costs, this project could result in the savings of millions of dollars each year.

B. PAVEMENT DESIGN - W.R. HUDSON, CHAIRMAN

A2B00 Pavement Design

PROBLEM NO. 1

I. NAME OF PROBLEM - Data Collection Needs for Pavement Rehabilitation and Pavement Management

II. THE PROBLEM - In the technical presentations of the 1980 FCP Review Conference, it was continuously repeated in the pavement sessions that "we have inadequate data to verify this result or that model, etc." In most instances, the data needed is time - history data of pavement performance. Active support is needed for setting up realistic sampling, data collection and data processing efforts for collection of such performance history data.

The same basic type of data is also needed for the entire pavement management process. The data is required at 3 levels of data intensity and breadth or data quantity.

1. Network Level. Relatively sparse annual sampling of a few variables such as a) serviceability or roughness, b) pavement distress or cracking, c) skid resistance and d) perhaps deflection or simple structural evaluation and maintenance costs.

2. Project Level. More detailed data on each project placed under construction or rehabilitation. More detailed samples of condition and structure as related to redesign and construction.

3. Research Verification. An intense study of a few existing pavement sections in detail with time history of performance, maintenance, costs, environment, etc.

III. OBJECTIVES - To outline pavement data needs and provide guidelines at three levels on a nationwide basis to begin codified development of an adequate data base for pavement management and improvements.

IV. CURRENT ACTIVITIES - At present no one is providing a coordinated nationwide data base. The FHWA planning activity, HPMS, is taking some data but none on a standard, stable basis of long term predictive value.

V. URGENCY - Very urgent to begin now. This data base should be national in scope in order to minimize cost to any single state. For example, only 20 sections per state would yield a total of 1000 in the nationwide data base; enough data to verify most pavement models. Consideration should be given to encouraging development of these data activities and continuing support for them. A project is probably needed to establish guidelines for these activities and for outling potential funding and realistic operational approaches to the problem.

PROBLEM NO. 2

I. NAME OF PROBLEM - Determination of Pavement Performance Models Using Combined Data from Accelerated Pavement Testing and Long Term Field Performance Observations

II. THE PROBLEM - It has been pointed out many times that the basic problem with improved pavement management or pavement design and pavement overlay methodologies lies in the improved modeling of pavement performance - time relationships. It is verified that the AASHO road test relationships are the best available pavement performance relationships available since they are used primarily in the AASHO

interim pavement design guides for performance relationships and serve as the design standard for the Federal Highway Administration and for most of the State Departments of Transportation in the USA. Recent research suggests that these AASHO road test relationships need considerable modification and verification for current construction and maintenance and rehabilitation conditions as well as for alternative environments. In the twenty years since the completion of the AASHO road test little significant improvements have been made in these observed relationships.

III. OBJECTIVES -

A. To develop reliable pavement performance relationships for a variety of environmental traffic and material conditions over the entire United States.
B. To relate pavement performance and life cycle histories to significant factors such as environment, traffic loading and maintenance practices.

IV. CURRENT ACTIVITIES - In 1964 and 1965 the National Cooperative Research Program recommended a series of pavement performance observations in NCHRP Report 2 and 2A. Subsequent developments in the pavement management field have outlined the value of improved observations of pavement performance. Many people have continually said since 1962 that we do "not have time to wait for observations of field performance to determine relationships." Nevertheless, considerable time has passed and no significant improvements in pavement performance relationships have been made. Thus, it appears obvious that conscientious observations of existing pavement performance are essential to the improvement of pavement performance and design relationships.

It is true that significant improvements and modifications in pavement materials have been made in the last ten years and will continue to be made. Therefore, it is highly desirable that they be combined with conscientious observations of existing pavements and accelerated testing. The Federal Highway Administration is developing an accelerated pavement testing system which potentially can be used to develop data related to the performance of new pavement materials and design systems. It is proposed in this problem statement that a combined approach be carried out beginning as soon as possible to collect significant information on the performance of pavement materials under a variety of traffic and environmental conditions and that this performance measure include observations of pavement performance in the field under existing conditions and under accelerated conditions.

Field conditions should include observations of already existing pavement sections, part of a network pavement management system. Equally important is the addition of the observation plan, an experimental or special sessions which are constructed as a result of innovative materials, construction or design techniques. Thus, in the final analysis it will be essential to combine: (a) the results of accelerated testing procedures, (b) the results of long term observations of existing pavements and, (c) the specialized field observation of test sections or experimental sections to develop the overall methodologies and models which will be needed for the management of the nation's pavement system in the future.

Potential Benefits - This research project can provide the information necessary to determine pavement performance relationships which are urgently needed by all highway agencies throughout the United States if improved pavement performance is to be obtained with existing design and construction methodologies.

IV. URGENCY - This research project is extremely urgent since the absence of rational pavement performance models is hampering the developing of improved pavement design and performance data throughout the United States at the present time. It is thus urged that conscientious field observations begin at the earliest possible date in as many states as possible and that the accelerated pavement testing program of the Federal Highway Administration be coordinated with this data collection operation.

Consequently, jointly it is extremely important that the experiment design associated with the experimental testing in the accelerated pavement program be well designed in order to provide statistically competent data that can be used for future performance predictions. Significant resources and time can be wasted unless satisfactory statistical relationships are employed in the accelerated pavement experiment design.

It is extremely important that this research problem statement be implemented at the earliest possible date. It is a trueism that performance of pavements takes a minimum of five years to provide significant relationships. Nevertheless, unless we begin these observations at the earliest possible date, we will never have the necessary data to improve/develop the performance relationships that are needed for improving pavement design and management techniques.

A2B01 Rigid Pavement Design - R.A.McComb

PROBLEM NO. 1

I. NAME OF PROBLEM - Structural Optimization of Pavement Cross Sections

II. THE PROBLEM - Deterioration of highway pavements, in many instances, develops initially along the edges of the pavement and on the wheel paths. This deterioration develops because of adverse load placement and distribution conditions and inherent weaknesses in the pavement along the edges. The concentration of wheel loads along the pavement edges results in high stresses in the concrete and foundation, and oftentimes nonuniform support to the slab because of pumping which results in cracking and faulting along the edges while other areas of the cross selection may be structurally sound.

III. OBJECTIVES - The objective of the research is to develop methodology which will provide equal service life over the full pavement cross section. Specific objectives are to evaluate the effects of load placement, shoulders, proper drainage across the section, nonuniform slab and/or base thickness, reinforcement in specified areas, and variable traffic distribution.

IV. CURRENT ACTIVITIES -

A. The U.S.Army Corp of Engineers Waterways Experiment Station has just completed a study sponsored by the Federal Highway Administration to evaluate the effects on load placement, pavement cross sections, and traffic distributions on pavement performance (deterioration).

B. Suggested key words: Highway pavements, rigid pavements, structural design, performance,deterioration, cracking, pumping, fatigue, traffic distribution, load placement.

V. URGENCY - This study is considered important and of immediate value because of the deterioration of the interstate system and the need to rehabilitate this system in a fashion which will preclude development of similar deterioration. In addition, the need exists to fully utilize the entire pavement structure to avoid wastes of natural and monetary resources.

PROBLEM NO. 2

I. NAME OF PROBLEM - Effects of and Preventive Measures for Nonuniform Foundation Support for Rigid pavement Slabs

II. THE PROBLEM - Distress in rigid pavement can be related to the nonuniformity of support for the slabs resulting from such phenomena as warping or curling of the slabs, localized weakening of the foundation materials due to moisture, freezing and thawing, etc., differential subgrade movements, and erosion of foundation material due to pumping action. Since most, if not all, current design procedures assume uniform foundation support for thickness designs, the nonuniformity that develops results in premature slab cracking and/or unacceptable roughness requiring excessive maintenance or early rehabilitation.

III. OBJECTIVES - The objectives of this research are to assess the effects of nonuniform foundation support on rigid pavement performance and to develop methods for either preventing the occurence of nonuniform support and/or consideration of the effects of nonuniform support in determination of the thickness of rigid pavement which will yield the desired performance.

IV. CURRENT ACTIVITIES -

A. Highway research in progress has already been scanned in preparing this statement.

B. Suggested key words: rigid pavements, distress, foundation support, warping, curling, pumping

C. Several projects are determining the performance of rigid pavements and assessing both their structural

and functional conditions; however, little, if anything, is being done to determine how much of the adverse performance is attributable to nonuniform foundation support. In addition, only limited work has been accomplished to identify the sizes of voids in pavements and to introduce methodology which will recognize and account for nonuniform foundation support in design procedures.

V. URGENCY - The study on nonuniform foundation support for rigid pavements is considered highly important to the development of designs which will have higher probability of planned performance and thus savings of maintenance or rehabilitation resources.

PROBLEM NO. 3

I. NAME OF PROBLEM - Composite Design in Rigid Pavement Structures (with Special Application to Econocrete Composite Base Pavements)

II. THE PROBLEM - For many areas of the nation where quality concrete aggregates have become scarce or depleted, economy and ecology considerations may dictate that lesser quality aggregates be used. These aggregates may be incorporated into an econocrete composite base structure upon which is placed a relatively thin bonded wearing course. Presently, no design procedure is available to permit design of a composite rigid pavement.

III. OBJECTIVES - The realization of the inherent properties of econocrete is fully utilized in a composite design with the two layers intimately bonded. A composite design procedure should take account of physical properties of the component layers of the pavement system as well as appropriate traffic design data. Attention should be given to interface shear between the two top layers. A theoretical design procedure should be verified through applicable laboratory and field tests.

IV. CURRENT ACTIVITIES - Econocrete has found its widest use as a subbase for rigid pavements or as a base for flexible pavements. It has also been used for pavement shoulders, walkways, and light traffic roads. Layered system theory has been applied to provide a rational design procedure for composite pavements, but additional theoretical work is desirable ---coupled with appropriate field and laboratory tests.

V. URGENCY - The composite econocrete pavement system is a viable solution to pavement needs in areas deficient in quality aggregates, offering in many cases, economical, environmental, energy advantages.

A2B02 Flexible Pavement Design - R. G. Hicks

PROBLEM NO. 1

I. NAME OF PROBLEM - Thickness Design Coefficients for Energy Efficient Paving Materials

II. THE PROBLEM - Thickness Design Coefficients give the Structural Number of a pavement which links the design to expected performance. These were developed based on materials used at the AASHO Test Road. Subsequently, coefficients for other materials have been used in structural number calculations by various agencies.

Recently, there has been an uncertain supply of petroleum based products essential in transportation, and depletion of readily accessible high quality aggregate sources. Many agencies have salvaged old asphalt and concrete pavements, while others have utilized marginal and waste materials. It is essential that applicable thickness design coefficients be found for these materials.

Since it is unlikely these materials will fit narrow specifications, applicable thickness design coefficients should be found through a consistently applied procedure of laboratory or full scale testing.

III. OBJECTIVES - Develop a laboratory evaluation procedure which will provide adequate guidance on applicable thickness design coefficients for salvaged, marginal and waste paving materials.

A suggested test series is to run repeated load permanent deformation tests on 4 by 8 inch cylinders of various materials. Then cutting the cylinders in half and testing for unconfined compressive strength and modulus using 4 by 4 inch cylinders as per ASTM-D-1074. Beam fatigue tests should be run to develop plots of strain level versus loads to failure.

IV. CURRENT ACTIVITIES - Many agencies

are proceeding with mechanistic methods of pavement design which require materials to be characterized through specific methods of test.

V. URGENCY - Uncertain supplies of petroleum products are creating a growing demand for recycled paving materials. Environmental restrictions have increased use of marginal and waste materials. There is increasing pressure to approve higher permissible axle and gross vehicle weights. Therefore, pavement designers urgently need guidance on applicable thickness design coefficients for these energy efficient materials.

PROBLEM NO. 2

I. NAME OF PROBLEM - Flexible Pavement Structural Design Requirements for Low-Volume Roads

II. THE PROBLEM - There are no flexible pavement design procedures that have been specifically tailored for low-volume roads. Those in use today were developed for higher-volume highways and are intended to determine the design required to provide satisfactory service for a specific period of time with only minor structural maintenance. These procedures are being extended to low-volume roads which constitute the majority of the total highway mileage but are funded at a lower level than most highway systems. Concern has been expressed that current procedures tend to overdesign pavements for low-volume roads relative to the overall needs and available funds. Because of the low traffic volumes, many believe that lower levels of service can be performed during the pavement service life on low-volume roads than on higher-trafficked highways, which will permit stretching the available dollars to more miles of roads to better meet the overall needs. Support for this belief is expressed by the practice of many local agencies in utilizing stage construction in the design of new roads and tending to postpone indefinitely the construction of the second stage.

III. OBJECTIVES - The objectives of this study are to determine satisfactory levels of service for low-volume roads that are consistent with the needs and available funds, and to establish criteria that can be used to either modify existing methods or develop new flexible pavement structural design methods specifically tailored to the needs of low-volume roads.

IV. CURRENT ACTIVITIES - A variety of research activities are ongoing in the area of flexible pavement design but are not specifically addressing the needs of low-volume roads relative to the structural aspect. Those pertaining to low-volume roads are mostly directed toward geometric design and safety standards. The need for this type of work is expressed in the announcement and call for papers for the Second International Conference on Low-Volume Roads held August 20-23, 1979, at Ames, Iowa

Suggested key words - Flexible pavement, structural design, low-volume roads, surface distress, structural maintenance, pavement service level, performance, terminal Serviceability Index.

V. URGENCY - The problem is of high priority among local agencies, and the results will be of immediate value in the refinement of flexible pavement design procedure to respond to the specific needs of low-volume roads.

PROBLEM NO. 3

I. NAME OF PROBLEM - Effects of Environment and Traffic on Pavements

II. THE PROBLEM - The AASHO Road Test, conducted in 1958-60, was an accelerated test, and no comprehensive study could be made of the long-term environmental effects on pavement behavior. Loop One, in which most of the structural designs of the controlled-traffic test loops were incorporated, is in place today without ever having carried traffic. Also, in place as a part of Interstate 80 are many of the survivor test pavements from the original traffic tests which have now carried mixed traffic. Other sections of our Interstate system, such as parts of the New Jersey Turnpike, various parkways and expressways throughout the country, serve only automobile traffic with no heavy axle loads. Opportunities exist to explore the effects in the four environmental zones (wet-freeze, wet-no freeze and dry-no freeze) of automobile and mixed traffic interacting with the environment.

III. OBJECTIVES - The goal of this study is to develop logical regional factors for flexible pavement design. A

corollary output will be damage functions (equivalency factors) for an equitable cost allocation system to finance our nation's roads.

IV. CURRENT ACTIVITIES - A recently awarded FHWA research contract is entitled "Load Versus Environmental Effects for Zero-Maintenance." Another FHWA planning study will formulate a cost allocation system.

V. URGENCY - This research is urgently needed to develop a cost allocation procedure. As a result, the highways and roads should also exhibit improved performance and become more desirable public facilities.

A2B04 Surface Properties - D. L. Ivey

PROBLEM NO. 1

I. NAME OF PROBLEM - Short Term Pavement Slipperiness

II. THE PROBLEM - Pavements are frequently slippery for short periods or over short stretches, but long enough to present hazardous driving conditions. Examples are: Curves and other non-tangent sections; newly paved surfaces; patched surfaces; some pavements after start of rain; new mix designs with rapidly dropping resistance; pavements adjacent to roadwork.

III. OBJECTIVES - To identify pavements which may cause problems as defined above; to determine the causes for this condition; and to recommend steps for remedying the situation.

IV. CURRENT ACTIVITIES - One research study is underway which addresses skid resistance measurement in non-tangent sections.

V. URGENCY - Localized slippery conditions are usually recognized after a series of accidents. Prior identification is an urgent need.

A2B05 Pavement Condition Evaluation - K. H. McGee

PROBLEM NO. 1

I. NAME OF PROBLEM - Development of Guidelines for Control and Acceptance of Pavement Ride Quality

II. THE PROBLEM - There is mounting evidence that both maintenance and road user costs of highway pavements are related to the ride quality of those pavements. Other factors being equal, it can be assumed that pavements constructed with good ride quality will retain relatively better ride quality than pavements constructed rough. Therefore, pavements built with good ride quality should have relatively lower levels of maintenance and user costs for the life of the pavements.

There is little or no agreement within the highway industry as to how ride quality should be specified, how it should be controlled by the contractor, and how it should be accepted by the specifying agency. Many agencies have straightedge requirements on surface tolerances. These requirements, however, have not been shown to be directly related to ride quality as measured by most modern roughness measuring devices. Some agencies have instituted specifications where acceptance is based on the achievement of some minimum level of roughness as determined by a passenger car mounted device. At least two problems arise with these specifications: (1) the contractor has no way of knowing whether or not he is meeting the specification until after the fact, i.e., no good control method exists, (2) poor reproducibility of test results, particularly between supposedly identical devices, may mean that the accepting agency has a low level of confidence in its test results. It is anticipated that appropriate study would lead to the development of workable guidelines for pavement ride quality.

III. OBJECTIVES - The objective of the research is to develop workable guidelines for obtaining acceptable pavement ride quality. Such a guideline would identify the parameters relevant to ride quality, the methods of contractor control, and the approach to agency acceptance. Among the specific research activities one could define for the project are:

1. A literature search of the construction factors influencing pavement ride quality.

2. The identification of methods whereby contractors can obtain the ride quality of pavements they contract.

3. To assess the types of economically feasible equipment available for the determination of ride quality.

4. The identification of an accept-

able level of ride quality.

5. The development of appropriate guidelines for obtaining and specifying ride quality. The guidelines could include price adjustment factors, if appropriate. It is anticipated that price adjustment factors might be related to projected increase in maintenance or user costs as ride quality deteriorates below acceptable levels.

IV. URGENCY - Many highway agencies could make immediate use of the results of this project if successfully completed.

PROBLEM NO. 2

I. NAME OF PROBLEM - Research Proposal for the Development of Data Reduction procedures for Road Profile Measurements

II. THE PROBLEM - Although a method has been developed to bring an exact copy of road surface profile to the computer for analysis, the significant task remains to develop data processing methods for the reduction of the large volume of data into meaningful management information for the highway engineer. This task is even more difficult because the computer programmer who will develop the methods to be used must first determine from the highway engineer what information is required and how to process the road profile data to produce this information.

III. OBJECTIVES -

A. To determine the needs of the highway engineer that can be met by the appropriate data processing of road profile measurements that have been made and stored in magnetic tape for further data processing.

B. To determine what road profile data processing programs have already been developed by existing users of road profile measuring equipment.

C. Develop the requirements of a library of road profile data reduction programs that will meet the needs of the highway engineer in the management of the highway pavement system including the cost benefits associated with the proposed programs.

IV. CURRENT ACTIVITIES:

A. Highway Research in Progress Area One (Pavement), HRB and TRB Records 121, 214, 291, 311, 362, 471, 584, HRB Special Reports 116 and 133 and other HRB and TRB publications have been scanned in preparing this statement.

B. Suggested key words for this problem are:

Data Reduction Procedures
Data Processing Methods
Road Profile Measurement
Computer Program
GMR Profilometer
Pavement Management System
Serviceability Index (SI)
Road Roughness
Bituminous Fill Computation
Power Spectrum Analysis
Mays Meter
BPR Roughometer
Rolling Straight Edge

C. Several states, including Kentucky, Michigan, Pennsylvania, Texas and West Virginia, have developed computer programs for the reduction of road profile data to assist in the management of their highway pavement system.

Even with this start a significant amount of work remains to be done to bridge the gap between being able to measure road profile and being able to use the information contained in those measurements.

Programs that have been developed include:

1. The computer simulation of other measuring devices such as BPR Roughometer, Mays Road Meter and the Rolling Straight Edge,
2. Mays Road Meter correlation program,
3. Bituminous Fill Computation,
4. Serviceability Index (SI),
5. Power Spectrum Analysis, and
6. other selected methods for analyzing the amplitude - wave length content of the measured road surface profile.

V. URGENCY - The GMR Profilometer has been available to the highway community for fifteen years. It is presently used in five states as an effective tool in their pavement management system. However, one reason it is not used more extensively by more states is absence of a cost effective library of road profile data analysis and reduction computer programs to assist the highway engineer in his pavement management task.

A2B06 Theory of Pavement Systems - R. C. G. Haas

PROBLEM NO. 1

I. NAME OF PROBLEM - Shift Factors for Fatigue and Rutting in Flexible Pavements

II. THE PROBLEM - Fatigue and rutting distress are prime determinants of the service life of flexible pavements and it is difficult, if not impossible, to predict the appearance of these from laboratory test data alone. For example, laboratory fatigue data must be "shifted" by a factor of 10 to 30 to predict the actual number of load repetitions that are required to cause alligator cracking. The increase of rut depth does not appear to be predictable without making similar adjustments in the laboratory measurements of the permanent strain characteristics of each of the layers. There are good reasons to believe that these "shift factors" may be the result of the build-up and relaxation of residual stresses in the pavement layers in place. Determination of "shift factors" by making empirical correlations between lab test data and observed performance of test sections is a very expensive and time-consuming process. It should be possible to predict "shift factors" on fatigue and rutting from permanent strain and creep properties of the layered materials either as they are measured in the laboratory or, more appropriately, in place. Developing the methodology for measuring permanent strain and creep properties of materials in place together with analytical tools which can use these data to predict stresses in pavements should permit the calculation of realistic shift factors and eliminate the need for a large number of costly full-scale tests. It will also provide the capability of predicting the expected service life of existing pavements and of pavements to be constructed of new and previously untried materials.

III. OBJECTIVES -

1. To develop testing equipment and the associated software that is capable of measuring permanent strain and creep properties of pavement materials in the field.
2. To develop analytical methods that are capable of predicting residual stress histories in pavements.
3. To develop a procedure for calculating shift factors for fatigue and rutting which make use of measured permanent strain and creep properties of the layered materials as well as traffic rates.
4. To verify the procedure by comparison with the results of full scale tests that have already been conducted.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas have not been scanned in preparing this statement.

B. Suggested key words: residual stresses, creep, permanent strain, fatigue, rutting, shift factor, remaining life, prediction.

C. Two reports by Texas Transportation Institute show the results of calculations of the build-up of residual stresses and permanent strains in pavements. Some previous work in this area has been done in Australia at the University of New South Wales.

V. URGENCY - As more new materials are proposed for use in pavements to replace or extend asphalt the need for a procedure to accurately predict the remaining fatigue and rutting life of pavement, to extrapolate the results of accelerated tests on pavements to in-service conditions becomes more critical. The cost of construction and evaluation of test sections and the time delay while waiting for distress to appear require a less expensive, more rapid, and reliable method of assessing the merits of these new paving materials.

PROBLEM NO. 2

I. NAME OF PROBLEM - Weigh-in-Motion Truck Data

II. THE PROBLEM - An unbiased sample of heavy commercial vehicles is difficult to obtain with pit scales and portable scales because they can be avoided by truckers, and because of the limitations of time and location inherent with such scales. Consequently, there is uncertainity in the knowledge of traffic loading and in data for pavement design, for determining the effectiveness of truck weight enforcement, and for determining the effects of changes in load legislation on user patterns. Weighing vehicles in motion in the undisturbed traffic stream is an ideal way of obtaining unbiased data, particularly if the weighings are a continuous record of vehicle and axle weights, axle spacings, vehicle speed,

vehicle spacing, and time of day. Currently available weigh-in-motion equipment leaves much to be desired in the way of reliability of operation, particularly under adverse winter conditions, and in the degree of maintenance and attendance needed.

III. OBJECTIVES -

1. To test and evaluate new improved weigh-in-motion scale systems which appear to have solved many of the scale operation problems encountered with earlier scales.
2. To develop the most promising weigh-in-motion scale equipment so that it can be introduced as part of a weigh-in-motion data collection system.
3. Prepare typical data analyses and summary output formats, and the software programs to handle the large volumes of data which will be collected.
4. Prepare and evaluate alternative deployment scenarios for data collection with weigh-in-motion scales, using numbers of scale locations, permanent stations, and portable equipment as variables.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas have been scanned in preparing this statement.

B. Suggested key words: weigh-in-motion.

C. The Roads and Transportation Association of Canada has a project committee working on the development of the University of Saskatchewan scale in 4 Canadian provinces.

V. URGENCY - There is increasing demand for higher permissible vehicle load limits particularly with rising costs of fuel. Assessment of the effects of higher loads on existing pavement structures, on effectiveness of enforcement, and on changes in user patterns instituted by legislative changes, can be carried out more confidently with unbiased data from weigh-in-motion systems.

PROBLEM NO. 3

I. NAME OF PROBLEM - Rational Explanation and Derivation of Equivalency Factors

II. THE PROBLEM - Axle load equivalence factors were first developed on a large scale at the Ottawa, Illinois Road Test and have since been verified in several other tests. However, the factors are difficult to understand cannot be easily related to other applications or changes in conditions for instance:

18^k Single Axle Equivalency Factors

	Single Axle 18,000 lbs.	Two Single Axles 18,000 lbs. Each
Flexible	1.0	1.0 + 1.0 = 2.0
Rigid	1.0	1.0 + 1.0 = 2.0

	Tandem Axle 36,000 lbs.	Tri-Axle 54,000 lbs.
Flexible	1.38	?
Rigid	2.43	?

Current State Agencies are having to evaluate proposed changes in truck axle weights and configurations to be presented in a manner that can be understood by laymen.

The change in pavement performance between P. cement concrete and asphalt concrete due to the change in tandem axle equivalences from that of single axle is difficult to defend.

It is often necessary to attempt an evaluation of change in a time frame that does not allow adequate investigation and interpretation.

III. OBJECTIVES - The objective of this research is to provide agencies with design information needed to evaluate the effect of changes in axle weights and configurations, including types and pressures of tires in a minimum time.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress has not been scanned in preparing this statement.

B. Suggested key words: axle, equivalence, performance, weight, configuration

C. Several reports have verified equivalency factors or developed factors for other loads but only for the same type of pavement or for a particular wheel configuration.

V. URGENCY - A study of the correct application and usage of axle equivalence factors is urgently needed to enable agencies to evaluate proposed changes in truck weight and configuration laws.

A2B07 Strength & Deformation Characteristics of Pavement Sections - A. N. Hanna

PROBLEM NO. 1

I. NAME OF PROBLEM - Setting Clear Cut Standards for Determining Laboratory Mechanical Properties of Materials

II. THE PROBLEM - There are presently at least 15 procedures on the market for determining the fatigue characteristics and several methods for permanent deformation, modulus, and creep compliance for pavement component materials. Here we refer to pavement components because of the onslaught of new materials or modified conventional materials finding their way into actual construction. These materials have properties quite different from conventional asphalt concrete or plain Portland cement concrete and it is imperative that they be known. It is actually more so important to evaluate these newer materials because little or no past preformance histories are available to assist in their design. More and more highway departments are asking questions viz. what is the structural capacity of the new "popcorn" mixes, does sulphur asphalt mixes or Sulphlex perform better in fatigue than conventional asphalt concrete mixes, and is that fatigue performance different at elevated and at low temperatures. All of a sudden then it is anticipated that highway departments will seek to find ways of answering these questions. What they will find is a conglomerate of procedures each quite different from another i.e., should strain gages or LVDT's be used or should confinement be applied to specimens at high temperatures and if they are at what temperature should they not be applied. The problem then is one of developing simplified testing procedures, clearly written and well documented so that they can be used to determine the structural properties of pavement components.

III. OBJECTIVE - Develop clearly written test procedures and standard methods that are easy to follow but which incorporate the latest technology, including instrumentation, mathematical techniques, and the best of the available information in the area.

NOTE: This objective applies solely to the following properties: creep compliance, permanent deformation, fatigue, and modulus.

IV. CURRENT ACTIVITIES - There is no current activity specifically related to the development and standardization of test procedures.

V. URGENCY - Urgently needed so that new materials are not haphazardly used and so to protect our large investment in our nation's highways.

C. STRUCTURES - L. Oehler, Chairman

A2C01 General Structures - H. P. Loretzky

PROBLEM NO. 1

I. NAME OF PROBLEM - Acquisition of Data on Cyclic Stresses in Railroad Bridges

II. THE PROBLEM - In order to provide a design methodology for railroad bridges, both analytical and experimental techniques for predicting the loading history and the resulting stress history of railroad bridges from samples of current loading are needed.

III. OBJECTIVES - The major objectives are:

1. To compile a state of art review of existing stress history data from the United States and abroad so that the trends and characteristics of the stress range frequency distribution and the cycles for train passage can be identified.

2. Develop a program for acquiring the stress history of a number of bridge elements identified as critical when subjected to current load conditions.

3. Evaluate the data acquired so that characteristic stress history-frequency distribution curves can be developed for the typical types of main load carrying and auxiliary load carrying members in railroad bridges.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas are not applicable to this problem.

B. Suggested key words: cyclic loading, stress history, railroad bridges.

C. Some work on this problem has been done in recent years by the Canadian National Railways. Other recent studies have been undertaken in Europe under the auspices of the Organization of the European Railroads.

V. URGENCY - Recent developments in new cars and train loadings, the use of higher strength steels, and new welded bridge designs which are lighter than the old rivoted structures may have resulted in substantial changes between the calculated design stress and the

actual stress spectrum to which a railroad bridge is subjected. The response of older structures to new cars and train loadings needs further definition and there is an urgent need to acquire additional information on the stress range spectrum that is imposed on various railroad bridge components.

PROBLEM NO. 2

I. NAME OF PROBLEM - Survey of Characteristics of Overloaded and Oversized Highway Vehicles

II. THE PROBLEM - There has been an increase in the use of overloaded and oversized vehicles in the transportation network. Furthermore, some of the vehicles that used to be considered as overloaded and/or oversized, that required permit applications, no longer require them due to the legal across the board increase in limits. This increase has been dictated because of the economical advantages that the larger vehicles offer. It will be prudent to expect that there may be requests in the near future for additional increases in the limits. Frequency of the traverse of the overloaded and/or oversized vehicles has not been compiled on a nationwide basis. The effect of these vehicles on the deterioration of the transportation network has not been quantitatively defined, regardless of how approximate it may be.

III. OBJECTIVES - The research is intended to provide a compilation of the pertinent characteristics of the oversized, and overloaded vehicles such as the dimensions, axle weights, axle spacings, number of wheels per axle. The information is to be provided by the Departments of Transportation, carriers, and the field observations that have been made. The vehicles are to be grouped depending upon their pertinent characteristics, and the frequency of travel of these vehicles is to be determined. With available methodology, what type of vehicles should be considered as severely effecting the safety of the transportation network and its operation is to be determined.

IV. CURRENT ACTIVITIES -

A. Currently research is being conducted, and some has been completed, in a number of institutions such as Lehigh University, Case Western Reserve University, etc. Most "districts" of the states have been compiling information on overloaded and oversized vehicles. The predictions on the frequency of travel of these vehicles have already been completed by Roy Jorgensen and Associates, and Western Highway Institute, amongst many others.

B. Suggested key words: overloaded vehicles, oversized vehicles, permit operations, bridge and pavement deterioration, safety.

V. URGENCY - In view of the use of different design standards by different states and the interstate nature of the problem, and especially because of the recent increases in the permissible limits, it is essential that the effects of these be both qualitatively and quantitatively defined, where possible. The recent increases and especially the future increases may grossly alter the safety and rate of deterioration of the highway system. This issue is widely known and has been reported in the media.

PROBLEM NO. 3

I. NAME OF PROBLEM - Serviceability Limits for Highway Bridges

II. THE PROBLEM - Highway bridges need continuous maintenance, repair, and replacement. Uniform qualitative and quantitative criteria for the identification of the deteriorated components of the superstructure, and the amount of the deterioration, are not available. In view of the urgent need for bridge rehabilitation programs that may be implemented in the near future, it is essential that guidelines as such be developed through the integration of the contributions of the Departments of Transportations, reflecting their practices, and of the available research findings and field observations.

III. OBJECTIVES - The objective of the research is to develop broad based guidelines that can be used in the definition of the components of highway bridges that are in some state of distress and the extent of the deterioration towards the assignment of priorities in bridge rehabilitation. The research is to be confined to steel, reinforced or prestressed concrete bridges, or their combination thereof, with deck and girder systems.

