Evaluation of the Superpave Gyratory Compaction Procedure

Appendix to the Final Report

Prepared for:
National Cooperative Highway Research Program
Transportation Research Board
National Research Council

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This report has not been edited by TRB.

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APPENDIX A

Task 2: Gyratory Compactor User Questionnaire Individual Responses

Question 1: Do you have any suggestions that may change the gyratory compaction process to provide better evaluation of asphalt mixtures?

Response 1: May need to re-evaluate the N_{max} values for high numbers of gyrations, specimens are sometimes compacted to the point where the G_{mb} equals the G_{mm}. Although this may be an indication of the aggregate quality on the structure, it seems that the specimen has reached maximum compaction before the N_{max} number of gyrations.

Response 2: Review data (i.e. establish relationship) of G_{mb} computed versus G_{mb} measured. We've observed differences in void content by as much as 2 percent.

Response 3: Please verify that the Pine and the Troxler are comparable for all mixes, and continuous calibration of the gyratory in the field is not realistic because too many tests are performed. Calibration issues need to be addressed.

Response 4: Many of the low volume roads in Kansas have design ESALs well below 300,000. We need a lower design (N_{design}) at approximately 100,000 ESALs

Response 5: Have real concern for N_{design} and its affect on volumetrics (especially VMA). Believe that states will create multiple specifications if the issue is not resolved soon.

Response 6: Specific procedure for determining the mix and compaction temperatures, (possible use of DSR values?) Need clearly defined procedures for laboratory design and field control (assuming there are differences).

Response 7: The aging temperature should be increased to equal the compaction temperature and the aging time should be proportionally lowered.

Response 8: Currently, the Troxler SGC can only store 6 samples. This should be increased to hold as many as the user wishes.

Response 9: The tolerance on compaction pressure in paragraph 4.1 of AASHTO TP4 should be changed to ±10 kPa. This pressure tolerance is more of a compactor design/capability issue than operator tolerance issue. The tolerance on compaction pressure should be changed in paragraphs 7.2 and 8.14 to ±10 kPa.
Paragraph 8.1 in AASHTO TP4 should be amended to require a nominal specimen height of 115 mm with a tolerance of ±5 mm. The example aggregate batch mass in paragraph 8.1 should be changed to 4600 grams. Verbiage in paragraph 8.12 in AASHTO TP4 should be changed from, "Place the mixture into the mold in one lift" to "Quickly place the mixture into the mold using a transfer bowl or other suitable device."

Response 10: Why do we have to go +1.0% on asphalt binder? Wouldn't optimum and ±0.5% work just as well?

Response 11: The method of charging the mold should be evaluated. Perhaps it should be rodded as in the Marshall procedure. The 1.25 degree angle may be to harsh producing aggregate breakdown. Samples should be prepared at N_{design} to evaluate the actual void content. Why not use a 4" (100 mm) mold for small aggregate mixes?

Response 12: Superpave advocates a stony aggregate structure and usually low(er) asphalt contents. How do we design for fine, smooth mixes (3/8" top size) that are used for thin surface layers? These are often the best looking mixes and have not had performance problems when designed and used properly.

Response 13: What about 100 mm diameter specimens? We have done some studies and they are not that different than 150 mm.

Response 14: There needs to be a set way or procedure of loading the gyratory molds.

Response 15: Study the slope of density versus the number of gyrations plot.

Response 16: We did not experience any serious problems with the compaction process. However, variables in the SGC can be studied for this or future studies: torsional shear forces, stress at the top surface, and constant stress at the top surface.

Response 17: It appears the gyratory compactor may be providing more compactive effort than the traffic level warrants. Lowering the number of gyrations at N_{design}, to compensate for this, does not seem to affect the mix parameters. Would a lower angle of gyration provide a better representation of field compaction?

Response 18: Compaction is temperature dependent. The proper compaction temperature should be verified immediately before loading the assembled mold in the gyratory. Also the mixture temperature should be checked in several locations to insure you are not measuring a localized hot spot.

Response 19: Process is working well! Could improve the loading procedure, particularly for rocky mixtures.

Response 20: Compacting specimens to N_{max} and calculating the air voids at N_{design} consistently results in an error ranging from 0.5 to 1.0% air voids when compared to specimens compacted to N_{design}. Beginning in 1997, Illinois DOT will require field control specimens to be compacted to N_{design}.

Response 21: While not directly related to the operation of the gyratory compactor, we believe that short term aging should be conducted at the compaction temperature rather than 135°C, thereby, reducing the total time to prepare a specimen. This would eliminate the need to raise the specimens temperature from 135°C to the compaction temperature in the half hour allowed by the specifications. Our experience is that some designers raise the temperature gradually using the entire half hour resulting in a short term aging time of 4.5 hours (or 2.5) while others raise the temperature rapidly (by overheating the oven-sometimes to the extreme) resulting in a variable short term aging time. Could this minor difference have an affect on the results? If the compaction temperature were used to short term age it could also reduce the need for additional ovens in a production laboratory. Additionally, we believe the specifications should recommend (not specify) a mold loading procedure to be used. We are aware that the methods evaluated to date have not been shown to cause a significant difference, however, we believe a consistent method should be used between labs and one way to accomplish this would be to recommend a procedure. If nothing else it will serve as a base line for comparison purposes. Based on very limited experience using the gyratory to "design" an open graded mixture, we would be surprised if the compaction pressure or the number of gyrations do not need to be adjusted for each mix type.

Response 22: Increase the gyratory angle, this will allow a reduction in pressure to obtain the same air voids and thus reduce cracking of larger aggregates.

Response 23: Concerning the volumetric requirements, the VMA requirements of 14 for a 12.5

mm, 13 for a 19.0 mm, and 12 for a 25 mm mix are too high. To reach these VMA requirements, the combined aggregate gradation structure has to be pulled too far from the maximum density line. This leads to high asphalt cement contents and loose particle packing to create the VMA. This, in turn, leads to loss of stability and tender mix problems on the roadway. Should we be using the effective specific gravity for the aggregates? The mixture should be remixed with a spoon prior to placing in the mold. This can be done 15 minutes prior to placing in the mold to prevent excessive heat loss and segregation in coarse graded mixtures. On one project we compacted field loose mix samples to N_{max} (calculated N_{design}) and compacted to N_{design} for comparison. Differences in results for some tests were close to the allowable field tolerances. Should we be running the gyratory to N_{design} rather than N_{max} and back calculating to N_{design}?

Response 24: More study should be given to charging the mold as this can have significant impact on the outcome.

Response 25: Create a small matrix of gyrations versus ESALs and temperature. Require accurate temperature measurement device for all lab mixes. Provide a recommended procedure to produce a 7% void specimen utilizing N_{max} data (i.e. constant height or constant revolution).

In reviewing the responses to Question 1 the 4 major concerns about the gyratory compaction process can be given as follows:

1. There is a concern that the gyratory is providing more compactive effort than the traffic level warrants, especially for low volume roadways.
2. There is general opinion that there should be *one* specified procedure for the loading of the mixture into the gyratory molds. AASHTO TP4 at the present time states "Place the mixture into the mold in one lift." (9) There is concern that different loading procedures or techniques between laboratories may result in possible discrepancies in test results.
3. There were concerns that the back calculation of specimen density at N_{design} from the N_{max} density based upon a correction factor may be in error.
4. There is a desire to use 100 mm specimen size when the nominal aggregate size of the mixture permits.

Question 2: Have you had any experience with SMA, large stone, open graded, or gap graded mixtures using the Superpave gyratory compactor?

Response 1: Very limited work compacting open-graded mixes. No problem in terms of equipment operation.

Response 2: We have evaluated a number of large stone base mixtures with out SGC, including our one dedicated Superpave project for 1996. These mixtures were 37.5 mm nominal blends. We have noticed a higher degree of variability for the BSG (bulk specific gravity) of large stone base specimens, but that phenomenon may well be a result of the difficulty we have in accurately sampling such coarse mixes. Otherwise, the SGC has performed well in these instances.

Response 3: We have placed a 3/4" (19.0 mm) mix that was as coarse as the gradation limits would allow. It was almost gap graded. The placement of it went smooth and it is performing very good.

Response 4: We have only compacted our large stone base (302) mix from our first Superpave project. Also we have seen some coarse side gap graded mixes for Superpave projects not by choice but rather by necessity to get coarse side VMA.

Response 5: We have verified a SPS-9A (25 mm mix) design using this equipment.

Response 6: SMA: compared to a 50 blow design, gyratory designs have more aggregate passing the 4.75 mm sieve and less AC.
Large Stone: The sides of the specimen look good, but the ends do not. Will this adversely effect the design gradation or AC content?
Open Graded: At the present we use 100 gyrations. We have very little experience; what is the proper gyratory design procedure for open graded mixes?

Response 7: Have used the SGC for 37.5 mm and SMA mixes. Did experience aggregate breakdown from the SGC with the 37.5 mm mix but not with the SMA. Also used the SGC to design and control a 12.5 mm gap graded (SMA) mix. VTM for plant produced material is less than the lab design value. Used N_{design} of 100 gyrations.

Response 8: We have conducted only one SMA study-using Georgia granite.

Response 9: We are paving a 20,000 ton SMA job now. We have run the SGC at 100 gyrations and 50 blow Marshall. We are also paving a warranty job using 19.0 and 12.5 mixes with SGC field quality control.

Response 10: We have an SMA job in progress in Virginia. The mixture was designed by the Marshall method, but evaluated by the SGC and the Georgia Loaded Wheel Tester.

Response 11: Limited use, we are currently evaluating large aggregate, gap graded, and SMA mixtures using the SGC.

Response 12: Superpave mix designs were performed for open graded and gap graded mixtures. No significant problems were encountered.

Response 13: The state of Oregon will begin looking at using the gyratory compactor on open graded and SMA mixtures in early 1997.

Response 14: A SMA mixture in Arizona was designed using the Marshall procedure and checked during production with the gyratory. The gyratory developed lower voids than the 75 blow Marshall and a flatter VMA curve.

Response 15: Louisiana SMA mixtures have extremely low $N_{initial}$ density; however, VMA requirements are lower. $N_{initial}$ limits should be reduced for SMA and N_{max} may be raised.

The responses to Question 2 indicate that the use of the SGC for mixture types other than dense graded mixtures is at the very initial stages. This is to be expected since the use of the different mixture types is not as widespread as dense mixtures, and the fact that the SGC is a relatively new piece of equipment with many questions about its' use to be determined. Of the 14 respondents, 8 indicated that the SGC has been or will be used in the near future to design or field verify SMA mixtures.

Question 3: Have you had any experience with mixtures that fail to meet any of the Superpave gyratory compaction requirements (i.e. $N_{initial}$, N_{max}, VMA) but are known to provide good field performance?

Response 1: Most every mixture we have checked for informational purposes fails VMA with the SGC. These mixtures are the ones being placed everyday in Kentucky, and we feel many provide good performance.

Response 2: Road cores from old projects compacted to N_{max} show poor SGC requirements; however, they have performed quite well in the field.

Response 3: Actual project work is limited, but we have seen problems with high absorptive aggregates used in gradations below the restricted zone meeting the required VMA.

Response 4: A Superpave project in Cobb county displayed high dust/asphalt ratio. So far this mix has performed satisfactorily.

Response 5: All mixes in Wisconsin will most generally pass through the restricted zone while meeting other properties. Very few of our manufactured sands will meet the fine aggregate angularity requirements. Why?

Response 6: I am aware that some projects associated with NCHRP 9-7 and SPS-9A have not met some of the Superpave requirements during field production.

Response 7: Yes, preliminary tests indicate that the gradation used by Army and Air Force for high tire pressure HMA mixtures will not meet $N_{initial}$ criteria. This gradation has been placed all over the world. When high quality aggregates are used this gradation has excellent performance (i.e. no rutting).

Response 8: We have mixes that do not meet Superpave VMA requirements easily but have performed well. These are mostly soft limestone mixes.

Response 9: A mixture which meets Marshall mix design criteria was evaluated with the Superpave mix design. The mixture did not meet the VMA criteria of Superpave. A few other blends with the same aggregate also did not meet the Superpave VMA criteria.

Response 10: Some of the mixes we design are right at the minimum fine aggregate angularity requirement of 45% for ESALs > 3 million.

Response 11: The specified N_{design} values appear to result in higher compactive efforts. Illinois DOT has numerous Marshall mix designs which have performed well in the past yet fail VMA when compacted in the gyratory compactor to the specified N_{design} compactive effort.

Response 12: ADOT placed a mix on Interstate-17 that went through the restricted zone and would not meet the SHRP gradation specifications, but it is performing well.

Response 13: Interstate-10 Westover-Ramah; VMA in field was 12.7 for a 19.0 mm design (about 0.3 lower than the specification allows). Hamburg rut test indicated only 1 mm of rut in 20,000 passes. SST testing also confirmed a high predicted performance. The density at N_{max} for the design from the field was 98.5 $\%G_{mm}$.

The most frequent response to Question 3 was that there are numerous mixtures (mostly Marshall designed) which have a very good performance history, but will not meet the VMA requirements of Superpave volumetric mixture design. The fact that under the Superpave design procedure the VMA requirements are the same as Marshall, along with the consensus opinion that the gyratory gives more compaction than does the Marshall hammer would result in VMA being more difficult to achieve using the Superpave design system.

Question 4: Have you had any experience with mixtures that meet all the Superpave requirements, but are known to provide poor field performance?

Response 1: Several sections placed at WESTrack that were expected to perform "admirably" have rutted. Likely rehabilitation to be done in the Spring of 1997.

Response 2: As stated above, most mixtures we have checked did not satisfy the Superpave requirements for VMA. We have not intentionally analyzed a poor performing mixture with the SGC to date.

Response 3: In part; our first Superpave project mix went to the fine side to meet VMA. It was obviously sandy and "checked" at laydown. (Lot of small cracks at surface).

Response 4: The design passed easily, but in the field the dust increased causing the mix to close up. We need production and QC/QA specifications also.

Response 5: We may have some stripping on one of our Superpave jobs. The mix met all the requirements during design and production. It is still being investigated.

Response 6: Superpave mixture is bleeding within the first year. Appears that the design provided too much asphalt from possible poor procedures.

Response 7: In 1996 NYSDOT constructed a project using Superpave 25.0 mm and 12.5 mm mixture designs which both experienced severe longitudinal and lateral displacement (of at least 200 mm) during compaction. The designs were performed using the Superpave requirements for pavements with >3 but <10 million 80 kN ESALs (calculated over 20 years). The designs were prepared by the producer and laboratory verified by the State. During material production we experienced difficulties in maintaining the plant production within the Superpave volumetric requirements. Therefore, it is difficult to say if the problems encountered are the result of the design or inconsistent plant production. However, even on those days when the volumetric properties were met compaction problems were encountered. Also, the 25.0 mm and the 12.5 mm designs had binder contents well below those typically used in New York. The 25.0 mm was produced using a binder content of 3.8% and the 12.5 mm was produced using a binder content of 4.5%. No in-place performance information is currently available.

Response 8: In the 1996 construction season, MoDOT constructed three projects using Superpave mixes. Two of the projects displayed tender mix problems during the compaction of the mat. These mixes met all the Superpave materials and mix design criteria for Level I.

Response 9: Two mixes, one on SR-87 and another on SR 66 meet the Superpave volumetric criteria, but performance testing predicts that they will not perform well.

Response 10: There has been one mix (U.S. 90 - New Orleans) that met Superpave gradation and SGC volumetrics but was "tender" in the field. (i.e. moved > 1 inch under the roller).

As thought prior to distributing the questionnaire, there are not an abundance of projects which meet all of the Superpave requirements and exhibit poor field performance. The few projects that were mentioned included projects where stripping and bleeding occurred. According to the respondents these may be attributable to poor construction techniques.

Question 5: Have you used the Superpave gyratory compactor to compact 100 mm diameter specimens or specimens with heights other than 115 mm?

Response 1: We've done emulsion mix design using the SGC; compacting 100 mm diameter specimens to heights of approximately 64 mm. No problems.

Response 2: Tried to compact 76.2 mm samples for the ASTEC Asphalt Pavement Analyzer at 7.0% VTM with little luck.

Response 3: We have produced retained tensile strength specimens that stand about 110 mm tall. The SGC performs well in producing specimens of a specified height, but we don't fare well in achieving target voids.

Response 4: AASHTO T-283 (as modified by the Kansas DOT) requires a 95 mm sample.

Response 5: Have used the SGC to compact 150 mm diameter specimens for TSR and creep compliance and repeated load. Did not experience any difficulty with this procedure.

Response 6: One job was designed by AASHTO TP4-93, which stipulated a height of 100±1 mm. The specification was later changed to 115±1mm.

Response 7: We have compacted TSR samples to set heights (90 to 100 mm) to achieve air voids of 7±1%.

Response 8: 95 mm heights for AASHTO T-283 testing.

The responses to Question 5 indicate that several people have attempted to produce specimens, having heights other than 115 mm for tensile strength ratio (TSR) testing. Others have attempted to compact specimens to predetermined heights in order to evaluate the specimens in some type of laboratory wheel tracking device.

Question 6: Do you have any other comments, concerning the Superpave gyratory compaction procedure, that you believe will be useful to the research team in accomplishing the objectives of this project?

Response 1: Difficulty in meeting volumetric criteria for some specific type of aggregates was experienced. After consulting with the Superpave experts, the conclusion was drawn that the solution was to replace the aggregate components with aggregates from a different source. Recommendations or guidelines to meet volumetric criteria can be published or made available so that users (not experts) can find their way out.

Response 2: We have noted, in field verifying a given mixture day after day, how specimen height is an excellent indicator of volumetric properties. By simply comparing the final height of a specimen to earlier efforts, we could closely predict the voids and the VMA of that specimen. We also feel that two specimens per test may not be sufficient when analyzing large stone base mixtures. Due to the variability we observed, we produce three specimens per test.

Response 3: What is the best number of samples to test (2 or 3)?
Will various loading techniques and spading change the test results?
Can a hot specimen with high asphalt content be removed from the mold too soon?

Response 4: N_{design} at 300,000 ESALs is too severe for many of the roads in Kansas.

Response 5: We have experience with non gyratory compactor designed, high crushed aggregate mixtures that exhibit high tenderness. These mixes typically are slightly on the coarse side of the maximum density line and have minimum VMA. They will be a problem with Superpave.

Response 6: With tire rubber being used and mixed with the asphalt cement, should there be a different design procedure or will the current procedure be OK.

Response 7: The current level of N_{design}, VMA requirements, and $\%G_{mm}$ at $N_{initial}$ requirements require extremely harsh mixes. This is necessary on high volume routes. However, the requirements are overly conservative for low-volume routes. Some relief must be afforded during design for these lower volume routes.

Response 8: The accuracy and precision of the gyratory compactors should be evaluated.

Response 9: Since plant produced material generally yield lower VTM, the design procedure should allow VTM at N_{design} to be higher than the 4% specification. The 4 hour curing time does not seem necessary for all types of aggregates. This could be lowered to 1 to 2 hours for low absorptive aggregates. A procedure for using RAP with Superpave is needed. A procedure to determine the consensus properties of RAP aggregate is needed.

Response 10: It has been observed that during the compaction process for the preparation of specimens for testing on the shear tester and the indirect tensile tester, the compaction effort is greatly reduced around 30 gyrations in order to achieve the correct void content and to get the proper height (150 mm). I feel that by reducing the number of gyrations, the aggregate has not had the time to become completely seated as it does during the initial volumetric design process with higher number of gyrations. A possible fix for this might be to reduce the load applied, but to compact the samples to the proper number of gyrations.

Response 11: There are some engineers in our DOT who believe that 4% air voids are too high and the resulting AC content ends up being too low. They feel that given our climatic conditions (Montana) and aggregate type, stripping will result. On one of our Superpave mixes we were asked by these engineers to add 0.3% more AC to the mix even though the gyratory air voids fell well below 4%. In their experience, the 0.3% additional AC was needed to prevent stripping; however, they felt the mix was still strong enough to resist permanent deformation.

Response 12: The Superpave volumetric procedure is being used by CalMat in Arizona everyday. The design to field sample correlation has been very strong for air voids, VMA and for the TSR results. Strongest correlation are for the mixes below the restricted zone.

Response 13: We are concerned that the Superpave design procedure may result in mixtures with significantly reduced binder contents. Are the number of gyrations correct? Is the binder film thickness consistent with or greater than what we have gotten in the past with Marshall mixtures, or is it less? Should we be concerned about the designs with what appear to be low binder contents.

Response 14: Yes, we believe that a research team should follow up and refine the Superpave mix design.

1. VMA requirements should be lowered on dense graded mixes.
2. SMA Superpave design needs to be initiated.
3. Determine appropriate $N_{initial}$ for stable dense graded mixes.
4. We feel that there needs to be some evaluation about mix segregation during the gyration phase. Evaluation of possible draindown of asphalt and fines in coarse graded mixtures prior to placing in the mold. Should the mix process be revised to mold samples at N_{design} for evaluation and then run a check point at N_{max}? Are we seeing an accurate evaluation of mixtures at low asphalt to dust ratios? Mixtures with this condition are showing some data variability.

Response 15: $N_{initial}$, N_{design}, and N_{max} should be reviewed in terms of their relationship to traffic and temperature as the present gyration requirements may be more than indicated. A computer program should be developed to estimate VMA and a "seed" value for optimum asphalt content. A faster and more reliable method for determining the fine aggregate specific gravity of aggregates should be developed as errors in the present method often creates VMA problems that may not be real.

Response 16: Does time have an effect on results? (i.e. differences in specimen 1 versus specimen 2 versus specimen 3 of plant mix). Does laboratory design guidelines apply to field control using the gyratory compactor? (i.e. VMA). Do you have any recommendations in predicting the final height of a 4% void specimen or 7% void specimen from a sample compacted to N_{max}? Are we concerned with N_{max} for plant control? (i.e. can we make all field control specimens to a known density for verification tests) Does the slope of the compaction curve indicate anything?

Upon review of the responses to Question 6 it is once again evident that many people have concern over the design requirements in the Superpave design system. Concern was stated that the compactive effort (N_{design}), the VMA requirements, and the $\%G_{mm}$ at $N_{initial}$ require very harsh mixtures. It is feared that these mixtures, while being adequate for high traffic roadways, are very conservative for the low traffic roadways. The fact that the SGC typically results in less asphalt content required for a mixture when compared to the Marshall procedure makes some people very uneasy about the stripping potential of the mixture. One respondent stated that they added a small amount of asphalt cement to the designed mixture for this very fact.

NCHRP 9-9
APPENDIX B

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

New York Gravel Gap Graded Mixture

Specimens Compacted to N_{design} = 128

SGC: Pine Gyatory Compactor

MIX ID: NY-GRAV GAP GRADED — MATERIALS: New York Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.700 — Effective SG Agg (Gse)= 2.627 — Bulk SG Agg. (Gsb) = 2.589 — Percent Absorbed Asphalt (Pba)= 0.57

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD						
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)									
4.0-1	4.0	4141.6	113.3	101.5	2002.2	1793.7	2.367	2.120	2.367	2.472	85.780	95.752	8.649	3.45	4.2	12.2	65.3
4.0-2	4.0	4137.7	113.5	102.3	2005.7	1807.8	2.368	2.134	2.368	2.472	86.340	95.793	8.199	3.45	4.2	12.2	65.5
4.0-3	4.0	4169.9	113.5	102.0	2005.7	1802.5	2.378	2.137	2.378	2.472	86.451	96.197	8.454	3.45	3.8	11.8	67.8
AVG											86.190	95.914	8.434		4.1	12.1	66.2
S.D.											0.360	0.246	0.226		0.246	0.226	1.420
4.5-1	4.5	4177.5	114.4	102.4	2021.6	1809.6	2.387	2.137	2.387	2.454	87.067	97.270	8.849	3.95	2.7	12.0	77.2
4.5-2	4.5	4156.2	113.2	101.6	2000.4	1795.4	2.388	2.143	2.388	2.454	87.339	97.311	8.649	3.95	2.7	11.9	77.4
4.5-3	4.5	4174.7	113.8	102.1	2011.0	1804.3	2.389	2.143	2.389	2.454	87.342	97.351	8.681	3.95	2.6	11.9	77.7
AVG											87.249	97.311	8.726		2.7	11.9	77.4
S.D.											0.158	0.041	0.108		0.041	0.037	0.272
5.0-1	5.0	4196.0	114.0	102.2	2014.5	1806.0	2.389	2.142	2.389	2.437	87.883	98.030	8.801	4.45	2.0	12.3	84.0
5.0-2	5.0	4195.6	114.5	102.5	2023.4	1811.3	2.389	2.139	2.389	2.437	87.756	98.030	8.911	4.45	2.0	12.3	84.0
5.0-3	5.0	4192.6	113.6	101.6	2007.5	1795.4	2.399	2.146	2.399	2.437	88.042	98.441	9.019	4.45	1.6	12.0	87.0
AVG											87.894	98.167	8.910		1.8	12.2	85.0
S.D.											0.143	0.237	0.109		0.237	0.212	1.696

Specimens Compacted to $N_{maximum}$ = 208

SGC: Pine Gyatory Compactor

MIX ID: NY-GRAV GAP GRADED — MATERIALS: New York Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.700 — Effective SG Agg (Gse)= 2.627 — Bulk SG Agg. (Gsb) = 2.589 — Percent Absorbed Asphalt (Pba)= 0.57

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	S	T	U
						17.67*D	17.67*E	17.67*F													
4.0-1	4.0	4165.6	113.4	101.9	100.4	2003.9	1800.7	1774.2	2.403	2.128	2.368	2.403	2.472	86.065	95.778	97.209	8.171	3.45	4.2	12.2	65.4
4.0-2	4.0	4179.7	114.0	102.1	100.6	2014.5	1804.3	1777.7	2.402	2.120	2.367	2.402	2.472	85.747	95.741	97.168	8.375	3.45	4.3	12.2	65.2
4.0-3	4.0	4172.0	113.5	102.0	100.6	2005.7	1802.5	1777.7	2.399	2.126	2.366	2.399	2.472	86.017	95.715	97.047	8.088	3.45	4.3	12.3	65.1
AVG														85.943	95.744	97.141	8.211		4.3	12.2	65.2
S.D.														0.172	0.032	0.084	0.148		0.032	0.029	0.176

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

Georgia Granite Gap Graded Mixture

Specimens Compacted to N_{design} = 128

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN GAP GRADED — MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.020; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse)= 2.728; Bulk SG Agg. (Gsb) = 2.707; Percent Absorbed Asphalt (Pba)= 0.29

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD						
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)									
4.0-1	4.0	4141.8	107.2	97.4	1894.4	1721.2	2.468	2.242	2.468	2.568	87.320	96.106	7.620	3.72	3.9	12.5	68.8
4.0-2	4.0	4127.4	107.2	96.8	1894.4	1710.6	2.467	2.228	2.467	2.568	86.747	96.067	8.083	3.72	3.9	12.5	68.6
4.0-3	4.0	4142.9	108.9	97.7	1924.4	1726.5	2.463	2.210	2.463	2.568	86.047	95.911	8.555	3.72	4.1	12.7	67.7
AVG											86.705	96.028	8.086		4.0	12.5	68.3
S.D.											0.638	0.103	0.468		0.103	0.094	0.582
4.5-1	4.5	4148.1	107.4	97.1	1897.9	1715.9	2.483	2.245	2.483	2.548	88.103	97.449	8.106	4.22	2.6	12.4	79.4
4.5-2	4.5	4157.8	107.1	97.2	1892.6	1717.7	2.483	2.253	2.483	2.548	88.441	97.449	7.813	4.22	2.6	12.4	79.4
4.5-3	4.5	4147.5	106.0	96.2	1873.2	1700.0	2.489	2.259	2.489	2.548	88.653	97.684	7.833	4.22	2.3	12.2	81.0
AVG											88.399	97.527	7.917		2.5	12.3	80.0
S.D											0.277	0.136	0.164		0.136	0.122	0.909
5.0-1	5.0	4134.7	106.2	95.8	1876.7	1692.9	2.493	2.249	2.493	2.528	88.958	98.616	8.376	4.72	1.4	12.5	88.9
5.0-2	5.0	4187.9	107.2	97.0	1894.4	1714.1	2.491	2.254	2.491	2.528	89.161	98.536	8.132	4.72	1.5	12.6	88.4
5.0-3	5.0	4167.0	106.3	96.5	1878.5	1705.3	2.495	2.265	2.495	2.528	89.596	98.695	7.892	4.72	1.3	12.4	89.5
AVG											89.238	98.616	8.133		1.4	12.5	88.9
S.D.											0.326	0.079	0.242		0.079	0.070	0.570

Specimens Compacted to $N_{maximum}$ = 208

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN-GAP GRADED — MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.020; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse)= 2.728; Bulk SG Agg. (Gsb) = 2.707; Percent Absorbed Asphalt (Pba)= 0.29

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	S	T	U
						17.67*D	17.67*E	17.67*F													
4.0-1	4.0	4154.1	108.0	96.8	95.3	1908.5	1710.6	1684.1	2.497	2.203	2.458	2.497	2.568	85.801	95.728	97.235	8.384	3.72	4.3	12.8	66.7
4.0-2	4.0	4158.8	107.6	97.0	95.2	1901.4	1714.1	1682.3	2.503	2.215	2.457	2.503	2.568	86.236	95.660	97.469	8.236	3.72	4.3	12.9	66.3
4.0-3	4.0	4168.0	107.7	96.9	95.4	1903.2	1712.4	1685.9	2.504	2.218	2.465	2.504	2.568	86.372	95.998	97.508	8.165	3.72	4.0	12.6	68.2
AVG														86.136	95.796	97.404	8.262		4.2	12.8	67.1
S.D.														0.298	0.179	0.147	0.112		0.179	0.163	0.987

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

Nevada Gravel Gap Graded Mixture

Specimens Compacted to N_{design} = 128

SGC: Pine Gyatory Compactor

MIX ID: NV-GRAV GAP GRADED | MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse)= 2.647 | Bulk SG Agg. (Gsb) = 2.559 | Percent Absorbed Asphalt (Pba)= 1.34

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD						
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)									
4.0-1	4.0	4648.5	127.8	114.8	2258.4	2028.7	2.365	2.124	2.365	2.490	85.318	94.980	8.380	2.72	5.0	11.3	55.5
4.0-2	4.0	4656.8	127.8	115.1	2258.4	2034.0	2.375	2.139	2.375	2.490	85.903	95.382	8.221	2.72	4.6	10.9	57.6
4.0-3	4.0	4656.0	128.2	115.0	2265.5	2032.2	2.386	2.140	2.386	2.490	85.957	95.823	8.557	2.72	4.2	10.5	60.2
AVG											85.726	95.395	8.386		4.6	10.9	57.8
S.D.											0.354	0.422	0.168		0.422	0.394	2.351
4.5-1	4.5	4658.9	128.4	115.0	2269.0	2032.2	2.379	2.131	2.379	2.472	86.194	96.238	8.711	3.22	3.8	11.2	66.5
4.5-2	4.5	4646.3	127.2	113.9	2247.8	2012.8	2.386	2.137	2.386	2.472	86.429	96.521	8.753	3.22	3.5	11.0	68.2
4.5-3	4.5	4666.2	128.6	114.7	2272.5	2026.9	2.390	2.132	2.390	2.472	86.233	96.683	9.064	3.22	3.3	10.8	69.3
AVG											86.285	96.481	8.843		3.5	11.0	68.0
S.D											0.126	0.225	0.193		0.225	0.208	1.437
5.0-1	5.0	4644.7	126.9	113.8	2242.5	2011.0	2.390	2.143	2.390	2.454	87.338	97.392	8.720	3.73	2.6	11.3	76.9
5.0-2	5.0	4672.3	126.6	113.7	2237.2	2009.2	2.397	2.153	2.397	2.454	87.724	97.677	8.632	3.73	2.3	11.0	78.9
5.0-3	5.0	4613.3	125.7	112.8	2221.3	1993.3	2.382	2.138	2.382	2.454	87.105	97.066	8.640	3.73	2.9	11.6	74.6
AVG											87.389	97.378	8.664		2.6	11.3	76.8
S.D.											0.313	0.306	0.049		0.306	0.279	2.134

Specimens Compacted to $N_{maximum}$ = 208

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN-GAP GRADED | MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse)= 2.647 | Bulk SG Agg. (Gsb) = 2.559 | Percent Absorbed Asphalt (Pba)= 1.34

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	K	*L*		*N*	*O*	*P*		*Q*	*R*	*S*	*T*	*U*
						17.67*D	17.67*E	17.67*F													
4.3-1	4.3	4631.5	125.3	112.0	110.5	2214.2	1979.2	1952.7	2.428	2.141	2.395	2.428	2.479	86.374	96.631	97.943	8.483	3.02	3.4	10.4	67.7
4.3-2	4.3	4624.2	127.3	113.7	112.1	2249.6	2009.2	1981.0	2.407	2.120	2.373	2.407	2.479	85.502	95.729	97.096	8.501	3.02	4.3	11.3	62.0
4.3-3	4.3	4599.6	126.3	112.9	111.3	2231.9	1995.1	1966.8	2.406	2.120	2.372	2.406	2.479	85.529	95.680	97.055	8.452	3.02	4.3	11.3	61.8
AVG														85.802	96.013	97.365	8.478		4.0	11.0	63.8
S.D														0.496	0.535	0.501	0.025		0.535	0.496	3.324

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

Alabama Limestone Gap Graded Mixture

Specimens Compacted to N_{design} = 128

SGC: Pine Gyatory Compactor

MIX ID: AL-LMS GAP GRADED

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.741 | Effective SG Agg (Gse)= 2.727 | Bulk SG Agg. (Gsb) = 2.699 | Percent Absorbed Asphalt (Pba)= 0.39

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	MEASURED Bulk at Ndesign (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	S	T	U
					17.67*D	17.67*E		C*G*J/(C/I)									
3.0-1	3.0	4140.8	108.8	97.2	1922.7	1717.7	2.468	2.205	2.473	2.598	84.868	95.189	8.951	2.62	4.8	11.1	56.7
3.0-2	3.0	4125.5	108.3	96.9	1913.8	1712.4	2.467	2.207	2.468	2.598	84.962	94.996	8.703	2.62	5.0	11.3	55.7
3.0-3	3.0	4126.2	107.7	96.6	1903.2	1707.1	2.463	2.209	2.463	2.598	85.033	94.804	8.475	2.62	5.2	11.5	54.7
AVG											84.954	94.996	8.710		5.0	11.3	55.7
S.D.											0.083	0.192	0.239		0.192	0.180	0.999
3.5-1	3.5	4147.0	107.8	96.0	1905.0	1696.5	2.497	2.224	2.497	2.577	86.289	96.896	9.199	3.12	3.1	10.7	71.0
3.5-2	3.5	4145.2	107.7	96.0	1903.2	1696.5	2.499	2.228	2.499	2.577	86.439	96.973	9.137	3.12	3.0	10.7	71.6
3.5-3	3.5	4144.5	108.2	96.3	1912.1	1701.8	2.498	2.223	2.498	2.577	86.273	96.934	9.247	3.12	3.1	10.7	71.3
AVG											86.334	96.934	9.194		3.1	10.7	71.3
S.D.											0.091	0.039	0.055		0.039	0.036	0.267
4.0-1	4.0	4165.3	107.3	95.5	1896.1	1687.6	2.515	2.238	2.515	2.558	87.507	98.319	9.378	3.62	1.7	10.5	84.1
4.0-2	4.0	4163.9	107.9	96.1	1906.8	1698.2	2.513	2.238	2.513	2.558	87.497	98.241	9.318	3.62	1.8	10.6	83.4
4.0-3	4.0	4159.1	107.7	96.0	1903.2	1696.5	2.511	2.238	2.511	2.558	87.499	98.163	9.249	3.62	1.8	10.7	82.8
AVG											87.501	98.241	9.315		1.8	10.6	83.4
S.D.											0.005	0.078	0.064		0.078	0.071	0.625

Specimens Compacted to $N_{maximum}$ = 208

SGC: Pine Gyatory Compactor

MIX ID: AL-LMS GAP GRADED

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.741 | Effective SG Agg (Gse)= 2.727 | Bulk SG Agg. (Gsb) = 2.699 | Percent Absorbed Asphalt (Pba)= 0.39

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	HEIGHTS Nmaximum (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	VOLUMES Nmaximum (cc)	MEASURED Bulk at Nmaximum (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	CORRECTED BULK Nmaximum (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	S	T	U
						17.67*D	17.67*E	17.67*F													
3.3-1	3.3	4153.2	108.2	96.5	95.4	1912.1	1705.3	1685.9	2.505	2.209	2.476	2.505	2.585	85.441	95.801	96.905	8.406	2.92	4.2	11.3	62.8
3.3-2	3.3	4154.2	107.9	96.8	95.3	1906.8	1710.6	1684.1	2.508	2.215	2.469	2.508	2.585	85.692	95.518	97.021	8.307	2.92	4.5	11.5	61.1
3.3-3	3.3	4155.1	107.8	96.9	95.5	1905.0	1712.4	1687.6	2.503	2.217	2.467	2.503	2.585	85.780	95.429	96.828	8.101	2.92	4.6	11.6	60.7
AVG														85.638	95.582	96.918	8.271		4.4	11.5	61.5
S.D.														0.176	0.194	0.097	0.156		0.194	0.180	1.096

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

Alabama Limestone Large Stone Mixture

Specimens Compacted to N_{design} = 128

SGC: Pine Gyatory Compactor

MIX ID: AL-LMS LARGE STONE — MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.741 — Effective SG Agg (Gse)= 2.725 — Bulk SG Agg. (Gsb) = 2.699 — Percent Absorbed Asphalt (Pba)= 0.36

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD						
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)									
3.5-1	3.5	4099.4	110.1	97.1	1945.6	1715.9	2.477	2.185	2.473	2.575	84.836	96.039	9.716	3.15	4.0	11.6	65.8
3.5-2	3.5	4094.0	111.3	97.1	1966.8	1715.9	2.469	2.154	2.468	2.575	83.650	95.845	10.576	3.15	4.2	11.8	64.7
3.5-3	3.5	4105.2	110.7	97.5	1956.2	1723.0	2.468	2.174	2.468	2.575	84.416	95.845	9.912	3.15	4.2	11.8	64.7
AVG											84.301	95.909	10.068		4.1	11.7	65.0
S.D.											0.601	0.112	0.451		0.112	0.103	0.653
4.0-1	4.0	4111.0	110.8	97.4	1958.0	1721.2	2.469	2.170	2.469	2.555	84.947	96.634	10.136	3.65	3.4	12.2	72.4
4.0-2	4.0	4111.9	110.0	96.8	1943.9	1710.6	2.475	2.178	2.475	2.555	85.245	96.869	10.082	3.65	3.1	12.0	73.8
4.0-3	4.0	4095.0	110.6	97.0	1954.5	1714.1	2.462	2.159	2.462	2.555	84.511	96.360	10.277	3.65	3.6	12.4	70.7
AVG											84.901	96.621	10.165		3.4	12.2	72.3
S.D.											0.369	0.255	0.101		0.255	0.231	1.561
4.5-1	4.5	4103.4	111.4	98.6	1968.6	1742.4	2.466	2.183	2.466	2.536	86.067	97.240	9.691	4.15	2.8	12.7	78.3
4.5-2	4.5	4114.1	110.5	97.0	1952.7	1714.1	2.474	2.172	2.474	2.536	85.637	97.555	10.337	4.15	2.4	12.5	80.4
4.5-3	4.5	4124.1	111.2	97.8	1965.1	1728.3	2.463	2.166	2.463	2.536	85.418	97.121	10.151	4.15	2.9	12.9	77.6
AVG											85.707	97.305	10.060		2.7	12.7	78.8
S.D.											0.330	0.224	0.333		0.224	0.201	1.440

Specimens Compacted to $N_{maximum}$ = 208

SGC: Pine Gyatory Compactor

MIX ID: AL-LMS LARGE STONE — MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.741 — Effective SG Agg (Gse)= 2.727 — Bulk SG Agg. (Gsb) = 2.699 — Percent Absorbed Asphalt (Pba)= 0.39

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	S	T	U
						17.67*D	17.67*E	17.67*F													
3.5-1	3.5	4119.3	111.4	98.2	96.4	1968.6	1735.3	1703.5	2.505	2.168	2.459	2.505	2.575	84.183	95.498	97.282	9.605	3.12	4.5	12.1	62.7
3.5-2	3.5	4109.7	113.3	99.8	97.9	2002.2	1763.6	1730.0	2.494	2.155	2.447	2.494	2.575	83.690	95.010	96.854	9.653	3.12	5.0	12.5	60.2
3.5-3	3.5	4116.1	111.4	97.7	95.9	1968.6	1726.5	1694.7	2.512	2.162	2.466	2.512	2.575	83.980	95.756	97.553	9.952	3.12	4.2	11.8	64.2
AVG														83.951	95.422	97.230	9.737		4.6	12.1	62.4
S.D.														0.248	0.379	0.352	0.188		0.379	0.349	2.021

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 4: Develop Compaction Procedures for Gap Graded and Large Stone Mixtures

Georgia Granite Large Stone Mixture

Specimens Compacted to N_{design} = 128

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN LARGE STONE

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse)= 2.724; Bulk SG Agg. (Gsb) = 2.707; Percent Absorbed Asphalt (Pba)= 0.24

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD						
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	S	T	U
					17.67*D	17.67*E		C/G*J/(C.I)									
3.0-1	3.0	4094.4	110.5	99.5	1952.7	1758.3	2.401	2.162	2.401	2.595	83.314	92.524	7.989	2.77	7.5	14.0	46.5
3.0-2	3.0	4086.2	110.4	99.8	1950.9	1763.6	2.426	2.193	2.426	2.595	84.511	93.487	7.785	2.77	6.5	13.1	50.2
3.0-3	3.0	4092.6	110.2	99.0	1947.4	1749.5	2.414	2.169	2.414	2.595	83.571	93.025	8.200	2.77	7.0	13.5	48.3
AVG											83.798	93.012	7.991		7.0	13.5	48.3
S.D											0.631	0.482	0.207		0.482	0.448	1.851
3.5-1	3.5	4116.6	109.6	98.9	1936.8	1747.7	2.437	2.199	2.437	2.575	85.401	94.641	8.014	3.27	5.4	13.1	59.2
3.5-2	3.5	4115.7	110.7	100.2	1956.2	1770.7	2.420	2.190	2.420	2.575	85.066	93.981	7.731	3.27	6.0	13.7	56.2
3.5-3	3.5	4117.0	110.1	99.3	1945.6	1754.8	2.426	2.188	2.426	2.575	84.972	94.214	8.016	3.27	5.8	13.5	57.2
AVG											85.147	94.278	7.920		5.7	13.5	57.5
S.D.											0.226	0.335	0.163		0.335	0.307	1.528
4.0-1	4.0	4122.6	111.1	99.5	1963.3	1758.3	2.452	2.196	2.452	2.555	85.949	95.969	8.691	3.77	4.0	13.0	69.1
4.0-2	4.0	4139.7	110.4	98.9	1950.9	1747.7	2.452	2.197	2.452	2.555	85.972	95.969	8.670	3.77	4.0	13.0	69.1
4.0-3	4.0	4130.6	111.4	99.6	1968.6	1760.1	2.451	2.191	2.451	2.555	85.768	95.930	8.813	3.77	4.1	13.1	68.9
AVG											85.896	95.956	8.725		4.0	13.1	69.0
S.D.											0.111	0.023	0.077		0.023	0.020	0.124

Specimens Compacted to $N_{maximum}$ = 208

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN-LARGE STONE

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

AC Sp. Gr. (Gb) = 1.028; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse)= 2.724; Bulk SG Agg. (Gsb) = 2.707; Percent Absorbed Asphalt (Pba)= 0.24

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Phe)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	S	T	U
						17.67*D	17.67*E	17.67*F													
4.0-1	4.0	4116.1	108.8	98.3	97.1	1922.7	1737.1	1715.9	2.475	2.209	2.445	2.475	2.555	86.452	95.686	96.869	7.638	3.77	4.3	13.3	67.6
4.0-2	4.0	4140.1	111.4	100.1	98.7	1968.6	1768.9	1744.2	2.472	2.190	2.437	2.472	2.555	85.721	95.398	96.751	8.088	3.77	4.6	13.6	66.1
4.0-3	4.0	4132.1	110.1	99.6	98.3	1945.6	1760.1	1737.1	2.478	2.212	2.446	2.478	2.555	86.592	95.720	96.986	7.622	3.77	4.3	13.3	67.7
AVG														86.255	95.602	96.869	7.782		4.4	13.4	67.1
S.D.														0.467	0.177	0.117	0.264		0.177	0.160	0.923

NCHRP 9-9
APPENDIX C

Summary Information for Task 6A: Evaluation of the Effect of Varying Short Term Aging Temperature

Binder	PG 52-28 Binder															
Aggregate	NY Gravel				GA Granite				AL Limestone				OH Limestone			
Gradation	Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
Aging Temp, C	135	128	135	128	135	128	135	128	135	128	135	128	135	128	135	128
Gmm 1	2.453	2.454	2.444	2.447	2.533	2.514	2.538	2.532	2.581	2.576	2.546	2.546	2.511	2.498	2.499	2.500
Gmm 2	2.460	2.447	2.444	2.444	2.524	2.522	2.536	2.537	2.582	2.577	2.510	2.545	2.513	2.508	2.495	2.494
Gmm Ave	2.457	2.451	2.444	2.446	2.529	2.518	2.537	2.535	2.582	2.577	2.528	2.546	2.512	2.503	2.497	2.497
Gmm σ	0.005	0.005	0.000	0.002	0.006	0.006	0.001	0.004	0.001	0.001	0.025	0.001	0.001	0.007	0.003	0.004
Gmb 1	2.347	2.355	2.354	2.349	2.435	2.445	2.448	2.458	2.483	2.485	2.450	2.462	2.411	2.394	2.374	2.359
Gmb 2	2.339	2.349	2.357	2.365	2.435	2.443	2.446	2.454	2.478	2.479	2.454	2.452	2.410	2.397	2.373	2.370
Gmb 3	2.339	2.340	2.357	2.360	2.428	2.445	2.448	2.458	2.474	2.480	2.452	2.450	2.399	2.392	2.364	2.365
Gmb Ave	2.342	2.348	2.356	2.358	2.433	2.444	2.447	2.457	2.478	2.481	2.452	2.455	2.407	2.394	2.370	2.365
Gmb σ	0.005	0.008	0.002	0.008	0.004	0.001	0.001	0.002	0.005	0.003	0.002	0.006	0.007	0.003	0.006	0.006
Air Voids 1	4.5%	3.9%	3.7%	3.9%	3.7%	2.9%	3.5%	3.0%	3.8%	3.6%	3.1%	3.3%	4.0%	4.4%	4.9%	5.5%
Air Voids 2	4.8%	4.1%	3.6%	3.3%	3.7%	3.0%	3.6%	3.2%	4.0%	3.8%	2.9%	3.7%	4.1%	4.2%	5.0%	5.1%
Air Voids 3	4.8%	4.5%	3.6%	3.5%	4.0%	2.9%	3.5%	3.0%	4.2%	3.7%	3.0%	3.8%	4.5%	4.4%	5.3%	5.3%
Air Voids Ave	4.7%	4.2%	3.6%	3.6%	3.8%	2.9%	3.5%	3.1%	4.0%	3.7%	3.0%	3.6%	4.2%	4.3%	5.1%	5.3%
Air Voids σ	0.2%	0.3%	0.1%	0.3%	0.2%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.3%	0.3%	0.1%	0.2%	0.2%
VMA 1	12.9%	12.6%	12.1%	12.3%	13.3%	13.0%	12.7%	12.3%	10.9%	10.8%	13.3%	12.9%	14.6%	15.2%	14.6%	15.2%
VMA 2	13.2%	12.8%	12.0%	11.7%	13.3%	13.1%	12.7%	12.4%	11.1%	11.0%	13.2%	13.3%	14.7%	15.1%	14.7%	14.8%
VMA 3	13.2%	13.2%	12.0%	11.9%	13.6%	13.0%	12.7%	12.3%	11.2%	11.0%	13.3%	13.3%	15.0%	15.3%	15.0%	15.0%
VMA Ave	13.1%	12.9%	12.1%	12.0%	13.4%	13.0%	12.7%	12.3%	11.1%	11.0%	13.3%	13.2%	14.8%	15.2%	14.8%	15.0%
VMA σ	0.2%	0.3%	0.1%	0.3%	0.1%	0.0%	0.0%	0.1%	0.2%	0.1%	0.1%	0.2%	0.2%	0.1%	0.2%	0.2%
%Gmm @ Ni 1	88.6%	88.9%	86.9%	86.2%	89.1%	89.8%	87.2%	87.3%	85.3%	85.5%	85.0%	84.8%	86.4%	86.1%	84.0%	83.4%
%Gmm @ Ni 2	88.2%	88.7%	87.1%	87.0%	89.0%	89.8%	87.1%	87.2%	85.3%	85.3%	85.4%	84.8%	86.6%	86.4%	83.8%	83.6%
%Gmm @ Ni 3	88.3%	88.4%	87.0%	86.6%	88.9%	89.9%	87.2%	87.5%	85.1%	85.2%	85.4%	84.6%	86.2%	86.2%	83.5%	83.7%
%Gmm @ Ni Ave	88.4%	88.6%	87.0%	86.6%	89.0%	89.8%	87.2%	87.3%	85.3%	85.3%	85.3%	84.8%	86.4%	86.2%	83.8%	83.5%
%Gmm @ Ni σ	0.2%	0.3%	0.1%	0.4%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%	0.1%	0.2%	0.2%
Slope 1	6.02	6.28	8.13	8.54	6.28	6.36	8.03	8.39	9.40	9.52	10.29	10.32	8.33	8.24	9.61	9.64
Slope 2	6.09	6.23	8.08	8.45	6.34	6.23	8.07	8.31	9.24	9.48	10.14	9.98	8.08	8.15	9.76	9.83
Slope 3	6.04	6.19	8.21	8.58	6.20	6.23	8.02	8.26	9.27	9.55	10.03	10.09	8.05	8.14	9.69	9.55
Slope Ave	6.05	6.23	8.14	8.52	6.27	6.28	8.04	8.32	9.30	9.52	10.15	10.13	8.16	8.18	9.69	9.68
Slope σ	0.04	0.05	0.07	0.07	0.07	0.08	0.02	0.06	0.09	0.03	0.13	0.17	0.15	0.06	0.07	0.14

Binder	AAG-1 Binder															
Aggregate	NY Gravel				GA Granite				AL Limestone				OH Limestone			
Gradation	Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
Aging Temp, C	135	131	135	131	135	131	135	131	135	131	135	131	135	128	135	128
Gmm 1	2.446	2.441		2.457	2.512	2.520	2.535	2.543	2.584	2.575	2.553	2.551				
Gmm 2	2.435	2.450	2.459	2.453	2.536	2.520	2.538	2.536	2.576	2.582	2.553	2.549				
Gmm Ave	2.441	2.446	2.459	2.455	2.524	2.520	2.537	2.540	2.580	2.579	2.553	2.550				
Gmm σ	0.008	0.006		0.003	0.017	0.000	0.002	0.005	0.006	0.005	0.000	0.001				
Gmb 1	2.349	2.346	2.369	2.378	2.443	2.439	2.449	2.451	2.497	2.498	2.465	2.480				
Gmb 2	2.346	2.354	2.378	2.381	2.439	2.436	2.451	2.453	2.487	2.490	2.460	2.461				
Gmb 3	2.347	2.341	2.367	2.375	2.438	2.435	2.453	2.440	2.486	2.493	2.456	2.473				
Gmb Ave	2.347	2.347	2.371	2.378	2.440	2.437	2.451	2.448	2.490	2.494	2.460	2.471				
Gmb σ	0.002	0.007	0.006	0.003	0.003	0.002	0.002	0.007	0.006	0.004	0.005	0.010				
Air Voids 1	3.7%	4.1%	3.7%	3.1%	3.2%	3.2%	3.4%	3.5%	3.2%	3.1%	3.4%	2.7%				
Air Voids 2	3.9%	3.7%	3.3%	3.0%	3.4%	3.3%	3.4%	3.4%	3.6%	3.4%	3.6%	3.5%				
Air Voids 3	3.8%	4.3%	3.7%	3.3%	3.4%	3.4%	3.3%	3.9%	3.6%	3.3%	3.8%	3.0%				
Air Voids Ave	3.8%	4.0%	3.6%	3.1%	3.3%	3.3%	3.4%	3.6%	3.5%	3.3%	3.6%	3.1%				
Air Voids σ	0.1%	0.3%	0.2%	0.1%	0.1%	0.1%	0.1%	0.3%	0.2%	0.2%	0.2%	0.4%				
VMA 1	12.8%	12.9%	11.6%	11.2%	13.1%	13.2%	12.6%	12.5%	10.4%	10.4%	12.8%	12.3%				
VMA 2	12.9%	12.6%	11.2%	11.1%	13.2%	13.3%	12.5%	12.5%	10.7%	10.6%	13.0%	13.0%				
VMA 3	12.9%	13.1%	11.6%	11.3%	13.2%	13.3%	12.5%	12.9%	10.8%	10.5%	13.1%	12.5%				
VMA Ave	12.9%	12.9%	11.5%	11.2%	13.2%	13.3%	12.5%	12.7%	10.6%	10.5%	13.0%	12.6%				
VMA σ	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.2%	0.3%				
%Gmm @ Ni 1	89.1%	88.8%	86.8%	87.5%	89.6%	89.6%	86.8%	86.8%	85.6%	85.7%	84.6%	85.4%				
%Gmm @ Ni 2	89.1%	88.9%	87.1%	87.1%	89.4%	89.5%	87.0%	86.7%	85.2%	85.4%	83.6%	84.4%				
%Gmm @ Ni 3	89.2%	88.6%	86.6%	87.1%	89.4%	89.3%	87.2%	86.0%	85.4%	85.6%	84.2%	85.2%				
%Gmm @ Ni Ave	89.1%	88.8%	86.8%	87.2%	89.5%	89.5%	87.0%	86.5%	85.4%	85.6%	84.1%	85.0%				
%Gmm @ Ni σ	0.0%	0.2%	0.2%	0.2%	0.1%	0.1%	0.2%	0.4%	0.2%	0.2%	0.6%	0.5%				
Slope 1	6.17	6.22	8.29	8.14	6.27	6.23	8.50	8.39	9.66	9.66	10.32	10.24				
Slope 2	6.10	6.35	8.37	8.57	6.26	6.22	8.39	8.62	9.71	9.66	11.11	10.46				
Slope 3	6.07	6.19	8.36	8.34	6.24	6.33	8.25	8.74	9.53	9.65	10.39	10.22				
Slope Ave	6.11	6.25	8.34	8.35	6.25	6.26	8.38	8.58	9.63	9.66	10.61	10.31				
Slope σ	0.05	0.09	0.04	0.21	0.01	0.06	0.12	0.18	0.09	0.01	0.43	0.13				

