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16. Abstract

Given that TxDOT is responsible for over 400 general aviation airports in Texas, the objectives of this project were to analyze current asphalt and base specifications for airport construction, and to modify Texas Department of Transportation (TxDOT) asphalt and base specifications for use in constructing Texas' general aviation airports. The intention was to submit these modified asphalt and base specifications to the Federal Aviation Administration (FAA) for approval. Although the aircraft loading on general aviation airports is considerably less severe than that on typical TxDOT highway pavements, the unit bid costs are considerably higher when using the FAA asphalt and base specifications.

The Center for Transportation Research conducted working sessions with TxDOT Aviation Division, TxDOT Materials and Tests Division, Federal Aviation Administration Southwest Region, airport consulting engineers, and representatives from the asphalt industry. From these working sessions an asphalt specification was developed as a modification to TxDOT Special Specification Item 3063, QA/QC Hot Mix Asphalt. These changes to Item 3063 were then submitted to the FAA for approval.

Additional research was conducted on base materials. The research team and the working group also reached a consensus option that grades 1 and 2 of TxDOT Item 247, flexible base, could be used as a substitute for FAA Items P-208 and P-209 base specifications. A memo was written justifying the use of TxDOT flexible base specification for general aviation airport construction in Texas and was also submitted to FAA with a request for approval for TxDOT use.

This report documents the specifications developed and the justification for TxDOT use on general aviation airports accommodating aircraft gross weights of 27,215 kg (60,000 lb) or less. Currently, the FAA is reviewing the specifications; in the meantime, TxDOT Project 0-1419 has begun to review other potential TxDOT specifications that might also be adapted for the construction of TxDOT's general aviation airports.

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PROPOSED ASPHALT AND BASE SPECIFICATIONS FOR TxDOT GENERAL AVIATION CONSTRUCTION

Michael T. McNerney
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Research Report 2920-1F

Research Project 7-2920
Revised Asphalt and Base Specifications for Airport Construction

conducted for the

Texas Department of Transportation

by the

CENTER FOR TRANSPORTATION RESEARCH
Bureau of Engineering Research
THE UNIVERSITY OF TEXAS AT AUSTIN

March 1996

IMPLEMENTATION STATEMENT

The Texas Department of Transportation (TxDOT) has requested Federal Aviation Administration approval of alternate asphalt and base specifications developed under this project for general aviation airports in Texas. TxDOT is currently awaiting FAA approval for use on federally funded projects of over 12,500 pound loading, but can use these specifications for state-funded projects until FAA approval is received. We estimate that the use of the asphalt specification developed under this project, along with the substitution of the TxDOT base specification, could save TxDOT over $800,000 per year if implemented.

Prepared in cooperation with the Texas Department of Transportation.

DISCLAIMERS

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SUMMARY

Given that TxDOT is responsible for over 250 general aviation airports in Texas, the objectives of this project were to analyze current asphalt and base specifications for airport construction, and to modify Texas Department of Transportation (TxDOT) asphalt and base specifications for use in constructing Texas' general aviation airports. The intention was to submit these modified asphalt and base specifications to the Federal Aviation Administration (FAA) for approval. Although the aircraft loading on general aviation airports is considerably less severe than that on typical TxDOT highway pavements, frequently the unit bid costs are considerably higher when using the FAA asphalt and base specifications.

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CHAPTER 1. INTRODUCTION

PURPOSE

The Texas Department of Transportation (TxDOT) Aviation Division is responsible for the planning and implementation of all airport improvement projects for all public airports within the state of Texas (the only exceptions are those airports designated as air carrier or reliever, which deal directly with the Federal Aviation Administration, or FAA). In a move to supplement this state responsibility, in 1993 the FAA provided the TxDOT Aviation Division with block grant authority for funding airport improvement projects, with the provision that TxDOT use FAA-approved specifications, or submit deviations for FAA review and approval.

In releasing Change 4 to Advisory Circular AC/150-5370-10A (dated July 7, 1992), the FAA revised Item P-401, "Plant Mix Bituminous Pavements Specifications," to require more statistical quality assurance testing, along with a penalty clause based on the laboratory tests. As a result of this specification change, TxDOT Aviation Division's unit cost for asphalt construction has significantly increased — and in some cases has doubled. The recent Change 5 to AC/150-5370-10A maintains these provisions.

The current FAA flexible base course specifications for airports described in Advisory Circular AC/150-5370-10A have been written with sufficient leeway to insure that the specifications can be met throughout the U.S. However, Texas has an abundant supply of high quality aggregates that are routinely specified for highway construction. Thus, if TxDOT standard highway specifications for asphalt and base materials could be modified for TxDOT Aviation Division use at general aviation airports without sacrificing quality, there is a high potential for significant cost savings, since asphalt and base construction are the two major expenses of the Division's Airport Improvement Program (AIP) funds. It is highly probable that revised TxDOT specifications for base and asphalt can be developed to yield both a superior product and a lower unit cost, since contractors experienced in the use of these materials represent potentially knowledgeable bidders. Accordingly, TxDOT's Aviation Division could conceivably improve quality and accomplish, within the limits of its tight budget, more airport improvement projects.

PROJECT SCOPE

As the major source of FAA funding for most airport pavement construction, the AIP is used to provide new runways, overlays, sealing, and the major rehabilitation of asphalt or concrete airport pavements. All AIP projects that obtain federal funding are required to use FAA-approved specifications in order to insure that the FAA is getting a quality product.

Accommodating aircraft loadings of up to 27,215 kg (60,000 lb) gross aircraft weight, the general aviation airport pavement is remarkably similar to highway pavements. But because most general aviation airports sustain relatively light-duty traffic loadings, their principle distress is a result of environmental impacts.

Until recently, each region of the FAA had its own variation of the P-401 national specification. As a result, asphalt pavements produced in one state under a regional specification acceptable in that state were, in many cases, considered unacceptable by a neighboring state. For this reason, the FAA rescinded the authority of the regions to approve the use of their region P-401 specification at approximately the same time that the latest change to P-401 was published. Unfortunately, the change from P-401 Southwest to national P-401, which required a comprehensive and statistical quality central program, resulted in significantly higher unit cost bids by all submitters in Texas.

The FAA is reluctant to allow states to adopt their own specifications, even when such specifications generate high numbers of bidders and good quality products. However, TxDOT is a solid leader in pavement technology, with a pavement research budget 4 to 8 times greater than that of the FAA. In recognition of this, the FAA has expressed a willingness to allow TxDOT Aviation Division to present for consideration a revised TxDOT specification for asphalt and base materials for airport construction. The FAA may be willing to allow only states that have shown a history of quality asphalt construction practices to present modified specifications.

The objective of this project was to specifically recommend a replacement specification for P-401 for general aviation airports in Texas, and to determine if a TxDOT flexible base specification could be substituted for FAA Items P-208 and P-209. We have since submitted these recommendations to the FAA for approval (the FAA regional office was kept informed on the progress of this research and participated in at least two technical review meetings).

ORGANIZATION OF REPORT

This report is based on transmittals to the FAA regarding the proposed asphalt and base specification. Specially, Chapter 2 discusses the changes made to TxDOT Special Specification Item 3063, Quality Control/Quality Assurance of Hot Mix Asphalt. Chapter 3 discusses and justifies the use of TxDOT Item 247 (flexible base), with limitations as replacements to FAA Items P-208 and P-209 (base materials). At the outset of this project, we believed that the existing TxDOT specification could be rewritten to fit the FAA specification. However, we subsequently determined that the significant differences in testing methods and design methods rendered that approach unfeasible and undesirable. If the TxDOT flexible base specification were changed even slightly, then all the experience gained by local district engineers and inspectors would need to be readjusted. After reviewing literature from the 1950s and 1970s, we determined a correlation between Texas Triaxial Class (TTC) and California Bearing Ratio (CBR). Accordingly, the research findings led us to recommend the substitution of P-208 and P-209 with the better grades and types of TxDOT Item 247 flexible base. Chapter 3 also describes how this material should be applied.

Chapter 4 discusses the applicable TxDOT test methods used in the place of ASTM test methods. In each case, FHWA approval has been provided for the adoption of the test method. Chapter 5 summarizes methods potentially useful for measuring and specifying the density of asphalt pavements in the longitudinal construction joint. Currently, Item 3063 specifies no joint density. The current P-401 specification allows for a 3 percent drop in Marshall density. This is an unresolved issue affecting industry; we have not reached any conclusions, but merely present five different specification approaches available from the literature. For TxDOT applications, we suggest that a joint density be specified, though not used as a pay factor.

Chapter 6 presents the conclusions of this research. Unfortunately, this project ended before the FAA issued a ruling on the approval of the adoption of the proposed specification. Project 0-1419, "Consolidation of Aviation and Highway Construction Specifications," is continuing the research on the proposed specifications; that project will also review other TxDOT specifications that could be adopted for construction of general aviation airports under review by the TxDOT Aviation Division.

Appendix A contains the draft asphalt specification discussed in Chapter 2, with changes identified in strikethru, bold, and underlined text. Based on the research findings, we recommend that Item 3063 be modified for general aviation airports in Texas; the result will be significant savings in cost — without degradation of the quality of pavement.

Appendix B and Appendix C contain FAA specifications P-209 and P-208, respectively, while Appendix D contains TxDOT Specification Item 247. Appendix E includes copies of the letters submitted to FHWA detailing the differences between the TxDOT and the American Association of State Highway and Transportation Officials (AASHTO) or ASTM equivalent test methods. In each case, TxDOT believes its test method is as restrictive or more restrictive than the ASTM or AASHTO counterpart. Appendix F describes TxDOT test methods that have no ASTM equivalent.

Appendix G includes, in chronological order, a copy of the letters requesting FHWA approval of the test methods. This chapter concludes that the use of TxDOT test methods is justified and, because of the requirement for certified technicians, will result in tighter quality control.

CHAPTER 2. ASPHALT SPECIFICATION

PROBLEM

Recent experience with the bidding of projects dealing with the national P-401 Asphalt Pavement Specification in Texas has raised concerns with respect to large paving contracts. If TxDOT, whose Aviation Division oversees the design and construction of airport pavements for nearly all general aviation airports in Texas, can develop a new specification for these airports' asphalt pavements based on current TxDOT highway specifications (one that still provides excellent quality asphalt pavements for airports), then considerable savings can be realized through lower unit costs. Since the state has more construction projects than funds to complete them, reduced unit costs obtained through lower competitive bids would result in the same budget completing more projects.

Although the final products are similar in constitution, construction, appearance, and utilization, there are a number of limitations that restrict the application of highway specifications to general aviation airport runways. The close similarity, however, in design, production, and construction makes it desirable to modify the TxDOT specifications only to the degree necessary for use on airport pavements, in order to make use of the extensive experience of TxDOT personnel and Texas' private contractors. The present FAA specifications, including the previous Southwest Region versions, are useful, generalized specifications, but they are designed to be adaptable to the whole southwest region; moreover, they require several procedures that are not allowed by the TxDOT specifications. This in effect restricts the use of a large segment of the Texas hot mix asphalt contracting industry. And a significant result of this situation is the lack of competitive bidding, which has proved costly to the State of Texas.

INVESTIGATION

We reviewed the current FAA P-401 specification (along with its last few modifications), and specifications previously used by the FAA Southwest Region, by the U.S. Air Force, by the Corps of Engineers Waterways Experiment Station, and by the Illinois DOT. We also reviewed the research findings of the Strategic Highway Research Program (SHRP) asphalt research program.

For the last five years, the Texas Department of Transportation has been developing a Quality Control/Quality Assurance specification for asphalt highway construction. During the last two construction seasons, several trial jobs were bid and constructed using Special Specification Item 3007. The success in implementing Item 3007 on a limited basis has led to the revision of that specification as Item 3063; at this time, it is regarded as the standard asphalt specification for highway construction in Texas. The QC/QA and testing certification aspects of the specification have significantly improved the quality of asphalt pavements in Texas, pavements that are already considered among the best in the nation.

DISCUSSION

The Special Specification, "Quality Control/Quality Assurance of Hot Mix Asphalt for Airfield Pavements," is provided in Appendix A in a special format to highlight changes made. The following changes have been made to the original TxDOT 3063 specification:

1. Page 1, 1. DESCRIPTION.
   A new paragraph has been inserted with reference to the Texas Department of Transportation's position and authority.

   Explanation: *The Texas DOT Standard and Special Specifications are generally understood to apply areas or rights of way that belong to the State of Texas. General Aviation Airports belong to other agencies or entities. This paragraph makes clear that although TxDOT is not the owner, they are the responsible agency for the design and construction.*

2. Page 2, 3. MATERIALS (1). AGGREGATE
   Removed the restrictions on the use of mineral filler and inserted the statement that the contractor could use mineral filler when necessary to meet design requirements.

   Explanation: *In a QC/QA specification, the contractor is the responsible agent for the design and control of the produced mixture. This change simply removes an unnecessary restriction as long as the material meets quality requirements.*

3. Page 2, 3. MATERIALS (1)(A) COARSE AGGREGATE
   The allowed use of lightweight aggregate is deleted. In order to provide for other potential satisfactory manufactured aggregates, the word *slag* was inserted in place of the word *manufactured.* A paragraph defining slag has been adopted from the FAA P401 specification and added to this specification. A definition and limitation of flat particles is added to this specification. The requirement for crushed faces is changed from *gravel* to *aggregate.* The requirement for "Polish Value" is considered not to apply to airfield pavements and has been deleted from the specification.

   Explanation: *Lightweight aggregate and provisions for a polish value requirement are not considered applicable to airfield pavements; therefore, all references to these materials, quality, and test procedures that pertain to them have been deleted from the recommended specification.*

4. Page 3, (B) RECLAIMED ASPHALT PAVEMENT (RAP)
   An additional requirement was inserted in the first paragraph requiring that the RAP material would further break down from the 5.08 cm (2-in.) maximum allowable size to the proper gradation when incorporated into the mixture.

Explanation: *There have been some instances where the RAP material was successfully crushed to passing the 5.08 cm (2-in.) sieve but would not further break down under the mixing action, resulting in a coarse void filled mixture.*

Reference to state-owned RAP sources have been deleted, together with the reference to polish value.

Explanation: *State-owned stockpiles of RAP material may not be considered to be available for use in aviation projects.*

5. Page 4, (C) <u>FINE AGGREGATE</u>

   The words, "*Unless otherwise shown on the plans,*" have been deleted from the first of the second paragraph to indicate that stone screenings will always be required.

   Explanation: *The type of traffic loadings and desired quality of the mixtures used in the pavements require the use of stone screenings to obtain the required density, strengths, and toughness.*

6. Page 5, TABLE 1.

   Aggregate quality requirements that refer only to lightweight aggregates have been deleted.
   The maximum loss under the Magnesium Sulfate Soundness test has been lowered from 30 to 18 percent.

   Explanation: *It is believed that aggregate testing shows high losses with the sulfate soundness tests. For those cases where prior experience has shown a satisfactory service, a note on the plans will allow their use.*

7. Page 6, 4. <u>HOT MIX ASPHALT.</u> (1) <u>JOB MIX FORMULA</u>

   Wording has been added that clearly allows the contractor to use either an in-house laboratory or an approved commercial laboratory, as defined by the TxDOT standard specifications. The job mix formula definition has also been changed so that the initial job mix formula (JMF 1) is the laboratory designed mix, the second job mix formula (JMF 2) is based on the results of the plant produced mix, and the third job mix formula (JMF 3) is based on the results of placing a test section.

   Explanation: *Unlike most highway paving projects, the standard airfield paving project is a short-term project, sometimes lasting only one day. This disallows the practice of using the first day or two to make the necessary adjustments in the paving mixture before continuing operations.*

8. Page 7, (A) <u>LABORATORY MIXTURE DESIGN (JMF 1).</u> 6th Paragraph

   Wording has been added to the first sentence to clearly state the acceptable limits when the mixture is tested for moisture susceptibility and the allowance for the addition of lime or a liquid anti-stripping additive if needed.

Explanation: *The intent of the existing TxDOT specification is that the mixture produced will meet the requirements for moisture susceptibility as stated in the standard specifications; this was not clear as presently written.*

9. Page 8, (A) continued, 1st paragraph
The engineer will be required to approve or disapprove the JMF 1 within 7 days.

Explanation: *TxDOT has recently changed the required time from seven (7) days in Item 3007 to ten (10) days in Item 3063. Because this extra time would delay the standard airfield pavement project, it is not recommended in this specification.*

10. Page 9, (B) <u>PLANT-PRODUCED TRIAL MIXES (JMF 2)</u> 1st paragraph
JMF 2 has been changed from a mixture for verification testing prior to the first day's production for placement, to a trial mixture prior to the construction of a test section.

Explanation: *The size of the average airfield pavement project does not allow the first day's production to be used for verification and fine-tuning of the mixture. Verification of the mixture is still necessary, perhaps more so than standard highway paving projects, because of the type and pattern of traffic. It was logically determined that a test section that might or might not remain a part of the finished pavement was the most practical method to achieve that verification.*

<u>LABORATORY MOLDED DENSITY</u> and <u>STABILITY</u>
Reference to Type F mixes is deleted. In addition, the required stability is increased from 35 to 45.