IV. CURRENT ACTIVITIES -

A. There have been various research projects completed, being executed, and envisioned by research institutions. There also exist, to

varying extents, guidelines that are being employed by the Departments of Transportation. The findings, however, have not been available in the unified form.

B. Key words: bridge superstructures, serviceability limits, deterioration, rehabilitation.

V. URGENCY - In view of the recent public cognizance of the distressed state of highway bridges, initiation of a nationwide bridge rehabilitation program is expected. A unified national effort will require the availability of guidelines that can be used for the identification of the bridges that need rehabilitation, and the urgency for any given bridge. To expedite these multibillion dollars worth of activities initiation and completion of the proposed research is imperative.

PROBLEM NO. 4

I. NAME OF PROBLEM - Development of Concise Criteria for Determining Highway Bridge Deck Acceptability

II. THE PROBLEM - A massive national effort is about to be launched to rehabilitate or replace a major portion of the Nation's bridges -- and the methods for determining whether or not a deck is acceptable have not been clearly defined. As a result, public agencies consider themselves forced to engage in exhaustive tests before making a decision. The value and applicability of many of these tests, which are available for use on specific structures, has not been determined on the basis of an overall review.

III. OBJECTIVE - The objective is to develop a definitive statement relevant to this problem, so that future decisions to rehabilitate or replace a particular concrete bridge deck can be made in a minimum amount of time, utilizing a minimum of indicated test procedures.

IV. CURRENT ACTIVITIES - Highway Research in Progress has not been investigated due to the lack of time available for preparing this statement. It is clear, however, that many research projects relating to the problem have been completed, or are in the process of being completed -- but the problem itself has not been addressed by a committee such as a TRB Committee which could formulate a procedure which could have a substantially-beneficial impact on this national problem were it adopted by other technical groups and public agencies.

V. URGENCY - Because of the rapidly-escalating effort to improve the condition of this Country's bridges, it is considered urgent that a criteria be developed such as that suggested in this statement.

PROBLEM NO. 5

I. NAME OF PROBLEM - Effectiveness of Waterproofing in Arresting Highway Bridge Deck Deterioration

II. THE PROBLEM - Many engineers believe that bridge deck deterioration due to corrosion of embedded reinforcing steel is arrestable by the application of a waterproofing layer such as a high-density concrete overlay -- which, while permitting water vapor to escape, prevents water and deicing salts from continuing to penetrate the structural slab. There has been no definitive research to indicate whether or not such waterproofing will arrest concrete bridge dick deterioration once that deterioration has actually begun, if in fact a waterproofing system is developed which is truly "waterproof".

III. OBJECTIVE - The objective is to develop -- on a partially-deteriorated concrete deck -- a conclusive demonstration for two types of waterproofing (one which permits the passage of water vapor, and one which does not) to determine whether or not the deck deterioration continues or is arrested, in order that the deck may remain in service. The development of specific techniques and products to achieve the result is another matter and has been the subject of much research, but a clarification of the result that could be expected has not been achieved.

IV. CURRENT ACTIVITIES - Highway Research in Progress has not been investigated due to a lack of time available for preparing this statement. It is not believed, however, that the basic question has been undertaken: whether or not preventing moisture from continuing to reach a damaged structural slab will arrest further deterioration.

V. URGENCY - Because of the rapidly-escalating effort to improve the condition of this Country's bridges, it is considered urgent to develop a solution to the basic question posed in this statement. The question of the effectiveness of various waterproofing techniques has been researched without

addressing the suggested basic question.

A2C02 Steel Bridges - J. W. Fisher

PROBLEM NO. 1

I. NAME OF PROBLEM - Interaction of Bracing and Secondary Members with Main Bridge Components

II. THE PROBLEM - Various assumptions made in bridge design are not born out by the actual bridge response. Recent experience indicates the need to more realistically predict loads and stresses in secondary members and what effect the secondary members have on load distribution to and stresses in main members. An additional critical consideration is the effect of displacements caused by secondary members on the main members.

Bridge specifications require various types of secondary members to resist wind and lateral loads. The secondary members are not counted upon in the analysis for primary loads. Furthermore, they may be responsible for displacement induced stresses that are not accounted for in the design.

III. OBJECTIVE -

1. To study the need for secondary members and the results of designing a bridge with some or all secondary members omitted.

2. Develop an analytical model to predict the three dimensional response and load distribution with secondary member effects included.

3. Conduct laboratory and field experiments to verify the model.

4. Prepare design recommendations on the need for secondary members and how to fully utilize them in the design of steel bridges.

The main emphasis should be on composite and noncomposite girder bridge systems.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 27 has been scanned in preparing this statement.

B. Suggested key words: load distribution, secondary members, girder bridges, loads and stresses.

C. Many projects have been undertaken to determine the cause of distress in main components in specific bridges which appear to be related to the effect of secondary members. Minimal additional studies have been undertaken on the beneficial effects of secondary members. There have been no studies of the effect of reducing or eliminating secondary members. None of the previous work has been general or systematic enough to produce meaningful analytical models or design recommendations.

V. URGENCY - Many recent failures of bridge components have been attributed to loads and stresses carried by secondary members which were not accounted for in design. Guidelines are urgently needed for the design of new bridges and for maintenance of existing structures.

PROBLEM NO. 2

I. NAME OF PROBLEM - Design Loads for Long Span Structures

II. THE PROBLEM - Current bridge design specifications account inadequately for the load spectrum of current and future highway traffic. This is particularly true for longer span structures where the current design lane loadings may not be an acceptable approximation of the actual loading which the structure will have to support.

III. OBJECTIVES - The objective is to adequately define current and future load spectra and their probabilities for various structural limit states, in particular the loading for static strength and the spectra of load for repetitive considerations and other service conditions.

The spectra and their frequency of occurrence should be compared to current design practices and new design recommendations should be developed.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 27 has been scanned in preparing this statement.

B. Key words: loads, spectrum & probabilities, frequency of occurrence, bridges, static and repetitive load criteria.

C. There have been a number of projects which have attempted to measure the weights of vehicles traveling the highway system.

V. URGENCY - Years of research have been devoted to the behavior of structural members, but very little has been done in determining the true loads which

a bridge will be subjected to. This is particularly urgent in light of the increasing trend to greater legal load limits nationwide. Current design loads were developed over 30 years ago and no longer are applicable to our current and future highway system.

PROBLEM NO. 3

I. NAME OF PROBLEM - Redundancy and Rational Criteria for Damage

II. THE PROBLEM - Highway and Railway bridge design and construction specifications now require special procedures for the fabrication of steel tension members whose "failure would cause collapse of the bridge". These requirements are contained within a "Fracture Control Plan" (FCP) which puts restrictions on the material properties and fabrication, and requires that the design engineer identify those members of a bridge which must meet these special requirements. The tension members judged to be in this category are those which represent a singular path to resisting imposed loads and whose failure would be expected to result in the collapse of the bridge. They are called "Fracture Criteria Members".

III. OBJECTIVE - There are varied opinions however, by design engineers about which members or components of a bridge belong in the FCM category. For example, some designers consider any girder bridge having less than three girders as being a non-redundant system whose tension flanges and tension portion of the web are fracture critical. Others disagree and state that even a single girder bridge exhibits sufficient redundancy if it is within an interior span of a continuous structure with sufficient anchorage longitudinally and transverse torsional stability. Failure of an interior girder span may survive collapse because of the cantilever support from the adjacent spans.

IV. CURRENT ACTIVITIES - Research is urgently needed to provide sufficient background upon which a classification of tensile elements existing in the various types of steel bridges can be categorized as fracture critical or not. Elements may be categorized and prioritized for inspection frequency and degree. Work is also needed to establish the degree of damage that can be detected in these elements with usual means before failure and collapse can be expected.

The proposed research should conform roughly to the following outline:

A. Literature survey

B. Review available experience with tension member damage that was or was not easily detected and did or did not result in collapse. Observe also the apparent redundancy and the amount of redundancy actually exhibited.

C. Run analytical tests on typical bridge types as three dimensional models with various main tension members severed.

D. Include, where bridges to be demolished are available, full scale tests to determine actual redundancy.

E. Recommend and study new bridge types that will be optimum for preventing collapse by fracture.

V. URGENCY - The results of the proposed study should contain recommendations for identifying and categorizing non-redundant tension members in the various standard steel bridge types and suggest advantageous new steel bridge types. This could possibly be published as a companion guide to AASHTO Specifications; i.e. an appendix to "Guide Specifications for Fracture Control" or as an NCHRP synthesis or as an AISC Journal.

Results could also be of value in revisions to AASHTO's "Manual for Maintenance Inspection of Bridges", in identifying and emphasizing members which should receive more frequent and more thorough inspections, i.e. non-destructive tests.

A2C03 Concrete Bridges - J. W. Fisher

PROBLEM NO. 1*

I. NAME OF PROBLEM - Shear Strength of Joints in Precast Segmental Bridges

II. THE PROBLEM - Precast segmental bridge construction has gradually gained acceptance in the United States over the past ten years. Because of resulting economy, the number of bridges being built with this technique is now growing rapidly. Many designers are following European practice for these bridges. In some cases, European consultants are doing the design.

The prevailing method of casting uses match-cast segments. Single or multiple keys are used in the webs of many bridges to transfer shear between segments during erection. In some bridges, shear keys are not used. Epoxy resins are often used between adjacent segments. However, some

recent bridges have not used epoxy.

III. OBJECTIVE - To determine the shear transfer strength across joints between adjacent segments of precast segmental bridges. Joints to be considered should include single large key, multiple lug-keys and no keys. Dry and epoxied joints should be tested.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 27 has been scanned in preparing this statement.

B. Bridges, Epoxy Jointing, Prestressed Concrete, Segmental Construction, Shear, Shear Keys.

C. None to the proposer's knowledge.

V. URGENCY - Due to the rapidly growing number of segmentally constructed bridges, there is a need to understand characteristics of the different shear key configurations and the role of the epoxy in shear transfer. The research findings can be implemented through design recommendations for inclusion in the AASHTO Specifications.

PROBLEM NO. 2

I. NAME OF PROBLEM - Concrete Properties for Early Transfer of Prestress

II. THE PROBLEM - Because of advances in concrete technology, it is possible to produce relatively high strength concrete at ages of eight to twelve hours. To facilitate placing of concrete, super plasticizers are added to the mix. In plant produced pretensioned concrete members, requirement for transfer of prestress is based on specified concrete strength at transfer. Although specified strength is reached, cracks have been observed in pretensioned beams upon transfer.

III. OBJECTIVES - To determine properties of concrete loaded at very early ages. Relationship between tensile strength, modulus of elasticity, creep and compressive strength at these ages should be established. Concrete with and without super plasticizers should be considered.

IV. CURRENT ACTIVITIES - To the proposer's knowledge, no systematic program has been conducted to determine properties at early ages.

V. URGENCY - In recent years, precast industry has started to use super plasticizers to facilitate placing concrete. In some plants prestress is transferred after several hours, when specified compressive strength is reached. Cracks have been observed in such cases.

Research findings might be implemented through design, manufacture and inspection guidelines.

PROBLEM NO. 3

I. NAME OF PROBLEM - Corrosion of Tendons in Prestressed Concrete Structures

II. THE PROBLEM - Tendons embedded in prestressed beams were considered adequately protected against corrosion. Observation of older structures has revealed that moisture did infiltrate dense concrete cover and did penetrate along the tendons if exposed or through cracks in concrete cover in the beam end faces.

III. OBJECTIVE - To determine corrosion rates of tendons when protected by concrete, grouts, sheathings. To determine the remaining life of such tendons, the corrosion rate of such tendons and the allowable residual life (corrosion/pitting) of such tendons affected. Study effect of corrosion on failure due to stress corrosion and fatigue. Determine ways to prevent further moisture infiltration.

IV. CURRENT ACTIVITIES - Some state-of-the-art work is reported in the NCHRP Report 90 (1970).

V. URGENCY - To prevent cumulative damage of corroded tendons and entire structures, this problem deserves immediate attention. Increasing age of P/S structures makes this an urgent problem.

PROBLEM NO. 4

I. NAME OF PROBLEM - Shear Strength of Precast Bridge Beams Reinforced with Welded Wire Fabric

II. THE PROBLEM - Relatively short-span precast beams are used extensively in the low-volume bridge market. Cost of tee or channel sections for this market could be reduced if it were shown that straight sheets of fabric could be used to meet the minimum shear reinforcement requirements.

III. OBJECTIVES - Investigate the shear strength of tee- or channel-shaped precast beams containing minimum amounts of welded wire fabric used as shear reinforcement. Various end anchorage conditions need to be tested. Develop recommendations that will reduce cost without impairment of performance.

IV. CURRENT ACTIVITIES -

A. No review of HRIP has been made.

B. Suggested key words: design, shear, welded wire fabric, precast concrete, prestressed concrete, bridges, anchorage.

C. Related research - none known.

V. URGENCY - Execution of this program is expected to lead to cost savings for beams needed for the low-volume bridge replacement market.

PROBLEM NO. 5

I. NAME OF PROBLEM - Fatigue Strength of Reinforcing Bars at Bar Cut-off Locations

II. THE PROBLEM - Current highway bridge specifications limit the service load stress range to which a reinforcing bar may be subjected. Often, compliance with these requirements necessitates the extension of bar cut-off locations beyond those selected to satisfy Load Factor moment capacity. This is due to the high stress range calculated in the remaining bars at the theoretical moment capacity bar cut-off location. However, each bar to be cut off would be continued a sufficient distance beyond the theoretical cut-off point to allow for full development of the bar. Thus, at the theoretical bar cut-off location, the actual stresses in the remaining bars are considerably lower than calculated.

III. OBJECTIVES - To determine the fatigue susceptibility of the remaining bars at a theoretical bar cut-off location.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Area 27 has been scanned in preparing this statement.

B. Dynamic loads; fatigue (materials); loads (forces); reinforced concrete; reinforcing steels; specifications; structural design.

C. NCHRP Projects HR4-7 and HR4-7/1, Fatigue strength of High Yield Reinforcing Bars.

V. URGENCY - The research findings would be implemented through recommended specifications to AASHTO. The results from this research could result in savings in steel reinforcement at bar cut-off locations.

A2C06 Culverts and Hydraulic Design - R. A. Parmelee

PROBLEM NO. 1

I. NAME OF PROBLEM - Design Live Loads for Culverts

II. THE PROBLEM - Current design specifications for culverts having a shallow depth of cover require that live loading be considered in the design, and prescribe empirical procedures for distributing the static wheel loads through the soil to the exterior envelope of the culvert. These loading requirements do not appear to be consistent with the physical reality of the installation and/or the nature of the actual loading, and in many instances these design procedures lead to appreciable increases in the strength of the culvert which may not be necessary.

III. OBJECTIVE - The objectives of this research are to:

A. Perform an experimental study of the nature and distribution of live loads throughout the vicinity of the culvert. These full-scale field measurements must be taken on a variety of culvert systems and installation types.

B. Using the field data and appropriate analytical models develop new analysis techniques and design recommendations for the response of culverts to the dynamic effects of live loads approaching and passing over a buried structure.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas: (unknown).

B. Suggested key words: analysis, culverts, design, live loads.

C. A project has been initiated in Canada by the Ontario Highway Department to measure the distribution of static concentrated loads through shallow fills over long-span culverts.

V. URGENCY - Refined methods have been developed recently for the analysis

and design of soil-culvert interactive systems for the effects of loading imposed by the bedding and backfill. The empirical criteria for live loading has not been revised for years, and these simplified methods appear to be inconsistent with our current understanding of load transmission. It is believed that the successful completion of this project will lead to truly rational live load criteria, and result in more economical culvert installations.

D. BITUMINOUS - J. Welborn, Chairman

A2D04 Characteristics of Bituminous Paving Mixtures to Meet Structural Requirements - B. F. Kallas

PROBLEM NO. 1*

I. NAME OF PROBLEM - The Effects of Deviations from Mixture Designs on the Service Life of New and Recycled Bituminous Concrete Mixtures

II. THE PROBLEM - Experience has shown that unplanned deviation from mixture designs often results in reduced performance or service life for new and recycled concrete mixtures. While this fact generally is acknowledged in the literature, it does not contain the specific information necessary to predict the degree of reduced performance associated with the various deviations. This need is critical, considering the vast mileage of Interstate pavement rapidly approaching the rehabilitation stage.

The specifications governing this rehabilitation may be divided into two basic types. The first, commonly referred to as the method specification, contains numerous controls over materials, equipment, and construction procedures. Advocates of this approach feel that such controls are necessary to insure the quality of the finished product.

The second type, the end result specification, places no restriction on the materials to be used or the methods of incorporating them into the completed product. The buyer's responsibility is reduced to accepting or rejecting the final product. However, acceptance often entails application of a payment system which accounts for the degree of non-compliance. In theory, the end result specification allows the contractor latitude to develop innovative approaches that eventually should lead to higher efficiency and lower bid prices.

Regardless of the type of specification used, all highway agencies still need sufficient information to adequately predict the effect of deviations from mix design on pavement service life. With method specifications, this information is needed to dictate the degree of construction control required to assure a quality product. With end result specifications, the information should be the basis for payment adjustment factors. With both types of specifications, the knowledge is necessary to justify when the completed work should be totally rejected.

The data needed to quantify the effect of mixture deviations can best be obtained through extensive laboratory studies. Fatigue and deformation data should be generated using repeated load tests on laboratory specimens containing controlled deviations from an optimum mix design. The recycled and new bituminous concrete mixtures shall also be conditioned in the laboratory to evaluate the influence of climate variables (temperature, water-induced damage, etc.) on their structural properties. These data should then be evaluated through the use of theoretical models to predict the degree of reduced service life.

III. OBJECTIVES -

1. Determine mixture factors which affect pavement service life.
2. Determine the nature of the effects and relate to the deviation from an optimum mixture design.
3. Quantify these effects with respects to pavement service life.
4. Development payment adjustment factors and criteria for determining when total rejection is necessary.

IV. CURRENT ACTIVITIES - Suggested key words: Asphalt Mixtures, Mixture deviations, Mixture Performance, Serviceability, Payment Adjustment Factors, Specifications, Asphalt Mixture Design.

V. URGENCY - The study of effect of deviations from mixture designs is considered critical in view of the vast mileage of Interstate Pavement rapidly approaching the rehabilitation stage.

PROBLEM NO. 2

I. NAME OF PROBLEM - Properties of Emulsified Asphalt Mixtures for Highway Construction & Maintenance

II. THE PROBLEM - Considerable effort has been spent in recent years in developing information on the fundamental properties of hot-mix asphalt concrete and similar mixtures. However, comparatively little has been done to determine energy trade offs and properties utilizing emulsified asphalt mixtures. There is a need to develop more information on such fundamental mixture properties as dynamic modulus (resilient modulus), fatigue characteristics, resistance to permanent deformation (creep), of both uncured and cured emulsified asphalt mixtures and on how these properties affect structural design and performance of pavements constructed with such mixtures.

III. OBJECTIVES -

1. Determine the factors which affect curing of emulsified asphalt mixtures.
2. Determine the effects of curing, stress condition, temperature, and other factors on dynamic modulus (resilient modulus), fatigue and other fundamental properties of emulsified asphalt mixtures.
3. Determine effects of water and moisture vapor on fundamental properties of cured emulsified asphalt mixtures.
4. Determine the properties in the cured state to be used for structural design.
5. Relate the fundamental properties to structural design requirements and performance.
6. Devise a plan for collecting field data to determine possible long-term changes under various conditions of environment, etc.

IV. CURRENT ACTIVITIES - Suggested key words: Emulsified Asphalts, Emulsified Asphalt Mixtures, Structural Design, Thickness Design, Mixture Properties, Dynamic Modulus, Resilient Modulus, Fatigue Properties, Rutting, Optimization.

V. URGENCY - The study of emulsified asphalt mixtures is considered very important in view of their increased use throughout the United States.

A2D05 General Asphalt Problems - W. K. Parr

PROBLEM NO. 1

I. NAME OF PROBLEM - Criteria for Selecting the Optimum Grade of Asphalt for More Durable Pavements

II. THE PROBLEM - Hardness of the asphalt in asphalt concrete pavements often can be related to the performance and durability of the pavement. Initially, the hardness of the asphalt should be based on the selection of the proper consistency grade to accommodate pavement design, environment, long life and traffic loading conditions. Thereafter hardness depends on mixture design for optimum asphalt and void contents and construction factors such as type of mixing plant, time and temperature of mixing, placing and final compaction. After a period of time under traffic the void content should be reduced to an approximate range of two to four percent to result in a lower rate of hardening and a more durable pavement.

Current practice generally does not recognize the extent of the changes in asphalt properties during plant mixing, placing and compacting asphalt concrete when selecting the grade of asphalt in laboratory design procedures. Discrepencies have been observed in the amount of hardening that occurs in different types of modern mixing plants and the hardening that occurs in laboratory aging tests. Asphalt cements are known to differ in their susceptability to hardening as measured by laboratory thin-film heat tests. Either the thin-film TFOT or the rolling thin-film (RTFOT) tests are used by most of the states in the United States to evaluate the hardening characteristics of asphalt cements during plant mixing. However, there is substantial evidence that the increase in consistency of the residues from the above tests is appreciably greater than the increase in consistency resulting from asphalt mixing plants operating under normal conditions.

From the above discussion of the "Problem" there is a need to examine present criteria for selecting the consistency grade and amount of asphalt cement recognizing the hardening of the asphalt in laboratory heat and mix design procedures compared to the hardening that occurs during plant mixing, hot storage, spreading and compacting asphalt concrete mixtures.

III. OBJECTIVES - The primary objective of this research is to develop criteria for selecting the optimum grade and amount of asphalt for asphalt concrete mixtures to accommodate pavement design, environment, long life and traffic loading conditions to result in more durable pavements.

To obtain the above objective the following factors should be identified and evaluated:

A. The amount of hardening of the asphalt during mix design and testing procedures, and laboratory heat tests. Include differences in specification grading systems and the effect of temperature in mix design and the heat tests.

B. The amount of hardening that occurs in batch and drum-dryer type mixing plants. The effect of the following variables should be included:

1. Time of mixing
2. Mixing temperature
3. Moisture content of the aggregate before and after the drying process and the amount remaining in the mix.
4. Temperature and time of asphalt concrete in storage systems (surge and storage).

C. Evaluate viscosity and penetration systems in relation to the hardening that occurs during (A) mix design and (B) plant mixing.

IV. CURRENT ACTIVITIES - When drum-dryer mixers first came into common use there was a tendency to operate the plants at lower mixing temperature resulting in asphalt binders of lower viscosity or higher penetration. The lower mixing temperature also resulted in higher moisture contents in the mix. At times this resulted in stripping and contributed to the "tender" mix problem. Some of the States relaxed the heating and moisture requirements on the basis of energy savings. More recently there is a move to increase the mixing temperature and lower the maximum moisture requirements. Only limited factual information has been published and to our knowledge there is no comprehensive research underway to resolve the problem.

V. URGENCY - The advent of the drum-dryer mixing process and the varied asphalt supply since the embargo make it an urgent task to develop the data proposed in this study. Such information will provide the basis to develop criteria for selecting the optimum grade of asphalt for more durable asphalt concrete pavements.

E. CONCRETE - C. F. Crumpton, Chairman

A3E01 Performance of Concrete-Physical Aspects - D. Stark

PROBLEM NO. 1*

I. NAME OF PROBLEM - Significance of Laboratory Tests as Related to Concrete Field Performance

II. THE PROBLEM - Many laboratory tests are run on concrete in an effort to predict performance of similar concrete in the field. Laboratory freezing and thawing, alkali -aggregate reactivity, and concrete strengths are examples of such tests. Little definite research has been conducted to specifically correlate such tests, which are run under controlled laboratory conditions, with the performance of the concrete under actual field conditions.

III. OBJECTIVES - The objectives of the proposed research can be categorized as follows:

1. Evaluation of the problem of establishing failure criteria in the field.
2. Development of laboratory tests that will relate properties of concrete to concrete failure in the field.
3. Evaluation of current laboratory tests for their usefulness in relating properties of concrete to concrete failure in the field.
4. Developing procedures of using test results to predict probability of failure.

What constitutes failure of concrete in a transportation related structure is most difficult to answer. It is suggested that for each service environment and each level of service, failure criteria must be established. In order to make the task manageable, the research problem should be restricted to highway concrete pavement and concrete bridge decks. Failure criteria to be established might consider factors such as micro- and macro-cracking, deflection, disintegration, abrasion, volume change, and aesthetic qualities. Scaling, D-line cracking and popouts are typical of outward signs that should be evaluated as to how much can be tolerated before failure is reached.

Existing tests along with any new test procedures should be selected and demonstration projects should be developed to show how the test results can be used to predict failure.

IV. CURRENT ACTIVITIES - Many Departments of Transportation in the course of daily activity are collecting the information that should prove to be essential in accomplishing this project. A survey of these activities should be considered part of this project. As an example of what is meant, several agencies used ASTM C 666,

Standard Method of Test for Resistance of Concrete to Rapid Freezing and Thawing, and in so doing collected a considerable amount of data (in the form of durability factor, weight change and length change) for concrete specimens that are representative of concrete being placed in the field. An organized attempt to correlate existing and new data with field performance should be fruitful. Coordination with ASTM Subcommittee C09.03.15 on Weathering of Concrete would be appropriate, since this Subcommittee is collecting laboratory data.

V. URGENCY - This problem is urgent from the standpoint that it has been an ongoing one that ultimately has probably cost the nation billions of dollars over the years.

PROBLEM NO. 2

I. NAME OF PROBLEM - Stability of the Air-Void System of Concrete as Influenced by Chemical Admixtures, Pozzolans, Cement Properties, and Other Factors

II. THE PROBLEM - There is a significant incidence of scaling and deterioration of air-entrained concrete exposed to a freezing and thawing environment, particularly in the presence of deicing chemicals. In many instances evaluation of the air-void system of the hardened concrete yields a lower air content and higher bubble spacing factor than normally deemed necessary. Sometimes the air content in the hardened concrete is much lower than that which was measured on the fresh concrete. It is known that some fly ashes require higher admixture doses or cause more rapid loss of air-entrainment, but changes in the sources of the other ingredients -- cement, air-entraining admixture, water-reducing admixture, or the fine aggregate -- can also have an important influence on air void stability.

III. OBJECTIVES -

1. To determine the mechanism or mechanisms which causes the decrease in air content and increase in bubble spacing factor in plastic concrete during agitation, handling, and placing operations.

2. To determine for those concrete mixtures which do tend to have unstable air-voids systems, what kind of mixing, agitating, handling and placing operations cause greater problems. For example, is speed of mixing or agitating in truck mixers important; or is frequency or duration of compactive effort a factor in damaging the air-void system.

3. To determine what classes of air-entraining admixtures are more advantageous in providing stable air-void systems when used with combinations of materials or production and placing procedures which tend to cause loss of air in concrete.

4. To develop improved techniques of measuring air-void parameters (air content, specific surface, and spacing factor) on fresh or hardened concrete. Specifically,means is needed to distinguish between fly ash cenospheres and air-voids in polished surfaces of hardened concrete.

5. To develop a laboratory recommended practice for the evaluation of combinations of materials in paste, mortar, or concrete with respect to their effect on the stability of the air-void system.

IV. CURRENT ACTIVITIES - Several companies and research organizations are currently doing research in this important area of interest. However, no firm conclusions have been developed yet toward the achievement of the above objectives.

V. URGENCY - Of highest urgency is the achievement of objectives with respect to the air-void system in fly ash concrete since a significant amount of fly ash is now being used both for energy savings and economic reasons both in blended cements and as a separate pozzolanic admixture. This category includes the use of normal range water reducers since often these admixtures are used in conjunction with fly ash in concrete. Second level priority concerns the air-void system properties in non-fly ash concrete containing normal and high range water reducing admixtures. High range water reducing admixtures are relatively new in the North American market, but some researchers have found inadequate air-void systems in concrete containing these admixtures particularly when used to produce concrete with low water-cement ratio and medium to stiff consistency. Normal range water reducing admixtures, ASTM C494 types A, D, and E should also be investigated since the use of these admixtures is very widespread.

PROBLEM NO. 3

I. NAME OF PROBLEM - Prediction of Bridge Deck Life as Influenced by Corrosion of Steel Reinforcement

II. THE PROBLEM - Bridge decks constructed in areas of deicing salt usage and in seawater environments have been subject to premature deterioration costing millions of dollars. Research has shown that the causes of this distress are most often chloride penetration into the concrete and the reinforcing steel corrosion which is subsequently induced. Various methods have been developed to combat this corrosion, in both new and existing structures including: thicker concrete cover over the reinforcing steel, higher quality (low water cement ratio) concrete which is properly consolidated, latex modified concrete, epoxy coated reinforcing steel, waterproof membranes with asphaltic concrete wearing surfaces, polymer impregnated and polymer concretes, and internally sealed (wax bead) concrete. Similarly, methods for studying and identifying the magnitude of the problem (delamination detection, half-cell potentials, chloride analyses and rate of corrosion probes) have been developed and are now commonly used.

Initial decisions to make many of the changes in design and construction procedures in use today were based on comparative laboratory studies which were not related to actual performance life. However, in many instances, experimental field studies have been underway for sufficient time that predictions of service life could be made if all the laboratory and field data were synthesized.

III. OBJECTIVE - To identify and analyse all laboratory and field data on the effect of commonly used design and construction procedures for the protection of bridge decks constructed in corrosive environments; and to utilize the data to predict the extension in bridge deck life which can be expected from the use of each procedure in (1) new construction and (2) rehabilitation, when applicable.

IV. CURRENT ACTIVITIES -

A. There are many ongoing studies in the Federal Highway Administration's Federally Coordinated Program (FCP) Project 4K, "Cost Effective Rigid Concrete Construction and Rehabilitation in Adverse Environments." Applicable NCHRP Projects are included in the FCP and Annual Progress Reports are prepared on the FCP Project. Additionally, NCHRP Synthesis 57, Durability of Concrete Bridge Decks, provides an excellent summary of present practices.

B. Experimental bridge deck studies are being performed by the states.

V. URGENCY - There is a great need to know the actual increase in life that has been achieved by the many changes in bridge deck design and construction procedures which have occurred in recent years. Costs of the procedures vary many fold and the user must know the life of the procedures in order to choose the most effective means of protecting or extending the life of bridge decks.

PROBLEM NO. 4

I. NAME OF PROBLEM - Validation of Requirements for Frost Resistance of Concrete

II. THE PROBLEM - It has been assumed with confidence in most quarters for some years that portland cement concrete produced in accordance with the current standards of good practice will be immune to the action of freezing and thawing regardless of whether or not such action is accelerated by the use or non-use of any of the normally used chemical deicing agents. This concept is more and more being questioned. Again, people are asking whether there is something important, chemically, about any of the normal deicing agents, especially urea. People are questioning whether the criteria for adequacy of the air-void system is air-entrained concrete are applicable to all kinds of hydraulic-cement concrete particularly those which contain large amounts of materials such as pozzolan and slag. Research is therefore needed to review the data upon which the current standards of good practice have been based, to review and confirm or disprove the assumption that there is no significant role played by deicers other than to melt ice, produce water, thus indirectly increase moisture content, and thaw concrete, thus making it susceptible to additional freezing. Such research should be coordinated with closely related research now in progress that suggests that certain air-entraining admixtures are more effective in producing and maintaining an appropriate stable air-void system as the concrete hardens than others, especially when high-alkali cements

are used, and also that certain combinations of air-entraining admixtures and high-range water-reducing admixtures are capable of producing concrete having a satisfactory air-void system while others are not.

III. OBJECTIVES -

(a) Assemble and assess the reports of frost resistance of concrete that does not comply with current requirements and lack of frost resistance of concrete that does comply.

(b) Report apparent need, if any is found, for relaxation or tightening of requirements.

(c) Obtain laboratory results confirming or refuting proposed changes.

(d) Adopt revised requirements if needed or explain purported anomalies.

IV. CURRENT ACTIVITIES - Work related to this topic is going on in an uncoordinated fashion. NRMCA is working on factors affecting the interaction of mineral admixtures and air-void systems. PCA has worked on relation of air-void system requirements and water-cement ratio. Many agencies have studied non-frost resistant concrete that they have encountered, often with inconclusive results as to why it behaved poorly.