Binder	PG 64-22 Binder															
Aggregate	NY Gravel				GA Granite				AL Limestone				OH Limestone			
Gradation	Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
Aging Temp, C	135	145	135	145	135	145	135	145	135	145	135	145	135	145	135	145
Gmm 1	2.453	2.442	2.442	2.442	2.517	2.500	2.537	2.531	2.576	2.574	2.544	2.543	2.501	2.495	2.486	2.490
Gmm 2	2.452	2.447	2.442	2.447	2.519	2.510	2.532	2.533	2.578	2.575	2.546	2.545	2.512	2.520	2.484	2.497
Gmm Ave	2.453	2.445	2.442	2.445	2.518	2.505	2.535	2.532	2.577	2.575	2.545	2.544	2.507	2.508	2.485	2.494
Gmm σ	0.001	0.004	0.000	0.004	0.001	0.007	0.004	0.001	0.001	0.001	0.001	0.001	0.008	0.018	0.001	0.005
Gmb 1	2.346	2.335	2.369	2.352	2.436	2.443	2.451	2.459	2.479	2.486	2.456	2.466	2.402	2.392	2.362	2.369
Gmb 2	2.346	2.342	2.360	2.356	2.444	2.437	2.448	2.463	2.478	2.486	2.453	2.460	2.400	2.387	2.379	2.388
Gmb 3	2.348	2.336	2.368	2.363	2.436	2.442	2.452	2.457	2.472	2.477	2.454	2.468	2.401	2.396	2.379	2.393
Gmb Ave	2.347	2.338	2.366	2.357	2.439	2.441	2.450	2.460	2.476	2.483	2.454	2.465	2.401	2.392	2.373	2.383
Gmb σ	0.001	0.004	0.005	0.006	0.005	0.003	0.002	0.003	0.004	0.005	0.002	0.004	0.001	0.005	0.010	0.013
Air Voids 1	4.3%	4.5%	3.0%	3.8%	3.3%	2.5%	3.3%	2.9%	3.8%	3.4%	3.5%	3.1%	4.2%	4.6%	4.9%	5.0%
Air Voids 2	4.3%	4.2%	3.4%	3.6%	2.9%	2.7%	3.4%	2.7%	3.8%	3.4%	3.6%	3.3%	4.2%	4.8%	4.3%	4.2%
Air Voids 3	4.3%	4.4%	3.0%	3.3%	3.3%	2.5%	3.3%	3.0%	4.1%	3.8%	3.6%	3.0%	4.2%	4.4%	4.3%	4.0%
Air Voids Ave	4.3%	4.4%	3.1%	3.6%	3.2%	2.6%	3.3%	2.9%	3.9%	3.6%	3.6%	3.1%	4.2%	4.6%	4.5%	4.4%
Air Voids σ	0.0%	0.2%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%	0.0%	0.2%	0.4%	0.5%
VMA 1	12.9%	13.3%	11.6%	12.2%	13.3%	13.1%	12.5%	12.3%	11.0%	10.8%	13.1%	12.8%	14.9%	15.3%	15.1%	14.8%
VMA 2	12.9%	13.1%	11.9%	12.1%	13.0%	13.3%	12.7%	12.1%	11.1%	10.8%	13.2%	13.0%	15.0%	15.5%	14.5%	14.1%
VMA 3	12.9%	13.3%	11.6%	11.8%	13.3%	13.1%	12.5%	12.3%	11.3%	11.1%	13.2%	12.7%	15.0%	15.1%	14.5%	14.0%
VMA Ave	12.9%	13.2%	11.7%	12.0%	13.2%	13.1%	12.6%	12.2%	11.1%	10.9%	13.2%	12.8%	15.0%	15.3%	14.7%	14.3%
VMA σ	0.0%	0.1%	0.2%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.0%	0.2%	0.4%	0.5%
%Gmm @ Ni 1	88.6%	88.7%	87.4%	86.4%	89.3%	90.2%	87.2%	87.7%	85.2%	85.4%	84.6%	85.0%	86.3%	86.1%	83.7%	83.9%
%Gmm @ Ni 2	88.7%	88.7%	87.2%	86.5%	89.9%	89.9%	86.8%	87.9%	85.2%	85.6%	84.5%	84.9%	86.3%	86.0%	84.5%	84.4%
%Gmm @ Ni 3	88.6%	88.4%	87.5%	86.9%	89.4%	90.1%	87.2%	87.6%	84.9%	85.2%	84.7%	85.2%	86.4%	86.1%	84.2%	84.5%
%Gmm @ Ni Ave	88.6%	88.6%	87.4%	86.6%	89.5%	90.1%	87.1%	87.7%	85.1%	85.4%	84.6%	85.0%	86.3%	86.0%	84.1%	84.3%
%Gmm @ Ni σ	0.0%	0.2%	0.1%	0.3%	0.3%	0.2%	0.3%	0.1%	0.1%	0.2%	0.1%	0.2%	0.0%	0.1%	0.4%	0.3%
Slope 1	6.14	5.94	8.34	8.51	6.49	6.35	8.23	8.16	9.57	9.66	10.34	10.34	8.24	8.10	9.81	9.60
Slope 2	6.07	6.14	8.18	8.54	6.20	6.41	8.53	8.15	9.52	9.54	10.31	10.26	8.17	8.01	9.72	9.89
Slope 3	6.15	6.23	8.22	8.43	6.36	6.43	8.29	8.16	9.53	9.54	10.16	10.27	8.18	8.18	10.04	9.93
Slope Ave	6.12	6.10	8.25	8.49	6.35	6.39	8.35	8.16	9.54	9.58	10.27	10.29	8.20	8.10	9.86	9.81
Slope σ	0.04	0.15	0.08	0.06	0.14	0.04	0.15	0.01	0.03	0.07	0.09	0.04	0.04	0.08	0.16	0.18

Binder	PG 76-22 Binder															
Aggregate	NY Gravel				GA Granite				AL Limestone				OH Limestone			
Gradation	Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
Aging Temp, C	135	155	135	155	135	155	135	155	135	155	135	155	135	155	135	155
Gmm 1	2.431	2.447	2.439	2.447	2.516	2.510	2.531	2.532	2.572	2.575	2.538	2.544	2.501	2.486	2.473	2.489
Gmm 2	2.438	2.439	2.443	2.444	2.511	2.521	2.531	2.531	2.576	2.562	2.540	2.544	2.489	2.510	2.473	2.487
Gmm Ave	2.435	2.443	2.441	2.446	2.514	2.516	2.531	2.532	2.574	2.569	2.539	2.544	2.495	2.498	2.473	2.488
Gmm σ	0.005	0.006	0.003	0.002	0.004	0.008	0.000	0.001	0.003	0.009	0.001	0.000	0.008	0.017	0.000	0.001
Gmb 1	2.339	2.351	2.335	2.351	2.451	2.440	2.441	2.451	2.475	2.489	2.463	2.470	2.422	2.413	2.389	2.396
Gmb 2	2.348	2.351	2.341	2.346	2.448	2.439	2.452	2.455	2.482	2.482	2.461	2.461	2.422	2.421	2.377	2.390
Gmb 3	2.346	2.351	2.333	2.354	2.447	2.442	2.454	2.450	2.481	2.484	2.468	2.463	2.417	2.413	2.369	2.396
Gmb Ave	2.344	2.351	2.336	2.350	2.449	2.440	2.449	2.452	2.479	2.485	2.464	2.465	2.420	2.416	2.378	2.394
Gmb σ	0.005	0.000	0.004	0.004	0.002	0.002	0.007	0.003	0.004	0.004	0.004	0.005	0.003	0.005	0.010	0.003
Air Voids 1	3.9%	3.8%	4.3%	3.9%	2.5%	3.0%	3.6%	3.2%	3.8%	3.1%	3.0%	2.9%	2.9%	3.4%	3.4%	3.7%
Air Voids 2	3.6%	3.8%	4.1%	4.1%	2.6%	3.0%	3.1%	3.0%	3.6%	3.4%	3.1%	3.3%	2.9%	3.1%	3.9%	3.9%
Air Voids 3	3.6%	3.8%	4.4%	3.7%	2.6%	2.9%	3.0%	3.2%	3.6%	3.3%	2.8%	3.2%	3.1%	3.4%	4.2%	3.7%
Air Voids Ave	3.7%	3.8%	4.3%	3.9%	2.6%	3.0%	3.2%	3.1%	3.7%	3.3%	3.0%	3.1%	3.0%	3.3%	3.8%	3.8%
Air Voids σ	0.2%	0.0%	0.2%	0.2%	0.1%	0.1%	0.3%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%	0.4%	0.1%
VMA 1	13.2%	12.7%	12.8%	12.2%	12.8%	13.2%	12.9%	12.5%	11.2%	10.7%	12.9%	12.6%	14.2%	14.5%	14.1%	13.8%
VMA 2	12.9%	12.7%	12.6%	12.4%	12.9%	13.2%	12.5%	12.4%	10.9%	10.9%	13.0%	13.0%	14.2%	14.3%	14.5%	14.1%
VMA 3	12.9%	12.7%	12.9%	12.1%	12.9%	13.1%	12.4%	12.6%	11.0%	10.9%	12.7%	12.9%	14.4%	14.5%	14.8%	13.8%
VMA Ave	13.0%	12.7%	12.8%	12.3%	12.9%	13.1%	12.6%	12.5%	11.0%	10.8%	12.8%	12.8%	14.3%	14.5%	14.5%	13.9%
VMA σ	0.2%	0.0%	0.2%	0.2%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.2%	0.4%	0.1%
%Gmm @ Ni 1	88.9%	89.0%	86.2%	86.1%	90.0%	89.6%	86.5%	86.7%	85.5%	86.2%	85.4%	85.5%	87.8%	87.2%	85.5%	84.9%
%Gmm @ Ni 2	89.2%	89.1%	86.5%	85.9%	89.9%	89.4%	87.0%	86.8%	85.6%	85.9%	85.4%	84.9%	87.5%	87.5%	85.1%	84.6%
%Gmm @ Ni 3	89.3%	89.1%	86.1%	86.1%	89.8%	89.6%	87.0%	86.6%	85.5%	86.0%	85.9%	85.1%	87.4%	87.1%	84.3%	85.0%
%Gmm @ Ni Ave	89.1%	89.1%	86.3%	86.0%	89.9%	89.5%	86.8%	86.7%	85.5%	86.0%	85.5%	85.2%	87.6%	87.3%	85.0%	84.8%
%Gmm @ Ni σ	0.2%	0.1%	0.2%	0.1%	0.1%	0.1%	0.3%	0.1%	0.1%	0.2%	0.3%	0.3%	0.2%	0.2%	0.6%	0.2%
Slope 1	6.18	6.30	8.25	8.74	6.53	6.42	8.67	8.77	9.26	9.28	10.09	10.02	8.06	8.18	9.60	9.87
Slope 2	6.26	6.19	8.12	8.71	6.49	6.58	8.59	8.83	9.41	9.31	10.03	10.28	8.27	8.19	9.54	9.91
Slope 3	6.16	6.19	8.23	8.79	6.56	6.53	8.67	8.84	9.44	9.33	9.84	10.19	8.23	8.22	9.94	9.83
Slope Ave	6.20	6.23	8.20	8.75	6.53	6.51	8.64	8.81	9.37	9.30	9.99	10.16	8.19	8.20	9.70	9.87
Slope σ	0.05	0.06	0.07	0.04	0.03	0.08	0.05	0.04	0.10	0.02	0.13	0.13	0.11	0.02	0.21	0.04

Binder	PG 76-22 Binder								PG 64-22 Binder							
Aggregate	GA Granite								GA Granite							
Gradation	Fine				Coarse				Fine				Coarse			
Aging Temp, C	135		155		135		155		135		145		135		145	
Aging Time, hrs	2	4	2	4	2	4	2	4	2	4	2	4	2	4	2	4
Gmm 1	2.536	2.516	2.516	2.510	2.536	2.531	2.534	2.532	2.529	2.517	2.522	2.500	2.539	2.537	2.540	2.531
Gmm 2	2.535	2.511	2.513	2.521	2.537	2.531	2.533	2.531	2.537	2.519	2.537	2.510	2.542	2.532	2.540	2.533
Gmm Ave	2.536	2.514	2.515	2.516	2.537	2.531	2.534	2.532	2.533	2.518	2.530	2.505	2.541	2.535	2.540	2.532
Gmm σ	0.001	0.004	0.002	0.008	0.001	0.000	0.001	0.001	0.006	0.001	0.011	0.007	0.002	0.004	0.000	0.001
Gmb 1	2.452	2.451	2.445	2.440	2.466	2.441	2.459	2.451	2.446	2.436	2.456	2.443	2.456	2.451	2.452	2.459
Gmb 2	2.451	2.448	2.447	2.439	2.465	2.452	2.465	2.455	2.443	2.444	2.453	2.437	2.456	2.448	2.447	2.463
Gmb 3	2.447	2.447	2.441	2.442	2.461	2.454	2.458	2.450	2.439	2.436	2.447	2.442	2.452	2.452	2.447	2.457
Gmb Ave	2.450	2.449	2.444	2.440	2.464	2.449	2.461	2.452	2.443	2.439	2.452	2.441	2.455	2.450	2.449	2.460
Gmb σ	0.003	0.002	0.003	0.002	0.003	0.007	0.004	0.003	0.004	0.005	0.005	0.003	0.002	0.002	0.003	0.003
Air Voids 1	3.3%	2.5%	2.8%	3.0%	2.8%	3.6%	2.9%	3.2%	3.4%	3.3%	2.9%	2.5%	3.3%	3.3%	3.5%	2.9%
Air Voids 2	3.3%	2.6%	2.7%	3.0%	2.8%	3.1%	2.7%	3.0%	3.6%	2.9%	3.0%	2.7%	3.3%	3.4%	3.7%	2.7%
Air Voids 3	3.5%	2.6%	2.9%	2.9%	3.0%	3.0%	3.0%	3.2%	3.7%	3.3%	3.3%	2.5%	3.5%	3.3%	3.7%	3.0%
Air Voids Ave	3.4%	2.6%	2.8%	3.0%	2.9%	3.2%	2.9%	3.1%	3.6%	3.2%	3.1%	2.6%	3.4%	3.3%	3.6%	2.9%
Air Voids σ	0.1%	0.1%	0.1%	0.1%	0.1%	0.3%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
VMA 1	12.7%	12.8%	13.0%	13.2%	12.0%	12.9%	12.3%	12.5%	12.9%	13.3%	12.6%	13.1%	12.4%	12.5%	12.5%	12.3%
VMA 2	12.8%	12.9%	12.9%	13.2%	12.0%	12.5%	12.0%	12.4%	13.1%	13.0%	12.7%	13.3%	12.4%	12.7%	12.7%	12.1%
VMA 3	12.9%	12.9%	13.1%	13.1%	12.2%	12.4%	12.3%	12.6%	13.2%	13.3%	12.9%	13.1%	12.5%	12.5%	12.7%	12.3%
VMA Ave	12.8%	12.9%	13.0%	13.1%	12.1%	12.6%	12.2%	12.5%	13.1%	13.2%	12.7%	13.1%	12.4%	12.6%	12.6%	12.2%
VMA σ	0.1%	0.1%	0.1%	0.1%	0.1%	0.2%	0.1%	0.1%	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%
%Gmm @ Ni 1	89.5%	90.0%	89.8%	89.6%	87.4%	86.5%	87.2%	86.7%	89.4%	89.3%	90.0%	90.2%	87.1%	87.2%	87.1%	87.7%
%Gmm @ Ni 2	89.4%	89.9%	90.2%	89.4%	87.5%	87.0%	87.7%	86.8%	89.3%	89.9%	89.9%	89.9%	87.0%	86.8%	87.0%	87.9%
%Gmm @ Ni 3	89.4%	89.8%	89.8%	89.6%	87.1%	87.0%	87.0%	86.6%	89.0%	89.4%	89.7%	90.1%	87.0%	87.2%	86.7%	87.6%
%Gmm @ Ni Ave	89.4%	89.9%	89.9%	89.5%	87.3%	86.8%	87.3%	86.7%	89.3%	89.5%	89.9%	90.1%	87.0%	87.1%	86.9%	87.7%
%Gmm @ Ni σ	0.1%	0.1%	0.2%	0.1%	0.2%	0.3%	0.4%	0.1%	0.2%	0.3%	0.2%	0.2%	0.0%	0.3%	0.2%	0.1%
Slope 1	6.29	6.53	6.42	6.42	8.56	8.67	8.52	8.77	6.17	6.49	6.12	6.35	8.33	8.23	8.20	8.16
Slope 2	6.34	6.49	6.19	6.58	8.40	8.59	8.31	8.83	6.20	6.20	6.11	6.41	8.41	8.53	8.12	8.15
Slope 3	6.19	6.56	6.29	6.53	8.57	8.67	8.67	8.84	6.29	6.36	6.13	6.43	8.23	8.29	8.40	8.16
Slope Ave	6.27	6.53	6.30	6.51	8.51	8.64	8.50	8.81	6.22	6.35	6.12	6.39	8.32	8.35	8.24	8.16
Slope σ	0.08	0.03	0.12	0.08	0.10	0.05	0.18	0.04	0.06	0.14	0.01	0.04	0.09	0.15	0.14	0.01

Superpave Mix Design
NCHRP 9-9
12.5 mm Gravel Fine

SUMMARY OF DESIGN INFORMATION

Design		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2340	n/a
Asphalt %	4.8%	n/a	Max. Sp. Gravity (G_{mm})	2.442	n/a
VMA	13.2%	14.0% min.	Density @ 9 gyrations	89.0%	89% max.
VFA	70%	65% - 75%	Density @ 208 gyrations	97.0%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	1.7	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.1%	2318	6.0%	13.3%	55%	2.467	3.3%
4.6%	2329	4.9%	13.4%	63%	2.449	3.8%
5.1%	2356	3.1%	12.8%	76%	2.431	4.3%
5.6%	2376	1.6%	12.5%	88%	2.414	4.8%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.1%	87.3%	94.0%	94.9%
4.6%	88.3%	95.1%	96.1%
5.1%	89.7%	96.9%	97.9%
5.6%	90.8%	98.4%	99.5%

Aggregate Blend BSG	2.565
Aggregate Effective SG	2.623
Asphalt Absorption	0.9%
Asphalt Specific Gravity	1.03

Aggregates

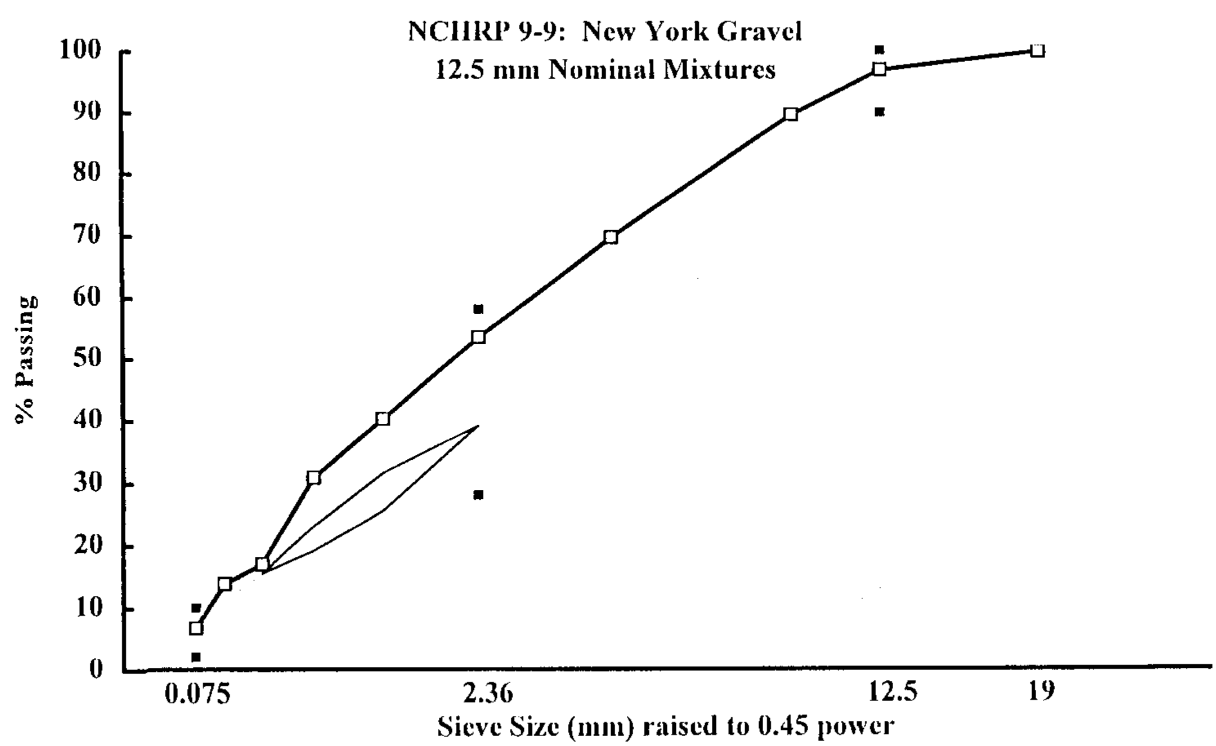
Percent	Aggregate	Bulk SG
11.0%	Gravel 1's	2.547
29.0%	Gravel 1A's	2.526
55.0%	Crushed Gravel Sand	2.583
5.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

	NY 2's	NY 1's	NY 1As	Cr. Sand	Filler	
Fine	0.0%	11.0%	29.0%	55.0%	5.0%	

Sieve						Fine Gradation
25 mm	100.0	100.0	100.0	100.0	100.0	100.0
19 mm	74.0	*100.0*	100.0	100.0	100.0	100.0
12.5 mm	8.0	72.0	100.0	100.0	100.0	96.9
9.5 mm	1.0	5.0	100.0	100.0	100.0	89.6
4.75 mm	0.0	1.0	33.0	100.0	100.0	69.7
2.36 mm	0.0	0.0	0.0	88.0	100.0	53.4
1.18 mm	0.0	0.0	0.0	64.0	100.0	40.2
0.6 mm	0.0	0.0	0.0	47.0	99.0	30.8
0.3 mm	0.0	0.0	0.0	22.0	96.0	16.9
0.15 mm	0.0	0.0	0.0	17.0	90.0	13.9
0.075 mm	0.0	0.0	0.0	5.0	80.2	6.8



SUMMARY OF MIX DESIGN - COMPACTION

12.5 Gravel Fine

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.1%	87.3%	94.9%	94.0%	5.79
4.6%	88.3%	96.1%	95.1%	5.93
5.1%	89.7%	97.9%	96.9%	6.25
5.6%	90.8%	99.5%	98.4%	6.59

SUMMARY OF MIX DESIGN - VOLUMETRICS

12.5 Gravel Fine

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.1%	6.0%	13.3%	54.9%	2318	2.1
4.6%	4.9%	13.4%	63.5%	2329	1.8
5.1%	3.1%	12.8%	75.9%	2356	1.6
5.6%	1.6%	12.5%	87.6%	2376	1.4

Superpave Mix Design
NCHRP 9-9
12.5 mm Gravel Coarse

SUMMARY OF DESIGN INFORMATION

Design		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2352	n/a
Asphalt %	4.7%	n/a	Max. Sp. Gravity (G_{mm})	2.448	n/a
VMA	12.2%	14.0% min.	Density @ 9 gyrations	86.8%	89% max.
VFA	67%	65% - 75%	Density @ 208 gyrations	97.4%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	1.0	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.1%	2333	5.5%	12.3%	55%	2.469	3.0%
4.6%	2348	4.2%	12.3%	66%	2.451	3.5%
5.1%	2366	2.8%	12.1%	77%	2.434	4.0%
5.6%	2372	1.8%	12.3%	85%	2.416	4.5%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.1%	85.7%	94.5%	95.8%
4.6%	86.6%	95.8%	97.1%
5.1%	87.4%	97.2%	98.6%
5.6%	87.9%	98.2%	99.6%

Aggregate Blend BSG	2.553
Aggregate Effective SG	2.626
Asphalt Absorption	1.1%
Asphalt Specific Gravity	1.03

Aggregates

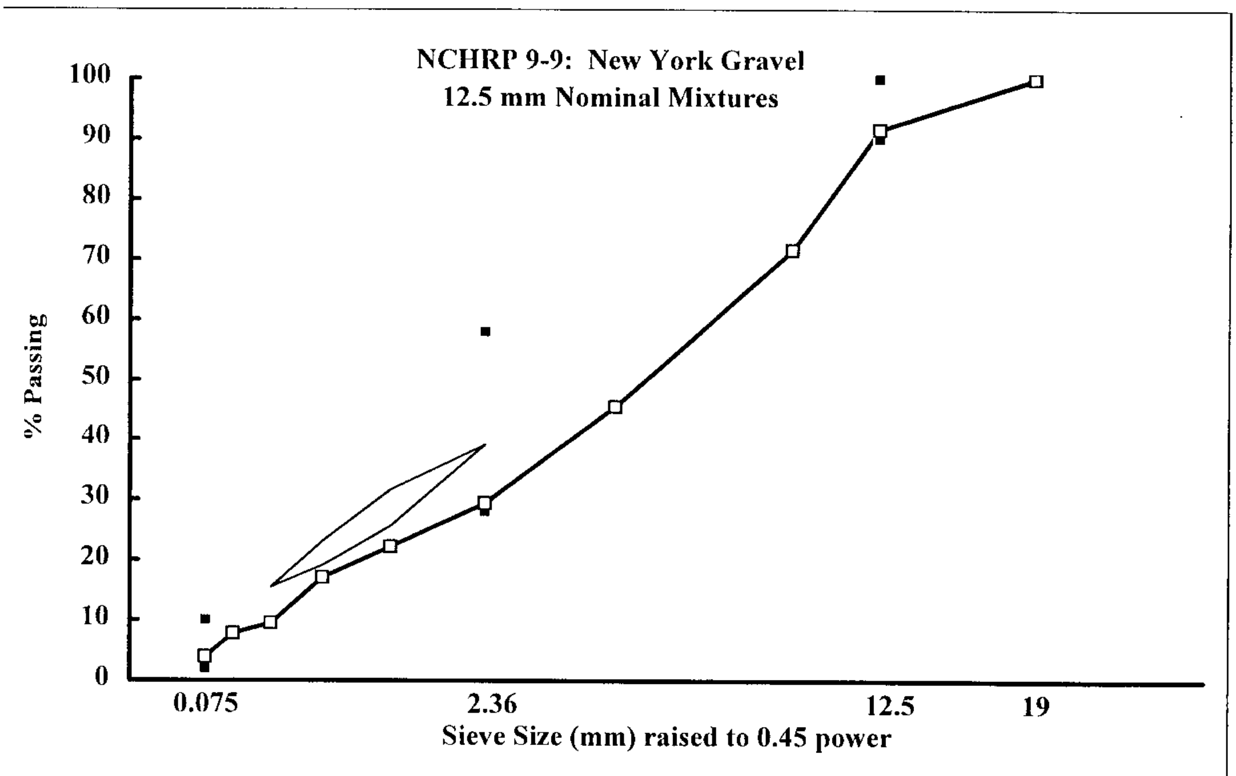
Percent	Aggregate	Bulk SG
30.0%	Gravel 1's	2.547
37.0%	Gravel 1A's	2.526
30.0%	Crushed Gravel Sand	2.583
3.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

	NY 2's	NY 1's	NY 1As	Cr. Sand	Filler	
Coarse	0.0%	30.0%	37.0%	30.0%	3.0%	

Sieve						Coarse Gradation
25 mm	100.0	100.0	100.0	100.0	100.0	100.0
19 mm	74.0	***100.0***	100.0	100.0	100.0	100.0
12.5 mm	8.0	72.0	100.0	100.0	100.0	91.6
9.5 mm	1.0	5.0	100.0	100.0	100.0	71.5
4.75 mm	0.0	1.0	33.0	100.0	100.0	45.5
2.36 mm	0.0	0.0	0.0	88.0	100.0	29.4
1.18 mm	0.0	0.0	0.0	64.0	100.0	22.2
0.6 mm	0.0	0.0	0.0	47.0	99.0	17.1
0.3 mm	0.0	0.0	0.0	22.0	96.0	9.5
0.15 mm	0.0	0.0	0.0	17.0	90.0	7.8
0.075 mm	0.0	0.0	0.0	5.0	80.2	3.9



SUMMARY OF MIX DESIGN - COMPACTION

12.5 Gravel Coarse

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.1%	85.7%	95.8%	94.5%	7.67
4.6%	86.6%	97.1%	95.8%	7.99
5.1%	87.4%	98.6%	97.2%	8.51
5.6%	87.9%	99.6%	98.2%	8.86

SUMMARY OF MIX DESIGN - VOLUMETRICS

12.5 Gravel Coarse

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.1%	5.5%	12.3%	55.5%	2333	1.3
4.6%	4.2%	12.3%	65.6%	2348	1.1
5.1%	2.8%	12.1%	76.8%	2366	1.0
5.6%	1.8%	12.3%	85.1%	2372	0.9

Superpave Mix Design
NCHRP 9-9
12.5 mm Granite Fine

SUMMARY OF DESIGN INFORMATION

Design		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2425	n/a
Asphalt %	4.3%	n/a	Max. Sp. Gravity (G_{mm})	2.526	n/a
VMA	13.6%	14.0% min.	Density @ 9 gyrations	88.8%	89% max.
VFA	70%	65% - 75%	Density @ 208 gyrations	97.0%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	1.9	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.1%	2417	4.6%	13.8%	67%	2.533	3.9%
4.6%	2437	3.1%	13.6%	77%	2.514	4.4%
5.1%	2454	1.6%	13.4%	88%	2.495	4.9%
5.6%	2467	0.4%	13.4%	97%	2.477	5.4%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.1%	88.3%	95.4%	96.3%
4.6%	89.5%	96.9%	97.8%
5.1%	90.8%	98.4%	99.1%
5.6%	92.8%	99.6%	100.0%

Aggregate Blend BSG	2.689
Aggregate Effective SG	2.702
Asphalt Absorption	0.2%
Asphalt Specific Gravity	1.03

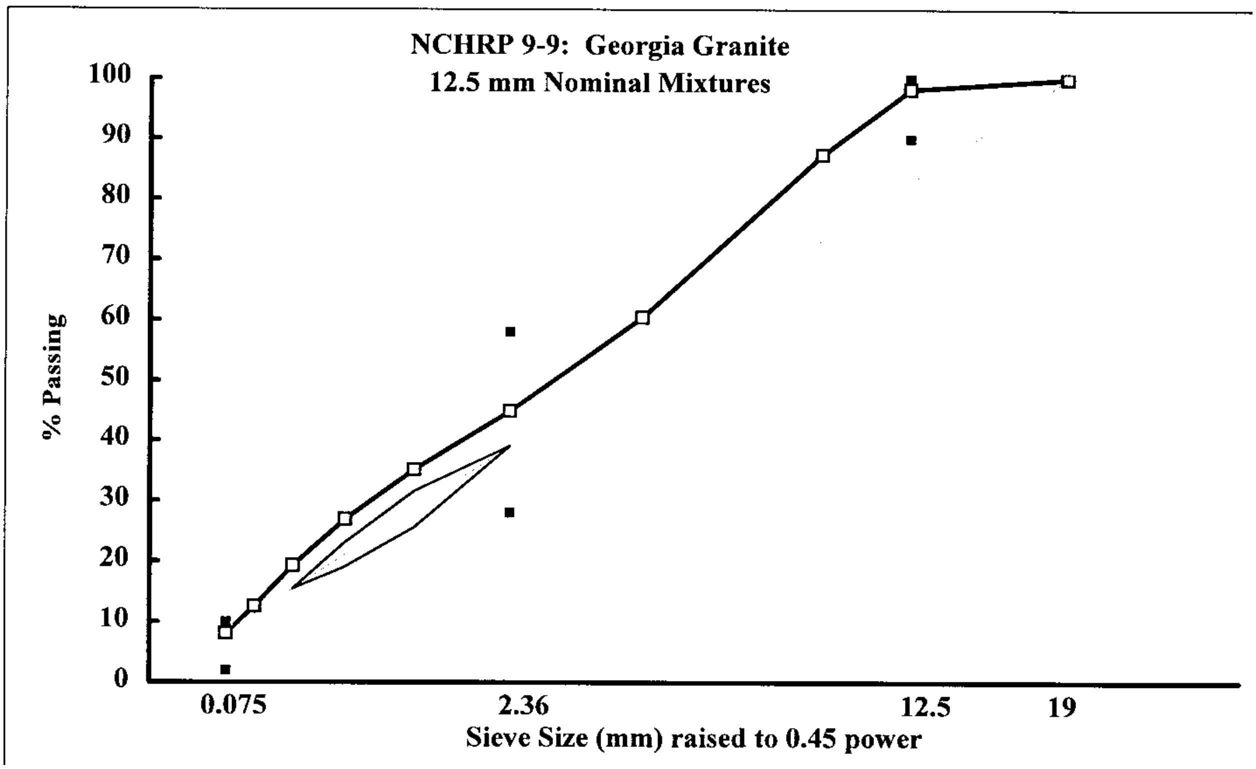
Aggregates

Percent	Aggregate	Bulk SG
0.0%	Granite 67's	2.682
35.0%	Granite 78's	2.676
65.0%	Granite 810's	2.696
0.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

	GA 4's	GA 67's	GA 78's	GA 810's	Filler		
Fine	0.0%	0.0%	35.0%	65.0%	0.0%		
Sieve							Fine Gradation
50 mm	100.0						
37.5 mm	96.0						
25 mm	18.5	100.0	100.0	100.0	100.0		100.0
19 mm	5.0	*100.0*	100.0	100.0	100.0		100.0
12.5 mm	1.6	70.1	95.0	100.0	100.0		98.3
9.5 mm	1.4	38.0	63.8	100.0	100.0		87.3
4.75 mm	1.3	8.6	10.1	87.6	100.0		60.5
2.36 mm	1.3	5.9	2.8	67.6	100.0		44.9
1.18 mm	1.2	4.9	2.0	53.0	100.0		35.2
0.6 mm	1.2	4.0	1.5	40.6	99.0		26.9
0.3 mm	1.0	3.1	1.2	29.0	96.0		19.3
0.15 mm	0.6	2.0	0.8	19.0	90.0		12.6
0.075 mm	0.4	1.1	0.5	12.2	80.2		8.1



SUMMARY OF MIX DESIGN - COMPACTION

12.5 Granite Fine

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.1%	88.3%	96.3%	95.4%	6.22
4.6%	89.5%	97.8%	96.9%	6.39
5.1%	90.8%	99.1%	98.4%	6.51
5.6%	92.8%	100.0%	99.6%	5.90

SUMMARY OF MIX DESIGN - VOLUMETRICS

12.5 Granite Fine

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.1%	4.6%	13.8%	66.8%	2417	2.1
4.6%	3.1%	13.6%	77.2%	2437	1.8
5.1%	1.6%	13.4%	87.7%	2454	1.6
5.6%	0.4%	13.4%	97.2%	2467	1.5

Superpave Mix Design
NCHRP 9-9
12.5 mm Granite Coarse

SUMMARY OF DESIGN INFORMATION

Design

		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2435	n/a
Asphalt %	4.2%	n/a	Max. Sp. Gravity (G_{mm})	2.537	n/a
VMA	13.0%	14.0% min.	Density @ 9 gyrations	87.0%	89% max.
VFA	69%	65% - 75%	Density @ 208 gyrations	97.2%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	1.3	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.1%	2428	4.4%	13.3%	67%	2.541	3.7%
4.6%	2456	2.6%	12.7%	80%	2.522	4.2%
5.1%	2454	1.9%	13.3%	85%	2.503	4.8%
5.6%	2464	0.8%	13.4%	94%	2.484	5.3%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.1%	86.6%	95.6%	96.8%
4.6%	87.9%	97.4%	98.6%
5.1%	88.2%	98.1%	99.3%
5.6%	89.1%	99.2%	100.0%

Aggregate Blend BSG	2.685
Aggregate Effective SG	2.711
Asphalt Absorption	0.4%
Asphalt Specific Gravity	1.03

Aggregates

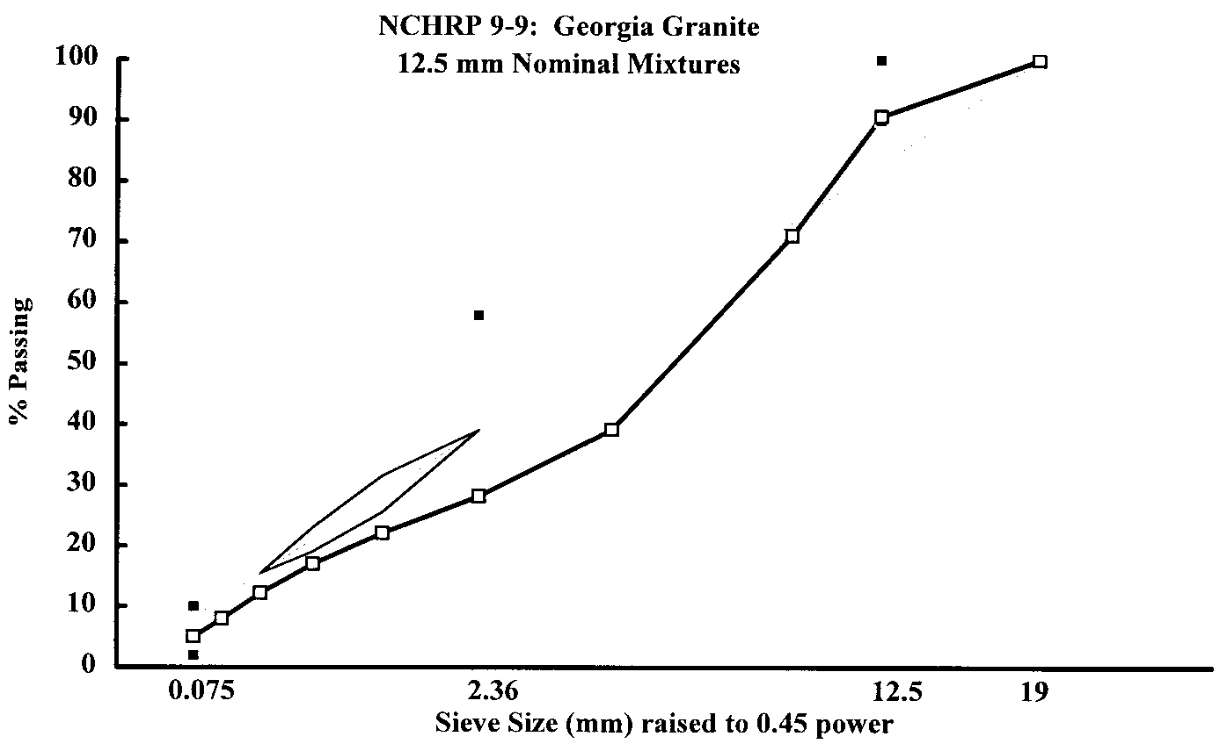
Percent	Aggregate	Bulk SG
25.0%	Granite 67's	2.682
37.0%	Granite 78's	2.676
38.0%	Granite 810's	2.696
0.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

	GA 4's	GA 67's	GA 78's	GA 810's	Filler	
Coarse	0.0%	25.0%	37.0%	38.0%	0.0%	

Sieve						Coarse Gradation
50 mm	100.0					
37.5 mm	96.0					
25 mm	18.5	100.0	100.0	100.0	100.0	100.0
19 mm	5.0	*100.0*	100.0	100.0	100.0	100.0
12.5 mm	1.6	70.1	95.0	100.0	100.0	90.7
9.5 mm	1.4	38.0	63.8	100.0	100.0	71.1
4.75 mm	1.3	8.6	10.1	87.6	100.0	39.2
2.36 mm	1.3	5.9	2.8	67.6	100.0	28.2
1.18 mm	1.2	4.9	2.0	53.0	100.0	22.1
0.6 mm	1.2	4.0	1.5	40.6	99.0	17.0
0.3 mm	1.0	3.1	1.2	29.0	96.0	12.2
0.15 mm	0.6	2.0	0.8	19.0	90.0	8.0
0.075 mm	0.4	1.1	0.5	12.2	80.2	5.1



SUMMARY OF MIX DESIGN - COMPACTION

12.5 Granite Coarse

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.1%	86.6%	96.8%	95.6%	7.78
4.6%	87.9%	98.6%	97.4%	8.25
5.1%	88.2%	99.3%	98.1%	8.56
5.6%	89.1%	100.0%	99.2%	8.76

SUMMARY OF MIX DESIGN - VOLUMETRICS

12.5 Granite Coarse

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.1%	4.4%	13.3%	66.6%	2428	1.4
4.6%	2.6%	12.7%	79.5%	2456	1.2
5.1%	1.9%	13.3%	85.4%	2454	1.1
5.6%	0.8%	13.4%	93.9%	2464	1.0

Superpave Mix Design
NCHRP 9-9
12.5 mm Limestone (AL) Fine

SUMMARY OF DESIGN INFORMATION

Design		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2478	n/a
Asphalt %	3.5%	n/a	Max. Sp. Gravity (G_{mm})	2.581	n/a
VMA	11.2%	14.0% min.	Density @ 9 gyrations	84.7%	89% max.
VFA	64%	65% - 75%	Density @ 208 gyrations	97.3%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	2.8	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.1%	2494	2.4%	11.0%	78%	2.557	3.6%
4.6%	2504	1.3%	11.2%	88%	2.537	4.1%
5.1%	2501	0.7%	11.7%	94%	2.518	4.6%
5.6%	2487	0.5%	12.7%	96%	2.499	5.1%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.1%	86.3%	97.6%	98.9%
4.6%	87.3%	98.7%	99.5%
5.1%	88.5%	99.3%	99.8%
5.6%	89.4%	99.5%	99.9%

Aggregate Blend BSG	2.689
Aggregate Effective SG	2.730
Asphalt Absorption	0.6%
Asphalt Specific Gravity	1.03

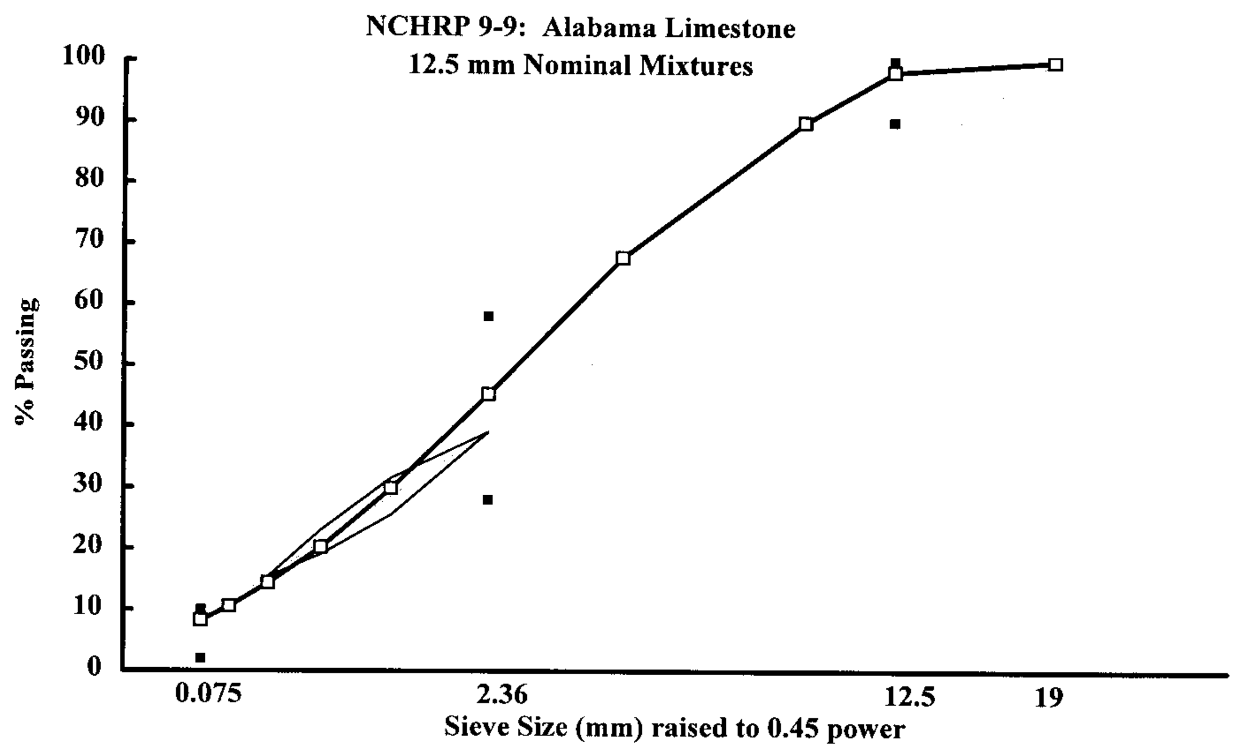
Aggregates

Percent	Aggregate	Bulk SG
0.0%	Limestone 67's	2.718
34.0%	Limestone 78's	2.713
64.0%	Limestone 10's	2.678
2.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

		AL 67's	AL 78's	AL 10's	Filler		
Fine		0.0%	34.0%	64.0%	2.0%		
Sieve							
50 mm							Fine
37.5 mm							Gradation
25 mm		100.0	100.0	100.0	100.0		100.0
19 mm		*100.0*	100.0	100.0	100.0		100.0
12.5 mm		70.8	94.8	100.0	100.0		98.2
9.5 mm		41.4	70.2	100.0	100.0		89.9
4.75 mm		1.8	17.2	93.6	100.0		67.8
2.36 mm		0.3	2.0	66.6	100.0		45.3
1.18 mm		0.3	0.4	43.4	100.0		29.9
0.6 mm		0.3	0.4	28.3	99.0		20.2
0.3 mm		0.3	0.4	19.3	96.0		14.4
0.15 mm		0.3	0.4	13.6	90.0		10.6
0.075 mm		0.3	0.4	10.3	80.2		8.3



SUMMARY OF MIX DESIGN - COMPACTION
12.5 Limestone (AL) Fine

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.1%	86.3%	98.9%	97.6%	9.80
4.6%	87.3%	99.5%	98.7%	9.88
5.1%	88.5%	99.8%	99.3%	9.36
5.6%	89.4%	99.9%	99.5%	8.80

SUMMARY OF MIX DESIGN - VOLUMETRICS
12.5 Limestone (AL) Fine

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.1%	2.4%	11.0%	77.8%	2494	2.3
4.6%	1.3%	11.2%	88.3%	2504	2.0
5.1%	0.7%	11.7%	94.4%	2501	1.8
5.6%	0.5%	12.7%	96.1%	2487	1.6

Superpave Mix Design
NCHRP 9-9
12.5 mm Limestone (AL) Coarse

SUMMARY OF DESIGN INFORMATION

Design		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2452	n/a
Asphalt %	4.5%	n/a	Max. Sp. Gravity (G_{mm})	2.554	n/a
VMA	13.3%	14.0% min.	Density @ 9 gyrations	84.2%	89% max.
VFA	70%	65% - 75%	Density @ 208 gyrations	97.6%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	1.1	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.1%	2442	5.0%	13.3%	62%	2.570	3.5%
4.6%	2455	3.7%	13.3%	72%	2.550	4.0%
5.1%	2455	3.0%	13.7%	78%	2.530	4.5%
5.6%	2449	2.5%	14.4%	83%	2.511	5.0%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.1%	83.3%	95.0%	96.7%
4.6%	84.5%	96.3%	97.9%
5.1%	85.5%	97.0%	98.7%
5.6%	86.0%	97.5%	99.2%

Aggregate Blend BSG	2.700
Aggregate Effective SG	2.745
Asphalt Absorption	0.6%
Asphalt Specific Gravity	1.03

Aggregates

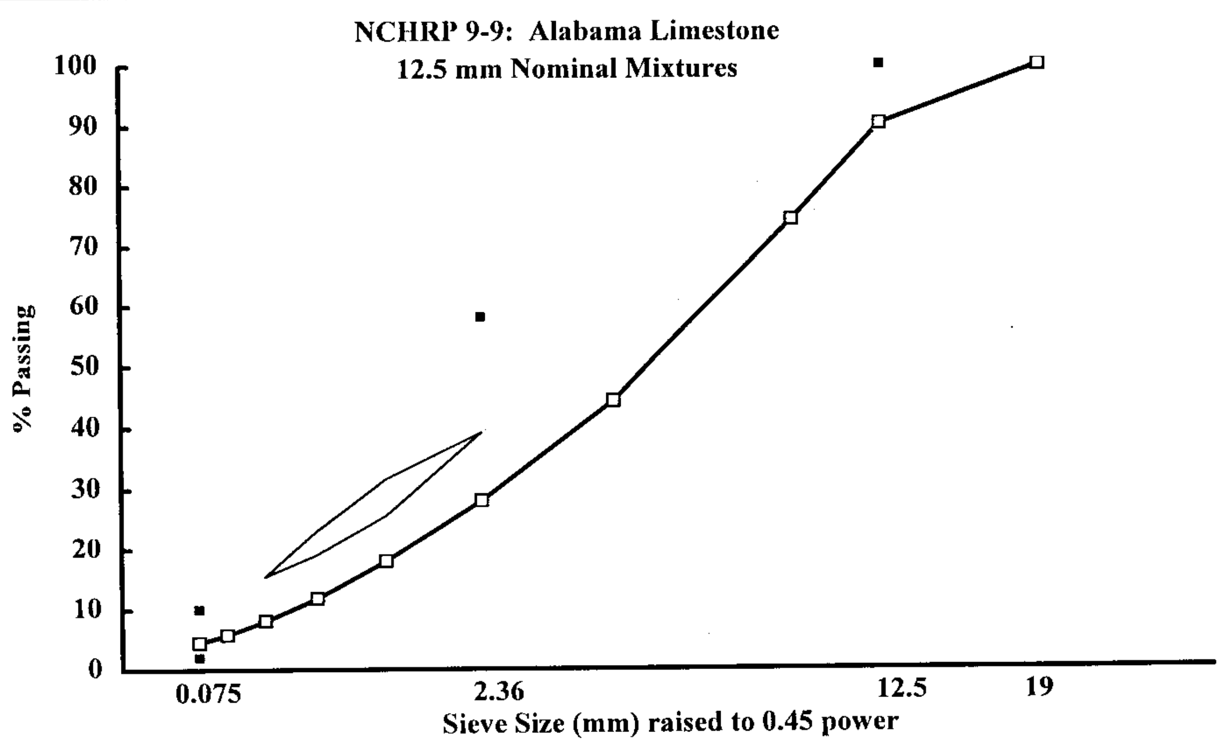
Percent	Aggregate	Bulk SG
28.0%	Limestone 67's	2.718
31.0%	Limestone 78's	2.713
41.0%	Limestone 10's	2.678
0.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

		AL 67's	AL 78's	AL 10's	Filler	
Coarse	0.0%	28.0%	31.0%	41.0%	0.0%	

Sieve	AL 67's	AL 78's	AL 10's	Filler	Coarse Gradation
50 mm					
37.5 mm					
25 mm	100.0	100.0	100.0	100.0	100.0
19 mm	*100.0*	100.0	100.0	100.0	100.0
12.5 mm	70.8	94.8	100.0	100.0	90.2
9.5 mm	41.4	70.2	100.0	100.0	74.4
4.75 mm	1.8	17.2	93.6	100.0	44.2
2.36 mm	0.3	2.0	66.6	100.0	28.0
1.18 mm	0.3	0.4	43.4	100.0	18.0
0.6 mm	0.3	0.4	28.3	99.0	11.8
0.3 mm	0.3	0.4	19.3	96.0	8.1
0.15 mm	0.3	0.4	13.6	90.0	5.8
0.075 mm	0.3	0.4	10.3	80.2	4.4



SUMMARY OF MIX DESIGN - COMPACTION

12.5 Limestone (AL) Coarse

%AC	$\%G_{mm}$ @ N=9	$\%G_{mm}$ @ N=208	$\%G_{mm}$ @ N=128	Slope, k
4.1%	83.3%	96.7%	95.0%	10.13
4.6%	84.5%	97.9%	96.3%	10.17
5.1%	85.5%	98.7%	97.0%	9.98
5.6%	86.0%	99.2%	97.5%	10.01