Explanation: *Type F mixtures are considered too fine for airfield pavements. The pattern and amount of traffic requires a more dense and stable mixture than that normally suitable for highway use.*

11. Page 10, (C) <u>PRODUCTION MIXES FOR TEST SECTIONS (JMF 3)</u>
This section has been changed from mixes for the first day's production to be placed on the roadway, to establish the JMF that will be the basis for payment for the project, to the production for the test sections. The payment for the first day's production for the test sections will not be automatically based on a factor of 1.00. The provisions set forth in subarticle 4.(2) will determine any pay adjustment factor.

Explanation: *As previously stated, the length of the average airfield project is such that any refinement of the JMF must be accomplished prior to placement.*

12. Page 10, (2) <u>TEST SECTIONS</u>
This is a completely new section developed to provide for the production and placement of the required test sections. The size, depth, and method of construction are detailed, together with sampling and acceptance criteria.

Explanation: *The need for the test section has been stated. This section is to provide for its construction.*

13. Page 11, (3) <u>JOB-MIX FORMULA ADJUSTMENTS</u>
This section has been retained but renumbered.

14. Page 13, TABLE 2. MIXTURE REQUIREMENTS
Type F mix is deleted from the table, since it is no longer allowed. The minimum stability requirement is 45. A note is added that when CMHB mixes are allowed, they are required to meet the requirements of this specification. It is recommended that CMHB mixes not be allowed until further research is conducted on these mixes to determine their applicability to airport pavement.

Explanation: *Changes were made so that the table would agree with the text of the specification.*

15. Page 18, 7. <u>CONSTRUCTION METHODS</u> (2) <u>TACK COAT</u>
Subsection is renumbered from (2) to (3). References to coating curb and gutter and structures are deleted. Cold joints are required to have a thin coat applied prior to laying the adjacent section.

Explanation: *References to adjacent structures and curb and gutter are not applicable to airfield pavements.*

16. Page 18, (3) <u>TRANSPORTING HOT MIX ASPHALT</u>
Subsection is renumbered from (3) to (4). Wording added to require covering and insulation of truck bodies in cool weather or on long hauls.

Explanation: *The average airfield paving project is not large enough for the contractor to move in a mix plant. Therefore, it is anticipated that the contractor may be obtaining the mixture from a remote plant.*

17. Page 19, (5) <u>PLACING</u> 3rd Paragraph
Subsection is renumbered from (5) to (6). The offset dimension of successive courses of asphaltic material is increased from 15.24 cm (6 in.) to 30.48 cm (12 in.).

Explanation: *The increased distance is considered a safety factor with a pavement that has very low traffic on most of its surface. The joint will be constructed over a portion of pavement that has been subjected to a more controlled compactive effort.*

18. Page 19, (6) <u>COMPACTING</u>
Subsection is renumbered from (6) to (7). Paragraphs 2, 3, and 4 have been deleted and replaced with requirements about areas that may be inaccessible to rollers and a further statement that the type and size of the compaction equipment and rolling patterns is at the discretion of the contractor.

Explanation: *All pavements will have the requirements for air voids. The defining of specific equipment, patterns, and procedures is inappropriate for a QA/QC type specification.*

19. Page 19, (7) <u>OPENING TO TRAFFIC</u>
Subsection is renumbered from (7) to (8). The wording referring to control of contractor's traffic on open pavement is deleted since it does not apply.

20. Page 19, 8. ACCEPTANCE PLAN (1) GENERAL.
A lot is still defined as consisting of four (4) sublots, but an exception clause has been added with the words, "*UNLESS OTHERWISE DEFINED HEREIN.*" All sections under this section have been modified to be applicable to airfield pavements.

Explanation: *As previously noted under the section defining the Job Mix Formulas, the restricted amount of hot mix asphalt production and placement for airfield pavements does not allow itself to the same definitions as for a standard highway paving project. The acceptance plan has had to be tailored to the production of potentially comparatively small daily quantities of hot mix.*

21. Page 19, (2) PRODUCTION LOT
The definition of a " Production Lot" has been changed to not exceed 1,812 metric tons (2,000 tons) per day, or for a half day if production is expected to be between 1,812 metric tons (2,000 tons) and 3,624 metric tons (4,000 tons) with similar subdivisions for tonnages over 3,624 metric tons (4,000 tons). Optional plans have been deleted along with the provisions for the production of small quantities.

Explanation: *The average placement of a general aviation airfield pavement would come under the definition for small quantities and, in effect, allow potentially untested and possibly substandard material to be placed. The projects are not of sufficient magnitude to allow for "Optional Plans."*

22. Page 20, (5) MISCELLANEOUS APPLICATIONS.
The definition of "miscellaneous applications" has been modified to include any portion of the paving operation that might not be runway related and specifies that any pay adjustment factor will be defined as part of a standard lot.

Explanation: *The standard highway definition that "miscellaneous applications" apply to turnouts, driveways, gores, etc., does not apply to airfield pavement construction. If there is any need for this subsection to apply, the pay factor will be considered as part of the active lot.*

23. Page 20, (6) SHOULDERS
This subsection has been eliminated completely and the remaining subsections renumbered accordingly.

Explanation: *Typically shoulders for general aviation facilities are unpaved or of the same material as the runway.*

24. Page 22, (12) IN-PLACE AIR VOID CONTENT, third paragraph
Wording has been added to this paragraph to provide for the taking of cores to determine the joint density and to specify the acceptable value.

Explanation: *An acceptable amount of density is necessary at the joints in airfield pavements to provide the important resistance to moisture intrusion and short-term aging of the pavement, which in turn may lead to early and usually unnecessary failures.*

25. Page 22, TABLE 3. OPERATIONAL TOLERANCES
The minimum stability is increased to 45. The note limiting the application of operational tolerances to the No. 10 and No. 200 sieves has been deleted.

Explanation: *The susceptibility of an airfield to early aging and damage requires that a higher degree of stability and product control be upheld.*

26. Page 28, (19) RIDE QUALITY.
This subsection has been deleted and a new subsection, (18) SMOOTHNESS, inserted in its place. The new wording specifies the allowable variation, perpendicular and parallel, in the surface and the manner by which it is measured. In addition, it is required that the finished surface of the pavement not vary more than the allowed amount from the planned elevations, cross sections and gradelines.

Explanation: *The existing specification does not contain the necessary working to cover this. A reference is made to a ride quality specification that does not apply to airfield pavement construction.*

27. Page 29, 9. MEASUREMENT (1)COMPOSITE WEIGHT METHOD
A paragraph has been added that requires the contractor to furnish a scale ticket for each load of material delivered to the project.

Explanation: *This measure is intended to assist both the contractor and the engineer in accounting for plant production and placement to determine lot and sublot location, and to provide a greater degree of control when material may be delivered from remote or existing hot mix plants.*

28. Page 29, (2) COMPOSITE VOLUMETRIC METHOD
This subsection has been eliminated in its entirety.

Explanation: *It is intended that only the weight method be used in this specification.*

29. Page 29, 10. PAYMENT
Reference to the Composite Volumetric Method of measurement and payment is deleted.

30. Page 29, 10. PAYMENT, Last Paragraph
The paragraph stating that state-owned RAP will be available at no cost to the contractor is eliminated.

Explanation: *The use of RAP is not prohibited, but the state is not obligated to furnish any of this material.*

31. Page 33, TABLE 7. PAY ADJUSTMENT FACTORS FOR IN-PLACE AIR VOIDS
This table has been changed to restrict the allowable range of air voids to a maximum of 8 percent before removal is required.

Explanation: *The critical need is for the airfield pavement to have an adequate in-place density as measured by air voids to help prevent premature aging, moisture intrusion and instability.*

32. Page 34, TABLE 8. TEST METHODS AND MINIMUM CERTIFICATION LEVELS,
 1. AGGREGATE QUALITY
 Test methods that refer to lightweight aggregate testing are deleted.

33. Page 35, 5. ROADWAY
 Reference to the profilograph test for road roughness is deleted.

CONCLUSION

We conclude that the Item 3063 Special Specification is one of the best in the nation. Minor revisions of the Item 3063 specification were warranted in order to adapt it for general aviation airport construction. Generally, highway pavements sustain loads higher than those associated with general aviation airports in Texas. The controlling factor in the design tends to its resistance to environmental impacts (rather than resistance to rutting). We have evaluated these differences and have submitted a Special Specification for use by general aviation airports in Texas.

This specification has retained, as much as possible, the look and spirit of the Special Specification 3063. This is a significant departure from FAA P-401 in several ways. In a few instances, direct comparison of specific details might lead one to conclude that the specification is more lenient that P-401. However, we believe that for the few specific details of P-401 that were relaxed, experience in Texas has shown that alternate specifications perform extremely well. The Course Matrix High Binder (CMHB) mixes were retained in this specification to keep the option open in the future. However, there is some concern that these mixes could ravel under aircraft loading. We therefore recommend that they not be used for airport construction until further research can prove their applicability under aircraft loading.

There are several items in this specification that improve upon P-401. First and foremost is the specification's requirement that technicians be certified in a rigorous training program to ensure that they perform the testing according to Texas standards. The training program has resulted in the correction of deficient testing procedures and has yielded excellent agreement among testing laboratories.

The Item 3063 procedure of Contractor Quality Control Testing, TxDOT or TxDOT agent Verification Testing, and TxDOT Materials and Test Division referee testing, has been retained. This has worked extremely well in practice, such that so far only one job has ever resorted to referee testing.

The pay factors in the Special Specification are based on only those items that affect quality. This is not a method specification: The contractor has some latitude as to how he/she accomplishes the job. However, the pay factors are based on those items that affect performance.

CHAPTER 3. BASE SPECIFICATION

PROBLEM

Because TxDOT oversees the design and construction of airport pavements for nearly all general aviation airports in Texas, it consequently uses a significant amount of base materials, the specifications for which are those sanctioned by the FAA. At the same time, the Texas Department of Transportation Materials and Test Division also tests, monitors, and specifies flexible base materials for all highway construction in the state. And generally, TxDOT experience with buying and using these base materials is such that district engineers know exactly how much the materials cost, how well they will perform, and how they should be specified. Now, if TxDOT's Aviation Division were permitted to use an existing, commonly used flexible base specification in place of the comparatively seldom-used FAA base specifications, then it is highly probable that these base materials could be purchased at a reduced cost. It would also follow that, because budget limitations preclude the attainment of all needed airport construction, some airports improvement projects that might not get funded *could* be funded using the cost savings obtained by using less expensive materials.

INVESTIGATION

Our initial investigation revealed that there is a fundamental difference in how TxDOT and the FAA measure base material strength; that is, Texas has developed a strength measurement based on the Texas Triaxial test method, while the FAA design method uses the California Bearing Ratio (CBR). The CBR laboratory test requires that specimens be soaked in water for 4 days in order to saturate the soil; by contrast, the Texas Triaxial test requires that specimens be wetted by capillary action from the bottom for a period of 10 days (for soils having a plasticity index greater than 15, the number of days is equal to the plasticity index).

The proposed task of this research project was to modify the Texas flexible base specification so that it could substitute for the FAA base specifications. However, further investigation revealed that the better option is to use the existing TxDOT base specifications (with specific limitations) for the following reasons:

1. TxDOT district engineers are acquainted with the price, availability, and performance of the materials needed to satisfy the current flexible base specifications. Thus, any changes made in the specification would tend to void such experience, along with the benefits that accrue through experience; in addition, the economy of scale obtained from large quantities purchased by the department would also be lost.
2. If a new, modified specification was developed based on the Texas Triaxial testing method, a whole new design procedure must be developed for designing airport pavements.

If it is feasible to use TxDOT base specifications in lieu of FAA base specifications for general aviation class airports in Texas, then we must address the following questions:

1. Are general aviation flexible airport pavements so totally different that district engineers cannot provide guidance to the design engineer on base materials and specifications?
2. Who will be responsible for making the final decision regarding which specifications to use for each specific project? Will it be a design engineer, who is a consultant hired by TxDOT, or will it be TxDOT, as an agent for the owner?
3. Is the quality of base course material specified by FAA overly excessive for general aviation class airports? And can lower-quality base materials be used effectively by compensating with increased thicknesses of the base or asphalt layers?
4. Which TxDOT flexible base specification types and grades are acceptable? And do they provide the necessary structural capacity and amount of resistance to moisture susceptibility?

PROPOSED SOLUTION

We concluded that, unlike the situation with asphalt concrete, there is no need to change the flexible base specifications in order to reap a potential benefit from lower-cost materials. It is only necessary to prove that the design of general aviation flexible pavements can safely be accommodated by substituting a specific subset of the TxDOT specified and approved flexible base materials and, if necessary, increasing the thickness of the base or asphalt layers. It would also be necessary to specify which types and grades of TxDOT flexible base materials are suitable for airport pavement construction, and to demonstrate that those base materials and specifications will provide acceptable performance.

Indeed, FAA Advisory Circular AC 150/5320-6C, "Airport Pavement Design and Evaluation," states in Chapter 5: "Since the base and subbase course materials discussed in Chapter 3 are more than adequate for light aircraft, full consideration should be given to the use of locally available, less expensive materials which are entirely satisfactory for these pavements. These materials may include locally available granular materials, soil aggregate mixtures, or soils stabilized with Portland cement or lime." [1]

In order to establish that the TxDOT flexible base specification can be substituted for FAA-specified airport base materials, this chapter:

1. describes the proposed TxDOT flexible base materials for airport pavements;
2. correlates Texas Triaxial Class and California Bearing Ratio;
3. reports Texas' experience with Texas Triaxial Class and base materials;
4. provides a sample airfield pavement design using TxDOT flexible base specifications;
5. describes the cost savings obtained by using TxDOT flexible base specifications; and
6. justifies the use of TxDOT flexible base specifications.

PROPOSED TxDOT BASE FOR FLEXIBLE AIRPORT PAVEMENTS

The most commonly used FAA specifications for base course materials in Texas are Items P-209 and P-208. These are published in FAA Advisory Circular AC 150/5370-10A and are included as Appendices B and C in this report. In AC 5320-6C, the allowable base course specifications for aircraft greater than 13,590 kg (30,000 lb) gross weight are:

Item P-201 Bituminous Base Course
Item P-209 Crushed Aggregate Base Course [see Appendix B]
Item P-211 Lime Rock Base Course
Item P-214 Penetration Macadam Base Course
Item P-215 Cold Laid Bituminous Base Course
Item P-304 Cement Treated Base Course

In addition to the base materials listed above, the allowable base course specifications for aircraft weighing less than 13,590 kg (30,000 lb) gross weight include:

Item P-206 Dry-Bound or Water-Bound Macadam Base Course
Item P-208 Aggregate Base Course [see Appendix C]
Item P-210 Caliche Base Course
Item P-212 Shell Base Course
Item P-213 Sand-Clay Base Course
Item P-216 Mixed In-Place Base Course
Item P-301 Soil Cement Base Course

Table 3.1 compares FAA Items P-208 and P-209 and TxDOT Item 247 flexible base specifications (see Appendix D). Gradation, density, and moisture susceptibility (as specified by liquid limit and plasticity index) are among the important differences between the FAA and TxDOT crushed aggregate base course materials. There are also differences in the testing procedures for wear resistance and thickness of the base materials in place. Additionally, the TxDOT specification has no equivalent specifications for flatness, sulfate soundness, or fractured faces in Type A & B aggregates (not considered a significant problem for base materials).

The surface smoothness of 0.635 cm (1/4-in.) deviation from a 4.8-m (16-foot) straightedge is more restrictive than that for FAA base specifications. The density requirements specified by TxDOT for flexible base materials correspond to the density requirements of the FAA base materials for aircraft greater than 27,215 kg (60,000 lb) gross aircraft weight. For all general aviation airports to which this report applies, the density requirements for FAA base materials are significantly less than those established in the TxDOT specifications. Gradation curves of TxDOT flexible base materials of different grades are also provided in Appendix D of this report.

Thus, the recommended base specifications for general aviation airports up to 27,215 kg (60,000 lb) gross aircraft weight in Texas are as follows:

1. Use TxDOT specification Item 247 flexible base according to the following provisions:

    a. Use only Type A — Crushed Stone, Type B Crushed <u>but not Uncrushed</u> Gravel, or Type C — Crushed Gravel. Type D material is unacceptable.

Pavement Materials Table

	P-208	P-209	Item 247				P-210	P-211
			Type A	Type B	Type C	TypeD		
Description	aggregate base course	crushed aggregate base course	flexible base				caliche base	lime rock base (Florida Only)
			crushed stone	crushed or uncrushed gravel	crushed gravel	as shown on plans		
Fractured Faces	specified percent No.4 retained have1 or more fractured faces	of crushed No. 4 100% - 1 90% - 2 fractured faces			60% of No. 4 with 2 fractured faces			
Wear	ASTM C131		Grades 1-3					
	uncrushed: ≤ 45 @ 500 rev crushed: ≤ 50 @ 500 rev	≤ 45	Wet Ball Mill	Max- (1) 40	(2) 45 (3) 50			
			max. increase	in passing -	No. 40 - 20			
			Note: use LA	Abraision for	Lightweight	Aggregates		
Gradation	1", 1.5", 2" (Table 1)	Design Range (Table 1)	Grades 1 - 5				2" 100 No.4 15-35 No.200 0-15	3.5" 100 3/4" 50-100
Liquid Limit (LL) Plasticity Index (PI)	< No. 40 LL= 25 PI= 6	< No. 40 LL= 25 PI= 4	Grade 1:	LL= 35	Grades 2-5:	LL= 40	LL= 35	LL= 25
			Grade 1:	PI= 10	Grades 2-5:	PI= 12	PI= 10	PI= 6
Flatness	Free excess flat/elongated	< No. 40 15% flat/elongated						

Table 3.1 Comparison of FAA and TxDOT flexible base specifications

Pavement Materials Table (Cont.)