V. URGENCY - This topic was rated 4 on a scale of 1-10 by the TRB Committee on Research on Physical Factors Affecting Concrete Durability at its meeting in January 1980.

A2E02 Performance of Concrete-Chemical Aspects - B. Erlin

PROBLEM NO. 1*

I. NAME OF PROBLEM - Chemical Behavior of Waste Materials in Concrete

II. THE PROBLEM - The chemical behavior of many waste materials when incorporated into cement and/or concrete has not been adequately determined to ensure that deleterious reactions do not develop. A variety of waste materials and industrial by-products are either being blended with cements or are being considered for use as aggregates in concrete, such as fly ash, blast furnace slag, glass cullet, residue from the combustion or municipal refuse mill tailings, waste mining rock, etc. Increasingly larger amounts of such waste materials will be incorporated into concrete because of changing patterns of supply and demand of materials and energy, economic factors and heightened concern for the quality of the environment. The research needed includes such as the determination of the possibility of deleterious chemical reactions caused by the use of recycled concrete from building demolition contaminated with gypsum plaster possibly causing disruptive sulfate reactions; investigation of the probability of fly ash having sufficiently high alkali contents that they increase the severity of deleterious reactions between cements and alkali-sensitive aggregates; investigation of the reactions possible between the components of incinerated municipal waste and the components of cement and concrete.

III. OBJECTIVES - The objective is to develop relationships between the chemical and mineralogical composition of waste materials and their chemical performances in concrete. Emphasis is to be given to those waste materials that either are being incorporated in concrete at a high level or whose use is anticipated to rapidly increase.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress Areas 32, 34, and 35 have been scanned in preparing this statement.

B. Suggested key words: Concrete, Industrial By-Products, Waste Materials.

C. A RILEM Symposium by correspondence is currently being conducted on the "Use of Waste Materials in the Construction Industry." Many projects are being carried out to identify the sources and availability of waste materials, but little is being given to their chemical behavior in concrete.

V. URGENCY - The use of waste materials, especially fly ash, in cement and concrete is rapidly increasing. Some areas in the United States lack good quality aggregate which will soon necessitate the increased use of waste materials such as waste rock and mill tailings as aggregate. Air pollution regulations will apparently force many cement manufacturers to produce portland cements with higher alkali contents than those presently on the market. In addition, the Resource Conservation and Recovery Act of 1976 (Public Law 94-580) will for the most part require agencies using Federal

funds for procurement to use construction materials that contain the highest percentage of recovered material practicable.

PROBLEM NO. 2

I. NAME OF PROBLEM - Identifying Alkali-Silica, Reactive Silica, and Silicous Rocks Such as Quartz and Quartzite in Concrete Aggregates

II. THE PROBLEM - The highway network around the Pentagon, a naval dry rock in Charleston, South Carolina, bridges in the road system of the Georgia DOT, several dams and locks belonging to Federal Aviation agencies, and other structures, have developed alkali-silica reaction to a damaging extent, and examination of the concrete has shown that the quartz in the aggregate has participated in the reaction. The reaction develops slowly over 20 years or more, but can be unsightly and even dangerous to the structural integrity of the structures affected. Some of the instances of alkali-silica reaction leading to distress in concrete structures have been recorded [1, 2, 3, 4, 5] in which the reactive aggregates have been rocks of types that would not be expected to be reactive with alkalies in cement using current criteria. New evidence has also been developed of alkali-silica reaction in concrete containing shales and hornfelses where the alkali is released from the aggregate by cation exchange with the clay-mica in the aggregate with the Ca++ in the mortar. The rock types involved have included phyilites, agrillites, graywackes, and metamorphosed subgraywackes, granite gneisses, shales, and hornfelses, and vein quartz and quartzite. Differing opinions of the reactive vectors and on the mechanism of reaction have been expressed.[4, part IV; 1, 5, 6] Although detailed petrographic examinations have been published for some reactive varieties, [4, part II] the identification of reactive species is not sufficiently exact. For example, it is said that "some" graywackes are reactive. Metamorphic subgraywackes have been found to be reactive aggregates in two TVA dams.

III. OBJECTIVES - Define more precisely which rocks are alkali-silica reactive and which are not. Determine if, in addition to defective structure, perhaps the presence of trace elements also triggers alkali reactions. Examine large numbers of particles which are known to be reactive in concrete and search for a common causal feature or features. Specific objectives include:

A. To develop criteria that will permit demonstration of reactivity in slowly reactive rocks within reasonable laboratory testing times.

B. To advance means other than the specification of low-alkali cement that will effectively control slowly developing alkali-silica reaction.

C. To establish more perfectly the mechanisms of the reaction, including those mechanisms that cause low quartz to become reactive.

D. Verify whether or not the quartz affected, which occurs as vein quartz and quartzite, is all highly metamorphic quartz with a high angle of undulatory extinction.

E. Verify whether or not the mica in some granite gneiss takes part in the reaction as has been alleged.

F. Set forth criteria for recognition of reactive quartz and quartzite.

G. Reproduce the reaction in the laboratory.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress has not been scanned in preparing this statement.

B. Several programs of low to moderate size are underway in the U. S., Canada, Denmark, and other countries. Coordination and exchange of information proceeds informally and at a low rate.

C. A proposed "standard" alkali-silica reactive aggregate has been prepared by Purdue University.

D. Some work has been done at the USAE Waterways Experiment Station on this topic.

E. Suggested key words: alkali-silica reaction, alkali-silicate reaction, graywacke, low quartz, agillite, shale, hornfels, granite gneiss, arenite, quartzite.

V. URGENCY - While some of the structures affected require repair and monitoring in the future to maintain assurance of satisfactory performance, others of similar age are affected by alkali-silica reaction but are serving their purpose and can be expected to continue. In order to establish a way to recognize reactive metamorphic quartz, a standard convention for the orientation of the quartz grains needs to be established; this is basic research that should be carried on at a

university strong in optical mineralogy and crystallography. Tests carried out at 60°C in moist storage need 36 months to develop expansion of 0.10 percent. Since the recent studies have increased the number of rocks known to be alkali reactive and have even more increased the rocks suspected of being alkali reactive, it is essential to obtain more precise information to aid in distinguishing between reactive and nonreactive types of rocks.

Energy conservation in cement plants has already affected the ability of some plants to produce low-alkali cement; future cement plants will return even more of the alkali to the cement. It is urgent to learn now, while some lead time is available at least in parts of North America, how much alkali can be tolerated with highly reactive to slowly reactive rocks.

The problem is urgent with the increasing alkali content of cement already affecting choice of aggregates; it is highly relevant because it affects all of North America where concrete pavements and highway construction are used; it can be implemented as a laboratory program of some but not unsurmountable difficulty, and the laboratory findings can be confirmed in the field.

General estimate of cost to accomplish: $500K.

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PROBLEM NO. 3

I. NAME OF PROBLEM - Chemical and Hydration Reactions at or Near 0°C. Forming Deleterious but Unstable Hydrates in Portland Cement Concrete

II. THE PROBLEM - It is not known what physico-chemical reactions may occur in concrete at or below 0°C that may be deterimental to the life of the concrete. In any salt which forms more than one state of hydration the higher hydrate occurs at lower temperatures (Holden & Singer, 1960). The formation of a high hydrate phase of calcium chloroaluminate $3CaO.Al_2O_3.CaCl_2 + 30H_2O$ (Savvina & Serb-Serbina 1958, Serb-Serbina, Savvina and Zhurina 1956) in hardened portland cement concrete at temperatures below 0°C is reported to be deterimental to hardened concrete just as is the formation of Ettringite. Calcium carbonate forms a hexahydrate at or near 0°C (Johnson, Merwin and Williamson, 1916) Relict crystals of the hexahydrate of calcium carbonate have been found in concrete which has been subject to a freezing and thawing environment in the presence of deicing salts (Pattengill, Crumpton and Badgley, 1972). Work in Denmark has shown that the change from the hexahydrate to calcite is accompanied by expansive forces far greater than the tensile strength of concrete. Hydrohalite $NaCl.2H_2O$ is another substance that forms at 0°C which might form during concrete deicing operations.

Studies conducted by Blaser and

Scherer (1969) have shown that salt heave in certain western soils is due to the crystallization of hydrous sodium sulfate where it is present in quantities amounting to only about 0.5%. During a drop in temperature the hydrous sulfate begins to form. The resultant crystal growth exerts pressure on the soils causing uplift damage to floor slabs, walks and driveways of some building structures (Sodium sulfate is often found as a powdery efflorescence on the bottom surfaces of concrete bridge decks near cracks and pores). Blaser and Scherer point out that the soil expansion is sometimes incorrectly identified as expanding clay rather than salt heave. It is processes similar in nature to salt heave in soils but perhaps involving different substances and different temperatures that is suggested in the research being recommended here.

III. OBJECTIVES - Detailed and fundamental studies of low temperature (near 0°C) chemical and hydration reactions between the various constitutents of hardened concrete, water, and/or deicing chemicals should be investigated. Such research would require maintaining the desired low temperature of the specimens while the studies are being conducted. Study of the concrete after it warms up would not detect the substances and reactions which may occur because most of them are unstable at higher temperatures. Cycling of the temperature up and down several degrees either side of 0°C may be desirable, therefore, any study techniques would require low temperature capabilities. Some possibilities are low temperature differential thermal analysis, such as used by Dunn and Hudec (1965, Part I and 2), low temperature X-ray analysis, low temperature petrographic analysis, low temperature infrared spectroscopy, and any other means suitable to conducting such studies.

IV. CURRENT ACTIVITIES - There appears to be little current activity in this area of concrete research but the references used herein can provide useful information on the formation of some unstable substances.

V. URGENCY - The urgency is uncertain but concrete often deteriorates rapidly when deicing salts are used yet all of the reactions that might be occurring have not been studied, especially those that may occur at or near the melting point of ice. It is important to find out what reactions occur under these conditions.

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Serb-Serbina, N. N., Savvina, Yu. A., and Zhurina, V. S. The Formation of Hydrated Calcium Chloro-Aluminates and Their Effect on the Structure of Hardened Cement: (In Russian) Doklady Akademic Nauk USSR, 3 (3), pp. 659-662, 1956.

A2E03 Mechanical Properties of Concrete - V. M. Malhotra

PROBLEM NO. 1*

I. NAME OF PROBLEM - In-Place Determination of Mechanical Properties of

Concrete

II. THE PROBLEM - The current practice of acceptance of the crushing strength of the concrete cylinders, which are cast and cured independent of the parent concrete as 'representative' of the concrete used oversimplifies the problem. Taking core samples from the actual structure is not always possible and in situations where core samples can be obtained, the integrity of the structure is damaged by varying degrees depending on the size, number and location of core samples. It is well known that concrete in a structure may have a considerably different strength from that in the comparison test cylinders. Acceptance of the tests on comparison specimens as representative of the concrete used inhibits the realistic design for in-place concrete. The lack of knowledge of the actual strength of concrete in a structure requires the use of a large factor of safety than would otherwise be necessary.

There are several methods to evaluate the quality and strength of in-place concrete. Some of these are non-destructive like ultra-sonic, resonance, radioactive, electrical, and hardness and some are partially or semi-destructive like the pullout and probe or penetration tests. These tests measure different parameters, many still not properly defined. Controversy still exists as to what in-place strength is and whether it is determinable. Considerable amount of future research is needed to adequately improve the accuracy of in-place testing of concrete.

III. OBJECTIVES -

1. To prepare a comprehensive state-of-the-art on the various methods used for the evaluation of strength and quality of in-place concrete.
2. To critically compare the currently used methods and recommend appropriate methods and develop standard procedures for these methods recommended.
3. To encourage the use of in-place testing and realization of the economic significance of in-place testing by suitable publications.

IV. CURRENT ACTIVITIES - In-place test methods are under development by ASTM C09.02.05 (impact-rebound, identation and pullout) and C09.03.01 (pushout cylinders). The seven papers published in Highway Research Record No. 378 represent advancements in non-destructive testing and they contribute directly or indirectly to solutions of the problem of in-place testing of concrete. Research is in progress which is directly or indirectly connected with in-place testing of concrete in several states (North Carolina, Pennsylvania, Vermont and West Virginia).

V. URGENCY - There is a great potential and urgent need for in-place determination of the mechanical properties of concrete. Two fields where in-place testing could prove to be superior to traditional methods are quality control in construction of structural members, both precast and cast-in-place, and monitoring strength development to determine acceptance times for the removal of form work or transfer of prestressing forces to concrete.

Inspection authorities urgently require in-place safety and load-bearing capacity test methods. In-place testing also promises savings in time, money and resources, and improvement in quality control and realistic design.

PROBLEM NO. 2

I. NAME OF PROBLEM - Satisfactory Heat Treatment of Hardened Concrete

II. THE PROBLEM - Hardened concrete containing wax beads or thermosetting polymers must be heated to remove moisture and to melt the wax, or polymerize the concrete. Cracks are frequently found in these concretes after they have been subjected to a heat treatment. The cracks tend to decrease the strength and increase the permeability of the concrete and thereby nullify the benefit sought through the use of the wax beads or the polymer additives, which primarily is to decrease the permeability of the concrete.

III. OBJECTIVE - The objective of the research would be to develop guidelines for satisfactory heat treatment of hardened concrete. More specifically, an effort will be made to (1) identify the characteristics of the concretes and the heating processes which contribute to cracking, and (2) describe them in quantitative terms so that the phenomenon of crack formation can be fully understood and appropriate steps can be taken to minimize or eliminate the cracking.

IV. CURRENT ACTIVITIES - Internally sealed concrete and polymer impregnated concrete (PIC) are the names typically applied to two types of bridge deck protective systems which have been tried on an experimental basis in recent years. Approximately 20 bridges have been constructed with internally sealed concrete overlays and a similar number have been repaired or constructed with PIC that requires a heat treatment for impregnation and polymerization. Cracks have been noted in the hardened concrete on many of these structures after the concrete has been subjected to the heat treatment. Guidelines for applying heat treatments have been developed by the FHWA but no one has been able to fully explain the process by which the cracks form or to identify all the contributing factors.

V. URGENCY - On the basis of laboratory findings, internally sealed concrete and PIC appear to provide excellent potential for protecting bridge decks from deicing salts. When properly sealed with melted wax or polymers, the concretes are virtually impermeable. However, until satisfactory field heat treatments can be obtained on a regular basis, the full benefits of the systems cannot be realized. Consequently, the research proposed here is urgently needed.

A2E04 Batching, Mixing, Placing & Curing of Concrete - R. E. Hay

PROBLEM NO. 1*

I. NAME OF PROBLEM - Evaluation of Methods and Materials to Assure Adequate Curing of Grooved Concrete Pavement

II. THE PROBLEM - For many years the standard texturing and curing of portland cement pavement for most state highway departments has been to mechanically apply a liquid membrane curing compound at the rate of one gal/200 sq. ft. to a burlap drag texture utilizing materials meeting the AASHTO M 148 requirement of not more than 0.55 kg/m^2 moisture loss in 72 hours. With the recent emphasis to improve friction values of the pavement surfaces, many states are now grooving the pavements transversely with wire tines approximately 0.10" in diameter to a depth of approximately 0.10" at a spacing of ½" to 1" while the concrete is still plastic. There is evidence that most liquid forming membranes do not meet the specified moisture loss requirements of AASHTO 148 when applied to a deeply textured pavement. The vertical surfaces of the grooves and the ragged edges left by the tines increase the surface area to be cured. Also, vertical surfaces more than likely do not receive the same coverage of curing compound as horizontal surfaces, and that curing compound that does land many tend to sag.

It is important to the life of the pavement surface that all elements of the texture retain moisture for the first seven days.

A research study is needed to determine whether a curing problem exists for deeply textured portland cement concrete pavement and if so, how can it best be resolved to extend the effective life of the grooved pavement.

III. OBJECTIVES - Conduct in-depth literature surveys to study the state-of-the-art relative to the curing of concrete pavement as well as needs for improvement. Evaluate methods and/or materials that show promise for improving the current practice of curing grooved concrete pavements specifically as follows:

1. Determine the moisture loss which can be allowed on a deeply textured concrete surface and still provide adequate hydration of the cement for durable concrete.

2. Determine if a new test method should be developed in lieu of AASHTO M 148 for concrete with deeply textured surface and, if so, develop the new method.

3. Develop or obtain new products which are compatible with concrete paving operations and will provide adequate curing of deeply textured concrete surfaces.

IV. CURRENT ACTIVITIES - A review by NCHRP staff and a HRIS search indicated no research had been done on effectiveness of curing tined pavements yet there is reason to believe inadequate curing is being obtained in the field.

V. URGENCY - Many states are placing grooved concrete pavement. The life of the surface is very dependent on its ability to cure properly. Effective life of grooved pavement might be greatly extended if more effective curing methods and/or materials were available.

PROBLEM NO. 2

I. NAME OF PROBLEM - Duration of Enforced Curing

II. THE PROBLEM - Most documents covering the curing of concrete stipulate a minimum period of time after placement during which it is required that positive steps must be taken to maintain it in a condition such that it does not undergo changes in temperature or moisture content that may be regarded as harmful. The recently published report of ACI Committee 308 (April 1971) stipulates, with regard to pavements in para. 3.1.3, 7 days or the time necessary to obtain 70 percent of the specified strength. Then in para. 3.2.3 on structures and buildings, it gives the same sentence but adds that for some structural members curing periods may be increased to 28 days. In 3.3.3 on mass concrete, it says for concrete without pozzolan, 2 weeks; for concrete with pozzolan, 3 weeks; and for heavily reinforced mass sections, 7 days. The Corps of Engineers Guide Specifications, in its most recent edition of April 1971 in para. -16.1, bases duration of curing strictly on type of cementitious material used and gives times ranging from 3 days to 28 days. With Type III cement, 3 days; with Type I cement, 7 days; with Type II, Type V, or portland blast-furnace-slag cement, 14 days; with Type IV or blends containing pozzolan, natural cement, or slag cement, 21 days; except if these are used in navigation locks, then 28 days. The problem is that neither the type of cementitious material nor the type of structure nor the specified strength really controls the choice of duration of enforced curing since the proper duration depends upon the attainment of desired properties of strength and durability in the concrete. When curing has been maintained long enough, it is uneconomical to continue it simply because the rules say that for that type of structure or that type of cementitious medium it shall be continued longer. What is needed are criteria that may be applied to the particular concrete that will indicate when the desired conditions have been sufficiently approached, then the expense of further protection can be terminated.

Data need to be developed either from experiment or analysis of existing information to indicate the relationship between curing method and effectiveness, between duration of a given method and effectiveness,and the combination of method plus duration as related to degree of effectiveness needed as a function of exposure (durability) and strength.

III. OBJECTIVES - The objective is to rationalize the relationship of objective plus method plus time when the selected method is used on the given concrete in the given environment.

IV. CURRENT ACTIVITIES - None

V. URGENCY - The benefit would be to permit revision of curing standards to include rational recommendations which applied would increase the cost of a very few projects which are now inadequately cured, even when the specified procedures are followed, and reduce the cost of curing in a majority of projects where, if the specified procedures are followed, curing is continued longer than needed. Incidentially, a benefit of such research would be to remove the onus now associated in many specifications with the use of mixtures containing pozzolans which are penalized by being required to be cured longer than mixtures proportioned to develop identical strengths at the same ages.

PROBLEM NO. 3

I. NAME OF PROBLEM - Placing Concrete Underwater

II. THE PROBLEM - Whenever practical, the placing of concrete underwater should be avoided. At times, it is physically or fiscally impractical to dry a foundation prior to concrete placement, therefore, it is necessary to place concrete underwater. To this end, numerous problems exist or are created when attempting to accomplish this. Materials and equipment are available to furnish good concrete for this purpose, however, since the location is underwater, inspection of the concrete placement is difficult. Control must be primarily from above the water surface. Flowability and Workability of the concrete, in addition attempting to prevent washing the cement out of the concrete, should be specified and controlled closely. When placing concrete underwater, the placement should be slowly commenced to minimize scouring of the bottom. The proper placement of the concrete always remain a problem, therefore, should be closely defined. Definite requirements, procedures of placement, control and inspection of construction

need to be defined and set forth to provide adequate information for this type of construction.

III. OBJECTIVES - To develop acceptable systems and procedures for placing concrete underwater, the following specific objectives must be accomplished:

1. Define the appropriate needs requirements, along with the necessary type of placement for those requirements.
2. Define the proper concrete mix proportions for the various common types and sizes of aggregate that would be used.
3. Determine the proper slump necessary for the appropriate type of placement.
4. Define guidelines for determining the flowability and workability of concrete underwater, if possible.
5. Define the use of air-entraining agents (versus non-air-entrained concrete), pozzolans, water-reducing, set-controlling agents (amount needed, if any) to help obtain proper flowability of concrete placed underwater.
6. Define the type of cement best suited for the various needs of concrete placement underwater.
7. Define the spacing of tremies that is necessary versus that of cold joints.
8. Determine the concrete strength in-place versus the concrete strength obtained by cylinders.
9. Develop proper inspection procedures.
10. Define certain precautions that are necessary for good construction.

IV. CURRENT ACTIVITIES -

A. Highway Research In Progress areas 22, 32, 33, 41 and 63 have been scanned in preparing this statement.

B. Suggested key words: placing concrete underwater, tremie concrete.

C. A partial list of related research activities which have been completed or are underway in this area follows:

1. Gerwick, B. C. "Underwater Concrete Construction," Mechanical Engineering, Vol. 94, No. 11, November 1972 (HRIS Accession No. 32214189).

2. Greaves, I.S. "Underwater Concreting," Civil Engineering and Public Works Review, Vol. 68, No. 806, September 1973 (HRIS Assession No. 41265559).

3. Hedefine, A., and Silano, L.G. "Newport Bridge Foundation," Civil Engineering ASCE, Vol. 38, No. 10,October 1968 (HRIS Accession No. 63235412).

4. Hillen, H.F. and Schoewert, L.C. "Underwater Transporting of Concrete with the Hydro-Value," American Concrete Institute Journal and Proceedings, Vol. 69, No. 9, September 1972 (HRIS Accession No. 33215603).

5. Montin, S. et. al. "Underwater Concrete, Survey of Literature," Swedish Council for Building Research, Report No. R38: 1976 (HRIS Accession No. 32165638).

6. Naito, T. et. al. "New Method of Underwater Concreting by Kajima's Double-Tube Tremie Method," Kajima Institute of Construction Technology (HRIS Accession No. 33087529).

7. Steijaert, P.D. "Holland Evaluates Hydrovalving Concrete," New Civil Engineer, Vol. 11, October 1972 (HRIS Accession No. 33215762).

V. URGENCY - In view of the difficulties encountered in placing concrete underwater, primarily the difficulty of inspection and adequate control, in addition to the possibility of obtaining less than an adequate quality of concrete, this research should receive a high priority.

PROBLEM NO. 4

I. NAME OF PROBLEM - Simple Calibration Checks for Batch Weighing Systems (New Load Cell Types and Water Gages)

II. THE PROBLEM - Specifications for most scales or weigh batchers contain two kinds of tolerances, scale accuracy and batching accuracy tolerances. The scale accuracy tolerances are applicable during calibration to ensure accurate equipment. Batching accuracy tolerances are intended to govern under operating conditions when it is not practical to require the scale to come to static equilibrium. Water is sometimes weighed on a scale but most times it is measured by volume in a meter.

Scale calibration procedures vary widely between different agencies and are not highly standardized. These requirements are given as by ASTM Specification C94, National Ready Mixed Concrete Association, National Bureau of Standards and the Concrete Plant Manufacturer's Bureau.

There is a need for some simple, quick calibration checks for batch

weighing systems through the use of new load cell types and water gages, primarily to obtain better accuracy but also to be able to accomplish this in a rapid manner and be standardized.

III. OBJECTIVES - To develop acceptable simple calibration systems and procedures for the checking of batch weighing systems, the following specific objectives must be accomplished:

1. Define the appropriate needs requirements in this area.
2. Conduct in-depth literature surveys to evaluate the state-of-the-art on this subject.
3. Evaluate the present systems and methods to determine any shortcomings of these and what is needed for improvement.
4. Determine any possible new systems and methods available and to evaluate these under operating conditions. These may include new load cell types and water gages.
5. Attempt to standardize, if possible, the systems, methods and the use of these to check calibration on the batch weighing in the field.

IV. CURRENT ACTIVITIES - It is not known at this time, whether any research is being done to address itself to this particular need.

V. URGENCY - In view of the importance of accuracy in the weigh batching systems, both in scale accuracy and batching accuracy, and the need to improve the calibration checks for weigh batching systems, especially if these can be standardized, this research should receive due priority attention.

PROBLEM NO. 5

I. NAME OF PROBLEM - Abrasion Resistance Surface Durability, and Skid Resistance of Concrete Pavements

II. THE PROBLEM - Safe traffic operations require pavements to have adequate skid resistance. Our ability to attain and retain skid resistance will play an increasingly important role in specifications for p.c. concrete pavements and bridge decks.

Concrete pavement surfaces can be thought of as passing through three states:

Stage 1 - Initial Texture. This stage begins when the pavement is opened to traffic and continues until initial texture is worn smooth. Skid resistance, particularly at higher speeds, depends largely on the macrotexture of the initial finish.

Stage 2 - Mortar. This stage begins when the initial texture is worn smooth and continues until coarse aggregate is exposed. Skid resistance is dependent primarily on the microtexture of the mortar which is a function of the properties of the fine aggregate and cement paste.

Stage 3 - Exposed Aggregate. This stage begins when the coarse aggregate becomes exposed. Tire contact with the mortar phase is reduced and macrotexture may increase depending upon the degree to which coarse aggregate and mortar wear differentially.

The problem is to influence the abrasion resistance of pavement concrete and its components so as to prolong the time required to reach Stage 2 and to maximize skid resistance in Stages 2 and 3.

III. OBJECTIVES -

A. Identify the role of the cement paste phase as regards the initial skid resistance of conventionally textured and grooved pcc pavements and the retention of skid resistance through all three stages of the pavement's surface.

B. Identify the effects of curing compounds on the skid resistance and serviceability of roadway and bridge deck pavements (conventionally textured and grooved pavements).

C. Establish meaningful evaluative criteria for skid resistance characteristics of both fine and coarse aggregates in conventionally textured pcc pavements.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 22, 25, 26, 32 and 51 have been scanned in preparing this statement.

B. Suggested key words: concrete pavement durability, concrete properties, abrasion, skid resistance, wear resistance.

C. A partial list of related research activities which have been completed or are under way in this area follows.

1. Colley, B. E. et. al., "Factors Affecting Skid Resistance and Safety of Concrete Pavements," HRB Spec. Rep. 101 (1969)

2. Chamberlin, W. P. and Amsler, D. E., "Pilot Field Study of Concrete Pavement Texturing Methods," Highway

Research Board Record No. 389 (1972)

3. Weller, D. E. and Maynard, D. P., "The Influence of Materials and Mix Design on the Skid Resistance Value and Texture Depth of Concrete," RRL Report LR 334 (1970).

4. Iowa State Highway Commission, "Skid Resistance of Concrete Pavements," Project No. HR-168, (HRIS Accession No. 26 232140).

5. Virginia Highway and Transportation Research Council, "Durability of Certain Configurations for Providing Skid Resistance on Concrete Pavements," VHTRC Project No. 70 (HRIS Accession No. 104171).

6. California Department of Transportation, "Improve Portland Cement Concrete Wearing Surfaces," Project No. 19-635293, (HRIS Accession No. 26 232162).

7. North Carolina State University, "Surface Wear and Skid Resistance Properties of Portland Cement Concrete Pavements," Project No. HPR 74-3, (HRIS Accession No. 26 233036).

8. Ledbetter, W. B. et al., "Evaluation of Full-Scale Experimental Concrete Highway Finishes," Research Report 141-4F, Texas Transportation Institute, 1974.

9. Neal, Spring, Woodstrom and Spellman, "Portland Cement Concrete Pavement Texture Quality Investigation," Interim Report, CA-DOT-TL-3126-10-75-07, January 1975.

10. Missouri State Highway Department, "An Investigation of the Durability of the Skid Resistance of Wire Combed PCC Pavement Surfaces," Study 74-5, May 1976.

V. URGENCY - A high priority is warranted because of the accelerated wear and loss of skid resistance being experienced on many concrete pavements now being built. The problem has become acute with the resent emphasis on deeper textures, many of which wear at correspondingly higher rates.

PROBLEM NO. 6

I. NAME OF PROBLEM - The Role of Soluble Salts in the Water Evaporating from Fresh Concrete

II. THE PROBLEM - There is evidence that alkali sulfates -- as may be derived from portland cement clinker -- or chloride salts, or other soluble materials may occur in variable and sometimes rather high concentrations in the solution that is formed over time from the mixing water in concrete. As this solution evaporates, after finishing of a structure, the remaining solution becomes supersaturated. There are rather ill-documented reports of scaling and perhaps other problems related to this phenomenon.

III. OBJECTIVE - Identify the nature of the mechanisms that are involved in this phenomenon and, if necessary, to develop methods to remedy the detrimental effects.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 32 has been scanned in preparing this statement.

B. Suggested key words: concrete sealing, salt corrosion of concrete, abrasion resistance.

C. A partial list of related research activities underway or completed is as follows:

Fookes, Peter J. and Collis, Laurence, Aggregates and the Middle East, Concrete, November 1975, IX(II) 14-19.

Fookes, Peter J. and Collis, Laurence, Problems in the Middle East, Concrete, July 1975, IX (7) 12-17.

French, W. J., The Migration and Precipitation of Water Soluble Ions in Concrete, paper to be presented at the 4th International Symposium on Alkalis in Cement and Concrete, Purdue University, June 5-8, 1978.

Fookes, Peter J. and Collis, Laurence, Cracking and the Middle East, Concrete, February 1976, X(2) 14-19.

Fookes, Peter J., A Plain Man's Guide to Cracking in the Middle East, Concrete, September 1976, X(5) 20-22.

French, W. J. and Poole, Alan, Alkali-Aggregate Reactions and the Middle East Concrete, January 1976, X(1) 18-20

V. URGENCY - The need for such research is becoming progressively more urgent with the increasing probability of such soluble salts being present in larger than previously experienced amounts as derived from cements, aggregates, admixtures, and mixing water.

A2E05 Chemical Additions and Admixtures for Concrete - T. J. Larsen

PROBLEM NO. 1 *

I. NAME OF PROBLEM - Effect of Admixtures on Slump Loss on Concrete

II. THE PROBLEM - Concrete mixes which do not contain admixtures sometimes suffer untimely loss of workability, described as "slump loss," and this is obviously inefficient and costly. At the present time admixtures are in widespread use. These admixtures sometimes alleviate, and sometimes aggrevate, slump loss. In the latter case, the situation can sometimes be remedied and sometimes, not. Elimination of the admixture is not always the answer, for it may be needed for other purposes. The effect of admixtures on slump loss is the subject of much speculation, but in few if any cases are all the fundamental mechanisms involved fully understood.

III. OBJECTIVES -

1. Representative admixture types commonly used (Sections 1.1.1 through 1.1.5 of ASTM C494-77) should be evaluated under carefully controlled laboratory conditions with a variety of cements known to suffer untimely slump loss with admixtures, without admixtures, and in both cases. When the field phenomena are successfully recreated in the laboratory, the most complete analysis that is possible should be made of the total situation and all mix components, with especial emphasis on cement and admixture composition (both physical and chemical properties).

2. The data analysis should lead to a set of hypotheses, each of which should suggest critical experiments to confirm or deny that hypothesis.

3. Recommended remedial actions should evolve from confirmed hypotheses.

IV. CURRENT ACTIVITIES - Several limited, empirical projects have been and are being conducted. Speculative theories have been evolved. However, these investigations lack the necessary depth and scope to generate convincing or widely applicable solutions to the field problems. Suggested keywords are: admixtures, slump loss, early hydration, cement composition, and test methods.

V. URGENCY - Significant time and money are being lost on a widespread scale because this problem and what to do about it are not well understood.

PROBLEM NO. 2

I. NAME OF PROBLEM - Use of Infrared to Determine Admixture Uniformity

II. THE PROBLEM - Many state departments of transportation employ Section 5.1.1 of ASTM Specification C494-77 as one means of determining uniformity of successive lots of admixture from the same source. The criterion is that the infrared absorption patterns be "essentially similar." This is a subjective and qualitative factor which is sometimes interpreted to mean that absorption patterns of successive lots, when superimposed, must be identical. This ignores all sources of variance other than significant change in admixture composition and is not realistic. Quantitative ranges of permissible variation in parameters of infrared absorption patterns are needed to establish "essential similarity."