SUMMARY OF MIX DESIGN - VOLUMETRICS

12.5 Limestone (AL) Coarse

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.1%	5.0%	13.3%	62.5%	2442	1.3
4.6%	3.7%	13.3%	71.9%	2455	1.1
5.1%	3.0%	13.7%	78.3%	2455	1.0
5.6%	2.5%	14.4%	82.8%	2449	0.9

Superpave Mix Design
NCHRP 9-9
12.5 mm Limestone (OH) Fine

SUMMARY OF DESIGN INFORMATION

Design		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2403	n/a
Asphalt %	5.8%	n/a	Max. Sp. Gravity (G_{mm})	2.503	n/a
VMA	14.8%	14.0% min.	Density @ 9 gyrations	86.8%	89% max.
VFA	73%	65% - 75%	Density @ 208 gyrations	97.9%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	1.4	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.0%	2329	9.5%	15.9%	40%	2.574	2.2%
4.5%	2347	8.1%	15.7%	49%	2.554	2.7%
5.0%	2371	6.5%	15.3%	58%	2.534	3.3%
5.5%	2394	4.8%	15.0%	68%	2.515	3.8%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.0%	82.4%	90.5%	92.2%
4.5%	83.5%	91.9%	93.6%
5.0%	84.7%	93.5%	95.4%
5.5%	86.0%	95.2%	97.1%

Aggregate Blend BSG	2.617
Aggregate Effective SG	2.745
Asphalt Absorption	1.8%
Asphalt Specific Gravity	1.03

Aggregates

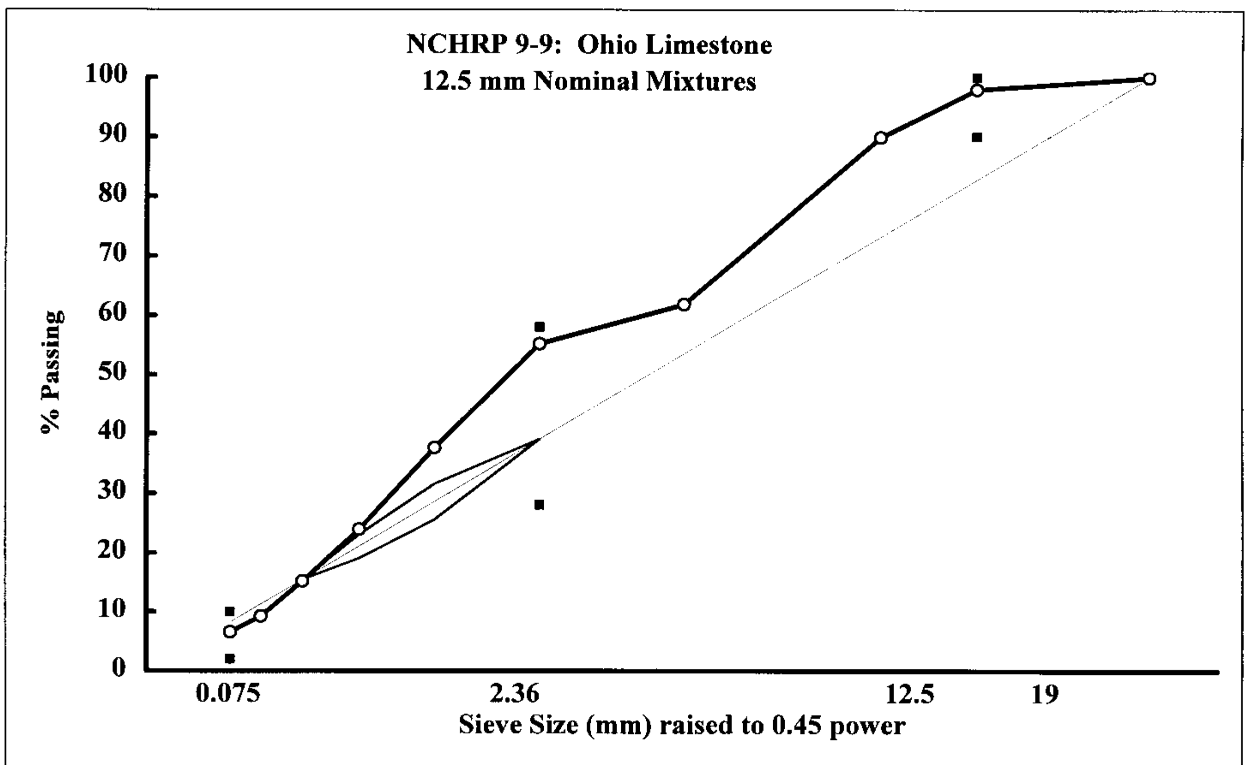
Percent	Aggregate	Bulk SG
40.0%	Limestone 78's	2.568
30.0%	Limestone 8's	2.568
30.0%	Limestone MS	2.739
0.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

	OH 67's	OH 78's	OH 8's	OH MS	Filler	
Fine	0.0%	13.0%	29.0%	53.0%	5.0%	

Sieve						Fine Gradation	0 Gradation	0 Gradation
25 mm	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0
19 mm	85.4	100.0	100.0	100.0	100.0	100.0	0.0	0.0
12.5 mm	25.0	85.2	99.6	100.0	100.0	98.0	0.0	0.0
9.5 mm	7.2	60.7	82.7	100.0	100.0	89.9	0.0	0.0
4.75 mm	0.9	12.6	7.6	100.0	100.0	61.8	0.0	0.0
2.36 mm	0.8	3.2	1.8	93.0	100.0	55.2	0.0	0.0
1.18 mm	0.8	2.2	1.2	60.4	100.0	37.6	0.0	0.0
0.6 mm	0.8	2.0	1.0	34.8	99.0	23.9	0.0	0.0
0.3 mm	0.8	2.0	1.0	18.6	96.0	15.2	0.0	0.0
0.15 mm	0.8	1.8	0.9	8.0	90.0	9.2	0.0	0.0
0.075 mm	0.6	1.6	0.8	4.1	80.2	6.6	0.0	0.0



SUMMARY OF MIX DESIGN - COMPACTION

12.5 Limestone (OH) Fine

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.0%	82.4%	92.2%	90.5%	7.02
4.5%	83.5%	93.6%	91.9%	7.29
5.0%	84.7%	95.4%	93.5%	7.64
5.5%	86.0%	97.1%	95.2%	7.95

SUMMARY OF MIX DESIGN - VOLUMETRICS

12.5 Limestone (OH) Fine

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.0%	9.5%	15.9%	40.4%	2329	2.3
4.5%	8.1%	15.7%	48.6%	2347	2.0
5.0%	6.5%	15.3%	57.9%	2371	1.7
5.5%	4.8%	15.0%	67.8%	2394	1.5

Superpave Mix Design
NCHRP 9-9
12.5 mm Limestone (OH) Coarse

SUMMARY OF DESIGN INFORMATION

Design

		Criteria			Criteria
Air Voids	4.0%	4.0%	Density (kg/m^3)	2399	n/a
Asphalt %	5.9%	n/a	Max. Sp. Gravity (G_{mm})	2.481	n/a
VMA	14.2%	14.0% min.	Density @ 9 gyrations	84.9%	89% max.
VFA	72%	65% - 75%	Density @ 208 gyrations	98.4%	98% max.
% Ret. Tensile Strength	n/a	80% min.	Dust Proportion	0.5	0.6 - 1.2

Properties at Design Gyrations

AC (%)	Weight kg/m^3	Air Voids (%)	VMA (%)	VFA (%)	Theoretical S. G.	Effective AC (%)
4.0%	2326	8.9%	14.7%	39%	2.554	3.2%
4.5%	2337	7.8%	14.7%	47%	2.535	3.7%
5.0%	2356	6.4%	14.5%	56%	2.515	4.2%
5.5%	2370	5.1%	14.4%	65%	2.496	4.7%

AC (%)	Density 9 gyrations	Density 128 gyrations	Density 208 gyrations
4.0%	81.0%	91.1%	93.2%
4.5%	81.8%	92.2%	94.4%
5.0%	82.9%	93.6%	95.9%
5.5%	83.8%	94.9%	97.3%

Aggregate Blend BSG	2.660
Aggregate Effective SG	2.722
Asphalt Absorption	0.9%
Asphalt Specific Gravity	1.03

Aggregates

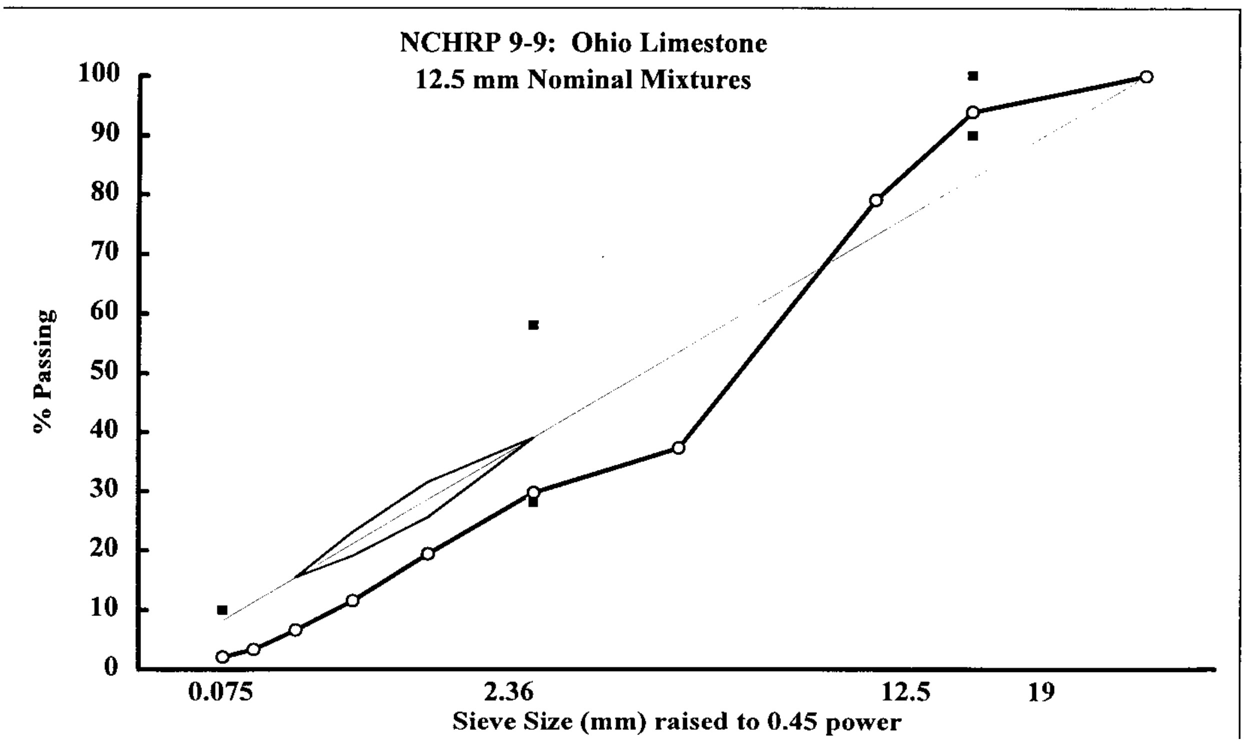
Percent	Aggregate	Bulk SG
13.0%	Limestone 78's	2.568
29.0%	Limestone 8's	2.568
53.0%	Limestone MS	2.739
5.0%	Filler	2.650

Binder PG 64-22

AGGREGATE BLENDING

	OH 67's	OH 78's	OH 8's	OH MS	Filler	
Coarse	0.0%	40.0%	30.0%	30.0%	0.0%	

Sieve						Coarse Gradation	Gradation	Gradation
25 mm	100.0	100.0	100.0	100.0	100.0	100.0	0.0	0.0
19 mm	85.4	100.0	100.0	100.0	100.0	100.0	0.0	0.0
12.5 mm	25.0	85.2	99.6	100.0	100.0	94.0	0.0	0.0
9.5 mm	7.2	60.7	82.7	100.0	100.0	79.1	0.0	0.0
4.75 mm	0.9	12.6	7.6	100.0	100.0	37.3	0.0	0.0
2.36 mm	0.8	3.2	1.8	93.0	100.0	29.7	0.0	0.0
1.18 mm	0.8	2.2	1.2	60.4	100.0	19.4	0.0	0.0
0.6 mm	0.8	2.0	1.0	34.8	99.0	11.5	0.0	0.0
0.3 mm	0.8	2.0	1.0	18.6	96.0	6.7	0.0	0.0
0.15 mm	0.8	1.8	0.9	8.0	90.0	3.4	0.0	0.0
0.075 mm	0.6	1.6	0.8	4.1	80.2	2.1	0.0	0.0



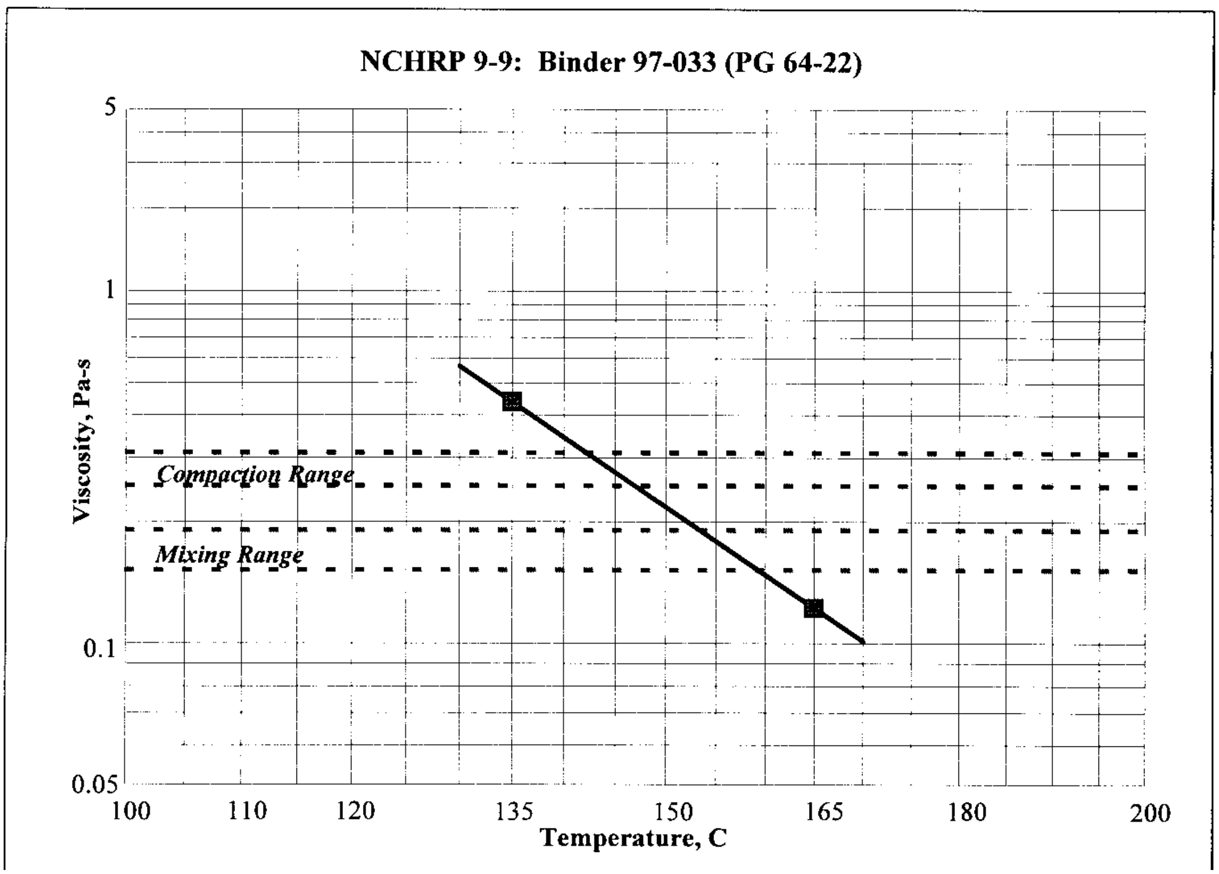
SUMMARY OF MIX DESIGN - COMPACTION
12.5 Limestone (OH) Coarse

%AC	%G_{mm} @ N=9	%G_{mm} @ N=208	%G_{mm} @ N=128	Slope, k
4.0%	81.0%	93.2%	91.1%	8.75
4.5%	81.8%	94.4%	92.2%	9.03
5.0%	82.9%	95.9%	93.6%	9.28
5.5%	83.8%	97.3%	94.9%	9.63

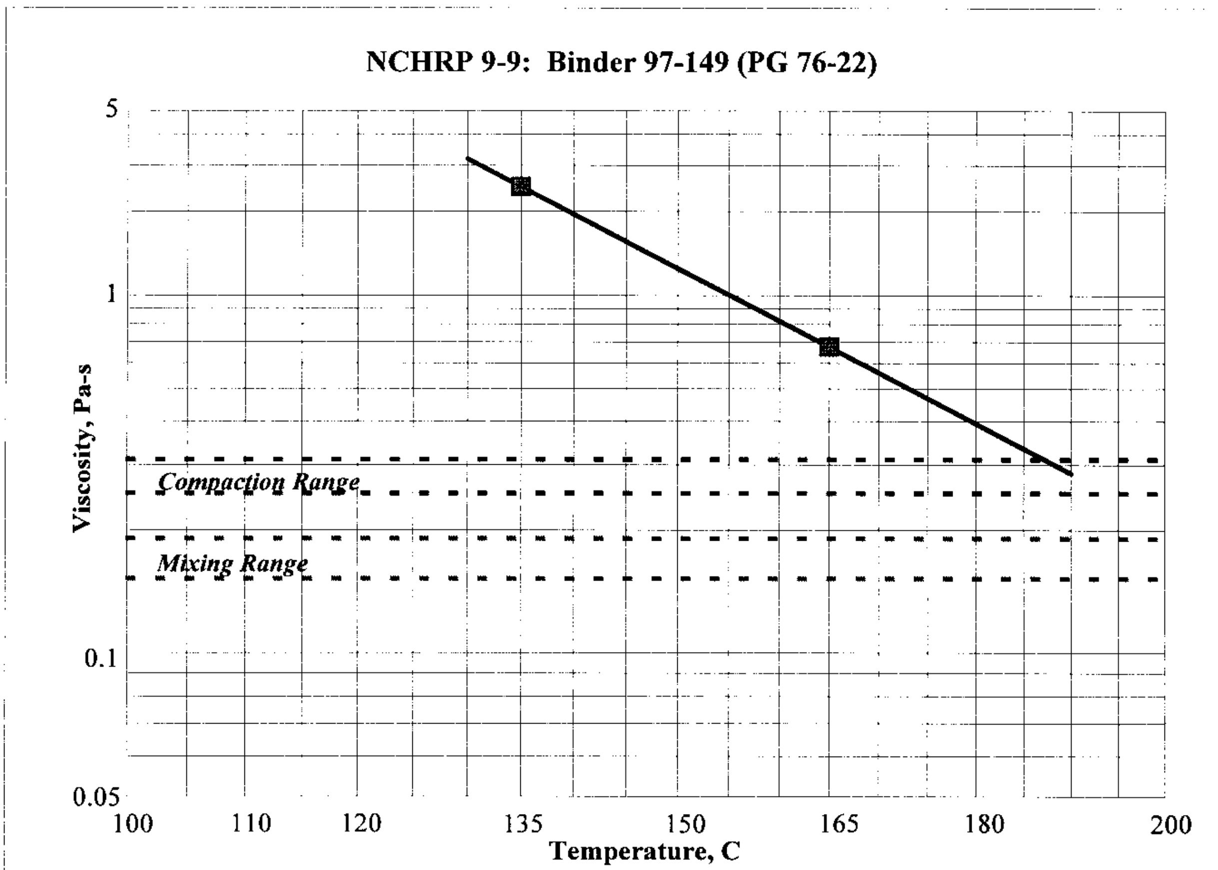
SUMMARY OF MIX DESIGN - VOLUMETRICS
12.5 Limestone (OH) Coarse

%AC	%Air Voids	%VMA	%VFA	Density kg/m^3	Dust Prop.
4.0%	8.9%	14.7%	39.1%	2326	0.8
4.5%	7.8%	14.7%	47.0%	2337	0.7
5.0%	6.4%	14.5%	56.1%	2356	0.6
5.5%	5.1%	14.4%	64.8%	2370	0.5

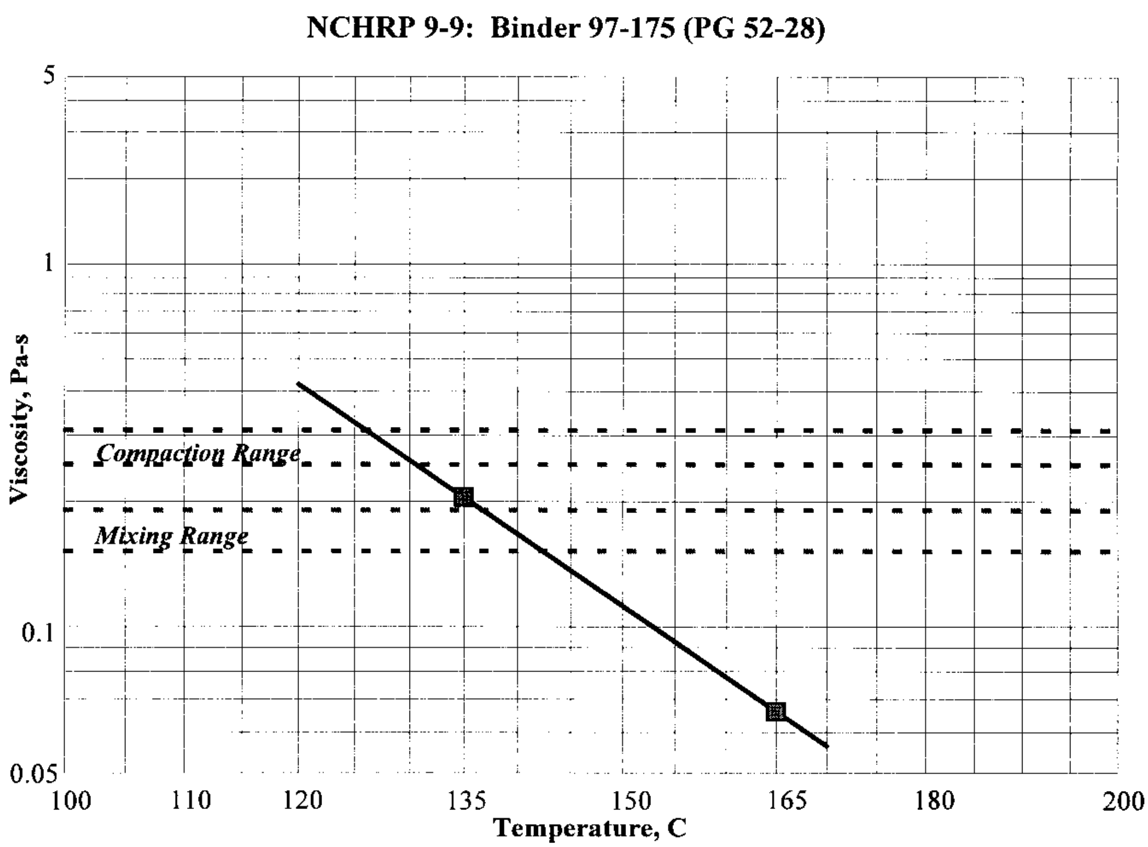
Binder	**97-033 (PG 64-22)**		
Temp	Viscosity (cp)	Mixing Temperature Range, C	153 - 159
135	**438**	Compaction Temperature Range, C	142 - 147
165	**121**		



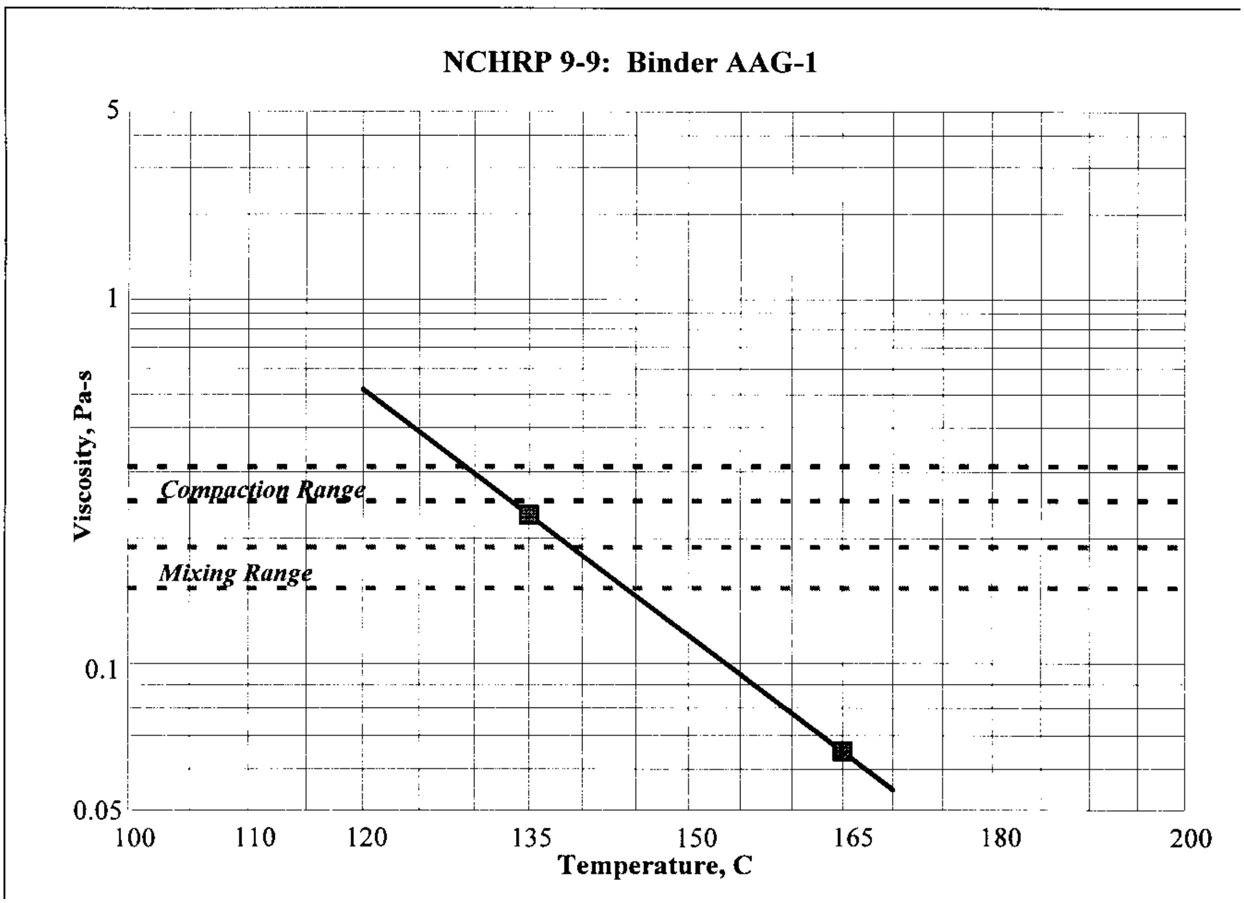
Binder	97-149 (PG 76-22)				
Temp	Viscosity (cp)	Mixing Temperature Range, C	204	-	212
135	**2475**	Compaction Temperature Range, C	187	-	194
165	**675**				



Binder	**97-175 (PG 52-28)**		
Temp	Viscosity (cp)	Mixing Temperature Range, C	137 - 142
135	**205**	Compaction Temperature Range, C	126 - 131
165	**66**		



Binder	**AAG-1**		
Temp	Viscosity (cp)	Mixing Temperature Range, C	139 - 144
135	**230**	Compaction Temperature Range, C	129 - 133
165	**65**		



NCHRP 9-9
APPENDIX D

Summary Information for Task 6B: Evaluation of the Effect of Mixture Depth on the Required Number of Superpave Gyratory Compactor Gyrations.

		Granite		Gravel		Limestone	
No. Gyr's	Log_{10}(Gyr.)	Gmb	%Gmm	Gmb	%Gmm	Gmb	%Gmm
30	1.477					2.386	93.4
30	1.477					2.367	92.7
30	1.477					2.43	95.1
60	1.778	2.397	94.5			2.48	97.1
60	1.778	2.395	94.4	2.317	94.6	2.449	95.9
60	1.778	2.432	95.9	2.327	95.1	2.463	96.4
90	1.954	2.446	96.4	2.334	95.3	2.474	96.9
90	1.954	2.419	95.3	2.343	95.7	2.506	98.1
90	1.954	2.453	96.7	2.327	95.1	2.517	98.6
120	2.079	2.454	96.7	2.349	96.0	2.516	98.5
120	2.079	2.431	95.8	2.354	96.2	2.52	98.7
120	2.079	2.457	96.8	2.352	96.1	2.494	97.7

Rice (Gmm)	
Granite	2.537
Gravel	2.448
Limestone	2.554

Summary Of Compaction Results

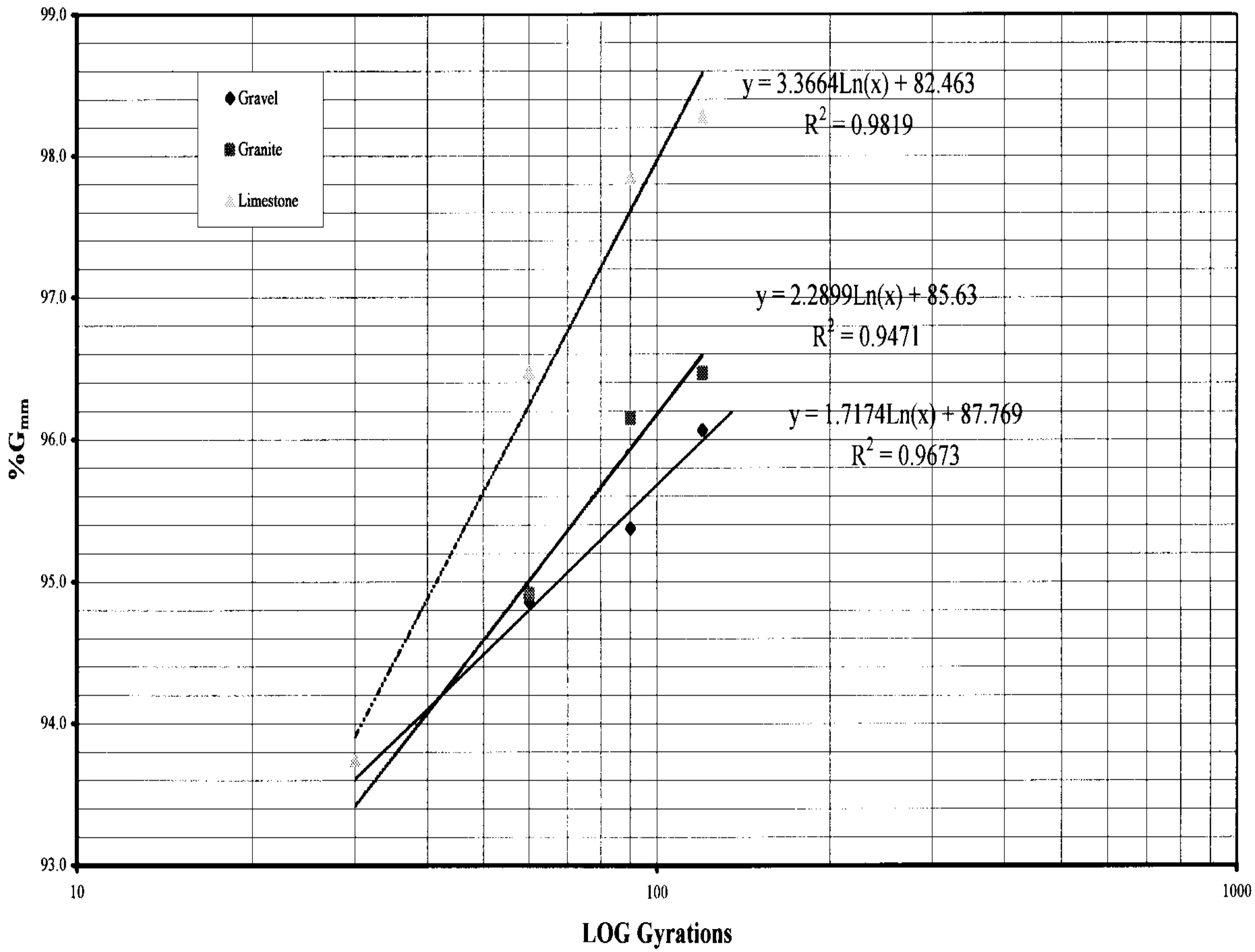
Gyrations	$\%G_{mm}$		
	Gravel	Granite	Limestone
30			93.7
60	94.9	94.9	96.5
90	95.4	96.2	97.8
120	96.1	96.5	98.3

Data Depicted in Chart N827 kPa

Compaction Curve Equation From Figure 6B.1

Agg.	Equation from N827kPa Chart	Gyrations Yeilding 96 % G_{mm}
Granite	INVLn((y-85.63)/2.2899)=	93
Gravel	INVLn((y-87.593)/1.7549)=	120
Limestone	INVLn((y-82.463)/3.3664)=	56

y = 96% G_{mm}



99.0
98.0
97.0
96.0
95.0
94.0
93.0
10
100
1000
%G_{mm}
LOG Gyrations
Gravel
Granite
Limestone
y = 3.3664Ln(x) + 82.463
R^2 = 0.9819
y = 2.2899Ln(x) + 85.63
R^2 = 0.9471
y = 1.7174Ln(x) + 87.769
R^2 = 0.9673

Gravel Compacted To 120 Gyrations[1] Using Different Pressure

	Gravel			
Pressure	Specimen 1	Specimen 2	Specimen 3	Average
828 kPa				
689 kPa	94.9	96.0		95.5
551 kPa	94.4	93.4		93.9
414 kPa	93.2	93.6		93.4

[1] Number of gyrations with 827 kPa to yield 4.0% air voids.

Granite Compacted To 96 Gyrations[2] Using Different Pressure

	Granite			
Pressure	Specimen 1	Specimen 2	Specimen 3	Average
828 kPa	97.0	96.3	97.1	96.8
689 kPa	96.9	94.3	96.7	96.0
551 kPa	94.8	95.0	93.9	94.6
414 kPa	93.2	93.7	93.5	93.5

[2] Number of gyrations with 827 kPa to yield 4.0% air voids.

Limestone Compacted To 56 Gyrations[3] With Different Pressure

	Limestone			
Pressure	Specimen 1	Specimen 2	Specimen 3	Average
828 kPa				
689 kPa	94.6	94.8	94.3	94.6
551 kPa	95.3	96.3	96.0	95.9
414 kPa	96.1	96.7	94.7	95.8

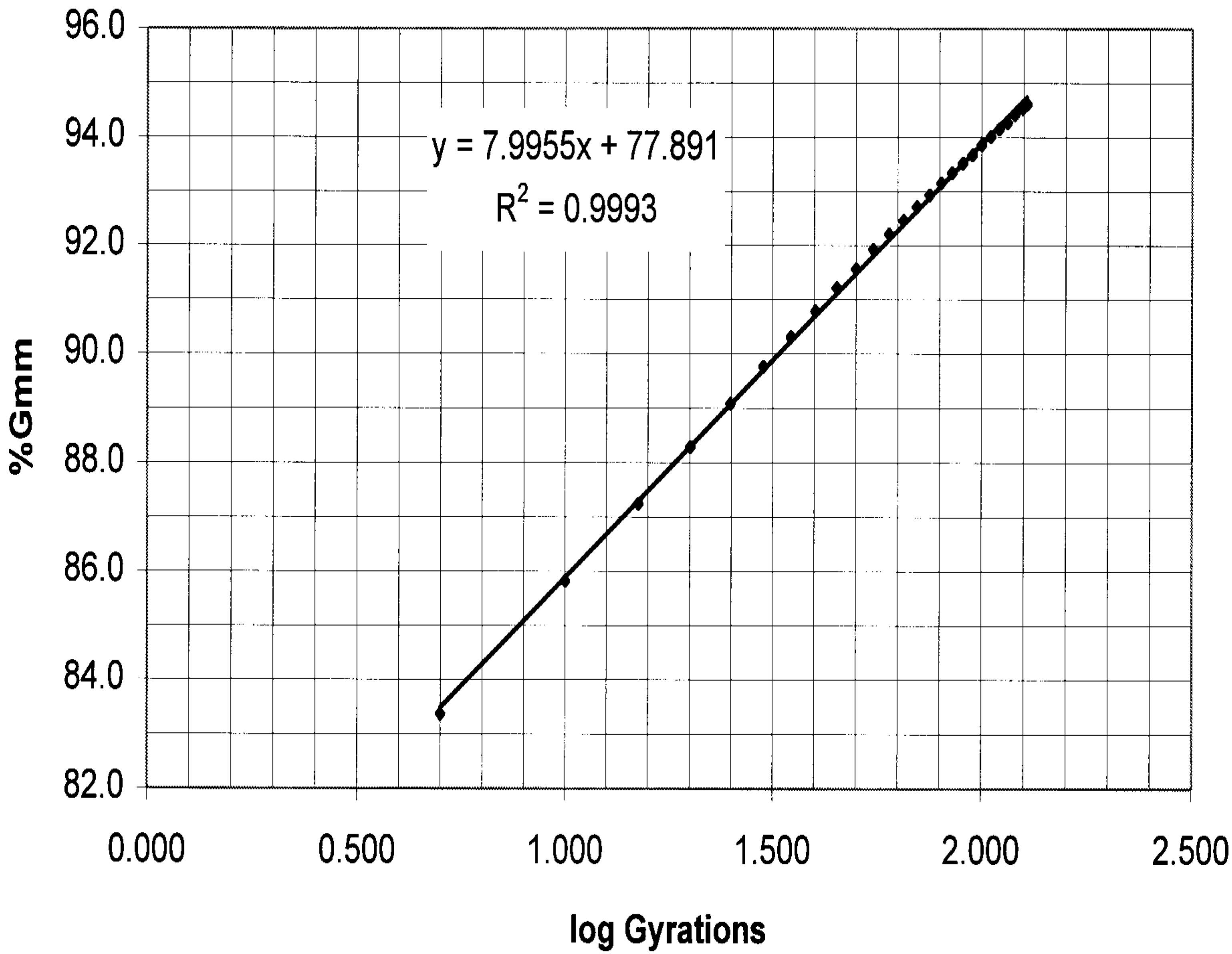
[3] Number of gyrations with 827 kPa to yield 4.0% air voids.

Gyr.	Spec 1 Height	Spec 2 Height	Spec 3 Height	Ave.	Calc. Bulk	Calc.%Gmm	log Gyrat.
5	141.7	141.7		141.7	2.041	83.4	0.699
10	137.6	137.7		137.7	2.101	85.8	1.000
15	135.3	135.5		135.4	2.136	87.2	1.176
20	133.7	133.9		133.8	2.161	88.3	1.301
25	132.5	132.7		132.6	2.181	89.1	1.398
30	131.5	131.7		131.6	2.197	89.8	1.477
35	130.7	130.9		130.8	2.211	90.3	1.544
40	130.0	130.2		130.1	2.223	90.8	1.602
45	129.4	129.6		129.5	2.233	91.2	1.653
50	128.9	129.1		129.0	2.241	91.6	1.699
55	128.4	128.6		128.5	2.250	91.9	1.740
60	128.0	128.2		128.1	2.257	92.2	1.778
65	127.6	127.9		127.8	2.263	92.5	1.813
70	127.3	127.5		127.4	2.270	92.7	1.845
75	127.0	127.2		127.1	2.275	92.9	1.875
80	126.7	126.9		126.8	2.280	93.2	1.903
85	126.4	126.7		126.6	2.285	93.3	1.929
90	126.2	126.4		126.3	2.289	93.5	1.954
95	126.0	126.2		126.1	2.293	93.7	1.978
100	125.7	126.0		125.9	2.298	93.9	2.000
105	125.5	125.8		125.7	2.301	94.0	2.021
110	125.3	125.6		125.5	2.305	94.2	2.041
115	125.2	125.4		125.3	2.308	94.3	2.061
120	125.0	125.2		125.1	2.311	94.4	2.079
125	124.8	125.1		125.0	2.314	94.5	2.097
128	124.7	125.0		124.9	2.316	94.6	2.107
				Gmb=	2.316	Data in Gravel Compaction Chart	

Rice	Gravel			
2.448	%Gmm at Changing Compaction Pressures			
	kPa	%Gmm	Formula From Gravel Compaction Chart	Est. Gyr.[1]
	827	96.1	$10^{((y-77.891)/7.9955)}$ =	189
	689	95.5	$10^{((y-77.891)/7.9955)}$ =	159
	551	93.9	$10^{((y-77.891)/7.9955)}$ =	101
	414	93.4	$10^{((y-77.891)/7.9955)}$ =	87

[1] Estimated gyrations using 600 kPa to match density at different pressure.

N_{827}=120

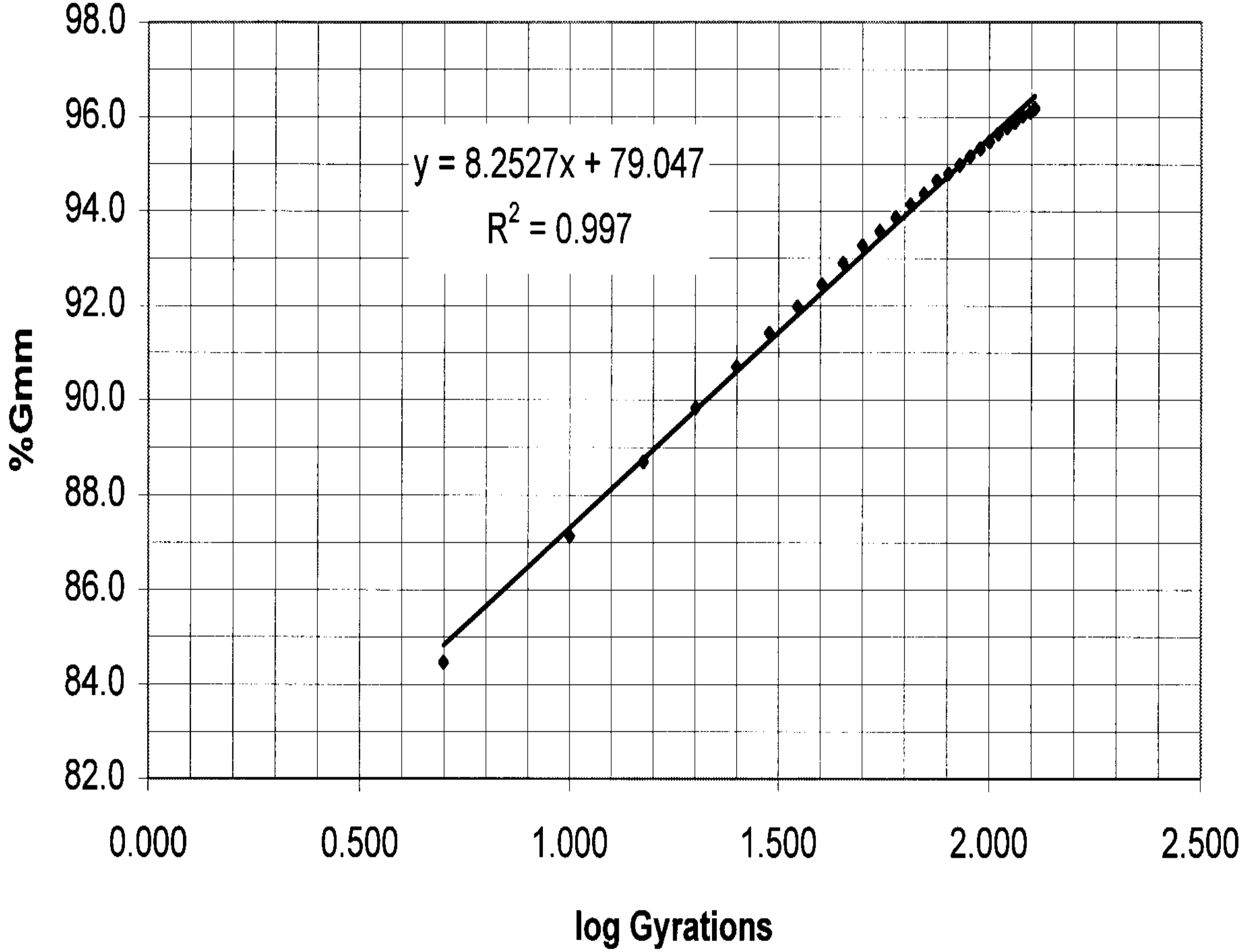

y = 7.9955x + 77.891
R2 = 0.9993
%Gmm
log Gyrations
96.0
94.0
92.0
90.0
88.0
86.0
84.0
82.0
0.000
0.500
1.000
1.500
2.000
2.500

Gyr.	Spec 1 Height	Spec 2 Height	Spec 3 Height	Ave.	Calc. Bulk	Calc.%Gmm	log Gyrat.
5	134.2	134.4	137.7	135.4	2.143	84.5	0.699
10	130.3	130.4	133.2	131.3	2.210	87.1	1.000
15	128.1	128.1	130.7	129.0	2.250	88.7	1.176
20	126.6	126.5	128.9	127.3	2.279	89.8	1.301
25	125.5	125.4	127.5	126.1	2.301	90.7	1.398
30	124.6	124.4	126.4	125.1	2.319	91.4	1.477
35	123.8	123.7	125.6	124.4	2.333	92.0	1.544
40	123.2	123.1	124.9	123.7	2.345	92.4	1.602
45	122.7	122.5	124.2	123.1	2.357	92.9	1.653
50	122.2	122.0	123.7	122.6	2.366	93.3	1.699
55	121.9	121.6	123.2	122.2	2.374	93.6	1.740
60	121.5	121.3	122.8	121.9	2.381	93.9	1.778
65	121.2	120.9	122.4	121.5	2.388	94.1	1.813
70	120.9	120.6	122.1	121.2	2.394	94.4	1.845
75	120.6	120.3	121.7	120.9	2.401	94.6	1.875
80	120.4	120.1	121.5	120.7	2.405	94.8	1.903
85	120.2	119.9	121.2	120.4	2.410	95.0	1.929
90	120.0	119.7	120.9	120.2	2.414	95.2	1.954
95	119.8	119.5	120.7	120.0	2.418	95.3	1.978
100	119.6	119.3	120.5	119.8	2.422	95.5	2.000
105	119.4	119.1	120.3	119.6	2.426	95.6	2.021
110	119.3	118.9	120.1	119.4	2.430	95.8	2.041
115	119.1	118.8	120.0	119.3	2.433	95.9	2.061
120	119.0	118.6	119.8	119.1	2.436	96.0	2.079
125	118.9	118.5	119.7	119.0	2.438	96.1	2.097
128	118.8	118.4	119.6	118.9	2.440	96.2	2.107
				Gmb=	2.440	Data in Granite Compaction Chart	

Rice	Granite			
2.537	%G_{mm} at Changing Compaction Pressures			
	kPa	%Gmm	Formula From Granite Compaction Chart	Est. Gyr.[1]
	827	96.8	$10^{((y-79.047)/0.2527)}$ =	142
	689	96.5	$10^{((y-79.047)/0.2527)}$ =	130
	551	95.9	$10^{((y-79.047)/0.2527)}$ =	110
	414	94.6	$10^{((y-79.047)/0.2527)}$ =	77

[1] Estimated gyrations using 600 kPa to match density at different pressure.