	P-208	P-209	Item 247				P-210	P-211
			Type A	Type B	Type C	TypeD		
Sulfate Soundness		12% after 5 cycles						
Compaction Moisture	± 1.5 % optimum	± 1.5 % optimum	Item 204 -	Sprinkling			± 1.5 % optimum	± 1.5 % optimum
Density	D698 < 60,000 lbs. D1557 > 60,000 lbs. 100% of max density	D698 < 60,000 lbs. D1557 > 60,000 lbs. (nuclear ok) 100% of density req.	TEX - 113 E TEX - 115 E 100% of	requirements Engineer to 4 of 5 ok, density req.	 determine 1 ≤3.0 lbs/cf		D698 < 60,000 lbs. D1557 > 60,000 lbs. 100% of max density	D698 < 60,000 lbs. D1557 > 60,000 lbs. 100% of max density
Surface	3/8" from 16' straight-edge	3/8" from 16' straight-edge	1/4" in 16'	straight-edge			3/8" from 16' straight-edge	3/8" from 16' straight-edge
Thickness	test cores @300 sq. yds. - 1/2"	sub lot size - 1/2"	4000 sq. yds.	- 1/2"			test cores @300 sq. yds. - 1/2"	test cores @300 sq. yds. - 1/2"

Table 3.1 Continued

b. Use grade 1 (Triaxial Class 1) or grade 2 (Triaxial Class 1 to 2.3) materials. Grade 3, 4, and 5 materials are unacceptable.

c. Grade 1 material can be assumed to have a CBR value equal to 80 and, thus, does not require changes in FAA design procedures, whether using the advisory circular or the computer program.

d. Grade 2 materials can be assumed to have a CBR value not lower than 60 but will require adjustments in design procedures to account for a CBR lower than the 80 CBR assumed by the FAA design curves in AC150/5320-6C. Although not documented, experiments indicate that the FAA flexible pavement design computer program assumes a CBR value of 60 for P-208 base material and 80 for P-209 base material.

e. If grade 2 materials are used and the liquid limit must be 35 or lower, and, further, if the PI is greater than 10 and less than or equal to 12, the engineer may require the addition of lime to reduce moisture susceptibility.

2. TxDOT no longer has a caliche base material specification in the 1993 guidebook, owing to the difficulty in defining what is a caliche material in all parts of Texas [2]. For TxDOT, specifying quality caliche base materials is normally accomplished by specifying Item 247 Type D flexible base material, which is "Type as shown on plans." If the use of caliche base materials is to be considered for airport construction that is federally funded, it is suggested that the design engineer consider either using FAA Item P-210 specification or modifying P-210 based on local experience and seeking approval on an individual project basis. Item 247, Type D flexible base materials, is not recommended for FAA approval under this project.

CORRELATION BETWEEN TEXAS TRIAXIAL AND CALIFORNIA BEARING RATIO

In assessing the possibility of using TxDOT flexible base materials for airport construction, we reviewed the literature in order to correlate the California Bearing Ratio with the Texas Triaxial Class. Chester McDowell, former Materials and Test Soils Engineer for the Texas Highway Department, did considerable research in flexible pavement design and strength of materials. He published a report [4] that provides two references to correlate Texas Triaxial Class with California Bearing Ratio values. Dick Ahlvin, an airfield pavement engineer for the Waterways Experiment Station, reviewed the HRB Bulletin and published in the discussion his slight adjustments to Chester McDowell's correlation of CBR versus TTC. Figure 3.1 shows both the McDowell and Ahlvin correlation of CBR and Texas Triaxial Class.

From these documents we concluded that a Texas Triaxial Class 1 base material is equivalent to a CBR of 100. Therefore, relative to strength, a grade 1 flexible base material is equivalent to or much better than a P-209 crushed base material that is assumed to have a CBR value of 80.

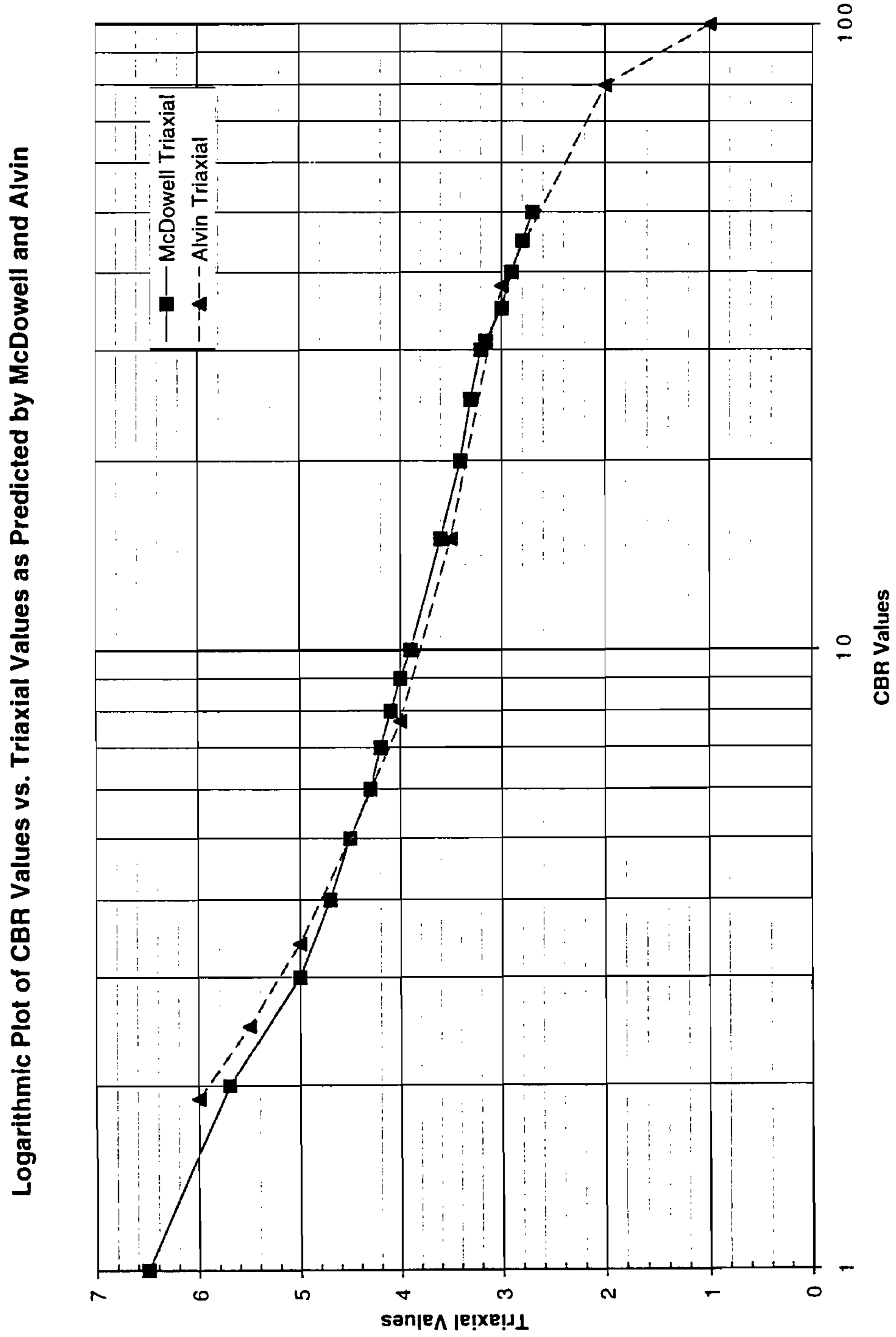


Figure 3.1 Correlation between CBR and Texas Triaxial Class

We also concluded that a grade 2 material that has a Texas Triaxial Class of 2.3 or less must have a CBR value of 65 or greater. However, the current design charts in FAA Advisory Circular AC 150/5320-6C can only be used to calculate the pavement layer thicknesses required to protect above a layer with CBR values of 50 and lower. Therefore, it would be highly conservative to assume that any grade 2 materials would have a CBR value of at least 50.

The correlation chart also indicates that a Texas Triaxial Class 2.0 material would meet the strength of an assumed 80 CBR for the FAA base materials in the FAA design method. If actual Triaxial Class tests were conducted and a grade 2 material was consistently shown to have a Texas Triaxial Class value of 2.0 or less, then a CBR design value of 80 could also be justified according to the Ahlvin correlation. However, as shown later in the design example, the difference with respect to design thickness between assuming an 80 and 60 CBR base for the heaviest duty general aviation airport would increase both the asphalt and base layer thicknesses by only 2.54 cm (1 in.).

Therefore, we suggest that for constructing general aviation airport pavements in Texas, flexible base materials of grades 1 and 2 should be designed conservatively, as shown in Table 3.2.

Table 3.2 Design CBR values for TxDOT flexible base for general aviation airports

TxDOT Grade	Texas Triaxial Class	Assumed CBR Value	Design CBR Value
Grade 1	Class 1	100	80
Grade 2 with test data for Class 2.0	Class 2.0	80	80
Grade 2	Class 2.3	80 to 65	60

TEXAS EXPERIENCE WITH TEXAS TRIAXIAL AND BASE MATERIALS

Clearly, airfield pavements and highway pavements differ in their respective designs. In the case of general aviation airports, those airport pavements are designed for gross aircraft weights that range from 5,662 kg (12,500 lb) to 13,590 kg (30,000 lb) to 27,215 kg (60,000 lb). But the major difference between flexible pavement designs for general aviation airports and those for Texas highways is that highways are designed to resist rutting or fatigue failure, while airport flexible pavements often do not receive enough traffic on the pavement to keep the asphalt from hardening as a result of environmental factors.

The best way to resist rutting in a flexible highway pavement is to make the asphalt stiffer; yet that also makes it more susceptible to low temperature cracking and to fatigue cracking. Recent advances in the Strategic Highway Research Program (SHRP) have shown that, with proper selection of the asphalt binder, it is possible to design asphalt pavements that are both stiff and crack resistant. In the near future, all asphalt binder material sold will be based on the SHRP performance graded specification, rather than on the commonly used penetration grades or viscosity grades of asphalt.

In base materials for general aviation airports, the current P-209 base specification is known to be excessive (as related to strength of the material). Sometimes general aviation airports are upgraded to carry loads slightly heavier than those specified in the initial design. However, there seems to be little doubt that a TxDOT flexible base grade 1 or 2 material can carry the load required for general aviation airports. If the general-aviation-designed pavement were used as a highway, it would carry a truck load far greater than the loading expected of a general aviation airport.

Thus, the pivotal question as to whether the TxDOT base material can be substituted effectively for FAA-specified material has to do with *moisture susceptibility.* Although relatively moderate, Texas' climate and temperature does vary substantially throughout the state. The amount of rainfall around the state also varies widely. The FAA national base specification is meant to be used throughout the U.S., from Florida to Alaska to Hawaii.

Plasticity index (PI) is one indication of how well (or how poorly) a soil will sustain loads during times of saturation. As shown in Table 3.1, the FAA national specification requires a PI of 4 or less for P-209, and 6 or less for P-208. The less stringent TxDOT specification requires a PI of 10 or less for grade 1 material, and 12 or less for grades 2 through 5. The FAA does allow a PI of 10 or less for Item P-210 caliche base course.

At first glance, this seems to be a significant difference. However, even the national specification allows increases in PI if local experience has shown acceptable performance with higher PIs. A soil with a PI of 4 or less is essentially a cohesionless soil (e.g., sand). TxDOT experience has shown that base materials should have some cohesion to improve strength and to achieve proper density. In some parts of Texas, it would be nearly impossible or far too expensive to obtain a base material having a PI of 4.

We recommend that, during the design of each airport pavement requiring base materials, the TxDOT district engineer be consulted as to the district's experience with the PI of available base materials. The design engineer should be comfortable with base materials having a PI of 10. If the quality of available local materials requires using a base material having a PI of 10 to 12, strong consideration should be given to lime-treating the base material. Care must be taken so as not to overtreat the base with lime; and cement-stabilized base material should not be used for base material for flexible pavements. Additionally, unstabilized base course should not be placed over a stabilized base course.

The important factor to keep in mind is that the plasticity index has little effect on triaxial strength if the percent passing the number 30 sieve remains low. Figure 3.2, derived from a study conducted by Yoder and Witczak, shows the relationship of plasticity index to the triaxial strength of a 2.54-cm (1-in.) maximum size gravel. They found that "the plasticity specification gives an added factor of safety, but on the other hand, if the quantity of binder is controlled within close limits to a value equal or less than optimum, as reflected by density, the plasticity value becomes less significant. The use of this specification without regard to climatic conditions, grading and the strength of the mix can cause overly conservative decisions to be made relative to the quality of base course." [5]

Although TxDOT allows a liquid limit for grade 2 flexible base materials of 45, this specification requires that the maximum allowable liquid limit of 35 required for grade 1 material be the limit for airport construction. This is only slightly higher than the liquid limit of 25 allowed in P-208 and P-209, and is equal to the liquid limit of 35 allowed in P-210.

Density

There is a significant difference in the density requirements of the FAA specifications and the TxDOT flexible base specifications. The most obvious difference is that TxDOT uses a TEX standard test rather than an AASHTO or ASTM standard; however, the TxDOT test methods have all been approved by FHWA. The most significant difference in density is that FAA specifies 100 percent of the standard proctor density test (25 blows with a 2.5-kg [5.5-lb] hammer falling 305 mm [12 in.]) for airports designed for 27,215 kg (60,000 lb) gross weight aircraft or less. TxDOT TEX 113E specifies 100 percent of the modified proctor density (50 blows with a 4.5-kg [10-lb] hammer falling 457 mm [18 in.]) for all flexible base materials. There are other differences in the tests, but in comparing compactive effort, the TxDOT density specification is nearly twice as compactive as the standard proctor (ASTM D-698 @ 12,400 ft-lb.f/ft^3 versus TEX-113E @ 22,913 ft-lb.f/ft^3). The FAA requires only the more conservative modified proctor density (ASTM D-1557 @ 56,000 ft-lb.f/ft^3) for airports designed for aircraft with greater than 27,215 kg (60,000 lb) gross weights. The higher density requirement of the TxDOT specification is significant and should be considered when evaluating other TxDOT requirements that are less restrictive (e.g., liquid limit and plasticity index).

Wear Resistance

Another difference in the TxDOT and FAA specifications is the testing method for wear resistance of the aggregates. The FAA method specifies the LA Abrasion Test, with a less than 45 or 50 percent abrasion at 500 revolutions. The TxDOT specification is the Wet Ball Mill Test, which is considered more appropriate for base materials; maximum abrasion values are 40 and 45 for grades 1 and 2, respectively (also at 500 revolutions). TxDOT specifies the LA Abrasion Test for lightweight aggregates used in base materials. The differences in specifications are not significant for general aviation base materials.

Surface and Thickness Measurements

The TxDOT flexible base specification is more restrictive in surface smoothness than the FAA specification. TxDOT specifies a maximum surface smoothness deviation of 0.635 cm (1/4-in.) from a 4.8-m (16-foot) straightedge, while the FAA specifies 0.677 cm (3/8-in.) maximum deviation from a 4.8-m (16-foot) straightedge.

For thickness measurements, both specifications indicate that the measurement of thickness obtained from cores must be less than 1.27 cm (1/2 in.), though the specifications differ in how many cores must be taken. P-208, P-210, and P-211 each specify "depth tests or cores" every 300 square yards, which many feel is unnecessary and costly. P-209 specifies depth tests or cores for each of four sublots. TxDOT specifies cores in accordance with TEX 140-E for each 4,000 square yards. Common practice has been to amend the core testing requirements of P-208 where possible. The TxDOT recommendation should be sufficient in all but small jobs, which can be amended by the engineer. The engineer should have some flexibility in specifying the number of tests required to ensure adequate control of thickness without being overly restrictive.

EXAMPLE AIRFIELD PAVEMENT DESIGN USING TxDOT FLEXIBLE BASE SPECIFICATIONS

The recommended implementation is to modify the design procedures and to replace FAA base specifications with TxDOT flexible base specifications. In this section we present example design problems derived from this recommendation.

Compare two aircraft loading cases using the FAA base and TxDOT base. The first aircraft loading case, a 27,215 kg (60,000 lb), single-wheel aircraft, represents probably the highest possible loading of a general aviation airport; and while it is not a typical loading, it often is used for design growth. The second example loading case is based on the heaviest loading possible for FAA light aircraft designs: a 13,590 kg (30,000 lb), single-wheel aircraft. Both cases describe loadings more severe than is considered normal for many TxDOT general aviation airports.