III. OBJECTIVES -

1. Identify and quantify factors affecting variance in infrared absorption pattern parameters using different operators and instruments for a fixed set of reference admixture samples, and a specific technique of sample taking and sample preparation. The reference admixtures are nominally the same admixture, but vary in composition within the established quality control limitations of the manufacturer.

2. Analyze the resulting data to generate allowable quantitative ranges of variation for each parameter of the infrared absorption spectra that define no statistically significant difference within a predetermined confidence limit.

IV. CURRENT ACTIVITIES - Essentially none exist. Suggested key words: admixtures, infrared, composition, and test methods.

V. URGENCY - Use of admixtures has become widespread and is steadily increasing. It is just as vital that they meet meaningful, quantitative uniformity requirements as it is for all other components of concrete mixes to do so.

PROBLEM NO. 3

I. NAME OF PROBLEM - Develop a Method for Determining the Fly Ash Content of Hardened Portland Cement-Fly Ash

Concrete

II. THE PROBLEM - The use of fly ash as a partial substitute for portland cement in concrete is on the increase and predicted by the National Ash Association to continue to do so in the coming years. There is no reliable or accepted method for determining or even estimating the fly ash content of hardened concrete. This puts the purchaser of the fly ash concrete at a great disadvantage and the manufacturer of the concrete the opportunity to use more ash/yd^3 than specified.

III. OBJECTIVE - Establish a method, either chemical or physical, for determining the fly ash content of portland cement-fly ash concrete.

IV. CURRENT ACTIVITIES - A chemical analysis of hardened fly ash concrete for its SO_3 content is being used in a few laboratories to estimate the amount of fly ash present. However, in order to relate the measured SO_3 content to fly ash content, the % SO_3 in both the cement and fly ash used in the concrete must be known. This information is seldom available and retain samples of the two are almost unavailable.

V. URGENCY - The cause for fly ash concrete problems cannot be reliably determined without having some method for measuring the fly ash content of concrete.

PROBLEM NO. 4

I. NAME OF PROBLEM - Admixtures in Hot Weather Concreting

II. THE PROBLEM - Admixtures such as retarders, water reducing retarders, and air entrainments are used with various success during hot weather concreting to regulate the set of concrete. In addition to selecting admixture type or combination of admixtures, the dosage rate may vary, dependent on the environmental conditions and on the structure cross section. For instance, a higher retardant rate may be used in the morning than in the afternoon of a hot day. Also, the temperature within the structure will depend on its dimension. Presently, no guidelines are available to suggest admixture type to use to avoid coincidence of maximum environmental and hydration temperature.

III. OBJECTIVE - Available research data and other information shall be used to draw pertinent information to prepare a guideline for the use of admixtures in hot weather concreting. These guidelines shall provide a trouble-shooting chart for problems that may arise and for their correction.

IV. CURRENT ACTIVITIES - The belief is that sufficient information exists in the literature for preparation of the guidelines. However, substantiating data may be required from laboratory investigations.

V. URGENCY - A sufficient amount of concrete is presently discarded during hot weather concreting to justify the investigation. The justifications for concrete rejection are high temperature, low slump, low air content, and the concrete is not placeable without retempering with increased w/c-ratio. The belief is that some of the concretes placed may have inferior properties due to the causes mentioned. These descrepancies may be circumvented by the proper use of admixtures.

A2E06 Basic Research Pertaining to Portland Cement and Concrete - N. R. Greening

PROBLEM NO. 1*

I. NAME OF PROBLEM - Performance and Characterization of Blended Cements

II. THE PROBLEM - In view of the national need to conserve resources, blended cements containing by-products will, at least partially, be substituted for portland cements in many forms of construction. Basic knowledge of the factors affecting the performance of blended cements and new methods of characterization of blended cements are needed to help identify the ranges of practically useful compositions and to facilitate their rational use in construction.

III. OBJECTIVES -

A. To develop methods for the characterization of blended cements in terms of phase composition and phase distribution (including particle size and shape) which are necessary for determining the mechanisms of the reactions which determine performance in concrete.

B. To apply the methods developed in (A) to improvement of understanding of the factors affecting the perform-

ance of concretes made from blended cements containing fly ashes, slags, and other by-products in construction. Examples of performance characteristics to be considered are rate of strength development, workability, behavior with chemical admixtures, resistance to freezing and thawing, sulfate attack, soundness, creep, alkali-aggregate reactions, corrosion of reinforcing steel, salt scaling, and fire resistance.

IV. CURRENT ACTIVITIES -

A. No HRIS scans have been made.

B. Suggested slags in cement and concrete, blended cements, fly ash, blast-furnace slags in cement and concrete are under way, but there is no coordinated program. Research is being carried out by the U. S. Army Corps of Engineers, the Water and Power Resources Service, the National Bureau of Standards and the Portland Cement Association.

V. URGENCY - Existing specifications reflect the past excellent experience with blended cements and concretes containing carefully selected slags, fly ashes and natural pozzolans under restricted limits. Research is required to broaden the specifications and to improve our ability to predict the performance of concretes containing blended cements.

PROBLEM NO. 2

I. NAME OF PROBLEM - Sulfate Resistance of Blended Cements

II. THE PROBLEM - In consequence of the energy shortage and the desire to reduce manufacturing costs, the production of Type IP cement (portland-pozzolan cement meeting ASTM C595) has considerably increased in the United States. IP has been shown to resist sulfate attack materially better than Type I cement. If IP's can be shown to resist sulfate comparably to Type II (moderate sulfate resistant cement) IP's may replace Type II cements if moderate heat of hydration can also be obtained. Economies gained in money go to the cement manufacturers, but it is a general advantage to the nation to use in blended cements fly ash and granulated slag, materials that already contain the energy input otherwise needed to make more portland cement clinker. Blast furnace slag and fly ash require less energy added in the cement plant than the production of portland cement clinker. Some fly ashes and granulated blast furnace slags give superior sulfate resistance to cements in which they are blended. Some fly ashes and probably some slags do not.

III. OBJECTIVES - To determine the factors related to portland cement that affect the sulfate resistance of concretes made from blended cements; to determine the factors related to the fly ashes and slags used in blended cements that affect the sulfate resistance of concretes containing them; to develop a cement that will tolerate high soluble sulfate levels in the aggregate or the environment to enable use of sulfate-containing aggregates and to make it possible to produce enduring concrete structures in the most severe environments of sulfate attack.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress has not been scanned in preparing this statement.

B. Key words: Fly ash, pozzolan, slag, blended cement, tricalcium aluminate, available alumina, sulfate attack on concrete, dilution, silica content of pozzolan, portland blast-furnace slag; expansive systems.

C. Work is in process on this topic in the National Bureau of Standards, the University of California, the Waterways Experiment Station, and the PCA.

V. URGENCY - Type II (moderate sulfate resistant) cement is harder to find, so users who have relied on it to make concrete for moderate sulfate attack need to know whether, and which, IP and IS cements are good enough. They also need to know more about the mechanisms involved in the reactions during hydration of blended cements and about their reactions during sulfate attack.

PROBLEM NO. 3

I. NAME OF PROBLEM - Attack of Concrete by Chloride Solutions

II. THE PROBLEM - Scaling and deterioration of concrete surfaces through use of deicer chemicals is a common occurrence in the northern part of the United States where winters are severe. The most common deicers are calcium chloride and sodium chloride, used either singly or mixed. In the past, a commonly held belief has been that

the detrimental effect of these chloride deicers is primarily physical, resulting from freezing and thawing and wetting and drying of the concrete in the presence of concentrated chloride solutions. Recently, however, evidence has been presented suggesting that detrimental chemical reactions may also occur between hydrated cement paste and chloride solutions. While the physical effects of chloride deicers seem well supported by research reported in the literature, the possible role of chemical reactions in the deterioration is not as well documented. While there is evidence that chlorides can react with C_3A and calcium aluminate hydrates, the importance of these reactions with respect to durability is not clear. Other questions needing answers are (1) Do chloride solutions react with calcium silicate hydrates also, and if so, what is the mechanism and what is the practical importance of such reactions? There appears to be little or no data on this subject. (2) Does concrete exposed to sea water deteriorate mainly because of sulfate attack or is chloride involved also. It has been stated that a given concrete in sea water is more resistant than it is when exposed to fresh water of the same sulfate concentration.

III. OBJECTIVES -

1. To determine if chloride solutions react chemically with hydrated cement pastes to a significant degree, and if so, if such reactions are of practical importance to durability.
2. To study possible interactions or synergistic effects of chloride and sulfate ions in reactions with cement paste.

IV. URGENCY - In view of the serious problem of deicer scaling of bridge decks and pavements, this project deserves high priority. While corrosion of reinforcing steel is considered to be the main cause of bridge deck deterioration, chemical reaction of chlorides with the cement paste matrix may be found to be relevant to the problem as well.

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F. CONSTRUCTION - D. S. Gedney, Chairman

A2F01 Rigid Pavement Construction - M. L. Powell

PROBLEM NO. 1

I. NAME OF PROBLEM - Investigation of the Wear Performance of P.C.C. pavement Surfaces Constructed Using Type 1P Cement

II. THE PROBLEM - There is a considerable research and performance data on the performance of concrete made with Type 1P cement or fly-ash cement used in structures. However, the performance of this type concrete in pavements has not sufficiently been evaluated under traffic for resistance to wear. Since 1P cement is gaining widespread interest throughout the U.S.A., it would be most desirable to accomplish this work.

III. OBJECTIVES - Research proposed: accelerated wear tests using test tracks or laboratory wheels incorporating 1P cement in the slabs are warranted. State highway agencies should also be encouraged to construct

test sections along with control sections under varying traffic conditions.

IV. CURRENT ACTIVITIES - Estimate of problem funding and research period: 3 years - $50,000 - $150,000.

V. URGENCY - The resistance to wear of the pavement surface is most critical when texturing, such as tining, is used. Therefore, with the present emphasis on skid resistant surfaces, it is imperative that data be collected as soon as possible.

PROBLEM NO. 2

I. NAME OF PROBLEM - Optimization of Macro-texture (Roadway Surface Texture) and Rideability for Concrete Pavements

II. THE PROBLEM - The optimum road surface desired is one which will offer the best of skid resistance with the best riding quality possible. In order to accomplish this we need to establish relationships between specifications, macrotexture and rideability and develop ways of measurement for each.

III. OBJECTIVES -

A. Determine the relationship between specifications and (1) optimum macrotexture and (2) optimum rideability.

B. Refine ways of measurement for macrotexture and rideability.

IV. CURRENT ACTIVITIES -

A. As a result of the AASHO Road Test most highway engineers have adopted the psi-psr concept for measuring pavement rideability or serviceability. Some states use the BPR Roughometer as their measurement of pavement rideability. The only recent research into the relationship between Record 535 "Development of a Specification to Control Rigid Pavement Roughness," by James E. Bryden of New York DOT.

B. Rideability, roughness, surface tolerance, specifications, roadmeter.

C. No related research activities reported.

D. Texturing methods and requirements have varied considerably from state to state and many times within states. Methods such as brooms, drags, tines, vibrating grooves, etc., have been used and experimented. Due to the development of new equipment in recent years and the present emphasis on attaining durable skid resistant surfaces, it is believed that efforts toward more uniform methods are feasible and desirable. Experimental construction of transverse and longitudinal texturing in fresh concrete has resulted in a trend towards heavier macrotexturing. A synthesis of nationwide uses and recommended optimum procedures is needed.

E. This effort would be appropriate for NCHRP 20-5.

VI. URGENCY -

A. There is a wide variance in State Highway Department specifications regarding surface tolerances and methods of measurement. There is also a fairly wide range in the roughness or rideability of completed pavements. More uniform specifications and compliance with specifications would permit contractors and equipment manufacturers to respond in a more positive manner to the problem of building smooth riding pavements. Modern roadmeters are available to measure psi. Attempts should be made to determine whether current specifications on construction are really related to final riding qualities as measured by roadmeters.

B. There is an immediate need to reduce wet weather skidding accidents on concrete pavements, therefore, work should begin on this synthesis as soon as possible.

PROBLEM NO. 3

I. NAME OF PROBLEM - Utilization of an Open-Graded Stabilized and Free-Draining Subbase

II. THE PROBLEM - Research Problem Statement: Drainage layers are gaining nationwide interest. Even though there is a considerable amount of information on their performance as far as draining the water is concerned, there is very little published information on (a) stability of drainage layers using various types of aggregates under construction equipment, (b) drainage layers as part of a composite black base construction and (c) effects of stripping of the asphalt under heavy rainfall.

III. OBJECTIVES - Research Proposed: There is a lack of uniformity in the procedures used by the various states

and there exists the need to develop national guidelines for using open-graded stabilized subbases. A synthesis of nationwide uses of draining subbases including selected on-site surveys is warranted at this time. The synthesis should identify reasons for the varied utilization and definite problems, if any, which need further attention. This effort would be appropriate for NCHRP Project 20-5

IV. CURRENT ACTIVITIES - Estimate of problem funding and research period: 2 years - $50 - 100,000.

V. URGENCY - Pavement maintenance now exceeds 50 percent of the maintenance dollar and the effects of water cause the major repair jobs. This trend will continue unless the water can be controlled. This is an immediate problem and work should begin as soon as possible on the synthesis.

A2F03 Earthwork Construction - C.M.Higgins

PROBLEM NO. 1

I. NAME OF PROBLEM - Construction Practices for Incorporation of Sanitary Waste in Highway Embankments

II. THE PROBLEM - Millions of tons of trash proliferate in America's cities each day. Environmental considerations preclude normal disposal procedures such as burning or dumping. Land-use constraints prohibit any large scale land fill construction sites. Thus, answers must be found to the trash surplus problem.

One interesting and highly potential use is to incorporate the trash in an orderly, designed process as part of a normally placed highway embankment. Unanswered questions as to lift thickness, degree of breakdown, bio-degrading protection, artificial vent systems to preclude internal gas buildup, rodent protection, method of placement, and long-term strength characteristics must be examined.

III. OBJECTIVE - the objective of this research is to develop the procedures necessary to properly incorporate sanitary waste products within roadway embankments.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas, including the FHWA, Federally Coordinated Projects, HRIS service bureau, and ASCE indices have been scanned in preparing this statement.

B. Suggested key words: sanitary waste, highway embankments, landfills, waste products.

C. There is no known related research activities in this area.

V. URGENCY - Waste products created by man and their safe and sanitary disposal are everyone's problem. The transportation industry holds the potential to a key solution to some part of this problem. Additionally, it is becoming more difficult to buy expensive and scarce fill materials for large embankment construction. Conservation of natural materials is becoming a greater national issue. We must do our part.

Since a few states have experimented with utilization of some waste products in embankment fills, the research can augment the technology currently being developed piecemeal, and greatly advance the improved use of a surplus nuisance into a workable construction material.

PROBLEM NO. 2

I. NAME OF PROBLEM - Develop Rapid Non-Destructive Control Test for Determining Engineering Sufficiency of Constructed Embankments

II. THE PROBLEM - The one universal approach to evaluating engineering sufficiency of highway embankment fills is to mechanically compare a unit weight ratio of a known in-place volume with an artifically prepared maximum. Percent compaction of this prescribed maximum value may not be the degree of strength, stability or whatever, to assure satisfactory performance of the fill for its intended purpose.

Millions of dollars are expended each year by transportation agencies in the training of field personnel, implementation testing, and compilation of results to "control" embankment construction. It is assumed that such control will assure serviceability.

The test is not rapid, can be non-destructive if nuclear means are used, but the test may not be defining the proper parameter. In many instances, the engineer may be specifying far greater requirements than are needed.

III. OBJECTIVES - It is intended to study those parametric relationships necessary to judge the engineering

sufficiency of embankment fill construction procedures. A rapid, nondestructive field test would be developed to evaluate the parametric relations in keeping with the prescribed use of the finished embankment.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas including TRB, HRIS, FHWA, FCP and ASCE indices have been scanned in preparing this statement.

B. Suggested key words: rapid test, embankment construction, nondestructive test, engineering sufficiency.

C. There is considerable research, both under way and completed on the subject of compaction of soil and rock materials. This is not the major thrust of this project. A parametric study of the variables effecting the supporting ability of the fill for its intended purpose is needed and is presently not yet available.

V. URGENCY - The present approach to embankment construction is the stronger, the better. This means heavier compactive effort, greater use of heavy equipment, thinner left thicknesses, etc., all of which may not be required in all instances. Hence, considerable money, time and energy are being expended for a questionable end result. This problem must be solved and as soon as possible.

PROBLEM NO. 3

I. NAME OF PROBLEM - More Efficient Utilization of Wet Earth Materials in Embankment Construction

II. THE PROBLEM - The problem of drying wet soil is a major deterrent to construction progress. The traditional process is almost entirely dependent on the weather and entails many hours of aeration and manipulation to bring the embankment material to the desired moisture content. The procedure is costly in time, labor and energy. Methods, equipment and additives need to be developed to permit more efficient drying or stabilization of wet earth materials being placed in compacted embankments. Methods that heretofore were considered too costly may now merit reconsideration in the light of rising energy costs and shortages. The problem grows more acute each day. Without progressive, energy saving procedures the cost of embankment construction in money and energy may become completely prohibitive.

III. OBJECTIVES - To develop methods which will permit more efficient utilization of wet earth materials in embankment construction with resultant savings in energy and increased construction activity during weather not conducive to conventional drying.

IV. CURRENT ACTIVITIES - Subject areas: No. 33 Construction No. 41 Construction and Maintenance Equipment.

Key words: earthwork, wet earth materials, drying, energy consumption, energy optimization.

PROBLEM NO. 4

I. NAME OF PROBLEM - Improved Moisture-Density Requirements

II. THE PROBLEM - Compaction of soil and rock materials is one of the most effective means for improving the engineering properties of those materials for use in highway embankments and pavements. Compaction requirements, usually based upon AASHTO T-99 or AASHTO T-180, have been used by many agencies for years. The efforts to achieve the required moisture content and density significantly affect construction costs and associated energy consumption. Excessive compaction requirements are wasteful and of no significant benefit.

Compaction requirements would clearly be most cost-effective if related to the required engineering properties of the embankment or roadbed. The engineering properties, in turn, depend upon the location of the soil and rock material within the structure and the imposed loads during construction and during the life of the structure. Should the embankment and the subbase be divided into zones with different compaction requirements for each?

III. OBJECTIVES -

A. To determine the required engineering characteristics (which should include but not be limited to; volume stability and bearing capacity) for different zones in embankments and pavement bases.

B. To determine the practical

advantages (which should include but not be limited to; economics and rate of construction) of varying the moisture-density requirements from one zone to another.

C. To develop recommendations for improved moisture-density requirements for highway embankments and pavement bases.

IV. CURRENT ACTIVITIES - Items from the Transportation Research Information Service were reviewed in preparing this statement. The study "Improving Embankment Design and Performance," being conducted at Purdue University, is more closely related to the subject study than any of the others listed.

V. URGENCY - Embankment construction is typically the largest single item in highway construction. Any reduction in unit cost will result in significant savings in overall construction costs.

VI. Estimated Cost -

A. $150,000 if laboratory and field tests on one construction project are included.

B. $400,000 if a wide variety of soil materials and construction equipment are included.

PROBLEM NO. 5

I. NAME OF PROBLEM - Improved Techniques for Measuring the Acceptability of Compacted Soil

II. THE PROBLEM - Soils used in earthwork construction are normally compacted to improve their strength and reduce settlement. During construction the normal existing field control, to meet these objectives, is by indirect means using moisture and soil density criteria developed in the laboratory. Indirect control weakens the feedback process from construction engineer to designer. This increases the probability that changed field conditions (from that assumed in design) will not be recognized and/or won't be recycled through the design process: this often results in either under design or over design. Under design normally results in failure to meet service objectives and is accompanied by higher maintenance costs and premature reconstruction: both of these factors are accompanied by higher energy demands. Over design usually results in higher than necessary construction costs accompanied by higher energy usage.

Field control via methods that tie directly to materials characterization used in design would have the following advantages:

1. Value engineering principles could be more readily used to take advantage of new techniques, or field conditions not anticipated during design.
2. It would be possible to directly address the problem that laboratory processing of materials sometimes does not accurately predict performance characterization (or acceptability) of field processed soil.
3. It is much easier for construction engineers to feedback critical information to designers to insure the original service objectives will be met. This is especially important where materials performance properties within the project change significantly and where frequent materials changes can be expected.

III. OBJECTIVES - The goal for research in this area would be to develop new methods or validate existing procedures that enable more optimal usage (minimize costs and energy comsumption) of soil materials.

New technology would: (1) develop methods of measuring properties of field processed soils that insure original design requirements are met. (2) Reduce construction costs and construction energy demand through more optimal usage of soil materials. (3) Open opportunities for contractors to use value engineering in earthwork construction

IV. CURRENT ACTIVITIES -

A. Highway research in areas 32, 61, and 62 have been scanned in preparing this statement.

B. Suggested key words: compaction, soil properties, stability, embankments, quality control, energy, value engineering.

C. Although some work has been done in this area very little recognition was given to possible benefits in energy conservation and possible application of value engineering to the problems.

V. URGENCY - The problem of determining the acceptability of field processed soils has long been recognized as a major problem in earthwork construction. Task Force A2T61 recommended this subject for further research

because of the opportunity for significant energy savings by more optimal use of soil materials.

PROBLEM NO. 6

I. NAME OF PROBLEM - Deep Compaction of Granular Soils

II. THE PROBLEM - Frequently during wharf construction loose granular soil deposits exist or must be placed as underwater fill behind costly bulkheads or on slopes under expensive wharf structures. It is often deemed necessary to compact these materials to reduce the possibility of structural collapse under moderate to catastrophic earthquakes.

III. OBJECTIVES -

1. To determine under what conditions compaction of these materials is desirable or beneficial.
2. To objectively determine the most productive and economical means for achieving desirable compaction.
3. To determine the optimum means for evaluating deep compaction.

IV. CURRENT ACTIVITIES - Current deep compaction activities are mainly in the hands of proprietory interests who are marketing patented procedures.

V. URGENCY - Resolution of the problems outlined in this proposal could result in a considerable energy savings as well as having a sizeable economic impact.

PROBLEM NO. 7

I. NAME OF PROBLEM - Improving Trench Backfill Monitoring Procedures and Trench Backfill Design

II. THE PROBLEM - Excessive pavement distress develops over trenches dug for utilities, storm drains, sewers, etc. due to the lack of adequate compaction of backfill material. The state of the art of monitoring backfill does not insure adequate compaction of trench backfill.

III. OBJECTIVES - Establish a trench backfill procedure to include type of backfill material, methods of compaction and procedure for backfill to minimize trench settlement and overlying pavement distress. Establish guidelines as to the proper monitoring of trench backfill.

IV. CURRENT ACTIVITIES - No known activities currently underway.

V. URGENCY - Excessive pavement distress over trenches causes rough pavement requiring pavement resurfacing, and in extreme cases, complete trench re-excavation and backfill with a new pavement. Costs associated with correction of trench backfill are substantial.

A2F04 Construction of Bridge and Structures - R. M. Barnoff

PROBLEM NO. 1

I. NAME OF PROBLEM - Epoxy Coating of Prestress Strand

II. THE PROBLEM - In continuous prestressed concrete box girder structures the prestress strands are located in the top slab or the deck over the negative moment areas, thereby, becoming exposed to deicing chemicals and the corrosive condition that these chlorides induce. In normal concrete bridge decks the corrosion of deck steel does not normally effect the structural integrity of the total structure but only the deck. This is not the case with continuous box girder bridges where the principle prestress load carrying strands are placed in the concrete deck and would be subjected to active corrosion due to chloride contamination, thereby, effecting the structural integrity of the total structure.

III. OBJECTIVES - The objective is to develop the feasibility of epoxy coating prestressing strand in a manner similar to that commonly done with normal mild steel rebars used in today's concrete bridge decks.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 4, 6, 10, 12 and 18 have been scanned in preparing this statement.
B. Suggested key words: prestressed concrete, prestress strands, epoxy coating, bridge decks, deicing chemicals.
C. Epoxy coating of rebars as protection has recently proven viable following research by FHWA's Fairbanks Research Laboratory which proved its effectiveness. NCHRP Project 12-5 should be useful for this proposed project but it was complete in 1968 prior to the use of epoxy coat-

ing on rebars.

V. URGENCY - The increasing use of prestress concrete bridges in the form of long span segmental bridges increased the potential damage that an ever increasing use of deicing chemicals (chloride) can have on a major structure. To date we have concentrated on protecting the top layer of concrete bridge deck rebars but directly beneath these rebars we currently place prestress strands in the negative moment regions of the bridge and it behooves us to start protecting the strand at the earliest possible time where any stress ocrrosion of the strand would be critical to the integrity of the bridge.

PROBLEM NO. 2

I. NAME OF PROBLEM - Rehabilitation of Concrete Bridge Decks Subjected to Principal Load Carrying Stresses

II. THE PROBLEM - The removal and/or rehabilitation of the normal stringer supported concrete bridge deck is today fairly routine and equally successful. However, there is much greater concern over the proper manner of replacing entire or large concrete bridge deck areas when the deck is an integral part of the total structure carrying principal stresses.

III. OBJECTIVES - The objective would be to develop limits of deck removal that would be permissible while utilizing acceptable procedures. This limit could vary depending on procedures followed. A second objective would be to identify acceptable procedures including specifications for special materials that are critical to success of each procedure or system found acceptable.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 6, 10, 12, 14 and 18 have been scanned in preparing this statement.

B. Suggested key words: concrete bridge decks, rehabilitation, continuous bridges.

C. Currently many projects are involved with the rehabilitation of unstressed or stringer supported decks and this data should be useful to the development of materials and procedures for similar concrete bridge decks that are subjected to principal load carrying stresses.

V. URGENCY - Rehabilitation of concrete bridge decks is today of national importance with an estimated need of 1.7 billion dollars just to rehabilitate those bridge decks on the Interstate System. Many of the decks are in poor or moderate condition (approximately 4,000) and many of these are box girder, continuous prestress or other such structures where the deck furnishes an integral segment of the overall bridge support system. These decks if not rehabilitated in the near future can cause a serious impact on our nation's highway systems if the only answer is a replacement of the entire bridge.

PROBLEM NO. 3

I. NAME OF PROBLEM - Testing Weld Heat-Affected-Zone for Fracture Touchness

II. THE PROBLEM - For three decades, welding metallurgists and welding engineers have been testing weld joints for notch sensitivity. Little difficulty has been encountered in the case of deposited weld metal, but heat-affected-zone test results can be very misleading. The main problem in testing weld heat-affected-zone is the steep gradient of microstructure present.

III. OBJECTIVES - The objective of this research is to evaluate the precrack Charpy impact composite specimen as a test of weld heat-affected-zone in bridge steels.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 4, 10 and 12 have been scanned in preparing this statement.

B. Suggested key words: weld testing, fracture mechanics, fracture toughness.

C. Background: In the mid-1950's, researchers at the Watertown Arsenal (now AMMRC) developed a test method based on the Charpy V-notch (CVN) impact test for determining:

1. the relative touchness of the weld metal and weld heat-affected-zone.
2. the microstructure causing crack initiation and
3. the transition-temperature behavior of the weld metal and weld heat-affected-zone simultaneously.

The test method utilizes a composite test specimen, usually double the standard Charpy width, containing both weld metal and weld heat-affected-

zone in each test piece. Four to six test specimens are required to determine the magnitude of low-energy blow to initiate cracking in the test piece and five to ten tests are required to determine the resistance to crack propagation in the weld joint as a function of temperature.

Thus, a method is available for getting meaningful data on both the crack-initiation and crack-propagation resistance of weld heat-affected-zone but the method has not been used on bridge steels.

V. URGENCY - In fracture critical bridge members (components whose failure could cause collapse of the bridge) there is an urgent need for data on weld-heat-affected-zone (HAZ) toughness. There is no provision in the AWS/AASHTO Structural Welding Code for HAZ testing, and yet the weld region is the most likely place for crack initiation.

When fatigue cracks form at the toe of a fillet weld or at the toe of the weld reinforcement of a butt-weld splice, the crack is initially in HAZ. A method for measuring the properties of the HAZ is necessary. if we are to understand the weld behavior, and if we are to realistically specify weld-joint properties.

PROBLEM NO. 4

I. NAME OF PROBLEM - Standard Load Test for Bridges

II. THE PROBLEM - No standards exist for full scale load testing of highway bridges. Standardized methods of loading and measurement are not available for general use. Acceptable truck parameters and acceptability criteria including dynamic testing would be invaluable to researchers, state highway departments and other agencies in order to provide a common basis for the comparison of data and evaluation of test results.

III. OBJECTIVES - The objective would be to develop a detailed and complete load testing specification including data collection techniques to be adopted nationwide.

IV. CURRENT ACTIVITIES - None

V. URGENCY - Under the national bridge inspection and rating program many structures considered borderline may, in fact (as shown in Ontario), be satisfactory. Such determination can only be made by load test. Accordingly, considerable savings could be attained in many instances if standardized full scale testing procedures were available.

A2F05 Construction Management - E.R.Scyoc

PROBLEM NO. 1

I. NAME OF PROBLEM - Financial Factors as a Contingency Cost in Construction

II. THE PROBLEM - Once all direct costs are calculated, the contractor must decide what extra margin to add to his bid. Because of the high risks, intense competition, high working capital requirements and relatively low profit margins involved in the construction market today, an important set of questions that must be answered is related to the costs of financing the project. Examples of these questions are: what percentage of work completed will be paid, how promptly will it be paid, what are the chances of owner imposed delays to project completion, how stable will labor and material prices remain over the life of the contract and if the size of the contract is changed, will equitable compensation be made for the change. While it may be possible for a given owner to specify all the answers to these questions, doing so would negate many of the considerable advantages of the competitive bid construction system. By not putting any specific limitations on the answers to these questions, the owner virtually assures that, either construction costs will be exorbitant because all bidders considered the risks high, or the low bidder or bidders will lose money resulting in poor quality, unfinished work or bankruptcy. In any of these cases litigation is almost surely the final result. Establishing the proper balance for limitations on these contingency costs will use, to maximum advantage, the competitive construction industry and will assure the owner of greater cost efficiency for his project.

III. OBJECTIVES - The objective of this research is to identify the financial contingencies, to determine the effect of limitations as related to risk-taking by either the owner or contractor, and to recommend methods that may be used to determine the

most efficient balance to the limitations on financial costs factors.

IV. CURRENT ACTIVITIES -

A. Studies have been made, primarily in the building construction field, that have identified specific problems and made worthwhile recommendations. A number of experiments have been carried out in various parts of the construction industry with varying degrees of success. Because of limited funding, and limiting conditions, many of these studies and experiments have been very limited in scope, and few have been evaluated as to their effectiveness after the fact.

B. Suggested key words: construction costs, construction financing, contract procedures, contingency costs.

C. No such research activities are known to exist on a comprehensive national or industry-wide basis.

V. URGENCY - Available construction money has not kept pace with rising construction costs, resulting in less volume of physical construction each year. To provide the needs of society, owners are searching for high cost effectiveness. Contractors are striving to be more competitive in a shrinking market. The knowledge and recommendations resulting from this research could provide significant benefit to both parties and therefore, increase the cost effectiveness of construction dollars to society.

A2F07 Fabrication & Inspection of Metal Structures - K. H. Frank

PROBLEM NO. 1

I. NAME OF PROBLEM - Weld Repair Procedures and Criteria

II. THE PROBLEM - Repair of welds and members which are rejected during fabrication is a costly process. Present codes and specifications do not address this subject in any detail. Repaired weldments have resulted in service fractures. The cracking found in the I-79 Neville Island Bridge and the new Pt. Pleasant Bridge have both been the result of weld repairs. Repair procedures for both weldments and cosmetic repairs to plates need to be developed which result in economical repairs which increase rather than decrease the service life. The present state of the art leaves many engineers with the concern that "the cure is worse than the illness."