N_{827}=96



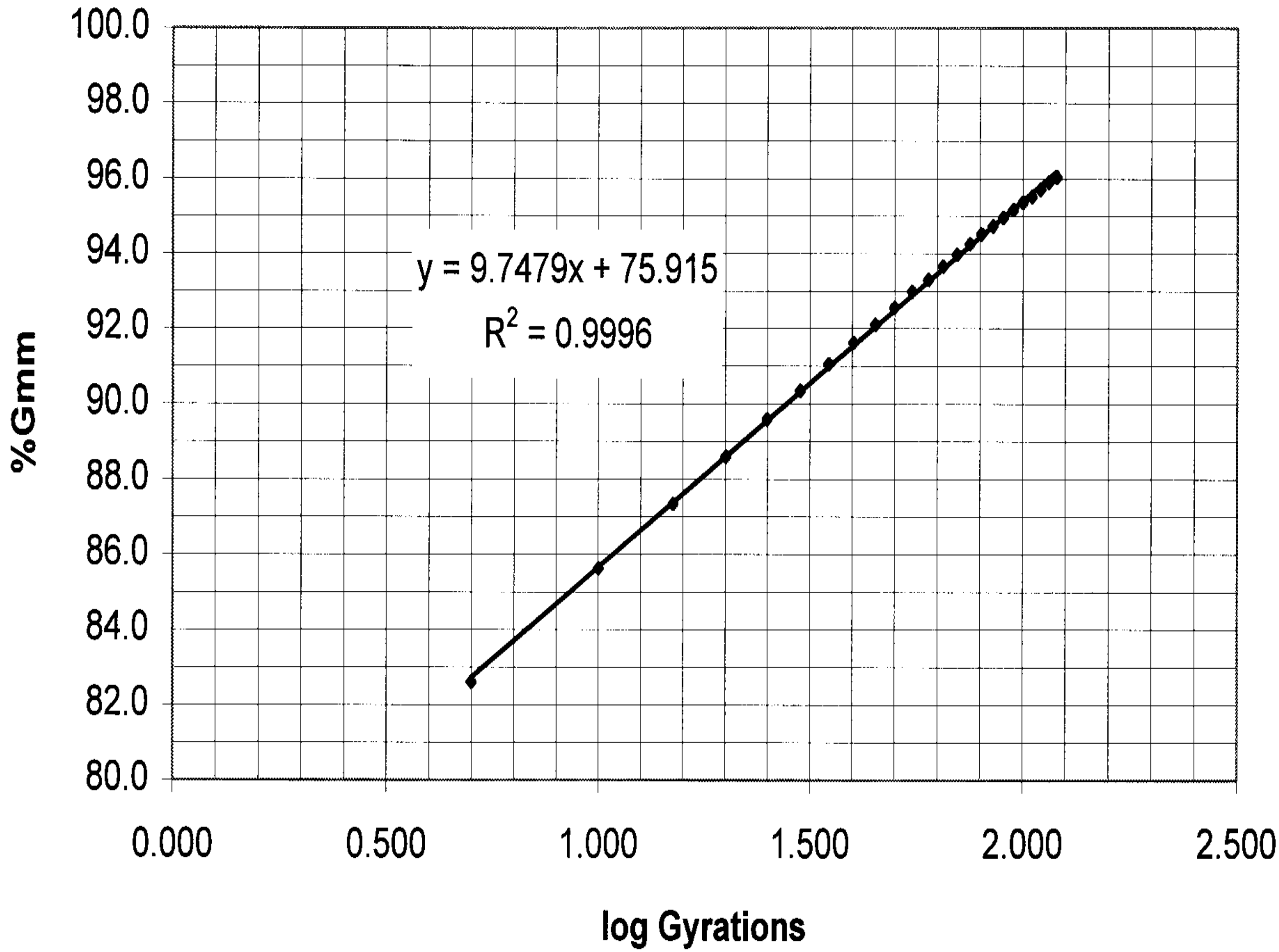
y = 8.2527x + 79.047
R^2 = 0.997
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
82.0
%Gmm
0.000
0.500
1.000
1.500
2.000
2.500
log Gyrations

Gyr.	Spec 1 Height	Spec 2 Height	Spec 3 Height	Ave.	Calc. Bulk	Calc.%Gmm	log Gyrat.
5	134.4	138.1	138.6	137.0	2.110	82.6	0.699
10	129.0	133.5	134.1	132.2	2.187	85.6	1.000
15	126.6	130.8	131.4	129.6	2.231	87.3	1.176
20	125.0	128.8	129.5	127.8	2.263	88.6	1.301
25	123.7	127.3	128.1	126.4	2.288	89.6	1.398
30	122.7	126.2	127.0	125.3	2.307	90.3	1.477
35	121.8	125.2	126.0	124.3	2.325	91.0	1.544
40	121.1	124.4	125.2	123.6	2.340	91.6	1.602
45	120.5	123.7	124.5	122.9	2.352	92.1	1.653
50	119.9	123.1	123.9	122.3	2.364	92.6	1.699
55	119.4	122.5	123.3	121.7	2.375	93.0	1.740
60	119.0	122.1	122.9	121.3	2.383	93.3	1.778
65	118.6	121.6	122.4	120.9	2.392	93.7	1.813
70	118.2	121.2	122.0	120.5	2.400	94.0	1.845
75	117.8	120.9	121.6	120.1	2.407	94.2	1.875
80	117.5	120.5	121.3	119.8	2.414	94.5	1.903
85	117.3	120.2	121.0	119.5	2.419	94.7	1.929
90	117.0	119.9	120.7	119.2	2.425	95.0	1.954
95	116.7	119.7	120.4	118.9	2.431	95.2	1.978
100	116.5	119.4	120.2	118.7	2.436	95.4	2.000
105	116.3	119.2	120.0	118.5	2.440	95.5	2.021
110	116.1	119.0	119.7	118.3	2.444	95.7	2.041
115	115.9	118.7	119.5	118.0	2.449	95.9	2.061
120	115.7	118.6	119.3	117.9	2.453	96.0	2.079
125	115.5	118.4	119.1	117.7	2.457	96.2	2.097
128	115.4	118.3	119.0	117.6	2.459	96.3	2.107
				Gmb=	2.459	Limestone Compaction Chart	

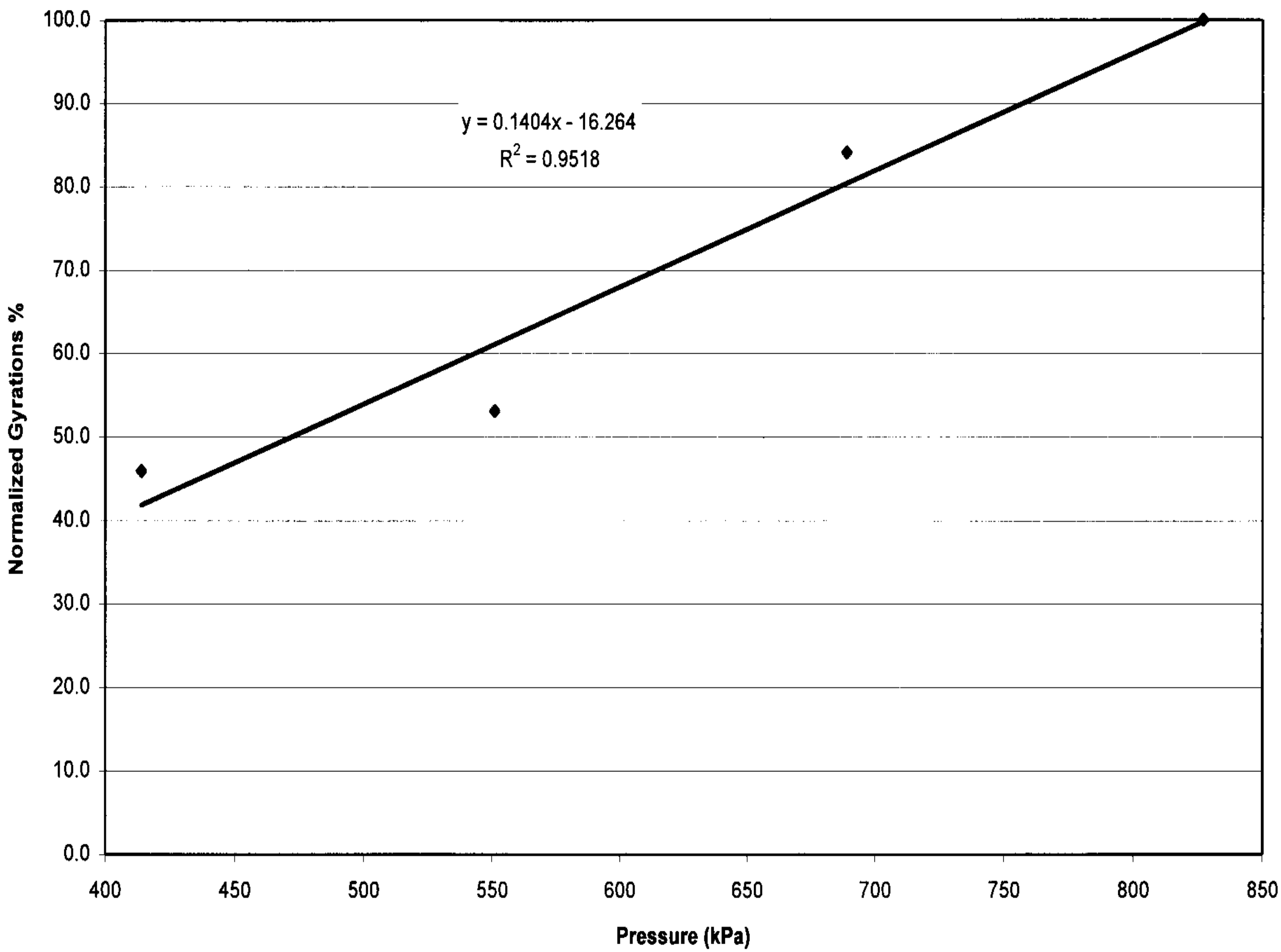
Rice	AL Limestone			
2.554	$\%G_{mm}$ at Changing Compaction Pressures			
	kPa	%Gmm	Formula From Limestone Compaction Ch a	Est. Gyr.[1]
	827	96.8	$10^{((y-75.92)/9.7479)}$ =	139
	689	96	$10^{((y-75.92)/9.7479)}$ =	115
	551	94.6	$10^{((y-75.92)/9.7479)}$ =	83
	414	93.4	$10^{((y-75.92)/9.7479)}$ =	62

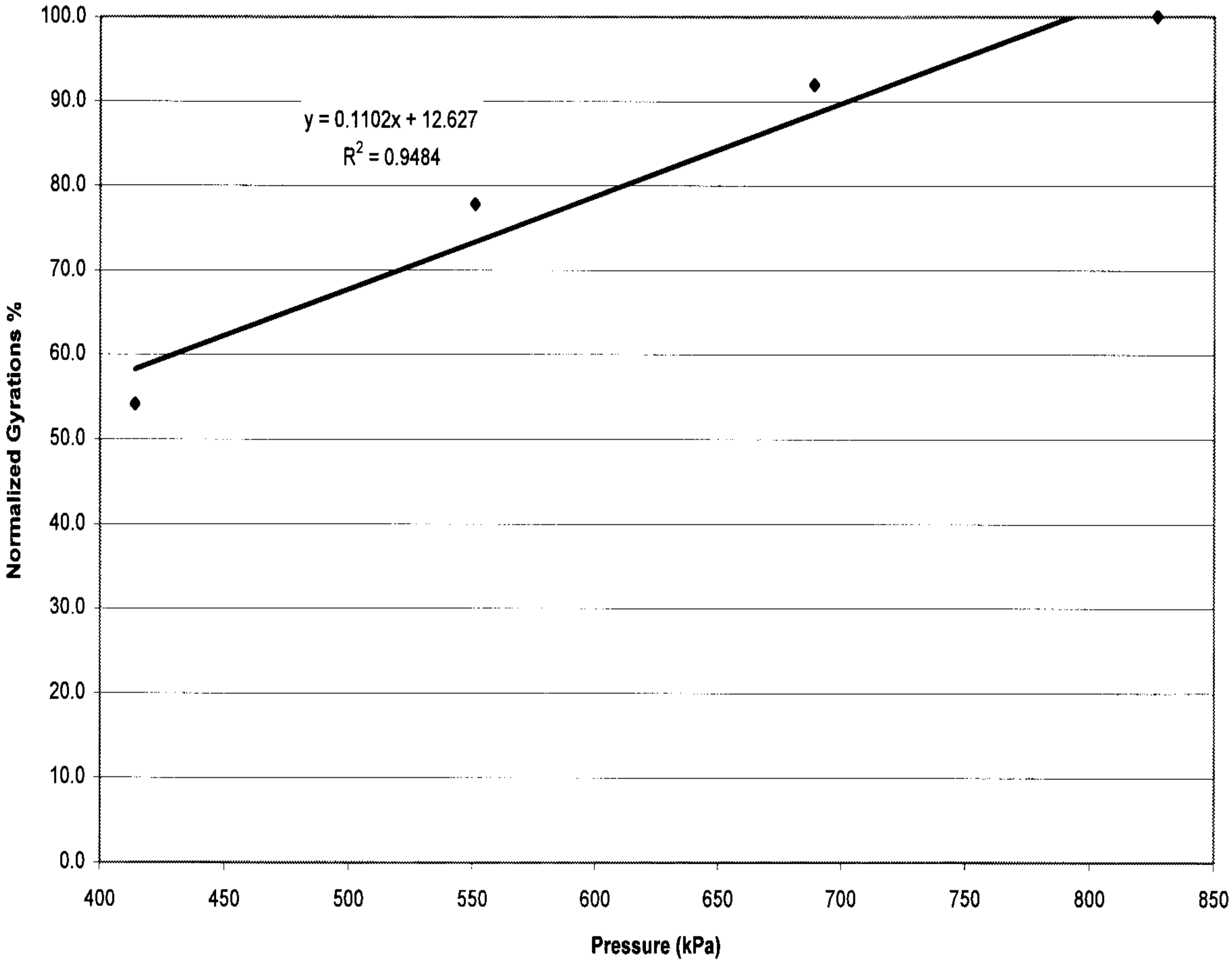
[1] Estimated gyrations using 600 kPa to match density at different pressure.

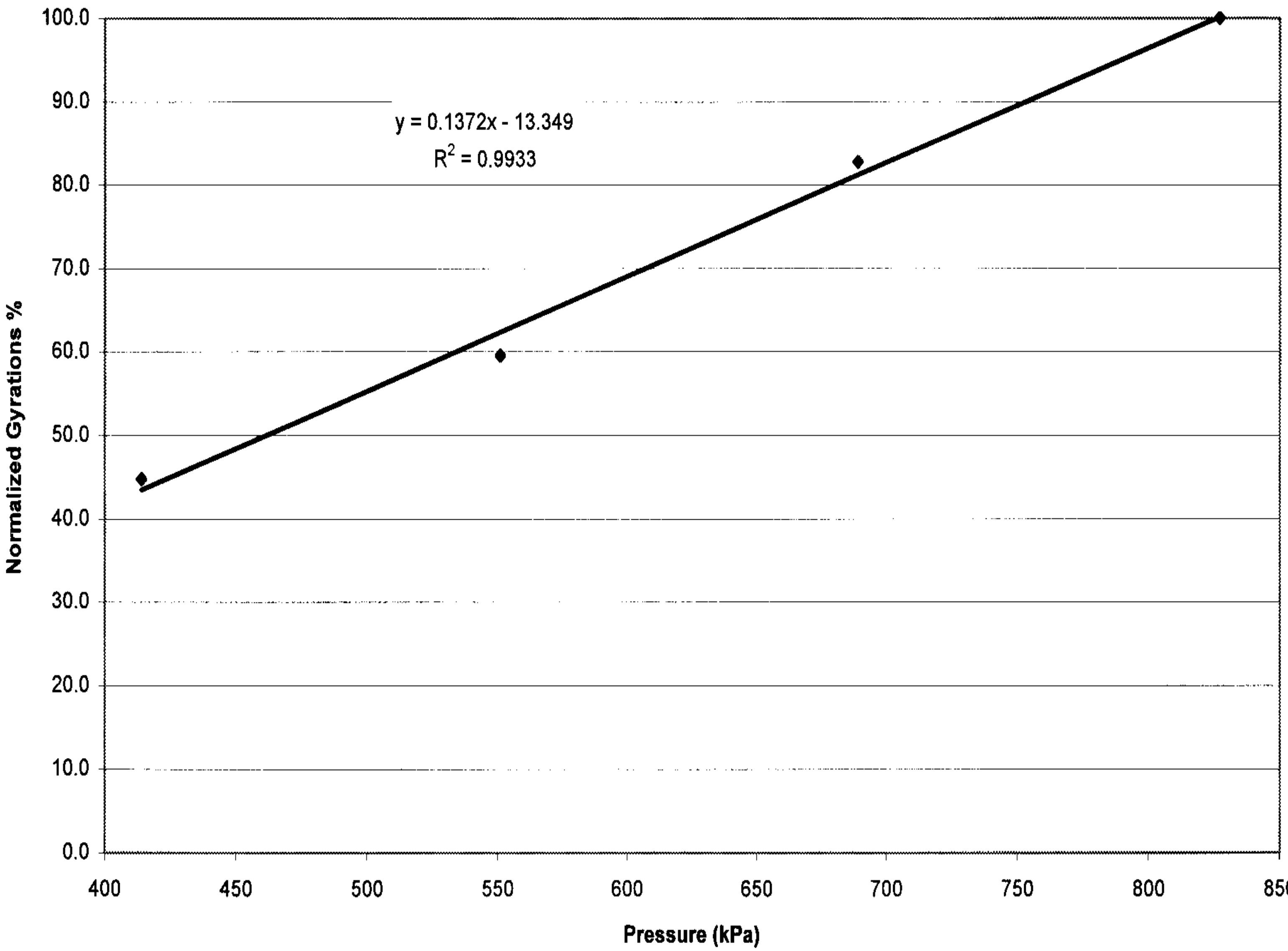
N_{827}=56


y = 9.7479x + 75.915
R^2 = 0.9996
%Gmm
100.0
98.0
96.0
94.0
92.0
90.0
88.0
86.0
84.0
82.0
80.0
0.000
0.500
1.000
1.500
2.000
2.500
log Gyrations

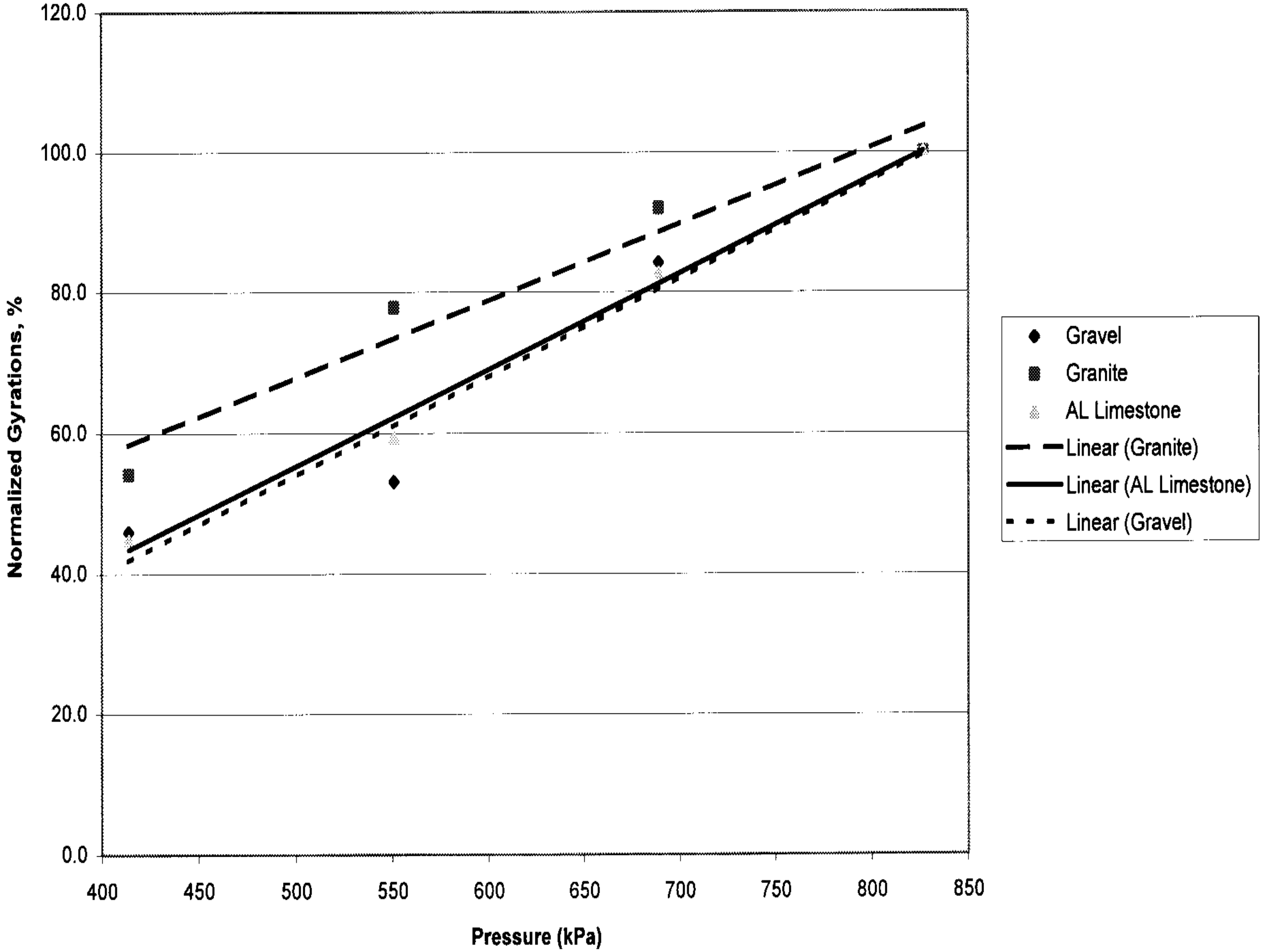
kPa	X GYR.		Est. Gyr.@689kPa	% Gyr.		%Gmm
Gravel						
827	120	or	189	100.0	=	96.1
689	120	or	159	84.1	=	95.5
551	120	or	101	53.1	=	93.9
414	120	or	87	46.0	=	93.4
Granite						
827	96	or	142	100.0	=	96.8
689	96	or	130	92.0	=	96.5
551	96	or	110	77.8	=	95.9
414	96	or	77	54.1	=	94.6
AL Limestone						
827	56	or	139	100.0	=	96.8
689	56	or	115	82.8	=	96.0
551	56	or	83	59.5	=	94.6
414	56	or	62	44.8	=	93.4
Average						
827				100		
689				86		
551				63		
414				48		

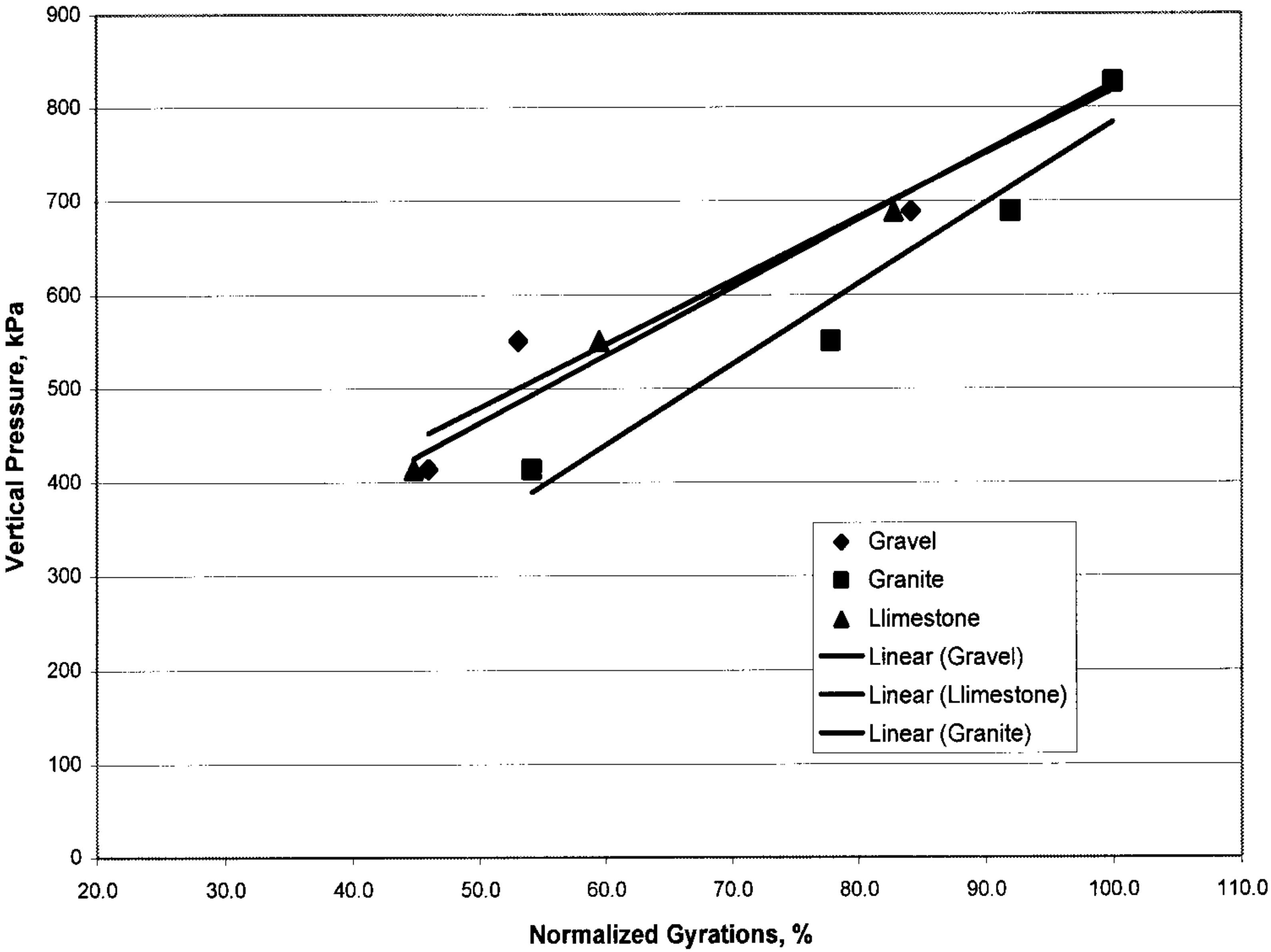

y = 0.1404x - 16.264
R2 = 0.9518
Normalized Gyrations %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
400
450
500
550
600
650
700
750
800
850
Pressure (kPa)

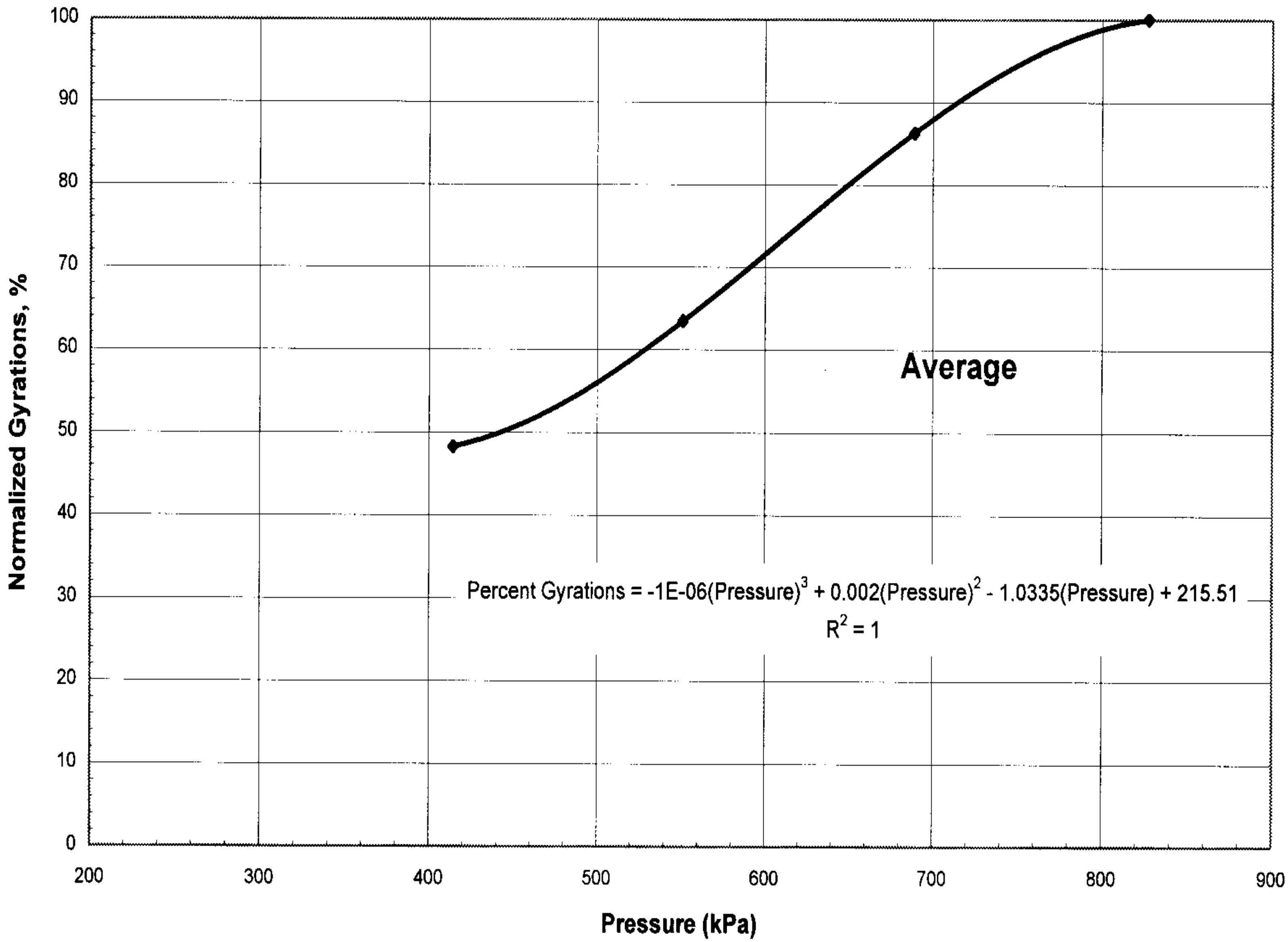

y = 0.1102x + 12.627
R2 = 0.9484
Normalized Gyrations %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
400
450
500
550
600
650
700
750
800
850
Pressure (kPa)

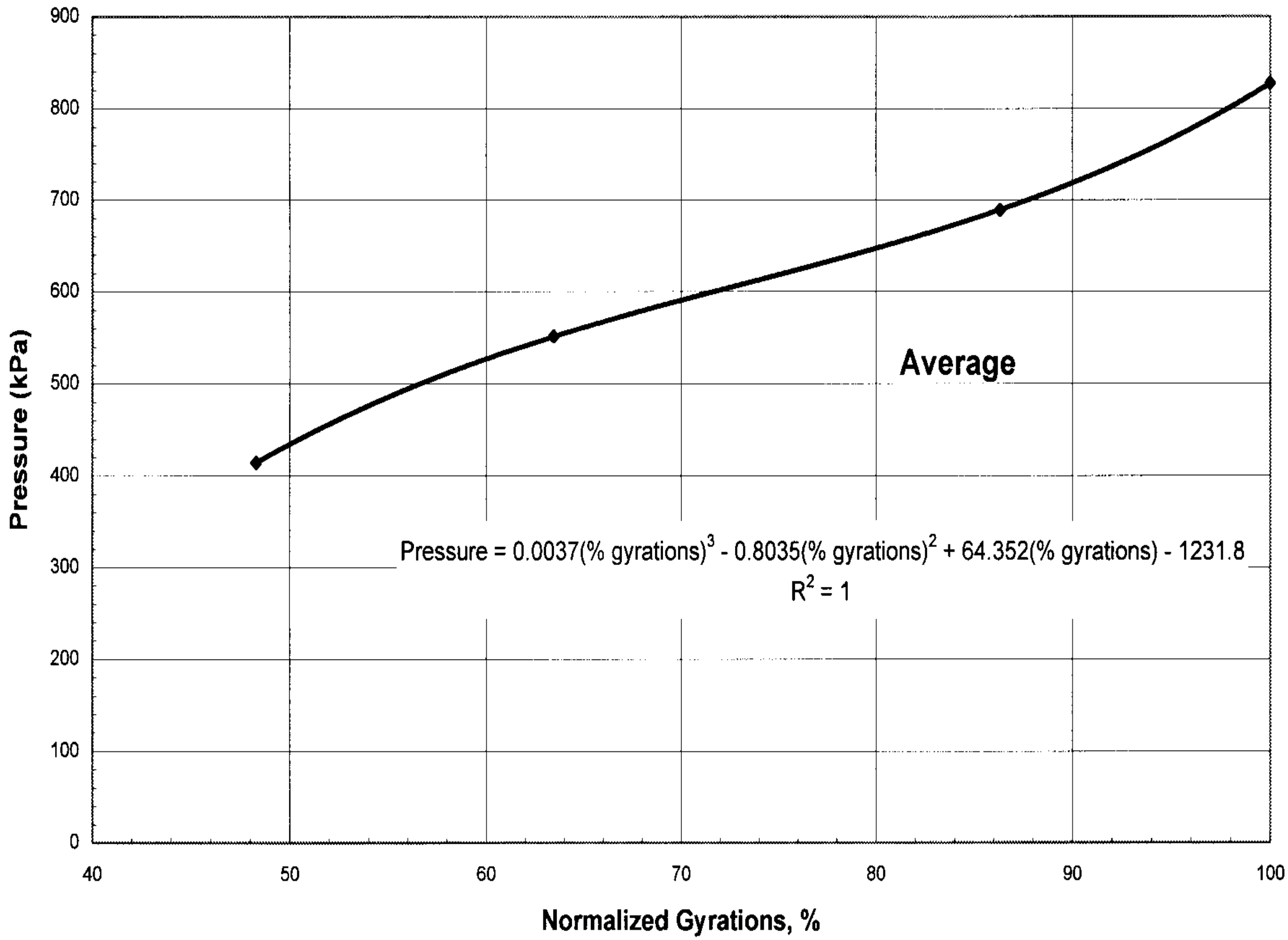


y = 0.1372x - 13.349
R^2 = 0.9933
Normalized Gyrations %
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
400
450
500
550
600
650
700
750
800
850
Pressure (kPa)

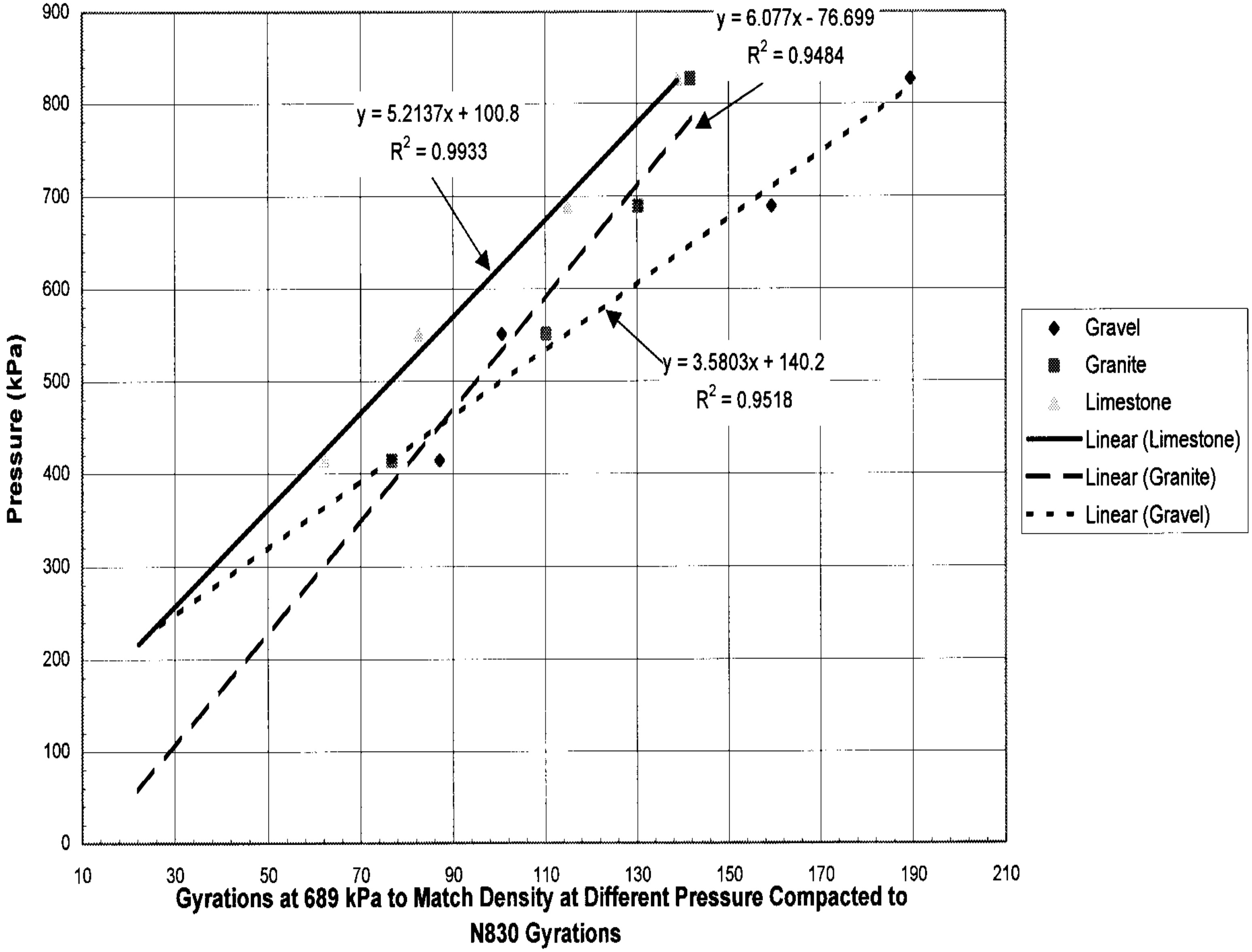

Normalized Gyrations, %
120.0
100.0
80.0
60.0
40.0
20.0
0.0
400
450
500
550
600
650
700
750
800
850
Pressure (kPa)
Gravel
Granite
AL Limestone
Linear (Granite)
Linear (AL Limestone)
Linear (Gravel)


Vertical Pressure, kPa
900
800
700
600
500
400
300
200
100
0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
110.0
Normalized Gyrations, %
Gravel
Granite
Llimestone
Linear (Gravel)
Linear (Llimestone)
Linear (Granite)

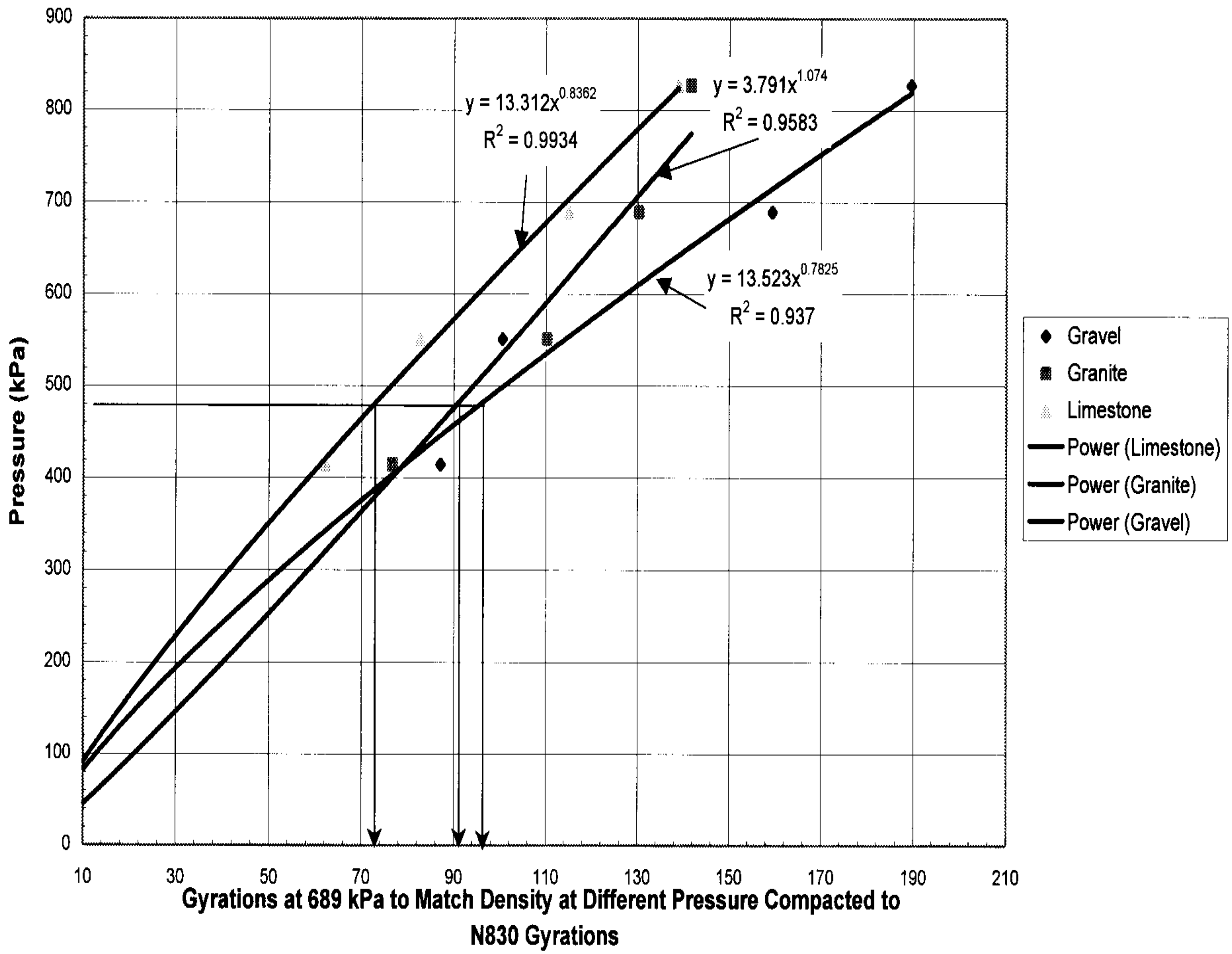

Normalized Gyrations, %
Pressure (kPa)
Average
Percent Gyrations = -1E-06(Pressure)^3 + 0.002(Pressure)^2 - 1.0335(Pressure) + 215.51
R^2 = 1
0
10
20
30
40
50
60
70
80
90
100
200
300
400
500
600
700
800
900



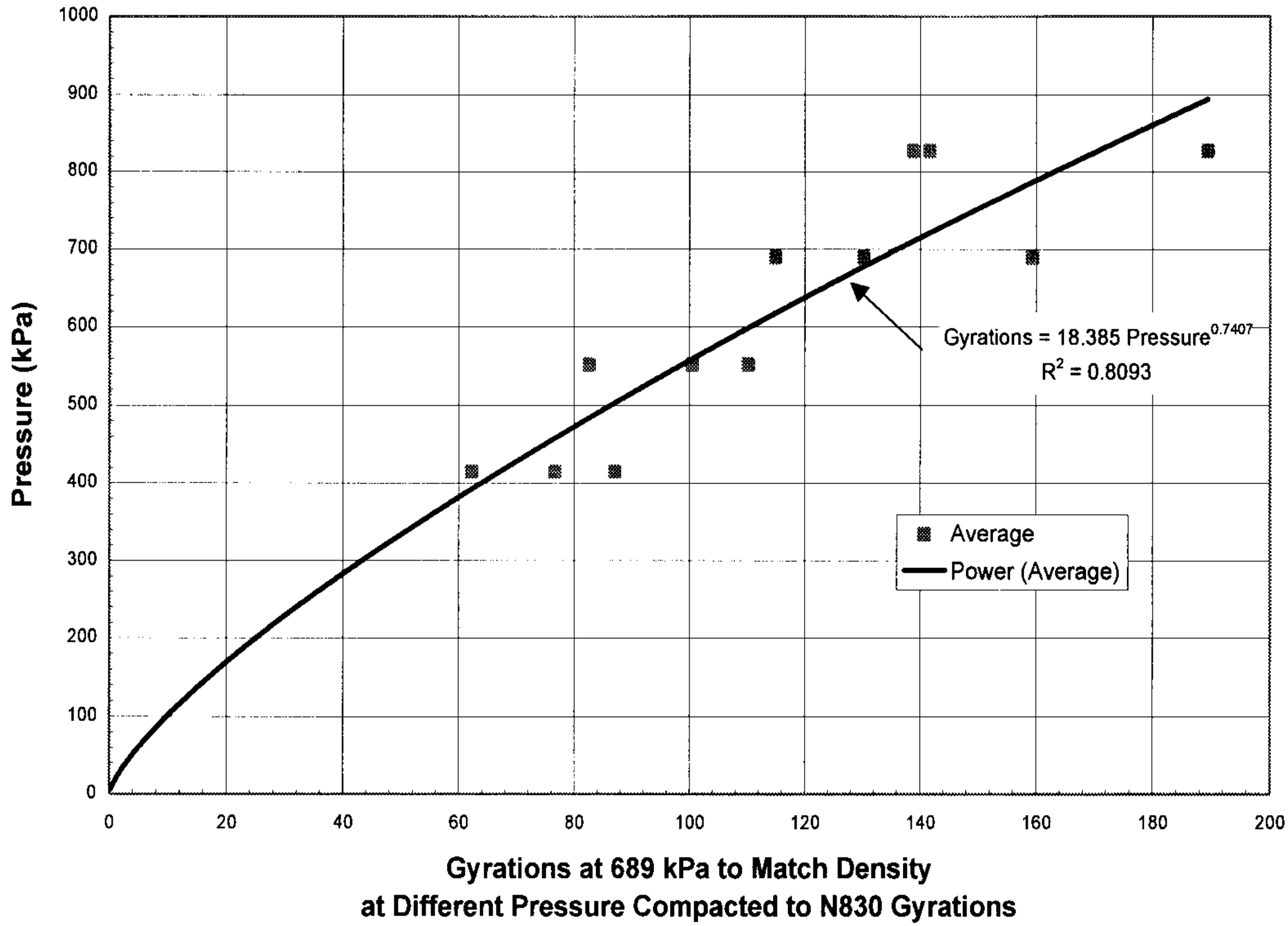
Average
Pressure = 0.0037(% gyrations)^3 - 0.8035(% gyrations)^2 + 64.352(% gyrations) - 1231.8
R^2 = 1
Pressure (kPa)
Normalized Gyrations, %
0
100
200
300
400
500
600
700
800
900
40
50
60
70
80
90
100



y = 6.077x - 76.699
R2 = 0.9484
y = 5.2137x + 100.8
R2 = 0.9933
y = 3.5803x + 140.2
R2 = 0.9518
Pressure (kPa)
0
100
200
300
400
500
600
700
800
900
10
30
50
70
90
110
130
150
170
190
210
Gyrations at 689 kPa to Match Density at Different Pressure Compacted to N830 Gyrations
Gravel
Granite
Limestone
Linear (Limestone)
Linear (Granite)
Linear (Gravel)



Pressure (kPa)
0
100
200
300
400
500
600
700
800
900
10
30
50
70
90
110
130
150
170
190
210
Gyrations at 689 kPa to Match Density at Different Pressure Compacted to N830 Gyrations
y = 13.312x^0.8362
R^2 = 0.9934
y = 3.791x^1.074
R^2 = 0.9583
y = 13.523x^0.7825
R^2 = 0.937
Gravel
Granite
Limestone
Power (Limestone)
Power (Granite)
Power (Gravel)



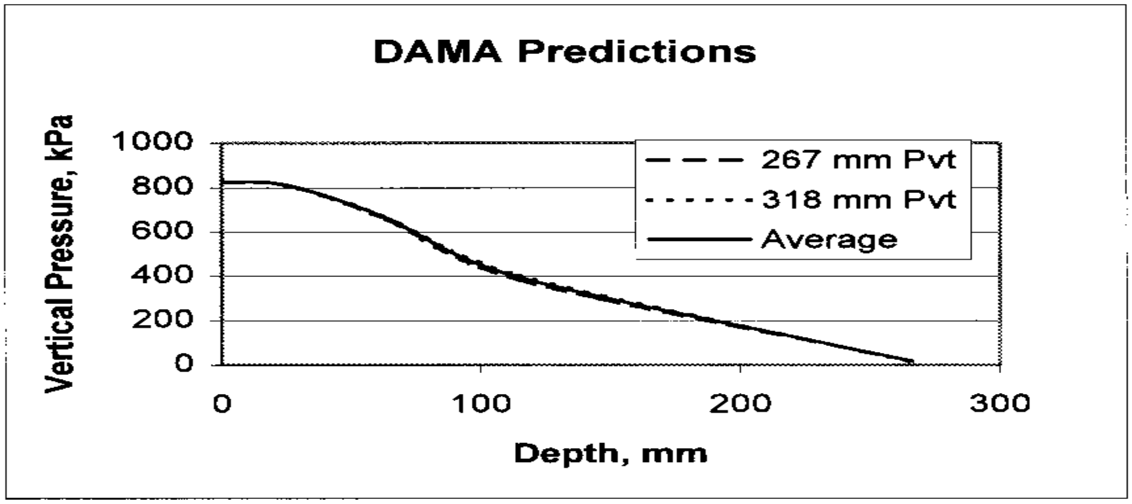
Pressure (kPa)
1000
900
800
700
600
500
400
300
200
100
0
0
20
40
60
80
100
120
140
160
180
200
Gyrations = 18.385 Pressure^0.7407
R^2 = 0.8093
Average
Power (Average)
Gyrations at 689 kPa to Match Density
at Different Pressure Compacted to N830 Gyrations

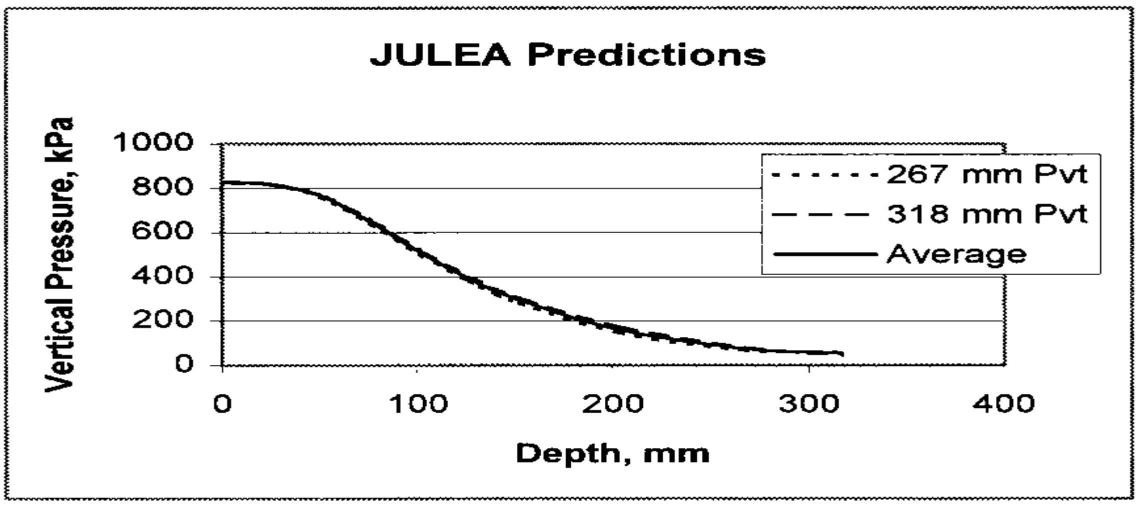
Vertical Stress Prediction From DAMA

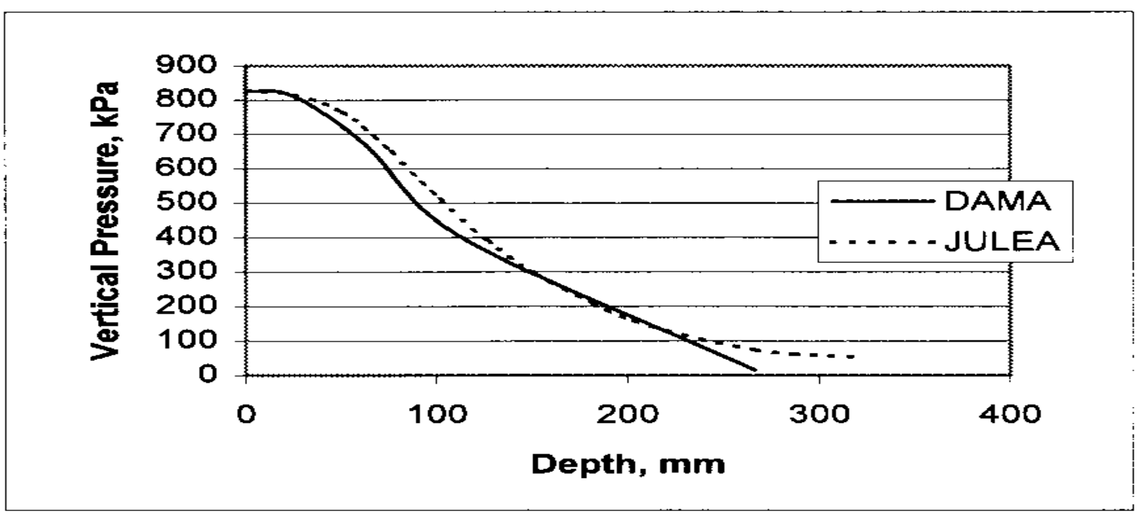
Depth, mm	267 mm Pvt	318 mm Pvt	Average
0	827	827	827
25	810	812	811
64	660	667	663
114	386	407	396
267	16	12	14

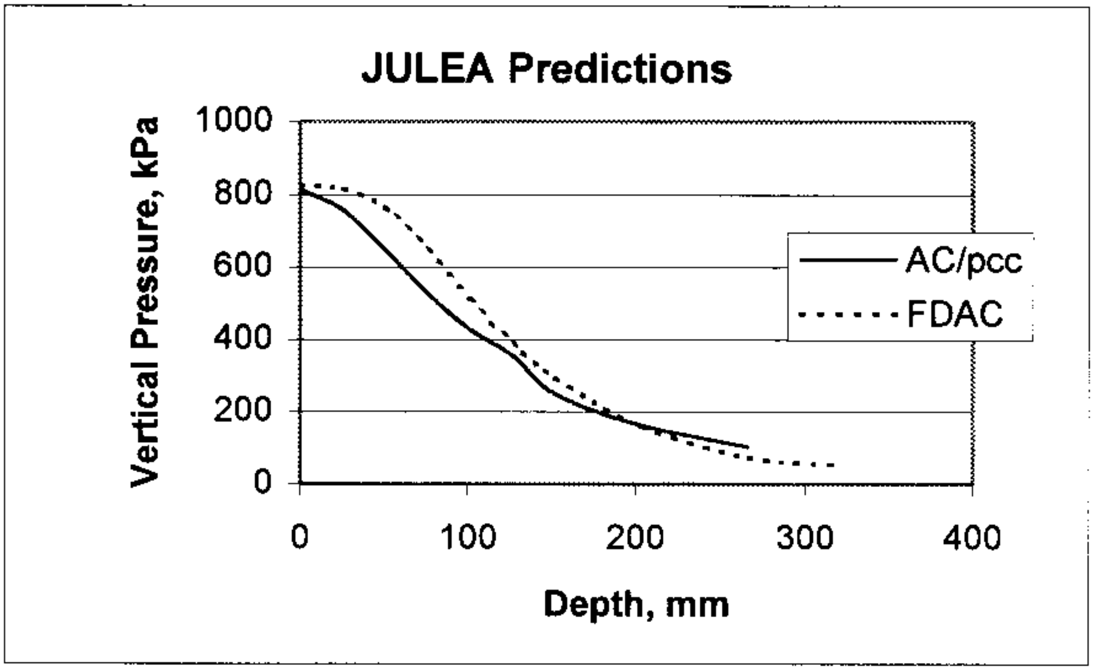
Vertical Stress Prediction From JULEA

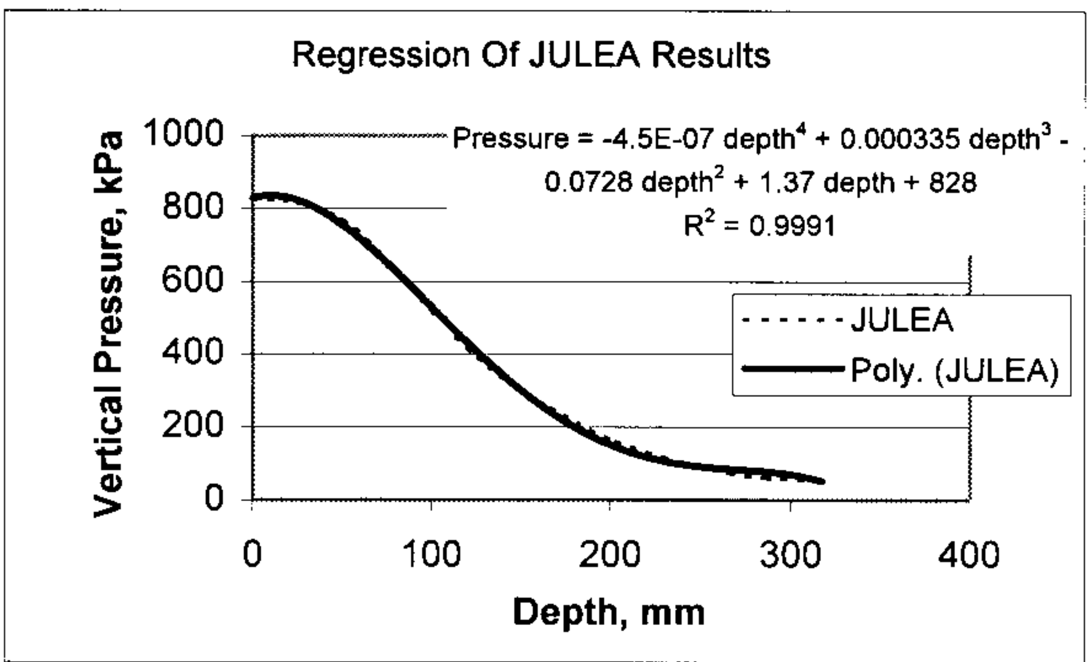
Depth, mm	267 mm Pvt	318 mm Pvt	Average	AC/ Pcc
0	827	827	827	815
25	816	818	817	758
51	761	768	764	647
76	642	655	649	526
102	503	519	511	427
127	380	399	390	353
152	282	304	293	248
203	147	173	160	162
267	69	80	74	102.661
318	59	48	54	


DAMA Predictions
Vertical Pressure, kPa
1000
800
600
400
200
0
0
100
200
300
Depth, mm
267 mm Pvt
318 mm Pvt
Average


JULEA Predictions
Vertical Pressure, kPa
1000
800
600
400
200
0
0
100
200
300
400
Depth, mm
267 mm Pvt
318 mm Pvt
Average


Vertical Pressure, kPa
900
800
700
600
500
400
300
200
100
0
0
100
200
300
400
Depth, mm
DAMA
JULEA


JULEA Predictions
Vertical Pressure, kPa
1000
800
600
400
200
0
0
100
200
300
400
Depth, mm
AC/pcc
FDAC


Regression Of JULEA Results
Pressure = -4.5E-07 depth^4 + 0.000335 depth^3 -
0.0728 depth^2 + 1.37 depth + 828
R^2 = 0.9991
Vertical Pressure, kPa
1000
800
600
400
200
0
0
100
200
300
400
Depth, mm
JULEA
Poly. (JULEA)

```
DDDDDDDD        AAAAA        MMM      MMM        AAAAA
DDDDDDDDD      AAAAAAA       MMMM    MMMM       AAAAAAA
DD     DDD    AAA   AAA      MMMMM MMMMM       AAA   AAA
DD      DDD  AAA     AAA     MM MMMMM MM      AAA     AAA
DD       DD  AAA     AAA     MM  MMM  MM      AA       AA
DD       DD  AA       AA     MM       MM      AA       AA
DD       DD  AAAAAAAAAAA     MM       MM      AAAAAAAAAAA
DD      DDD  AAAAAAAAAAA     MM       MM      AAAAAAAAAAA
DD     DDD   AA       AA     MM       MM      AA       AA
DDDDDDDDD    AA       AA     MM       MM      AA       AA
DDDDDDDD     AA       AA     MM       MM      AA       AA
```

THIS PROGRAM WAS DEVELOPED FOR THE ASPHALT INSTITUTE
BY PROF. M. W. WITCZAK AND DAEKYOO HWANG.