To emphasize the potential differences in the effect of the two different base specifications on the design, we chose a weak subgrade. All the following example flexible pavement designs in this report assume the following underlying soil conditions: (1) a subgrade CBR of 5 and (2) a subbase CBR of 20.

27,215 kg (60,000 lb) Gross Aircraft Weight Example Design

1. Maximum gross weight 27,215 kg (60,000 lb) aircraft, single-wheel gear, 6,000 annual departures, 20-year design life.
2. Design Example 1 assumes Type A base materials of grade 1 (Triaxial Class 1) were used and achieved a CBR value of 80; therefore, no changes to FAA design procedures are needed and the example is exactly the same as if P-209 base material were specified.
3. Design Example 2 assumes Type A, B, or C base materials at grade 2 (Triaxial Class 1 to 2.3) were specified. The minimum base value of CBR of 60 was assumed, since CBR testing was not accomplished.

Design Example 1 Using AC 150/5320-6C

1. Using Figure 3.3, total pavement thickness equals 66 cm (26.0 in.).
2. Using Figure 3.3, 25.4 cm (10 in.) of thickness are required to protect the subbase of CBR 20. Therefore, 66 cm (26 in.) of total pavement minus 10 above the subgrade yields 40.6 cm (16 in.) of subbase thickness.
3. The note attached to the Figure 3.3 design chart also specifies a minimum thickness of the bituminous surface of 10.16 cm (4 in.) in critical areas and 7.6 cm (3 in.) in non-critical areas.

4. Therefore, deducting the required bituminous thickness from the 25.4 cm (10 in.) required above the subbase leaves the base design thickness requirements at 15.24 cm (6 in.) for critical areas and 17.78 cm (7 in.) for non-critical areas.
5. Checking the minimum base course thickness using Figure 3.12 requires a minimum base course thickness of 17.27 cm ≅ 17.78 cm (6.8 ≅ 7.0 in.). If 27.94 cm (11 in.) of combined surface and base courses are used, the subbase can be reduced from 40.6 cm (16 in.) to 38.1 cm (15 in.) to keep within a 66 cm (26 in.) total pavement thickness.
6. Thus, the final design thickness are as follows:

Critical Areas	**Non-Critical Areas**
10.16 cm (4 in.) surface bituminous pavement	7.6 cm (3 in.) surface bituminous pavement
17.78 cm (7 in.) base material	15.24 cm (6 in.) base material
P-209 (or Item 247, Type A, Grade 1) base material with CBR of 80	34.29 cm (13.5 in.) subbase
38.1 cm (15 in.) subbase material with CBR 20	

As a check of this design procedure, we ran the FAA flexible pavement design computer program using P-209 with slightly different results. There is no difference in this design procedure if TxDOT Type A, grade 1 base material, is specified. Assuming no frost effects, the following computer results were obtained:

Critical Areas	**Non-Critical Areas**
10.16 cm (4 in.) surface	7.6 cm (3 in.) surface
15.24 cm (6 in.) base material	13.71 cm (5.4 in.) base material
40.64 cm (16 in.) subbase material	36.57 cm (14.4 in.) subbase material

The difference in the computer program and the advisory circular was the extra 2.54 cm (1 in.) of base material added by Figure 3.12 because of the weak subgrade of CBR 5. Therefore, if the computer program is used, we recommend that the minimum thickness of base material be checked with Figure 3.12 for bases designed for heavier than light aircraft.

Design Example 2 Using AC 150-5320-6C

Design example 2 differs from example 1 in that either P-208 base material was specified (which the FAA advisory circular does not recommend for aircraft greater than 13,590 kg [30,000 lb]) or TxDOT Item 247, Flexible Base Type A, B, or C was used with grade 2. With a Triaxial Class of 2.0 or better, the assumed CBR can be 80. With a Triaxial Class of 2.3, the assumed CBR can be 60 or better.

1. Using Figure 3.3, as in the first example, total pavement thickness remains at 66 cm (26 in.).

2. Using Figure 3.3, again, 25.4 cm (10 in.) of thickness are required to protect the subbase of CBR 20. Therefore, 66 cm (26 in.) of total pavement minus 10 above the subgrade yields 40.64 cm (16.0 in.) of subbase thickness.
3. If Figure 3.3 is used to calculate the thickness required to protect the base material, a CBR of 50 is the highest CBR on the chart and should be used instead of 60. Figure 3.3 also specifies a minimum thickness of bituminous surface of 10.16 cm (4 in.) in critical areas and 7.62 (3 in.) in non-critical areas. However, using Figure 3.3 to calculate the thickness required to protect a base material with CBR 50 requires a thickness of 10.16 cm (4 in.). Therefore, the minimum pavement thickness needed to protect the assumed value of 50 CBR for 27,215 kg (60,000 lb), single-gear aircraft with 6,000 annual operations is 10.16 cm (4 in.).
4. Deducting the required bituminous thickness from the 25.4 cm (10 in.) required above the subbase leaves the base design thickness requirement at 15.24 cm (6 in.) for both critical and non-critical areas.
5. As in the first example, checking the minimum base course thickness using Figure 3.12 requires a minimum base course thickness of 17.27 cm ≅ 17.78 cm (6.8 ≅ 7.0 in.). The advisory circular allows the use of 90 percent of critical area thickness in base and subbase for non-critical areas. Non-critical areas could therefore be reduced to 15.49 cm (6.1 in.), which rounds out to 15.24 cm (6 in.).
6. Thus the final design thicknesses are as follows:

Critical Areas:	**Non-Critical Areas:**
10.16 cm (4 in.) surface bituminous pavement	10.16 cm (4 in.) surface bituminous pavement
17.78 cm (7 in.) base material	15.24 cm (6 in.) base material
P-208 (or Item 247, Type A, Grade 2) base material with CBR of 60	
38 cm (15 in.) subbase material with CBR 20	34.29 cm (13.5 in.) subbase

To verify this design procedure, we again ran the FAA flexible pavement design program, this time specifying for design example 1 the P-208 material. Assuming no frost effects, the computer program provided the following results:

Critical Areas:	**Non-Critical Areas:**
12.7 cm (5 in.) surface	10.16 cm (4 in.) surface
15.24 cm (6 in.) base material	13.7 cm (5.4 in.) base material
38 cm (15 in.) subbase material	36.5 cm (14.4 in.) subbase material

Between P-208 and P-209 base material, the FAA computer program shows a difference of an additional 2.54 cm (1 in.) of surface material required for both critical and non-critical areas. While it is not documented, the FAA computer program assumes a CBR of 80 for P-209 and a CBR of 60 for P-208.

For the above example problem, the differences between the FAA computer program and the design method in the advisory circular charts is an extra 2.54 cm (1 in.) of surface course suggested for critical areas. There is no difference if you substitute TxDOT flexible base grade 1 material for P-209. The advisory circular does not suggest the use of P-208 base material for aircraft gross loads greater than 13,590 kg (30,000 lb). However, if the design is calculated assuming a CBR of 60 under this heavy loading condition, then one should not add another 2.54 cm (1 in.) of asphalt surface material to the design.

Design Example 3 for a 13,590 kg (30,000 lb) Gross Weight Aircraft

Design example 3 assumes a 13,590 kg (30,000 lb) aircraft, the weight of which represents the cut-off point between the light aircraft design method and the regular design method. The design example findings below assume, for both procedures, 6,000 annual departures, a CBR 5 subgrade, and a CBR 20 subbase. Using the regular design procedure in Figure 3.3 provides the following answers:

- Minimum surface thickness = 10.16 (4 in.).
- Total pavement thickness to protect subbase = 15.24 cm (6 in.) (therefore, 5.08 cm or 2 in. of base)
- Total pavement thickness = 44.45 cm (17.5 in.) (therefore, 29.21 cm or 11.5 in. of subbase)

The lowest value on the minimum base thickness chart in Figure 3.12 is 15.24 cm (6 in.), but the computed value for a 44.45-cm (17.5-in.) pavement would less than 15.24 cm (6 in.). However, a 5.08-cm (2-in.) base layer is impractical and difficult to compact over a 20 CBR subbase. Therefore, the 10.16 cm (4 in.) minimum thickness for this design would probably be too conservative. As a conservative design, some additional thickness of the base would be substituted for an equal thickness of subbase, which is exactly what is reported using the computer program.

Using the FAA flexible design computer program with P-209 base for a 22,650 kg (50,000 lb), single-gear aircraft reduced to a 13,590 kg (30,000 lb) design weight yields similar results of 44.45-cm (17.5-in.) for total pavement thickness and 10.16 cm (4 in.) of bituminous surface; however, the program suggests 10.16 cm (4 in.) of base and, therefore, only 24.13 cm (9.5 in.) of subbase.

Repeating the FAA flexible design computer program with a P-208 base adds another 2.54 cm (1 in.) of asphalt surface and reduces 2.54 cm (1 in.) of subbase for the following cross section:

- 12.7 cm (5.0 in.) surface bituminous pavement
- 10.16 cm (4.0 in.) P-208 base material
- 21.6 cm (8.5 in.) subbase

However, the FAA has a separate design example for light aircraft, which it considers to be aircraft having gross weights of up to 13,590 kg (30,000 lb). The separate design method is based on a separate set of pavement testing empirical data.

Design Example 4: Light Aircraft Design Method for 13,590 kg (30,000 lb) Aircraft

If the design assumption is that the airfield pavement and base material are designed for light aircraft using either the procedures in Chapter 5 or the "Light Aircraft" selection in the computer program, slightly different designs can be justified.

The design procedure for light aircraft, fully specified in Figure 5.2, should be used for all areas of the airfield; no reductions should be made for non-critical areas. Use of the design curve requires a CBR value of the subgrade and the design weight of the aircraft. Using Figure 5.2 for light aircraft assumes a minimum 5.08-cm (2-in.) surface course. Using Figure 5.2 for a 13,590 kg (30,000 lb) light aircraft with a subgrade CBR of 5 results in a total pavement thickness of 44.45-cm (17.5-in.). Using Figure 5.2 for a 13,590 kg (30,000 lb) light aircraft with a subbase of 20 results in a pavement thickness required of 19.8 cm (7.8 in.) above the subbase. Therefore, subtracting the 5.08 cm (2 in.) of surface yields 14.7 cm (5.8 in.) of base material, which is not specified as either P-209 or P-208. When using the FAA flexible design computer program and selecting "Light Aircraft" follows this example with precisely the same results.

ANALYSIS OF DESIGN EXAMPLES

When using TxDOT Item 247 flexible base material in lieu of P-208 or P-209, there are no changes to the design procedure for light aircraft up to 13,590 kg (30,000 lb). When designing a base material to resist loading up to 27,215 kg (60,000 lb) aircraft, the FAA design procedures can be followed. The use of P-208 will require an additional 2.54 cm (1 in.) of surface material over P-209. The use of TxDOT Type A grade 1 material can be substituted for P-209 if concerns over liquid limit and plasticity index are addressed without changing the design procedure. TxDOT Type A, B, or C material can be used as a substitute for P-208 and can follow FAA design procedures. However, there can be differences in the design procedure between the advisory circular and the FAA flexible design computer program.

EXAMPLE OF COST SAVINGS USING TxDOT FLEXIBLE BASE SPECIFICATIONS

The following example was taken from TxDOT aviation files at random as two example pavements recently constructed using P-209 base materials. The Brenham, Texas, airport is located in a rural area about 180 km (112 miles) east of Austin. The New Braunfels, Texas, airport is located about 48 km (30 miles) south of Austin on I-35, just east of the Balcones fault and near sources of quarried aggregate. According to TxDOT district engineers' records of unit costs, the costs of P-209 material for these two example airports were 210 percent and 280 percent over the cost of high quality Type A, grade 2 base material used for highways.

Even considering the added cost of up to an additional 2.54 cm (1 in.) of surface and/or base materials in the thickness design, there is great potential for cost savings in the construction of general aviation airport pavements in Texas using TxDOT base material specifications.

For the two airport projects in Brenham and in New Braunfels, assuming that an extra 2.54 cm (1 in.) of base material would have been required, a cost savings of $111,580 would have been realized by substituting Type A, grade 2 flexible base material for P-209. Both airport designs used only 5.08 cm (2 in.) of surface material, as they were designed for 13,590 kg (30,000 lb) maximum gross weight aircraft (which would not change in this substitution).

Table 3.3 Comparison of base material costs

Airport Location	Cost FAA Base	Cost TxDOT Flexbase
Brenham	P-209 $37.39/cy	Type A, Grade 2 $17.75/cy
New Braunfels	P-209 $20.00/cy	Type A, Grade 2 $7.15/cy

JUSTIFICATION FOR USING TxDOT FLEXIBLE BASE SPECIFICATIONS

We conclude that the use of TxDOT flexible base specifications for general aviation airport construction is justified. The strengths achieved will be more than adequate, even given the limitations of grade 1 or 2 material. However, care must be taken with the design to avoid problems with moisture susceptibility. The FAA design procedures can be used to correlate Texas Triaxial Class to CBR values. The TxDOT flexible base specifications will provide high quality base materials at a lower cost .

CHAPTER 4. TxDOT TEST METHODS

PROBLEM

The objective of Project 2920 was to revise a Texas asphalt pavement specification for use in general aviation airport construction. The specification selected as a base specification was Special Specification Item 3007, which has recently been modified for statewide adoption as Special Specification Item 3063 (Quality Control/Quality Assurance of Hot Mix Asphalt). In producing a new specification to replace FAA Item P-401 for airport construction, it was necessary to determine if either existing ASTM testing specifications or TxDOT testing specifications should be used. This chapter reports the findings of our investigation of the TxDOT test methods, used in Special Specification Item 3063 (Quality Control/Quality Assurance of Hot Mix Asphalt). It also assesses their applicability to the specification we suggest be used instead of the FAA hot mix asphalt specification for airfield pavements.

INVESTIGATION

We began by reviewing correspondence (obtained from TxDOT's Materials and Test Division) requesting FHWA approval to use TxDOT test methods on federal projects. With only one exception, every test method used in the TxDOT 3063 specification was approved for use on federal projects. This test method has been submitted for approval.

Table 3.1 lists each test method using the TxDOT identification system. It also describes each test method as provided in the 3063 specification. For the test methods with AASHTO and/or ASTM equivalents, the equivalent test method is listed in the table's third column. If the test method was approved but did not have an AASHTO and/or ASTM equivalent, a description of the test method is provided in Appendix F. Column four in the table provides information concerning the date the test method was approved for use on federal projects. Appendix G contains copies of these letters in a chronological order. Appendix E includes copies of the submissions sent to the FHWA detailing the differences between the TxDOT and the AASHTO or ASTM equivalent test methods. This appendix lists TxDOT's rationale in asserting that their test method was at least as restrictive as their equivalent test methods — and in most cases more restrictive than the AASHTO or ASTM counterpart.

The test methods employed by TxDOT in the Item 3063 specification are the basis for the testing used in the proposed aviation specification. The aviation specification will use all but two of the methods used in Item 3063. These are TEX-404-A (determination of unit weight of the aggregate) and TEX-1000-S (profilograph testing). The first of these was omitted because the aviation specification does not allow the use of light-weight aggregates, while the latter was omitted because the test method is not applicable to airfield pavements.

CONCLUSIONS

The test methods to be incorporated into the aviation specification are currently in use and are familiar to contractors using the Item 3063 specification. These test methods are at least as restrictive, and in most cases more restrictive, than the AASHTO or ASTM test methods they replace. The FHWA has also approved the use of TxDOT test methods in those situations where there are no equivalent AASHTO or ASTM test methods.

The use and satisfactory performance of TxDOT testing methods have been well documented on both state and federal projects. It should also be pointed out that Texas provides a certification process for contractors and laboratory technicians to ensure that these tests are performed correctly. The adoption of the Special Specification Item 3063 as the standard for asphalt pavement construction in Texas requires that the contractor and testing laboratory technicians be certified to conduct these tests.

Approval granted by the U.S. Department of Transportation, Federal Highway Administration, for the use of the TxDOT testing methods should be adequate justification for their use for Federal Aviation Administration projects in Texas. It is the conclusion of the research team that the TxDOT test methods are more than satisfactory for use in airport construction in Texas, and that requiring the technicians performing these tests to be certified will increase the quality of the asphalt pavement construction.

CHAPTER 5. ASPHALT JOINT DENSITY

PROBLEM

This chapter describes the various approaches other agencies have taken in requiring asphalt pavement joint density (as against mat density). Special Specification Item 3007 required no particular density at the joint. Yet it is considered prudent by many agencies to require some specific joint density (density that is somewhat less restrictive than the density in the asphalt mat). In researching requirements for an airport asphalt pavement specification, we assessed various other agencies' approach to the problem of joint density. This chapter documents our findings.

FINDINGS

This section reports on the following agencies' approach to asphalt joint density:

- Transportation Research Board
- Iowa Department of Transportation
- Louisiana Department of Transportation and Development
- New Jersey Department of Transportation
- New York Department of Transportation

The scope of this project did not include the development of a recommended procedure for the subject hot mix asphalt specification for general airport pavements. The seriousness of the problems that could occur as a result of inadequate density and/or seal at the joints did, however, prompt us to review previous research, which included (1) the results of highway hot mix asphalt pavement research undertaken by four states, and (2) a presentation at the Transportation Research Board's Annual Meeting on airfield pavements.