III. OBJECTIVES - Determine the proper welding procedures to be used to repair defects found in weldments and in plate surfaces. The use of repair procedures other than welding should be evaluated. Removal of plate surface defects by grinding should be evaluated. Parameters such as; type and method of excavation, preheat, electrode size, process, post heat, etc. should be evaluated to determine the best method of repairing internal weld defects.

The results of this study should be of a form that allows them to be readily incorporated into present specifications. Definite repair guidelines and limitations on variables should be included.

IV. CURRENT ACTIVITIES -

A. Research in Progress - unknown

B. Suggested key words - welding, weld repair.

V. URGENCY - The results of this study will reduce the cost and increase the service life of welded bridges. The cracking which has occurred from weld repairs has resulted in the expenditure of millions of dollars for field retrofitting. This research should eliminate many of these problems and costs.

PROBLEM NO. 2

I. NAME OF PROBLEM - Evaluation of Weld Qualification Tests

II. THE PROBLEM - The new specification for fracture critical members require extensive weld qualification testing. Numerous testing of weldments to meet these qualification requirements have been performed. No one at present is synthesizing the results to determine variability of the results when the same procedures are used by different fabricators or by the same fabricator at different times. In addition, the successful welding procedures used for various weldments are not being summarized. These test results are very valuable information. They provide the data to determine the variability of weldment performance when the presently essential variables are the same and consequently the need for requalifi-

cation if the variables are unchanged. A summary of the successful procedures would provide fabricators and states with a guide for selection of proper procedures for future weldments.

III. OBJECTIVES - Analyse the results of the weld qualification tests that have been performed on fracture critical members. Determine the variability of weldment performance when identical procedures are used by different fabricators and/or the same fabricator at different times. Evaluate the successful qualification results to provide a guide for procedures to be used in future weldments.

IV. CURRENT ACTIVITIES -

A. No known research in progress.

B. Suggested key words: welding weld testing.

V. URGENCY - The results should reduce the cost of fabrication of welded bridges by eliminating the duplication of testing on weldments made with identical procedures.

PROBLEM NO. 3

I. NAME OF PROBLEM - Sensitivity Evaluation of Nondestructive Inspection Methods

II. THE PROBLEM - Metal bridges are inspected by visual and other nondestructive methods. In addition to properties of the metal and the local stress level, the transition from subcritical to critical crack growth depends on the crack size. Data on the size of cracks that can be detected with a high degree of reliability under field conditions are not available for the nondestructive inspection methods. Knowledge of the characteristics of NDI methods under field conditions will allow reliability evaluation of members subject to fatigue crack growth and specification of fracture toughness consistant with growth of cracks to a size that can be detected with confidence.

III. OBJECTIVES - To determine the statistical distributions for the sensitivities of the principal NDI methods under field conditions so that the probability of not detecting a crack of specified size with a given nondestructive method can be estimated with confidence and the best inspection method for a given set of conditions can be determined.

IV. CURRENT ACTIVITIES -

A. No known research in progress.

B. Suggested key words: nondestructive tests, x-ray inspection, magnetic particle tests, penetrants, ultrasonic tests, cracks, crack detection, crack propagation, fatigue, inspection.

V. URGENCY - Research is needed for proper specification of material properties in fracture critical members as the critical crack size must be great enough to be detected with assurance and little information is available regarding capabilities of nondestructive inspection methods for detecting cracks of a specified size.

PROBLEM NO. 4

I. NAME OF PROBLEM - Development of reference Blocks for use in Ultrasonic Inspection of Steel Structural Weldments

II. THE PROBLEM - A variety of test blocks are now used by various agencies for qualification of ultrasonic test procedures for weld inspection. Development of a standardized series of blocks would allow general acceptance of procedure qualification, eliminate duplication of the qualifying process for different agencies, and result in greater uniformity of inspection. Surface and coupling characteristics of ASTM E428 and other reference blocks are not similar to characteristics of fabricated structural steel.

III. OBJECTIVES - To develop a series of test blocks with surfaces comparable to as rolled and/or other surface conditions typical of newly fabricated steel (lightly rusted or sandblasted might also be appropriate) and with defects that adequately simulate the cracks and other planar defects which are best detected by the ultrasonic method.

IV. CURRENT ACTIVITIES -

A. Research in progress - unknown.

B. Suggested key words: ultrasonic testing, nondestructive testing, inspection, flaw detection, quality control, test blocks, reference blocks, ultrasonic reference

blocks.

V. URGENCY - Successful development and a favorable cost-benefit ratio appear nearly certain.

G. GENERAL MATERIALS - D. Peterson, Chairman

A2G01 Mineral Aggregates - T. P. Teng

PROBLEM NO. 1*

I. NAME OF PROBLEM - Characterization of Acceptable Aggregates for Portland Cement Concrete Pavement

II. THE PROBLEM - Information on (1) the correlation between aggregate properties and their performance in PCC pavement and (2) appropriate test methods predictive of that performance need to be developed. The lack of this information prevents optimum use of currently available aggregates and also proper development of new supplies of aggregates for PCC pavement construction.

III. OBJECTIVES -

A. Determine the correlation between quantitatively different levels of aggregate properties and their performance in PCC pavements.

B. Develop suitable test methods for predicting field performance through review and modification of existing tests or development of new test procedures where existing methods are inadequate or nonexistant.

C. Develop aggregate specifications based on fundamental properties. These specifications would relate to performance criteria so that aggregate selection can be suited to the requirements of a particular job and location.

IV. CURRENT ACTIVITIES -

A. This problem statement is a modification of Problem Statement No. 48 which was developed on NCHRP Project 4-10. The modification limits the area addressed to the characterization of aggregates used in PCC pavements. This change was required by the undertaking of NCHRP Study 10-12 (see current research, Item C).

B. Suggested key words: aggregates, aggregate properties, aggregate characteristics, physical and chemical properties, engineering characteristics construction materials, PCC aggregates.

C. Current related research includes the NCHRP Project 10-12 on the acceptance of aggregates used in bituminous paving mixtures. This research is addressing the problem originally raised in Problem Statement No. 48 only as it applies to bituminous mixtures. Therefore, that portion of the problem concerning PCC concrete aggregates is yet to be attacked. Other research includes studies of the wear resistance, abrasion resistance, polishing characteristics, load deformation characteristics as a function of geometric properties, touchness, and petrological characteristics of selected aggregates. In a limited number of studies, performance is being related to aggregate properties.

V. URGENCY - Information on the characteristics of aggregates that affect performance in portland cement concrete is needed to permit the design of pavements that will serve traffic throughout their design life. A high priority should be assigned to this effort to enable the development or revision of design criteria and, thereby, reduce the number of pavements that will be constructed to "improper" standards.

PROBLEM NO. 2

I. NAME OF PROBLEM - Determination of Significant Properties of Aggregates for use in Untreated Aggregate Road Surfaces

II. THE PROBLEM - The characterization of aggregates for use in untreated gravel or crushed stone road surfaces has, for many years, been based on the properties desired for dense-graded untreated aggregate bases. It has been widely assumed that aggregate in untreated surfaces behaves in the same way as aggregate in flexible pavements containing asphalt or other cementing agents. Current specifications usually address gradation, durability, abrasion resistance, Atterberg limits, and relative compaction. These do not adequately characterize a good surfacing aggregate. Many aggregates failing one or more of these tests have performed well, while others passing all stated tests have failed. Some aggregates possess a natural cementing property which is not recognized in generally accepted testing procedures and is apparently not

understood.

The relationship between field performance and the properties of aggregate in untreated road surfacing must be determined through new research which is independent of treated paving materials. Important properties to be studied include physical characteristics, degradation, and mineralogy. The relevance of existing tests should be determined and new test procedures developed if needed. The interactions between fundamental aggregate properties, traffic type and volume, and climate should be explored and explained. Significant properties and relationships must be translated to practical design criteria and field construction control tests.

III. OBJECTIVES - The objectives of this research are to:

A. Determine what properties of aggregates are essential, desirable, nonessential, or detrimental to the performance of untreated aggregate surfaced roads.

B. Determine the relevance of existing tests and develop new tests if needed.

C. Produce practical criteria which can be specified by designers and checked by construction inspectors.

IV. CURRENT ACTIVITIES -

A. Research sponsored by the USDA Forest Service is underway to determine layer equivalents for use in pavement structural design equations and to quantify the rate of aggregate surface loss related to traffic type and volume, snowplowing, and maintenance technique.

There are two tasks within Project 5M of Federal Highway Administration's Federally Coordinated Program for Research and Development which are relevant to this problem. Task 5M-2, "Surfaces for Low Volume Roads," deals with methods to improve design, construction, and maintenance of unsurfaced or gravel surfaced roads. Task 5M-3, "Utilization of Lower Quality Standard Materials and Use of Waste Materials for the Construction and Maintenance of Low Volume Roads," addresses the economics of using lower quality and waste materials in low volume roads. This task also will provide guidelines for design, construction and maintenance of low volume roads using these materials.

C. Suggested key words: surfaces, gravel surfaces, untreated surfaces, gravel roads, unsurfaced roads, crushed stone surfaces.

V. URGENCY - There are about 2 million miles of unsurfaced or aggregate surfaced roads in the United States and a huge mileage worldwide. More is being added each year. Proper characterization of surfacing aggregates could potentially save millions of dollars in construction and maintenance costs annually.

A2G02 Coating, Signing & Marking Materials-W. E. Douglas

PROBLEM NO. 1

I. NAME OF PROBLEM - Instant Dry Traffic Paint

II. THE PROBLEM - There are numerous supposedly instant dry traffic paints on the market, but these paints do not dry within 20 seconds in all conditions usually found on the roadway during the painting season. The materials which currently approach this ideal tend to be less durable than slower drying paints.

III. OBJECTIVE - a 20-second dry traffic paint should be developed which is truly an instant dry paint and has adequate durability to be economical.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress does not address this problem.

B. Traffic Paint, Traffic Striping.

C. There does not appear to be any related Highway Research in Progress which deals directly with this problem.

V. URGENCY - Traffic striping is performed on most highways which have significant traffic volumes, in some states as low as 100 ADT. Traffic cones are usually required to protect drying paint. As this is a hazardous and costly component of the striping operation, it should be eliminated by using fast drying paints which obviate the need for coning.

PROBLEM NO. 2

I. NAME OF PROBLEM - Compare Sign Costs: Upper vs Upper/Lower Case Legends

II. THE PROBLEM - Use of signs with

Upper/Lower Case legends on all interstate roads as is prescribed in the regulatory manuals necessities use of increased sign sizes, greatly increased sign supports and foundations, and substantially increased costs. However, there are other high speed, multi-lane, divided expressways that utilize signs with all upper case legends. Reportedly, the latter experience no abnormal accident rates, yet their directional signs and supports were fabricated and erected at significantly lower costs.

III. OBJECTIVE - To determine whether or not the cost/benefit factor warrants the continued use of current expressway sign practices. In other words, is there an increase in travel safety that justifies the increased costs required for the much larger upper/lower case signing?

IV. CURRENT ACTIVITIES - (I have no information that would enable me to comment on this section.)

V. URGENCY - It is difficult to identify the exact urgency of the recommended study but if it were to be conducted and the conclusions support the use of signs with upper case legends only, considerable cost avoidance could be realized. I can't estimate the cost of such a study but the first step could be a comparison of traffic volumes, speeds and accidents on a multi-lane divided expressway with directional guide signs employing only upper case legends with the same data for a similar road using guide signs in conformance with the current interstate standards.

PROBLEM NO. 3

I. NAME OF PROBLEM - Economical Primers or Substrates for Traffic Paints

II. THE PROBLEM - The adhesion of traffic paints is better to asphalt than to portland cement concrete or to some aggregates used in asphalt-type paving. The space between aggregate particles protruding above the asphalt surfaces of asphalt-type pavements are voids into which traffic paint is placed. These painted voids add little to the visibility of the markings because in dry weather the voids collect dirt and during wet weather they hold water. The effectiveness of a stripe is reduced when it is covered by dirt or water. The current trend toward skid-resistant pavements is resulting in higher protruding aggregates.

The cost of paint is increasing. Filling such voids with paint unnecessarily increases the cost of pavement markings.

III. OBJECTIVES -

1. Improved adhesion between painted pavement markings and concrete through use of a primer.
2. Develop primer-filler, more economical than paint, that can be used to fill voids between aggregate in asphalt-type pavement.
3. Provide raised base for paint stripe that will raise stripe above water on the road so that night visibility of the stripe will be improved during rain storms.
4. Develop procedures for applying acceptable systems.

IV. CURRENT ACTIVITIES - A search of NCHRP Areas 3, 4, 5, 9 and 17 failed to show any related activity. District 16 of the Texas State Department of Highways and Public Transportation has done some preliminary work.

V. SUGGESTED WORK -

1. Investigate use of asphalt-additive (such as latex) mixtures as adhesion improves.
2. Investigate asphalt-additive-filler mixtures as economical bases to fill voids and to elevate the stripe.
3. Develop and evaluate other systems that could be used as a primer or void filler.
4. Develop procedures for applying acceptable systems.

VI. URGENCY - Improving the efficiency and economics of pavement marking is a universal problem. The cost of marking materials has nearly doubled in the past five years and such costs continue to go up.

A2G03 Sealants & Fillers for Joints & Cracks - W. T. Burt III

PROBLEM NO. 1

I. NAME OF PROBLEM - A Study of Bridge Joint Movements

II. THE PROBLEM - Bridges move. The sealing system for the bridge must respond to the bridge movement. The movement may be a straight distance change caused by temperature and moisture or it may be a racking type of distortion

from the many variations of skews, horizontal, angular vertical and articulating motion patterns. There may also be impact, vibration of slab ends, or creep and plastic flow which cause permanent changes in deck length.

It is critical that bridge joints be sealed to prevent the entry of both water and incompressibles. Literally hundreds of examples can be shown of bridges with badly deteriorated pier caps, abutments and beam ends, which are caused by poorly sealed bridge joints.

III. OBJECTIVES - The main objectives of the program is to measure the amount and type of bridge joint movements. This should define the limits of the problem so that sealing systems can be designed to accommodate this movement.

Most bridges have at least some angle of skew. This may include two or more angular changes in the line of a joint, such as horizontal and vertical change, concentrated at the curb line. The joint measurements must include the curb areas because of its high vulnerability.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas, one, four, twelve and twenty-one have been scanned in preparing this statement.

B. Suggested key words: Bridges, Joints, Joint Seals, Pavement Movement, Temperature, Creep, Skew.

C. Related research activities would be the AASHO Road Test results, the Delmar By-pass project by N.Y. DOT, the work done by Cook and Minkarah for Ohio DOT and FHWA , Van Breemen's work in New Jersey and other records by pavement movement such as those by Kentucky and Connecticut.

V. URGENCY - This project is considered to be critical by TRB Committee A2G03. There are standing at the moment many bridges in need of immediate repair because this problem has not been solved.

The research findings could be immediately implemented in the form of a Guide Specification which would define the movement parameters for bridge joint seal design.

PROBLEM NO. 2

I. NAME OF PROBLEM - Restraining the End Movements of Rigid Jointed Pavements at Structures

II. THE PROBLEM - many bridge joints are made inoperative and, in some cases, even destroyed because rigid pavements often encroach on a structure. The lengthening of the pavement is usually caused by the infiltration of debris into the joints and cracks. Physically what happens is that the pavement expands as a unit from the mid-length point outward as a long column, but upon contracting each slab's movements are centered upon its own mid-length point because there is no elastic restoring force to push the column back together. These open joints become filled with debris and, on the next expansion cycle, the column pushes outward a little further. Eventually, the pavement either blows up or it shoves the abutment or endwall.

As it is difficult enough to design a bridge joint for normal movements, it presently becomes doubly difficult to predict and design against encroachment. The use of expansion joints or pressure relief joints in the pavement is not the answer, as it removes the elastic restraint and the pavement lengthens more quickly. It is not unusual to see a 4 inch pressure relief joint become completely closed in 3 or 4 years. A pressure relief joint saves the structure, but ruins the integrity of the pavement. Fortunately, a pavement is not inherently an unstable column as evidenced by the existing long sections (several miles) of continuously reinforced concrete pavements which do not blow-up. Similarly behaving are the long sections of short plain slabs, such as used in California, which seldom blow-up.

Present Lug systems used on CRCP have been effective in at least halving the normal movements, from 2 to 3 inches to less than 1 inch. Technology may be such that bridge end walls could be utilized and properly designed to resist thrust, much have economically.

III. OBJECTIVES - The objective of this study is to develop an anchorage system for the terminals of jointed rigid pavements to prevent the pavement from encroaching on bridge structures. In addition to the sparsely investigated pile/lag soil anchors and subbase friction, thrust-resistant endwalls and/or tiebacks will be investigated.

IV. CURRENT ACTIVITIES -

A. NCHRP Synthesis was published

on bridge approach slabs in 1969.

B. Several HPR studies have been conducted on bridge approach slabs, but most were concerned with settlement. Two HPR studies on settlement are underway.

C. TRB Committee A2B01 published SR 173 in 1977 on the subject, "Design of Terminals for Rigid Pavements to Control End Movements: State of the Art."

D. Mississippi conducted an HPR study in the mid-60's on controlling pavement end movements. An excellent report, but it hardly touches the solution.

E. Numerous reports are available on blow-ups, but none attacks the problem outlined here.

V. URGENCY - This study is considered urgent because of the widespread distress which exists around the country. Expensive joints are being destroyed and major arteries are repaired under extremely hazardous conditions for drivers and workers. If FHWA is to institute "Zero Maintenance" pavement concepts, the bridges and joints at the transitions must be compatible. Similarly, new pavements are added to the growing list for rehabilitation.

PROBLEM NO. 3

I. NAME OF PROBLEM - Measurement and Prediction of Joint Width Variation in Concrete Pavements

II. THE PROBLEM - Joints in concrete pavements are usually sealed without theoretical (numerical) consideration and coordination of factors such as the joint width, variation in joint width, capabilities of the sealant, and the time of year the joint is sealed. This leads to unpredictable behavior and varied effectiveness of the joint-sealant system.

III. OBJECTIVES - The main objective of this research is to come up with a method of predicting joint width variation so that proper initial joint width and a matching sealant can be used for a particular job. The research should include a literature study, establishment of a predictive model for joint movement, field measurements on actual pavements in different locations of the country, and finalization of a practical predictive model.

IV. CURRENT ACTIVITIES -

A. Bibliography and research in progress has been scanned.

B. Suggested key words: sealants, joints, pavements.

C. There are a number of data sources on joint movements and sealants, available, but a comprehensive field and theoretical study with a goal to predict joint movements for pavements is still lacking.

V. URGENCY - Since many joint sealing efforts have resulted in less-than-satisfactory results, the study appears to be timely and urgent. The knowledge gained should be useful not only for new concrete pavements but also for resealing and maintenance operations.

PROBLEM NO. 4

I. NAME OF PROBLEM - Pressure Relief Joints in Bridge Approaches

II. THE PROBLEM - Pressure from Accumulative Growth of Rigid Pavements adjacent to bridges have caused damage to bridge approach, slabs, abutments, decks, joints and superstructures.

III. OBJECTIVES -

1. Gather information on designs and/or repair methods used by various agencies to alleviate the problem.

2. Evaluate benefits and deteriments of the various design and repair methods and make information available to those concerned with the construction and maintenance of bridges and pavements.

3. Recommend future research to generate designs for economically feasible methods to relieve pressure and thereby prevent potential damage to pavements and bridges.

4. Assemble information concerning the effect of repair techniques on the service life, safety, performance and maintenance of the bridges and pavements.

IV. CURRENT ACTIVITIES -

A. NCHRP Summary of Research in Progress through 1978 in Area Twelve-Bridges and World Highway Research in Progress.

A limited literature search was performed. It included 4 of the 5 available systems; Smithsonian Science Information Exchange (SSIE), Lockheed Dialab, Compendex and National Transportation Information Service (NTIS).

"HRIS" has recently been removed from "on-line" therefore not available

through these channels.

Very little information was generated. It is believed that the scantry returns reflect the lack of research being done in this area rather than a flaw in the information services. Only appropriate report generated: "Pressure Relief Joints for Rigid Pavements", N. Y. State Department of Transportation.

B. Pressure relief, accumulated pavement growth.

C. Many agencies, especially in maintenance, are using techniques to relieve pressure both before and after substantial damage to bridge and pavement have occurred. Dissemination of this knowledge as well as design to accommodate pavement growth are unknown to the persons responsible for design, construction and maintenance to bridges and pavements.

V. URGENCY - The gathering of state of the art designs and techniques is considered highly important to reduce future damage to bridge and pavements so that persons responsible for design construction and maintenance have the best information available for correcting the problem. Failure to prevent the damage is costly from the standpoint of repair and also for injury or damage caused to the traveling public as a result of damage to the bridge or pavement.

The research findings could be immediately implemented in the form of guidelines which would describe the various conditions causing pressure point and after damage to the bridge or pavement.

SUPPLEMENT - The overall objective of this project is to provide guidance for the proper design construction of bridges and pavements thereby preventing damage caused by accummulated pressure from pavement growth and to identify, evaluate the effectiveness of repair techniques.
PHASE I -

Task 1 - Identify and categorize common types of structural damage to bridges and pavements caused by accumulated pressure.

Task 2 - Analyze the state of the art of bridge design and procedures for accommodating pressure relief by maintenance forces.

Task 3 - Based on existing experimental and field performance data, evaluate techniques that have been applied or may have application in preventing damage caused by pressures. Evaluate benefits and detriments to bridges and pavements for each design or technique.

Task 4 - Prepare a report summarizing the work and make it available to those responsible for design, construction and maintenance of bridges and pavements.

Task 5 - Propose a basic outline of future research topics for possible Phase II project.

PROBLEM NO. 5

I. NAME OF PROBLEM - Asphaltic Concrete Bridge Deck Overlays and Bridge Expansion Joints

II. THE PROBLEM - Numerous bridge decks have been and are being overlaid with asphaltic concrete as a result of bridge deck deterioration. The overlay is generally provided to protect a waterproof membrane system. A solution is needed to the apparently unavoidable migration, wearing or time dependent lowering of these asphaltic concrete overlays in areas adjacent to the expansion joint system.

The effect of this phenomena is to expose to the rigors of traffic the expansion joint system in a "sitting duck" manner with the result that it is literally beaten out of service prematurely. The high cost of this phenomena is staggering to bridge maintenance personnel around the world today. In snowplow areas, expansion systems are often ripped completely out of the deck and the cost plus the urgency of immediate repair is very high.

III. OBJECTIVES -

A. Identify and evaluate methods currently in use for sealing bridge joints where asphaltic concrete overlays are used.

B. Identify and evaluate the properties of various types of asphaltic concrete used to overlay bridge decks and the methods used for placing and compacting it next to the expansion joint system.

C. Determine the most suitable materials and methods for minimizing distress and failure of the overlay at the overlay-joint interface and the subsequent failure of the expansion joint system.

D. Develop and experimentally evaluate improved systems and guidelines for use by maintenance in repairing distressed joints.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 27, 31, 33, 34 and 40 were scanned in preparing this statement. An HRIS selection pertaining to sealants and fillers for joints and cracks made June 11, 1973 was also reviewed.

B. Suggested key words: bridges asphaltic concrete, flexible pavements, bituminous materials, expansion joints, joint sealers, and membranes.

V. URGENCY - The problem of bridge deck deterioration is universal and efforts are under way to find a solution. One method widely used is placing a waterproof membrane overlaid with asphaltic concrete. This also requires raising of the expansion joint system or the placement of a new system. This is the only practical method of restoring and protecting older bridge decks. It is therefore, urgent that a solution be found to the problem of the expansion joint system-overlay interface. The results could be immediately implementable in design and construction.

It is estimated that $100,000 would be required to accomplish this research.

This problem is certainly an aggravating one. With the current interest and activity in bridge deck resurfacing, the solution takes on some urgency. A design to eliminate the problem would be worthwhile, welcome and immediately implementable.

PROBLEM NO. 6

I. NAME OF PROBLEM - Sealing Cracks in Flexible Pavements

II. THE PROBLEM - The problem of cracking of flexible pavements is widespread throughout the country. This cracking may result from a number of factors including temperature (thermal), expansive soils, and load. If surface cracks are left untended, they may result in more serious structural damage to the pavement system. They permit the entrance of water which may saturate the subgrade and reduce the load carrying ability of the pavement or result in frost heaves. Pavement systems with free draining subgrade material may not have serious problems if water is allowed to enter. Many of the existing materials and methods used for crack sealing are not very effective or permanent. The problem is then determining which cracks are to be sealed (subgrade type, crack width), how they are to be sealed (equipment, materials, methods), and when. Efforts are underway to improve design and construction of pavements so as to minimize cracking; however, many pavements are in place where cracking is a serious problem.

III. OBJECTIVES -

A. To determine the extent of the cracking problem in flexible pavements and identify the existing materials and techniques used to seal the cracks. Evaluate the effectiveness of the various methods used.

B. Determine the consequences of not sealing cracks for flexible pavements composed of different types of materials in various layers such as subgrade materials variations.

C. Determine the types and magnitudes of movements occurring at cracks and determine the critical crack width or the point where it must be sealed.

D. Determine the required properties of a crack sealer such as movements, temperature, etc. and identify materials that will meet those requirements.

E. Develop criteria for crack sealing of flexible pavements to include evaluation of need for sealing, types of materials and equipment, and when the crack should be sealed.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 25, 26, 31, 33, 34 and 40 have been scanned in preparing this statement. HRIS selections made June 11, 1973 pertaining to sealants and fillers for joints and cracks were also reviewed.

B. Suggested key words: flexible pavements, asphaltic concrete, bituminous mixtures, cracking, crack sealing, and sealants.

C. There has been a very limited amount of formal research on crack sealing of flexible pavements and most of that was accomplished several years ago. The only recent research identified is an experimental crack sealing field study in Minnesota.

V. URGENCY - The solution of this problem is urgent for the many states with the flexible pavement cracking problem. The solution of the problem would help reduce costs on other maintenance activities. For example, why place a seal coat over the entire surface to temporarily cover the cracks when all

that was needed was crack sealing. The results could be implemented directly by an agency.

It is estimated that it would cost approximately $125,000 for this research.

PROBLEM NO. 7

I. NAME OF PROBLEM - Silicone Sealants for Highway Rigid Pavements

II. THE PROBLEM - The limited use of low modulus one component silicone sealants for sealing of contraction joints in rigid pavements shows that it has the capability to effectively seal out surface water if the right material is properly installed. The following questions need to be answered:

1. What physical properties should a seal have to be effective?

2. What performance can be expected?

3. Is the sealing with silicone cost effective?

What are the design criteria?

III. OBJECTIVE - The objective is to develop design criteria and specifications for silicone sealants and evaluate their performance.

IV. CURRENT ACTIVITIES -

A. Some successful installations have been made. Silicones have been proven as building sealants, but the disadvantage of a slow cure has precluded their use on highways.

B. Suggested key words: Sealants, silicone, specifications, performance.

C. Projects are being sealed in Georgia with low modulus silicone, but very little information is available on silicones as highway contraction joint sealants.

V. URGENCY - An effective highway joint sealant has been sought with some degree of success, but the ideal sealant system has not been found. Preformed seals have the disadvantage that they require a perfect joint if the seal is to be effective and often are not watertight. Field molded polymers undergo changes in properties with temperature. When the weather is cold and sealants are required to extend the modulus is higher and great stress is placed on bond surfaces. Silicones are relatively temperature stable and may extend in cold weather without producing significant increases in levels of stress on contact surfaces. They can also be applied in cool weather and since they are field molded can seal a joint with small spalls and imperfections. Silicones have the potential of providing a good durable seal. This potential should be investigated immediately for applicability as a roadway joint sealant.

A2G04 Adhesives, Bonding Agents and their Uses - W. T. McKeel, Jr.

PROBLEM NO. 1*

I. NAME OF PROBLEM - Structural Bonding Specifications

II. THE PROBLEM - Recent fatigue research and the new fatigue design specifications have highlighted the fact that all welded connections, even connections for secondary or temporary members, have a significant effect on the fatigue life of primary structural members. As a result of these new requirements, many of the welded connections that have been used by contractors in the past for finishing machine supports, form supports, etc., and by engineers for secondary attachments such as fill plates, scupper and gutter supports, etc., have had to be either redesigned or eliminated. Other types of welded attachments, longitudinal stiffeners and lateral connections for example, have had to be redesigned to the extent that fabricating cost for members containing such attachments have been substantially increased.

Having faced similar problems during the last several decades, the aircraft industry has been able to develop structural bonding methods which not only provide more economical connections but also connections with improved fatigue characteristics. For example, by using such methods, a threefold increase in the fatigue life of rotor blades for helicopters has been achieved.

Although presently uncontrolled by bridge engineers, some of these same methods have been accepted for bridge applications since most of the combination bearings presently being manufactured depend to a large extent upon structural bonding materials and techniques for their integrity.

Based upon a more general adapt-

ation of these methods to structural fabricating shops and to some limited field situations, this structural bonding technology could be made available to the bridge engineer and to the bridge contractor giving them a greater latitude in making economical, temporary or secondary connections with improved fatigue characteristics.

III. OBJECTIVES - Based on an evaluation of present structural bonding technology, prepare appropriate material, construction and design specifications suitable for use with various typical connection details on transportation structures. Illustrate the application of such specifications so that bridge engineers and contractors will be able to devise and use structurally bonded alternates for the temporary or secondary connections which are now almost exclusively welded.

IV. CURRENT ACTIVITIES - There is interest in this area of research but no efforts toward the adaptation of the specialized structural bonding technology of the aircraft industry to potential use on transportation structures are known. This problem statement is essentially one originated by the Ohio DOT, and a similar project is being formulated by the FHWA. Some use of anaerobic adhesives has been proposed to the PENNSYLVANIA DOT.

V. URGENCY - The use of welded connections is being restricted and the successful development of appropriate bonding specifications would result in immediate benefits.

PROBLEM NO. 2

I. NAME OF PROBLEM - Creep and Stress-Relief Properties of Epoxy Adhesives in Transportation

II. THE PROBLEM - Epoxy resins have been employed extensively as structural bonding agents in the aircraft industry. In this area their long term, time dependent properties have been well-characterized, allowing engineers to apply rational design procedures to adhesive bonded segments. However, most of the aerospace adhesives require elevated temperature cures, a factor which generally limits their use in transportation engineering applications because of the size of the structures involved. The ambient-cured compounds available to the highway engineer are usually defined by their short term mechanical, thermal, and chemical and water resistance properties. Their long-term properties such as creep and stress relaxation and the inter-related effects of humidity, water, varying ambient temperatures and vibration on these properties are almost never available. Information on creep and stress relaxation is necessary to provide assurance as to the long-term durability of bonded structures and to allow a rational consideration of the basic structural criteria of adhesives in primary load design.

III. OBJECTIVES -

1. Survey the literature for long-term test data and test methods applicable to bonded steel and PCC relevant to structural and mechanical design in the transportation field.
2. Develop tentative performance criteria giving particular attention to the shape factor.
3. Select a representative group of proprietary formulated epoxy compounds commonly used in the transportation field by contact with State Highway Departments and perform preliminary tests on these compounds simulating various typical field conditions of load, deflection, moisture, heat and vibration. Perform short-term tests, e.g., deflection temperature and initial creep curves.
4. Extrapolate initial results and compare data with a generic chemical description of the system obtained from the manufacturer.
5. Eliminate unpromising generic groups and expand testing on promising groups; optimize test conditions and record data for an initial period of one year.
6. Perform structural calculations and define limits of acceptance for typical adhesive applications in the transportation field for various types of joint configuration. Compare the most promising group for stress-relief and creep resistance with their short-term mechanical/thermal properties.
7. Prepare suggested specifications for epoxy compounds meeting selected generic classification and short-term mechanical tests which correlate with creep resistance and stress-relief.

IV. CURRENT ACTIVITIES - None known

V. URGENCY - The structural performance with time of most adhesives currently

used in transportation is unknown, a situation with the potential for failure. The urgency is heightened as the use of adhesives in bonding load carrying elements expands.