UPDATED BY R. W. MAY - LATEST REVISION: APRIL 1993

PLEASE DIRECT ALL INQUIRIES TO :

ASPHALT INSTITUTE
RESEARCH PARK DRIVE
P. O. BOX 14052
LEXINGTON, KENTUCKY 40512-4052

TELEPHONE :(606) 288-4960

DAMA USES THE CHEVRON N-LAYER PROGRAM AS THE
ANALYTICAL STRESS-STRAIN-DISPLACEMENT MODEL.

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***************************************************
*                                                 *
* ALL REASONABLE CARE HAS BEEN TAKEN IN THE       *
* PREPARATION OF THIS COMPUTER PROGRAM, DAMA,     *
* AND THE REPORT RR 82-2; HOWEVER, THE ASPHALT    *
* INSTITUTE CAN ACCEPT NO RESPONSIBILITY FOR      *
* THE CONSEQUENCES OF ANY INACCURACIES WHICH THEY *
* MAY CONTAIN, NOR THEIR SUITABILITY OR UTILITY   *
* FOR USE IN ANY SPECIFIC SET OF CIRCUMSTANCES.   *
*                                                 *
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***** NOTE *****

THE COMPUTER PROGRAM, DAMA, WAS WRITTEN FOR USE
WITH U.S. CUSTOMARY UNITS OF MEASUREMENTS, UNLESS
OTHERWISE STATED FOR A SPECIFIC INPUT VARIABLE.

Task 6B

LAYER AND MATERIAL PROPERTIES

LAYER NUMBER	MATERIAL TYPE	POISSON'S RATIO	THICKNESS (in.)	THICKNESS (mm)
1	ASPH. CONC.	.35	1.00	25.40
2	ASPH. CONC.	.35	1.50	38.10
3	ASPH. CONC.	.35	2.00	50.80
4	ASPH. CONC.	.35	8.00	203.20
5	SUBGR. SOIL	.45		

CURING CONDITIONS

LAYER NUMBER	MATERIAL TYPE	CURE TIME (MONTHS)	MONTH OPENED TO TRAFFIC	MONTHS CURED BEFORE OPENING
1	ASPH. CONC.	.0	JUNE	0
2	ASPH. CONC.	.0	JUNE	0
3	ASPH. CONC.	.0	JUNE	0
4	ASPH. CONC.	.0	JUNE	0

TRAFFIC CONDITION

NUMBER OF REPETITIONS PER MONTH 500

ENVIRONMENTAL CONDITIONS

JAN.	FEB.	MAR.	APR	MAY	JUNE	JULY	AUG.	SEPT	OCT.	NOV.	DEC.
(MEAN MONTHLY AIR TEMPERATURES, DEG. F)											
45.0	38.0	43.0	45.0	56.0	70.0	78.0	81.0	78.0	73.0	58.0	54.0
(MEAN MONTHLY AIR TEMPERATURES, DEG. C)											
7.2	3.3	6.1	7.2	13.3	21.1	25.6	27.2	25.6	22.8	14.4	12.2

LOAD CONFIGURATION AND COMPUTATIONAL POINTS

LOAD PER TIRE = 4500. lbs (20. kN)
CONTACT PRESSURE = 120.00 psi (827.40 kPa)
RADIUS OF LOAD = 3.45 in. (88. mm)
LOAD SPACING = 13.50 in. (343. mm)

COMPUTATIONAL POINT 1 X = 0.0 in. (0.0 mm) (CENTER OF ONE TIRE)
COMPUTATIONAL POINT 2 X = 3.45in. (88.mm) (EDGE OF ONE TIRE)
COMPUTATIONAL POINT 3 X = 6.75in. (171.mm) (MIDPOINT OF TWO TIRES)

MODULI CONDITIONS

ASPHALT STABILIZED LAYER

LAYER NUMBER	MATERIAL TYPE	POINT NUMBER	TEMP. (F)	TEMP. (C)	MODULUS EI (psi)	MODULUS EI (MPa)	MODULUS EF (psi)	MODULUS EF (MPa)
1	ASPH. CONC.							
		1	40.0	4.4	1631265.	11248.		
		2	50.0	10.0	1221738.	8424.		
		3	60.0	15.6	870171.	6000.		
		4	70.0	21.1	590470.	4071.		
		5	75.0	23.9	477874.	3295.		
		6	80.0	26.7	382300.	2636.		
		7	85.0	29.4	302368.	2085.		
		8	90.0	32.2	236466.	1630.		
		9	95.0	35.0	182876.	1261.		
		10	100.0	37.8	139880.	964.		
		11	110.0	43.3	79210.	546.		
		12	120.0	48.9	42973.	296.		

MODULUS PARAMETERS:Vis70F(21C)= 3.120 %Pass200= 5.0 Freq(Hz)=10.0
%AirVoids= 8.0 %VolEffAsph=11.0

ASPHALT STABILIZED LAYER

LAYER NUMBER	MATERIAL TYPE	POINT NUMBER	TEMP. (F)	TEMP. (C)	MODULUS EI (psi)	MODULUS EI (MPa)	MODULUS EF (psi)	MODULUS EF (MPa)
2	ASPH. CONC.							
		1	40.0	4.4	1676325.	11558.		
		2	50.0	10.0	1272491.	8774.		
		3	60.0	15.6	920745.	6349.		
		4	70.0	21.1	636165.	4386.		
		5	75.0	23.9	519950.	3585.		
		6	80.0	26.7	420303.	2898.		
		7	85.0	29.4	336074.	2317.		
		8	90.0	32.2	265849.	1833.		
		9	95.0	35.0	208075.	1435.		
		10	100.0	37.8	161152.	1111.		
		11	110.0	43.3	93702.	646.		
		12	120.0	48.9	52303.	361.		

MODULUS PARAMETERS:Vis70F(21C)= 3.120 %Pass200= 5.0 Freq(Hz)=10.0
%AirVoids= 8.0 %VolEffAsph=10.0

ASPHALT STABILIZED LAYER

LAYER NUMBER	MATERIAL TYPE	POINT NUMBER	TEMP. (F)	TEMP. (C)	MODULUS EI (psi)	MODULUS EI (MPa)	MODULUS EF (psi)	MODULUS EF (MPa)
3	ASPH. CONC.							
		1	40.0	4.4	1725045.	11894.		
		2	50.0	10.0	1328126.	9157.		
		3	60.0	15.6	977091.	6737.		
		4	70.0	21.1	688027.	4744.		
		5	75.0	23.9	568189.	3918.		
		6	80.0	26.7	464339.	3202.		
		7	85.0	29.4	375571.	2590.		
		8	90.0	32.2	300688.	2073.		
		9	95.0	35.0	238320.	1643.		
		10	100.0	37.8	187013.	1289.		
		11	110.0	43.3	111808.	771.		
		12	120.0	48.9	64305.	443.		

MODULUS PARAMETERS:Vis70F(21C)= 3.120 %Pass200= 5.0 Freq(Hz)=10.0
%AirVoids= 8.0 %VolEffAsph= 9.0

ASPHALT STABILIZED LAYER

LAYER NUMBER	MATERIAL TYPE	POINT NUMBER	TEMP. (F)	TEMP. (C)	MODULUS EI (psi)	MODULUS EI (MPa)	MODULUS EF (psi)	MODULUS EF (MPa)
4	ASPH. CONC.							
		1	40.0	4.4	1778095.	12260.		
		2	50.0	10.0	1389596.	9581.		
		3	60.0	15.6	1040419.	7174.		
		4	70.0	21.1	747464.	5154.		
		5	75.0	23.9	624066.	4303.		
		6	80.0	26.7	515925.	3557.		
		7	85.0	29.4	422389.	2912.		
		8	90.0	32.2	342500.	2362.		
		9	95.0	35.0	275093.	1897.		
		10	100.0	37.8	218883.	1509.		
		11	110.0	43.3	134768.	929.		
		12	120.0	48.9	80001.	552.		

MODULUS PARAMETERS:Vis70F(21C)= 3.120 %Pass200= 5.0 Freq(Hz)=10.0
%AirVoids= 8.0 %VolEffAsph= 8.0

SUBGRADE LAYER

LAYER NUMBER	MATERIAL TYPE	MONTH	MODULUS (psi)	MODULUS (MPa)
5	SUBGR. SOIL			
		JAN.	30000.	207.
		FEB.	40000.	276.
		MAR.	40000.	276.
		APR	2000.	14.
		MAY	3000.	21.
		JUNE	4000.	28.
		JULY	5000.	34.
		AUG.	5000.	34.
		SEPT	5000.	34.
		OCT.	5000.	34.
		NOV.	10000.	69.
		DEC.	20000.	138.

```
                      DAMAGE  MODELS

 FATIGUE DAMAGE :  NF = (F0) * M(F1) * (10**M) * (ET)**(-F2) * (MOD)**(-F3)

          WHERE

          NF IS LOAD REPETITIONS TO FAILURE
          F0 IS DISTRESS TO PERFORMANCE FACTOR
          10**M IS A MIX FACTOR (M= F4*(VBE/(VBE+VV)-F5)

                    VV IS VOLUME OF VOIDS IN ASPHALT MIX (PERCENT)
                    VBE IS VOLUME OF EFFECTIVE ASPHALT IN MIX (PERCENT)

          ET IS TENSILE STRAIN IN ASPHALT LAYER
          MOD IS MODULUS OF ASPHALT CONCRETE (psi)
          F1, F2 AND F3 ARE COEFFICIENTS OF LAB FATIGUE EQUATION
                    GIVEN BY    NF = F1 * ET**(-F2) * MOD**(-F3)


          PARAMETERS OF LAYER 1

          F0 =.18400E+02  F1 =.43250E-02  F2 =.32910E+01  F3 =.85400E+00

          F4 =.48400E+01  F5 = .69000E+00  VBE = 11.00     VV =  8.00

FINAL FATIGUE EQUATION: NF=.23084E-01*(ET)**(-.32910E+01)*MOD**(-.85400E+00)

          PARAMETERS OF LAYER 2

          F0 =.18400E+02  F1 =.43250E-02  F2 =.32910E+01  F3 =.85400E+00

          F4 =.48400E+01  F5 = .69000E+00  VBE = 10.00     VV =  8.00

FINAL FATIGUE EQUATION: NF=.17787E-01*(ET)**(-.32910E+01)*MOD**(-.85400E+00)

          PARAMETERS OF LAYER 3

          F0 =.18400E+02  F1 =.43250E-02  F2 =.32910E+01  F3 =.85400E+00

          F4 =.48400E+01  F5 = .69000E+00  VBE =  9.00     VV =  8.00

FINAL FATIGUE EQUATION: NF=.13291E-01*(ET)**(-.32910E+01)*MOD**(-.85400E+00)

          PARAMETERS OF LAYER 4

          F0 =.18400E+02  F1 =.43250E-02  F2 =.32910E+01  F3 =.85400E+00

          F4 =.48400E+01  F5 = .69000E+00  VBE =  8.00     VV =  8.00

FINAL FATIGUE EQUATION: NF=.95764E-02*(ET)**(-.32910E+01)*MOD**(-.85400E+00)


 DEFORMATION DAMAGE :  NF = D0 * EC**(-D1)

          WHERE

          NF IS LOAD REPETITIONS TO FAILURE
          D0 AND D1 ARE COEFFICIENTS FOR SUBGRADE DEFORMATION MODEL
          EC IS VERTICAL COMPRESSIVE STRAIN AT TOP OF SUBGRADE LAYER(S)

          D0 =.13650E-08       D1 =.44770E+01
```

THE
FEDERAL AVIATION ADMINISTRATION
PRESENTS

LAYERED ELASTIC ANALYSIS COMPUTER PROGRAM

Written by

Dr. Jacob Uzan
TECHNION , Haifa , Israel

Modified by

Dr. Walter R. Barker
Engr. Carlos R. Gonzalez

PAVEMENTS SYSTEM DIVISION
GEOTECHNICAL LABORATORY
U.S. ARMY WATERWAYS EXPERIMENT STATION
Vicksburg , Mississippi

DATE ===========> JUNE 5, 1998

STARTING TIME ==> 10:33: 1. 3 am

STRUCTURE NO. 1

Layer No.	Thickness	Elasticity Modulus	Poisson Ratio	Interface Condition
1	1.00	50000.00	.350	
				.000
				1.000
2	2.00	140000.00	.350	
				.000
				1.000
3	7.50	250000.00	.350	
				.000
				1.000
4		30000.00	.350	

AIRCRAFT NO. 1 - 18-KIP

Design Load of Aircraft : 18000.00
Fraction of Load on Main Gear : 50.00%
Gear Load : 9000.00

Number of Tires : 2

Tire No.	Radius (in)	Cont.Area (sq.in)	Cont.Press. (psi)	Tire Load (pounds)	X-coord. (in)	Y-coord. (in)
1	3.45	37.50	120.00	4500.00	.00	.00
2	3.45	37.50	120.00	4500.00	13.50	.00

Layer No. = 1
Depth = 1.00
X-coord. = .00
Y-coord. = .00

	Vertical	Horiz in X	Horiz in Y	Shear XY	Shear YZ	Shear XZ
Stress	1.184E+02	6.516E+01	6.648E+01	0.000E+00	0.000E+00	-3.522E-01
Strain	1.447E-03	8.599E-06	4.446E-05	0.000E+00	0.000E+00	-1.902E-05
Displt	9.540E-03	4.554E-04	0.000E+00			

```
 Layer No. =   2
 Depth     =       2.00
 X-coord.  =        .00
 Y-coord.  =        .00

         Vertical   Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  1.104E+02   4.593E+01   4.843E+01   0.000E+00   0.000E+00  -1.206E+00
Strain  5.525E-04  -6.894E-05  -4.484E-05   0.000E+00   0.000E+00  -2.326E-05
Displt  9.002E-03   3.479E-04   0.000E+00


 Layer No. =   3
 Depth     =       3.00
 X-coord.  =        .00
 Y-coord.  =        .00

         Vertical   Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  9.322E+01   3.321E+01   3.603E+01   0.000E+00   0.000E+00  -1.916E+00
Strain  2.759E-04  -4.811E-05  -3.288E-05   0.000E+00   0.000E+00  -2.069E-05
Displt  8.486E-03   2.529E-04   0.000E+00


 Layer No. =   3
 Depth     =       4.00
 X-coord.  =        .00
 Y-coord.  =        .00

         Vertical   Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  7.302E+01   1.836E+01   1.930E+01   0.000E+00   0.000E+00  -2.905E+00
Strain  2.394E-04  -5.581E-05  -5.074E-05   0.000E+00   0.000E+00  -3.138E-05
Displt  8.226E-03   1.517E-04   0.000E+00


 Layer No. =   3
 Depth     =       5.00
 X-coord.  =        .00
 Y-coord.  =        .00

         Vertical   Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  5.524E+01   9.213E+00   8.611E+00   0.000E+00   0.000E+00  -3.600E+00
Strain  1.960E-04  -5.254E-05  -5.578E-05   0.000E+00   0.000E+00  -3.888E-05
Displt  8.009E-03   5.832E-05   0.000E+00


 Layer No. =   3
 Depth     =       6.00
 X-coord.  =        .00
 Y-coord.  =        .00

         Vertical   Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  4.098E+01   2.469E+00   5.544E-01   0.000E+00   0.000E+00  -3.975E+00
Strain  1.597E-04  -4.827E-05  -5.861E-05   0.000E+00   0.000E+00  -4.293E-05
```

```
Displt  7.832E-03  -3.002E-05   0.000E+00


 Layer No. =    3
 Depth     =       8.00
 X-coord.  =        .00
 Y-coord.  =        .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  2.134E+01  -9.656E+00  -1.402E+01   0.000E+00   0.000E+00  -3.694E+00
Strain  1.185E-04  -4.887E-05  -7.242E-05   0.000E+00   0.000E+00  -3.990E-05
Displt  7.561E-03  -2.029E-04   0.000E+00


 Layer No. =    3
 Depth     =      10.50
 X-coord.  =        .00
 Y-coord.  =        .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  1.000E+01  -3.055E+01  -3.920E+01   0.000E+00   0.000E+00  -1.382E+00
Strain  1.377E-04  -8.133E-05  -1.280E-04   0.000E+00   0.000E+00  -1.493E-05
Displt  7.261E-03  -4.426E-04   0.000E+00


 Layer No. =    4
 Depth     =      12.00
 X-coord.  =        .00
 Y-coord.  =        .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  8.596E+00   9.399E-01   4.676E-02   0.000E+00   0.000E+00  -1.301E+00
Strain  2.750E-04  -6.950E-05  -1.097E-04   0.000E+00   0.000E+00  -1.171E-04
Displt  6.816E-03  -4.338E-04   0.000E+00
```

STRUCTURE NO. 2

Layer No.	Thickness	Elasticity Modulus	Poisson Ratio	Interface Condition
1	1.00	50000.00	.350	
				.000
				1.000
2	2.00	140000.00	.350	
				.000
				1.000
3	9.50	300000.00	.350	
				.000
				1.000
4		30000.00	.350	

AIRCRAFT NO. 1 - 18-KIP

Design Load of Aircraft : 18000.00
Fraction of Load on Main Gear : 50.00%
Gear Load : 9000.00

Number of Tires : 2

Tire No.	Radius (in)	Cont.Area (sq.in)	Cont.Press. (psi)	Tire Load (pounds)	X-coord. (in)	Y-coord. (in)
1	3.45	37.50	120.00	4500.00	.00	.00
2	3.45	37.50	120.00	4500.00	13.50	.00

Layer No. = 1
Depth = 1.00
X-coord. = .00
Y-coord. = .00

	Vertical	Horiz in X	Horiz in Y	Shear XY	Shear YZ	Shear XZ
Stress	1.187E+02	6.334E+01	6.422E+01	0.000E+00	0.000E+00	-2.617E-01
Strain	1.482E-03	-1.380E-05	9.746E-06	0.000E+00	0.000E+00	-1.413E-05
Displt	8.323E-03	3.704E-04	0.000E+00			

```
 Layer No. =    2
 Depth     =        2.00
 X-coord.  =         .00
 Y-coord.  =         .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  1.115E+02   4.460E+01   4.626E+01   0.000E+00   0.000E+00  -9.178E-01
Strain  5.692E-04  -7.579E-05  -5.979E-05   0.000E+00   0.000E+00  -1.770E-05
Displt  7.761E-03   2.945E-04   0.000E+00


 Layer No. =    3
 Depth     =        3.00
 X-coord.  =         .00
 Y-coord.  =         .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  9.510E+01   3.479E+01   3.713E+01   0.000E+00   0.000E+00  -1.486E+00
Strain  2.331E-04  -3.829E-05  -2.776E-05   0.000E+00   0.000E+00  -1.337E-05
Displt  7.235E-03   2.283E-04   0.000E+00


 Layer No. =    3
 Depth     =        4.00
 X-coord.  =         .00
 Y-coord.  =         .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  7.530E+01   2.056E+01   2.138E+01   0.000E+00   0.000E+00  -2.496E+00
Strain  2.021E-04  -4.428E-05  -4.058E-05   0.000E+00   0.000E+00  -2.247E-05
Displt  7.016E-03   1.552E-04   0.000E+00


 Layer No. =    3
 Depth     =        5.00
 X-coord.  =         .00
 Y-coord.  =         .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  5.790E+01   1.229E+01   1.193E+01   0.000E+00   0.000E+00  -3.299E+00
Strain  1.647E-04  -4.049E-05  -4.213E-05   0.000E+00   0.000E+00  -2.969E-05
Displt  6.833E-03   8.902E-05   0.000E+00


 Layer No. =    3
 Depth     =        6.00
 X-coord.  =         .00
 Y-coord.  =         .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  4.406E+01   6.675E+00   5.388E+00   0.000E+00   0.000E+00  -3.872E+00
Strain  1.328E-04  -3.544E-05  -4.123E-05   0.000E+00   0.000E+00  -3.485E-05
```

```
Displt  6.685E-03   2.817E-05   0.000E+00


 Layer No. =   3
 Depth     =       8.00
 X-coord.  =        .00
 Y-coord.  =        .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  2.508E+01  -2.133E+00  -4.776E+00  0.000E+00   0.000E+00  -4.260E+00
Strain  9.167E-05  -3.080E-05  -4.270E-05  0.000E+00   0.000E+00  -3.834E-05
Displt  6.465E-03  -8.448E-05   0.000E+00


 Layer No. =   3
 Depth     =      10.50
 X-coord.  =        .00
 Y-coord.  =        .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  1.160E+01  -1.370E+01  -1.815E+01  0.000E+00   0.000E+00  -3.191E+00
Strain  7.584E-05  -3.804E-05  -5.804E-05  0.000E+00   0.000E+00  -2.872E-05
Displt  6.263E-03  -2.282E-04   0.000E+00


 Layer No. =   4
 Depth     =      12.50
 X-coord.  =        .00
 Y-coord.  =        .00

        Vertical  Horiz in X  Horiz in Y   Shear XY    Shear YZ    Shear XZ

Stress  7.005E+00   7.393E-01   3.958E-02  0.000E+00   0.000E+00  -1.043E+00
Strain  2.244E-04  -5.755E-05  -8.904E-05  0.000E+00   0.000E+00  -9.383E-05
Displt  6.099E-03  -3.649E-04   0.000E+00

                CLOSING TIME ==> 10:33: 3.88 am
```

APPENDIX E
NCHRP 9-9

Mix Design Summary Information for Task 6C: Consolidation of the N_{design} Compaction Matrix and Evaluation of the $N_{initial}$ and $N_{maximum}$ Requirements

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Fine Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-F-40

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg (Gsa) = 2.701 | Effective SG Agg (Gse) 2.653 | Bulk SG Agg (Gsb) = 2.595 | Percent Absorbed Asphalt (Pba)= 0.87

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Nini (mm)	Ndes (mm)	Nini (cc)	Ndes (cc)	Bulk at Ndes (Gmb)	Nini (Gmb)	Ndes (Gmb)	TMD (Gmm)	Nini	Ndes	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	*K*	*L*	*N*	*O*	*P*		*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.5-1	4.5	4833.1	126.6	118.8	2237.2	2099.4	2.335	2.191	2.335	2.478	88.424	94.229	6.429	3.67	1.36	5.8	14.1	59.0
4.5-2	4.5	4796.5	126.6	119.0	2237.2	2102.9	2.306	2.168	2.306	2.478	87.472	93.059	6.186	3.67	1.36	6.9	15.1	54.1
4.5-3	4.5	4774.8	125.8	118.2	2223.1	2088.8	2.317	2.177	2.317	2.478	87.854	93.503	6.255	3.67	1.36	6.5	14.7	55.9
AVG											87.917	93.597	6.290			6.4	14.6	56.3
S.D.											0.479	0.591	0.125			0.591	0.539	2.450
5.0-1	5.0	4822.5	125.8	118.1	2223.1	2087.0	2.343	2.200	2.343	2.458	89.487	95.321	6.461	4.18	1.20	4.7	14.2	67.1
5.0-2	5.0	4825.1	126.5	118.8	2235.4	2099.4	2.332	2.190	2.332	2.458	89.099	94.874	6.395	4.18	1.20	5.1	14.6	65.0
5.0-3	5.0	4808.7	125.9	118.2	2224.8	2088.8	2.336	2.193	2.336	2.458	89.224	95.037	6.436	4.18	1.20	5.0	14.5	65.7
AVG											89.270	95.077	6.430			4.9	14.4	65.9
S.D.											0.198	0.227	0.033			0.227	0.204	1.091
5.5-1	5.5	4839.8	126.1	118.1	2228.4	2087.0	2.351	2.202	2.351	2.438	90.314	96.432	6.774	4.68	1.07	3.6	14.4	75.2
5.5-2	5.5	4819.7	125.4	117.6	2216.0	2078.2	2.353	2.207	2.353	2.438	90.510	96.514	6.647	4.68	1.07	3.5	14.3	75.6
5.5-3	5.5	4865.8	126.4	118.5	2233.7	2094.1	2.356	2.209	2.356	2.438	90.597	96.637	6.688	4.68	1.07	3.4	14.2	76.3
AVG											90.474	96.527	6.703			3.5	14.3	75.7
S.D.											0.145	0.103	0.065			0.103	0.092	0.567

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Fine Gradation, 68 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-F-68

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.701 | Effective SG Agg (Gse) 2.653 | Bulk SG Agg. (Gsb) = 2.595 | Percent Absorbed Asphalt (Pba)= 0.87

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Nini (mm)	Ndes (mm)	Nini (cc)	Ndes (cc)	Bulk at Ndes (Gmb)	Nini (Gmb)	Ndes (Gmb)	TMD (Gmm)	Nini	Ndes	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P		R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
4.5-1	4.5	4767.6	124.4	116.8	2198.3	2064.0	2.340	2.197	2.340	2.478	88.662	94.431	5.843	3.67	1.36	5.6	13.9	59.9
4.5-2	4.5	4782.9	124.4	116.9	2198.3	2065.8	2.345	2.204	2.345	2.478	88.927	94.633	5.778	3.67	1.36	5.4	13.7	60.8
4.5-3	4.5	4785.9	125.1	117.4	2210.7	2074.6	2.336	2.192	2.336	2.478	88.467	94.270	5.876	3.67	1.36	5.7	14.0	59.2
AVG											88.686	94.444	5.832			5.6	13.9	60.0
S.D.											0.231	0.182	0.050			0.182	0.166	0.834
5.0-1	5.0	4817.9	125.1	117.2	2210.7	2071.1	2.357	2.208	2.357	2.458	89.836	95.891	6.133	4.18	1.20	4.1	13.7	70.0
5.0-2	5.0	4809.8	124.5	116.7	2200.1	2062.3	2.365	2.217	2.365	2.458	90.188	96.216	6.105	4.18	1.20	3.8	13.4	71.8
5.0-3	5.0	4809.7	124.9	116.9	2207.2	2065.8	2.359	2.208	2.359	2.458	89.825	95.972	6.226	4.18	1.20	4.0	13.6	70.5
AVG											89.950	96.027	6.154			4.0	13.6	70.8
S.D.											0.207	0.169	0.063			0.169	0.152	0.923
5.5-1	5.5	4836.7	124.5	116.4	2200.1	2057.0	2.374	2.220	2.374	2.438	91.040	97.375	6.416	4.68	1.07	2.6	13.5	80.6
5.5-2	5.5	4824.6	124.5	116.4	2200.1	2057.0	2.365	2.211	2.365	2.438	90.695	97.006	6.392	4.68	1.07	3.0	13.9	78.4
5.5-3	5.5	4842.2	124.6	116.5	2201.9	2058.7	2.370	2.216	2.370	2.438	90.891	97.211	6.400	4.68	1.07	2.8	13.7	79.6
AVG											90.875	97.197	6.403			2.8	13.7	79.6
S.D.											0.173	0.185	0.012			0.185	0.164	1.103

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Fine Gradation, 93 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-F-93

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.701 | Effective SG Agg (Gse) 2.653 | Bulk SG Agg. (Gsb) = 2.595 | Percent Absorbed Asphalt (Pba)= 0.87

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Nini (mm)	Ndes (mm)	Nini (cc)	Ndes (cc)	Bulk at Ndes (Gmb)	Nini (Gmb)	Ndes (Gmb)	TMD (Gmm)	Nini	Ndes	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	*K*	*L*	*N*	*O*	*P*		*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.0-1	4.0	4819.9	125.7	117.6	2221.3	2078.2	2.311	2.162	2.311	2.498	86.552	92.514	5.596	3.17	1.58	7.5	14.5	48.4
4.0-2	4.0	4749.2	124.0	116.3	2191.3	2055.2	2.343	2.198	2.343	2.498	87.971	93.795	5.467	3.17	1.58	6.2	13.3	53.4
4.0-3	4.0	4786.0	125.6	117.7	2219.5	2079.9	2.338	2.191	2.338	2.498	87.708	93.595	5.526	3.17	1.58	6.4	13.5	52.6
AVG											87.410	93.301	5.529			6.7	13.8	51.5
S.D.											0.754	0.689	0.064			0.689	0.637	2.694
4.5-1	4.5	4792.6	124.7	116.7	2203.6	2062.3	2.356	2.205	2.356	2.478	88.977	95.077	5.725	3.67	1.36	4.9	13.3	63.0
4.5-2	4.5	4786.4	124.3	116.2	2196.6	2053.4	2.369	2.215	2.369	2.478	89.371	95.601	5.847	3.67	1.36	4.4	12.8	65.7
4.5-3	4.5	4789.1	124.3	116.4	2196.6	2057.0	2.361	2.211	2.361	2.478	89.223	95.278	5.684	3.67	1.36	4.7	13.1	64.0
AVG											89.191	95.319	5.752			4.7	13.1	64.2
S.D.											0.199	0.265	0.085			0.265	0.241	1.369
5.0-1	5.0	4801.2	124.7	116.4	2203.6	2057.0	2.367	2.209	2.367	2.458	89.888	96.298	6.016	4.18	1.20	3.7	13.3	72.3
5.0-2	5.0	4819.5	124.5	116.4	2200.1	2057.0	2.375	2.220	2.375	2.458	90.337	96.623	5.900	4.18	1.20	3.4	13.1	74.1
5.0-3	5.0	4805.9	124.2	116.0	2194.8	2049.9	2.377	2.220	2.377	2.458	90.320	96.705	5.993	4.18	1.20	3.3	13.0	74.6
AVG											90.182	96.542	5.970			3.5	13.1	73.7
S.D.											0.254	0.215	0.061			0.215	0.194	1.243

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Fine Gradation, 113 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-F-113

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.701

Effective SG Agg (Gse) 2.653

Bulk SG Agg. (Gsb) = 2.595

Percent Absorbed Asphalt (Pba)= 0.87

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Nini (mm)	Ndes (mm)	Nini (cc)	Ndes (cc)	Bulk at Ndes (Gmb)	Nini (Gmb)	Ndes (Gmb)	TMD (Gmm)	Nini	Ndes	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*		*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.0-1	4.0	4754.4	124.3	116.1	2196.6	2051.7	2.346	2.191	2.346	2.498	87.720	93.915	5.387	3.17	1.58	6.1	13.2	53.9
4.0-2	4.0	4766.2	124.4	116.3	2198.3	2055.2	2.348	2.195	2.348	2.498	87.875	93.995	5.322	3.17	1.58	6.0	13.1	54.3
4.0-3	4.0	4769.8	124.8	116.6	2205.4	2060.5	2.342	2.188	2.342	2.498	87.595	93.755	5.357	3.17	1.58	6.2	13.4	53.3
AVG											87.730	93.888	5.355			6.1	13.2	53.8
S.D.											0.140	0.122	0.033			0.122	0.113	0.528
4.5-1	4.5	4791.5	124.5	116.1	2200.1	2051.7	2.364	2.205	2.364	2.478	88.963	95.400	5.597	3.67	1.36	4.6	13.0	64.6
4.5-2	4.5	4787.2	124.4	116.0	2198.3	2049.9	2.365	2.205	2.365	2.478	88.995	95.440	5.604	3.67	1.36	4.6	13.0	64.8
4.5-3	4.5	4789.1	124.8	116.3	2205.4	2055.2	2.365	2.204	2.365	2.478	88.940	95.440	5.653	3.67	1.36	4.6	13.0	64.8
AVG											88.966	95.426	5.618			4.6	13.0	64.8
S.D.											0.028	0.023	0.030			0.023	0.021	0.122
5.0-1	5.0	4826.3	124.5	115.9	2200.1	2048.1	2.386	2.221	2.386	2.458	90.365	97.071	5.831	4.18	1.20	2.9	12.7	76.8
5.0-2	5.0	4813.6	124.0	115.4	2191.3	2039.3	2.391	2.225	2.391	2.458	90.528	97.274	5.867	4.18	1.20	2.7	12.5	78.1
5.0-3	5.0	4822.5	124.1	115.5	2193.0	2041.1	2.391	2.225	2.391	2.458	90.533	97.274	5.862	4.18	1.20	2.7	12.5	78.1
AVG											90.475	97.206	5.853			2.8	12.5	77.7
S.D.											0.095	0.117	0.019			0.117	0.106	0.746

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Fine Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-F-139

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.701

Effective SG Agg (Gse) 2.653

Bulk SG Agg. (Gsb) = 2.595

Percent Absorbed Asphalt (Pba)= 0.87

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK		
Specimen Number	Asphalt Content (%)	Mass (gm)	Nini (mm)	Ndes (mm)	Nini (cc)	Ndes (cc)	Bulk at Ndes (Gmb)	Nini (Gmb)	Ndes (Gmb)	TMD (Gmm)
A	B	C	D	E	G	H	J	K	L	N
					17.67*D	17.67*E		C/G*J/(C/J)		
4.0-1	4.0	4745.4	123.7	115.5	2186.0	2041.1	2.355	2.199	2.355	2.498
4.0-2	4.0	4755.8	123.4	115.3	2180.7	2037.5	2.364	2.209	2.364	2.498
4.0-3	4.0	4762.5	123.8	115.7	2187.7	2044.6	2.359	2.205	2.359	2.498
AVG										
S.D.										
4.5-1	4.5	4792.7	124.4	115.9	2198.3	2048.1	2.372	2.210	2.372	2.478
4.5-2	4.5	4800.3	124.6	116.0	2201.9	2049.9	2.375	2.211	2.375	2.478
4.5-3	4.5	4787.1	124.1	115.7	2193.0	2044.6	2.375	2.214	2.375	2.478
AVG										
S.D.										
5.0-1	5.0	4817.2	124.0	115.3	2191.3	2037.5	2.397	2.229	2.397	2.458
5.0-2	5.0	4818.7	124.1	115.3	2193.0	2037.5	2.398	2.228	2.398	2.458
5.0-3	5.0	4797.3	123.8	115.0	2187.7	2032.2	2.394	2.224	2.394	2.458
AVG										
S.D.										

	% TMD							
Specimen Number	Nini	Ndes	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	O	P		R	V	S	T	U
4.0-1	88.026	94.275	5.257	3.17	1.58	5.7	12.9	55.5
4.0-2	88.424	94.636	5.225	3.17	1.58	5.4	12.5	57.2
4.0-3	88.257	94.436	5.198	3.17	1.58	5.6	12.7	56.3
AVG	88.236	94.449	5.227			5.6	12.7	56.4
S.D.	0.200	0.181	0.030			0.181	0.167	0.848
4.5-1	89.182	95.722	5.502	3.67	1.36	4.3	12.7	66.3
4.5-2	89.228	95.843	5.565	3.67	1.36	4.2	12.6	67.0
4.5-3	89.356	95.843	5.457	3.67	1.36	4.2	12.6	67.0
AVG	89.255	95.803	5.508			4.2	12.6	66.8
S.D.	0.090	0.070	0.054			0.070	0.064	0.385
5.0-1	90.676	97.518	5.756	4.18	1.20	2.5	12.2	79.7
5.0-2	90.641	97.559	5.819	4.18	1.20	2.4	12.2	80.0
5.0-3	90.473	97.396	5.824	4.18	1.20	2.6	12.4	78.9
AVG	90.597	97.491	5.800			2.5	12.3	79.6
S.D.	0.109	0.085	0.038			0.085	0.076	0.562

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Fine Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-F-172

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.701 | Effective SG Agg (Gse) 2.653 | Bulk SG Agg. (Gsb) = 2.595 | Percent Absorbed Asphalt (Pba)= 0.87

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Nini (mm)	Ndes (mm)	Nini (cc)	Ndes (cc)	Bulk at Ndes (Gmb)	Nini (Gmb)	Ndes (Gmb)	TMD (Gmm)	Nini	Ndes	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P		R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
4.0-1	4.0	4744.7	123.0	114.7	2173.6	2026.9	2.369	2.209	2.369	2.498	88.436	94.836	5.180	3.17	1.58	5.2	12.4	58.2
4.0-2	4.0	4766.8	123.7	115.5	2186.0	2041.1	2.366	2.209	2.366	2.498	88.437	94.716	5.082	3.17	1.58	5.3	12.5	57.6
4.0-3	4.0	4766.1	123.9	115.6	2189.5	2042.8	2.367	2.208	2.367	2.498	88.408	94.756	5.138	3.17	1.58	5.2	12.4	57.8
AVG											88.427	94.769	5.133			5.2	12.4	57.9
S.D.											0.017	0.061	0.049			0.061	0.057	0.301
4.5-1	4.5	4797.4	123.5	115.2	2182.4	2035.8	2.382	2.222	2.382	2.478	89.666	96.126	5.229	3.67	1.36	3.9	12.3	68.6
4.5-2	4.5	4773.4	123.3	114.7	2178.9	2026.9	2.387	2.221	2.387	2.478	89.609	96.328	5.438	3.67	1.36	3.7	12.2	69.8
4.5-3	4.5	4798.1	123.8	115.4	2187.7	2039.3	2.385	2.223	2.385	2.478	89.716	96.247	5.286	3.67	1.36	3.8	12.2	69.3
AVG											89.664	96.234	5.317			3.8	12.2	69.2
S.D.											0.054	0.102	0.108			0.102	0.093	0.596
5.0-1	5.0	4806.2	122.7	114.2	2168.3	2018.1	2.412	2.245	2.412	2.458	91.331	98.129	5.502	4.18	1.20	1.9	11.7	84.0
5.0-2	5.0	4835.8	124.3	115.5	2196.6	2041.1	2.402	2.232	2.402	2.458	90.803	97.722	5.600	4.18	1.20	2.3	12.1	81.1
5.0-3	5.0	4827.9	123.6	114.9	2184.2	2030.5	2.410	2.240	2.410	2.458	91.146	98.047	5.586	4.18	1.20	2.0	11.8	83.4
AVG											91.093	97.966	5.562			2.0	11.8	82.8
S.D.											0.268	0.215	0.053			0.215	0.194	1.525

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel, Coarse Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-C-40			MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler											Percent Passing 0.075 mm		5		
AC Sp. Gr. (Gb) =		1.028	Apparent SG Agg. (Gsa) = 2.700		Effective SG Agg (Gse)= 2.642		Bulk SG Agg. (Gsb) = 2.589			Percent Absorbed Asphalt (Pba)= 0.80								
			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
5.5-1	5.5	4851.7	135.4	122.7	2392.7	2168.3	2.289	2.074	2.289	2.431	85.327	94.159	9.779	4.75	1.05	5.8	16.5	64.5
5.5-1	5.5	4591.7	126.7	115.3	2239.0	2037.5	2.302	2.095	2.302	2.431	86.173	94.694	9.434	4.75	1.05	5.3	16.0	66.8
5.5-3	5.5	4814.2	133.0	121.0	2350.3	2138.2	2.303	2.095	2.303	2.431	86.187	94.735	9.465	4.75	1.05	5.3	15.9	67.0
AVG											85.896	94.529	9.560			5.5	16.1	66.1
S.D.											0.493	0.321	0.191			0.321	0.285	1.379
6.0-1	6.0	4709.6	131.6	118.2	2325.6	2088.8	2.304	2.069	2.304	2.414	85.725	95.443	10.761	5.25	0.95	4.6	16.3	72.1
6.0-2	6.0	4844.5	132.5	120.2	2341.5	2124.1	2.306	2.092	2.306	2.414	86.658	95.526	9.819	5.25	0.95	4.5	16.3	72.5
6.0-3	6.0	4786.1	131.9	119.4	2330.9	2110.0	2.318	2.098	2.318	2.414	86.923	96.023	10.077	5.25	0.95	4.0	15.8	74.9
AVG											86.435	95.664	10.219			4.3	16.2	73.2
S.D.											0.629	0.314	0.487			0.314	0.275	1.499
6.5-1	6.5	4785.3	131.4	119.5	2322.0	2111.7	2.311	2.102	2.311	2.397	87.681	96.412	9.668	5.76	0.87	3.6	16.5	78.3
6.5-2	6.5	4910.3	132.9	121.2	2348.5	2141.8	2.331	2.126	2.331	2.397	88.685	97.247	9.480	5.76	0.87	2.8	15.8	82.6
6.5-3	6.5	4784.2	131.6	119.8	2325.6	2117.0	2.299	2.093	2.299	2.397	87.312	95.912	9.523	5.76	0.87	4.1	17.0	75.9
AVG											87.893	96.523	9.557			3.5	16.4	78.9
S.D.											0.711	0.674	0.099			0.674	0.584	3.384

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Coarse Gradation, 68 Gyrations

SGC: Pine Gyratory Compactor

MIX ID: NY GRAV-C-68

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]; Apparent SG Agg. (Gsa) = 2.700; Effective SG Agg (Gse)= 2.642; Bulk SG Agg. (Gsb) = 2.589; Percent Absorbed Asphalt (Pba)= 0.80

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
5.5-1	5.5	4793.9	130.5	118.4	2306.1	2092.3	2.344	2.127	2.344	2.431	87.481	96.421	9.054	4.75	1.05	3.6	14.4	75.2
5.5-1	5.5	4833.6	131.5	119.0	2323.8	2102.9	2.345	2.122	2.345	2.431	87.293	96.462	9.286	4.75	1.05	3.5	14.4	75.4
5.5-3	5.5	4778.3	131.4	119.1	2322.0	2104.7	2.293	2.078	2.293	2.431	85.494	94.323	8.942	4.75	1.05	5.7	16.3	65.2
AVG											86.756	95.736	9.094			4.3	15.1	71.9
S.D.											1.097	1.223	0.176			1.223	1.085	5.861
6.0-1	6.0	4866.1	131.5	119.1	2323.8	2104.7	2.366	2.143	2.366	2.414	88.769	98.012	9.360	5.25	0.95	2.0	14.1	85.9
6.0-2	6.0	4833.0	131.4	118.6	2322.0	2095.8	2.355	2.126	2.355	2.414	88.053	97.556	9.624	5.25	0.95	2.4	14.5	83.1
6.0-3	6.0	4815.0	131.7	119.1	2327.3	2104.7	2.323	2.101	2.323	2.414	87.024	96.230	9.324	5.25	0.95	3.8	15.7	75.9
AVG											87.949	97.266	9.436			2.7	14.8	81.7
S.D.											0.877	0.925	0.164			0.925	0.811	5.149
6.5-1	6.5	4857.7	131.5	118.6	2323.8	2095.8	2.353	2.122	2.353	2.397	88.535	98.164	9.753	5.76	0.87	1.8	15.0	87.8
6.5-2	6.5	4838.5	131.1	118.6	2316.7	2095.8	2.348	2.124	2.348	2.397	88.616	97.956	9.459	5.76	0.87	2.0	15.2	86.6
6.5-3	6.5	4828.6	130.7	118.2	2309.7	2088.8	2.343	2.119	2.343	2.397	88.399	97.747	9.468	5.76	0.87	2.3	15.4	85.4
AVG											88.516	97.956	9.560			2.0	15.2	86.6
S.D.											0.110	0.209	0.167			0.209	0.181	1.213

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Coarse Gradation, 93 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-C-93

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.025 | Apparent SG Agg. (Gsa) = 2.700 | Effective SG Agg (Gse)= 2.642 | Bulk SG Agg. (Gsb) = 2.589 | Percent Absorbed Asphalt (Pba)= 0.79

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
4.5-1	4.5	4770.5	129.7	117.2	2292.0	2071.1	2.348	2.122	2.348	2.465	86.073	95.254	8.617	3.74	1.34	4.7	13.4	64.6
4.5-2	4.5	4772.1	130.3	117.7	2302.6	2079.9	2.344	2.117	2.344	2.465	85.896	95.091	8.631	3.74	1.34	4.9	13.5	63.7
4.5-3	4.5	4796.6	130.3	117.8	2302.6	2081.7	2.347	2.122	2.347	2.465	86.079	95.213	8.573	3.74	1.34	4.8	13.4	64.3
AVG											86.016	95.186	8.607			4.8	13.5	64.2
S.D.											0.104	0.084	0.030			0.084	0.077	0.422
5.0-1	5.0	4816.1	130.7	117.8	2309.7	2081.7	2.361	2.128	2.361	2.448	86.927	96.446	8.935	4.25	1.18	3.6	13.4	73.4
5.0-2	5.0	4814.7	130.9	117.9	2313.2	2083.5	2.361	2.127	2.361	2.448	86.868	96.446	8.990	4.25	1.18	3.6	13.4	73.4
5.0-3	5.0	4798.5	129.3	116.8	2284.9	2064.0	2.374	2.144	2.374	2.448	87.602	96.977	8.800	4.25	1.18	3.0	12.9	76.5
AVG											87.132	96.623	8.908			3.4	13.2	74.5
S.D.											0.408	0.307	0.098			0.307	0.275	1.811
5.5-1	5.5	4827.0	130.3	117.3	2302.6	2072.9	2.384	2.146	2.384	2.431	88.283	98.067	9.184	4.75	1.05	1.9	13.0	85.1
5.5-2	5.5	4834.8	130.2	117.2	2300.8	2071.1	2.384	2.146	2.384	2.431	88.275	98.067	9.191	4.75	1.05	1.9	13.0	85.1
5.5-3	5.5	4805.0	129.8	116.8	2293.8	2064.0	2.382	2.143	2.382	2.431	88.171	97.984	9.211	4.75	1.05	2.0	13.1	84.6
AVG											88.243	98.039	9.195			2.0	13.0	84.9
S.D.											0.062	0.047	0.014			0.047	0.042	0.316

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Coarse Gradation, 113 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-C-113

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.020 | Apparent SG Agg. (Gsa) = 2.700 | Effective SG Agg (Gse)= 2.642 | Bulk SG Agg. (Gsb) = 2.589 | Percent Absorbed Asphalt (Pba)= 0.80

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/J)										
4.0-1	4.0	4770.6	131.7	118.5	2327.3	2094.1	2.323	2.090	2.323	2.482	84.213	93.594	8.157	3.24	1.55	6.4	13.9	53.8
4.0-2	4.0	4771.2	130.9	117.7	2313.2	2079.9	2.346	2.109	2.346	2.482	84.989	94.521	8.288	3.24	1.55	5.5	13.0	57.9
4.0-3	4.0	4760.7	131.1	118.2	2316.7	2088.8	2.360	2.128	2.360	2.482	85.728	95.085	8.136	3.24	1.55	4.9	12.5	60.6
AVG											84.977	94.400	8.194			5.6	13.1	57.4
S.D.											0.758	0.753	0.083			0.753	0.693	3.451
4.5-1	4.5	4790.8	130.6	117.3	2307.9	2072.9	2.359	2.119	2.359	2.465	85.954	95.700	8.475	3.74	1.34	4.3	13.0	66.9
4.5-2	4.5	4788.5	131.2	117.6	2318.5	2078.2	2.358	2.114	2.358	2.465	85.743	95.659	8.623	3.74	1.34	4.3	13.0	66.7
4.5-3	4.5	4774.6	131.5	117.9	2323.8	2083.5	2.336	2.094	2.336	2.465	84.966	94.767	8.523	3.74	1.34	5.2	13.8	62.2
AVG											85.554	95.375	8.540			4.6	13.3	65.2
S.D.											0.520	0.527	0.075			0.527	0.480	2.661
5.0-1	5.0	4801.3	131.2	117.5	2318.5	2076.4	2.366	2.119	2.366	2.448	86.558	96.650	8.776	4.24	1.18	3.3	13.2	74.6
5.0-2	5.0	4820.3	130.7	117.2	2309.7	2071.1	2.377	2.131	2.377	2.448	87.070	97.100	8.721	4.24	1.18	2.9	12.8	77.3
5.0-3	5.0	4821.2	132.1	118.3	2334.4	2090.5	2.362	2.115	2.362	2.448	86.407	96.487	8.765	4.24	1.18	3.5	13.3	73.6
AVG											86.679	96.746	8.754			3.3	13.1	75.2
S.D.											0.348	0.317	0.029			0.317	0.285	1.900

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Coarse Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-C-139

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.025; Apparent SG Agg. (Gsa) = 2.700; Effective SG Agg (Gse) = 2.642; Bulk SG Agg. (Gsb) = 2.589; Percent Absorbed Asphalt (Pba) = 0.79

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/J)										
4.0-1	4.0	4785.0	131.6	118.4	2325.6	2092.3	2.347	2.112	2.347	2.482	85.076	94.561	7.979	3.24	1.54	5.4	13.0	58.1
4.0-2	4.0	4786.5	130.4	117.3	2304.4	2072.9	2.354	2.118	2.354	2.482	85.315	94.843	8.015	3.24	1.54	5.2	12.7	59.4
4.0-3	4.0	4779.5	131.1	118.0	2316.7	2085.2	2.350	2.115	2.350	2.482	85.221	94.682	7.959	3.24	1.54	5.3	12.9	58.7
AVG											85.204	94.695	7.984			5.3	12.8	58.7
S.D.											0.120	0.141	0.029			0.141	0.130	0.684
4.5-1	4.5	4782.2	129.5	116.4	2288.5	2057.0	2.379	2.138	2.379	2.465	86.748	96.511	8.213	3.74	1.34	3.5	12.2	71.5
45-2	4.5	4820.4	130.8	117.3	2311.4	2072.9	2.376	2.131	2.376	2.465	86.441	96.389	8.369	3.74	1.34	3.6	12.4	70.8
4.5-3	4.5	4758.6	129.8	116.5	2293.8	2058.7	2.368	2.125	2.368	2.465	86.222	96.065	8.280	3.74	1.34	3.9	12.7	68.9
AVG											86.470	96.322	8.287			3.7	12.4	70.4
S.D.											0.265	0.231	0.078			0.231	0.210	1.349
5.0-1	5.0	4843.1	130.4	116.9	2304.4	2065.8	2.396	2.148	2.396	2.448	87.743	97.876	8.524	4.25	1.18	2.1	12.1	82.4
5.0-2	5.0	4793.1	129.9	116.4	2295.5	2057.0	2.384	2.136	2.384	2.448	87.265	97.386	8.514	4.25	1.18	2.6	12.5	79.1
5.0-3	5.0	4825.9	130.7	116.9	2309.7	2065.8	2.387	2.135	2.387	2.448	87.213	97.508	8.661	4.25	1.18	2.5	12.4	79.9
AVG											87.407	97.590	8.566			2.4	12.3	80.5
S.D.											0.292	0.255	0.082			0.255	0.229	1.719

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel , Coarse Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NY GRAV-C-172

MATERIALS: New York Gravel (2's, 1's, 1a's, and sand), Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.700 | Effective SG Agg (Gse) = 2.642 | Bulk SG Agg. (Gsb) = 2.589 | Percent Absorbed Asphalt (Pba) = 0.80

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	*K*	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.0-1	4.0	4814.0	129.5	116.3	2288.5	2055.2	2.375	2.133	2.375	2.482	85.935	95.689	7.894	3.24	1.55	4.3	11.9	63.9
4.0-2	4.0	4785.2	129.7	116.4	2292.0	2057.0	2.376	2.132	2.376	2.482	85.913	95.729	7.945	3.24	1.55	4.3	11.9	64.1
4.0-3	4.0	4760.6	129.1	116.1	2281.4	2051.7	2.373	2.134	2.373	2.482	85.981	95.608	7.792	3.24	1.55	4.4	12.0	63.4
AVG											85.943	95.676	7.877			4.3	11.9	63.8
S.D.											0.035	0.062	0.078			0.062	0.057	0.343
4.5-1	4.5	4768.4	128.3	115.0	2267.2	2032.2	2.399	2.150	2.399	2.465	87.234	97.323	8.166	3.74	1.34	2.7	11.5	76.7
45-2	4.5	4766.9	129.6	116.2	2290.2	2053.4	2.375	2.129	2.375	2.465	86.387	96.349	8.063	3.74	1.34	3.7	12.4	70.5
4.5-3	4.5	4809.8	129.8	116.4	2293.8	2057.0	2.393	2.146	2.393	2.465	87.057	97.079	8.112	3.74	1.34	2.9	11.7	75.1
AVG											86.893	96.917	8.113			3.1	11.9	74.1
S.D.											0.447	0.507	0.051			0.507	0.461	3.210
5.0-1	5.0	4809.5	129.9	116.2	2295.5	2053.4	2.396	2.143	2.396	2.448	87.553	97.876	8.355	4.24	1.18	2.1	12.1	82.4
5.0-2	5.0	4829.4	129.2	115.6	2283.2	2042.8	2.413	2.159	2.413	2.448	88.194	98.570	8.398	4.24	1.18	1.4	11.5	87.5
5.0-3	5.0	4784.9	128.7	115.1	2274.3	2034.0	2.403	2.149	2.403	2.448	87.789	98.162	8.396	4.24	1.18	1.8	11.8	84.5
AVG											87.846	98.203	8.383			1.8	11.8	84.8
S.D.											0.324	0.349	0.024			0.349	0.314	2.569