TRANSPORTATION RESEARCH BOARD

The Transportation Research Board (TRB) study, presented by Barati and Elzoghbi [6], described airfield pavements placed during the 1984 construction season in the FAA Eastern Region. Their study, which identified the potential problems that could be encountered with joints in hot mix asphalt pavement, found that:

1. joint densities and percent compaction values were consistently and significantly lower than the mat density;
2. joint density values were statistically significantly more variable than the mat; and
3. although there appeared to be a positive correlation between the average lot density of the mat and joint density, the magnitude was not consistent.

In addition, the report stated that, in determining the field compaction value, the FAA should not use percent compaction based on the laboratory Marshall value.

IOWA

In the January 1987 Iowa Highway Research Board Report, HR-215, "Improvements of Longitudinal Joints in Asphalt Pavements," Richard D. Smith [7] described methods that concentrated on rolling patterns to improve densities at the centerline longitudinal construction joints. He concluded that none of the methods were successful in preventing a longitudinal crack along the centerline after six (6) years of evaluation.

LOUISIANA

The Louisiana Transportation Research Center Final Report DTFH 71-88-509LA08, "Latex Modified Asphalt and Experimental Joint Treatments on Asphalt Concrete Overlays Experimental Project No. 3-Asphalt Additives," by Xing and Doucet [8], focused on 1940's-era jointed portland cement concrete pavement. Their report described eight (8) test areas:

1. three with asphalt impregnated joint membrane and conventional hot mix asphalt concrete;
2. one conventional joint treatment with conventional hot mix asphalt concrete;
3. one conventional joint treatment with latex modified hot mix asphalt concrete; and
4. three joints sawed and sealed: two with latex-modified hot mix asphalt concrete and one with conventional hot mix asphalt concrete.

The impregnated joint membrane sections pulled and pushed during construction, forming a hump at the joint. Their conclusions after 3 years were the following:

1. Sawing and sealing over existing transverse joints in conjunction with either conventional or latex-modified asphalt concrete appears to be the most effective method in controlling reflective cracking.
2. Latex-modified asphalt concrete has increased benefits over conventional when the conventional methods of treating joints are used.
3. Membranes were not effective and actually caused additional problems.

NEW JERSEY

A long-term study conducted for the New Jersey DOT was outlined in the study's final report, "Longitudinal Wedge Joint Study," by Ouinn, Baker, and Hellriegel [9]. This 5-year study was undertaken to develop a technique for producing more durable longitudinal construction joints in hot mix asphalt concrete pavements. The procedure they developed called for a joint to be formed by a 3:1 sloped face plate on the paver at the edge of the first mat placed. The resulting sloped wedge was not compacted at the time of placement of the first mat. The second, adjoining mat overlapped the wedge. A heater was used on the paver during the second mat placement and directed at the joint area. The conclusions of the study were the following:

1. The wedge joint technique produces higher, more uniform density than the conventional butt joint technique.
2. The observed improvements in density indicated that the joint was more resistant to opening or cracking under traffic and weathering.
3. It was determined that this type of joint was safer for the motorists changing traffic lanes, and the use of the heater eliminated the "cold" joint problem.

New Jersey ultimately adopted this procedure into their specifications.

NEW YORK

Technical Report 91-1, "Longitudinal Joint Construction in Asphalt Concrete Pavements," [10] described another attempt to improve the density and seal at the longitudinal joint interface. During the 1990 construction season, on projects being studied, a special inverted "V" notched screed was attached to the paver adjacent to the joint when placing the second mat. The purpose was to supply additional or extra material that would then be squeezed and compacted into the joint.

A major problem was that the paver had to follow the exact line; otherwise it would leave either too much or too little extra material, which in turn would result in either a hump or a void along the joint. The study concluded the following:

1. This technique was found to yield lower densities at the longitudinal joints.
2. Use of the "V" had to be exact.
3. When constructing the joint, overlapping the existing lane was important. The roller needed to be mostly on the hot mat.

This study recommended that New York DOT try the New Jersey wedge-type joint construction technique.

RECOMMENDATIONS

With respect to longitudinal joints (and probably to transverse construction joints), the present procedures set forth in the current Texas DOT hot mix asphalt specifications represent unsatisfactory solutions. The FAA specifications further recognize the problems in obtaining density at the joints by allowing 3 percent less density than the remainder of the mat.

Based on the limited literature search and on the review conducted and reported herein, the only advance appears to be the procedure developed by the New Jersey DOT. Its approach appears to recognize and address the two major concerns associated with placing a hot mix asphalt pavement that requires two or more lanes, namely, adequate density and a cohesive seal.

We recommend that the New Jersey methods be further investigated; what is needed is a study — one based on the New Jersey methods — that involves a sufficient number of trial construction projects to determine their adaptability to Texas. Until such a study can be undertaken, it is recommended that the proposed specifications being developed in this study continue to provide language requiring that density at the joints be within 2 percent of that within the rest of the mat.

CHAPTER 6. SUMMARY

The Center for Transportation Research, in a consensus reached with a Technical Working Group comprised of representatives from TxDOT, the FAA, and industry, has proposed a revised asphalt specification — one based on TxDOT Special Specification Item 3063, QA/QC Hot Mix Asphalt, and one that warrants adoption for general aviation airport construction in Texas. This revised specification has been submitted to the FAA for approval.

Because the specification reduces uncertainty and, moreover, can lead to more potential bidders, the Center for Transportation Research (CTR) estimates that the adoption of the revised asphalt specification will have the potential to reduce unit bid costs to the department up to 50 percent. The savings in unit costs pose no threat to quality and, in fact, will most likely improve asphalt pavement quality through contractor pay factor incentives and through better quality control measures. The quality control/quality assurance portion of this specification, coupled with the certification and training of technicians, has already paid significant dividends to Texas through better quality asphalt highway pavements.

Full compliance with the national P-401 specification — difficult to achieve using Texas aggregates — has resulted in bid prices higher than those for comparable highway projects. The proposed asphalt specification differs significantly from P-401, especially as regards mix design, test procedures, and pay factors. However, after careful analysis, CTR has concluded that the revised Item 3063 specification has been optimized for general aviation airports where rutting is much less of a problem than environmental degradation; moreover, construction with the new specification will probably outperform the current construction practices that make use of the P-401 specification.

The CTR team and the technical working groups have also reached a consensus on the use of grade 1 and 2 TxDOT Item 247, flexible base as a substitute for FAA Items P-208 and P-209. Although the TxDOT specification tests the material under Texas Triaxial Class rather than under California Bearing Ratio (CBR), there is sufficient documentation of a correlation to compare the two tests. The important differences between the TxDOT and FAA specifications have to do with gradation, density, and moisture susceptibility (as specified by liquid limit and plasticity index).

The proposed substitute of TxDOT Item 247 for P-208 and P-209 for general aviation airports under 27,215 kg (60,000 lbs) gross aircraft weight classification is as follows:

Use TxDOT specification Item 247, flexible base with the following limitations:

A. Use only Type A - Crushed Stone, Type B Crushed <u>but not Uncrushed</u> Gravel, or Type C - Crushed Gravel. Type D material is not acceptable

B. Use grade 1 (Triaxial Class 1) or grade 2 (Triaxial Class 1 to 2.3) materials. Grade 3, 4, and 5 materials are not acceptable.

C. Grade 1 material can be assumed to have a CBR value equal to 80 and does not require changes in FAA design procedures, whether using the advisory circular or the computer program.

D. Grade 2 materials can be assumed to have a CBR value not lower than 60 but will require adjustments in design procedures to account for a CBR lower than the 80 CBR assumed by the FAA design curves in AC150/5320-6C. Although not documented, it appears from experiments that the FAA Flexible Pavement Design computer program assumes a CBR value of 60 for P-208 base material and 80 for P-209 base material.

E. If grade 2 materials are used and the liquid limit must be 35 or lower, and if the PI is greater than 10 and less than or equal to 12, the engineer may require the addition of lime to reduce moisture susceptibility.

REFERENCES

1. FAA Advisory Circular, AC 150/5320-6C, "Airport Pavement Design and Evaluation," Department of Transportation, Washington, D.C., December 7, 1978, p. 127.
2. Texas Department of Transportation, *Standard Specifications for Construction of Highways, Streets and Bridges*, 1993.
3. McDowell, Chester, "Flexible Pavement Design Guide," Bulletin 327, The National Lime Association, Washington, D.C., 1976.
4. McDowell, Chester, "Wheel-Load-Stress Computations Related to Flexible Pavement Design," Highway Research Board, Washington, D.C., 1956.
5. Yoder, E. J. and M. W. Witczak, *Principles of Pavement Design*, New York: John Wiley and Sons, Inc., 1975, p.360.
6. Barati, Jr., J. L., and G. B. Elzoghbi, "Study of Joint Densities in Bituminous Airport Pavements," Transportation Research Board, January 1987.
7. Smith, Richard D., "Improvements of Longitudinal Joints in Asphalt Pavements," Iowa Highway Research Board Report, HR-215, January 1987.
8. Xing, William, and Roland J. Doucet, Jr., "Latex Modified Asphalt and Experimental Joint Treatments on Asphalt Concrete Overlays, Experimental Project No. 3—Asphalt Additives," Louisiana Transportation Research Center, Final Report DTFH 71-88-509LA08, 1991.
9. Ouinn, J., R. Baker, and E. Hellriegel, "Longitudinal Wedge Joint Study," NJHPR Study 7734, New Jersey DOT, November 1988.
10. "Longitudinal Joint Construction in Asphalt Concrete Pavements," New York DOT, Materials Bureau, Technical Report 91-1, January 1991.

APPENDIX A

Bold Type indicates additions to the specifications made by the research team. **<u>Bold Type Double Underlined</u>** indicates additions to Item 3007 made by TxDOT in 3063. ~~Strike through Text~~ indicates deletions (though, for clarity, some deleted text of 3007 is not shown). Four asterisks (****) in the left margin indicate changes have been made. A bold diamond (◆) in the left margin indicates a change from 3007 to 3063.

Draft 3-10-1995 Revision 5-1

This revision combines TxDOT 3063 with Revision 4

Special Specification

Item xxxx

Quality Control/Quality Assurance Of Hot Mix Asphalt

For Airfield Pavements

1. Description. This item shall govern for the construction of a base course, a level-up course, a surface course or any combination of these courses as shown on the plans, each course being composed of a compacted mixture of aggregate and asphalt material mixed hot in a mixing plant, in accordance with the typical sections and details shown on the plans and the requirements herein.

It is the intent of this specification that the contractor be responsible for all quality control and quality assurance of the hot mix asphalt, including mix design and testing with certified specialists. TxDOT shall be responsible for the verification of the mix design, verification testing and any required referee testing.

**** **The Texas Department of Transportation is the owner's representative and shall as such determine compliance with this specification. At the option of the department, consulting engineering firms may be utilized in the design and construction oversight for TxDOT.**

Quality control tests - those tests performed at the option of the contractor to control operations.

Quality assurance tests -those tests required by this specification to be performed by the contractor and used to determine specification compliance and pay adjustment factors.

Operational tests - those tests required by this specification to be performed to control mixture production.

Verification tests - those tests required by this specification to be performed by the engineer to verify the accuracy of the contractor's test results.

Referee tests - those tests performed by materials and tests division to resolve differences between contractor and engineer test results.

2. Certification of Testing Personnel. All sampling and testing (contractor and engineer) will be conducted by personnel certified by the TxDOT materials and tests division. The certification level required for performance of each test shall comply with requirements shown in Table 8. The contractor shall provide a list of certified personnel to be used on the project prior to beginning of production. An updated list shall be provided when personnel changes are made. A certified Level IA HMA specialist shall be at the plant prior to the beginning of and during plant production operations.

3. Materials. The contractor shall furnish materials to the project meeting the following requirements prior to mixing. Additional test requirements affecting the quality of individual materials or the paving mixture shall be required when indicated on the plans.

(1) Aggregate. The aggregate shall be composed of a coarse aggregate, a fine aggregate, and (~~if~~

**** ~~Required or allowed, a mineral filler and, **if specified,**~~)may include reclaimed asphalt pavement

◆ (RAP). ***The contractor may use a mineral filler when necessary to meet the design requirements.*** Samples of each aggregate shall be submitted for approval.

◆ Aggregates from each (~~stockpile~~) ***source*** shall meet the quality requirements of Table 1 and other requirements as specified herein. Aggregate quality testing will be performed by the engineer. The

◆ Aggregate contained in RAP will not be required to meet Table 1 requirements.(~~Except as shown on the plans.~~) Sampling and testing frequency will be as shown in the guide schedule for minimum sampling and testing for quality control/ quality assurance hot mix asphalt appended to this specification.

**** (a) Coarse aggregate. Coarse aggregate is defined as that part of the aggregate retained on a No. 10 sieve. The aggregate shall be natural **or slag** and shall be of uniform quality throughout. When specified on the plans, certain coarse aggregate material may be allowed, required or prohibited.

**** **Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot when tested in accordance with test method Tex-404-A.**

**** **The aggregate shall not contain more than seventeen (17) percent by weight of flat or elongated particles when tested according to test method Tex-224-F.**

**** **Aggregate** from each source shall be so crushed as to have a minimum of 85 percent of the particles retained on the No.4 sieve with two (2) or more mechanically induced crushed faces, as determined by test method Tex-460-A (Part I). The material passing the No.4 sieve and retained on the No.10 must be the product of crushing aggregate that was original retained on the No.4 sieve.

(b) Reclaimed asphalt pavement (RAP). RAP is defined as a salvaged, milled, pulverized, broken or crushed asphalt pavement. The RAP to be used in the mix shall be crushed or broken to the

**** Extent that 100 percent will pass the two (2) inch sieve **with the additional requirement that it will be further broken down to the proper gradation when incorporated into the mixture**.

◆ The contractor has the option to use up to 20 percent RAP ***in surfacing mixtures and up to 30 percent in base course mixtures.***

The stockpiled RAP shall not be contaminated by dirt or other objectionable materials. Unless otherwise shown on the plans, stockpiled, crushed RAP shall have either a decantation of five (5) percent or less or a plasticity index of eight (8) or less, when tested in accordance with test method Tex-406-A, Part I, or test method Tex-106-E, respectively. This requirement applies to stockpiled RAP from which the asphalt has not been removed by extraction.

Any contractor-owned RAP that is to be used on the project shall remain the property of the contractor while stockpiled and any unused contractor-owned RAP material shall be removed from the project site upon completion of the project.

**** Only RAP from designated sources may be used in surface courses. ~~(excess RAP removed from designated sources will remain the property of the state and shall be delivered to stockpile locations shown on the plans.~~)

(c) Fine aggregate. The fine aggregate is defined as that part of the aggregate passing the No.10 sieve and shall be of uniform quality throughout. A maximum of 15 percent of the total virgin

◆ Aggregate may be field sand or other uncrushed fine aggregate. ***The maximum amount of field sand may be less than 15 percent when shown on the plans.*** When specified on the plans, certain fine aggregate may be allowed, required or prohibited.

Stone screenings are required and shall be the result of a rock crushing operation. When shown on the plans, crushed gravel screenings may be used with, or in lieu of, stone screenings. Crushed gravel screenings must be the product of crushing aggregate that originally retained on the No. 4 sieve.

◆ ***Except in CMHB Mixtures*** screenings shall be supplied from sources whose coarse aggregate meet the los angeles abrasion and magnesium sulfate soundness loss requirements shown in Table 1.

◆ (~~, unless otherwise shown on the plans.~~)

◆ (d) Mineral Filler. Mineral filler may consist of thoroughly dried stone dust.(~~, Portland~~

◆ **** ~~Cement or lime in accordance with astm designation d-242.~~) ***the use of fly ash will not be permitted. If other mineral is used, it must be approved by the engineer.*** The mineral filler shall be free from foreign matter.

(e) Baghouse Fines. The addition of fines collected by the baghouse or other air cleaning or dust collecting equipment is permitted.

****TABLE 1. AGGREGATE QUALITY REQUIREMENTS*

	Requirement	test method	slag or natural aggregate
	coarse aggregate		
****	Deleterious material, Percent,maximum	Tex-217-F Part I	1.5
	Decantation, Percent,maximum	Tex-217-A Part II	1.5
	Los Angeles abrasion, Percent,maximum	Tex-410-A	40**
	Magnesium sulfate soundness loss, 5 cycle,percent,maximum	Tex-411-A	**18*** **
	fine aggregate		
	linear shrinkage,maximum	Tex-107-E Part II	3
	combined aggregates ****		
	sand equivalent value,minimum	Tex-203-F	45

* Sampled during delivery to the plant or from the stockpile. All testing to determine aggregate quality will be performed by TxDOT unless otherwise shown on plans.

** Maximum abrasion loss for cmhb mixtures is 35.

*** Unless otherwise shown on the plans.

**** Aggregates without added mineral filler, RAP, or additives, combined as used in the job-mix formula.

(2) Asphalt Material.

(a) Asphalt Material. Asphalt material for the paving mixture shall be of the grade shown on the plans or designated by the engineer and shall meet the requirements of the Item 300, "asphalts, oils and emulsions".