PROBLEM NO. 3

I. NAME OF PROBLEM - Selection of an Optimum Material for Shear Key Grout for Prestressed Concrete Beams

II. THE PROBLEM - Various materials are in use as shear key grouts for prestressed concrete beams. To reduce costs it is desirable to use an inexpensive material such as a portland cement grout, but because of the inaccessibility for inspection and the importance of the shear key to the integrity of the wearing course, it is desirable to reduce the potential for placing a grout with insufficient strength by using a high strength material such as an epoxy grout.

III. OBJECTIVES -

1. Review existing design practice and performance of currently used shear key grout materials.
2. Select a grout material which satisfies the following criteria:
   a) Achieves required strength in a reasonable period of time.
   b) Is easily placed.
   c) Has a record of satisfactory performance as a shear key grout.
   d) Lowest possible cost.

IV. CURRENT ACTIVITIES- None

V. URGENCY - Since there are many materials which appear to be providing satisfactory service, the research required to determine an optimum material is not urgent. There is a potential for reduced construction costs of prestressed concrete bridges.

PROBLEM NO. 4

I. NAME OF PROBLEM - Identification of Dangerous Chemicals Used in Transportation Adhesives and Sealants

II. THE PROBLEM - A greater awareness of the human health hazards of industrial chemicals has occurred over the past few years as a result of new medical findings and increased concern by both the general public, unions, industry and government. Problems of legal liability and widespread publicity have served to heighten these concerns.

Synthetic resin adhesives, grouts, mortars and sealants have been employed in a variety of applications for transportation construction and repair since the early 1950's when the ability to assess human health hazards, especially long-term hazards, was less sophisticated. The dangers of many industrial chemicals used traditionally have now been re-assessed or are undergoing reassessment.

A number of these findings have been encoded in the State and Federal regulations covering transportation, handling, and use such as CFR 29, 1910 (OSHA), CFR 16, 1500 (Federal Hazardous Substances Act), CFR 49 (DOT), CFR 21,121 (FDA) and the new EPA's "Toxic Substances Control Act" at present undergoing implementation. NIOSH summarizes existing toxicity information in their annual publication "Registry of Toxic Effects of Chemical Substances" and in NIOSH sub-file "Suspected Carcinogens."

Difficulties occur in implementing these regulations and other published findings by both Federal and State agencies and industrial formulators when developing, manufacturing and specifying synthetic resin-based compounds since interpretation requires specialized chemical knowledge and an understanding of bio-medical terminology. Compounded materials may be carcenogenic, poisonous, corrosive, irritant, sensitizing, or flammable or may present other unusual hazards, yet these may not be recognized by the formulator.

The result is that certain State Highway Departments who publish compositional-type specifications sometimes specify unusually hazardous materials unknowingly, a situation that also applies to some formulators in meeting the physical requirements of the majority of State Highway Department non-compositional, performance-type specifications.

A typical example is found in the AASHTO specifications: M 200-73, Class I

A coal tar pitch containing high boiling coal tar distillate is generally used to meet physical specification requirements; the distillate is a known human carcenogen; formula also typically contains phenol - a poison and DTA - a corrosive.

M235-73, Class I and Class II specifies butyl glycidyl ether, an extreme breathing hazard and mutagen and talc without a limit on the fiber content (fibrous talc is asbestos).

M237-73 specified butyl glycidyl ether and talc as in M235 and in addition asbestos, a known human

carcinogen and aminoethyl piperazine, a corrosive.

AASHTO M234-73 provides a caution label for M200, 235 and 237 which warns only against "severe dermatitis" and, as such, does not conform to the pre-emptive Federal regulations which require specific labels warning against specific hazards.

Fortunately only a minority of raw materials used in synthetic resin based compounds present extreme dangers such as carcinogenity and for practically all of these less hazardous alternatives are available. Therefore, the general objective of this project involves identifying the raw materials currently employed according to their specific hazards and any applicable state and Federal regulations to which they must conform during formulation, transportation, handling and use. Where potential or proven alternatives exist, these should also be identified.

This specific project is limited in scope to two-component, synthetic resin-based products that undergo chemical reaction at ambient temperatures upon addition of a catalyst, hardener, curing agent, or co-reactive resin--typically systems based on epoxies, polyesters, polyurethanes, vinyl esters, polyureas, and special acrylics and silicones.

In addition, environmental considerations of air, water, and earth pollution and the effect on other life forms are excluded; the project being limited to direct human health hazards. Due to the amount of information currently available, no significant amount of biological testing is envisaged and any such testing will be limited to short-term routine testing of a select group of raw materials where published data is clearly contradictory.

It is further intended that interpretation of available biological evidence be clearly referenced as to source in order to avoid legal implications of project findings as original source data.

III. OBJECTIVES -

1. Survey the State Highway Departments, relevant departments of the Federal Government, (e.g. Corps of Engineers) and relevant associations (e.g. AASHTO, ACI) and determine the generic classes of base synthetic resins used in transportation construction and repair (e.g. epoxies, polyesters, etc.) and obtain available specifications.

2. Prepare a comprehensive listing of industrial chemicals used in formulating the various generic classes of resins that cure at room temperature, derived from the standard text books on the subject, other well-recognized publications, the specifications from Task I and by contact with the major resin, hardener, and catalyst raw material manufacturers, selected major formulators and other sources of significant expertise in the field.

3. Classify these raw materials firstly by the type of synthetic resin in which they are commonly employed and secondly by their function in the formulation (e.g. 1 epoxy resins, 1.1 hardeners, 1.2 diluents, 1.3 flexibilizers, 1.4 plasticizers, 1.5 fillers, 1.6 liquid extenders, 1.7 pigments, 1.8 thixatroping agents, etc.)

4. Survey the available sources of toxicity data relating to industrial chemicals including NIOSH, the EPA Inventory List (being established under the Toxic Substances Control Act), the various CFR's previously listed and the medical data obtained by the various raw material manufacturers used to prepare their MSDS's on specific materials. Include in this survey existing and proposed State and Federal regulations covering handling and labeling during formula manufacture, transportation, application, and end use exposure of the various raw materials involved.

5. Classify each material according to its hazards and regulations using, as far as possible, terms easily understood by the typical formulator or specification engineer, (e.g. cancer-suspect agent, poison, corrosive for transportation, skin corrosive for handling, etc.). Terms used to describe the raw materials should not be trade names [1] or generic descriptions but the most commonly used chemical name and composition, if a mixture.

6. Review the hazard classifications for cancer-suspect agents, poisons and any other extremely dangerous materials and suggest potential or proven alternatives for these specific materials derived by contact with industry.

7. Identify any widely used raw materials where health hazard data from various sources is in clear conflict or does not exist and pre-

pare a budget for testing these raw materials by short-time tests contained in the CFT's. Such work, if any, will form Phase II of the project after Panel approved.

8. It is intended that the results of Phase I will be circulated to State Highway Departments, Federal agencies and formulators bidding on State and Federal performance specifications as a series of separate documents according to the generic classification of the synthetic resin base involved.

IV. CURRENT ACTIVITIES -

A. No HRIP in this specific area known.

B. Suggested key words: safety, toxicity, hazardous substances, toxic substances, toxicology, health hazards, handling, allergies, precautions, personnel protection, systemic effects, carcinogens, suspected carcinogens, skin corrosives, eye corrosives, poisons, skin irritants, eye irritants, skin sensitizers, dermatitis, antidotes, biological activity, transportation regulations, FDA approval

In relation to - resins, synthetic resins, epoxy resins, polyurethane resins, polyester resins, silicone resins, vinyl esters, polyureas, acrylics.

V. URGENCY - There is an immediate and urgent concern as to the health hazards posed by synthetic resin compounds to State maintenance forces, to contractors to the State and Federal Government, and to plant workers manufacturing for the State and Federal Government. There is the immediate and urgent question of the burden of legal liability where the State, Federal Government and such organizations as AASHTO specify dangerous raw materials without prior warning of same. This is an immediate concern regarding the supply of proprietary compounds which may contain dangerous raw materials, perhaps known or unknown to the smaller formulators, to State and Federal Government specifying the performance of materials; with incorrect or incomplete warning labels.

Although new toxicity data is still being generated, it is probably that this process will continue indefinitely, thus identification of the most dangerous raw materials, based on current knowledge would be beneficial since currently known dangerous materials are unlikely to be re-classified less dangerous, rather the reverse.

Estimate: Phase I - $50,000, Phase II - to be determined.

A2G05 Corrosion - H. J. Fromm

PROBLEM NO. 1*

I. NAME OF PROBLEM - Protection of Rebars from Corrosion in Continuously Reinforced Concrete Pavements

II. THE PROBLEM - Many miles of continuous reinforced concrete pavements (C.R.C.P.) have been laid in the United States. Deicing salts are now penetrating through the concrete to the reinforcing steel and causing corrosion of the steel. This corrosion is causing the pavements to crack and spall thus opening them to further damage. This damage is similar to that which has now been experienced for several years on concrete bridge decks.

III. OBJECTIVES - To find a means of preventing further corrosion and repairing C.R.C.P. pavements.

The application of cathodic protecting (CP) to such pavements using the technique developed for bridge decks would be too costly for such long stretches of road. This would involve a powered system with an electrically conductive asphaltic concrete lift covered with an asphaltic concrete wearing course. Some other method of applying cathodic protection should be sought. Since these pavements lay on ground which will vary in conductivity from one area to another it is possible that cathodic protection could be applied in a manner similar to that used for pipe lines. This technique should be investigated. Another method of repair could be to repair the current damage then overlay the pavement with a 2 inch layer of dense, low slump concrete or with a latex modified concrete. This method would rely on the tensile strength of the added concrete to prevent further corrosion by preventing further build up of corrosion.

IV. CURRENT ACTIVITIES - Some work using cathodic protection is being done in Minnesota. This should be carefully observed and some overlay techniques developed.

V. URGENCY - reasonable.

PROBLEM NO. 2

I. NAME OF PROBLEM - Thin Electrically Conductive Waterproof Layer for Cathodic Protection of Bridge Decks

II. THE PROBLEM - Many reinforced concrete bridge decks are showing distress due to the corrosion of the upper layers of reinforcing steel. The application of cathodic protection, after the decks are repaired, to prevent further corrosion requires the application of two lifts of asphaltic concrete, the first an electrically conductive layer and the second a wearing course. If the bridge is marginal in its load bearing capacity such added weight to the structure may be intolerable. Another problem with current mixes used for cathodic protection is that they are not waterproof and allow water to reach the concrete surface. If the concrete is of poor quality and does not contain entrained air freeze-thaw damage may result.

III. OBJECTIVES -

1. To develop a thin electrically conductive layer for the cathodic protection of bridge decks. Such a layer must have high electrical conductivity and be waterproof to prevent moisture from reaching the bridge deck surface.
2. To develop a method using wires or other means to distribute the electric current evenly throughout the thin conductive layer.

IV. CURRENT ACTIVITIES - Little active work

V. URGENCY - reasonable.

PROBLEM NO. 3

I. NAME OF PROBLEM - A non-Destructive Test to Detect Corrosion on Post-Tensioning Cables in Bridge Decks

II. THE PROBLEM - Many reinforced concrete bridges use transverse and/or longitudinal post-tensioning cables. These cables are encased in metal or plastic ducts and are grouted into the ducts. These ducts are fastened to the reinforcing steel bars. It is feared that in the case of the metal ducts, deicing salts may work their way down to their surface and promote corrosion of the ducts, then of the cables. At present there is no way of detecting corrosion of these cables. Since the duct is electrically connected to the rebars, cathodic protection cannot be applied to the cables since they are effectively shielded by the metal duct.

III. OBJECTIVE - To develop a non-destructive test to detect corrosion on post-tensioning cables of concrete bridge decks.

IV. CURRENT ACTIVITIES - None

V. URGENCY - Many of these post-tensioned decks exist and if corrosion destroys the cables and the damage is not detected, a tragedy may result.

H. EVALUATIONS, SYSTEMS AND PROCEDURES - C. S. Hughes III, Chairman

A2H01 Instrumentation Principles and Applications - T. M. Mitchell

PROBLEM NO. 1

I. NAME OF PROBLEM - Nuclear Determination of Portland Cement Concrete Density

II. THE PROBLEM - The attainment of adequate consolidation or densification in freshly placed portland cement concrete (PCC) is a crucial step in the construction of bridge deck and pavement structures. Adequate consolidation insures maximum strength and durability development, increases freeze-thaw resistance, and minimizes the permeability of the concrete to water and corrosion-inducing sodium chloride.

Over the past 5 years, a number of highway agencies have begun to use nuclear gages to control concrete density, particularly in bridge deck overlays. The nuclear gages determine the density rapidly and accurately, but the highway agency work has uncovered several specific questions which need to be researched. These include: What is the appropriate means of establishing density standards for a project, e.g., rodded or vibrated unit weight, or theoretical maximum density? What percentage of that density standard is necessary to optimize the properties of the PCC? In two course bridge deck construction or thin overlay placement, how can the effects of the underlying concrete on the nuclear gage's response best be eliminated?

III. OBJECTIVES - To complete development of methods for using nuclear gages in controlling the density of PCC overlays, bridge decks, and pavements.

IV. CURRENT ACTIVITIES - More than half

of the State highway agencies are currently extensively or experimentally using nuclear gages to control the density of PCC. The state-of-the-art and research needs are summarized in a paper which was presented at the 1980 TRB Annual Meeting ("State of the Art in Use of Nuclear Density Gages on Portland Cement Concrete").

V. URGENCY - Increasing

PROBLEM NO. 2

I. NAME OF PROBLEM - Quality Assurance Programs for Air and Water Quality and Noise Measurements

II. THE PROBLEM - When measuring air or water quality or noise pollution, the project engineer or other professional responsible for the measurements must determine the appropriate calibration methods for the monitoring equipment and the intervals for recalibration. There are several levels of sophistication in instrument calibration. The more sophisticated and time consuming methods are used in the laboratory every several months, while the simple methods are used hourly, daily or weekly in the field, depending on the type of equipment. When standard calibration procedures are not used, both the accuracy and the comparability of field measurements can suffer. In addition, personnel performing field measurements have attained varying degrees of expertise in operating monitoring equipment. If they are not periodically briefed or recertified in the operation of the monitoring equipment, an additional source of error may arise.

III. OBJECTIVES - To establish formal quality assurance programs for the collection of air and water quality and noise pollution data. These programs should include:

1) procedures for the laboratory calibration of equipment within specified limits and using materials traceable to the National Bureau of Standards;

2) guidelines or procedures to insure proper field calibration of equipment and a determination of the effect of using these simplified calibration procedures on the accuracy of the data; and

3) measures to train and certify personnel in the proper conduct of field measurements.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 52 has been scanned in preparing this statement.

B. Suggested key words: quality assurance, air quality measurements, noise measurements, water quality measurements.

C. In recognizing the need for quality assurance programs, California Department of Transportation personnel have developed programs for water quality testing, air quality monitoring, and noise measurements aimed at satisfying the needs of their state. Other states also take steps to insure proper calibration of equipment (traceable to the National Bureau of Standards), proper use of measurement techniques, and sufficient training of personnel. However, techniques and procedures vary among states and even among agencies within individual states.

V. URGENCY - With increased public awareness of environmental pollution associated with transportation facilities and increased frequency of legal action against transportation agencies, quality assurance programs are needed to insure the uniform collection of environmental pollution data and to insure the validity of measurement results. The development of quality assurance programs is urgent and such programs can be implemented by appropriate transportation agencies throughout the country.

PROBLEM NO. 3

I. NAME OF PROBLEM - Nuclear Density Determinations on Layered Bituminous Pavement Systems

II. THE PROBLEM - A variety of nuclear gagemodels are currently available commercially for determining the density of bituminous concrete. The depth responses, i.e., the relative contributions of each depth increment of the pavement to the gage readings, differ however among the various models. As a result, density determinations on layered systems must be interpreted carefully. This problem is particularly critical in situations where 20 to 40 mm overlays are being placed on existing bituminous pavements.

For example, during the investigations of some prematurely distressed overlays, it was observed that the densities obtained by the nuclear gages during construction had been influenced by the density of the

underlying original pavement. The original bituminous pavement, before resurfacing, had reached very high densities due to traffic compaction, and these densities were affecting the nuclear gage readings taken on the 20 to 40 mm overlays. This resulted in misleading nuclear values for the overlay densities, giving the appearance that all values met the specification requirement of 95 percent of the design density.

Whereas this problem is not generally encountered on new construction projects, it is being faced more and more frequently with the increasing number of resurfacing projects being undertaken by the various highway departments.

III. OBJECTIVES - Research should be conducted to achieve the following objectives:

1) To establish the depth of influence (the effective depth to which the nuclear gage reads the density) and the contribution of each depth increment to the gage reading for the various models of commercially available nuclear gages.

2) To determine the effect of thickness and density of the bituminous concrete on the depth of influence.

3) To develop practical procedures to account for the influence of depth and the densities of the underlying layers in arriving at the most accurate density of the surface.

4) To determine the effect of aggregate composition on the nuclear densities.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress. The California Department of Transportation is currently supporting development of new nuclear equipment and techniques for monitoring densities in thin overlays in their HP&R Project D-3-65, "Asphalt Concrete Compaction Study."

B. Field testing of a nuclear density device was reported in the Proceedings of Assoc. of Asphalt Paving Technologists, Vol. 32 in 1963 by Hughes and Ralston, who discussed the depth of influence but do not suggest a practical procedure to account for the underlying layers. Limited study using two nuclear gages (Troxler and Campbell) was conducted in 1975, by the Bureau of Materials, Testing & Research, Penn. DOT, using various combinations of precast bituminous concrete slabs. Depending upon the density of the top layer, the two gages had different depths of influence. The Maximum depth was estimated at 50 mm.

C. Suggested key words: bituminous concrete, asphalt concrete density, nuclear density, overlays, nuclear gage, rapid test methods, construction

V. URGENCY - Highway agencies are engaging in growing numbers of resurfacing jobs. Overlays of 20 to 40 mm thickness are common as efforts are made to stretch the tax dollars available for resurfacing. If the nuclear gages are to be used to determine the actual density of the top layer, it is of prime importance to develop procedures to account for the depth of influence and the densities of the underlying layers.

A2H02 Quality Assurance & Acceptance Procedures - G. W. Steele

PROBLEM NO. 1

I. NAME OF PROBLEM - Quality Assurance Through Pavement Feedback System

II. THE PROBLEM - A quality assurance program within the transportation agency involves, besides material sampling, testing and inspection, review and update of these procedures based on performance of the finished product. Conceptually, it is a feedback system and emphasizes the interrelations among various disciplines within the agency. Typically, a highway or transportation agency collects large volume of data on a pavement system. However, most of this is fragmented and, therefore, not geared to providing answers desired concerning planning, design, construction and maintenance needs. An organized method of collection, storage, retrieval and analysis of the volume of data is needed to provide all disciplines a tool for their functional activity. For example, we need to identify the material characteristics that could be related to pavement performance. Likewise, relevant performance criteria need to be defined in order to relate them to specifications and back to construction quality criteria.

III. OBJECTIVES - To develop an integrated quality assurance system, the following specific objectives must be accomplished:

1. Define various subsystems

relevant to quality assurance feedback system.

2. Identify, within each subsystem, various attributes that may have a bearing to the overall performance and decision making process.

3. Define a method of collecting and automated data handling system for storage and retrieval of the overall system.

4. Develop guidelines for relating performance data to material characterization and specifications.

IV. CURRENT ACTIVITIES - A few states, notably Texas, California, Colorado, Illinois, and Louisiana, have developed or are developing a computerized system for some or all of the subsystems considered to be a part of the overall system. The FHWA is preparing a report on the Construction Data Retrieval System which should be forthcoming soon. Very little information is available on material characteristics and pavement performance relationships, mainly due to lack of efficient and practical data base.

V. URGENCY - The soundness of a quality assurance system within an agency can only be judged when it can be related to the performance of the finished product. Present practices do not come anywhere close to providing information relative to the interrelation between design, construction, maintenance and performance. The problem of finding a solution is obviously a multidiscipline one and will involve pavement and maintenance committees. However, regardless of where the origin lies, it is an urgent one.

PROBLEM NO. 2

I. NAME OF PROBLEM - Review of Sampling and Testing Procedures in Regard to Quality as Related to Performance of the End Product

II. THE PROBLEM - Many testing and sampling procedures are rooted in tradition and may not be controlling the performance of the end product. Some materials are being undertested and others are being excessively tested without regard to performance related materials properties.

III. OBJECTIVES - Re-evaluate basic performance-related material properties. Take a fresh and innovative look at sampling and testing requirements. Prepare a report on the specification changes needed that will relate sampling and testing to performance. Provide more cost-effective sampling and testing.

PROBLEM NO. 3

I. NAME OF PROBLEM - Cost Effectiveness-Sampling and Testing

II. THE PROBLEM - The quantity of sampling and testing is not always commensurate with the cost or importance of the product. Sampling and testing should relate to factors such as initial cost of product, cost of testing, cost of not testing, variability of manufactured or project-produced product, percent failures, criticality of performance, e.g., bridge deck failures, bearing pad failures, or potholes in pavement. Sampling and testing are very expensive items, and programs should be cost effective.

III. OBJECTIVES - Determine what samples and tests on what items can be minimized or discontinued without reducing confidence in end-product quality. Survey existing practices in state testing operations. Prepare suggested guidelines, multistate/nationwide on optimum sampling frequency. Re-evaluate sampling and testing frequencies in regard to factors stated under problem above.

PROBLEM NO. 4

I. NAME OF PROBLEM - Benefits and Disbenefits of Quality Control in Inspection and Testing by the Contractor and Feasibility of Extending Contractor Responsibility for Quality Control

II. THE PROBLEM - As with most new programs, there are many contractors and state highway agencies that are still rather skeptical about the contractors performing their own quality control as related to quality assurance programs. This issue has generated much controversy and has polarized opinions, but there are not many facts to support arguments on either side of the issue. The problems are the lack of definition of terms used and the lack of knowledge of benefits obtained (such as cost, ease of contract administration, and speedy construction).

III. OBJECTIVES -

1) Identify philosophical, legal,

and contractual basis for use of state or owner process control and contractor process control alternatives.

2) Identify relative costs and benefits for both types of control procedures in specific dollar terms by reviewing actual experiences of states and contractors where contractor process control has been adopted.

3) Identify personnel requirements under both procedures.

4) Identify specific impact of contractor process control on small contractors in terms of dollar costs. Is it more or less as compared with that of larger contractors?

PROBLEM NO. 5

I. NAME OF PROBLEM - Development of More Effective Rapid Test Methods and Procedures and a Synthesis of Same

II. THE PROBLEM - Modern high-production plants have outdistanced the ability to adequately test and control production. There is a need to provide quick, reliable test results so that the contractor can modify the operation on a timely basis.

III. OBJECTIVES -

1) Accept or reject on a timely basis.

2) Develop a new or modified rapid testing procedure for each of the various types of construction.

3) Develop a synthesis that contains information on all known rapid test methods for major construction items. Indicate which methods offer possible alternatives to currently used control or acceptance test procedures for major construction items. Include a section providing information on appropriate standard sampling procedures for major highway items.

PROBLEM NO. 6

I. NAME OF PROBLEM - Development of a Decision Function for Optimizing the Frequency of Observation made on a Production Process or Lot of Materials or Construction for (a) Control Purposes and (b) Acceptance Purposes

II. THE PROBLEM - An acceptable standard for determining the resources that should be committed to quality-assurance activities (control and acceptance) is needed. The most satisfactory approach would be a mathematical model that could be solved to indicate the optimum number of observations or inspection activities by treating the cost of quality assurance as a premium expressed as a percentage of the probable amount of possible loss.

III. OBJECTIVE - Develop a decision function that will yield a value in terms of numbers of observations or units of inspection time that, within a given confidence interval, would be expected to result in an optimum balance between the buyer's and seller's risks, the probable amount of possible loss, and a practical number of observations or units of inspection time.

J. COMPACTION AND STABILIZATION - R. Thompson, Chairman

A2J03 Lime and Lime-Fly Ash Stabilization - T. W. Kennedy

PROBLEM NO. 1

I. NAME OF PROBLEM - Lime and Lime-Fly Ash Stabilization

II. THE PROBLEM - Lime and lime-fly ash stabilization procedures are widely utilized. Although there are several mixture design procedures being utilized to establish the required lime, fly ash and lime-fly ash contents required for stabilization, there are no procedures that have gained wide-scale acceptance and standardization. In most instances, the mixture design procedures are not sufficiently flexible for broad scale application to achieve various treatment objectives (modification, swell control, strengthening) or accommodate special situations encountered (fine aggregate sources, by-product aggregates, late season construction conditions, etc.) Quality criteria (strength, durability, volume stability, etc.) for lime, fly ash and lime-fly ash treated materials have not been well defined. The criteria generally do not account for the wide diversity of applications and range of service conditions (traffic, environmental factors, etc.) encountered in practice.

Most lime-fly ash construction is of the "plant mix" type while "mixed in place" procedures are normally used in soil-lime construction. The major quality control items of interest are (1) lime and fly ash quality, (2) soil or aggregate properties, (3) lime and fly ash quanti-

ties and distribution, (4) mixing, (5) pulverization, (6) compaction, and (7) curing. All aspects of the construction process must be carefully controlled. The degree of control varies depending on the stabilization objective. Satisfactory quality control tests, procedures, and appropriate quality criteria are essential to achieving adequate quality control. Although many aspects of lime, fly ash and lime-fly ash quality control are considered in current specifications, additional effort is needed to refine and expand the present practices and develop supplemental procedures where appropriate.

Priority research topics are:

1. Lime and fly ash quality effects on stabilization.
2. Quick lime utilization in soil-lime stabilization.
3. Cut-off date considerations in lime, fly ash and lime-fly ash.
4. Soil type (pedologic classification, mineralogy, etc.) and aggregate characteristic effects on stabilization.

III. OBJECTIVES - The general objectives are to establish component material (lime, fly ash, soil, aggregates) quality guidelines and criteria and to develop comprehensive mixture design procedures with associated quality criteria and construction quality control procedures for lime, fly ash and lime-fly ash stabilization. Mix design procedures and quality criteria must be adaptable to the entire spectrum of stabilization objectives and applications. The quality control procedures would: a) include appropriate field testing procedures, b) consider sampling and testing frequency, c) establish quality criteria, d) consider tolerances and allowable variability, e) provide rational methods for determining curing requirements and cut-off dates, if applicable, f) provide a method of construction acceptance, and g) provide for post-construction surveillance.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress area 62 and 64 have been scanned in preparing this statement.
B. Suggested key words for this problem are lime, soil-lime, lime stabilization, soil stabilization, fly ash, fly ash stabilization, lime-fly ash, mixture design, test procedures, quality control, construction, quality criteria.
C. Several on-going lime and lime-fly ash stabilization research projects were noted. None of the projects specifically addressed the topics listed in the priority ratings for this research needs statement.

V. URGENCY - There is an increased utilization of lime, fly ash and lime-fly ash stabilization in transportation construction. The energy and materials savings potential associated with stabilization will engender even greater utilization. Based upon the current state of the art and the judgment of currently active researchers this project area is classified as "urgently needed."

PROBLEM NO. 2

I. NAME OF PROBLEM - Lime, Fly Ash and Lime-fly Ash as a Maintenance Tool

II. THE PROBLEM - Future highway activities will be mostly maintenance oriented. Because of energy crisis and shortage of materials, the use of stabilization techniques will be more critical.

III. OBJECTIVES - To investigate the potential for the use of lime, fly ash and lime-fly ash as a material to be used in maintenance of transportation facilities.

IV. CURRENT ACTIVITIES - Current activities are minimal.

V. URGENCY - In light of the increased maintenance activities, this problem is rated as urgently needed.

A2J05 Soil-Bituminous Stabilization - J. A. Epps

PROBLEM NO. 1*

I. NAME OF PROBLEM - Cold-Mix In-Place Recycling

II. THE PROBLEM - Cold-mix in-place pavement recycling is becoming a popular pavement rehabilitation alternative. The economic, energy and materials conservation benefits of this form of recycling has been demonstrated in the literature. However, before in-place recycling will become widely accepted by the engineering community mixture design and structural pavement design coefficients will have to be more adequately defined.

III. OBJECTIVES -

(1) Determine laboratory material properties that can be utilized for pavement thickness design purposes. (2) Determine in place material properties that can be utilized for pavement thickness design purposes. (3) Establish appropriate mixture design methods and criteria for lime, cement and asphalt stabilizers in cold recycling operations. (4) Establish the effect of asphalt recycling agents on the properties of aged asphalts in cold mixture operations.

IV. CURRENT ACTIVITIES - NCHRP Project 1-17 has been recently completed. HP and R funded research is being conducted at the University of Illinois, Texas A&M University, the University of Texas and Ohio State University.

V. URGENCY - Many agencies are in need of the results of this study to implement the use of cold recycling for the rehabilitation of thousands of miles of highways.

PROBLEM NO. 2

I. NAME OF PROBLEM - Foamix Asphalt Mix Design

II. THE PROBLEM - Foamix Asphalt mixtures are being used to stabilize low quality aggregates and reclaimed aggregates for use as pavement base course layers. At the present time, no proven method of mix design exists for this type of binding agent and resulting asphalt mixtures.

III. OBJECTIVES - (1) To develop a correlation between laboratory test results and field performance for Foamix Asphalt materials; (2) to determine the uniformity of the dispersion of the foamed asphalt in the aggregate matrix; (3) to develop additives to help promote the dispersion of the foamed asphalt and aid in coating the course (4) to determine the optimum fluids (asphalt and water) content for the mixture; (5) and to measure the retained strength of the mixture when subjected to varying environmental conditions.

IV. CURRENT ACTIVITIES - (1) Laboratory research is currently underway at Mobil Oil, Conoco Inc., Douglas Oil, Colorado DOT, Texas A&M, Purdue, and Iowa State; (2) laboratory research is contemplated by Chicago Testing Laboratory and Utah DOT; (3) field installations have been completed by the Colorado DOT, North Dakota DOT, and Michigan DOT; (4) laboratory and field tests have been conducted in the countries of Australia and South Africa.

V. URGENCY - It is anticipated that several major Foamix Asphalt projects will be let to contract by various state highway departments during the 1980 construction season. Research is needed to assure that these projects will be adequately designed in terms of optimum mix characteristics using Foamix Asphalt binders.

PROBLEM NO. 3

I. NAME OF PROBLEM - Compilation of Field Performance Data for Soil-Bituminous Stabilized Pavement Layers

II. THE PROBLEM - Several mixture design and layer thickness design procedures exist for soil-bituminous stabilized soil-aggregate mixtures (where the soil or soil-aggregate mixture is not required to meet gradation specifications). Bituminous treatments meeting this definition have been used as: 1) stabilized subgrades in high quality pavement systems, 2) stabilized subbases in high quality pavement systems, and 3) low cost stabilized bases and wearing surfaces in low-volume secondary, country, or farm to market roads.

However, no generally accepted design procedures have been recognized since the field performance of these stabilized pavement components has not been evaluated on the basis of a statistically valid sample of case studies collected from throughout the United States. A meaningful development of standardized mixture and thickness design procedures cannot be achieved without field performance information.

III. OBJECTIVES - The major objectives of the proposed research are directly related to the severe deficiencies in the existing mixture design and layer thickness design procedures for soil-bituminous stabilized materials. Both design technologies can be properly assessed and improved only if the field performance of the stabilized soil materials can be evaluated. The field performance evaluation must have as a basis three files of information to define a single performance case study:

1. mixture and layer thickness design procedures used for the soil-bituminous stabilized layers.
2. as constructed mixture constituency and layer thickness, and
3. traffic and maintenance theory.

This type of evaluation has not been conducted since sufficient data have not been compiled and analyzed. The missing "feedback" loop needs to be developed in order that soil-bituminous stabilization mixture design and layer thickness design methods can be assessed, improved, and perhaps standardized.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 25, 26, 31, 34, and 62 have been scanned in the preparation of this statement.

B. Suggested key words: bituminous stabilization, pavement design, pavement performance, mixture design, thickness design.

C. NCHRP Synthesis of Research Practice 30, Bituminous Emulsions for Highway Pavements, has been printed and distributed in 1975.

V. URGENCY - This project warrants a high priority since bituminous stabilization will become increasingly important for low-cost/low-volume roads in areas characterized by surficial coarse grained soils. Asphaltic emulsions will have major secondary benefits since no heat, and therefore, no energy, is required for field mixing and the emulsion does not have a volatile solvent, but only water and an emulsifier. The utilization of emulsions and other bituminous products will be deterred by the absence of standardized design procedures.