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Fine Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-F-40

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.744 | Effective SG Agg (Gse)= 2.710 | Bulk SG Agg. (Gsb) = 2.710 | Percent Absorbed Asphalt (Pba)= 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
5.0-1	5.0	4812.3	123.0	115.6	2173.6	2042.8	2.379	2.236	2.379	2.504	89.292	95.008	6.329	5.00	1.00	5.0	16.6	69.9
5.0-2	5.0	4795.6	123.0	115.5	2173.6	2041.1	2.366	2.222	2.366	2.504	88.727	94.489	6.380	5.00	1.00	5.5	17.1	67.7
5.0-3	5.0	4833.8	124.0	116.5	2191.3	2058.7	2.369	2.226	2.369	2.504	88.886	94.609	6.336	5.00	1.00	5.4	17.0	68.2
AVG											88.969	94.702	6.348			5.3	16.9	68.6
S.D.											0.291	0.272	0.027			0.272	0.239	1.175
5.5-1	5.5	4843.5	123.3	115.7	2178.9	2044.6	2.390	2.243	2.390	2.489	90.104	96.022	6.554	5.50	0.91	4.0	16.7	76.1
5.5-2	5.5	4846.2	123.6	116.1	2184.2	2051.7	2.386	2.241	2.386	2.489	90.045	95.862	6.441	5.50	0.91	4.1	16.8	75.4
5.5-3	5.5	4849.7	123.7	116.0	2186.0	2049.9	2.389	2.240	2.389	2.489	90.008	95.982	6.616	5.50	0.91	4.0	16.7	75.9
AVG											90.052	95.956	6.537			4.0	16.7	75.8
S.D.											0.048	0.084	0.089			0.084	0.073	0.395
6.0-1	6.0	4873.9	123.5	115.7	2182.4	2044.6	2.407	2.255	2.407	2.472	91.221	97.371	6.810	6.00	0.83	2.6	16.5	84.1
6.0-2	6.0	4868.1	123.8	115.9	2187.7	2048.1	2.401	2.248	2.401	2.472	90.930	97.128	6.863	6.00	0.83	2.9	16.7	82.8
6.0-3	6.0	4872.7	123.2	115.6	2177.1	2042.8	2.409	2.260	2.409	2.472	91.440	97.451	6.657	6.00	0.83	2.5	16.4	84.5
AVG											91.197	97.317	6.776			2.7	16.6	83.8
S.D.											0.256	0.168	0.107			0.168	0.144	0.873

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Fine Gradation, 68 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-F-68

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.744 | Effective SG Agg (Gse)= 2.710 | Bulk SG Agg. (Gsb) = 2.710 | Percent Absorbed Asphalt (Pba)= 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/J)										
4.5-1	4.5	4793.7	122.2	114.9	2159.5	2030.5	2.380	2.238	2.380	2.523	88.697	94.332	5.707	4.50	1.11	5.7	16.1	64.9
4.5-2	4.5	4797.4	122.4	115.1	2163.0	2034.0	2.377	2.235	2.377	2.523	88.594	94.213	5.691	4.50	1.11	5.8	16.2	64.4
4.5-3	4.5	4805.2	122.4	115.1	2163.0	2034.0	2.377	2.235	2.377	2.523	88.594	94.213	5.691	4.50	1.11	5.8	16.2	64.4
AVG											88.629	94.253	5.696			5.7	16.2	64.5
S.D.											0.059	0.069	0.010			0.069	0.061	0.291
5.0-1	5.0	4827.2	122.4	115.0	2163.0	2032.2	2.396	2.251	2.396	2.504	89.902	95.687	5.859	5.00	1.00	4.3	16.0	73.1
5.0-2	5.0	4827.5	122.2	114.7	2159.5	2026.9	2.403	2.256	2.403	2.504	90.077	95.966	5.965	5.00	1.00	4.0	15.8	74.4
5.0-3	5.0	4832.1	122.4	114.9	2163.0	2030.5	2.402	2.255	2.402	2.504	90.049	95.927	5.953	5.00	1.00	4.1	15.8	74.2
AVG											90.009	95.860	5.926			4.1	15.9	73.9
S.D.											0.094	0.151	0.058			0.151	0.133	0.732
5.5-1	5.5	4850.8	121.8	114.3	2152.4	2019.8	2.423	2.274	2.423	2.489	91.354	97.348	6.071	5.50	0.91	2.7	15.5	82.9
5.5-2	5.5	4858.0	122.3	114.7	2161.2	2026.9	2.420	2.270	2.420	2.489	91.186	97.228	6.119	5.50	0.91	2.8	15.6	82.2
5.5-3	5.5	4853.2	122.6	114.8	2166.5	2028.7	2.413	2.259	2.413	2.489	90.779	96.947	6.247	5.50	0.91	3.1	15.9	80.7
AVG											91.106	97.174	6.145			2.8	15.7	82.0
S.D.											0.296	0.206	0.091			0.206	0.179	1.106

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Fine Gradation, 93 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-F-93

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse) = 2.710; Bulk SG Agg. (Gsb) = 2.710; Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/J)										
4.5-1	4.5	4737.6	120.3	112.8	2125.9	1993.3	2.397	2.248	2.397	2.523	89.083	95.006	5.560	4.50	1.11	5.0	15.5	67.8
4.5-2	4.5	4785.7	121.4	113.8	2145.3	2011.0	2.394	2.244	2.394	2.523	88.947	94.887	5.576	4.50	1.11	5.1	15.6	67.3
4.5-3	4.5	4807.8	122.1	114.4	2157.7	2021.6	2.395	2.244	2.395	2.523	88.940	94.927	5.619	4.50	1.11	5.1	15.6	67.5
AVG											88.990	94.940	5.585			5.1	15.6	67.5
S.D.											0.080	0.061	0.031			0.061	0.054	0.277
5.0-1	5.0	4817.6	121.3	113.6	2143.5	2007.5	2.419	2.265	2.419	2.504	90.473	96.605	5.756	5.00	1.00	3.4	15.2	77.7
5.0-2	5.0	4840.6	121.9	114.1	2154.2	2016.3	2.419	2.264	2.419	2.504	90.424	96.605	5.802	5.00	1.00	3.4	15.2	77.7
5.0-3	5.0	4822.4	121.5	113.7	2147.1	2009.2	2.419	2.264	2.419	2.504	90.404	96.605	5.821	5.00	1.00	3.4	15.2	77.7
AVG											90.434	96.605	5.793			3.4	15.2	77.7
S.D.											0.036	0.000	0.033			0.000	0.000	0.000
5.5-1	5.5	4838.3	121.2	113.3	2141.8	2002.2	2.435	2.276	2.435	2.489	91.454	97.830	5.985	5.50	0.91	2.2	15.1	85.6
5.5-2	5.5	4860.8	121.5	113.8	2147.1	2011.0	2.439	2.284	2.439	2.489	91.781	97.991	5.829	5.50	0.91	2.0	15.0	86.6
5.5-3	5.5	4844.9	122.2	114.0	2159.5	2014.5	2.422	2.259	2.422	2.489	90.778	97.308	6.129	5.50	0.91	2.7	15.5	82.7
AVG											91.338	97.710	5.981			2.3	15.2	85.0
S.D.											0.511	0.357	0.150			0.357	0.310	2.025

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Fine Gradation, 113 Gyrations

SGC: Pine Gyratory Compactor

MIX ID: GA GRAN-F-113

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm = 5

AC Sp. Gr. (Gb) = [illegible]

Apparent SG Agg. (Gsa) = 2.744 | Effective SG Agg (Gse) = 2.710 | Bulk SG Agg. (Gsb) = 2.710 | Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
4.0-1	4.0	4782.6	121.9	114.2	2154.2	2018.1	2.388	2.237	2.388	2.542	88.008	93.942	5.160	4.00	1.25	6.1	15.4	60.7
4.0-2	4.0	4780.6	122.4	114.4	2163.0	2021.6	2.382	2.226	2.382	2.542	87.581	93.706	5.326	4.00	1.25	6.3	15.6	59.7
4.0-3	4.0	4774.6	122.1	114.2	2157.7	2018.1	2.382	2.228	2.382	2.542	87.643	93.706	5.272	4.00	1.25	6.3	15.6	59.7
AVG											87.744	93.784	5.253			6.2	15.5	60.0
S.D.											0.231	0.136	0.085			0.136	0.123	0.564
4.5-1	4.5	4819.1	121.4	113.4	2145.3	2003.9	2.420	2.261	2.420	2.523	89.597	95.918	5.496	4.50	1.11	4.1	14.7	72.3
4.5-2	4.5	4800.2	121.8	113.8	2152.4	2011.0	2.404	2.246	2.404	2.523	89.025	95.283	5.442	4.50	1.11	4.7	15.3	69.1
4.5-3	4.5	4800.8	121.7	113.7	2150.6	2009.2	2.407	2.249	2.407	2.523	89.131	95.402	5.453	4.50	1.11	4.6	15.2	69.7
AVG											89.251	95.534	5.464			4.5	15.1	70.4
S.D.											0.304	0.337	0.029			0.337	0.300	1.665
5.0-1	5.0	4835.9	121.7	113.5	2150.6	2005.7	2.426	2.263	2.426	2.504	90.357	96.885	5.677	5.00	1.00	3.1	15.0	79.2
5.0-2	5.0	4820.4	121.5	113.3	2147.1	2002.2	2.424	2.260	2.424	2.504	90.272	96.805	5.681	5.00	1.00	3.2	15.0	78.7
5.0-3	5.0	4830.1	121.9	113.8	2154.2	2011.0	2.422	2.261	2.422	2.504	90.298	96.725	5.589	5.00	1.00	3.3	15.1	78.3
AVG											90.309	96.805	5.649			3.2	15.0	78.7
S.D.											0.044	0.080	0.052			0.080	0.070	0.432

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Fine Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-F-139

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]

Apparent SG Agg. (Gsa) = 2.744

Effective SG Agg (Gse) = 2.710

Bulk SG Agg. (Gsb) = 2.710

Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.0-1	4.0	4777.9	121.3	113.5	2143.5	2005.7	2.400	2.246	2.400	2.542	88.343	94.414	5.107	4.00	1.25	5.6	15.0	62.7
4.0-2	4.0	4777.9	121.8	113.9	2152.4	2012.8	2.390	2.235	2.390	2.542	87.922	94.020	5.130	4.00	1.25	6.0	15.3	61.0
4.0-3	4.0	4784.0	121.5	113.8	2147.1	2011.0	2.392	2.240	2.392	2.542	88.136	94.099	5.017	4.00	1.25	5.9	15.3	61.3
AVG											88.134	94.178	5.084			5.8	15.2	61.7
S.D.											0.210	0.208	0.060			0.208	0.187	0.903
4.5-1	4.5	4795.3	121.4	113.4	2145.3	2003.9	2.409	2.250	2.409	2.523	89.190	95.482	5.293	4.50	1.11	4.5	15.1	70.1
4.5-2	4.5	4802.5	121.8	113.7	2152.4	2009.2	2.407	2.247	2.407	2.523	89.058	95.402	5.337	4.50	1.11	4.6	15.2	69.7
4.5-3	4.5	4797.1	121.6	113.6	2148.8	2007.5	2.408	2.250	2.408	2.523	89.163	95.442	5.282	4.50	1.11	4.6	15.1	69.9
AVG											89.137	95.442	5.304			4.6	15.1	69.9
S.D.											0.070	0.040	0.029			0.040	0.035	0.192
5.0-1	5.0	4836.4	121.4	113.2	2145.3	2000.4	2.436	2.271	2.436	2.504	90.713	97.284	5.528	5.00	1.00	2.7	14.6	81.4
5.0-2	5.0	4829.3	121.5	113.2	2147.1	2000.4	2.430	2.264	2.430	2.504	90.415	97.045	5.577	5.00	1.00	3.0	14.8	80.1
5.0-3	5.0	4822.9	121.2	113.0	2141.8	1996.9	2.430	2.266	2.430	2.504	90.479	97.045	5.523	5.00	1.00	3.0	14.8	80.1
AVG											90.536	97.125	5.542			2.9	14.7	80.5
S.D.											0.157	0.138	0.030			0.138	0.121	0.781

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Coarse Gradation, 40 Gyrations

MIX ID: GA GRAN-C-40			MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcite Mineral Filler												Percent Passing 0.075 mm		5	
AC Sp. Gr. (Gb) =		1.028	Apparent SG Agg. (Gsa) = 2.744		Effective SG Agg (Gse)= 2.702		Bulk SG Agg. (Gsb) = 2.707			Percent Absorbed Asphalt (Pba)= 0.00								
			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
4.5-1	4.5	4808.1	128.4	117.5	2269.0	2076.4	2.375	2.173	2.375	2.518	86.314	94.321	8.866	4.50	1.11	5.7	16.2	65.0
4.5-2	4.5	4789.6	128.1	117.3	2263.7	2072.9	2.363	2.164	2.363	2.518	85.932	93.844	8.761	4.50	1.11	6.2	16.6	63.0
4.5-3	4.5	4801.8	128.1	117.2	2263.7	2071.1	2.377	2.175	2.377	2.518	86.368	94.400	8.894	4.50	1.11	5.6	16.1	65.3
AVG											86.205	94.189	8.841			5.8	16.3	64.4
S.D.											0.237	0.301	0.070			0.301	0.267	1.249
5.0-1	5.0	4815.5	127.6	116.4	2254.9	2057.0	2.398	2.188	2.398	2.497	87.606	96.035	9.334	5.00	1.00	4.0	15.8	75.0
5.0-2	5.0	4802.3	127.3	116.2	2249.6	2053.4	2.396	2.187	2.396	2.497	87.588	95.955	9.265	5.00	1.00	4.0	15.9	74.6
5.0-3	5.0	4808.8	127.5	116.5	2253.1	2058.7	2.395	2.188	2.395	2.497	87.640	95.915	9.163	5.00	1.00	4.1	15.9	74.4
AVG											87.611	95.968	9.254			4.0	15.9	74.6
S.D.											0.026	0.061	0.086			0.061	0.054	0.300
5.5-1	5.5	4859.7	128.3	116.8	2267.2	2064.0	2.414	2.198	2.414	2.476	88.757	97.496	9.677	5.50	0.91	2.5	15.7	84.1
5.5-2	5.5	4831.8	127.5	116.1	2253.1	2051.7	2.419	2.203	2.419	2.476	88.963	97.698	9.673	5.50	0.91	2.3	15.6	85.2
5.5-3	5.5	4842.9	127.9	116.6	2260.2	2060.5	2.413	2.200	2.413	2.476	88.845	97.456	9.534	5.50	0.91	2.5	15.8	83.9
AVG											88.855	97.550	9.628			2.5	15.7	84.4
S.D.											0.103	0.130	0.081			0.130	0.112	0.719

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Coarse Gradation, 68 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-C-68

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.025; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse) = 2.707; Bulk SG Agg. (Gsb) = 2.707; Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.0-1	4.0	4737.2	126.5	116.1	2235.4	2051.7	2.375	2.180	2.375	2.539	85.850	93.541	7.788	4.00	1.25	6.5	15.8	59.1
4.0-2	4.0	4749.4	126.5	115.7	2235.4	2044.6	2.388	2.184	2.388	2.539	86.023	94.053	8.132	4.00	1.25	5.9	15.3	61.2
4.0-3	4.0	4741.4	126.4	115.7	2233.7	2044.6	2.378	2.177	2.378	2.539	85.731	93.659	8.029	4.00	1.25	6.3	15.7	59.5
AVG											85.868	93.751	7.983			6.2	15.6	59.9
S.D.											0.147	0.268	0.176			0.268	0.241	1.107
4.5-1	4.5	4811.4	126.3	115.1	2231.9	2034.0	2.420	2.205	2.420	2.518	87.585	96.108	8.631	4.50	1.11	3.9	14.6	73.4
4.5-2	4.5	4703.4	123.4	112.4	2180.7	1986.3	2.432	2.215	2.432	2.518	87.975	96.585	8.719	4.50	1.11	3.4	14.2	76.0
4.5-3	4.5	4967.1	129.0	118.7	2279.6	2097.6	2.414	2.221	2.414	2.518	88.215	95.870	7.752	4.50	1.11	4.1	14.8	72.2
AVG											87.925	96.187	8.368			3.8	14.6	73.8
S.D.											0.318	0.364	0.535			0.364	0.323	1.933
5.0-1	5.0	4839.2	126.1	114.8	2228.4	2028.7	2.442	2.223	2.442	2.497	89.034	97.797	8.875	5.00	1.00	2.2	14.3	84.6
5.0-2	5.0	4836.1	125.6	114.2	2219.5	2018.1	2.451	2.229	2.451	2.497	89.249	98.158	9.023	5.00	1.00	1.8	14.0	86.8
5.0-3	5.0	4842.3	126.5	115.2	2235.4	2035.8	2.434	2.217	2.434	2.497	88.770	97.477	8.818	5.00	1.00	2.5	14.6	82.7
AVG											89.017	97.811	8.906			2.2	14.3	84.7
S.D.											0.240	0.341	0.105			0.341	0.298	2.067

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Coarse Gradation, 93 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-C-93

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.744 | Effective SG Agg (Gse)= 2.707 | Bulk SG Agg. (Gsb) = 2.707 | Percent Absorbed Asphalt (Pba)= 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	*K*	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
3.5-1	3.5	4749.5	125.1	114.5	2210.7	2023.4	2.405	2.201	2.405	2.560	85.985	93.945	7.472	3.50	1.43	6.1	14.3	57.6
3.5-2	3.5	4753.2	126.6	115.6	2237.2	2042.8	2.398	2.190	2.398	2.560	85.533	93.672	7.639	3.50	1.43	6.3	14.5	56.4
3.5-3	3.5	4751.3	125.3	114.8	2214.2	2028.7	2.401	2.200	2.401	2.560	85.930	93.789	7.377	3.50	1.43	6.2	14.4	56.9
AVG											85.816	93.802	7.496			6.2	14.4	57.0
S.D.											0.247	0.137	0.133			0.137	0.125	0.579
4.0-1	4.0	4781.6	126.3	115.1	2231.9	2034.0	2.416	2.202	2.416	2.539	86.717	95.156	7.920	4.00	1.25	4.8	14.3	66.2
4.0-2	4.0	4765.9	125.3	114.1	2214.2	2016.3	2.417	2.201	2.417	2.539	86.686	95.195	7.987	4.00	1.25	4.8	14.3	66.4
4.0-3	4.0	4771.8	125.8	114.6	2223.1	2025.1	2.413	2.198	2.413	2.539	86.576	95.037	7.942	4.00	1.25	5.0	14.4	65.6
AVG											86.660	95.129	7.950			4.9	14.3	66.0
S.D.											0.074	0.082	0.034			0.082	0.074	0.396
4.5-1	4.5	4823.1	126.6	114.8	2237.2	2028.7	2.431	2.204	2.431	2.518	87.546	96.545	8.446	4.50	1.11	3.5	14.2	75.7
4.5-2	4.5	4801.2	126.2	114.5	2230.1	2023.4	2.429	2.204	2.429	2.518	87.522	96.465	8.394	4.50	1.11	3.5	14.3	75.3
4.5-3	4.5	4831.9	126.0	114.3	2226.6	2019.8	2.451	2.223	2.451	2.518	88.301	97.339	8.484	4.50	1.11	2.7	13.5	80.3
AVG											87.790	96.783	8.442			3.2	14.0	77.1
S.D.											0.443	0.483	0.045			0.483	0.429	2.793

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Coarse Gradation, 113 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-C-113

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]; Apparent SG Agg. (Gsa) = 2.744; Effective SG Agg (Gse) = 2.707; Bulk SG Agg. (Gsb) = 2.707; Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/J)										
3.5-1	3.5	4733.4	125.7	114.5	2221.3	2023.4	2.393	2.180	2.393	2.560	85.148	93.477	7.243	3.50	1.43	6.5	14.7	55.6
3.5-2	3.5	4730.1	125.7	114.4	2221.3	2021.6	2.393	2.178	2.393	2.560	85.073	93.477	7.307	3.50	1.43	6.5	14.7	55.6
3.5-3	3.5	4745.0	125.8	114.5	2223.1	2023.4	2.396	2.181	2.396	2.560	85.187	93.594	7.311	3.50	1.43	6.4	14.6	56.1
AVG											85.136	93.516	7.287			6.5	14.7	55.8
S.D.											0.058	0.068	0.038			0.068	0.062	0.276
4.0-1	4.0	4775.1	125.7	114.1	2221.3	2016.3	2.419	2.196	2.419	2.539	86.482	95.274	7.645	4.00	1.25	4.7	14.2	66.7
4.0-2	4.0	4780.4	126.3	114.5	2231.9	2023.4	2.414	2.188	2.414	2.539	86.194	95.077	7.724	4.00	1.25	4.9	14.4	65.8
4.0-3	4.0	4772.4	126.1	114.2	2228.4	2018.1	2.416	2.188	2.416	2.539	86.176	95.156	7.809	4.00	1.25	4.8	14.3	66.2
AVG											86.284	95.169	7.726			4.8	14.3	66.2
S.D.											0.172	0.099	0.082			0.099	0.089	0.483
4.5-1	4.5	4792.6	125.5	113.5	2217.8	2005.7	2.438	2.205	2.438	2.518	87.565	96.823	8.050	4.50	1.11	3.2	14.0	77.3
4.5-2	4.5	4801.7	126.0	113.9	2226.6	2012.8	2.444	2.209	2.444	2.518	87.740	97.061	8.105	4.50	1.11	2.9	13.8	78.7
4.5-3	4.5	4814.6	125.9	113.7	2224.8	2009.2	2.443	2.206	2.443	2.518	87.620	97.021	8.175	4.50	1.11	3.0	13.8	78.4
AVG											87.642	96.968	8.110			3.0	13.9	78.1
S.D.											0.090	0.128	0.063			0.128	0.113	0.739

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Coarse Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-C-139

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm = 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.744 | Effective SG Agg (Gse) = 2.707 | Bulk SG Agg. (Gsb) = 2.707 | Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
3.5-1	3.5	4748.3	125.3	114.0	2214.2	2014.5	2.409	2.192	2.409	2.560	85.615	94.102	7.139	3.50	1.43	5.9	14.1	58.2
3.5-2	3.5	4761.6	125.7	114.4	2221.3	2021.6	2.407	2.191	2.407	2.560	85.571	94.023	7.110	3.50	1.43	6.0	14.2	57.9
3.5-3	3.5	4742.4	125.5	114.2	2217.8	2018.1	2.401	2.185	2.401	2.560	85.344	93.789	7.104	3.50	1.43	6.2	14.4	56.9
AVG											85.510	93.971	7.118			6.0	14.2	57.7
S.D.											0.145	0.163	0.019			0.163	0.148	0.698
4.0-1	4.0	4772.8	125.4	113.7	2216.0	2009.2	2.430	2.203	2.430	2.539	86.777	95.707	7.512	4.00	1.25	4.3	13.8	68.9
4.0-2	4.0	4776.0	125.7	113.9	2221.3	2012.8	2.428	2.200	2.428	2.539	86.651	95.628	7.552	4.00	1.25	4.4	13.9	68.5
4.0-3	4.0	4776.2	126.2	114.4	2230.1	2021.6	2.426	2.199	2.426	2.539	86.615	95.549	7.515	4.00	1.25	4.5	14.0	68.1
AVG											86.681	95.628	7.526			4.4	13.9	68.5
S.D.											0.085	0.079	0.022			0.079	0.071	0.406
4.5-1	4.5	4796.1	125.0	113.0	2208.9	1996.9	2.453	2.218	2.453	2.518	88.066	97.419	7.867	4.50	1.11	2.6	13.5	80.8
4.5-2	4.5	4801.3	125.1	112.9	2210.7	1995.1	2.458	2.218	2.458	2.518	88.097	97.617	8.008	4.50	1.11	2.4	13.3	82.1
4.5-3	4.5	4810.1	125.3	113.5	2214.2	2005.7	2.450	2.219	2.450	2.518	88.136	97.299	7.708	4.50	1.11	2.7	13.6	80.1
AVG											88.100	97.445	7.861			2.6	13.4	81.0
S.D.											0.035	0.161	0.150			0.161	0.143	0.995

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Georgia Granite , Coarse Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: GA GRAN-C-172

MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.020 | Apparent SG Agg. (Gsa) = 2.744 | Effective SG Agg (Gse) = 2.707 | Bulk SG Agg. (Gsb) = 2.707 | Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E	C/G*J/(C/J)											
3.5-1	3.5	4766.8	124.5	113.2	2200.1	2000.4	2.426	2.206	2.426	2.560	86.164	94.766	6.962	3.50	1.43	5.2	13.5	61.3
3.5-2	3.5	4744.2	124.3	113.0	2196.6	1996.9	2.425	2.205	2.425	2.560	86.115	94.727	6.970	3.50	1.43	5.3	13.6	61.1
3.5-3	3.5	4714.7	123.7	112.4	2186.0	1986.3	2.414	2.193	2.414	2.560	85.683	94.297	6.972	3.50	1.43	5.7	13.9	59.1
AVG											85.987	94.596	6.968			5.4	13.7	60.5
S.D.											0.265	0.260	0.005			0.260	0.237	1.205
4.0-1	4.0	4768.5	124.7	112.8	2203.6	1993.3	2.440	2.207	2.440	2.539	86.930	96.101	7.423	4.00	1.25	3.9	13.5	71.1
4.0-2	4.0	4767.3	123.7	112.1	2186.0	1981.0	2.450	2.220	2.450	2.539	87.446	96.495	7.324	4.00	1.25	3.5	13.1	73.3
4.0-3	4.0	4773.8	124.8	113.0	2205.4	1996.9	2.438	2.207	2.438	2.539	86.943	96.022	7.348	4.00	1.25	4.0	13.5	70.6
AVG											87.106	96.206	7.365			3.8	13.4	71.6
S.D.											0.294	0.253	0.051			0.253	0.228	1.422
4.5-1	4.5	4801.3	124.9	112.6	2207.2	1989.8	2.460	2.218	2.460	2.518	88.076	97.697	7.787	4.50	1.11	2.3	13.2	82.6
4.5-2	4.5	4790.0	124.0	112.0	2191.3	1979.2	2.466	2.227	2.466	2.518	88.457	97.935	7.671	4.50	1.11	2.1	13.0	84.1
4.5-3	4.5	4815.7	124.0	112.1	2191.3	1981.0	2.474	2.237	2.474	2.518	88.824	98.253	7.632	4.50	1.11	1.7	12.7	86.3
AVG											88.452	97.961	7.696			2.0	13.0	84.3
S.D.											0.374	0.279	0.081			0.279	0.248	1.855

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone, Fine Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-F-40

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.02[illegible] | Apparent SG Agg. (Gsa) = 2.736 | Effective SG Agg (Gse) = 2.731 | Bulk SG Agg. (Gsb) = 2.685 | Percent Absorbed Asphalt (Pba) = 0.64

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
4.5-1	4.5	4803.8	122.7	113.2	2168.3	2000.4	2.436	2.247	2.436	2.541	88.445	95.868	8.219	3.88	1.29	4.1	13.4	69.1
4.5-2	4.5	4774.2	121.4	112.1	2145.3	1981.0	2.444	2.257	2.444	2.541	88.814	96.183	8.159	3.88	1.29	3.8	13.1	70.8
4.5-3	4.5	4794.5	121.8	113.0	2152.4	1996.9	2.436	2.260	2.436	2.541	88.941	95.868	7.670	3.88	1.29	4.1	13.4	69.1
AVG											88.734	95.973	8.016			4.0	13.3	69.6
S.D.											0.258	0.182	0.301			0.182	0.164	1.002
5.0-1	5.0	4836.3	122.6	113.2	2166.5	2000.4	2.449	2.261	2.449	2.521	89.696	97.144	8.247	4.39	1.14	2.9	13.4	78.6
5.0-2	5.0	4795.0	121.7	112.4	2150.6	1986.3	2.449	2.262	2.449	2.521	89.720	97.144	8.220	4.39	1.14	2.9	13.4	78.6
5.0-3	5.0	4826.8	122.8	113.3	2170.1	2002.2	2.449	2.260	2.449	2.521	89.629	97.144	8.322	4.39	1.14	2.9	13.4	78.6
AVG											89.682	97.144	8.263			2.9	13.4	78.6
S.D.											0.047	0.000	0.053			0.000	0.000	0.000
5.5-1	5.5	4812.3	121.8	112.4	2152.4	1986.3	2.458	2.268	2.458	2.503	90.623	98.202	8.392	4.89	1.02	1.8	13.5	86.7
5.5-2	5.5	4879.0	123.3	113.9	2178.9	2012.8	2.451	2.264	2.451	2.503	90.457	97.922	8.266	4.89	1.02	2.1	13.7	84.9
5.5-3	5.5	4828.8	122.1	112.5	2157.7	1988.0	2.464	2.270	2.464	2.503	90.702	98.442	8.570	4.89	1.02	1.6	13.3	88.3
AVG											90.594	98.189	8.410			1.8	13.5	86.6
S.D.											0.125	0.260	0.153			0.260	0.229	1.696

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Fine Gradation, 68 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-F-68

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.736

Effective SG Agg (Gse)= 2.731

Bulk SG Agg. (Gsb) = 2.685

Percent Absorbed Asphalt (Pba)= 0.64

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
3.5-1	3.5	4750.6	120.8	111.6	2134.7	1972.1	2.441	2.255	2.441	2.580	87.407	94.612	7.297	2.88	1.74	5.4	12.3	56.1
3.5-2	3.5	4746.8	121.1	112.0	2140.0	1979.2	2.439	2.256	2.439	2.580	87.431	94.535	7.194	2.88	1.74	5.5	12.3	55.7
3.5-3	3.5	4750.9	121.5	112.6	2147.1	1989.8	2.416	2.239	2.416	2.580	86.784	93.643	6.947	2.88	1.74	6.4	13.2	51.7
AVG											87.207	94.264	7.146			5.7	12.6	54.5
S.D.											0.367	0.538	0.180			0.538	0.499	2.418
4.0-1	4.0	4773.9	121.7	112.2	2150.6	1982.7	2.438	2.248	2.438	2.561	87.766	95.197	7.526	3.38	1.48	4.8	12.8	62.6
4.0-2	4.0	4777.0	121.8	112.5	2152.4	1988.0	2.433	2.247	2.433	2.561	87.748	95.002	7.346	3.38	1.48	5.0	13.0	61.6
4.0-3	4.0	4777.8	121.9	112.4	2154.2	1986.3	2.439	2.249	2.439	2.561	87.814	95.236	7.517	3.38	1.48	4.8	12.8	62.8
AVG											87.776	95.145	7.463			4.9	12.9	62.3
S.D.											0.034	0.126	0.101			0.126	0.115	0.635
4.5-1	4.5	4800.2	121.9	112.7	2154.2	1991.6	2.439	2.255	2.439	2.541	88.742	95.986	7.337	3.88	1.29	4.0	13.2	69.7
4.5-2	4.5	4810.2	121.7	112.1	2150.6	1981.0	2.461	2.267	2.461	2.541	89.212	96.852	7.737	3.88	1.29	3.1	12.5	74.7
4.5-3	4.5	4805.1	121.0	111.4	2138.2	1968.6	2.470	2.274	2.470	2.541	89.494	97.206	7.811	3.88	1.29	2.8	12.1	77.0
AVG											89.149	96.681	7.628			3.3	12.6	73.8
S.D.											0.380	0.628	0.255			0.628	0.567	3.735

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Fine Gradation, 113 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-F-113			MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcite Mineral Filler											Percent Passing 0.075 mm		5		
AC Sp. Gr. (Gb) =		1.028	Apparent SG Agg. (Gsa) = 2.736		Effective SG Agg (Gse)= 2.731		Bulk SG Agg. (Gsb) = 2.685			Percent Absorbed Asphalt (Pba)= 0.64								
			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
3.0-1	3.0	4737.7	120.8	111.2	2134.7	1965.1	2.446	2.252	2.446	2.599	86.634	94.113	6.504	2.37	2.11	5.9	11.6	49.4
3.0-2	3.0	4723.3	121.5	111.9	2147.1	1977.4	2.422	2.231	2.422	2.599	85.827	93.190	6.403	2.37	2.11	6.8	12.5	45.5
3.0-3	3.0	4717.0	122.7	113.1	2168.3	1998.6	2.387	2.200	2.387	2.599	84.657	91.843	6.249	2.37	2.11	8.2	13.8	40.7
AVG											85.706	93.049	6.385			7.0	12.6	45.2
S.D.											0.994	1.142	0.129			1.142	1.072	4.336
3.5-1	3.5	4753.1	121.7	111.6	2150.6	1972.1	2.441	2.238	2.441	2.580	86.760	94.612	6.828	2.88	1.74	5.4	12.3	56.1
3.5-2	3.5	4769.9	121.0	111.1	2138.2	1963.3	2.459	2.258	2.459	2.580	87.512	95.310	6.781	2.88	1.74	4.7	11.6	59.6
3.5-3	3.5	4662.6	119.1	108.9	2104.7	1924.4	2.456	2.246	2.456	2.580	87.041	95.194	7.089	2.88	1.74	4.8	11.7	59.0
AVG											87.105	95.039	6.899			5.0	11.9	58.3
S.D.											0.380	0.374	0.166			0.374	0.347	1.901
4.0-1	4.0	4772.9	120.2	109.9	2124.1	1942.1	2.484	2.271	2.484	2.561	88.682	96.993	7.227	3.38	1.48	3.0	11.2	73.1
4.0-2	4.0	4774.3	122.3	112.4	2161.2	1986.3	2.480	2.279	2.480	2.561	88.998	96.837	6.816	3.38	1.48	3.2	11.3	72.1
4.0-3	4.0	4777.0	122.4	112.4	2163.0	1986.3	2.480	2.277	2.480	2.561	88.926	96.837	6.880	3.38	1.48	3.2	11.3	72.1
AVG											88.869	96.889	6.974			3.1	11.3	72.4
S.D.											0.166	0.090	0.221			0.090	0.083	0.600

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Fine Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-F-139

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.736 | Effective SG Agg (Gse)= 2.731 | Bulk SG Agg. (Gsb) = 2.685 | Percent Absorbed Asphalt (Pba)= 0.64

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
3.0-1	3.0	4745.7	122.0	112.3	2155.9	1984.5	2.422	2.229	2.422	2.599	85.780	93.190	6.233	2.37	2.11	6.8	12.5	45.5
3.0-2	3.0	4735.8	122.2	112.6	2159.5	1989.8	2.417	2.227	2.417	2.599	85.691	92.997	6.146	2.37	2.11	7.0	12.7	44.8
3.0-3	3.0	4729.4	122.3	112.6	2161.2	1989.8	2.423	2.231	2.423	2.599	85.834	93.228	6.220	2.37	2.11	6.8	12.5	45.7
AVG											85.769	93.138	6.200			6.9	12.5	45.3
S.D.											0.072	0.124	0.047			0.124	0.116	0.477
3.5-1	3.5	4760.3	121.9	112.1	2154.2	1981.0	2.449	2.252	2.449	2.580	87.291	94.922	6.419	2.88	1.74	5.1	12.0	57.6
3.5-2	3.5	4762.5	121.9	112.2	2154.2	1982.7	2.453	2.258	2.453	2.580	87.512	95.078	6.364	2.88	1.74	4.9	11.8	58.4
3.5-3	3.5	4718.6	121.3	111.4	2143.5	1968.6	2.458	2.257	2.458	2.580	87.496	95.271	6.541	2.88	1.74	4.7	11.7	59.4
AVG											87.433	95.090	6.442			4.9	11.8	58.5
S.D.											0.123	0.175	0.090			0.175	0.162	0.911
4.0-1	4.0	4773.4	121.6	111.4	2148.8	1968.6	2.483	2.275	2.483	2.561	88.822	96.954	6.841	3.38	1.48	3.0	11.2	72.9
4.0-2	4.0	4765.7	121.3	111.1	2143.5	1963.3	2.486	2.277	2.486	2.561	88.909	97.071	6.866	3.38	1.48	2.9	11.1	73.7
4.0-3	4.0	4781.1	122.0	111.8	2155.9	1975.7	2.488	2.280	2.488	2.561	89.027	97.150	6.833	3.38	1.48	2.9	11.0	74.2
AVG											88.919	97.058	6.847			2.9	11.1	73.6
S.D.											0.103	0.098	0.018			0.098	0.090	0.668

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Fine Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-F-172

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]; Apparent SG Agg. (Gsa) = 2.736; Effective SG Agg (Gse) = 2.731; Bulk SG Agg. (Gsb) = 2.685; Percent Absorbed Asphalt (Pba) = 0.64

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
3.0-1	3.0	4708.3	118.5	109.3	2094.1	1931.5	2.442	2.252	2.442	2.599	86.664	93.959	5.904	2.37	2.11	6.0	11.8	48.7
3.0-2	3.0	4736.9	118.6	109.6	2095.8	1936.8	2.435	2.250	2.435	2.599	86.580	93.690	5.754	2.37	2.11	6.3	12.0	47.6
3.0-3	3.0	4726.5	118.9	109.8	2101.1	1940.3	2.430	2.244	2.430	2.599	86.342	93.497	5.792	2.37	2.11	6.5	12.2	46.8
AVG											86.529	93.716	5.817			6.3	12.0	47.7
S.D.											0.167	0.232	0.078			0.232	0.218	0.986
3.5-1	3.5	4753.3	121.7	111.6	2150.6	1972.1	2.463	2.259	2.463	2.580	87.542	95.465	6.412	2.88	1.74	4.5	11.5	60.5
3.5-2	3.5	4753.0	121.7	111.6	2150.6	1972.1	2.468	2.263	2.468	2.580	87.720	95.659	6.425	2.88	1.74	4.3	11.3	61.6
3.5-3	3.5	4752.2	121.7	111.7	2150.6	1973.9	2.460	2.258	2.460	2.580	87.514	95.349	6.341	2.88	1.74	4.7	11.6	59.9
AVG											87.592	95.491	6.393			4.5	11.5	60.6
S.D.											0.112	0.157	0.045			0.157	0.145	0.871
4.0-1	4.0	4774.8	121.6	111.4	2148.8	1968.6	2.488	2.279	2.488	2.561	89.000	97.150	6.596	3.38	1.48	2.9	11.0	74.2
4.0-2	4.0	4787.2	119.1	109.2	2104.7	1929.7	2.489	2.282	2.489	2.561	89.110	97.189	6.539	3.38	1.48	2.8	11.0	74.5
4.0-3	4.0	4769.7	121.2	110.9	2141.8	1959.8	2.492	2.280	2.492	2.561	89.036	97.306	6.693	3.38	1.48	2.7	10.9	75.3
AVG											89.049	97.215	6.609			2.8	11.0	74.6
S.D.											0.056	0.081	0.078			0.081	0.074	0.570

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Coarse Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-C-40

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.741; Effective SG Agg (Gse) = 2.728; Bulk SG Agg. (Gsb) = 2.699; Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
4.5-1	4.5	4784.0	127.4	114.9	2251.3	2030.5	2.405	2.169	2.405	2.539	85.429	94.722	10.291	4.11	1.22	5.3	14.9	64.6
4.5-2	4.5	4783.7	127.0	114.4	2244.3	2021.6	2.408	2.169	2.408	2.539	85.431	94.840	10.419	4.11	1.22	5.2	14.8	65.1
4.5-3	4.5	4785.6	128.3	115.3	2267.2	2037.5	2.408	2.164	2.408	2.539	85.231	94.840	10.641	4.11	1.22	5.2	14.8	65.1
AVG											85.363	94.801	10.450			5.2	14.8	64.9
S.D.											0.115	0.068	0.177			0.068	0.061	0.314
5.0-1	5.0	4816.9	128.6	115.1	2272.5	2034.0	2.424	2.170	2.424	2.520	86.093	96.190	11.181	4.62	1.08	3.8	14.7	74.0
5.0-2	5.0	4810.5	127.4	114.7	2251.3	2026.9	2.431	2.189	2.431	2.520	86.852	96.468	10.648	4.62	1.08	3.5	14.4	75.5
5.0-3	5.0	4810.5	128.5	115.0	2270.8	2032.2	2.425	2.170	2.425	2.520	86.120	96.230	11.195	4.62	1.08	3.8	14.6	74.3
AVG											86.355	96.296	11.008			3.7	14.6	74.6
S.D.											0.430	0.150	0.312			0.150	0.133	0.802
5.5-1	5.5	4810.4	126.9	114.0	2242.5	2014.5	2.450	2.201	2.450	2.501	88.003	97.961	11.027	5.12	0.98	2.0	14.2	85.7
5.5-2	5.5	4819.1	126.4	113.8	2233.7	2011.0	2.447	2.203	2.447	2.501	88.088	97.841	10.800	5.12	0.98	2.2	14.3	84.9
5.5-3	5.5	4822.3	127.2	114.3	2247.8	2019.8	2.440	2.193	2.440	2.501	87.667	97.561	10.956	5.12	0.98	2.4	14.6	83.3
AVG											87.919	97.788	10.927			2.2	14.4	84.6
S.D.											0.223	0.205	0.116			0.205	0.180	1.230

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Coarse Gradation, 68 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-C-68

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.741 | Effective SG Agg (Gse) = 2.728 | Bulk SG Agg. (Gsb) = 2.699 | Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
4.0-1	4.0	4761.4	125.7	112.8	2221.3	1993.3	2.440	2.190	2.440	2.558	85.598	95.387	9.914	3.61	1.38	4.6	13.2	65.1
4.0-2	4.0	4790.3	126.1	112.9	2228.4	1995.1	2.448	2.192	2.448	2.558	85.682	95.700	10.145	3.61	1.38	4.3	12.9	66.7
4.0-3	4.0	4766.3	125.7	112.6	2221.3	1989.8	2.441	2.187	2.441	2.558	85.481	95.426	10.072	3.61	1.38	4.6	13.2	65.3
AVG											85.587	95.504	10.044			4.5	13.1	65.7
S.D.											0.101	0.170	0.118			0.170	0.155	0.900
4.5-1	4.5	4784.0	127.4	112.9	2251.3	1995.1	2.454	2.175	2.454	2.539	85.652	96.652	11.141	4.11	1.22	3.3	13.2	74.6
4.5-2	4.5	4806.8	126.5	113.2	2235.4	2000.4	2.459	2.200	2.459	2.539	86.667	96.849	10.312	4.11	1.22	3.2	13.0	75.7
4.5-3	4.5	4784.5	125.9	112.6	2224.8	1989.8	2.461	2.201	2.461	2.539	86.689	96.928	10.370	4.11	1.22	3.1	12.9	76.2
AVG											86.336	96.810	10.608			3.2	13.0	75.5
S.D.											0.592	0.142	0.463			0.142	0.128	0.847
5.0-1	5.0	4815.3	126.3	112.9	2231.9	1995.1	2.484	2.220	2.484	2.520	88.113	98.571	10.591	4.62	1.08	1.4	12.6	88.6
5.0-2	5.0	4825.1	126.4	112.9	2233.7	1995.1	2.473	2.209	2.447	2.520	87.654	97.103	9.570	4.62	1.08	2.9	13.9	79.1
5.0-3	5.0	4800.3	126.5	113.0	2235.4	1996.9	2.460	2.197	2.460	2.520	87.201	97.619	10.551	4.62	1.08	2.4	13.4	82.2
AVG											87.656	97.765	10.237			2.2	13.3	83.3
S.D.											0.456	0.745	0.578			0.745	0.661	4.851

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone, Coarse Gradation, 93 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-C-93

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]; Apparent SG Agg. (Gsa) = 2.741; Effective SG Agg (Gse) = 2.728; Bulk SG Agg. (Gsb) = 2.699; Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
3.5-1	3.5	4740.6	125.2	111.9	2212.5	1977.4	2.452	2.192	2.452	2.577	85.042	95.149	9.487	3.11	1.61	4.9	12.3	60.7
3.5-2	3.5	4754.4	125.6	112.2	2219.5	1982.7	2.451	2.190	2.451	2.577	84.963	95.111	9.524	3.11	1.61	4.9	12.4	60.5
3.5-3	3.5	4744.2	125.1	111.9	2210.7	1977.4	2.453	2.194	2.453	2.577	85.144	95.188	9.427	3.11	1.61	4.8	12.3	60.9
AVG											85.050	95.149	9.480			4.9	12.3	60.7
S.D.											0.091	0.039	0.049			0.039	0.036	0.201
4.0-1	4.0	4767.2	125.7	112.3	2221.3	1984.5	2.458	2.196	2.458	2.558	85.847	96.091	9.615	3.61	1.38	3.9	12.6	68.9
4.0-2	4.0	4779.8	125.6	112.1	2219.5	1981.0	2.469	2.204	2.469	2.558	86.146	96.521	9.738	3.61	1.38	3.5	12.2	71.4
4.0-3	4.0	4782.7	126.1	112.5	2228.4	1988.0	2.456	2.191	2.456	2.558	85.657	96.013	9.719	3.61	1.38	4.0	12.6	68.5
AVG											85.884	96.208	9.691			3.8	12.5	69.6
S.D.											0.246	0.274	0.066			0.274	0.249	1.605
4.5-1	4.5	4806.3	125.0	111.4	2208.9	1968.6	2.479	2.209	2.479	2.539	87.014	97.637	9.971	4.11	1.22	2.4	12.3	80.8
4.5-2	4.5	4782.2	125.2	111.6	2212.5	1972.1	2.495	2.224	2.495	2.539	87.593	98.267	10.019	4.11	1.22	1.7	11.7	85.2
4.5-3	4.5	4790.0	126.2	112.3	2230.1	1984.5	2.485	2.211	2.485	2.539	87.093	97.873	10.118	4.11	1.22	2.1	12.1	82.4
AVG											87.233	97.926	10.036			2.1	12.0	82.8
S.D.											0.314	0.318	0.075			0.318	0.286	2.251

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Coarse Gradation, 113 Gyrations

SGC: Pine Gyratory Compactor

MIX ID: AL LMS-C-113

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]

Apparent SG Agg. (Gsa) = 2.741

Effective SG Agg (Gse) = 2.728

Bulk SG Agg. (Gsb) = 2.699

Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
3.5-1	3.5	4738.5	125.8	111.3	2223.1	1966.8	2.461	2.177	2.461	2.577	84.491	95.499	9.572	3.11	1.61	4.5	12.0	62.5
3.5-2	3.5	4752.7	126.1	111.4	2228.4	1968.6	2.468	2.180	2.468	2.577	84.606	95.770	9.708	3.11	1.61	4.2	11.8	64.0
3.5-3	3.5	4751.9	125.2	111.1	2212.5	1963.3	2.472	2.194	2.472	2.577	85.122	95.925	9.394	3.11	1.61	4.1	11.6	64.9
AVG											84.740	95.731	9.558			4.3	11.8	63.8
S.D.											0.336	0.216	0.158			0.216	0.199	1.216
4.0-1	4.0	4774.8	124.9	110.6	2207.2	1954.5	2.496	2.210	2.496	2.558	86.405	97.576	9.715	3.61	1.38	2.4	11.2	78.4
4.0-2	4.0	4785.8	126.0	111.1	2226.6	1963.3	2.490	2.196	2.490	2.558	85.831	97.342	10.010	3.61	1.38	2.7	11.4	76.8
4.0-3	4.0	4778.3	125.4	111.0	2216.0	1961.5	2.492	2.206	2.492	2.558	86.233	97.420	9.728	3.61	1.38	2.6	11.4	77.3
AVG											86.156	97.446	9.817			2.6	11.3	77.5
S.D.											0.295	0.119	0.167			0.119	0.109	0.840
4.5-1	4.5	4832.2	126.6	111.3	2237.2	1966.8	2.506	2.203	2.506	2.539	86.772	98.700	10.372	4.11	1.22	1.3	11.3	88.5
4.5-2	4.5	4793.8	125.9	110.6	2224.8	1954.5	2.504	2.200	2.504	2.539	86.637	98.622	10.422	4.11	1.22	1.4	11.4	87.9
4.5-3	4.5	4781.3	125.6	110.4	2219.5	1950.9	2.502	2.199	2.502	2.539	86.617	98.543	10.370	4.11	1.22	1.5	11.5	87.3
AVG											86.675	98.622	10.388			1.4	11.4	87.9
S.D.											0.084	0.079	0.029			0.079	0.071	0.616

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Coarse Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-C-139

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.0??