(b) Tack Coat. Asphalt materials, shown on the plans or approved by the engineer, shall meet the requirements of Item 300, "asphalts, oils and emulsions".

◆ ~~(3) additives. Additives to facilitate mixing and/or improve the quality of the hot mix asphalt or tack coat shall be used when shown on the plans or may be used with the authorization of the engineer.~~)

4. Hot mix asphalt. The hot mix asphalt paving mixture shall consist of a uniform mixture of aggregate,

◆ Asphalt materials and, ***if required, antistripping*** additives. (~~, if allowed or required.~~)

**** (1) Job-mix formula. The job-mix formula shall be developed by the contractor **using either his laboratory, or an approved commercial laboratory** and verified by the engineer. The job-mix formula shall identify and list a single value of each component to be used in the mix and a single value for each sieve which describes the combined gradation of the aggregates used. The initial job-mix formula (JMF 1) shall be developed using the required laboratory mixture

**** Design procedure; the second job-mix formula (JMF 2) **shall** be based on plant-produced trial

**** Mix or mixes **for the production of the test section** and the third job-mix formula (JMF 3)

**** Shall be based on the results of the **test sections.**

(a) Laboratory mixture design (JMF 1). A laboratory mixture design shall be performed by the contractor's Level II certified specialist. The laboratory mixture design process shall use the project aggregates, asphalt materials and additives, if allowed or required. Based on these laboratory test results the contractor shall develop and supply to the engineer the initial job-mix formula (JMF 1).

The laboratory mixture design shall be furnished by the contractor in accordance with test method Tex-204-F. The contractor shall furnish the engineer the mixture design report and all applicable worksheets identified in test method Tex-204-F.

◆ (~~the bulk specific gravity shall be reported for each aggregate source.~~) ***When it suspected that there is a significant difference between the specific gravities for the individual aggregates, then the specific gravity shall be determined for all aggregates.*** If the bulk specific gravity values differ by 0.300 or more, the mixture shall be by the volumetric method, test method Tex-204-F, Part II. (~~The bulk specific gravity of aggregates in RAP shall be determined on extracted aggregates.~~)
When properly proportioned. for the mixture type specified, the blend of aggregates shall produce an aggregate gradation which conforms to the limits of the master grading shown Table 2. The gradation of the aggregate will be determined in accordance with test method Tex-200-F, Part II.

The master grading limits for the appropriate mixture type and the job mix formula (JMF 1) gradation shall be plotted on a gradation chart with sieve sizes raised to the 0.45 power. This plot must show that the laboratory mixture design formula is within the limits of the master grading.

The stability or creep properties of the mixture will be determined by the engineer in accordance with test method Tex-208-F or Tex-231-F respectively. The stability or creep properties shall conform to the requirements indicated in Table 2, unless otherwise shown on the plans.

The voids in the mineral aggregate (VMA) shall be determined as a mixture design requirement only, in accordance with test method Tex-207-F, and shall not be less than the value indicated in Table 2.

**** The mixture of aggregate, asphalt material and additives proposed for use shall be evaluated for moisture susceptibility in the mixture design stage only by test method Tex-531-C **and shall have TSR values no less than 0.75. If the TSR values are less than 0.75, the aggregates shall be rejected or treated with hydrated lime or a liquid anti-stripping agent**

to reduce the moisture susceptibility of the aggregate and achieve an acceptable TSR value. Production verification testing using test method Tex-530-C may be required when shown on the plans. When production verification testing is required, the engineer will determine the location and frequency of testing and will perform the test. The contractor may choose to use either lime or a liquid antistripping agent to reduce the moisture susceptibility of the aggregate. The addition of antistripping agents shall be in accordance with Item 301,"asphalt antistripping agents", **and have a TSR value of 0.75 or greater when tested by Tex-531-C**. The engineer may waive testing for moisture susceptibility if a similar design, using the same materials, has proven satisfactory.

◆ ***When the antistripping additive type and rate is shown on the plans, then the moisture susceptibility testing and requirements shall be waived.***

**** Approval of the laboratory mixture design will be the responsibility of the engineer. Approval will be based on the test results presented, TxDOT stability or creep test results, and unless prior experience makes it unnecessary, verification laboratory testing by the engineer's Level II certified specialist. Verification laboratory testing for JMF 1 is limited to VMA, ***laboratory molded air voids*** and, ***when required,*** moisture susceptibility. The engineer will approve or disapprove the submitted laboratory mixture design within **seven (7) working days**. Referee testing will be used to resolve differences between the engineer and the contractor in determinations of vma and moisture susceptibility. Referee test results will be provided within 10 working days from receipt of the sample at the referee laboratory.

◆ (~~the laboratory mixture design shall include as a minimum, the aggregate sources, gradation and proportions, the asphalt source and grade, the job mix formula, type of additive if applicable, specific gravities of the aggregates and asphalt, vma calculations, 0.45 power gradation plot, results of moisture susceptibility testing and the theoretical maximum specific gravity of the mixture.~~) sufficient quantities of all materials used in the mixture design shall be submitted to the engineer when the mix design report is submitted. The nuclear gauge calibration pans prepared during the laboratory mixture design shall be retained by the contractor for later use as necessary. In addition, the contractor laboratory molded specimens shall be submitted for stability or creep testing.

The approved initial job-mix formula (JMF 1) shall be the basis for the contractor to prepare the plant-produced trial mixes.

The contractor shall notify the engineer of any changes of source of materials. If a source of material changes, a new laboratory mixture design shall be required unless otherwise approved by the engineer. The engineer may request a new laboratory mixture design if the asphalt material grade is changed.

**** ◆ (b) Plant produced trial mixes (JMF 2). The contractor shall provide a plant-produced trial mixture for verification testing prior to the **construction of the test section/s/.** (~~the engineer will~~) test for (~~stability,~~) laboratory molded density, asphalt material content and aggregate gradation ***shall be performed by the contractor and verified by the engineer***. At the request of the contractor, the engineer may waive trial mixes if similar designs have proven satisfactory. The engineer will approve the JMF 2 within 24 hours when all of the following requirements are met.

**** Laboratory molded density: 95.0 to 97.0 percent theoretical maximum specific gravity for mixture Types A, B, C, **and** D or 96.0 to **98.0** percent of theoretical maximum specific gravity for mixture types CMHB-F and CMHB-C.

Combined aggregate gradation: within the limits of the master grading shown in Table 2 and the operational tolerances shown in Table 3 of the job mix formula (JMF 1).

**** Stability. Minimum of **45** unless otherwise shown on the plans for mixture

**** Types A, B, C, **and** D. No stability requirement for mixture types CMHB-F and CMHB-C.

◆ *Asphalt: within +/- 0.5 percent of the JMF 1 target asphalt content.*

◆ \When (~~verification~~) test results do not meet the above requirements, additional

◆ **** Plant-produced trial mixes shall be produced and (~~verification~~) tests performed prior to approval of the plant-produced trial mix. The approved plant-produced trial mix (JMF 2) shall be the basis for the contractor to prepare the hot mix asphalt **for the test section.**

The contractor shall notify the engineer of any changes in material between the laboratory mixture design and plant-produced trial mix or mixes during the trial mix stage.

**** ◆ (c) **Production mixes for test sections (JMF 3). All production for the first day shall be for the test sections.** At the end of the **test section** production, the job-mix formula will be approved for further production if the requirements in Section 4.(1)(b) are met. The (~~engineer~~) *contractor* will perform sufficient tests to insure that the mixture meets the specifications. ***The engineer may cease production when test results indicate that the mixture does not meet the operational tolerances shown in Table 3.***

**** The **test section** production mix shall be the basis for the contractor to establish the job-mix formula upon which payment is based. This job-mix formula (JMF 3) will be the basis for payment on the entire project unless JMF 3 is adjusted as described in Subarticle 4.(**3**).

**** ◆ The pay adjustment factor for the **test section** production mix will be 1.00 **except as set forth in Subarticle 4.(2).** ***However, the contractor may elect to waive the 1.00 pay factor for the test section and begin acceptance testing in accordance with article 8 and pay adjustments in accordance with article 11. This notification must be made in writing to the engineer and prior to production of the test section.***

**** (2) **Test Sections. Prior to full production, the contractor shall prepare and place a quantity of the asphalt mixture according to the job mix formula. The**

amount of the mixture should be sufficient to construct a test section 300 feet long and 20 to 30 feet wide placed in a minimum of two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

Random samples of the mixture shall be taken at the plant and tested and evaluated as specified herein. A minimum of three random cores shall be taken from the finished test section pavement mat and three from the longitudinal joint and tested in accordance with the procedures specified herein.

The mixture shall be considered acceptable if the test values are within the limits specified in this specification as set forth in Subsection 4.(1)(b).

If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling patterns shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the contractor's expense. If the second test section does meet the specification requirements, both sections may remain in place and full production begun unless the first section would require removal according to Section 11.(4), Tables 5, 6, and 7. Under these conditions, the first section must be removed at the contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted by the engineer.

(3) Job-mix Formula Adjustments. If during production, it is determined that adjustments to the job-mix formula are necessary to achieve the specified

requirements or to more nearly match the mineral aggregate production, the contractor may adjust the job-mix formula prior to beginning a new lot within the following limits without a laboratory redesign of the mixture.

Changes in the job-mix formula aggregate gradation will be allowed provided these changes do not exceed:

1. The limits of the master grading shown in Table 2.
2. The operational tolerances for gradation shown in Table 3 for JMF 1. For passing No.200, the operational tolerances shall be applied to JMF (3) as determined by extraction testing.

Changes in gradation and/or asphalt material content must also meet the stability requirements and laboratory molded density requirements. The adjusted job-mix formula will become the job-mix formula for future production.

At any time during the performance of the contract, the contractor may submit a new laboratory mixture design as detailed in Section 4.(1)(a). Plant-produced trial mixes will be required to verify the new laboratory mixture design as described in Section 4.(1)(a) and Section 4.(1)(b).

TABLE 2. MIXTURE REQUIREMENTS

Master Grading
(percent passing by weight) ~~(on volume)~~

Sieve Size	A Coarse Base	B Fine Base	C Coarse Base	D Fine Surface	CMHB-F Fine Surface	CMHB-C Coarse Surface
1-1/2"	100*					
1-1/4"	95-100					
1"		100 *				
7/8"	70-90	95-100	100 *			100 *
5/8"		75-95	95-100			98-100
1/2"	50-70			100 *	100 *	
3/8"		60-80	70-85	85-100	**85-100**	**50-70**
1/4"						
No. 4	30-50	40-60	43-63	50-70	**40-60**	**30-45**
No. 10	20-34	27-40	30-40	32-42	5-25	15-25
No. 40	5-20	10-25	10-25	11-26	**6-20**	**6-20**
No. 80	2-12	3-13	3-13	4-14	**6-18**	**6-18**
No. 200	1-6**	1-6**	1-6**	1-6**	**6-10**	**6-10**

* ***A tolerance of 2 percent is allowed***

** 2-8 for JMF

Mixture properties

Percent Minimum VMA	(~~11~~)***12***	(~~12~~)***13***	(~~13~~)***14***	(~~14~~)***15***	(~~14~~)***15***	(13)***14***
Stability, Minimum	~~(35)~~ **45**	~~(35)~~ **45**	~~(35)~~ **45**	~~(35)~~ **45**		
Creep Slope		in/in/sec maximum			**4.0**x10-8	**4.0**x10-8
Creep Stiffness		psi minimum			6,000	6,000
Permanent Strain		in/in maximum			**6.0**x10-4	**6.0**x10-4

****Note: when CMHB mixtures are allowed, they will meet the requirements of this specification.**

5. Equipment.

(1) General. All equipment for the handling of all materials, mixing, placing and compacting of the mixture shall be maintained in good repair and operating condition. The engineer may cease production until defective equipment is repaired or replaced.

(2) Mixing plants. Automatic proportioning devices shall be required for all plants and documentation as to their accuracy may be required by the engineer.

◆ ***If a liquid or emulsified additive is to be introduced into the asphaltic material at the mix plant, it shall be added to the asphalt line at the required rate by means of an in-line metering device. The contractor shall demonstrate that the meter meets the requirements of Item 520, "weighing and measuring equipment". An in-line blending device is required to disperse the additive into the asphaltic material. A sampling port shall be provided on the asphalt line near the outlet of the additive blending device so that the modified asphaltic material may be sampled. The measuring, blending, and sampling equipment and its location must be approved by the engineer.***

(3) Fuel. When using fuel oil heavier than grade No. 2, or when using waste oil, the contractor shall insure that the fuel delivered to the burner is at a viscosity of 100 ssu or less, when tested in accordance with test method Tex-534-C, to insure complete burning of the fuel. Higher viscosities may be allowed by the engineer if recommended by the burner manufacturer. If necessary, the contractor shall preheat the oil to maintain the required viscosity.

The contractor shall provide means for obtaining a sample of the fuel, just prior to entry into the burner, in order to perform the viscosity test. The contractor shall perform this test or provide a laboratory test report that will establish the temperature of the fuel necessary to meet the viscosity requirements. There shall be an in-line thermometer to check the temperature of the fuel delivered to the burner.

Regardless of the burner fuel used, the burner or combination of burners and types of fuel used shall provide a complete burn of the fuel and not leave any fuel residue that will adhere to the heated aggregate.

(4) Surge-storage system and scales. A surge-storage system may be used to minimize the production interruptions during the normal day's operations. A device such as a gob hopper or other device approved by the engineer to prevent segregation in the surge-storage bin shall be used. The mixture shall be weighed upon discharge from the surge-storage system.

When a surge-storage system is used, scales shall be standard platform truck scales or other equipment such as weigh hopper (suspended) scales and shall conform to Item 520, "weighing and measuring equipment". If truck scales are used, they shall be placed at a location approved by the engineer. If other weighing equipment is used, the engineer may require weight checks by truck scales for the basis of approval of the equipment.

Temporary storing or holding the hot mix asphalt by the surge-storage system will be required for drum-mix plants during the normal day's operation. Overnight storage will not be permitted unless authorized on the plans or in writing by the engineer.

(5) Recording Device and Record Printer. The mixture shall be weighed for payment. If a surge-storage system is used, an automatic recording device and a digital record printer shall provided to indicate the date, project identification number, vehicle identification, total weight of the load, tare weight of the vehicle, the weight of asphaltic mixture in each load and the number of loads for the day, unless otherwise indicated on the plans. When surge-storage is not used, batch weights will be used as the basis for payment and automatic recording devices and automatic digital record printers in accordance with Item 520, "weighing and measuring equipment", will be required.

◆ ~~((6) Dryer. The dryer shall continually agitate the aggregate during heating. The temperature shall be controlled so that the aggregate will not be damaged in the drying and heating operations. The dryer shall be of sufficient size to keep the plant in continuous operation.)~~

(6)(7) Laboratory. The contractor shall establish, maintain and operate a laboratory. The laboratory shall be equipped to perform the tests indicated in the specification. All quality assurance and operational testing shall be performed at the contractor's on-site laboratory unless otherwise approved by the engineer. All test equipment at the laboratory shall be calibrated and certified in accordance with the 900-k series of TxDOT's manual of testing procedures or the manufacturer's recommendations. The engineer will verify that all the necessary equipment, materials and current test procedures are present and that all equipment meets these requirements prior to the production of hot mix asphalt.

6. Stockpiling, storage and feeding of materials.

(1) Storage and heating of asphalt materials. The asphalt material storage capacity shall be ample to meet the requirements of the plant. Asphalt shall not be heated to a temperature in excess of that specified in Item 300,"asphalts, oils and emulsions". All equipment used in the storage and handling of asphalt material shall be kept in a clean condition at all times and shall be operated in such a manner that there will be no contamination with foreign material. The heating apparatus shall be equipped with a continuously recording thermometer with a 24-hour chart that will record the temperature of the asphalt at the location of the highest temperature.

Continuous recordings shall be made for asphalt and hot mix asphalt temperatures. These recordings shall be delivered to the engineer on a daily basis.

◆ ~~((2) Stockpiling of aggregates. Prior to stockpiling of aggregates, the area shall be cleaned of trash, weeds and grass and shall be relatively smooth and well drained. The stockpiling shall be done in a manner that will minimize aggregate degradation, segregation, and/or mixing of one stockpile with another, and will not allow contamination with foreign material.)~~

◆ ~~((3) Feeding and drying of aggregate. The feeding of various sizes of aggregate and RAP, if applicable, to the dryer shall be done through the cold aggregate bins and the proportioning device in such a manner that a uniform and constant flow of materials in the required proportions will be maintained. The aggregate shall be dried and heated to the temperature necessary to produce a mixture having the selected discharge temperature.)~~

◆ *(2)*~~(4)~~ Scalping screen. A scalping screen shall be required after the cold feeds and ahead of the combined aggregate belt scales for drum-mix plants***, modified weigh batch plants*** and specialized recycling type plants.

◆ *(3)*~~(5)~~ Plants using RAP. If RAP is used, a separate cold bin shall be required. The RAP feed system shall be equipped to remove particles over two (2) inches in size prior to the weighing device. There shall be adequate cold bin controls to provide a uniform amount of RAP to the mixture.