K. SOIL MECHANICS - L. H. Moore, Chairman

A2K01 Soils and Rock Instrumentation - E. T. Selig

PROBLEM NO. 1

I. NAME OF PROBLEM - Landslide Measurement System

II. THE PROBLEM - To insure safety of traveling public it is necessary to predict when a transportation facility in a landslide area becomes unsafe and must be closed. Predictions of safety are based on rates and magnitudes of movement of the landslide and therefore, accurate, dependable measuring methods must be devised.

III. OBJECTIVES - Develop a low cost, accurate, dependable landslide measuring system and prepare a detailed installation and operations manual. The system must be capable of measuring movements of up to 2 feet with an accuracy of 1/4 inch. It also must survive the field environment (frost, ice, salt, rain, snowplows, etc.).

IV. CURRENT ACTIVITIES - Methodologies of landslide prediction based on movement are being developed by various states (New York, California, etc.) and some private organizations. Each has problems with the accuracy and dependability of the field instrumentation used. Also, obtaining records is very labor intensive and therefore costly. No investigators contacted are satisfied with the present measurement systems.

V. URGENCY - The need for an adequate measuring system (or systems) is increasing as the needs for improving highway (transportation) safety is increasing.

PROBLEM NO. 2

I. NAME OF PROBLEM - Sub-Audible Rock Noise Measurement Applications to Landslide Monitoring

II. THE PROBLEM - The S.A.R.N. system has been used in the tunneling and mining industries for years to predict rock falls. A similar methodology should be applicable to soil or combined soil and rock landslides. Recently California has used the S.A.R.N. methods in conjunction with other measurements to predict landslide movements.

III. OBJECTIVES - To develop a methodology for predicting landslide movements based on micro-seismic technology.

IV. CURRENT ACTIVITIES - None known

V. URGENCY - Related to needs for predicting landslide movement

A2K02 Embankments and Earth Slopes - R. A. Forsyth

PROBLEM NO. 1*

I. NAME OF PROBLEM - Development of a

Rational Design Procedure for Membrane Reinforcement of Soft Soils

II. THE PROBLEM - The use of geotextiles for reinforcement of soft foundation embankment soils will undoubtedly proliferate in the foreseeable future due to the obvious economics possible by acceleration of fill placement rate and a firmer working table. The engineering properties of the fabric for optimum performance at a given site have not yet been established since the fabric-soil interaction has not been characterized analytically. Testing techniques are fabric industry related and not necessarily geotextile applicable.

III. OBJECTIVES - To develop an analytic procedure consistent with empirical experience to characterize the interaction of the fabric and soil in the reinforcement mode. To develop specifications using the analytical characterization which will assure optimum performance. To develop testing techniques which analyze the fabric properties such that the evaluations are applicable to geotextile applications.

IV. CURRENT ACTIVITIES - Fabric reinforcement for fill construction has been successfully utilized at a number of sites on an experimental basis. The simple model of using the fabric grab tensile strength as a resistance force in conventional slip failure analyses of such magnitude as to be unacceptable.

V. URGENCY - This research is considered to be extremely high priority since the use of fabric reinforcement offers the possibility of significant savings for construction over soft soils.

PROBLEM NO. 2

I. NAME OF PROBLEM - Effects of Underground Construction Techniques on Area Subsidence

II. THE PROBLEM - Construction specifications normally permit the construction contractor a great deal of latitude in the methods selected for excavation support and dewatering systems, holding him fully responsible for the correction of any detrimental effects of area subsidence. Many contractors lack the necessary expertise to evaluate the detrimental effects of normal construction procedures, as there is normally no practical experience to use as a guide in any new location involved. The shifting of the burden to the contractor was possible in the past only because underground construction was a highly specialized art, and engineers did not have the theoretical tools or sophisticated devices needed for proper evaluation of the problems involved. Today, with the vast background of technical experience available, as well as special investigative and monitoring procedures developed, the engineer is in a position to better serve the owner and the community in taking full responsibility for the control of underground construction.

III. OBJECTIVES -

A. Assemble a bibliography on all available methods of underground construction and excavation support systems. Summarize available knowledge as to the applicability of each system to various soil stratifications, including rock tunnels and rock excavation.

B. Establish a checklist of potential field hazards associated with each system of underground support including the effects associated with various applicable methods of dewatering.

C. Review the applicability of available Soil and Rock Mechanics theory to the evaluation of area subsidence related to the various methods of underground construction, excavation support as well as dewatering systems. Assemble a bibliography on available theory and empirical design approaches.

IV. CURRENT ACTIVITIES - Investigate the effects of Pile Driving, Dewatering, Rock Blasting, Tunnelling Equipment & Procedures, Soldier Beams & Lagging, Interlocking Steel Sheeting, Shotcrete, and any other systems, including methods of anchoring and bracing on area subsidence, investigation, testing, and monitoring procedures should be included in the review.

V. URGENCY - Area subsidence can have extensive adverse effects on existing as well as newly installed structures. Damages induced often result in costly claims and reconstruction which can be avoided if available knowledge were employed in developing the initial designs and instrumentation controls to avoid undesirable area subsidence and its irreversible effects. The practice of shifting the responsibility to the

contractor is no longer realistic, as the burden will nevertheless fall on the engineer to provide all necessary information to permit proper evaluation of construction conditions. The contractor, with only a limited time to evaluate and bid construction work is forced to be very conservative in his pricing unless the engineer can fully describe the safe methods of construction to be used. The engineer should be in a position to safeguard the owner and minimize construction contingencies by leaving as little as possible to chance, and not to encumber the contractor with avoidable risks. In so doing, any increase in investigation and design costs will be more than compensated by the reduction in contingent costs of construction uncertainties and claims.

PROBLEM NO. 3

I. NAME OF PROBLEM - Deep Insitu Stabilization for the Correction of Settlement and Stability Problems

II. THE PROBLEM - Many of the new deep stabilization techniques developed during the past 20 years are becoming more attractive and feasible each day. Methods such as stone columns, dynamic consolidation and deep chemical stabilization have provided solutions where conventional treatments were unfeasible. Designers of these systems presently rely on past experience and empirical approaches to develop adequate treatment procedures.

Research is needed to define design procedures, construction control measures and resulting soil parameters. Rational and cost effective designs, which address settlement and stability characteristics of the stabilized soil are sorely needed.

III. OBJECTIVES -

A. To develop cost effective, rational design guidelines for the above mentioned techniques. Theoretical analysis, laboratory and field testing and documented case studies will be required.

B. To encourage the acceptance and implementation of these and other new techniques at appropriate locations.

C. To encourage the development of new and improved methods of deep insitu stabilization.

IV. CURRENT ACTIVITIES -

A. Suggest key words: settlement, stabilization, stone columns, chemical stabilization, dynamic consolidation.

B. Most states have had little or no experience with these techniques.

V. URGENCY - The unique problems which were the catalysis in development of these methods are no longer extraordinary. Restrictions of right-of-way, environmental constraints, maintenance of traffic and time have all become equally important to economics in design of facilities. Many of our conventional treatment measures are no longer considered acceptable at some locations and it appears that future developments will further limit our available tools.

A2K03 Foundation of Bridges and Other Structures - C. N. Laughter

PROBLEM NO. 1

I. NAME OF PROBLEM - Full Scale Field Load Tests on Pile Groups in Sand

II. THE PROBLEM - Over the years a considerable number of full scale field load tests have been conducted on single piles, but very few full scale field load tests have been conducted on pile groups in sand. Of course, there are no foundations constructed on single piles and pile foundation design must include consideration of group action. Both bearing capacity and settlement of the group must be considered. Design for bearing capacity normally involves the use of a "Group Efficiency Factor" and the factors currently used were established primarily from model studies. Also, there is no established design criteria for settlement of pile groups in sand.

III. OBJECTIVES - The broad objective is to develop design criteria for pile groups by conducting full scale field load tests on groups founded entirely in sand. Specific objectives are as follows:

A. To instrument the group so that the action of individual piles can be determined,

B. To develop group efficiency factors for different pile spacings and for different pile shapes, and

C. To relate the settlement of the pile group to that of a single pile in the group.

IV. CURRENT ACTIVITIES -

A. No Highway Research in Progress

areas have been scanned in preparing this statement.

B. Suggested key words for this problem are: pile groups, field load tests, bearing capacity, settlement, sand.

C. Related research would include any research currently being done on single piles and any model studies on pile groups or field performance studies of in service pile group foundations in sand.

V. URGENCY - The proposed research would be a long term effort to develop reliable design criteria for foundations on pile groups in sand which in turn would reduce foundation costs. Currently used design criteria are based primarily on model studies and have not been verified by full scale performance tests.

The cost of this research would be high, probably $500,000 or more and should probably be at least a 3-year study. The cost could be reduced by testing actual foundations under actual loading conditions.

PROBLEM NO. 2

I. NAME OF PROBLEM - New Design and Construction Standards for Timber Pile Foundations

II. THE PROBLEM - The expenditures for pile foundations represent a very significant percentage of the cost of highway structures, particularly for small bridges. The cost for producing the most used types of piles such as steel and concrete are increasing in proportion to such factors as energy production costs as well as other inflationary factors. Transporting costs for piles are also part of price increases.

Timber piles are frequently overlooked by the designer in favor of steel or concrete types. This stems largely from what is felt to be traditional low load capacities prescribed by current specifications and an accompanying concern for durability in various types of environments.

The traditionally and current specification values for timber pile capacities are believed to be largely unsubstantiated. Treatment for durability is also not believed to be as difficult a problem to solve as in the past.

III. OBJECTIVES - It is felt that the application of modern pile capacity determination procedures to timber piles would result in an upgrading or more accurate definition of capacity over traditional values. This would then reflect a greater design reliability and possible substantial savings when compared to the lower range of capacity for steel and concrete piles.

This study would also have to address itself to economical methods for insuring longevity of timber piles. This phase would not be limited to marine environments but also to areas of fluctuating groundwater. Current and new methods of treating piles for this purpose could be reviewed and evaluated.

Attempts to study rapid pore pressure dissipation adjacent to timber piles might also be worthy of examination. This aspect of the program could be optional. However, a modest static load test program for timber piles in various types of soil would be mandatory in this study. It would also be advisable to perform and evaluate dynamic loads testing on timber piles.

IV. CURRENT ACTIVITIES - No current research is believed in progress oriented specifically to timber piles. Much of the other research on piles presently under way, however, might be applicable in part to this study.

V. URGENCY - The potential economy for using timber piles where appropriate could be a direct and quickly achieved benefit with new reliable design and construction criteria.

The cost of this research should not be too expensive, i.e. estimated at probably less than $75,000.

PROBLEM NO. 3

I. NAME OF PROBLEM - Evaluation of Bituminous and Other Coatings to Reduce Pile Drag

II. THE PROBLEM - Pile drag can be compensated for in a rational pile design in several ways. Bituminous coatings have been proved effective in reducing pile drag, however not enough research has been undertaken which can establish reliable design parameters for the design engineer. Research is needed to evaluate the various types and thicknesses of bituminous and possibly coatings of other types of materials

under varying installation and soil conditions and more importantly, to follow up with design data which can be employed by the engineer. Different coatings should be tested on different pile types for varying soil conditions. The piles must be thoroughly instrumented and monitored during pile driving and for a considerable period thereafter.

III. OBJECTIVES - The research should culminate in a useful (to the design engineer) comparison and evaluation of the coatings and other variables in the experiment. The effectiveness of each coating should be stated in terms that can be translated by the designer into design parameters and specifications.

IV. CURRENT ACTIVITIES -

A. No substantial activities. Just a limited literature search.

B. Suggested key words: pile drag, bituminous coatings, negative skin friction, pile design.

C. Not enough background to answer this question on related research activities.

V. URGENCY - This research is badly needed to give the engineer a reliable tool so that effective and economic pile designs which are subject to drag conditions may be progressed.

PROBLEM NO. 4

I. NAME OF PROBLEM - Pile Group Action

II. THE PROBLEM - Field tests on single test piles have shown that the transfer of load from a pile to the soil or vice versa can be predicted using the effective stress approach. Very few, if any , field tests have been performed on groups of test piles. Since most engineering structures that use pile foundations are supported on groups of piles, a field test program is urgently required in order to find correlation between the behavior of pile groups and single piles. Such correlations would provide improved design methods and consequently more economical pile foundations.

III. OBJECTIVES - To carry out a field testing program on various groups of piles in different soils to study the stress transfer in positive and in negative skin friction.

IV. CURRENT ACTIVITIES -

A. Research on single piles or pile groups is currently under way in Canada, England and Sweden.

B. Suggested key words: piles, pile groups, effective stress, positive friction, negative skin friction or downdrag, pile tests.

V. URGENCY - Much information on the behavior of single test piles is available and has been published. This knowledge cannot be applied directly to the design of pile foundations because it has never been correlated with the behavior of pile groups. Unless this is done soon, the present experience will remain academic. The profession needs this correlation now to improve the design of pile groups. Cost estimate: $150,000 - $200,000.

PROBLEM NO. 5

I. NAME OF PROBLEM - Construction Verification of Bearing Values

II. THE PROBLEM - Verification of excavations in engineered fill and/or in situ soils and shales, for compliance with predetermined design bearing values is a routine assignment in construction monitoring.

The adequacy of the bearing area materials to provide the design values is generally based on visual inspection and "good professional judgment", with little other documentations. Simple field test devices are fabricated for use in local materials, but over a widely spread geographic area.

The literature suggests in situ penetration and shear testing as an aid to judgment in approving footing areas.

III. OBJECTIVES - To develop economical, uniform, portable field test equipment and procedures for evaluating the suitability of compacted fills and excavations in soils and shales, to support the loads assumed in design of footings.

IV. CURRENT ACTIVITY - An article appeared in the June 1979 issue of the ASTM Geotechnical Testing Journal, relative to this need.

V. URGENCY - Soil and shale bearing footing areas are being approved daily, often with little or no documentation. Development of the mentioned equipment and procedures would give considerable "peace of mind" to field construction engineers and inspectors as well as designers.

PROBLEM NO. 6

I. NAME OF PROBLEM - The Bearing Capacity of Compacted Earth Bridge Approach Embankments

II. THE PROBLEM - The height of the usual bridge approach fills ranges from 18 feet to 35 feet. The material used for such embankments, typically comes from local sources. Local materials may be glacial tills, fresh water, or marine deposits. While the in-situ shear strength characteristics of such materials are well known, the performance and suitability of these as a load-bearing structure in their remoulded and compacted state, should be further investigated.

In the past, the bearing capacity of these compacted fills was estimated rather than computed or evaluated on the basis of parameters, or small or full-scale tests results. As a rule, such estimates were believed to be very conservative - consequently, the bridge designer shied away from placing spread footings within the fill and instead, utilized pile support or other deep foundations for the abutments.

Evidently, the latter design - in many cases - might not have been the most economical solution.

III. OBJECTIVES -

A. To develop methods for the evaluation of the suitability of compacted fills, to carry bridge abutment loads constructed of (a) granular, (b) heterogeneous, and (c) various cohesive materials.

B. To study the stress distribution under spread footings, constructed with above approach fills.

To determine the best geometry of approach fills for the suitability of supporting abutment loads on spread footings.

IV. CURRENT ACTIVITIES -

A. Transportation research in progress areas 62 and 65 have been scanned in preparing this statement, but no references were identified.

B. Suggested key words: foundations, spread footings, compacted embankments, bearing capacity, settlement.

C. Current related research activities include: (1) an FHWA contract on tolerable movement criteria for highway bridges by West Virginia University, (2) An FHWA staff study on correlation of shallow foundation movements with superstructure distress manifestations, (3) A laboratory study of bearing capacity of foundations on a sloped embankment has been completed at the University of Ottawa, Canada, for the Ontario Ministry of Transportation and Communications, and an associated field trial is now underway.

Further studies are proposed by FHWA on the Behavior and Efficiency of Spread Footings.

V. URGENCY - The economics possible offer great economic benefits, particularly as timber piles become scarce and shells for CIP piles may become short in supply.

A2K05 Mechanics of Earth Masses and Layered Systems - H. E. Wahls

PROBLEM NO. 1

I. NAME OF PROBLEM - Mechanics of Membrane Reinforced Embankments

II. THE PROBLEM - The application of fabrics for engineering purposes has increased in recent years. Fabrics have been used for filters in drainage systems, erosion control membranes, pavement overlay reinforcement, reflective crack prevention and bridge deck "salt" membranes. Some have also cited the successful application of fabric membrane for reinforcement to improve the stability of embankments on soft soil foundations. However, not much technical information regarding the basic mechanics, or the basic theory, and design criteria has been developed and reported.

III. OBJECTIVES - The objective is to evaluate the system and develop theoretical information necessary to understanding the basic mechanics of soil-membrane interaction and to establish design criteria.

IV. CURRENT ACTIVITIES - The use of prefabricated bituminous surfacing (PBS) in military road and airfield construction in India and Southeast Asia during the Second World War by the British Army was probably the earliest application of membranes in soil and site improvements. The U.S. Army Corps of Engineers has also utilized membranes and fabrics for waterproof and dust control surfacing for rapid construction of military airfields and heliports, for permanent road and airfield pavement foundations

with encapsulated soil layers. In recent years, the use of fabrics for engineering purposes has increased rapidly. Such uses have included fabrics for erosion control, for filters in drainage systems, for soil reinforcements in highway embankment, earth dams, and in soft soil foundations. Several industries have published catalogues and bulletins for promoting fabric products in engineering applications and reporting the engineering properties of such fabrics and membranes. The use of fabrics and membranes was the subject of several articles published in Highway Focus of the Federal Highway Administration, Vol. 9, No. 1, May 1977, and in the Proceedings of International Conference on the Use of Fabrics in Geotechnics, Paris, April 20-21, 1977. The Transportation Research Circular, April 1979, cited more than 250 papers regarding test methods and use criteria for fabrics. Most recently the California Department of Transportation used fabrics for earthwork reinforcement over soft foundation soil in construction of a test section for the east approach embankment to Dumbarton Bridge in the fall of 1979.

SUGGESTED RESEARCH PROCEDURES - In order to study the mechanics and the interaction of membrane and soil, the following research procedures are suggested:

1. Compile state-of-the-art information on the use of membranes for earthwork reinforcement.
2. Laboratory testing and evaluation of the engineering properties of commercial available membrane products.
3. Develop soil-fabric interaction theory.
4. Develop methods and criteria and specifications for design and construction of membrane reinforced embankment.
5. Field instrumentation to study the performance of the membrane reinforced embankments.
6. Evaluation of the field data and verification of the design equations (if any) from the field performance studies.
7. Report the research results and make recommendations for future studies.

V. URGENCY - The proposed research is considered highly important to evaluate the mechanics of the membrane-soil system and to evaluate the current applications of membrane reinforced embankment, especially on soft soil foundation to save time and money by preventing possible failures in future construction projects.

PROBLEM NO. 2

I. NAME OF PROBLEM - Modeling Tension Behavior in Granular Materials

II. THE PROBLEM - In a layered pavement system the lower part of a granular base course layer is subjected to tensile stresses. Since the granular material cannot take any significant level of tension, a redistribution of stresses and strains occur in the system. With the present trend of returning to thicker granular bases as petroleum prices increase, research in this important area is of immediate importance.

III. OBJECTIVES - The main objective is to develop a realistic analytical model of the granular base which mechanistically handles the problem of tension in the granular material. Specific objectives are to:

A. Develop a thorough understanding of the behavior of granular materials using carefully instrumented pavement sections.

B. Develop a realistic analytical model that is compatible with observed material response.

C. Verify response predictions.

D. Analyze the effect of various factors such as grain size, gradation and density on pavement response.

IV. CURRENT ACTIVITIES - Limited work is presently being conducted at the Waterways Experiment Station (Walt Barker and R. H. Ledbetter), the University of Illinois (L. Raad), Georgia Institute of Technology (R. D. Barksdale), Virginia Polytechnical Institute & State University (C. S. Desai), University of Nottingham (S. F. Brown). Also it is understood that work is being conducted at the University of Minnesota (Otto Strock) and McGill University (R. N. Yong).

V. URGENCY - Because of rapidly rising petroleum prices, considerable interest is once again being shown in the utilization of granular bases in pavement construction. However, suitable methods of predicting granular base response are not presently available. Therefore, an urgent need exists for developing

a mechanistic model and information on the fundamental behavior of granular materials.

A2K06 Subsurface Drainage - L. K. Moulton

PROBLEM NO. 1

I. NAME OF PROBLEM - Performance of Geotextiles in Railroad Track Structure

II. THE PROBLEM - The more progressive railroads have recognized that many of their track structure support problems can be traced to contaminated ballast, and that in many instances the contamination is due to the pumping of the subgrade soil up into the ballast. In an attempt to arrest or reduce this pumping, these railroads are using various types of geotextiles as separator-filters between the subgrade and ballast. It is estimated that up to 10,000,000 sq. yds. of these geotextiles have been installed in each of the past three years. A recent study by DeLeuw, Cather & Company on sections of the Northeast Corridor indicate a wide range in the performance of geotextiles in this application, depending on the type of subgrade soil, the type and weight of geotextile, loadings, the design of the installation, and environmental conditions. This may be due to the lack of past performance history of filters acting under dynamic conditions, with a corresponding lack of design parameters for these conditions.

III. OBJECTIVES - The goal of this study is to develop field information on the performance of geotextiles in railroad track structures in order to establish valid relationships between the various design factors of repeated loads, soil type, design of installation, type of geotextile, and environmental conditions.

IV. CURRENT ACTIVITIES - The FHWA is sponsoring a study by Oregon State University to develop use criteria and test methods for geotextiles. At least two instrumented test installations of track structures incorporating fabrics are being tested. One of these is at the Pueblo, Colorado test area.

V. URGENCY - This research is urgently needed to establish the engineering requirements of geotextiles in railroad track-bed structures, and thus ensure a cost-effective solution to the pumping problem.

PROBLEM NO. 2

I. NAME OF PROBLEM - Predicting Permeability of Materials for Pavement Subdrainage

II. THE PROBLEM - A major factor contributing to the rapid development of pavement distress is excessive moisture in the pavement structural section. Water is the principal factor causing loss of strength and resiliency in the subgrade and structural section of pavement systems.

In order to decrease the effects of water on pavement systems considerable effort is now being directed toward the design and construction of subsurface drainage systems. However, in the design of these drainage systems satisfactory effort has not been made to define the permeability characteristics of the existing pavement materials or the drainage materials themselves. Because of the importance of the permeability or hydraulic conductivity properties in effective subdrainage design it is necessary to develop a quick, efficient, and economical procedure for measuring this property both in the field and in the laboratory.

III. OBJECTIVES - The general objective of this project is to develop a procedure for determining the saturated hydraulic conductivity (permeability) of highway materials from basic material properties. The specific objectives are:

1. Determine the basic material properties which directly affect permeability.
2. Establish a predictive permeability model based on material properties which can be used in pavement design.
3. Validate the permeability model by use of controlled laboratory or field tests.

IV. CURRENT ACTIVITIES -

A. HPR studies in Illinois, New Jersey, and Ohio.
B. FHWA Reports for in-situ field permeability test method.
C. FHWA Workshops - Water in pavements.
D. Organization for Economic Co-operation and Development - Water in Roads.
E. FHWA Highway Subdrainage

Manual.

F. FHWA Reports on Improving Subdrainage and Shoulders of Existing Pavements.

V. URGENCY - The effects of moisture on pavement systems have been widely documented. In order to design effective pavement subdrainage systems the material saturated hydraulic conductivity properties must be known. Because of the broad range of structural materials and drainage materials used in pavements, a quick and accurate procedure which can be used to predict material saturated hydraulic conductivity based on basic material properties is needed. This need is especially evident where the hydraulic conductivity must be determined on in-situ materials in the field. The benefits that may be derived from the proposed research are primarily economical. The study is foreseen as an important step leading to the goal of designing pavement subsurface drainage systems based on well defined hydraulic parameters.

PROBLEM NO. 3

I. NAME OF PROBLEM - Performance of Pavement Subdrains in a Freeze-Thaw Environment

II. THE PROBLEM - An important factor affecting pavement performance and life is the presence of water in the pavement system. In the northern United States deterioration of asphalt and concrete pavements is greatest in the late winter and spring when repeated freeze-thaw cycles occur. The excess water in the pavement materials, subbase, and subgrade contributes to rapid structural damage to the pavement under traffic loads. Subdrains and/or drainage layers in the pavement are the only available methods for removing this water. However, often the subdrain system is frozen and may be inoperative. Recent pilot studies in an FHWA project entitled "Improving Subdrainage and Shoulders of Existing Pavements," conducted at the University of Illinois indicated that there is an optimum subdrain depth for various climatic regions. The study indicates that a more thorough investigation is needed to develop procedures for designing subdrain systems which operate effectively in the freeze-thaw environment.

III. OBJECTIVES - The major objective of this research is to determine the performance of pavement subdrain systems constructed under current practice in a freezing environment. This will involve, theoretical studies, field instrumentation, and monitoring of the freeze thaw behavior of the pavement, subdrains, and the pipe system to the outlet.

If deficiencies are determined in present installations a research plan should be developed for improved designs.

IV. CURRENT ACTIVITIES - Highway Research in Progress areas have been scanned and, except for the pilot study at the University of Illinois, no known studies are currently under way.

V. URGENCY - The Federal Highway Administration's "Guidelines for the Design of Subsurface Drainage Systems for Highway Structural Sections" and the Federal Highway Administration's "Water in Pavement" Workshops presented throughout the United States demonstrated the need for drainage in pavements. In northern states the efficiency of pavement underdrain systems may be seriously impaired in the pavement section and at the outlet during the critical freeze-thaw period when a significant amount of pavement distress occurs.

L. GEOLOGY AND PROPERTIES OF EARTH MATERIALS - D. L. Royster - Chairman

A2L01 Exploration and Classification of Earth Materials - R. B. Johnson

PROBLEM NO. 1*

I. NAME OF PROBLEM - Physical Properties of Soils Related to Geophysical Subsurface Exploration

II. THE PROBLEM - The physical properties of conductivity, density and velocity of soils and bedrock are measured by geophysical techniques. The correlation of the measured physical properties with soil types and/or bedrock is one of the major components of the interpretation of geophysical data. The correlation between physical properties of soils and/or bedrock may vary from area to area; however, broad ranges of physical properties can be correlated with soil types and bedrock. Correlation data are available in numerous textbooks and articles, but a comprehensive study or library search of such data is not available.

III. OBJECTIVES - The physical properties of soils are affected by numerous factors and may vary from area to area. The proposed study, which may take the form of a library search, would present the data in a systematic way. The data may be grouped as relating to differing climatic and geographical regions, i.e., tropical, temperate, arctic, foothills, plains, etc. The objective of this study is to further the understanding and behavior of the physical properties of soils and bedrock under varying climatic and geologic conditions, which would lead to improved interpretation of the geophysical data.

IV. CURRENT ACTIVITIES -

A. The TRIS data base for key words "geophysical exploration" and "soil physical properties" was scanned in preparation of this statement.

B. Suggested key words for this problem: geophysical explorations, geophysical measurements, soil physical properties, correlation, subsurface exploration.

C. The Federal Highway Administration Materials Division is currently sponsoring research in two projects dealing with this topic - Project 5-B-2, Tunneling Technology and Project 4-E, Remote Sensing and Geophysical Testing. Some reports have been issued.

V. URGENCY - The need for a systematic study of physical properties is a long-standing one. The availability of a set of data resulting from the proposed study would enhance many fold the value of geophysical surveys, thus improving their cost effectiveness. It is considered that the problem is urgent.

PROBLEM NO. 2

I. NAME OF PROBLEM - Evaluation of Equipment and Procedures for Sampling Sand and Gravel Deposits

II. THE PROBLEM - The difficulties encountered in attempting to obtain representative samples of cohesionless sands and gravels have been recognized for many years by those responsible for locating natural sources of these materials. These difficulties may be subdivided as follows:

A. Gradation changes caused by faulty sampling equipment and techniques.

B. Contamination by overburden materials as sample is brought to the surface.

C. Mixing and loss of identity of materials from different subsurface units.

D. Inability of equipment to bring samples to the surface. This occurs most frequently when the bed lies below the water table.

III. OBJECTIVES -

A. Determine the ability of presently available equipment to obtain representative samples of sands and gravels above and below the water table.

B. Develop, if possible, new equipment and techniques capable of obtaining representative samples of sand and gravel under all conditions.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 31, 32, 33, 34, 35, 61, 62 and 64 have been scanned in preparing this statement.

B. Suggested key words: subsurface exploration, borings, sampling, soils, soil gradation, sand, gravel, aggregates.

C. No studies meeting the overall objectives of the proposed problem statement were discovered. However, related research titled "Evaluation of International Literature on the Sampling of Aggregates" is currently being conducted at Darmstadt Technical University, Germany. At present the Darmstadt study is confined to review of literature, but studies of actual technical and statistical problems encountered in sampling natural aggregates are contemplated.

V. URGENCY - This problem is considered to be of continuing urgency in the area of soil and aggregate exploration.

PROBLEM NO. 3

I. NAME OF PROBLEM - Evaluation of Geophysical Methods and Instruments as Applied to Subsurface Exploration for Transportation Corridors

II. THE PROBLEM - There have been numerous developments in geophysical instrumentation and interpretation techniques in recent years. Some techniques and instruments have been tested in detail over a variety of geologic conditions. Others have had a minimum of field testing to establish their potential

usefulness and/or limitations in subsurface exploration. This problem may be subdivided as follows:

A. Analysis and comparison of geophysical methods and instrumentation as applicable to subsurface exploration.

B. Analysis and comparison of interpretive techniques with special emphasis on transportation applications.

III. OBJECTIVES - Specific objectives are:

A. Determination of those geophysical methods most appropriate for transportation applications.

B. Evaluation of modern geophysical instruments in regard to their applications and limitations.

C. Examination of new interpretive techniques and comparison with established procedures.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 21, 35, 61, 62 and 63 have been scanned in preparing this statement.

B. Suggested key words: geophysics, subsurface exploration, depth to bedrock, physical properties.

C. The Federal Highway Administration Materials Division is currently sponsoring research in two projects dealing with this topic - Project 5-B-2, Tunneling Technology and Project 4-E, Remote Sensing and Geophysical Testing. Some reports have been issued.

V. URGENCY - The use of geophysics for subsurface exploration is increasing. Knowledge of appropriate methods, equipment, applications, and interpretation will help the practicing engineer select the appropriate geophysical technique for the problem at hand. The problem is considered to be of continuing interest in transportation engineering.

A2L04 Frost Action - W. M. Haas

PROBLEM NO. 1*

I. NAME OF PROBLEM - Changes in Soil Stiffness and Strength Induced by Frost Action

II. THE PROBLEM - Moisture changes and other effects induced by freeze-thaw cycles significantly alter the strength and stiffness properties of soil, and thereby affect the performance of the pavement. Current pavement design methods do not adequately account for reduced subgrade support conditions caused by these frost induced changes. Reduction factors are estimated on the basis of judgment and limited field performance studies rather than test procedures. Recently developed mechanistic pavement design methods which are based on calculated stresses and strains and make use of cumulative damage principles require an accurate assessment of the seasonal variation in strength and stiffness. The use of a resilient modulus test appears to be the best procedure for characterizing the response of subgrade and base materials under freeze-thaw conditions; however, other parameters should also be examined. The development of laboratory test procedures will need to be verified by comparing predicted theoretical pavement response to measured deflections in the field.

III. OBJECTIVES - The general objective of this research is to determine the methods for characterizing the effects of frost action on the strength and stiffness of subgrade soils and granular unbound base course materials. The specific objectives are:

1. Evaluate pavement response and performance models currently in use or being developed to determine which strength or stiffness parameters of soil and unbound base courses affected by freeze-thaw serve as the most useful and important input parameters to the preferred models.

2. Determine laboratory and field procedures for evaluating the selected strength and stiffness parameters.

3. Develop predictive models of the selected strength and stiffness parameters in terms of readily measured soil properties.

4. Validate the strength and stiffness models by means of controlled laboratory and field tests.

5. Couple the strength and stiffness models with pavement response and performance models for use in design and evaluation of pavements affected by frost action.