Apparent SG Agg. (Gsa) = 2.741 | Effective SG Agg (Gse) = 2.728 | Bulk SG Agg. (Gsb) = 2.699 | Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
3.0-1	3.0	4731.2	124.8	110.9	2205.4	1959.8	2.468	2.193	2.468	2.596	84.481	95.069	8.907	2.61	1.92	4.9	11.3	56.4
3.0-2	3.0	4731.3	125.2	111.1	2212.5	1963.3	2.458	2.181	2.458	2.596	84.021	94.684	8.970	2.61	1.92	5.3	11.7	54.4
3.0-3	3.0	4733.6	126.1	111.5	2228.4	1970.4	2.458	2.173	2.458	2.596	83.721	94.684	9.222	2.61	1.92	5.3	11.7	54.4
AVG											84.074	94.813	9.033			5.2	11.5	55.1
S.D.											0.382	0.222	0.166			0.222	0.207	1.131
3.5-1	3.5	4751.4	125.0	110.6	2208.9	1954.5	2.485	2.199	2.485	2.577	85.321	96.430	9.345	3.11	1.61	3.6	11.2	68.0
3.5-2	3.5	4751.6	125.5	110.9	2217.8	1959.8	2.481	2.192	2.481	2.577	85.075	96.275	9.422	3.11	1.61	3.7	11.3	67.0
3.5-3	3.5	4752.7	125.1	110.7	2210.7	1956.2	2.484	2.198	2.484	2.577	85.296	96.391	9.333	3.11	1.61	3.6	11.2	67.7
AVG											85.231	96.365	9.367			3.6	11.2	67.6
S.D.											0.136	0.081	0.048			0.081	0.074	0.504
4.0-1	4.0	4763.5	124.3	109.6	2196.6	1936.8	2.511	2.214	2.511	2.558	86.554	98.163	9.765	3.61	1.38	1.8	10.7	82.8
4.0-2	4.0	4781.8	124.6	109.9	2201.9	1942.1	2.512	2.216	2.512	2.558	86.616	98.202	9.746	3.61	1.38	1.8	10.7	83.1
4.0-3	4.0	4773.5	124.8	110.0	2205.4	1943.9	2.506	2.209	2.506	2.558	86.349	97.967	9.773	3.61	1.38	2.0	10.9	81.3
AVG											86.506	98.111	9.761			1.9	10.7	82.4
S.D.											0.140	0.126	0.014			0.126	0.114	0.978

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone , Coarse Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: AL LMS-C-172

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm = 5

AC Sp. Gr. (Gb) = 1.020 | Apparent SG Agg. (Gsa) = 2.741 | Effective SG Agg (Gse) = 2.728 | Bulk SG Agg. (Gsb) = 2.699 | Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
3.0-1	3.0	4730.6	123.7	109.8	2186.0	1940.3	2.487	2.208	2.487	2.596	85.036	95.801	8.713	2.61	1.92	4.2	10.6	60.5
3.0-2	3.0	4738.7	124.7	110.6	2203.6	1954.5	2.475	2.195	2.475	2.596	84.559	95.339	8.725	2.61	1.92	4.7	11.1	57.8
3.0-3	3.0	4729.8	124.4	110.5	2198.3	1952.7	2.479	2.202	2.479	2.596	84.823	95.493	8.636	2.61	1.92	4.5	10.9	58.7
AVG											84.806	95.544	8.691			4.5	10.9	59.0
S.D.											0.239	0.235	0.048			0.235	0.220	1.347
3.5-1	3.5	4647.5	120.4	106.6	2127.6	1883.8	2.516	2.228	2.516	2.577	86.442	97.633	9.057	3.11	1.61	2.4	10.0	76.4
3.5-2	3.5	4754.4	124.3	109.9	2196.6	1942.1	2.500	2.210	2.500	2.577	85.773	97.012	9.096	3.11	1.61	3.0	10.6	71.9
3.5-3	3.5	4759.1	124.0	109.5	2191.3	1935.0	2.508	2.215	2.508	2.577	85.942	97.322	9.211	3.11	1.61	2.7	10.3	74.1
AVG											86.053	97.322	9.122			2.7	10.3	74.1
S.D.											0.348	0.310	0.080			0.310	0.286	2.290
4.0-1	4.0	4769.3	123.7	109.2	2186.0	1929.7	2.526	2.230	2.526	2.558	87.174	98.749	9.369	3.61	1.38	1.3	10.2	87.7
4.0-2	4.0	4770.2	123.4	108.9	2180.7	1924.4	2.524	2.227	2.524	2.558	87.077	98.671	9.384	3.61	1.38	1.3	10.2	87.0
4.0-3	4.0	4778.1	123.7	109.3	2186.0	1931.5	2.525	2.231	2.525	2.558	87.219	98.710	9.300	3.61	1.38	1.3	10.2	87.3
AVG											87.156	98.710	9.351			1.3	10.2	87.3
S.D.											0.073	0.039	0.045			0.039	0.036	0.339

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Fine Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV-GRV-F-40

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible] | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse) = 2.650 | Bulk SG Agg. (Gsb) = 2.554 | Percent Absorbed Asphalt (Pba) = 1.46

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
6.0-1	6.0	4758.8	127.6	118.5	2254.9	2094.1	2.303	2.139	2.303	2.420	88.378	95.165	7.515	4.63	1.08	4.8	15.2	68.3
6.0-2	6.0	4740.3	125.7	116.5	2221.3	2058.7	2.328	2.158	2.328	2.420	89.158	96.198	7.796	4.63	1.08	3.8	14.3	73.4
6.0-3	6.0	4743.8	127.0	117.8	2244.3	2081.7	2.305	2.138	2.305	2.420	88.348	95.248	7.640	4.63	1.08	4.8	15.2	68.7
AVG											88.628	95.537	7.651			4.5	14.9	70.1
S.D.											0.459	0.574	0.141			0.574	0.511	2.882
6.5-1	6.5	4786.2	127.0	117.5	2244.3	2076.4	2.334	2.159	2.334	2.403	89.863	97.129	8.045	5.14	0.97	2.9	14.6	80.3
6.5-2	6.5	4759.1	126.1	116.8	2228.4	2064.0	2.332	2.160	2.332	2.403	89.888	97.045	7.925	5.14	0.97	3.0	14.6	79.8
6.5-3	6.5	4764.0	126.4	116.9	2233.7	2065.8	2.332	2.157	2.332	2.403	89.752	97.045	8.076	5.14	0.97	3.0	14.6	79.8
AVG											89.834	97.073	8.016			2.9	14.6	80.0
S.D.											0.073	0.048	0.080			0.048	0.042	0.271
7.0-1	7.0	4810.7	126.0	117.0	2226.6	2067.6	2.357	2.189	2.357	2.386	91.729	98.785	7.813	5.64	0.89	1.2	14.2	91.4
7.0-2	7.0	4775.5	126.9	117.5	2242.5	2076.4	2.328	2.156	2.328	2.386	90.342	97.569	8.003	5.64	0.89	2.4	15.2	84.0
7.0-3	7.0	4823.6	127.8	118.2	2258.4	2088.8	2.334	2.159	2.334	2.386	90.473	97.821	8.137	5.64	0.89	2.2	15.0	85.5
AVG											90.848	98.058	7.984			1.9	14.8	87.0
S.D.											0.766	0.642	0.162			0.642	0.557	3.915

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel, Fine Gradation, 68 Gyrations

SGC: Pine Gyratory Compactor

MIX ID: NV-GRV-F-68

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.020; Apparent SG Agg. (Gsa) = 2.722; Effective SG Agg (Gse) = 2.650; Bulk SG Agg. (Gsb) = 2.554; Percent Absorbed Asphalt (Pba) = 1.46

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/J)										
5.5-1	5.5	4714.2	125.7	116.6	2221.3	2060.5	2.312	2.145	2.312	2.437	88.003	94.871	6.956	4.12	1.21	5.1	14.5	64.5
5.5-2	5.5	4730.6	125.1	115.8	2210.7	2046.4	2.338	2.164	2.338	2.437	88.806	95.938	7.223	4.12	1.21	4.1	13.5	69.9
5.5-3	5.5	4712.3	124.6	115.3	2201.9	2037.5	2.345	2.170	2.345	2.437	89.043	96.225	7.274	4.12	1.21	3.8	13.2	71.5
AVG											88.617	95.678	7.151			4.3	13.7	68.6
S.D.											0.545	0.713	0.171			0.713	0.643	3.648
6.0-1	6.0	4766.9	124.9	115.4	2207.2	2039.3	2.367	2.187	2.367	2.420	90.370	97.810	7.534	4.63	1.08	2.2	12.9	83.0
6.0-2	6.0	4750.8	124.6	115.2	2201.9	2035.8	2.360	2.182	2.360	2.420	90.164	97.521	7.451	4.63	1.08	2.5	13.1	81.1
6.0-3	6.0	4751.3	124.8	115.2	2205.4	2035.8	2.359	2.178	2.359	2.420	89.981	97.479	7.594	4.63	1.08	2.5	13.2	80.9
AVG											90.172	97.603	7.526			2.4	13.1	81.7
S.D.											0.195	0.180	0.072			0.180	0.160	1.161
6.5-1	6.5	4790.7	126.8	116.9	2240.7	2065.8	2.342	2.159	2.342	2.403	89.852	97.462	7.706	5.14	0.97	2.5	14.3	82.2
6.5-2	6.5	4785.3	126.0	116.3	2226.6	2055.2	2.350	2.169	2.350	2.403	90.266	97.794	7.625	5.14	0.97	2.2	14.0	84.2
6.5-3	6.5	4778.7	126.4	116.7	2233.7	2062.3	2.348	2.168	2.348	2.403	90.213	97.711	7.594	5.14	0.97	2.3	14.0	83.7
AVG											90.110	97.656	7.642			2.3	14.1	83.4
S.D.											0.225	0.173	0.058			0.173	0.152	1.045

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Fine Gradation, 93 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV-GRV-F-93

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse)= 2.650 | Bulk SG Agg. (Gsb) = 2.554 | Percent Absorbed Asphalt (Pba)= 1.46

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
5.0-1	5.0	4686.7	125.0	115.5	2208.9	2041.1	2.320	2.144	2.320	2.454	87.355	94.540	6.744	3.61	1.38	5.5	13.7	60.2
5.0-2	5.0	4702.1	126.4	116.9	2233.7	2065.8	2.305	2.132	2.305	2.454	86.869	93.928	6.626	3.61	1.38	6.1	14.3	57.4
5.0-3	5.0	4689.3	125.2	115.7	2212.5	2044.6	2.320	2.144	2.320	2.454	87.366	94.540	6.733	3.61	1.38	5.5	13.7	60.2
AVG											87.196	94.336	6.701			5.7	13.9	59.2
S.D.											0.284	0.353	0.065			0.353	0.322	1.574
5.5-1	5.5	4710.6	125.4	115.7	2216.0	2044.6	2.326	2.146	2.326	2.437	88.062	95.445	6.930	4.12	1.21	4.6	13.9	67.3
5.5-2	5.5	4727.9	125.8	116.0	2223.1	2049.9	2.330	2.148	2.330	2.437	88.161	95.609	6.991	4.12	1.21	4.4	13.8	68.2
5.5-3	5.5	4570.3	122.1	112.4	2157.7	1986.3	2.329	2.144	2.329	2.437	87.976	95.568	7.126	4.12	1.21	4.4	13.8	67.9
AVG											88.067	95.541	7.016			4.5	13.8	67.8
S.D.											0.093	0.085	0.101			0.085	0.077	0.437
6.0-1	6.0	4760.5	125.9	115.9	2224.8	2048.1	2.349	2.162	2.349	2.420	89.356	97.066	7.237	4.63	1.08	2.9	13.5	78.3
6.0-2	6.0	4764.7	126.6	116.5	2237.2	2058.7	2.336	2.150	2.336	2.420	88.828	96.529	7.228	4.63	1.08	3.5	14.0	75.2
6.0-3	6.0	4755.3	126.5	116.4	2235.4	2057.0	2.333	2.147	2.333	2.420	88.708	96.405	7.225	4.63	1.08	3.6	14.1	74.6
AVG											88.964	96.667	7.230			3.3	13.9	76.1
S.D.											0.345	0.351	0.006			0.351	0.313	2.012

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Fine Gradation, 113 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV-GRV-F-113

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028

Apparent SG Agg. (Gsa) = 2.722; Effective SG Agg (Gse) = 2.650; Bulk SG Agg. (Gsb) = 2.554; Percent Absorbed Asphalt (Pba) = 1.46

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	MEASURED Bulk at Ndesign (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
5.0-1	5.0	4720.7	126.3	116.2	2231.9	2053.4	2.327	2.141	2.327	2.454	87.242	94.825	6.594	3.61	1.38	5.2	13.4	61.5
5.0-2	5.0	4719.5	127.0	116.9	2244.3	2065.8	2.312	2.128	2.312	2.454	86.721	94.214	6.515	3.61	1.38	5.8	14.0	58.7
5.0-3	5.0	4700.5	126.7	116.2	2239.0	2053.4	2.319	2.127	2.319	2.454	86.667	94.499	6.810	3.61	1.38	5.5	13.7	60.0
AVG											86.877	94.512	6.640			5.5	13.7	60.0
S.D.											0.317	0.306	0.153			0.306	0.279	1.418
5.5-1	5.5	4721.0	126.2	115.7	2230.1	2044.6	2.338	2.143	2.338	2.437	87.955	95.938	6.941	4.12	1.21	4.1	13.5	69.9
5.5-2	5.5	4731.6	126.8	116.3	2240.7	2055.2	2.329	2.136	2.329	2.437	87.655	95.568	6.882	4.12	1.21	4.4	13.8	67.9
5.5-3	5.5	4738.7	127.4	116.9	2251.3	2065.8	2.322	2.131	2.322	2.437	87.428	95.281	6.829	4.12	1.21	4.7	14.1	66.5
AVG											87.679	95.596	6.884			4.4	13.8	68.1
S.D.											0.265	0.329	0.056			0.329	0.297	1.704
6.0-1	6.0	4710.0	124.4	114.0	2198.3	2014.5	2.366	2.168	2.366	2.420	89.595	97.769	7.108	4.63	1.08	2.2	12.9	82.7
6.0-2	6.0	4752.3	126.0	115.4	2226.6	2039.3	2.355	2.157	2.355	2.420	89.127	97.314	7.119	4.63	1.08	2.7	13.3	79.8
6.0-3	6.0	4734.1	124.9	114.6	2207.2	2025.1	2.364	2.169	2.364	2.420	89.630	97.686	7.005	4.63	1.08	2.3	13.0	82.2
AVG											89.451	97.590	7.077			2.4	13.1	81.6
S.D.											0.281	0.242	0.063			0.242	0.216	1.535

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Fine Gradation, 139 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV-GRV-F-139

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.020 | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse) = 2.650 | Bulk SG Agg. (Gsb) = 2.554 | Percent Absorbed Asphalt (Pba) = 1.46

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
					17.67*D	17.67*E		C/G*J/(C/I)										
5.0-1	5.0	4716.8	124.6	114.5	2201.9	2023.4	2.355	2.164	2.355	2.454	88.187	95.966	6.544	3.61	1.38	4.0	12.4	67.5
5.0-2	5.0	4722.3	126.1	115.8	2228.4	2046.4	2.333	2.142	2.333	2.454	87.304	95.069	6.532	3.61	1.38	4.9	13.2	62.7
5.0-3	5.0	4722.0	125.1	115.0	2210.7	2032.2	2.352	2.162	2.352	2.454	88.106	95.844	6.509	3.61	1.38	4.2	12.5	66.8
AVG											87.865	95.626	6.528			4.4	12.7	65.7
S.D.											0.488	0.486	0.018			0.486	0.444	2.577
5.5-1	5.5	4738.0	127.7	116.8	2256.6	2064.0	2.331	2.132	2.331	2.437	87.490	95.654	6.868	4.12	1.21	4.3	13.7	68.4
5.5-2	5.5	4732.2	124.7	114.4	2203.6	2021.6	2.367	2.171	2.367	2.437	89.105	97.128	6.749	4.12	1.21	2.9	12.4	76.9
5.5-3	5.5	4739.0	125.0	114.6	2208.9	2025.1	2.367	2.170	2.367	2.437	89.047	97.128	6.798	4.12	1.21	2.9	12.4	76.9
AVG											88.547	96.637	6.805			3.4	12.9	74.0
S.D.											0.916	0.851	0.060			0.851	0.767	4.896
6.0-1	6.0	4768.7	124.4	114.3	2198.3	2019.8	2.388	2.194	2.388	2.420	90.666	98.678	6.739	4.63	1.08	1.3	12.1	89.1
6.0-2	6.0	4770.4	124.4	114.3	2198.3	2019.8	2.386	2.192	2.386	2.420	90.590	98.595	6.734	4.63	1.08	1.4	12.2	88.5
6.0-3	6.0	4751.3	124.6	114.4	2201.9	2021.6	2.374	2.180	2.374	2.420	90.069	98.099	6.755	4.63	1.08	1.9	12.6	84.9
AVG											90.442	98.457	6.743			1.5	12.3	87.5
S.D.											0.325	0.313	0.011			0.313	0.279	2.233

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Fine Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV-GRV-F-172

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse)= 2.650 | Bulk SG Agg. (Gsb) = 2.554 | Percent Absorbed Asphalt (Pba)= 1.46

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
5.0-1	5.0	4695.0	125.2	115.1	2212.5	2034.0	2.336	2.148	2.336	2.454	87.512	95.192	6.215	3.61	1.38	4.8	13.1	63.3
5.0-2	5.0	4704.3	125.1	114.8	2210.7	2028.7	2.344	2.151	2.344	2.454	87.653	95.518	6.365	3.61	1.38	4.5	12.8	65.0
5.0-3	5.0	4701.4	125.5	115.3	2217.8	2037.5	2.344	2.153	2.344	2.454	87.754	95.518	6.283	3.61	1.38	4.5	12.8	65.0
AVG											87.640	95.409	6.288			4.6	12.9	64.4
S.D.											0.122	0.188	0.075			0.188	0.172	0.977
5.5-1	5.5	4734.4	125.7	115.1	2221.3	2034.0	2.353	2.155	2.353	2.437	88.411	96.553	6.590	4.12	1.21	3.4	12.9	73.4
5.5-2	5.5	4724.8	125.9	115.2	2224.8	2035.8	2.346	2.147	2.346	2.437	88.084	96.266	6.622	4.12	1.21	3.7	13.2	71.7
5.5-3	5.5	4727.8	125.4	114.8	2216.0	2028.7	2.354	2.155	2.354	2.437	88.429	96.594	6.609	4.12	1.21	3.4	12.9	73.6
AVG											88.308	96.471	6.607			3.5	13.0	72.9
S.D.											0.194	0.179	0.016			0.179	0.161	1.032
6.0-1	6.0	4755.2	125.7	114.9	2221.3	2030.5	2.368	2.165	2.368	2.420	89.444	97.851	6.805	4.63	1.08	2.1	12.8	83.3
6.0-2	6.0	4764.8	125.5	114.7	2217.8	2026.9	2.378	2.173	2.378	2.420	89.808	98.264	6.844	4.63	1.08	1.7	12.5	86.1
6.0-3	6.0	4776.4	126.1	115.1	2228.4	2034.0	2.373	2.166	2.373	2.420	89.504	98.058	6.923	4.63	1.08	1.9	12.7	84.7
AVG											89.585	98.058	6.857			1.9	12.7	84.7
S.D.											0.195	0.207	0.060			0.207	0.184	1.409

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Coarse Gradation, 40 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV GRV-C-40

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcite Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse) = 2.636 | Bulk SG Agg. (Gsb) = 2.559 | Percent Absorbed Asphalt (Pba) = 1.17

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	MEASURED Bulk at Ndesign (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/I)										
6.5-1	6.5	4687.8	131.8	119.8	2329.1	2117.0	2.271	2.064	2.271	2.393	86.261	94.902	9.568	5.40	0.93	5.1	17.0	70.1
6.5-2	6.5	4722.5	131.6	119.6	2325.6	2113.5	2.290	2.081	2.290	2.393	86.970	95.696	9.662	5.40	0.93	4.3	16.3	73.6
6.5-3	6.5	4736.7	132.9	120.6	2348.5	2131.2	2.279	2.068	2.279	2.393	86.422	95.236	9.760	5.40	0.93	4.8	16.7	71.5
AVG											86.551	95.278	9.663			4.7	16.7	71.7
S.D.											0.371	0.399	0.096			0.399	0.349	1.804
7.0-1	7.0	4648.6	131.1	119.0	2316.7	2102.9	2.261	2.052	2.261	2.376	86.377	95.160	9.725	5.91	0.85	4.8	17.8	72.9
7.0-2	7.0	4700.4	131.2	119.0	2318.5	2102.9	2.284	2.072	2.284	2.376	87.189	96.128	9.898	5.91	0.85	3.9	17.0	77.2
7.0-3	7.0	4672.3	131.2	119.1	2318.5	2104.7	2.275	2.065	2.275	2.376	86.919	95.749	9.778	5.91	0.85	4.3	17.3	75.5
AVG											86.828	95.679	9.800			4.3	17.4	75.2
S.D.											0.414	0.488	0.088			0.488	0.421	2.194
7.5-1	7.5	4675.3	131.3	119.3	2320.3	2108.2	2.258	2.052	2.258	2.359	86.970	95.719	9.687	6.41	0.78	4.3	18.4	76.7
7.5-2	7.5	4678.1	131.4	119.4	2322.0	2110.0	2.264	2.057	2.264	2.359	87.208	95.973	9.705	6.41	0.78	4.0	18.2	77.8
7.5-3	7.5	4704.1	131.4	119.2	2322.0	2106.4	2.278	2.066	2.278	2.359	87.601	96.566	9.928	6.41	0.78	3.4	17.7	80.6
AVG											87.260	96.086	9.773			3.9	18.1	78.4
S.D.											0.318	0.435	0.134			0.435	0.371	1.979

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel, Coarse Gradation, 68 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV GRV-C-68

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible]

Apparent SG Agg. (Gsa) = 2.722; Effective SG Agg (Gse) = 2.636; Bulk SG Agg. (Gsb) = 2.559; Percent Absorbed Asphalt (Pba) = 1.17

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	G	H	J	K	L	N	O	P	Q	R	V	S	T	U
			7		17.67*D	17.67*E		C/G*J/(C/I)										
6.0-1	6.0	4660.8	130.4	118.2	2304.4	2088.8	2.280	2.067	2.280	2.410	85.755	94.606	8.964	4.90	1.02	5.4	16.2	66.8
6.0-2	6.0	4713.4	131.8	119.3	2329.1	2108.2	2.295	2.077	2.295	2.410	86.197	95.228	9.147	4.90	1.02	4.8	15.7	69.6
6.0-3	6.0	4722.5	130.3	118.1	2302.6	2087.0	2.317	2.100	2.317	2.410	87.139	96.141	9.116	4.90	1.02	3.9	14.9	74.1
AVG											86.364	95.325	9.076			4.7	15.6	70.2
S.D.											0.707	0.772	0.098			0.772	0.684	3.673
6.5-1	6.5	4752.0	131.0	118.4	2315.0	2092.3	2.325	2.101	2.325	2.393	87.813	97.158	9.464	5.40	0.93	2.8	15.0	81.1
6.5-2	6.5	4712.3	130.8	118.0	2311.4	2085.2	2.317	2.090	2.317	2.393	87.349	96.824	9.596	5.40	0.93	3.2	15.3	79.3
6.5-3	6.5	4699.1	130.6	117.8	2307.9	2081.7	2.308	2.082	2.308	2.393	86.995	96.448	9.573	5.40	0.93	3.6	15.7	77.3
AVG											87.386	96.810	9.544			3.2	15.4	79.3
S.D.											0.410	0.355	0.070			0.355	0.311	1.893
7.0-1	7.0	4701.6	130.0	117.3	2297.3	2072.9	2.318	2.092	2.318	2.376	88.028	97.559	9.652	5.91	0.85	2.4	15.8	84.5
7.0-2	7.0	4787.3	131.5	118.6	2323.8	2095.8	2.325	2.097	2.325	2.376	88.254	97.854	9.722	5.91	0.85	2.1	15.5	86.2
7.0-3	7.0	4722.4	130.6	117.9	2307.9	2083.5	2.318	2.093	2.318	2.376	88.072	97.559	9.608	5.91	0.85	2.4	15.8	84.5
AVG											88.118	97.657	9.661			2.3	15.7	85.1
S.D.											0.120	0.170	0.057			0.170	0.147	0.950

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Coarse Gradation, 93 Gyrations

SGC: Pine Gyratory Compactor

MIX ID: NV GRV-C-93

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = [illegible] | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse) = 2.636 | Bulk SG Agg. (Gsb) = 2.559 | Percent Absorbed Asphalt (Pba) = 1.17

			HEIGHTS		VOLUMES		MEASURED	CORRECTED BULK			% TMD							
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Ninitial (cc)	Ndesign (cc)	Bulk at Ndesign (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
			8															
5.5-1	5.5	4749.1	131.4	118.5	2322.0	2094.1	2.324	2.096	2.324	2.427	86.355	95.756	8.824	4.39	1.14	4.2	14.2	70.1
5.5-2	5.5	4662.1	129.4	116.9	2286.7	2065.8	2.310	2.087	2.310	2.427	85.985	95.179	8.630	4.39	1.14	4.8	14.7	67.2
5.5-3	5.5	4706.2	129.7	117.1	2292.0	2069.3	2.327	2.101	2.327	2.427	86.565	95.880	8.743	4.39	1.14	4.1	14.1	70.7
AVG											86.302	95.605	8.732			4.4	14.3	69.3
S.D.											0.294	0.374	0.097			0.374	0.335	1.872
6.0-1	6.0	4726.0	130.4	117.4	2304.4	2074.6	2.319	2.088	2.319	2.410	86.631	96.224	9.004	4.90	1.02	3.8	14.8	74.5
6.0-2	6.0	4737.3	130.8	117.7	2311.4	2079.9	2.336	2.102	2.336	2.410	87.222	96.929	9.112	4.90	1.02	3.1	14.2	78.4
6.0-3	6.0	4738.1	130.4	117.4	2304.4	2074.6	2.336	2.103	2.336	2.410	87.266	96.929	9.070	4.90	1.02	3.1	14.2	78.4
AVG											87.040	96.694	9.062			3.3	14.4	77.1
S.D.											0.354	0.407	0.054			0.407	0.361	2.222
6.5-1	6.5	4710.3	130.3	117.2	2302.6	2071.1	2.334	2.099	2.334	2.393	87.729	97.534	9.204	5.40	0.93	2.5	14.7	83.3
6.5-2	6.5	4703.2	129.5	116.1	2288.5	2051.7	2.337	2.095	2.337	2.393	87.554	97.660	9.485	5.40	0.93	2.3	14.6	84.0
6.5-3	6.5	4761.4	131.2	117.7	2318.5	2079.9	2.342	2.101	2.342	2.393	87.798	97.869	9.452	5.40	0.93	2.1	14.4	85.2
AVG											87.694	97.688	9.380			2.3	14.6	84.2
S.D.											0.126	0.169	0.154			0.169	0.148	1.000

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel , Coarse Gradation, 172 Gyrations

SGC: Pine Gyatory Compactor

MIX ID: NV GRV-C-172

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 | Apparent SG Agg. (Gsa) = 2.722 | Effective SG Agg (Gse) = 2.636 | Bulk SG Agg. (Gsb) = 2.559 | Percent Absorbed Asphalt (Pba) = 1.17

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	MEASURED Bulk at Ndesign (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Slope Nini - Ndes %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	*B*	*C*	*D*	*E*	*G*	*H*	*J*	K	*L*	*N*	*O*	*P*	*Q*	*R*	*V*	*S*	*T*	*U*
					17.67*D	17.67*E		C/G*J/(C/J)										
4.5-1.	4.5	4698.7	131.5	118.3	2323.8	2090.5	2.304	2.073	2.304	2.463	84.154	93.544	7.600	3.38	1.48	6.5	14.0	53.9
4.5-2	4.5	4696.6	131.0	117.8	2315.0	2081.7	2.308	2.075	2.308	2.463	84.265	93.707	7.642	3.38	1.48	6.3	13.9	54.6
4.5-3	4.5	4654.9	129.9	116.8	2295.5	2064.0	2.308	2.075	2.308	2.463	84.257	93.707	7.649	3.38	1.48	6.3	13.9	54.6
AVG											84.225	93.653	7.630			6.3	13.9	54.4
S.D.											0.061	0.094	0.026			0.094	0.086	0.390
5.0-2	5.0	4664.0	130.8	117.2	2311.4	2071.1	2.303	2.064	2.303	2.445	84.399	94.192	7.927	3.89	1.29	5.8	14.5	60.0
5.0-2	5.0	4683.9	130.5	117.0	2306.1	2067.6	2.322	2.082	2.322	2.445	85.145	94.969	7.952	3.89	1.29	5.0	13.8	63.5
5.0-3	5.0	4694.9	130.8	117.3	2311.4	2072.9	2.318	2.079	2.318	2.445	85.021	94.806	7.920	3.89	1.29	5.2	13.9	62.8
AVG											84.855	94.656	7.933			5.3	14.1	62.1
S.D.											0.400	0.410	0.017			0.410	0.372	1.884
5.5-1	5.5	4747.9	132.2	118.1	2336.2	2087.0	2.335	2.086	2.335	2.427	85.948	96.209	8.305	4.39	1.14	3.8	13.8	72.5
5.5-2	5.5	4691.3	130.7	116.9	2309.7	2065.8	2.331	2.085	2.331	2.427	85.904	96.044	8.208	4.39	1.14	4.0	13.9	71.6
5.5-3	5.5	4720.8	130.2	116.2	2300.8	2053.4	2.346	2.094	2.346	2.427	86.269	96.663	8.412	4.39	1.14	3.3	13.4	75.0
AVG											86.040	96.305	8.308			3.7	13.7	73.0
S.D.											0.199	0.320	0.102			0.320	0.287	1.789

National Center for Asphalt Technology
NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure
Task 6C: Consolidation of the Ndesign Matrix
Georgia Granite ($N_{maximum}$ Summary)

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN-COARSE — MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler — Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.744 — Effective SG Agg (Gse) = 2.702 — Bulk SG Agg. (Gsb) = 2.702 — Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD								
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
4.4-1 (104)	4.4	4774.9	125.1	114.0	112.5	2210.7	2014.5	1988.0	2.456	2.209	2.424	2.456	2.522	87.575	96.102	97.383	8.369	4.40	1.14	3.9	14.2	72.6
4.4-2 (104)	4.4	4803.1	125.5	114.5	113.0	2217.8	2023.4	1996.9	2.456	2.211	2.424	2.456	2.522	87.684	96.107	97.383	8.276	4.40	1.14	3.9	14.2	72.7
AVG														87.629	96.104	97.383	8.323			3.9	14.2	72.7
S.D.														0.077	0.004	0.000	0.066			0.004	0.004	0.021
4.2-1 (181)	4.2	4790.2	125.0	113.4	111.8	2208.9	2003.9	1975.7	2.471	2.210	2.436	2.471	2.531	87.320	96.252	97.629	7.611	4.20	1.19	3.7	13.6	72.5
4.2-2 (181)	4.2	4782.8	125.5	113.5	111.8	2217.8	2005.7	1975.7	2.464	2.195	2.427	2.464	2.531	86.725	95.895	97.353	7.845	4.20	1.19	4.1	13.9	70.6
AVG														87.023	96.073	97.491	7.728			3.9	13.8	71.5
S.D.														0.420	0.253	0.196	0.166			0.253	0.227	1.364
3.9-1 (288)	3.9	4787.7	123.8	111.8	110.5	2187.7	1975.7	1952.7	2.493	2.225	2.464	2.493	2.543	87.502	96.894	98.034	7.217	3.90	1.28	3.1	12.4	74.9
3.9-2 (288)	3.9	4756.9	123.3	111.5	110.2	2178.9	1970.4	1947.4	2.483	2.219	2.454	2.483	2.543	87.267	96.502	97.641	7.108	3.90	1.28	3.5	12.7	72.5
AVG														87.384	96.698	97.837	7.162			3.3	12.5	73.7
S.D.														0.166	0.277	0.278	0.077			0.277	0.251	1.683

SGC: Pine Gyatory Compactor

MIX ID: GA-GRAN-FINE — MATERIALS: Georgia Granite, Ergon 64-22 Binder and Dolcito Mineral Filler — Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.744 — Effective SG Agg (Gse) = 2.710 — Bulk SG Agg. (Gsb) = 2.710 — Percent Absorbed Asphalt (Pba) = 0.00

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD								
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
5.1-1 (104)	5.1	4814.9	121.7	114.2	113.2	2150.6	2018.1	2000.4	2.428	2.258	2.407	2.428	2.501	90.301	96.231	97.081	5.786	5.10	0.98	3.8	15.5	75.6
5.1-2 (104)	5.1	4831.7	121.7	114.2	113.2	2150.6	2018.1	2000.4	2.433	2.263	2.412	2.433	2.501	90.487	96.429	97.281	5.798	5.10	0.98	3.6	15.3	76.7
AVG														90.394	96.330	97.181	5.792			3.7	15.4	76.1
S.D.														0.131	0.140	0.141	0.008			0.140	0.123	0.720
4.7-1 (181)	4.7	4805.3	121.8	113.7	112.8	2152.4	2009.2	1993.3	2.429	2.250	2.410	2.429	2.515	89.444	95.816	96.581	5.268	4.70	1.06	4.2	15.0	72.1
4.7-2 (181)	4.7	4804.9	121.3	113.4	112.5	2143.5	2003.9	1988.0	2.437	2.260	2.418	2.437	2.515	89.869	96.130	96.899	5.190	4.70	1.06	3.9	14.7	73.7
AVG														89.656	95.973	96.740	5.229			4.0	14.9	72.9
S.D.														0.300	0.222	0.225	0.056			0.222	0.197	1.133
4.5-1 (288)	4.5	4789.4	120.3	112.4	111.5	2125.9	1986.3	1970.4	2.446	2.267	2.426	2.446	2.523	89.856	96.172	96.948	4.859	4.50	1.11	3.8	14.2	73.1
4.5-2 (288)	4.5	4807.0	120.6	112.7	111.9	2131.2	1991.6	1977.4	2.448	2.271	2.431	2.448	2.523	90.028	96.339	97.027	4.796	4.50	1.11	3.7	14.1	74.0
AVG														89.942	96.255	96.988	4.828			3.7	14.2	73.6
S.D.														0.121	0.118	0.056	0.045			0.118	0.105	0.636

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Nevada Gravel ($N_{maximum}$ Summary)

SGC: Pine Gyratory Compactor

MIX ID: NV-GRAV-COARSE

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028; Apparent SG Agg. (Gsa) = 2.722; Effective SG Agg (Gse) = 2.636; Bulk SG Agg. (Gsb) = 2.559; Percent Absorbed Asphalt (Pba) = 1.17

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	HEIGHTS Nmaximum (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	VOLUMES Nmaximum (cc)	MEASURED Bulk at Nmaximum (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	CORRECTED BULK Nmaximum (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
6.3-1 (104)	6.3	4834.6	135.5	122.6	120.7	2394.5	2166.5	2132.9	2.328	2.074	2.292	2.328	2.400	86.405	95.497	97.000	9.040	5.20	0.96	4.5	16.1	72.0
6.3-2 (104)	6.3	4844.1	135.1	122.0	120.1	2387.4	2155.9	2122.3	2.339	2.079	2.303	2.339	2.400	86.638	95.941	97.458	9.233	5.20	0.96	4.1	15.7	74.1
AVG														86.521	95.719	97.229	9.137			4.3	15.9	73.1
S.D.														0.164	0.314	0.324	0.136			0.314	0.276	1.508
5.5-1 (181)	5.5	4849.8	135.4	121.4	119.6	2392.7	2145.3	2113.5	2.359	2.084	2.324	2.359	2.427	85.856	95.757	97.198	8.373	4.39	1.14	4.2	14.2	70.1
5.5-2 (181)	5.5	4810.8	135.3	121.3	119.6	2390.9	2143.5	2113.5	2.364	2.090	2.331	2.364	2.427	86.102	96.039	97.404	8.344	4.39	1.14	4.0	13.9	71.6
AVG														85.979	95.898	97.301	8.359			4.1	14.1	70.8
S.D.														0.174	0.199	0.146	0.021			0.199	0.179	1.048
5.4-1 (288)	5.4	4805.4	133.0	118.9	117.3	2350.3	2101.1	2072.9	2.365	2.086	2.333	2.365	2.431	85.801	95.976	97.285	7.869	4.29	1.17	4.0	13.7	70.7
5.4-2 (288)	5.4	4827.0	133.7	119.6	117.9	2362.7	2113.5	2083.5	2.366	2.086	2.332	2.366	2.431	85.825	95.943	97.326	7.881	4.29	1.17	4.1	13.8	70.6
AVG														85.813	95.959	97.306	7.875			4.0	13.8	70.6
S.D.														0.017	0.023	0.029	0.008			0.023	0.021	0.125

SGC: Pine Gyratory Compactor

MIX ID: NV-GRAV-FINE

MATERIALS: Nevada Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028; Apparent SG Agg. (Gsa) = 2.722; Effective SG Agg (Gse) = 2.650; Bulk SG Agg. (Gsb) = 2.554; Percent Absorbed Asphalt (Pba) = 1.46

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	HEIGHTS Nmaximum (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	VOLUMES Nmaximum (cc)	MEASURED Bulk at Nmaximum (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	CORRECTED BULK Nmaximum (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
5.6-1 (104)	5.6	4848.8	130.0	120.3	118.9	2297.3	2125.9	2101.1	2.365	2.163	2.337	2.365	2.434	88.869	96.034	97.165	7.079	4.49	1.11	4.0	13.8	71.2
5.6-2 (104)	5.6	4805.9	128.9	118.9	117.5	2277.9	2101.1	2076.4	2.359	2.150	2.331	2.359	2.434	88.347	95.777	96.919	7.314	4.49	1.11	4.2	14.0	69.8
AVG														88.608	95.906	97.042	7.197			4.1	13.9	70.5
S.D.														0.369	0.182	0.174	0.166			0.182	0.163	0.962
5.6-1 (181)	5.6	4880.1	130.6	119.3	117.9	2307.9	2108.2	2083.5	2.372	2.141	2.344	2.372	2.434	87.976	96.309	97.453	6.996	4.49	1.11	3.7	13.5	72.7
5.6-2 (181)	5.6	4807.7	127.7	117.7	116.3	2256.6	2079.9	2055.2	2.361	2.150	2.333	2.361	2.434	88.341	95.847	97.001	6.393	4.49	1.11	4.2	13.9	70.2
AVG														88.159	96.078	97.227	6.694			3.9	13.7	71.5
S.D.														0.258	0.327	0.320	0.427			0.327	0.293	1.770
5.2-1 (288)	5.2	4818.0	127.7	117.0	115.6	2256.6	2067.6	2042.8	2.384	2.158	2.355	2.384	2.447	88.194	96.260	97.425	6.325	4.09	1.22	3.7	12.7	70.6
5.2-2 (288)	5.2	4896.8	130.3	119.6	118.2	2302.6	2113.5	2088.8	2.374	2.154	2.346	2.374	2.447	88.008	95.881	97.017	6.173	4.09	1.22	4.1	13.1	68.5
AVG														88.101	96.070	97.221	6.249			3.9	12.9	69.6
S.D.														0.132	0.268	0.289	0.108			0.268	0.243	1.501

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

Alabama Limestone ($N_{maximum}$ Summary)

SGC: Pine Gyratory Compactor

MIX ID: AL LMS-COARSE

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028; Apparent SG Agg. (Gsa) = 2.741; Effective SG Agg (Gse) = 2.728; Bulk SG Agg. (Gsb) = 2.699; Percent Absorbed Asphalt (Pba) = 0.40

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD								
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
4.2-1 (104)	4.2	4749.2	126.2	112.6	110.6	2230.1	1989.8	1954.5	2.478	2.172	2.434	2.478	2.550	85.164	95.450	97.176	10.250	3.81	1.31	4.5	13.6	66.6
4.2-2 (104)	4.2	4775.2	126.5	112.8	110.8	2235.4	1993.3	1958.0	2.488	2.179	2.444	2.488	2.550	85.459	95.839	97.569	10.333	3.81	1.31	4.2	13.3	68.6
AVG														85.312	95.645	97.373	10.291			4.4	13.4	67.6
S.D.														0.209	0.275	0.277	0.059			0.275	0.248	1.444
3.6-1 (181)	3.6	4766.2	126.1	110.8	109.0	2228.4	1958.0	1926.2	2.513	2.172	2.472	2.513	2.573	84.424	96.081	97.668	9.777	3.21	1.56	3.9	11.7	66.5
3.6-2 (181)	3.6	4740.7	126.0	110.9	109.1	2226.6	1959.8	1928.0	2.501	2.166	2.460	2.501	2.573	84.164	95.624	97.202	9.625	3.21	1.56	4.4	12.1	63.9
AVG														84.294	95.853	97.435	9.701			4.1	11.9	65.2
S.D.														0.183	0.323	0.330	0.108			0.323	0.297	1.847
3.2-1 (288)	3.2	4741.1	124.4	109.4	107.7	2198.3	1933.3	1903.2	2.525	2.186	2.486	2.525	2.588	84.468	96.050	97.566	8.975	2.81	1.78	4.0	10.8	63.6
3.2-2 (288)	3.2	4736.1	124.0	109.5	107.8	2191.3	1935.0	1905.0	2.523	2.193	2.484	2.523	2.588	84.752	95.975	97.488	8.727	2.81	1.78	4.0	10.9	63.1
AVG														84.610	96.012	97.527	8.851			4.0	10.9	63.4
S.D.														0.201	0.053	0.055	0.175			0.053	0.049	0.320

SGC: Pine Gyratory Compactor

MIX ID: AL LMS-FINE

MATERIALS: Alabama Limestone, Ergon 64-22 Binder and Dolcito Mineral Filler

Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028; Apparent SG Agg. (Gsa) = 2.736; Effective SG Agg (Gse) = 2.731; Bulk SG Agg. (Gsb) = 2.685; Percent Absorbed Asphalt (Pba) = 0.64

			HEIGHTS			VOLUMES			MEASURED	CORRECTED BULK				% TMD								
Specimen Number	Asphalt Content (%)	Mass (gm)	Ninitial (mm)	Ndesign (mm)	Nmaximum (mm)	Ninitial (cc)	Ndesign (cc)	Nmaximum (cc)	Bulk at Nmaximum (Gmb)	Ninitial (Gmb)	Ndesign (Gmb)	Nmaximum (Gmb)	TMD (Gmm)	Ninitial	Ndesign	Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L		N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
4.3-1 (104)	4.3	4793.8	120.3	110.6	109.4	2125.9	1954.5	1933.3	2.489	2.263	2.462	2.489	2.549	88.799	96.587	97.646	7.549	3.91	1.28	3.4	12.7	73.1
4.3-2 (104)	4.3	4759.3	119.9	110.3	109.0	2118.8	1949.2	1926.2	2.492	2.265	2.463	2.492	2.549	88.876	96.612	97.764	7.584	3.91	1.28	3.4	12.7	73.3
AVG														88.837	96.599	97.705	7.567			3.4	12.7	73.2
S.D.														0.055	0.018	0.083	0.024			0.018	0.016	0.105
3.8-1 (181)	3.8	4789.9	120.5	110.4	109.1	2129.4	1950.9	1928.0	2.506	2.269	2.476	2.506	2.569	88.319	96.399	97.548	6.813	3.41	1.47	3.6	11.7	69.3
3.8-2 (181)	3.8	4775.3	120.5	110.2	108.9	2129.4	1947.4	1924.4	2.503	2.262	2.473	2.503	2.569	88.052	96.282	97.431	6.924	3.41	1.47	3.7	11.8	68.6
AVG														88.185	96.340	97.489	6.868			3.7	11.8	68.9
S.D.														0.189	0.083	0.083	0.079			0.083	0.076	0.504
3.6-1 (288)	3.6	4746.6	119.1	109.0	107.8	2104.7	1926.2	1905.0	2.513	2.275	2.485	2.513	2.576	88.299	96.480	97.554	6.342	3.21	1.56	3.5	11.2	68.7
3.6-2 (288)	3.6	4765.0	119.8	109.3	108.1	2117.0	1931.5	1910.3	2.511	2.266	2.483	2.511	2.576	87.957	96.407	97.477	6.523	3.21	1.56	3.6	11.3	68.2
AVG														88.128	96.443	97.516	6.433			3.6	11.3	68.4
S.D.														0.242	0.052	0.055	0.128			0.052	0.048	0.329

National Center for Asphalt Technology

NCHRP 9-9: Refinement of the Superpave Gyratory Compaction Procedure

Task 6C: Consolidation of the Ndesign Matrix

New York Gravel ($N_{maximum}$ Summary)

SGC: Pine Gyatory Compactor

MIX ID: NY-GRAV-COARSE — MATERIALS: New York Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler — Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.700 — Effective SG Agg (Gse) = 2.642 — Bulk SG Agg. (Gsb) = 2.589 — Percent Absorbed Asphalt (Pba) = 0.80

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	HEIGHTS Nmaximum (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	VOLUMES Nmaximum (cc)	MEASURED Bulk at Nmaximum (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	CORRECTED BULK Nmaximum (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	% TMD Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
5.6-1 (104)	5.6	4833.6	131.0	118.7	116.9	2315.0	2097.6	2065.8	2.382	2.126	2.346	2.382	2.428	87.546	96.618	98.105	9.010	4.85	1.03	3.4	14.5	76.6
5.6-2 (104)	5.6	4815.8	130.5	118.8	117.1	2306.1	2099.4	2069.3	2.373	2.129	2.339	2.373	2.428	87.699	96.336	97.735	8.563	4.85	1.03	3.7	14.7	75.1
AVG														87.623	96.477	97.920	8.787			3.5	14.6	75.9
S.D.														0.108	0.199	0.262	0.316			0.199	0.176	1.073
4.7-1 (181)	4.7	4776.7	129.9	116.0	115.0	2295.5	2049.9	2032.2	2.393	2.119	2.372	2.393	2.458	86.189	96.516	97.356	8.244	3.94	1.27	3.5	12.7	72.5
4.7-2 (181)	4.7	4790.6	129.9	117.0	115.4	2295.5	2067.6	2039.3	2.393	2.126	2.360	2.393	2.458	86.488	96.024	97.356	8.023	3.94	1.27	4.0	13.1	69.7
AVG														86.338	96.270	97.356	8.133			3.7	12.9	71.1
S.D.														0.212	0.348	0.000	0.156			0.348	0.315	1.993
4.1-1 (288)	4.1	4790.2	129.4	116.0	114.5	2286.7	2049.9	2023.4	2.405	2.128	2.374	2.405	2.479	85.844	95.760	97.015	7.655	3.34	1.50	4.2	12.1	64.9
4.1-2 (288)	4.1	2796.7	129.1	115.8	114.2	2281.4	2046.4	2018.1	2.414	2.135	2.381	2.414	2.479	86.139	96.033	97.378	7.701	3.34	1.50	4.0	11.8	66.4
AVG														85.992	95.896	97.196	7.678			4.1	11.9	65.6
S.D.														0.209	0.192	0.257	0.033			0.192	0.177	1.103

SGC: Pine Gyatory Compactor

MIX ID: NY-GRAV-FINE — MATERIALS: New York Gravel, Ergon 64-22 Binder and Dolcito Mineral Filler — Percent Passing 0.075 mm: 5

AC Sp. Gr. (Gb) = 1.028 — Apparent SG Agg. (Gsa) = 2.701 — Effective SG Agg (Gse) = 2.653 — Bulk SG Agg. (Gsb) = 2.595 — Percent Absorbed Asphalt (Pba) = 0.87

Specimen Number	Asphalt Content (%)	Mass (gm)	HEIGHTS Ninitial (mm)	HEIGHTS Ndesign (mm)	HEIGHTS Nmaximum (mm)	VOLUMES Ninitial (cc)	VOLUMES Ndesign (cc)	VOLUMES Nmaximum (cc)	MEASURED Bulk at Nmaximum (Gmb)	CORRECTED BULK Ninitial (Gmb)	CORRECTED BULK Ndesign (Gmb)	CORRECTED BULK Nmaximum (Gmb)	TMD (Gmm)	% TMD Ninitial	% TMD Ndesign	% TMD Nmaximum	Slope Nini - Nmax %	%Effective Asphalt (Pbe)	P200/Pbe Ratio (DP)	VTM (%)	VMA (%)	VFA (%)
A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P		Q	R	V	S	T	U
						17.67*D	17.67*E	17.67*F														
5.0-1 (104)	5.0	4806.4	124.3	116.5	115.4	2196.6	2058.7	2039.3	2.381	2.211	2.359	2.381	2.458	89.932	95.953	96.867	5.918	4.24	1.18	4.0	13.5	69.9
5.0-2 (104)	5.0	4791.2	123.5	116.2	115.1	2182.4	2053.4	2034.0	2.380	2.218	2.357	2.380	2.458	90.241	95.910	96.827	5.620	4.24	1.18	4.1	13.5	69.7
AVG														90.086	95.931	96.847	5.769			4.1	13.5	69.8
S.D.														0.219	0.030	0.029	0.211			0.030	0.027	0.163
4.7-1 (181)	4.7	4831.6	124.8	116.3	115.2	2205.4	2055.2	2035.8	2.394	2.210	2.371	2.394	2.470	89.467	96.006	96.923	5.504	3.94	1.27	4.0	12.7	68.6
4.7-2 (181)	4.7	4790.6	123.2	115.7	114.4	2177.1	2044.6	2021.6	2.395	2.224	2.368	2.395	2.470	90.038	95.874	96.964	5.113	3.94	1.27	4.1	12.8	67.8
AVG														89.753	95.940	96.943	5.308			4.1	12.8	68.2
S.D.														0.403	0.094	0.029	0.276			0.094	0.085	0.521
4.4-1 (288)	4.4	4791.0	124.0	115.5	114.4	2191.3	2041.1	2021.6	2.391	2.206	2.368	2.391	2.482	88.876	95.416	96.334	5.110	3.64	1.37	4.6	12.6	63.5
4.4-2 (288)	4.4	4776.9	123.7	115.1	113.9	2186.0	2034.0	2012.8	2.395	2.205	2.370	2.395	2.482	88.850	95.489	96.495	5.238	3.64	1.37	4.5	12.5	63.9
AVG														88.863	95.452	96.414	5.174			4.5	12.5	63.7
S.D.														0.018	0.051	0.114	0.090			0.051	0.047	0.274

NCHRP 9-9
APPENDIX F

Statistical Analysis Output

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure
Class Level Information

Class	Levels	Values
NDESIGN	6	113 139 172 40 68 93
AGG	4	ALLMS GAGRAN NVGRAV NYGRAV
GRAD	1	FINE

Number of observations in data set = 72

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Dependent Variable: VMA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	137.44757778	5.97598164	115.50	0.0001
Error	48	2.48353333	0.05174028		
Corrected Total	71	139.93111111			

R-Square	C.V.	Root MSE	VMA Mean
0.982252	1.678226	0.22746489	13.55388889

Source	DF	Type I SS	Mean Square	F Value	Pr > F
NDESIGN	5	34.85796111	6.97159222	134.74	0.0001
AGG	3	102.45197778	34.15065926	660.04	0.0001
GRAD	0	0.00000000	.	.	.
NDESIGN*AGG	15	0.13763889	0.00917593	0.18	0.9997
NDESIGN*GRAD	0	0.00000000	.	.	.
AGG*GRAD	0	0.00000000	.	.	.
NDESIGN*AGG*GRAD	0	0.00000000	.	.	.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
NDESIGN	5	34.85796111	6.97159222	134.74	0.0001
AGG	3	102.45197778	34.15065926	660.04	0.0001
GRAD	0	0.00000000	.	.	.
NDESIGN*AGG	15	0.13763889	0.00917593	0.18	0.9997
NDESIGN*GRAD	0	0.00000000	.	.	.
AGG*GRAD	0	0.00000000	.	.	.
NDESIGN*AGG*GRAD	0	0.00000000	.	.	.

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 48 MSE= 0.05174

Number of Means	2	3	4	5	6
Critical Range	.1867	.1964	.2027	.2073	.2108

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	NDESIGN
A	14.76000	12	40
B	14.06500	12	68
C	13.58417	12	93
D	13.27083	12	113
E	12.95500	12	139
F	12.68833	12	172

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 48 MSE= 0.05174

Number of Means	2	3	4
Critical Range	.1524	.1603	.1655

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	AGG
A	15.36889	18	GAGRAN
B	13.64222	18	NVGRAV
C	13.14000	18	NYGRAV
D	12.06444	18	ALLMS

Level of GRAD	N	-------------VMA------------- Mean	SD
FINE	72	13.5538889	1.40387347

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure
Class Level Information

Class	Levels	Values
NDESIGN	6	113 139 172 40 68 93
AGG	4	ALLMS GAGRAN NVGRAV NYGRAV
GRAD	1	COARSE

Number of observations in data set = 72

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Dependent Variable: VMA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	23	188.26392778	8.18538816	104.22	0.0001
Error	48	3.76980000	0.07853750		
Corrected Total	71	192.03372778			

R-Square	C.V.	Root MSE	VMA Mean
0.980369	2.049785	0.28024543	13.67194444

Source	DF	Type I SS	Mean Square	F Value	Pr > F
NDESIGN	5	125.23047778	25.04609556	318.91	0.0001
AGG	3	52.29450556	17.43150185	221.95	0.0001
GRAD	0	0.00000000	.	.	.
NDESIGN*AGG	15	10.73894444	0.71592963	9.12	0.0001
NDESIGN*GRAD	0	0.00000000	.	.	.
AGG*GRAD	0	0.00000000	.	.	.
NDESIGN*AGG*GRAD	0	0.00000000	.	.	.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
NDESIGN	5	125.23047778	25.04609556	318.91	0.0001
AGG	3	52.29450556	17.43150185	221.95	0.0001
GRAD	0	0.00000000	.	.	.
NDESIGN*AGG	15	10.73894444	0.71592963	9.12	0.0001
NDESIGN*GRAD	0	0.00000000	.	.	.
AGG*GRAD	0	0.00000000	.	.	.
NDESIGN*AGG*GRAD	0	0.00000000	.	.	.

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 48 MSE= 0.078538

Number of Means	2	3	4	5	6
Critical Range	.2300	.2419	.2497	.2554	.2598

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	NDESIGN
A	16.0817	12	40
B	14.5467	12	68
C	13.6142	12	93
D	13.0608	12	113
E	12.5467	12	139
F	12.1817	12	172

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 48 MSE= 0.078538

Number of Means	2	3	4
Critical Range	.1878	.1975	.2039

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	AGG
A	14.43167	18	NVGRAV
A			
A	14.34056	18	GAGRAN
B	13.61389	18	NYGRAV
C	12.30167	18	ALLMS

Level of GRAD	N	VMA Mean	VMA SD
COARSE	72	13.6719444	1.64459733

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure
Class Level Information

Class	Levels	Values
NDESIGN	6	113 139 172 40 68 93
AGG	4	ALLMS GAGRAN NVGRAV NYGRAV
GRAD	2	COARSE FINE

Number of observations in data set = 144

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Dependent Variable: VMA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	47	326.21324167	6.94070727	106.55	0.0001
Error	96	6.25333333	0.06513889		
Corrected Total	143	332.46657500			

R-Square	C.V.	Root MSE	VMA Mean
0.981191	1.874861	0.25522321	13.61291667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
NDESIGN	5	145.90665833	29.18133167	447.99	0.0001
AGG	3	137.59438611	45.86479537	704.11	0.0001
GRAD	1	0.50173611	0.50173611	7.70	0.0066
NDESIGN*AGG	15	4.46286389	0.29752426	4.57	0.0001
NDESIGN*GRAD	5	14.18178056	2.83635611	43.54	0.0001
AGG*GRAD	3	17.15209722	5.71736574	87.77	0.0001
NDESIGN*AGG*GRAD	15	6.41371944	0.42758130	6.56	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
NDESIGN	5	145.90665833	29.18133167	447.99	0.0001
AGG	3	137.59438611	45.86479537	704.11	0.0001
GRAD	1	0.50173611	0.50173611	7.70	0.0066
NDESIGN*AGG	15	4.46286389	0.29752426	4.57	0.0001
NDESIGN*GRAD	5	14.18178056	2.83635611	43.54	0.0001
AGG*GRAD	3	17.15209722	5.71736574	87.77	0.0001
NDESIGN*AGG*GRAD	15	6.41371944	0.42758130	6.56	0.0001

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.065139

Number of Means	2	3	4	5	6
Critical Range	.1462	.1539	.1590	.1627	.1656

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	NDESIGN
A	15.42083	24	40
B	14.30583	24	68
C	13.59917	24	93
D	13.16583	24	113
E	12.75083	24	139
F	12.43500	24	172

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.065139

Number of Means	2	3	4
Critical Range	.1194	.1257	.1298

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	AGG
A	14.85472	36	GAGRAN
B	14.03694	36	NVGRAV
C	13.37694	36	NYGRAV
D	12.18306	36	ALLMS

NCHRP 9-9 TASK 6C: VOIDS IN MINERAL AGGREGATE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: VMA

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.065139

Number of Means	2
Critical Range	.08444

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	GRAD
A	13.67194	72	COARSE
B	13.55389	72	FINE

NCHRP 9-9 TASK 6C: %Gmm @ Ninitial DATA ANALYSIS

General Linear Models Procedure
Class Level Information

Class	Levels	Values
NDESIGN	6	113 139 172 40 68 93
AGG	4	ALLMS GAGRAN NVGRAV NYGRAV
GRAD	2	COARSE FINE

Number of observations in data set = 144

NCHRP 9-9 TASK 6C: %Gmm @ Ninitial DATA ANALYSIS

General Linear Models Procedure

Dependent Variable: GMMNI

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	47	394.94448889	8.40307423	105.10	0.0001
Error	96	7.67553333	0.07995347		
Corrected Total	143	402.62002222			

R-Square	C.V.	Root MSE	GMMNI Mean
0.980936	0.321772	0.28276045	87.87611111

Source	DF	Type I SS	Mean Square	F Value	Pr > F
NDESIGN	5	8.39872222	1.67974444	21.01	0.0001
AGG	3	37.71207222	12.57069074	157.23	0.0001
GRAD	1	340.58702500	340.58702500	4259.82	0.0001
NDESIGN*AGG	15	3.69239444	0.24615963	3.08	0.0004
NDESIGN*GRAD	5	0.30254167	0.06050833	0.76	0.5832
AGG*GRAD	3	3.17004722	1.05668241	13.22	0.0001
NDESIGN*AGG*GRAD	15	1.08168611	0.07211241	0.90	0.5643

Source	DF	Type III SS	Mean Square	F Value	Pr > F
NDESIGN	5	8.39872222	1.67974444	21.01	0.0001
AGG	3	37.71207222	12.57069074	157.23	0.0001
GRAD	1	340.58702500	340.58702500	4259.82	0.0001
NDESIGN*AGG	15	3.69239444	0.24615963	3.08	0.0004
NDESIGN*GRAD	5	0.30254167	0.06050833	0.76	0.5832
AGG*GRAD	3	3.17004722	1.05668241	13.22	0.0001
NDESIGN*AGG*GRAD	15	1.08168611	0.07211241	0.90	0.5643

NCHRP 9-9 TASK 6C: %Gmm @ Ninitial DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: GMMNI

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.079953

Number of Means	2	3	4	5	6
Critical Range	.1620	.1705	.1761	.1803	.1835

Means with the same letter are not significantly different.