When RAP is used, positive weight measurement of RAP shall be provided by the use of belt scales or other approved devices or methods.

If RAP is used, it shall be mixed and blended so that there is no evidence of unseparated particles in the mixture as it leaves the mixer.

7. Construction Methods.

(1) General. It shall be the responsibility of the contractor to produce , transport, place and compact the specified paving mixture in accordance with the requirements herein.

◆ ***The asphaltic mixture or tack coat shall not be placed when the air temperature is below 50 f and is falling, it may be placed when the air temperature is above 40 f and is rising. The air temperature shall be taken in the shade away from artificial heat.***

◆ ***If at any time prior to placement the temperature of the mixture falls below 212 f, the quantity of that mixture shall be determined to the satisfaction of the engineer and removed from the project at the expense of the contractor.***

◆ ***(2) Adverse Weather Conditions. Unless otherwise approved by the engineer, no mixture shall be produced when the existing pavement surface is wet or damp or the surface temperature is less than 40 f. In the event that the mixture produced prior to production cessation is placed on a wet or damp or cold surface and it does not bond to the existing pavement, ravels, or has other***

surface irregularities, the mixture shall be removed or repaired to the satisfaction of the engineer. Removal or repair shall be at the expense of the contractor.

◆ **** *(3)*~~(2)~~Tack Coat. Tack coat shall be used at the direction of the engineer. The surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the engineer. The surface shall be given a uniform application of tack coat using asphalt materials of this specification. Tack coat shall be applied at a rate not to exceed 0.05 gallon residual asphalt material per square yard of surface area***, except that in CMHB mixtures the rate shall not exceed .07 gallon residual asphalt material per square yard of surface area***. Where the paving mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the engineer. All **cold** joints shall be painted with a thin uniform application of tack coat. During the application of tack coat, care shall be taken to prevent splattering of adjacent pavemen~~t, curb and gutter and structures~~. The tack coat shall be rolled with pneumatic tire roller when directed by the engineer.

◆*****(4)*~~(3)~~ Transporting Hot Mix Asphalt. The hot mix shall be hauled to the work site in tight vehicles previously cleaned of all foreign material. **In cool weather or for long hauls, tight covering and insulating of the truck bodies may be required.** ***Diesel shall not be used as a truck bed release agent.***

◆ *(5)*~~(4)~~ Windrow Pick-up Equipment. Windrow pick-up equipment, when used, shall be constructed in such a manner that substantially all the mixture deposited on the roadbed is picked up and loaded into the spreading and finishing machine. The mixture shall not be contaminated with foreign material. The loading equipment shall be designed so that it does not interfere with the spreading and finishing machine in obtaining the required line, grade and surface without resorting to hand finishing.

◆ *(6)*~~(5)~~ Placing. The hot mix asphalt shall be dumped and spread on the approved prepared surface with a spreading and finishing machine. When properly compacted, the finished pavement shall be smooth, of uniform texture and density and shall meet the requirements of the typical cross sections and the surface tests. In addition, the placing of the hot mix asphalt shall be done without tearing, shoving, gouging or segregating the mixture and without producing streaks in the mat.

**** Construction joints of successive courses of asphaltic material shall be offset at least ~~(six)~~ **twelve (12)** inches.

◆ *(7)*~~(6)~~ Compacting. The pavement shall be compacted thoroughly and uniformly with the necessary rollers to obtain the compaction and cross section of the finished paving mixture meeting the requirements of the plans and specifications.

All places not accessible to the roller, or in such positions as will not allow thorough compaction with the rollers, shall be thoroughly compacted with lightly oiled tamps. Rolling with a trench roller may be required by the engineer on widened areas, in trenches and other limited areas.

With the exception of the above requirements, the type and size of compaction equipment and the rolling patterns used will be entirely at the discretion of the contractor.

◆ *(8)*~~(7)~~ Opening to Traffic. The compacted pavement shall be opened to traffic when directed by the engineer.

8. Acceptance Plan.

**** (1) General. Acceptance of the hot mix asphalt will be based on the acceptance plan described herein. Random sampling of the hot mix asphalt shall be performed on a lot and sublot basis. A lot shall consist of four (4) **equal** sublots **unless otherwise** defined herein.

**** (2) Production Lot. A "production lot" shall consist of **one day's production not to exceed 2,000 tons, or a half day's production where a day's production is expected to consist of between 2,000 and 4,000 tons, or similar subdivisions for tonnages over 4,000 tons.**

If the day's production does not produce four (4) sublots, then additional sublots from the next day's production shall be used to compose four (4) sublots and a pay adjustment factor will be determined based on these four (4) sublots. When necessary, additional sublots shall be carried forward and combined with the next day's production to compose the required four (4) sublots per lot. The contractor may select a different sublot size for each lot based upon the anticipated production. However, once a sublot size has been selected for a lot, the sublot size cannot be varied until the next lot's production.

◆ (3) Placement Lot. A "placement lot" shall consist of ***four (4) "placement sublots".*** (~~the area of hot mix asphalt placed on the project for a "production lot".~~) a "placement sublot" shall consist (~~of approximately one-fourth~~) of the area (~~of hot mix asphalt~~) placed ***during*** ~~(in)~~ one (1) ***"production sublot".*** ~~(lot.)~~

◆ (4) Sampling and Testing. All sampling locations shall be determined by the random sampling procedure defined in test method Tex-225-F. The engineer ~~(, in the presence of the contractor,~~) is responsible for establishing the random sampling plan.

◆ All hot mix asphalt samples obtained by the contractor shall be immediately split ***in accordance with test method Tex-200-F*** (~~with a mechanical sample splitter, unless otherwise approved by the engineer,~~) to produce the contractor's quality assurance sample, the state's verification sample and the state's referee sample. The sample size shall be sufficient to allow for all testing associated with operational tolerances, quality assurance, verification testing and referee testing. The contractor shall obtain all samples and may elect to sample more frequently for quality control purposes. Hot mix asphalt shall be obtained from trucks at the plant in accordance with test method Tex-222-F.

Verification and referee samples shall be properly labeled and delivered to the engineer daily. Unused verification and referee test samples may be discarded after the contractor accepts the pay adjustment factor for that lot.

**** (5) Miscellaneous Applications. Miscellaneous applications **for** areas that are not subjected to primary traffic, the pay adjustment factor will be determined **as part of a standard lot.**

◆ (6) Level-ups and Thin Overlays. ***Placement pay adjustment factor shall be 1.00*** (~~in-place air voids will not be included in pay adjustment factor determinations~~) for layer thicknesses designated on the plans less than one and one-half (1-1/2) inches or for level-up areas. The contractor shall be required to establish a rolling pattern that will achieve in-place air voids in accordance with Subarticle 7.*(7)* ~~(6)~~. ***Total*** pay adjustment will be based on ***TPA 2 as shown in Subarticle 11.(3).*** (t~~he production pay factor only.~~)

(7) Multiple Projects. If hot mix asphalt for multiple projects is simultaneously produced from a single mixing plant, the projects will be considered as independent unless both the engineer and the contractor agree otherwise in writing.

(8) Control Charts. The results of all assurance, verification and referee testing shall be plotted by the contractor on control charts as directed in test method Tex-233-F.

(9) Aggregate Gradation. For determination of the pay adjustment factors, gradations will be determined in accordance with test method Tex-210-F. Cold feed belt or hot bin samples may be used for acceptance testing provided an approved correlation is available. The contractor shall supply a correlation between gradations obtained from the cold feed belt or hot bins and gradations from extracted samples. This correlation will be based on a minimum of three (3)

◆ Sample pairs according to test method Tex-229-F and shall be verified by the contractor ***and approved by the engineer*** once every five *(5)* production days.

When cold feed belt samples are used for drum-mix plants, aggregate samples shall be obtained from the cold feed in close proximity to the drum charging chutes. The cold feed belt shall be stopped for sampling according to test method Tex-229-F or a cold feed diverter may be used.

Aggregate gradation acceptance will be based on the percent of aggregate passing the No. 10 and No. 200 sieves (by volume or by weight).

(10) Asphalt Material Content. For determination of pay adjustment factors, the asphalt material content will be based on test method Tex-228-F (nuclear gauge). The asphalt material content shall be obtained on hot mix asphalt samples obtained from the trucks at the plant as described in Subarticle 8.(4).

(11) In-place Air Void Content. For determination of pay adjustment factors, in-place air voids will be determined by test method Tex-207-F. This method will use the bulk specific gravity of core samples (test method Tex-207-F) from the pavement and the theoretical maximum specific gravity of the hot mix asphalt obtained from the truck sample (test method Tex-227-F). The core samples will be randomly located (test method Tex-225-F) from that area of the pavement which corresponds to the placement sublot being tested. Theoretical maximum specific gravity used for air voids determination will be the average of the values obtained for the four (4) production sublots. For quality assurance purposes, two (2) cores shall be obtained side-by-side from each placement sublot and the average air void content of the two (2) samples shall be reported.

If the layer thickness before trimming of any core in a sublot is 1-1/4 inch or less, the contractor may elect not to include the air void determinations for that sublot and the pay factor for that sublot shall be 1.00. However, this decision must be made prior to trimming of the core and the rejected core delivered immediately to the engineer.

**** Six (6) inch diameter cores shall be obtained from the **traffic** lane only for Types A and B hot mix asphalt and four (4)inch diameter cores may be obtained from the **traffic** lane only for other types of hot mix asphalt. No core shall be taken within two (2) feet of construction joints (longitudinal or transverse) or the pavement edge **except for a minimum of two (2) four (4) inch cores to be taken randomly within two (2) feet of each joint for the sole purpose of determining the joint density. The joint density shall be no lower than two (2) percent lower than the pavement mat**. The engineer is responsible for determining the random location and for submitting the sampling plan to the contractor. The contractor is responsible for obtaining all cores and performing acceptance testing within two (2) working days following placement operations.

Additional cores required for referee testing shall be taken from the same location as the cores obtained for acceptance testing.

(12) Operational Tolerances. The hot mix asphalt shall be produced, placed and compacted to meet specified operational tolerances for each sublot. The operational

tolerances for the job-mix formula are shown in Table 3. Test method Tex-207-F and test method Tex-227-F shall be used to determine laboratory molded bulk density. Test method Tex-208-F will be used to determine stability.

The contractor shall select the target discharge temperature of the mixture between 250° F and 350° F. The mixture, when discharged from the mixer, shall not vary from this selected temperature more than 25° F, but in no case shall the temperature exceed 360° F.

◆ ~~(If at any time prior to placement the temperature of the mixture falls below 212° F, the quantity of that mixture shall be determined to the satisfaction of the engineer and removed from the project at the expense of the contractor.)~~

If, during production, the gradation on any single sieve other than No. 10 and No. 200, the laboratory molded density, the moisture content or the stability are outside of the tolerances shown in Table 3, the contractor shall closely evaluate available information and determine the likely cause or causes of the problem. If any two (2) consecutive test results for any one (1) property are outside the tolerances, corrective action shall be taken by the contractor. If three (3) consecutive test results for any one (1) property are outside the tolerances, production shall cease until test results or other information indicate, to the satisfaction of the engineer, that the next material to be produced will meet the specified values.

◆ ***The operational tolerance shall be evaluated on each sublot for all applicable sieve sizes other than the No. 10 and the No. 200. For laboratory molded bulk density and stability, the operational tolerance shall be evaluated on one randomly selected sublot for each production lot. The randomly selected sublot shall determined by the engineer.***

(13) Quality Control. The contractor may elect to sample and test more frequently and/or perform tests other than those specified to control the quality of the hot mix asphalt. Results of quality control tests will not be used for pay adjustment purposes.

(14) Quality Assurance. Pay adjustment factors are based on the quality assurance tests. Lots and sublots for the quality assurance program plan are described in Subarticle 8.(2). Sampling and testing shall be performed in accordance with Subarticle 8.(4).

The pay adjustment factors from Tables 5, 6 and 7 will also be used as a basis for plant control.

Pay adjustment factors are determined for aggregate gradation (No. 10 and No. 200 sieves), the asphalt material content, and in-place air voids. If any pay adjustment factors for aggregate gradation on either the No. 10 sieve or the No. 200 sieve, asphalt material content or in-place air voids are determined to be below 1.00 for a lot, the contractor shall closely

- Evaluate available information and determine the likely cause or causes of the problem. ***If an individual pay adjustment factor for two (2) consecutive lots is below 1.00, corrective action shall be taken by the contractor.*** If an individual pay adjustment factor for three (3) consecutive lots is below 1.00, production shall cease until test results or other information indicate, to the satisfaction of the engineer, that the next material to be produced will meet the specified values.

TABLE 3. OPERATIONAL TOLERANCES

Item	Tolerance
Percent passing each sieve 1-1/2 " through No. 10	Plus or minus 5 ***
Percent passing each sieve No. 40 through No. 200	Plus or minus 3 ***
~~Moisture content, percent~~	~~0 to 1~~
Laboratory molded bulk density,	
Percent of theoretical maximum	
Sp. Gr. *	95.0 to 97.0
	Minimum **45**
Stability **	No maximum

* For CMHB mixtures, the laboratory molded density range is 96.0 - **98.0**. Test will be based on a single sample selected at random from the four (4) sublots. A laboratory molded bulk density above 97.5 (**98.5** (~~99.0~~) for CMHB mixtures) shall cause production to cease until test results or other information indicates, to the satisfaction of the engineer, that the next material to be produced will meet the specified range.

** Stability is not measured for CMHB mixtures.

*** When within applicable tolerances, the gradation of the produced mixture fall outside the master grading limits for any of the sieve sizes from largest sieve size on which aggregate may be retained down through the No. 80 seive. Tolerance applies to amount retained between two consecutive sieve sizes.

(15) Verification tests. The contractor shall provide the engineer with all split samples intended for verification testing. Verification testing will be performed by the engineer on these samples. A minimum of one (1) in 12 sublots will be subjected to verification testing. Verification testing will be performed for those tests identified for operational control and quality assurance testing. The results from the contractor conducted operational control and quality assurance tests and the engineer's verification tests will be checked against the maximum difference shown in Table 4.

If the contractor and the engineer's test results are within the tolerances shown in Table 4, the contractor performed quality assurance test results will be used to determine the pay adjustment factors. If the quality assurance tests and the verification tests are not within the tolerances shown in Table 4, verification tests will be performed on the remaining sublots

◆ For that lot ***unless the engineer and the contractor agree otherwise.***. If the engineer and the contractor can agree on a pay adjustment factor based on the results of either all the quality assurance test results or all the verification test results for the lot in question, then no further action is needed. If an agreement cannot be made, then referee testing as

◆ Specified in Subarticle 8.***(16)***~~(17)~~ will be performed.

TABLE 4. MAXIMUM ALLOWABLE DIFFERENCES BETWEEN QUALITY ASSURANCE AND VERIFICATION TESTS

	Test Method No.	Test Description	Max. Difference
	Tex-210-F	Sieve Analysis:	
	or		
◆	Tex-200-F *	for ***5/8" and larger***~~(sieves larger than 7/8")~~	Plus or minus 5.0
◆		for sieves smaller than ***5/8"***~~(7/8")~~ and larger than No. ***200*** ~~(10)~~	Plus or minus 3.0
◆		~~(No. 10 sieve~~	~~plus or minus 3.0)~~
		No. 200 sieve	Plus or minus 1.6
	Tex-228-F	(Nuclear) Asphalt Material Content	Plus or minus 0.3
◆	Tex- 207-F	In-place Air Voids**	Plus or minus ***1.0***(~~2.0~~)
◆	***Tex-207-F***	***Laboratory Molded Air Voids***	***Plus or minus 2.0***
	Tex-227-F	Theoretical Maximum (Rice) Gravity	Plus or minus 0.020
	Tex-207-F	Laboratory Molded Bulk Specific Gravity	Plus or minus 0.020

*Test Method Tex-200-F (Part I or II) may be used on aggregate obtained from the cold feed belt

◆ or hot bin samples if suitable correlations are available. ***The maximum difference applies to amount retained between two consecutive sieve sizes.***

** In-place air voids for verification testing and referee testing will be determined from the same

◆ cores as used for assurance testing when possible. ***In addition, the contractor's verified theoretical maximum gravity will be used to determine and verify the in-place air voids.***

◆ Quality assurance test results shall be made available not later than the second working day after mix production. Verification test results will be available within five (5) working days after mix production. Referee test results will be available within ***(10)*** ~~(20)~~ working days after receipt of the mix production sample by the referee laboratory.

(16) Referee tests. The TxDOT Materials and Tests Division will perform the referee tests. These tests are final and will establish pay adjustment factors for the lot(s) in question.

TxDOT will be responsible for costs of referee testing.

(17) Irregularities or segregation. If a pattern of surface irregularities including but not limited to color, texture, roller marks, tears, uncoated aggregate particles, or segregation is detected, the contractor shall make an investigation into the cause or causes and immediately take the necessary corrective action. Placement may continue for no more than one (1) day of production from the time the contractor is first notified and while corrective actions are being taken. If no corrective action is taken or if the problem exists after one day, paving shall cease until the contractor further investigates the causes and the engineer approves further corrective action.