6. By observations of actual pavements in service, validate the pavement performance model to verify the determined relationship between frost-dependent material parameters and development of pavement distress such as cracking and rutting.

IV. CURRENT ACTIVITIES -

A. Frost Research in Progress.

1. The development of laboratory techniques and procedures for characterizing the stress-strain response of subgrade soils in the frozen, thawing, and thawed states is under way at the U. S. Army Cold Regions Research and Engineering Laboratory (CRREL).
2. The development of laboratory techniques and procedures for index tests for determining an order ranking of frost susceptibility of subgrade soils is under way or completed at several research agencies such as FHWA, CRREL, Purdue University, Massachusetts DPW, Pennsylvania DOT, New Hampshire DOT and several foreign countries.
3. Mathematical modeling projects are currently under way at CRREL. The oil and gas industries also are engaged in modeling frost action affecting pipelines.
4. Full-scale field testing of frost heave and thaw weakening are currently under way at several sites in Pennsylvania, Massachusetts, and New York. Frost heave of buried pipelines is being tested in Alaska and Alberta.
5. By current field and laboratory investigation in Alaska, relationships are being defined between fines content in subgrades and granular bases, extent of thaw weakening shown by spring deflections, and evidence of pavement distress by cracking and rutting.

B. Suggested key words: frost action, freeze-thaw, thaw weakening, resilient modulus, pavement damage accumulator, materials characterization, soil strength, soil stiffness, and pavement response.

V. URGENCY - There is no fundamental way, currently available, to accurately account for the significant reduction in strength and stiffness due to frost action on pavement systems. There is a critical need for a broad data base of actual values of resilient modulus and other suitable parameters of a wide variety of subgrade soils and base course materials, measured throughout the year including periods of freezing, thawing and recovery. These actual field measurements are necessary to verify analytical and laboratory predictive techniques which are in turn urgently needed to improve pavement design in seasonal frost areas.

PROBLEM NO. 2

I. NAME OF PROBLEM - Tolerable Frost Heaves in Pavements

II. THE PROBLEM - In seasonal frost areas where frost penetrates below the pavement structure into subgrades which are frost susceptible, heaving of the pavement surface occurs. Such heaving and the accompanying distortions usually disappear after the spring thaw. However, excessive frost heave results in the appearance of hazardous bumps, differential heaves, distortions, and cracks, which affect the subsequent performance of the pavement, shortening its useful life. If the greatest amount of heave which can be tolerated in winter is known for each different type of pavement, then more economical pavement structures can be designed.

III. OBJECTIVES - The determination of the smallest amounts of frost heave which will result in initiating various kinds of pavement distress in different pavement designs.

IV. CURRENT ACTIVITIES -

A. Transportation Research in Progress Areas 24, 40, 62, and 64, have been scanned in preparing this statement.

B. Suggested keywords: Frost heaves, Tolerable, Pavement, Design.

C. FHWA/FAA/CRREL, Pennsylvania, Alaska, have studies in progress with respect to frost penetration, frost heave, frost susceptibility of different materials, loss of stability on thawing, and related pavement distress.

LCPC (France) have developed a method for the consideration of frost in the design of flexible pavements, allowing for loss of soil bearing capacity.

V. URGENCY - Useful lives of pavement structures in seasonal frost areas appear to be influenced as much by climatic factors as by traffic loading, and there is a tendency to construct much stiffer structures there than in non-frost areas. There are economics to be explored by designing pavements to accommodate tolerable heave.

A2L05 Engineering Geology - R. L. Schuster

PROBLEM NO. 1*

I. NAME OF PROBLEM - Design of Horizontal Drains in Soil or Rock

II. THE PROBLEM - Recent equipment

developments have caused a rapid expansion in the use of horizontal drains in all types of soil and rock. At present, there is no proven way of determining where and to what length and slope such drains should be drilled for optimum effect except where the geology is well enough known to permit seeking specific joints, faults, or strata.

There is no general way of predicting the shape or extent of the zone of influence of the drains. Drilled drains are expensive and can be useless or even detrimental if poorly located. Present placement methods may provide more drainage than is necessary. It is desirable to know the service life and have a better understanding of the behavior of these drains during the service life.

The design and construction of collector systems affects the ultimate performance of the entire drain installation. Types of materials and methods of handling the collected water need study.

III. OBJECTIVES - The objectives of this research are to answer the following questions:

1. With respect to soil and rock conditions:
   a) What is the optimum location, spacing, slope and casing type for drains?
   b) What is the zone of influence around the drains?
   c) How should pipe size and slot size be determined?
2. How should performance be monitored?
3. How can the need for individual pipe or system maintenance be determined?
4. How can maintenance best be accomplished?
5. What are the characteristics and performance of various collector system designs?
6. What service life can be expected?

IV. CURRENT ACTIVITIES -

A. The TRIS data base was surveyed using the key words "horizontal" and "drains".

B. Suggested key words: drain, subsurface drainage, horizontal drains, drain performance, drawdown.

C. The only research currently active is a project in California jointly sponsored by the Federal Highway Administration and the California Department of Transportation. The study, titled "The Effectiveness of Horizontal Drains", is a survey of existing installations to determine how well they have performed. A study of design methods is not included. This project is estimated for completion in June 1979.

The TRIS data base also lists a Federal Highway Administration pilot project on horizontal drain maintenance reported in 1974 in "Special Reports on the Use of Equipment and Methods of Maintenance." No other recent or current research related to the key words was found.

V. URGENCY - A large amount of horizontal drain work is being done, especially in the control of landslides. Criteria leading to successful installations and accurate estimates of bid quantities would be valuable to designers and construction engineers.

PROBLEM NO. 2

I. NAME OF PROBLEM - Application of Photogrammetric Methods to Monitoring of Slopes

II. THE PROBLEM - Interstate and modern highway construction has resulted in the creation of more and larger rock cuts. Natural weathering of the rock in these cuts tends to cause increasing rates of failure with time, and these failures have potential hazard to users. After failure, it is frequently impossible to reconstruct previous conditions; thus the precise cause of failure often cannot be determined.

Concurrently, agencies are faced with increasingly tight maintenance budgets. Efficient, inexpensive monitoring of slopes is needed to aid in maintenance planning. Many agencies have sophisticated photogrammetric groups for map production. These groups have the expertise to conduct terrestrial photogrammetric monitoring of rock slopes, but such work is rarely requested.

III. OBJECTIVES -

1. To prepare a state-of-the-art summary on photo logging of rock slopes defining:
(a) the geotechnical data required and constraints concerning data accuracy, repetitive coverage, etc.
(b) photogrammetric options and economics, including alternative

equipment and procedures.

2. To prepare a review of cases where these techniques have been applied, and a critique of each application.

3. To undertake one or more demonstration projects.

4. To prepare a "guidebook of recommended practice" to assist engineers in applying the technique to future studies.

IV. CURRENT ACTIVITIES -

A. The TRIS data base was surveyed using the suggested key words.

B. Suggested key words: photogrammetry, rock slopes, equipment, methods, slope stability.

C. The use of terrestrial photogrammetry to study slope stability in open pit mines has been reported in the April 1971 "Photogrammetric Record", a publication of the Photogrammetric Society (England). More recent work in this area has been conducted by the Canadian Department of Energy, Mines and Resources, Mines Branch, Ottawa, Canada. No other current research projects were found by the TRIS search.

V. URGENCY - The existence of many large rock slopes having increasing failure potentials, coupled with ever tighter maintenance budgets, suggests that improved rock slope monitoring methods would be valuable to many transportation agencies.

The need for a systematic study of physical properties is a long-standing one. The availability of a set of data resulting from the proposed study would enhance many fold the value of geophysical surveys, thus improving their cost effectiveness. It is considered that the problem is urgent.

PROBLEM NO. 3

I. NAME OF PROBLEM - Construction Methods for Horizontal Drains

II. THE PROBLEM - Over the past several years, numerous techniques for drilling and installing horizontal drains have been developed by contractors; however, little information has been published or made available on the effectiveness of these techniques. Designers may not be aware of the extent of current technology and have difficulty preparing proper specifications.

III. OBJECTIVES -

1. Prepare a state of the art summary covering: (1) equipment capabilities, (2) drilling methods and techniques, (3) borehole guidance procedures and capabilities, (4) hole stabilization techniques.
2. Review existing installations to determine the geologic conditions, drilling techniques used, production rate achieved, costs, and problems encountered.
3. Survey requirements and needs for environmental controls.
4. Develop a demonstration project to evaluate newer techniques and equipment available and determine opportunities and limitations with respect to geologic materials and conditions.

IV. CURRENT ACTIVITIES -

A. The TRIS data base was surveyed for the key words "drilling equipment" and "horizontal drains."

B. Suggested key words: drilling equipment, drilling methods, drilling machines, horizontal drains, subsurface drainage, and drainage practices.

C. No research covering this area was found in the literature survey. A study jointly sponsored by the California Department of Transportation and the Federal Highway Administration titled "The Effectiveness of Horizontal Drains" is a survey of existing installations. This survey may gather historical data on installation methods used.

V. URGENCY - The use of horizontal drains is increasing, especially in the eastern half of the United States. Many new contractors are entering the field using methods and techniques which have not been available recently. Designers in preparing specifications for bid purposes are having difficulty properly specifying approaches and techniques to achieve the desired effect resulting in construction difficulties, improperly constructed drains, and in some cases, legal action by contractors.

A2L06 Environmental Factors Except Frost - B. J. Dempsey

PROBLEM NO. 1*

I. NAME OF PROBLEM - Moisture Induced Strength Variations in Pavement Systems after Construction

II. THE PROBLEM - Moisture is a

fundamental variable in all problems of soil stability. It has special significance in pavement systems since subgrades are generally constructed in the surface soil which is usually subjected to large moisture content variations and strongly influenced by surrounding climatic conditions. It is for this reason that the problems of moisture movement in soils, moisture accumulations under pavement surfaces, and sub-grade moisture control are of prime importance relative to pavement construction, design, behavior, and performance.

The importance of including moisture effects in pavement design is indicated by the fact that more than 50 per cent of the flexible pavement failures at the AASHO Road Test occurred during the spring when moisture accumulations in the pavement system were the greatest. Numerous research studies in the field and laboratory have also shown that moisture content can have a pronounced effect on strength and deformation properties of pavement soils and materials.

The engineering problems associated with the behavior of pavement soils and materials responsive to moisture changes indicate that further study is required in reference to strength variations in pavement systems after construction.

III. OBJECTIVES - The general objective of this project is to develop a procedure for determining moisture induced strength variations in pavement systems after construction. Specific objectives are:

1. Determine the magnitude of moisture induced strength variations which can occur in various pavement soils and materials for a known set of conditions.

2. Develop procedures for predicting the magnitude of strength variation which can be expected to occur in the field based on intrinsic pavement conditions, material properties, climatic conditions, etc.

3. Develop procedures for utilizing the study findings in pavement design.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress at the University of Illinois entitled, IHR-604 - Moisture Movement and Moisture Equilibria in Pavement Systems, and IHR-605 - Subgrade Stability.

B. Transportation Research Studies conducted at Texas A and M University.

C. "Seasonal Strength of Pavements", George W. Ring.

D. "Water in Roads" Organization for Economic Cooperation and Development.

V. URGENCY - Numerous researchers have concluded that meaningful evaluation of the engineering properties of pavement soils and materials requires that the moisture properties be specified.

The benefits that may be derived from the proposed research are primarily economical. The study is foreseen as an important step leading towards the ultimate goal of including moisture in the design of pavement systems. With improved procedures for evaluating strength variations caused by moisture, pavement design techniques can be refined and pavement performance predictions can be improved. These improvements and refinements may result in financial savings in the initial design phase as well as minimizing moisture induced failures of in-service pavement systems.

The research could lead to an optimized design of the pavement system in relationship with its moisture environment; therefore, reducing the detrimental effects of moisture.

PROBLEM NO. 2

I. NAME OF PROBLEM - A Continuing Monitoring and Analyses of the Effectiveness of Various Modes of Controlling Expansive Soils on Construction Projects

II. THE PROBLEM - Expansive soils can be estimated as causing four billion dollars worth of damages in the United States in the last year. The problem is world wide where dry and then wetting climatic conditions and clay soils result in expansive movements. It affects a wide variety of transportation facilities including airports, heavy rail systems, highways and canals. A great deal of work has been done by many engineers around the world, at the universities, laboratories, agencies and in construction. Many solutions have been taken from the laboratory and are being applied on construction problems throughout the United States. An orderly analysis, at regular

intervals, of their effectiveness is needed to provide a measure of true economy of the various methods as well as a cost saving procedure of significance.

III. OBJECTIVES - The ability to evaluate effectiveness, economy and practical choice of options in the reduction of costs of the expansive soil movement is a general goal. The specific objectives are:

1. Determine what type of control measures are being currently tested under construction conditions.
2. To analyze their effectiveness and examine the way this effectiveness is being measured.
3. To continually bring forward more effective modes of controlling the expansive soil problem and to permit less effective methods to be equally well recognized.

IV. CURRENT ACTIVITIES -

A. Highway research on the moisture and expansive soil problem is being conducted at the University of Illinois.
B. Transportation research studies are being conducted at Texas A & M University.
C. The comprehensive examination of the expansive soils problem by the Waterways Experiment Station.
D Research at the Sandia Corporation, the U. S. Air Force and University of New Mexico.
E. Testing by the Mississippi State Highway Department.
F. Testing by the South Dakota Department of Transportation.
G. Testing by the Colorado Department of Transportation.
H. Testing by the Arizona State Highway Department.
I. Testing by the Texas State Department of Highways and Public Transportation.

V. URGENCY - This problem becomes more expensive with the passing of time. As man develops more sophisticated structures, pavements, more intensively uses the land, the destruction caused by the expansive soil becomes more and more expensive. Man was faced with the problem of using his resources with ever increasing wisdom and economy. Engineers are required to meet these needs or face the loss of the public acceptance as a profession that is attempting to solve significant world wide problems. This research could form an effective bridge between the university laboratory, governmental agencies, private and public construction in solving a problem of international significance.

PROBLEM NO. 3

I. NAME OF PROBLEM - Base Course Deterioration under Moisture and Load

II. THE PROBLEM - Base and sub-base courses, both unbound and stabilized by additives other than asphalt, are rarely constructed as free draining materials. Sometimes with only the compaction water in the pores of the material, repeated load applications cause the base course to deteriorate: fines are lost, and permanent deformation and pumping occur resulting in loss of support and premature loss of service life of pavements. Poor drainage conditions only accelerate the process. Standard laboratory tests on base course aggregates do not identify the potential that such materials have for this moisture-and-load-related deterioration.

One attempt at solving this problem that has not always been successful is the use of bituminous-stabilized base courses. There is a need to determine the cause of this moisture susceptibility of base courses, develop a test to identify it and additives or construction procedures to reduce or eliminate it.

III. OBJECTIVES -

1. To determine the physical or chemical cause of the moisture-and-load susceptibility of base courses.
2. To develop a laboratory test procedure which can identify such materials.
3. To verify the test procedure with a series of tests on base courses, some known to be susceptible and others to be resistant to deterioration under moisture and load.
4. To compose a specification which will reduce or eliminate the further use of these base course aggregates.
5. To develop an additive or additives which can improve the moisture-and-load susceptibility of base course aggregates.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas have not been scanned in preparing this statement.

B. Suggested key words: base course, aggregates, moisture-susceptibility, permanent deformation, additives, water-holding capacity, pore pressures, moisture characteristic curves.
C. Moisture characteristic curves for numerous Illinois subgrade soils are being measured by researchers at the University of Illinois.

V. URGENCY - The urgency of this problem is related primarily to the need to find alternatives to the use of bitumen in stabilizing base courses and to arresting the premature loss of service life of pavements due to moisture-and-load susceptible base courses.

M. RAILWAY SYSTEMS - T. B. Hutcheson, Chairman

A2M01 Track Structures System Design - P. S. Settle

PROBLEM NO. 1

I. NAME OF PROBLEM - In-Track Welding

II. THE PROBLEM - In-track weld failures and the need for an efficient, economical alternative to the thermite weld.

III. OBJECTIVE - Development and evaluation of an in-track welder that would provide a flash-butt weld equal to the present standard welders in use in many rail welding shops.

IV. CURRENT ACTIVITIES - Tests of Holland flash-butt in-track welder.

V. URGENCY -

PROBLEM NO. 2

I. NAME OF PROBLEM - Rail Fasteners

II. THE PROBLEM - Improved rail fastening system is needed to provide greater strength to resist rail turnover and buckling.

III. OBJECTIVE - Development and evaluation of rail fasteners that provide a greater longitudinal and lateral strength than the conventional cut spike and anchor arrangement.

IV. CURRENT ACTIVITIES - Laboratory tests of new and presently used rail fastening systems.

PROBLEM NO. 3

I. NAME OF PROBLEM - Lateral Strength of Track Structures

II. THE PROBLEM - Need for evaluating lateral strengths of mainline track to know where maintenance dollars should be spent to control gauge spread, rail turnover, etc.

III. OBJECTIVE - Investigation of the lateral strengths of various track structures to provide design and maintenance information for mainline continuous welded rail trackage.

IV. CURRENT ACTIVITIES - FRA-Battelle-Southern Railway prototype vehicle designed and tested to measure lateral strength parameters.

PROBLEM NO. 4

I. NAME OF PROBLEM - Transfer of Geotechnical Engineering Expertise of State Highway and Transportation Departments to Railroads

II. THE PROBLEM - The railroad industry as a whole, has not developed organizational units possessing training and experience in geotechnical engineering. Many state highway and transportation departments possess these resources. Consequently, many roadway track and structure problems are insufficiently investigated and constantly endured by maintenance without correction.

III. OBJECTIVES - To apply the expertise of the technology of the states to the railroads. This field includes subsurface exploration, field and laboratory testing, analysis and design for such subjects as foundations for structures and embankments; soil and rock slopes, landslides, subsurface drainage, subgrade and sub-ballast stabilization, durability of ballast, frost effects, filter materials, stream bank erosion control, etc.

IV. CURRENT ACTIVITIES - NYSDOT is furnishing technical assistance in geotechnical engineering to the railroads of N.Y. State.

V. URGENCY - The quicker this is accomplished, the sooner the maintenance expenditures for soft subgrades, weaving track, embankment subsidence, landslides, frost heaved track, washouts, will be drastically reduced.

PROBLEM NO. 5

I. NAME OF PROBLEM - Establishing A

Serviceability Rating System for Track

II. THE PROBLEM - One of the greatest contributions of the AASHO Test Road was the Present Serviceability Index (PSI) concept for rating pavement. Performance is the time rate of decline in serviceability. The railroads have no similar standard objective method for rapidly rating track nor defining performance.

III. OBJECTIVES - To establish a standard procedure and develop equipment for determining, by a combination of instrumentation and visual examination (the Photologger would be very adaptable to the latter), the present serviceability of track.

IV. CURRENT ACTIVITIES - Unknown

V. URGENCY - The sooner this is done, the quicker meaningful determinations of performance vs loadings and track systems can be obtained. This information can be used for selection of optimum track systems, components, priority, and maintenance scheduling purposes.

A2MO2 Rail Electrification Systems - L. L. Alston

PROBLEM NO. 1

I. NAME OF PROBLEM - Develop and Evaluate Rail Flaw Detection Techniques

II. THE PROBLEM - The increased utilization of high tonnage cars is changing the criteria for rail replacement from wear to fatigue initiated defects in many cases.

III. OBJECTIVES - Improved techniques to detect conditions which initiate and propogate defects should be developed. Criteria for rail replacement as a result of the presence of these defects should be established.

IV. CURRENT ACTIVITIES - (1) TSC; (2) FAST

V. URGENCY - Improve safety and ensure reliability of service, particularly for unit trains.

PROBLEM NO. 2

I. NAME OF PROBLEM - Cost Reduction of Signal and Communications Modification as a Result of Railroad Electrification

II. THE PROBLEM - The capital cost of electrifying a railroad is influenced by modifications required to existing signal and communications systems of the railroad and commercial communication systems. This requirement arises because of electromagnetic interference which may be either conductive or inductive in nature. This cost may be as large as 15% of the total electrification cost. It is important, however, to include in this cost only those modifications which would be required because of electrification and not the things added to modernize the signal and communication system.

III. OBJECTIVE - A set of standards should be developed which can be applied to future railroad electrification projects. This set of standards should be reached by a program which is designed to understand the effects of EMI in an electrified railroad environment followed by the development of low cost mitigative practices.

IV. CURRENT ACTIVITIES - Present activities include a joint AAR, AREA, IEEE and FRA program which is designed to understand the effects of EMI by developing standard test and computation tools and applying them at selected test locations

V. URGENCY - Electrification is presently being considered by several domestic railroads. Any cost reduction, as well as action to prevent future problems which can be taken now, will enhance the rate of return on investment of electrification.

PROBLEM NO. 2

I. NAME OF PROBLEM - Economics of Rail Electrification: A Computerized Planning, Evaluation, and Sensitivity Analysis Model

II. THE PROBLEM - The economic evaluation of rail electrification is a relatively complex problem involving the simultaneous consideration of many input parameters. Previous studies have largely identified the appropriate inputs, functional relationships, and analytic reports; however, the rapid divergence between the assumptions made and the real world's behavior have tended to make the results of little value. What is needed is to derive a comprehensive model, to develop a computer program which can convert the specified inputs into an

economic evaluation report and to make this program available to interested parties so that economic evaluations of the consequences of the rapidly changing energy markets on rail electrification projects can be quickly and efficiently performed.

III. OBJECTIVES - The development and distribution of a comprehensive, computer program which can be used to evaluate the economic returns and to perform sensitivity analyses of specific rail electrification projects.

IV. CURRENT ACTIVITIES - Several contract research organizations have recently performed analysis for DOT, DOE, and other interested parties. Although computer programs of limited scope have been used in support of some of these efforts, no comprehensive, user-oriented programs have been developed or are under development at this time.

V. URGENCY - The radical inflation rates in energy costs and the substantial variations in inflation rates among alternative energy sources have renewed interest in rail electrification. It is critical that accurate and timely analysis of the economic and energy supply implications of rail electrification be available to support industry and public policy evaluations.

PROBLEM NO. 3

I. NAME OF PROBLEM- Electric Traction

II. THE PROBLEM - Selection of traction equipment for motive power on electrified railroads directly affects operational performance including schedule speed, trailing tons which can be hauled per single unit and service dependability which results from the reliability and maintainability of the equipment itself. Likewise, the life cycle cost of electrification are also influenced by this equipment. The major areas of concern are procurement costs, maintenance costs and energy costs.

III. OBJECTIVES - Electric traction research should be directed toward the reduction of life cycle cost of electrification and the enhancement of operational performance. It is necessary to review both domestic and foreign experience with electric traction to ascertain special problems encountered, solutions proposed and tried and ensuing results. Examples of developments which may lead to reduction of the life cycle cost and enhancement of operational performance include thyristor controlled equipment, alternative traction equipment, such as three-phase AC drives and separately excited DC drives, with power factor improvement and harmonic generation suppression, regenerative braking with or without storage, microprocessor technology and dual mode motive power (catenary and diesel power).

IV. CURRENT ACTIVITIES - Several industrial projects, domestic and foreign, are now underway in several of the areas mentioned. German and Swiss prototype three-phase AC drive systems with power factor correction and harmonic suppression are running. Microprocessor control is now being applied domestically to rapid transit equipment. Regeneration on braking is being studied for main line railroads under special circumstances.

V. URGENCY - Electric motive power averages about 35% of the procurement costs and 75% of the energy cost of electrified railroads. Any research improvements which can reduce these costs will certainly favor a higher return on investment and allow electrification to be more attractive.

TASK FORCES

A2T51 Steering Committee to Develop the Second International Conference on Low-Volume Roads - M. B. Larsen

Research Needs Statements for this Task Force are listed in TRB Circular 214 dated January 1980.

A2T61 Optimizing the Use of Materials and Energy in Construction - W. B. Ledbetter

PROBLEM NO. 1

I. NAME OF PROBLEM - Factors for Estimating Energy Use in Construction and Rehabilitation of Highways

II. THE PROBLEM - It is becoming increasingly important in planning the construction and rehabilitation of highways to develop better estimates of both the energy used to construct the facility and also an understanding of the overall impact of the project on energy use during its lifetime. Such estimates are needed in order

that the energy effectiveness as well as the cost effectiveness can be utilized in deciding which of possible alternative construction procedures or materials should be used for a given project.

III. OBJECTIVES -

1. Collect existing data on actual energy use for various highway construction and rehabilitation projects and a description of any unusual conditions on the project that may have affected energy consumption.

2. Analyze data collected under (1) as well as published information on various processes to establish an estimate of low, normal, and high energy use factor for specific operations based on applicable units (ton-miles, lane-miles, square yards, etc.)

3. Develop a recommended procedure for estimating the total energy used by a given construction or rehabilitation technique. This procedure should recognize different energy categories such as embodied energy, transport energy, and construction energy, as well as the total involved. Indirect energy effects such as increased energy usage for the public caused by delays during construction or rehabilitation should also be considered. Consideration should also be given to assigning different weighted-factors for criticality of the energy source. Thus, energy from renewable sources would have the lowest.

4. Develop factors for embodied energy and energy of manufacture for highway construction materials and recommend a procedure for using these factors in preparing estimates on energy use.

IV. CURRENT ACTIVITIES - NCHRP Project 20-7, Task 8 deals with the broad aspects of these problems and the final report, "Energy and Transportation Systems", prepared by the California Department of Transportation offers guidelines for developing such estimates and also includes a summary of published energy factors for a number of highway construction materials as well as fuel usage for various construction operations. As indicated in the report, these factors are generally based on either theoretical considerations or are estimates based on a limited number of sources. Consequently, there is a need to collect and analyze data from actual highway projects.

V. URGENCY - The information to be developed by this project is needed now. In its absence each organization must seek its own sources of energy information and often different factors will be used in estimating energy impacts, leading to conflicting and confusing results. An even less desirable alternative is for each organization to ignore energy considerations in its design process. The availability of unbiased recommendations concerning uniform factors will eliminate this problem.

PROBLEM NO. 2

I. NAME OF PROBLEM - Quality Standards that Optimize the Use of Materials and Energy in Construction

II. THE PROBLEM - The majority of Quality Standards currently being utilized in construction are empirically founded and relate to actual performance only in an indirect way. In addition, these Quality Standards rarely encompass the aspects of optimizing the use of materials and energy or the matter of life cycle costs. In view of our current national situation with regard to materials shortages, the energy crisis, and limited monetary funding numerous Quality Standards must be re-evaluated. It is imperative that these Quality Standards be reassessed with respect to their direct effect on performance, their impact on life cycle costs, and their drain on energy resources. An integral part of this problem is to assess the sensitivity of these Quality Standards as they affect actual performance, total life cycle costs, and total energy consumption. Alternative Quality Standards must also be rapidly and accurately analyzed for purposes of optimization.

III. OBJECTIVES - In view of the above stated problem there is a dire need to develop a well defined systematic methodology for assessing the criticality of Quality Standards in light of performance, life cycle costs, and energy consumption. The development of such a methodology will provide the tools by which crucial decisions can be made with respect to wise allocation and the use of the resources of money, materials, and energy.

IV. CURRENT ACTIVITIES -

Highway Research in Progress areas Pavement Performance, Bituminous Materials and Mixes, Cement and Concrete, Construction, General Materials, Minerals Aggregates, and Maintenance have been scanned in preparing this statement.

Suggested key words for the problem: performance, skid resistance, riding quality, roughness, serviceability, deflection, faulting,deterioration, texture, loading effects, crack detectors, measurement systems, profiling systems, sensitivity analysis pavement evaluation, zero maintenance pavement, pavement life, pavement condition, pavement evaluation and rehabilitation, pavement serviceability standards, road smoothness, rideability, rutting, quality evaluations, probabilitation methods, improved pavement, fatigue, impulse index, rehabilitation forecasting, premium pavement, durability, reflection cracking, moisture effects, qualities of sand, predicting performance, service behavior, permeability, process control, quality control, rational, nuclear testing methods, wear properties, compaction, aging, rapid test methods, statistical specifications, uniformity, evaluation models, nondestructive testing,statistical evaluation, corrosion, delamination detector, sampling, materials test data systems, statistical quality control, simulation of uncertainty, density standards, acceptance sampling and testing, waste materials, new construction materials, precision of test methods, sampling techniques, accelerated tests, inspection, computer simulation, products evaluation, Quality Assurance, graduation control, maintenance rating techniques, energy saving methods, pavement maintenance, resurfacing priorities, maintenance costs, maintenance strategies. There are many related research activities currently in progress which if appropriately synthesized and integrated would yield the inputs, components, and techniques for developing the systematic methodology outlined above.

V. URGENCY - Since the transportation industry is one of the primary users of energy and materials, it is essential that the research outlined in this problem statement be addressed. Quality standards not only impact on materials usage but also affect the efficiency of high energy consumptive modes of transportation; automobiles, trucks, buses, etc. The proposed methodology could be implemented by incorporating it into current workshops relating to pavement design, maintenance management, quality assurance and the like.

Research and development costs for this work are estimated to cost $500,000.

PROBLEM NO. 3*

I. NAME OF PROBLEM - Energy Utilization Model for Highway Construction Quality Standards

II. THE PROBLEM - Determine the amount of energy consumed to meet various levels of quality in construction of highway facilities.

Many of the construction quality standards in use today were developed without consideration of the amount of energy consumed to meet the standard selected. Because energy is used to perform work and is common to all activities, there is a need to quantify the energy expended to meet various levels of quality.

There is an average amount to total energy use associated with each increment of quality specified in any construction process. The cost of this total energy must be considered in future evaluations of quality standards. "First energy" like "first cost" is not the only factor to be considered. Rather it is the total energy consumed over a lifetime of useful service of the facility which must be related to the standard of quality selected. The level of total energy cost should be correlated with the benefit of each level of quality above a minimum acceptable standard. The quality benefit may be in terms of lower life cycle cost, increased reliability , decreased maintenance, longer life or better environmental quality. Once determined the quality benefit could then be assessed against the total energy (cost) ratio. This ratio could aid the highway engineer in his determination of the optimum quality level.

III. OBJECTIVES - To develop an energy utilization model which will provide the highway engineer with a method for determining how much energy will be consumed for each additional increment of quality produced assuming a minimum standard for safety and reliability. The model must indicate the quality level which provides the optimum use of limited energy resources to produce the most effective result. The model should consider geographic, climatic, resource availability and other

pertinent factors which may affect quality standards. Labor and equipment are considered to be resources as well as fuels and other materials.

It is anticipated that the research will include at least the following tasks:

Task 1 - Assessment of the existing usage evaluation criteria, including measures of effectiveness currently in use and others which might be used.

Task 2 - Establishment of minimum quality standards for selected processes.

Task 3 - Development of an application manual which describes the theories, tools, procedures and data sources necessary to apply the energy/utilization model to highway construction standards.

Task 4 - Compilation of a handbook of relevant energy usage data for highway construction standards with sources identified.

Examples of the processes which may be selected for study include:

1. reduction of mixing temperatures for asphalt mixtures.
2. use of drum dryer.
3. plain vs reinforced concrete.
4. density specifications.
5. establishment of gradation bands.
6. selection of aggregate blends to ensure less volume/unit weight of material.

IV. CURRENT ACTIVITIES -

A. Highway Research in Progress areas 15, 22, 25, 26, 27, 31, 32, 33, 34, 35, 40, 41, 51, 62, 84 and 90 were scanned in preparing this statement and no research in progress was found.

B. Suggested key words for this problem are: energy, energy utilization, mathematical model, models, quality, quality control, quality standards, standards.

C. No direct research on this problem appears to be in progress. Some related studies have been made on energy conservation, particularly in connection with the consumption of fuel in construction equipment and various construction processes. TRB, Asphalt Institute, and the Texas State Department of Highways and Public Transportation have published reports in these areas.

V. URGENCY - This project is considered to be of the highest priority. No studies of the sort posed in this problem have been found so the approach developed herein will be unique.

Research findings may be implemented by making them available to transportation agencies throughout the nation. Studies of life cycle energy costs could be made a mandatory prerequisite to release of highway funds.