Duncan Grouping		Mean	N	NDESIGN
	A	88.30458	24	40
	B	88.03792	24	68
	B			
C	B	87.88042	24	93
C				
C	D	87.78292	24	113
	D			
E	D	87.67917	24	139
E				
E		87.57167	24	172

NCHRP 9-9 TASK 6C: %Gmm @ Ninitial DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: GMMNI

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.079953

Number of Means	2	3	4
Critical Range	.1323	.1392	.1438

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	AGG
A	88.22611	36	GAGRAN
A			
A	88.14361	36	NYGRAV
A			
A	88.14306	36	NVGRAV
B	86.99167	36	ALLMS

NCHRP 9-9 TASK 6C: %Gmm @ Ninitial DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: GMMNI

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.079953

Number of Means	2
Critical Range	.09355

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	GRAD
A	89.41403	72	FINE
B	86.33819	72	COARSE

NCHRP 9-9 TASK 6C: GYRATORY COMPACTION SLOPE DATA ANALYSIS

General Linear Models Procedure
Class Level Information

Class	Levels	Values
NDESIGN	6	113 139 172 40 68 93
AGG	4	ALLMS GAGRAN NVGRAV NYGRAV
GRAD	2	COARSE FINE

Number of observations in data set = 144

NCHRP 9-9 TASK 6C: GYRATORY COMPACTION SLOPE DATA ANALYSIS

General Linear Models Procedure

Dependent Variable: SLOPE

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	47	325.25204931	6.92025637	456.99	0.0001
Error	96	1.45373333	0.01514306		
Corrected Total	143	326.70578264			

R-Square	C.V.	Root MSE	SLOPE Mean
0.995550	1.609715	0.12305712	7.64465278

Source	DF	Type I SS	Mean Square	F Value	Pr > F
NDESIGN	5	42.21428681	8.44285736	557.54	0.0001
AGG	3	47.59616875	15.86538958	1047.70	0.0001
GRAD	1	226.77850069	226.77850069	14975.74	0.0001
NDESIGN*AGG	15	1.33637708	0.08909181	5.88	0.0001
NDESIGN*GRAD	5	0.48772014	0.09754403	6.44	0.0001
AGG*GRAD	3	6.31098542	2.10366181	138.92	0.0001
NDESIGN*AGG*GRAD	15	0.52801042	0.03520069	2.32	0.0071

Source	DF	Type III SS	Mean Square	F Value	Pr > F
NDESIGN	5	42.21428681	8.44285736	557.54	0.0001
AGG	3	47.59616875	15.86538958	1047.70	0.0001
GRAD	1	226.77850069	226.77850069	14975.74	0.0001
NDESIGN*AGG	15	1.33637708	0.08909181	5.88	0.0001
NDESIGN*GRAD	5	0.48772014	0.09754403	6.44	0.0001
AGG*GRAD	3	6.31098542	2.10366181	138.92	0.0001
NDESIGN*AGG*GRAD	15	0.52801042	0.03520069	2.32	0.0071

NCHRP 9-9 TASK 6C: GYRATORY COMPACTION SLOPE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: SLOPE

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.015143

Number of Means	2	3	4	5	6
Critical Range	.07051	.07420	.07665	.07845	.07984

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	NDESIGN
A	8.53125	24	40
B	8.07042	24	68
C	7.71125	24	93
D	7.46250	24	113
E	7.18375	24	139
F	6.90875	24	172

NCHRP 9-9 TASK 6C: GYRATORY COMPACTION SLOPE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: SLOPE

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.015143

Number of Means	2	3	4
Critical Range	.05757	.06059	.06259

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	AGG
A	8.38361	36	ALLMS
B	7.97944	36	NVGRAV
C	7.31694	36	NYGRAV
D	6.89861	36	GAGRAN

NCHRP 9-9 TASK 6C: GYRATORY COMPACTION SLOPE DATA ANALYSIS

General Linear Models Procedure

Duncan's Multiple Range Test for variable: SLOPE

NOTE: This test controls the type I comparisonwise error rate, not the experimentwise error rate

Alpha= 0.05 df= 96 MSE= 0.015143

Number of Means	2
Critical Range	.04071

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	GRAD
A	8.89958	72	COARSE
B	6.38972	72	FINE

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	NVGRV 68	NVGRV 82
Mean	15.59003885	14.72203885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.905343921	
P(T<=t) one-tail	0.021941145	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.043882289	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	NVGRV 68	NVGRV 82
Mean	14.15718755	13.90518755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	0.985615955	
P(T<=t) one-tail	0.190060447	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.380120895	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	NVGRV 76	NVGRV 93
Mean	15.07483885	14.15003885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.095463201	
P(T<=t) one-tail	0.01819043	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.03638086	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	NVGRV 76	NVGRV 93
Mean	14.01078755	13.72093755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.133653907	
P(T<=t) one-tail	0.160138737	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.320277474	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*NVGRV 86*	*NVGRV 105*
Mean	14.50283885	13.63643885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.899988449	
P(T<=t) one-tail	0.02205923	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.044118461	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*NVGRV 86*	*NVGRV 105*
Mean	13.83678755	13.53373755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.185281409	
P(T<=t) one-tail	0.150755421	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.301510841	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*NVGRV 96*	*NVGRV 119*
Mean	14.01083885	13.18283885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.771457105	
P(T<=t) one-tail	0.025127975	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.05025595	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*NVGRV 96*	*NVGRV 119*
Mean	13.67278755	13.33353755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.326865924	
P(T<=t) one-tail	0.127614899	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.255229798	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	NVGRV 109	NVGRV 135
Mean	13.49083885	12.85643885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.123444912	
P(T<=t) one-tail	0.05047488	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.100949761	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	NVGRV 109	NVGRV 135
Mean	13.47453755	13.12873755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.352484116	
P(T<=t) one-tail	0.123811614	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.247623229	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	NVGRV 126	NVGRV 153
Mean	13.01483885	12.73403885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	0.939885453	
P(T<=t) one-tail	0.200245598	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.400491196	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	NVGRV 126	NVGRV 153
Mean	13.24078755	12.92893755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.219699744	
P(T<=t) one-tail	0.144787855	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.289575711	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*NVGRV 142*	*NVGRV 172*
Mean	12.77803885	12.88603885
Variance	0.133886137	0.133886137
Observations	3	3
Pooled Variance	0.133886137	
Hypothesized Mean Difference	0	
df	4	
t Stat	-0.3614944	
P(T<=t) one-tail	0.368007863	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.736015726	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*NVGRV 142*	*NVGRV 172*
Mean	13.04718755	12.75318755
Variance	0.098056613	0.098056613
Observations	3	3
Pooled Variance	0.098056613	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.149885281	
P(T<=t) one-tail	0.157131933	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.314263866	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	GAGRN 68	GAGRN 82
Mean	14.83966867	14.53520187
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.465086877	
P(T<=t) one-tail	0.034655744	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.069311487	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	GAGRN 68	GAGRN 82
Mean	15.9150281	15.5986281
Variance	0.014926302	0.014926302
Observations	3	3
Pooled Variance	0.014926302	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.171801396	
P(T<=t) one-tail	0.01689971	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.03379942	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	GAGRN 76	GAGRN 93
Mean	14.65802073	14.33399254
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.623463789	
P(T<=t) one-tail	0.029293075	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.058586149	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	GAGRN 76	GAGRN 93
Mean	15.7294281	15.3775281
Variance	0.014926302	0.014926302
Observations	3	3
Pooled Variance	0.014926302	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.52767671	
P(T<=t) one-tail	0.012140674	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.024281348	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	GAGRN 86	GAGRN 105
Mean	14.45874298	14.14263904
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.559305869	
P(T<=t) one-tail	0.03134207	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.062684139	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	GAGRN 86	GAGRN 105
Mean	15.5154281	15.1639281
Variance	0.014926302	0.014926302
Observations	3	3
Pooled Variance	0.014926302	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.523666848	
P(T<=t) one-tail	0.012184648	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.024369296	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	GAGRN 96	GAGRN 119
Mean	14.28368526	13.94796002
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.718167856	
P(T<=t) one-tail	0.026543609	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.053087218	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	GAGRN 96	GAGRN 119
Mean	15.27719607	14.9511281
Variance	0.003187469	0.014926302
Observations	3	3
Pooled Variance	0.009056886	
Hypothesized Mean Difference	0	
df	4	
t Stat	4.196278748	
P(T<=t) one-tail	0.006868441	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.013736882	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*GAGRN 109*	*GAGRN 135*
Mean	14.08420412	13.75444967
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.66982592	
P(T<=t) one-tail	0.027908051	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.055816101	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*GAGRN 109*	*GAGRN 135*
Mean	15.05489607	14.7559281
Variance	0.003187469	0.014926302
Observations	3	3
Pooled Variance	0.009056886	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.847519705	
P(T<=t) one-tail	0.009170688	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.018341375	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*GAGRN 126*	*GAGRN 153*
Mean	13.85994731	13.56510255
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.387182935	
P(T<=t) one-tail	0.037699086	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.075398171	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*GAGRN 126*	*GAGRN 153*
Mean	14.81519607	14.5975281
Variance	0.003187469	0.014926302
Observations	3	3
Pooled Variance	0.009056886	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.801242576	
P(T<=t) one-tail	0.024374886	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.048749772	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*GAGRN 142*	*GAGRN 172*
Mean	13.67765866	13.39037333
Variance	0.02288267	0.02288267
Observations	3	3
Pooled Variance	0.02288267	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.325978694	
P(T<=t) one-tail	0.04030325	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.0806065	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*GAGRN 142*	*GAGRN 172*
Mean	14.64239607	14.5006281
Variance	0.003187469	0.014926302
Observations	3	3
Pooled Variance	0.009056886	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.824459869	
P(T<=t) one-tail	0.071069444	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.142138888	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	ALLMS 68	ALLMS 82
Mean	13.15346339	12.65911259
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.459336607	
P(T<=t) one-tail	0.012916695	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.025833389	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	ALLMS 68	ALLMS 82
Mean	12.52473486	12.25666665
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.334763292	
P(T<=t) one-tail	0.126430428	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.252860857	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	ALLMS 76	ALLMS 93
Mean	12.85976097	12.32671321
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.730127771	
P(T<=t) one-tail	0.01014731	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.020294619	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	ALLMS 76	ALLMS 93
Mean	12.36547087	12.07641873
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.439246362	
P(T<=t) one-tail	0.111743141	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.223486282	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	ALLMS 86	ALLMS 105
Mean	12.53334596	12.00624773
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.688494507	
P(T<=t) one-tail	0.010523247	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.021046493	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	ALLMS 86	ALLMS 105
Mean	12.18846805	11.90264212
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.423182428	
P(T<=t) one-tail	0.113885744	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.227771488	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	ALLMS 96	ALLMS 119
Mean	12.2428776	11.67574194
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.9686659	
P(T<=t) one-tail	0.008278574	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.016557147	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	ALLMS 96	ALLMS 119
Mean	12.03095777	11.72342101
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.5312848	
P(T<=t) one-tail	0.100227123	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.200454246	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	ALLMS 109	ALLMS 135
Mean	11.90752221	11.34262685
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.952988875	
P(T<=t) one-tail	0.008387953	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.016775907	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	ALLMS 109	ALLMS 135
Mean	11.84910691	11.54278499
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.525235918	
P(T<=t) one-tail	0.100945564	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.201891129	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	ALLMS 126	ALLMS 153
Mean	11.52480943	11.01212106
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.587658115	
P(T<=t) one-tail	0.011504918	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.023009836	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	ALLMS 126	ALLMS 153
Mean	11.64157588	11.36356388
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.38427534	
P(T<=t) one-tail	0.119246445	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.238492889	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
COARSE GRADATION	*ALLMS 142*	*ALLMS 172*
Mean	11.2091385	10.70302152
Variance	0.030632052	0.030632052
Observations	3	3
Pooled Variance	0.030632052	
Hypothesized Mean Difference	0	
df	4	
t Stat	3.541673298	
P(T<=t) one-tail	0.011988655	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.02397731	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances		
FINE GRADATION	*ALLMS 142*	*ALLMS 172*
Mean	11.47039918	11.1959506
Variance	0.060502507	0.060502507
Observations	3	3
Pooled Variance	0.060502507	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.366532387	
P(T<=t) one-tail	0.121773443	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.243546887	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	*NYGRV 68*	*NYGRV 82*
Mean	14.60415429	14.02866601
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.97911516	
P(T<=t) one-tail	0.059460974	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.118921948	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	*NYGRV 68*	*NYGRV 82*
Mean	13.66210346	13.36530346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.998603219	
P(T<=t) one-tail	0.058150937	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.116301874	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	*NYGRV 76*	*NYGRV 93*
Mean	14.26224669	13.64171014
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.134037031	
P(T<=t) one-tail	0.049877021	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.099754042	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	*NYGRV 76*	*NYGRV 93*
Mean	13.48818346	13.15685346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.231122657	
P(T<=t) one-tail	0.044749636	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.089499272	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	NYGRV 109	NYGRV 135
Mean	13.15371759	12.49610631
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.261537716	
P(T<=t) one-tail	0.043266588	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.086533175	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	NYGRV 109	NYGRV 135
Mean	12.66218346	12.56129346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	0.67937695	
P(T<=t) one-tail	0.267089732	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.534179464	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	NYGRV 126	NYGRV 153
Mean	12.7081904	12.11135481
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.052528959	
P(T<=t) one-tail	0.054687906	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.109375812	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	NYGRV 126	NYGRV 153
Mean	12.66218346	12.40325346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.743592761	
P(T<=t) one-tail	0.078090451	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.156180901	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	*NYGRV 86*	*NYGRV 105*
Mean	13.88225739	13.26864686
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.110218295	
P(T<=t) one-tail	0.051232621	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.102465242	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	*NYGRV 86*	*NYGRV 105*
Mean	13.28698346	12.95429346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.240280677	
P(T<=t) one-tail	0.04429718	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.08859436	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	*NYGRV 96*	*NYGRV 119*
Mean	13.54411464	12.88389536
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.270506672	
P(T<=t) one-tail	0.04283984	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.08567968	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	*NYGRV 96*	*NYGRV 119*
Mean	13.10378346	12.75073346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.377381626	
P(T<=t) one-tail	0.03810302	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.076206039	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

COARSE GRADATION	*NYGRV 142*	*NYGRV 172*
Mean	12.34070861	11.75152296
Variance	0.12683003	0.12683003
Observations	3	3
Pooled Variance	0.12683003	
Hypothesized Mean Difference	0	
df	4	
t Stat	2.026220663	
P(T<=t) one-tail	0.056348237	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.112696475	
t Critical two-tail	2.776450856	

t-Test: Two-Sample Assuming Equal Variances

FINE GRADATION	*NYGRV 142*	*NYGRV 172*
Mean	12.49290346	12.29970346
Variance	0.033080029	0.033080029
Observations	3	3
Pooled Variance	0.033080029	
Hypothesized Mean Difference	0	
df	4	
t Stat	1.300977567	
P(T<=t) one-tail	0.131573987	
t Critical one-tail	2.131846486	
P(T<=t) two-tail	0.263147973	
t Critical two-tail	2.776450856	

APPENDIX G
NCHRP 9-9

Draft Final Report for Task 3

Experimental Plan

The original intent of Task 3 of the NCHRP 9-9 project was to evaluate the effect of specimen size (diameter and height), and aggregate properties (maximum size, type, and gradation) on laboratory compacted volumetric properties. The experimental test plan included five variables: specimen diameter, specimen height, nominal maximum aggregate size, aggregate type, and aggregate gradation. Table 1 indicates the variables and the number of levels for each variable as was originally planned, and as completed. The experiment was stopped after panel review of the interim report.

Table 1: Variables for Task 3 Work Plan

	# of Levels	
Variable	Planned	Actual
Specimen Diameter	2	2
Height/Diameter Ratio	2	2
Nominal Aggregate Size	4	2
Aggregate Type	4	1
Aggregate Gradation	3	2

The levels are indicated as follows for each of the variables:

Specimen Diameter -- Two specimen diameters were used: ***150 mm*** and ***100 mm***.

Height to Diameter Ratio (H/D) -- Two H/D ratios will be used: ***0.75*** and ***0.63***. These ratios correspond to heights of 115 mm and 95 mm for the 150 mm diameter specimens and 75 mm and 63 mm for the 100 mm diameter specimens.

Nominal Aggregate Size -- Four nominal aggregate sizes were planned to be used: ***37.5 mm, 25 mm, 19 mm,*** and ***12.5 mm***. Only the ***19 mm*** and ***12.5 mm*** nominal aggregate sizes were tested.

Aggregate Type -- Four aggregate types were planned to be used: ***crushed gravel (New York), crushed limestone (Alabama), crushed limestone (Texas),*** and ***crushed granite (Georgia)***. Mineral filler will be added as needed to the aggregate types to generate the appropriate gradations. Only the ***crushed gravel (New York)*** was actually used in the experiment.

Aggregate Gradation -- Three aggregate gradations were planned to be used: ***coarse, medium,*** and ***fine***. The coarse gradation was developed below the restricted zone near the minimum limits of the control points for the nominal maximum size, 2.36 mm, and 0.075 mm sieves. The medium gradation was developed in the middle of the gradation control points without regard to the restricted zone. The fine gradation was developed above the restricted zone near the maximum limits of the control points for the nominal maximum size, 2.36 mm, and 0.075 mm sieves. Only the ***coarse*** and ***medium*** gradations were used in the experiment.

Each cell in the completed experiment will have 9 compacted specimens analyzed. Triplicate specimens were produced for three asphalt contents. The asphalt contents were selected based on trial compacted specimens (150 mm diameter and 115 mm height) of each aggregate size and gradation. The Superpave procedure was used to estimate the design asphalt content from the trial specimens. The three selected asphalt contents for each combination of aggregate size and gradation include the estimated design asphalt content, and asphalt contents 0.5% higher and lower than the design asphalt content.

One asphalt binder was used for the experiment. This asphalt binder classifies as a PG 64-22. The equiviscous temperature ranges calculated from the rotational viscometer are 155-161°C for mixing and 143-148°C for compaction.. All loose mixture specimens were subjected to four hours of short term aging at 135°C prior to compaction.

A full factorial experiment would require 192 cells to be filled. With nine compacted specimens per cell, a total of 1728 compacted specimens would be required to fill all the cells. Consequently, the experiment was reduced to a partial factorial. The experimental matrix is indicated in Table 2. Shaded cells indicate the intended treatments. Dark shaded cells indicate completion.

Table 2: Task 3 Experimental Matrix

			Coarse				Medium				Fine			
Dia.	H/D	Size	LS1	Gran	LS2	Grav	LS1	Gran	LS2	Grav	LS1	Gran	LS2	Grav
150	0.75	12.5												
		19												
		25												
		37.5												
	0.63	12.5												
		19												
		25												
		37.5												
100	0.75	12.5												
		19												
		25												
		37.5												
	0.63	12.5												
		19												
		25												
		37.5												

As indicated in Table 2, 80 of the 192 cells were intended to be filled within the matrix. A total of 720 compacted specimens were required to complete the partial factorial. At the time the experiment was stopped, 13 cells, including 117 compacted specimens, were completed.

Crushed Gravel (New York) Aggregate Blends

Work was completed only for the crushed gravel aggregate from New York. Four sizes of crushed gravel were supplied (designated as 2's, 1's, 1A's, and Crushed Sand), along with the individual gradations of each aggregate size. Blended gradations were developed using varying percentages of the individual fractions. Mineral filler was used to supplement the aggregate gradation for the fine set of sieves. Figures 1 and 2 indicate the combined gradations for the 19 mm and 12.5 mm nominal aggregate sizes. Although Figure 2 indicates three gradations for the 12.5 mm nominal gravel, only the coarse gradation was tested.

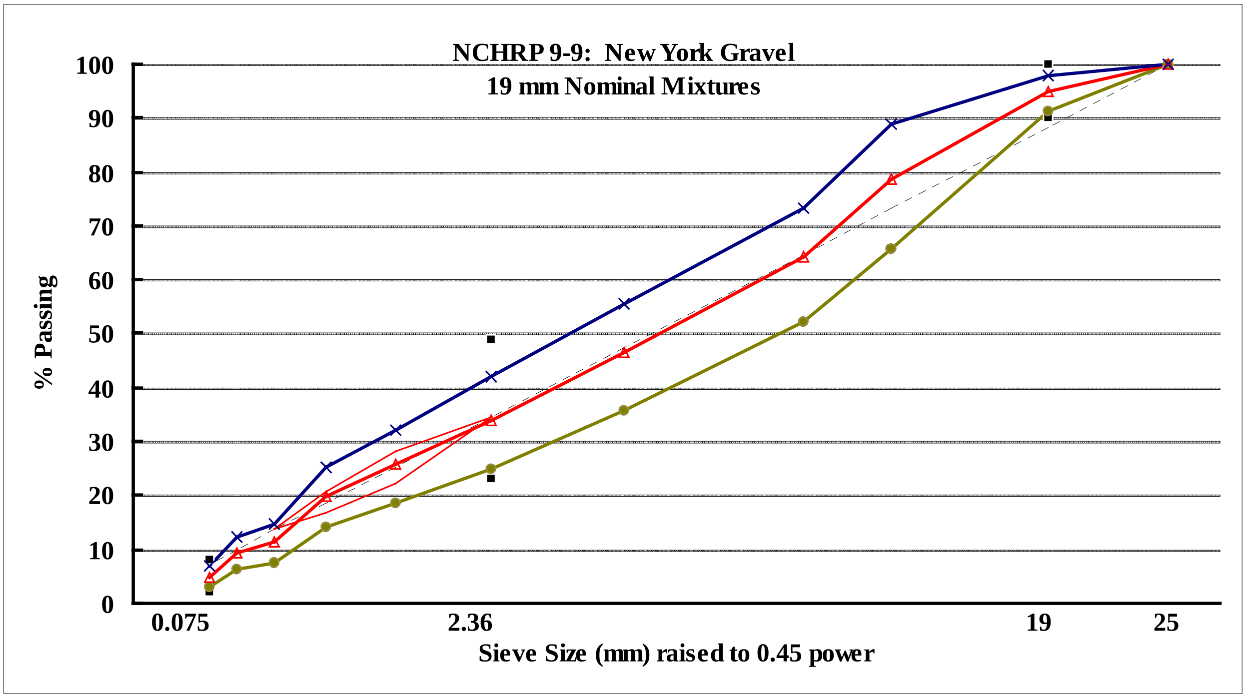

Figure 1: Combined Gradations for 19 mm Crushed Gravel

The bulk specific gravity of the aggregate was determined for each of the four supplied aggregate sizes. The bulk specific gravity of the blend gradations was used in calculating the percentage of voids in the mineral aggregate (VMA) for the compacted specimens. Other aggregate properties, such as fine aggregate angularity, were not determined for the blends.

The Superpave gyratory compactor (SGC) used in this experiment was supplied by Pine Instruments. Before beginning the experiment, the SGC was calibrated for pressure, height, and rotational speed. In accordance with instructions from Pine, the SGC angle was calibrated by determining the angle with an actual specimen during the compaction process. The angle was verified for three of the four aggregate blends at 150 mm diameter and 115 mm height. One of the blends was also used to verify the angle for 100 mm diameter specimens. Figure 3 illustrates the results of the verification of the angle for the various mixtures.

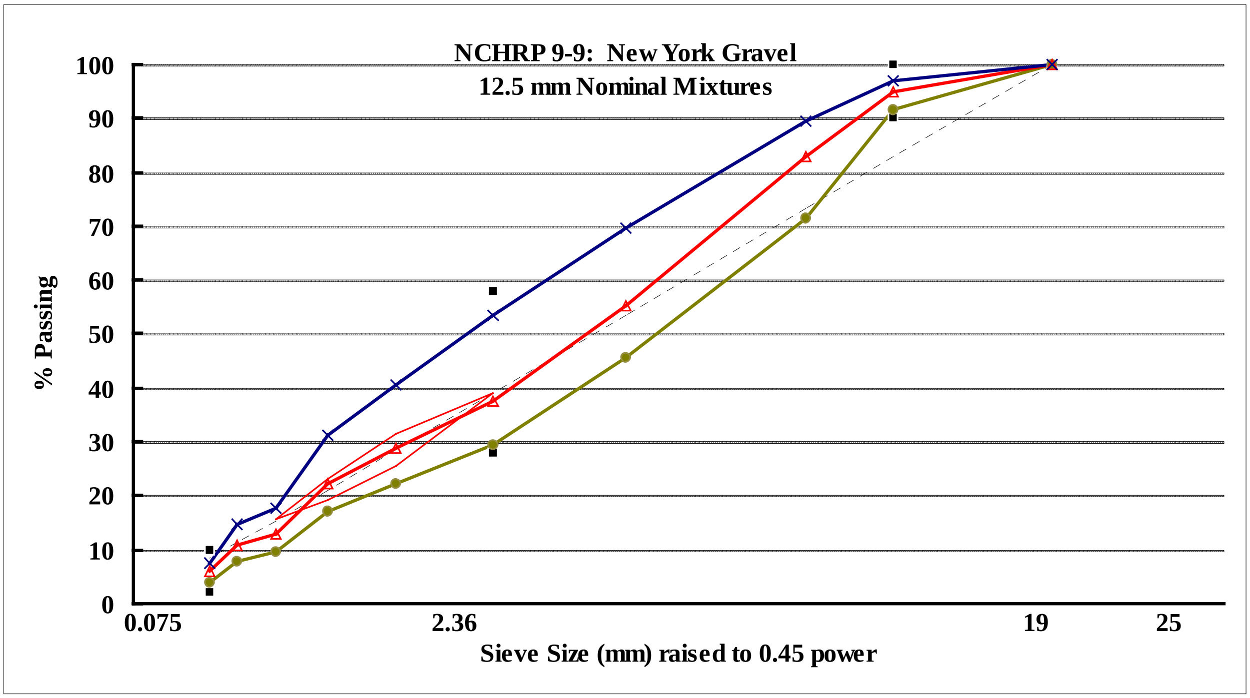

Figure 2: Combined Gradations for 12.5 mm Crushed Gravel

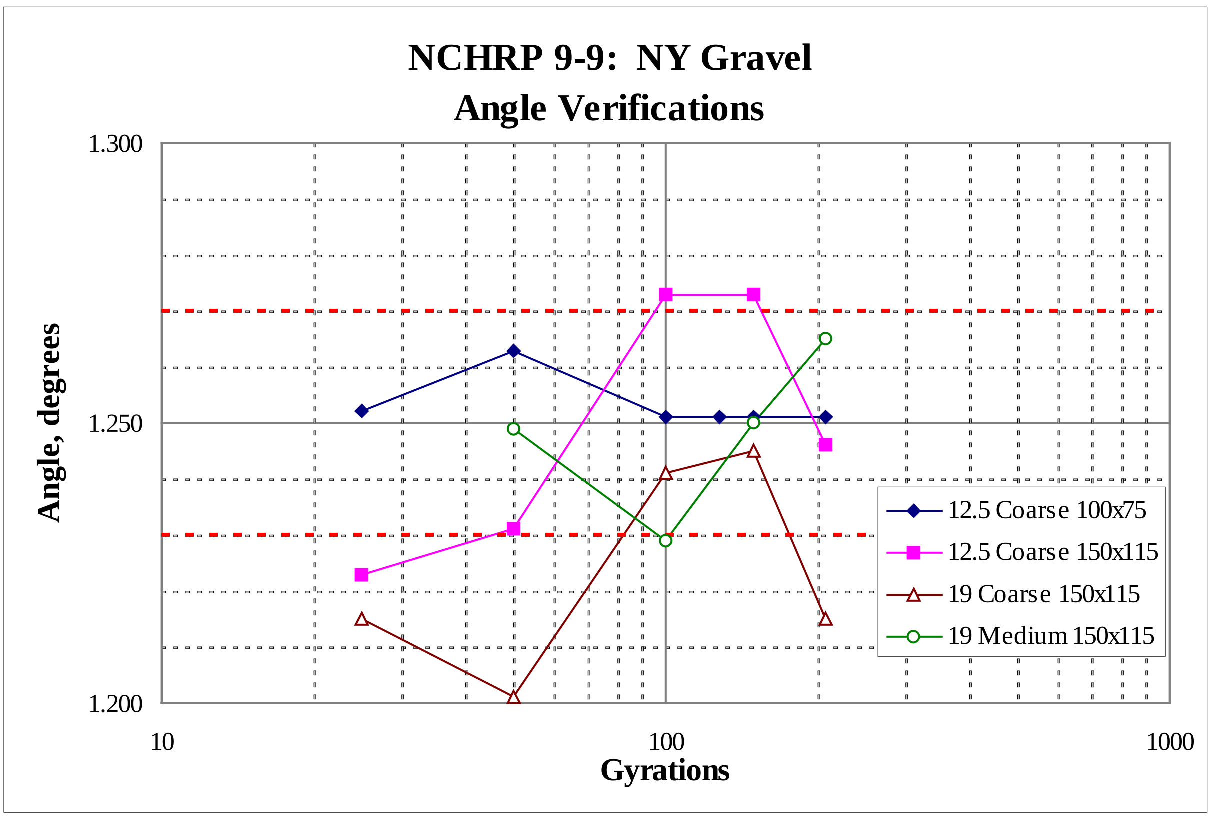

Figure 3: Verification of Compaction Angle

As illustrated in Figure 3, the angle of gyration varied some during the compaction process, but generally stayed between the current tolerance limits of 1.23 to 1.27 degrees.

After calibration, trial mix specimens were prepared for each of the four blends of the crushed gravel: 19 mm Coarse, 19 mm Medium, 19 mm Fine, and 12.5 mm Coarse. A trial asphalt content of 4.9% was selected. Specimens were compacted to the maximum number of gyrations chosen for this experiment. Compaction levels of 9, 128, and 208 gyrations were selected for initial, design, and maximum number of gyrations. The design asphalt contents for the crushed gravel blends are indicated in Table 3.

Table 3: Asphalt Contents for Crushed Gravel Blends

Blend	Estimated Design AC	Asphalt Contents for Cells
19 mm Coarse	4.0%	3.5%, 4.0%, 4.5%
19 mm Medium	3.7%	3.2%, 3.7%, 4.2%
19 mm Fine	3.7%	3.2%, 3.7%, 4.2%
12.5 mm Coarse	4.6%	4.1%, 4.6%, 5.1%

For each cell indicated in Table 2, three replicate specimens were planned to be compacted for each of three asphalt contents. As discussed previously, the 19 mm Fine Blend was not completed in this experiment. Only the specimens prepared at the "design" asphalt content were compacted to 208 gyrations. The specimens prepared at 0.5% higher and lower than the design asphalt content were compacted to the design number of gyrations, 128. The research team believed this would eliminate potential problems of determining volumetric properties using the correction factor determined at the maximum number of gyrations. It was thought that the correction factor would be less likely to influence the volumetric properties when the design asphalt content was used.

Results and Analysis

Testing was completed for the 19 mm Coarse, 19 mm Medium, and 12.5 mm Coarse blends for the crushed gravel.

The standard deviations of each set of three compacted specimens are low. Of the 36 sets of triplicate specimens completed (2 aggregate gradation, 2 aggregate sizes, 1 aggregate type, 2 specimen diameters, 2 H/D ratios, 3 asphalt contents), 26 sets had standard deviations of 0.2% or less for the percentage of air voids at the design number of gyrations. This would translate to a coefficient of variation less than 10%.

All three blends failed to meet minimum VMA requirements at the design number of gyrations. It should be noted that the VMA for the 19 mm Coarse blend varied (for the four combinations of diameter and H/D ratio) from 10.8% to 11.3% at the design asphalt content. The VMA for the 12.5 mm Coarse blend varied from 11.2% to 12.3% at the design asphalt content. This indicates an increase of approximately one percent in VMA as the nominal aggregate size decreases. Current Superpave requirements indicate a one percent increase in required VMA as nominal aggregate size decreases. This is a reasonable comparison since the gradations are similar for the respective nominal aggregate sizes. The design asphalt content increased by 0.5% as the nominal aggregate size decreased.

12.5 mm Coarse Crushed Gravel Blend

Some variation was noted in the volumetric properties for the 12.5 mm Coarse blend. The percentage of air voids varied as much as 1.3% for the different treatments. In general, the percentage of air voids was lower for the 100 mm diameter specimens than the 150 mm diameter specimens. The height to diameter ratio (H/D) indicated some effect on the percentage of air voids. However, the trend appears to indicate that the 0.75 H/D ratio results in lower air voids than the 0.63 H/D ratio. Some effect was anticipated based on the results of a ruggedness evaluation of the SGC *(1)*. This study concluded that some effect on air voids is apparent at approximately 12 mm difference in height. In this experiment, the 150 mm diameter specimens vary by as much as 20 mm in height. However, the trend of increasing air voids as the H/D is reduced is contrary to the data reported in this study. The expected trend line based on the ruggedness data indicated a decrease in air voids as the H/D decreased.

A statistical analysis was completed for the 12.5 mm Coarse Gravel Blend. An analysis of variance (ANOVA) was performed to analyze the percentage of air voids at the design number of gyrations for each of the three asphalt contents tested with the 12.5 mm Coarse Gravel blend. The ANOVA indicated that specimen diameter has a significant effect (at a significance level of 5%) on the percentage of air voids for all three asphalt contents. The 100 mm specimens had significantly lower air voids than the 150 mm specimens. The H/D ratio also had a significant effect (at a significance level of 5%) on the percentage of air voids for two of the three asphalt contents. The specimens with a lower H/D ratio (0.63) indicated higher air voids than specimens with a 0.75 H/D ratio. The interaction between diameter and H/D ratio was insignificant in all cases.

A paired comparison was made of each of the sample means using the t-test assuming unequal variances. Table 4 indicates the results of the paired comparisons.

Table 4: Paired Comparisons of Sample Means Using the t-test -- Air Voids

	Statistical Difference in Comparison (Y-yes, N-no)		
Comparison	4.1% AC	4.6% AC	5.1% AC
150 x 0.75 vs. 150 x 0.63	N	Y	Y
150 x 0.75 vs. 100 x 0.75	Y	Y	Y
150 x 0.75 vs. 100 x 0.63	Y	N	N
150 x 0.63 vs. 100 x 0.75	Y	Y	Y
150 x 0.63 vs. 100 x 0.63	Y	Y	N
100 x 0.75 vs. 100 x 0.63	Y	Y	Y

The data in Table 4 indicates that 14 of 18 comparisons of sample means show a statistical difference in the percentage of air voids at a significance level of five percent. These results confirm the results of the ANOVA that the two main effects, diameter and H/D ratio, have a significant effect on the percentage of air voids at the design number of gyrations.

The practical significance of this data was investigated by plotting the percentage of air voids versus asphalt content for each of the four combinations of specimen diameter and H/D ratio. In a design lab, the design asphalt content for the 12.5 mm Coarse blend would be as low as 4.3% (100 mm, 0.75 H/D) or as high as 4.7% (150 mm, 0.63 H/D). Two combinations resulted in a duplication of the estimated design asphalt content. The design VMA would differ as much as one percent (1%).

Another response variable that was selected to be analyzed was compaction slope. The compaction slope is calculated as follows:

$$\text{Slope} = \frac{\%G_{mm,\,design} - \%G_{mm,\,initial}}{Log(N_{design}) - Log(N_{initial})}$$

The compaction slope is an indication of the resistance of the asphalt mixture to compaction. The calculation incorporates both the $\%G_{mm}$ at N_{design} and the $\%G_{mm}$ at $N_{initial}$. By examining the compaction slope the user can identify if the difference in air voids at N_{design} is caused by differences early in the compaction process at $N_{initial}$. The compaction slope values are included in the summary sheets in the appendix.

An ANOVA was performed to analyze the compaction slope for each of the three asphalt contents tested with the 12.5 mm Coarse Gravel blend. The ANOVA indicated that, unlike the analysis of the percentage of air voids, none of the variables had a significant effect (at a significance level of 5%) on the compaction slope for all three asphalt contents. In all three cases for the 12.5 mm Coarse Gravel blend, the compaction slope generated during the compaction process was statistically the same. These results indicate that the statistical difference in percentage of air voids for this mixture was a function of the initial compaction.

A paired comparison was made of each of the sample means using the t-test assuming unequal variances. Table 5 indicates the results of the paired comparisons.

Table 5: Paired Comparisons of Sample Means Using the t-test -- Compaction Slope

	Statistical Difference in Comparison (Y-yes, N-no)		
Comparison	4.1% AC	4.6% AC	5.1% AC
150 x 0.75 vs. 150 x 0.63	N	N	N
150 x 0.75 vs. 100 x 0.75	N	Y	N
150 x 0.75 vs. 100 x 0.63	N	N	N
150 x 0.63 vs. 100 x 0.75	Y	Y	N
150 x 0.63 vs. 100 x 0.63	N	N	N
100 x 0.75 vs. 100 x 0.63	N	N	N

The data in Table 5 indicates that 3 of 18 comparisons of sample means show a statistical difference in the compaction slope at a significance level of five percent. These results confirm the results of the ANOVA that the two main effects, diameter and H/D ratio, do not have a significant effect on the compaction slope.

The fact that the compaction slopes are statistically the same for the various treatments is an indication that the asphalt mixtures are compacting in a similar manner regardless of the specimen diameter or H/D ratio. If the compaction slopes were different, it would be likely that some confounding effects, such as the interface between mold wall and asphalt mixture, would be present that would result in a difference in the compaction process. Since the compaction slopes are statistically the same, and the percentage of air voids are different, the densification curves for a given asphalt content are parallel, but translated. For the same asphalt content, this translation should only occur if the compaction parameters were different, but consistent, for the various treatments. In other words, if one set of specimens were compacted with an angle of 1.22 degrees and another set were compacted with an angle of 1.28 degrees, one would expect that the densification curves would look the same, but the air voids would be different. This concept is illustrated in Figure 4.

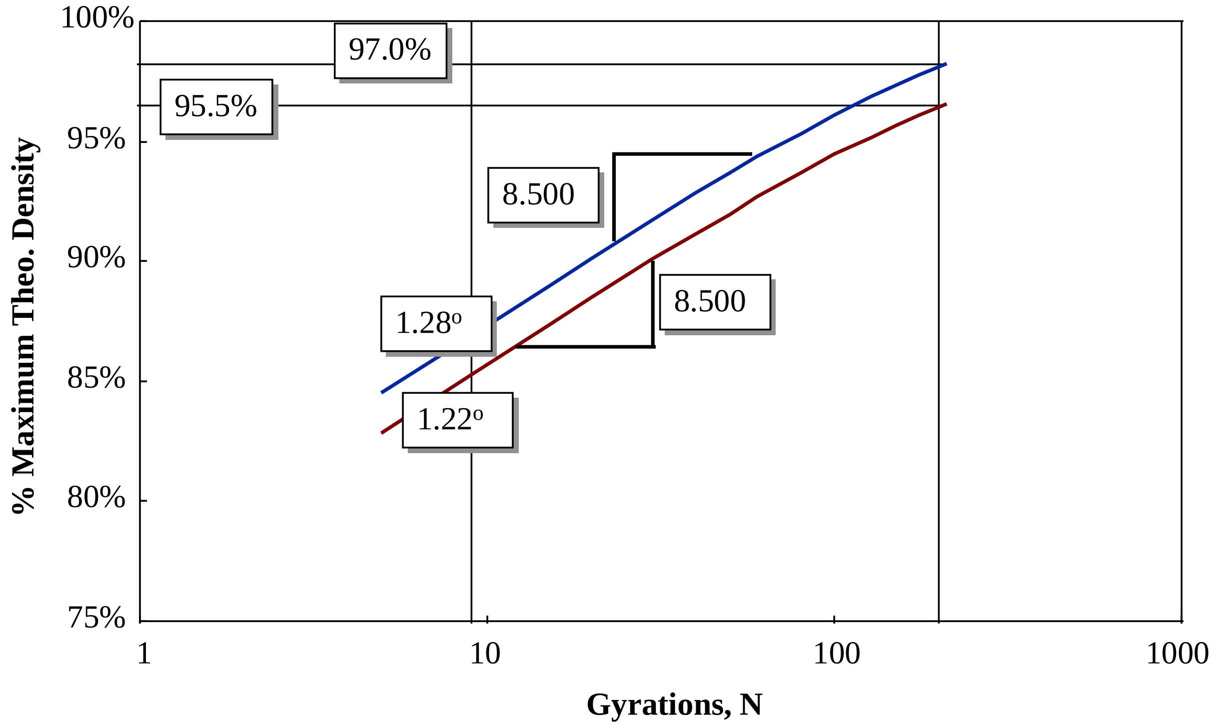

Figure 4: Example of Likely Effect of Compaction Angle on Densification Curves

The angle was verified before compaction, as illustrated previously in Figure 3. Therefore it is unlikely that there were significant differences in the angle during the compaction process between the various treatments. Likewise, the pressure was maintained constant (600 kPa) through the compaction process. The question then remains, what caused the compaction curves to be translated?

One hypothesis is that the vertical pressure should be adjusted for the 100 mm diameter specimens. The 600 kPa pressure was developed by the French LCPC using 150 mm diameter compacted specimens that were approximately 115 mm in height. If the amount of compaction energy imparted to the asphalt mixture is expressed as force per unit volume, it is clear that the 100 mm diameter specimens have a higher imparted compaction energy than the 150 mm diameter specimens. Typical data is illustrated in Table 6.

Table 6: Comparison of Compaction Energy per Unit Area and Volume

Size (mm)	Area (cm^2)	Volume (cm^3)	Force (N)	Force/Area (N/ cm^2)	Force/Volume (N/ cm^3)
150 x 115	176.7	2032.2	10602	60	5.2
150 x 95	176.7	1678.8	10602	60	6.3
100 x 75	78.5	589.0	4710	60	8.0
100 x 63	78.5	494.8	4710	60	9.5

The data in Table 6 indicate that, although the same vertical pressure is applied to the specimen, the actual force imparted per unit volume varies significantly. Since the force per volume increases as the diameter decreases, one would expect the 100 mm diameter specimens to have a lower percentage of air voids than the 150 mm specimens. This hypothesis concurs with the data for the 12.5 mm Coarse Gravel blend. However, based on Table 6, one would also expect the percentage of air voids to be less for the smaller H/D ratio specimens. The hypothesis does not concur with the data for the 12.5 mm Coarse Gravel Blend. The hypothesis does concur with the general findings in the ruggedness evaluation of the SGC *(1)*.

These findings are similar to the conclusions of a 1990 study regarding large stone mixtures *(2)*. In this study, large stone asphalt mixtures were prepared using 6 inch (150 mm) Marshall molds. The study indicated that originally the compaction method was altered to yield the same energy input per unit area. Initial comparisons indicated that the 6 inch (150 mm) Marshall specimens had higher air voids than the 4 inch (100 mm) Marshall specimens. The mixture used in the comparison was a 1/2 inch (12.5 mm) maximum aggregate size asphalt mixture. Following the preliminary comparisons, the Marshall compaction method was altered to provide equivalent input per unit volume.

The hypothesis can be easily tested by varying the vertical pressure in the study so that the numbers in the last column of Table 6 (Force/Volume) are equivalent. For instance, a 100 x 75 mm specimen would require a vertical pressure of approximately 390 kPa to generate the same force per unit volume as the 150 x 115 mm specimen experiences.

19 mm Coarse Crushed Gravel Blend

The 19 mm Coarse Gravel blend indicated some differences in volumetric properties for the 100 mm and 150 mm diameter specimens. The greatest differences were between the different H/D ratios of the 150 mm diameter specimens. The percentage of air voids varied as much as 1.1% for the different treatments. In all cases the percentage of air voids was lower for the 150 x 115 mm specimens than any of the other specimens.

An ANOVA was completed for the 19 mm Coarse Gravel Blend to analyze the percentage of air voids at the design number of gyrations for each of the three asphalt contents tested. The ANOVA indicated that specimen diameter did not have a significant effect (at a significance level of 5%) on the percentage of air voids for all three asphalt contents. The H/D ratio had a significant effect (at a significance level of 5%) on the percentage of air voids for two of the three asphalt contents. No apparent trend could be identified regarding the effect of H/D ratio on air voids. In three of six cases, the air voids decreased or stayed the same as the H/D ratio decreased. The interaction between diameter and H/D ratio was significant in only one instance.

A paired comparison was made of each of the sample means using the t-test assuming unequal variances. Table 7 indicates the results of the paired comparisons.

Table 7: Paired Comparisons of Sample Means Using the t-test -- Air Voids

	Statistical Difference in Comparison (Y-yes, N-no)		
Comparison	3.5% AC	4.0% AC	4.5% AC
150 x 0.75 vs. 150 x 0.63	Y	N	Y
150 x 0.75 vs. 100 x 0.75	Y	Y	Y
150 x 0.75 vs. 100 x 0.63	N	N	Y
150 x 0.63 vs. 100 x 0.75	N	N	N
150 x 0.63 vs. 100 x 0.63	N	N	Y
100 x 0.75 vs. 100 x 0.63	N	N	N

The data in Table 7 indicates that 7 of 18 comparisons of sample means show a statistical difference in the percentage of air voids at a significance level of five percent. These results confirm the mixed results of the ANOVA that the H/D ratio has a significant effect on the percentage of air voids at the design number of gyrations. In all three asphalt content mixtures, the paired comparison indicated a significant difference in air voids between the 150 x 115 mm specimens and the 100 x 75 mm specimens. This would seem to indicate that diameter has an effect on air voids. Some of the confusion with the analysis may result from the variances of the sets of specimens. In general, the variances were higher for the 19 mm Coarse Gravel blend specimens than the 12.5 mm Coarse Gravel blend specimens.

The practical significance of this data was investigated by plotting the percentage of air voids versus asphalt content for each of the four combinations of specimen diameter and H/D ratio. In a design lab, the design asphalt content for the 19 mm Coarse Gravel blend would be as low as 3.9% (150 mm, 0.75 H/D) or as high as 4.1% (100 mm, 0.75 H/D). Two combinations resulted in a duplication of the estimated design asphalt content. The design VMA would differ as much as 0.5%. These differences are not as great (approximately half) as those reported for the 12.5 mm Coarse Gravel blend specimens.

An ANOVA was also performed to analyze the compaction slope for each of the three asphalt contents tested with the 19 mm Coarse Gravel blend. The ANOVA indicated that the diameter of the specimen had a significant effect (at a significance level of 5%) on the compaction slope for one of the three asphalt contents. The effects of the H/D ratio, and the interaction of diameter and H/D ratio were insignificant in all cases.

A paired comparison was made of each of the sample means using the t-test assuming unequal variances. Table 8 indicates the results of the paired comparisons.

Table 8: Paired Comparisons of Sample Means Using the t-test -- Compaction Slope

	Statistical Difference in Comparison (Y-yes, N-no)		
Comparison	3.5% AC	4.0% AC	4.5% AC
150 x 0.75 vs. 150 x 0.63	Y	Y	N
150 x 0.75 vs. 100 x 0.75	N	N	N
150 x 0.75 vs. 100 x 0.63	N	Y	N
150 x 0.63 vs. 100 x 0.75	Y	N	Y
150 x 0.63 vs. 100 x 0.63	N	Y	N
100 x 0.75 vs. 100 x 0.63	N	N	N

The data in Table 8 indicates that 6 of 18 comparisons of sample means show a statistical difference in the compaction slope at a significance level of five percent. As noted before with the ANOVA, the comparisons are mixed, and do not conclusively indicate major effects of either main variable on the compaction slope.

19 mm Medium Crushed Gravel Blend

The 19 mm Medium Gravel blend indicated some differences in volumetric properties for the 100 mm and 150 mm diameter specimens. The greatest differences were consistently between the 150 x 115 mm specimens and the 100 x 63 mm specimens. The percentage of air voids varied as much as 1.3% for the different treatments. In all cases the percentage of air voids was lower for the 150 x 115 mm specimens than any of the other specimens.

An ANOVA was completed for the 19 mm Medium Gravel blend to analyze the percentage of air voids at the design number of gyrations for each of the three asphalt contents tested. The results of the ANOVA are indicated in the appendix. The ANOVA indicated that specimen diameter had a significant effect (at a significance level of 5%) on the percentage of air voids for all three asphalt contents. This effect was also have been significant at a level of 1%. In all cases, the air voids of the 150 mm diameter specimens were lower than the air voids of the 100 mm diameter specimens. The H/D ratio had a significant effect (at a significance level of 5%) on the percentage of air voids for one of the three asphalt contents. The air voids increased or stayed the same as the H/D ratio decreased. The interaction between diameter and H/D ratio was not significant in any case.

A paired comparison was made of each of the sample means using the t-test assuming unequal variances. Table 9 indicates the results of the paired comparisons.

Table 9: Paired Comparisons of Sample Means Using the t-test -- Air Voids

	Statistical Difference in Comparison (Y-yes, N-no)		
Comparison	3.2% AC	3.7% AC	4.2% AC
150 x 0.75 vs. 150 x 0.63	Y	N	N
150 x 0.75 vs. 100 x 0.75	Y	N	Y
150 x 0.75 vs. 100 x 0.63	Y	Y	N
150 x 0.63 vs. 100 x 0.75	Y	N	N
150 x 0.63 vs. 100 x 0.63	Y	Y	Y
100 x 0.75 vs. 100 x 0.63	N	N	Y

The data in Table 9 indicates that 10 of 18 comparisons of sample means show a statistical difference in the percentage of air voids at a significance level of five percent. All three comparisons of 150 x 0.63 specimens and 100 x 0.63 specimens indicate a significant difference in air voids. In general, the variances were lower for the 19 mm Medium Gravel blend specimens than the 19 mm Medium Gravel blend specimens.

The practical significance of this data was investigated by plotting the percentage of air voids versus asphalt content for each of the four combinations of specimen diameter and H/D ratio. In a design lab, the design asphalt content for the 19 mm Medium Gravel blend would be as low as 3.6% (150 mm, 0.75 H/D) or as high as 4.0% (100 mm, 0.63 H/D). The design VMA would differ as much as 1%. These differences are approximately the same as those reported for the 12.5 mm Coarse Gravel blend specimens.

An ANOVA was also performed to analyze the compaction slope for each of the three asphalt contents tested with the 19 mm Medium Gravel blend The ANOVA indicated that the diameter of the specimen had a significant effect (at a significance level of 5%) on the compaction slope for two of the three asphalt contents. The effects of the H/D ratio, and the interaction of diameter and H/D ratio were insignificant in all cases.

A paired comparison was made of each of the sample means using the t-test assuming unequal variances. Table 10 indicates the results of the paired comparisons.

Table 10: Paired Comparisons of Sample Means Using the t-test -- Compaction Slope

	Statistical Difference in Comparison (Y-yes, N-no)		
Comparison	3.2% AC	3.7% AC	4.2% AC
150 x 0.75 vs. 150 x 0.63	N	N	Y
150 x 0.75 vs. 100 x 0.75	N	N	N
150 x 0.75 vs. 100 x 0.63	Y	Y	N
150 x 0.63 vs. 100 x 0.75	N	N	N
150 x 0.63 vs. 100 x 0.63	Y	N	N
100 x 0.75 vs. 100 x 0.63	N	N	N

The data in Table 5 indicates that 4 of 18 comparisons of sample means show a statistical difference in the compaction slope at a significance level of five percent. As noted before with the ANOVA, the comparisons are mixed, and do not conclusively indicate major effects of either main variable on the compaction slope.

Conclusions and Recommendations

Analysis of the data for the crushed gravel blends indicates that the percentage of air voids in a compacted mixture specimen is significantly affected by specimen diameter in 6 of 9 cases. Specimen diameter affects compaction slope in 3 of 9 cases. The H/D ratio of the specimen affects air voids in 5 of 9 cases. The H/D ratio does not significantly affect compaction slope.

In the majority of cases compaction slope does not appear to be significantly affected by either of the two main factors, or their interaction. Consequently, differences in the percentage of air voids at the design number of gyrations are likely caused by differences in early compaction (at $N_{initial}$). This conclusion seems to indicate that compaction parameters could be altered for different specimen sizes to produce similar results. This hypothesis could be tested by varying the vertical pressure to produce equivalent input compaction energy. This research is recommended if the user plans to use 100 mm diameter SGC specimens instead of the standard 150 mm diameter specimens specified by AASHTO TP4.

Although the experiment only evaluated one aggregate type (3 mixtures total) there is sufficient data to suggest that specimen size (diameter and H/D ratio) significantly affects the volumetric properties of SGC compacted asphalt mixture specimens.

References

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