Individual loads of hot mix asphalt in the truck can be rejected by the engineer. Each rejected load will be tested at the request of the contractor. This request must be made within four (4) hours of rejection. If tests are within operational tolerances, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load. The engineer will perform sampling and testing. The acceptable tolerance for asphalt content shall be ± 0.5 percent from the target asphalt content.

**** (18) **Smoothness.The finished surfaces of the pavement shall not vary more than 1/4 inch for the surface course. Each lot shall be measured with a 16-foot straightedge. Measurements will be made perpendicular and parallel to the centerline.**

The finished surfaces of the pavement shall not vary from the gradelines, elevations and cross sections shown of the plans by more than 1/2 inch. The contractor shall correct at his cost pavement areas varying in excess of this amount by removing and replacing the defective work. Skin patching shall not be permitted for correction of low areas nor shall planing be permitted for correction of high areas.

9. Measurement. The quantity of hot mix asphalt will be measured by the composite weight.

(1) Composite Weight Method. Hot mix asphalt will be measured by the ton of 2000 pounds of the composite "hot mix asphalt" of the type actually used in the completed and accepted work in accordance with the plans and specifications for the project. The composite hot mix asphalt mixture is hereby defined as the asphalt, aggregate, RAP and additives as noted on the plans and/or approved by the engineer.

If mixing is done by a drum-mix plant or specialized recycling plant, measurement will be made on scales as specified herein.

If mixing is done by a weigh-batch or modified weigh-batch plant, measurement will be determined on the batch scales unless surge-storage is used. Records of the number of batches, batch design and the weight of the composite "hot mix asphalt" shall be kept. Where surge-storage is used, measurement of the material taken from the surge-storage bin will be made on truck scales or suspended hopper scales.

**** **The contractor shall furnish a scale ticket for each load of material.**

10. Payment. The work performed and materials furnished in accordance with this item and measured as provided under measurement will be paid for at the unit price bid for the hot mix asphalt" of the type specified and as determined in Article 11, "pay and adjustment factors".

Measurement Method	Bid Item	Unit Of Measure
Composite weight	Hot mix asphalt	Ton

The payment based on the unit bid price shall be full compensation for quarrying, furnishing all materials, additives, freight involvėd, sampling and testing, for all hot mix asphalt mixture design(s), for all quality control and quality assurance testing, for all heating, mixing,hauling, cleaning the existing base course or pavement, tack coat, placing, rolling and finishing hot mix asphalt, transporting RAP from designated sources, transporting any excess RAP to locations shown on the plans. and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

All templates, straightedges, core drilling equipment, scales and other weighing and measuring devices necessary for the proper construction, measuring and checking of the work shall be furnished, operated and maintained by the contractor at his expense.

The laboratory building and equipment for quality control and quality assurance testing shall be furnished, maintained, and operated by certified specialists at the contractor's own expense.

11. Pay Adjustment Factors.

(1) Pay Adjustment Factor for Production. The "pay adjustment factor for production" is based on the aggregate gradation on the No. 10 and No. 200 sieves and the

asphalt material content. These factors shall be based on the mean absolute deviation from the job-mix formula targets shown in tables 5 and 6. The mean absolute deviation is calculated as the sum of the absolute values of deviations from the job-mix formula targets for each of the four (4) sublots divided by four (4).

The pay adjustment factor for production shall be the lowest pay adjustment factor obtained for gradation on the No. 10 sieve, gradation on the No. 200 sieve and the asphalt material content, unless each of the individual pay adjustment factors is 1.00 or greater. If the individual pay adjustment factors for production are equal to or greater than 1.00, the highest individual pay adjustment factor will be used for calculation of the pay adjustment.

If the total pay adjustment factor for production for any lot is less than 1.00, the contractor has the option to remove and replace the lot or agree to accept the lot at an adjusted unit price determined by the total pay adjustment calculation. If the pay adjustment factor for production for any lot is less than 0.70, the material shall be removed at the expense of the contractor. Replacement material shall meet the requirements of this specification with payment made accordingly.

◆ ***(2) The pay adjustment factor for a placement lot shall be determined from Table 7 for the sublots that require air void measurement. For sublots that do not require air void measurement, the pay adjustment factor shall be 1.00. The pay adjustment factor for a placement lot shall be determined as the average of the four (4) pay adjustment factors for the sublots within that lot.***

◆ ~~((2) Pay adjustment factor for placement. The "pay adjustment factor for placement" is based on in-place air voids. The pay adjustment factor for in-place air voids for a placement lot shall be determined as the average pay adjustment factor obtained from Table 7 for the four (4) sublots that comprise the placement lot.)~~

If the total pay adjustment factor for placement for any lot is less than 1.00, the contractor has the option to remove and replace the lot or agree to accept the lot at an adjusted unit price determined by the total pay adjustment calculation. If the pay adjustment factor for placement for any lot is less than 0.70, the material shall be removed at the expense of the contractor. Replacement material shall meet the requirements of this specification with payment made accordingly.

(3) Total Pay Adjustment Calculation. Total pay adjustment (tpa) shall be based on the applicable pay adjustment factors for production and placement.

Pay Adjustment Calculations

- For production only TPA *1** = A
- For production and placement TPA 2 = $\frac{A+B}{2}$
- A = bid price x ***production*** (~~placement~~) lot quantity x pay adjustment factor for production
- B = bid price x placement lot quantity (~~tested for air voids~~) x pay adjustment factor for placement (~~+ (bid price x placement lot quantity not tested for air voids x 1.00)~~)

  Rounding of significant numbers for pay adjustment factors shall be rounded to two (2) decimal places. The mean absolute deviation shall be rounded to two (2) decimal places.
- **** applies only when the contractor is not responsible for placement of the mixture.***

12. Test methods and minimum certification levels.

TABLE 5. PAY ADJUSTMENT FACTORS FOR GRADATION

	Mean Absolute Deviation from Job-Mix Formula Target	
PayAdjust Factor	Pass No. 10	Pass No. 200
1.05	0.00 - 0.99	0.00 - 0.50
1.02	1.00 - 1.90	0.51 - 0.90
1.00	1.91 - 3.00	0.91 - 1.50
0.95	3.01 - 4.00	1.51 - 2.00
0.90	4.01 - 5.00	2.01 - 2.50
0.85	5.01 - 6.00	2.51 - 3.00
0.80	6.01 - 7.00	3.01 - 3.50
0.75	7.01 - 8.00	3.51 - 4.00
0.70	8.01 - 9.00	4.01 - 4.50
Remove	>9.00	>4.50

TABLE 6. PAY ADJUSTMENT FACTORS FOR ASPHALT MATERIAL CONTENT

Pay Adjust Factor	Mean Absolute Deviation From Job-Mix Formula Target
1.05	0.00 - 0.19
1.02	0.20 - 0.24
1.00	0.25 - 0.30
0.95	0.31 - 0.35
0.90	0.36 - 0.40
0.85	0.41 - 0.45
0.80	0.46 - 0.50
0.75	0.51 - 0.60
0.70	0.61 - 0.65
Remove	> 0.65

TABLE 7. PAY ADJUSTMENT FACTORS FOR IN-PLACE AIR VOIDS

	Pay Adjust Factor	Measured Air Voids (Average Of Two Cores Per Sublot)
	1.05	4.0 - 5.9
◆ ****	**1.00** *	6.0 - 6.9
****	**0.80**	**7.0 - 8.0**
◆ ****	~~(remove)~~ *0.00***	> 8.1

◆ **** a pay adjustment factor of 1.00 shall be used when mixture is placed but not measured for air voids.***

◆ ***** if the pay adjustment factor for the lot is less than 0.80, the entire lot is to be removed at the contractor's expense.***

TABLE 8. TEST METHODS AND MINIMUM CERTIFICATION LEVELS

Test	Contractor	TxDOT Certification	
		TxDOT	Level
1. Aggregate quality			
Sampling	Tex-400-A	Tex-400-A	IA
Washed sieve	Tex-200-F, Part II		IA
Coarse aggregate specific gravity	Tex-201-F	Tex-201-F	II
Fine aggregate specificgravity	Tex-202-F	Tex-202-F	II
L.A.Abrasion		Tex-410-A	
Soundness		Tex-411-A	
Pressure slake		Tex-431-A	
Crushed face count		Tex-460-A	
Linear shrinkage		Tex-107-E	
Sand equivalent		Tex-203-F	
2. Laboratory mix design and verification			
Design	Tex-204-F	Tex-204-F	II
	Tex-234-F	Tex-234-F	II
Mixing	Tex-205-F	Tex-205-F	II
Molding	Tex-206-F	Tex-206-F	IA
Density and VMA	Tex-207-F	Tex-207-F	II
Tensile strength	Tex-226-F	Tex-226-F	II
Rice gravity	Tex-227-F		IA
Nuclear gauge calibration	Tex-228-F	Tex-228-F	II
Boil test	Tex-530-C	Tex-530-C	II
Tensile ratio	Tex-531-C	Tex-531-C	II
Stability	Tex-208-F		
Creep	Tex-231-F		
3. Design verification - trial mix			
Molding		Tex-206-F	IA
Density		Tex-207-F	IA
Stability		Tex-208-F	IA
Extraction		Tex-210-F	IA
Moisture		Tex-212-F	IA
Sampling		Tex-222-F	IA
Tensile strength		Tex-226-F	II
Rice gravity		Tex-227-F	IA
Asphalt content		Tex-228-F	IA

Boil test		Tex-530-C	II
Tensile ratio		Tex-531-C	II
4. Plant operations			
Sampling	Tex-222-F	Tex-222-F	IA
Nuclear asphalt content	Tex-228-F	Tex-228-F	IA
Extraction or cold feed	Tex-229-F	Tex-229-F	IA
Random sampling		Tex-225-F	IA
Molding	Tex-206-F	Tex-206-F	IA
Density	Tex-207-F	Tex-207-F	IA
Rice gravity	Tex-227-F	Tex-227-F	IA
Moisture	Tex-212-F	Tex-212-F	IA
Stability		Tex-208-F	
**** 5. **Traffic lane**			
Air voids	Tex-207-F	Tex-207-F	IB
Random sampling		Tex-225-F	IB
Establish rolling pattern	Tex-207-F	Tex-207-F	IB

APPENDIX B

ITEM P-209 CRUSHED AGGREGATE BASE COURSE

DESCRIPTION

209-1.1 This item consists of a base course composed of crushed aggregates constructed on a prepared course in accordance with these specifications and in conformity to the dimensions and typical cross sections shown on the plans.

MATERIALS

209-2.1 AGGREGATE. Aggregates shall consist of clean, sound, durable particles of crushed stone, crushed gravel, or crushed slag and shall be free from coatings of clay, silt, vegetable matter, and other objectionable materials and shall contain no clay balls. Fine aggregate passing the No. 4 (4.75 mm) sieve shall consist of fines from the operation of crushing the coarse aggregate. If necessary, fine aggregate may be added to produce the correct gradation. The fine aggregate shall be produced by crushing stone, gravel, or slag that meet the requirements for wear and soundness specified for coarse aggregate.

The crushed slag shall be an air-cooled, blast furnace slag and shall have a unit weight of not less than 70 pounds per cubic foot (1.12 Mg/cubic meter) when tested in accordance with ASTM C 29.

The crushed aggregate portion which is retained on the No. 4 (4.75 mm) sieve shall contain not more than 15 percent, by weight, of flat or elongated pieces as defined in ASTM D 693 and shall have at least 90 percent by weight of particles with at least two fractured faces and 100 percent with at least one fractured face. The area of each face shall be equal to at least 75 percent of the smallest midsectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30° to count as two fractured faces.

The percentage of wear shall not be greater than 45 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent, after 5 cycles, when tested in accordance with ASTM C 88.

The fraction passing the No. 40 (0.42 mm) sieve shall have a liquid limit no greater than 25 and a plasticity index of not more than 4 when tested in accordance with ASTM D 4318. The fine aggregate shall have a minimum sand equivalent value of 35 when tested in accordance with ASTM D 2419.

a. Sampling and Testing. Aggregates for preliminary testing shall be furnished by the Contractor prior to the start of production. All tests for initial aggregate submittals necessary to determine compliance with the specification requirements will be made by the Engineer at no expense to the Contractor.

Samples of aggregates shall be furnished by the Contractor at the start of production and at intervals during production. The sampling points and intervals will be designated by the Engineer. The samples will be the basis of approval of specific lots of aggregates from the standpoint of the quality requirements of this section.

In lieu of testing, the Engineer may accept certified state test results indicating that the aggregate meets specification requirements.

Samples of aggregates to check gradation shall be taken by the Engineer at least once daily. Sampling shall be in accordance with ASTM D 75, and testing shall be in accordance with ASTM C 136 and C 117.

b. Gradation Requirements. The gradation (job mix) of the final mixture shall fall within the design range indicated in Table 1, when tested in accordance with ASTM C 117 and C 136. The final gradation shall be continuously well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on an adjacent sieve or vice versa.

TABLE 1. REQUIREMENTS FOR GRADATION OF AGGREGATE [1]

Sieve Size	Design Range Percentage by Weight Passing Sieves	Job Mix Tolerances Percent
2 in (50.0 mm)	100	
1½ in (37.0 mm)	95-100	±5
1 in (25.0 mm)	70-95	±8
¾ in (19.0 mm)	55-85	±8
No. 4 (4.75 mm)	30-60	±8
No. 30 (0.60 mm)	12-30	±5
No. 200 (0.075 mm)	0-8	±3

[1] Where environmental conditions (temperature and availability of free moisture) indicate potential damage due to frost action, the maximum percent of material, by weight, of particles smaller than 0.02 mm shall be 3 percent. It also may be necessary to have a lower percentage of material passing the No. 200 sieve to help control the percentage of particles smaller than 0.02 mm.

The job mix tolerances in Table 1 shall be applied to the job mix gradation to establish a job control grading band. The full tolerance still will apply if application of the tolerances results in a job control grading band outside the design range.

The fraction of the final mixture that passes the No. 200 (0.075 mm) sieve shall not exceed 60 percent of the fraction passing the No. 30 (0.60 mm) sieve.

CONSTRUCTION METHODS

209-3.1 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause shall be corrected at the Contractor's expense before the base course is placed thereon. Material shall not be placed on frozen subgrade.

209-3.2 MIXING. The aggregate shall be uniformly blended during crushing operations or mixed in a plant. The plant shall blend and mix the materials to meet the specifications and to secure the proper moisture content for compaction.

209-3.3 PLACING. The crushed aggregate base material shall be placed on the moistened subgrade in layers of uniform thickness with a mechanical spreader.

The maximum depth of a compacted layer shall be 6 inches (150 mm). If the total depth of the compacted material is more than 6 inches (150 mm), it shall be constructed in two or more layers. In multi-layer construction, the base course shall be placed in approximately equal-depth layers.

The previously constructed layer should be cleaned of loose and foreign material prior to placing the next layer. The surface of the compacted material shall be kept moist until covered with the next layer.

209-3.4 COMPACTION. Immediately upon completion of the spreading operations, the crushed aggregate shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the material to the required density.

The moisture content of the material during placing operations shall not be below, nor more than 1-1/2 percentage points above, the optimum moisture content as determined by ASTM [ ].

209-3.5 ACCEPTANCE SAMPLING AND TESTING FOR DENSITY. Aggregate base course shall be accepted for density on a lot basis. A lot will consist of one day's production where it is not expected to exceed 2400 square yards (2000 square meters). A lot will consist of one-half day's production where a day's production is expected to consist of between 2400 and 4800 square yards (2000 and 4000 square meters).

Each lot shall be divided into two equal sublots. One test shall be made for each sublot. Sampling locations will be determined by the Engineer on a random basis in accordance with statistical procedures contained in ASTM D 3665.

Each lot will be accepted for density when the field density is at least 100 percent of the maximum density of laboratory specimens prepared from samples of the base course material delivered to the job site. The specimens shall be compacted and tested in accordance with ASTM [ ]. The in-place field density shall be determined in accordance with ASTM D 1556 or D 2167. If the specified density is not attained, the entire lot shall be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached.

* *

The Engineer shall specify ASTM D 698 for areas designated for aircraft with gross weights of 60,000 pounds (27 200 kg) or less and ASTM D 1557 for areas designated for aircraft with gross weights greater than 60,000 pounds (27 200 kg).

* *

In lieu of the core method of field density determination, acceptance testing may be accomplished using a nuclear gage in accordance with ASTM D 2922. The gage should be field calibrated in accordance with paragraph 4 of ASTM D 2922. Calibration tests shall be conducted on the first lot of material placed that meets the density requirements.

Use of ASTM D 2922 results in a wet unit weight, and when using this method, ASTM D 3017 shall be used to determine the moisture content of the material. The calibration curve furnished with the moisture gages shall be checked as described in paragraph 7 of ASTM D 3017. The calibration checks of both the density and moisture gages shall be made at the beginning of a job and at intervals as determined by the Engineer.

If a nuclear gage is used for density determination, two random readings shall be made for each sublot.

209-3.6 FINISHING. The surface of the aggregate base course shall be finished by blading or with automated equipment especially designed for this purpose.

In no case will the addition of thin layers of material be added to the top layer of base course to meet grade. If the elevation of the top layer is 1/2 inch (12 mm) or more below grade, the top layer of base shall be scarified to a depth of at least 3 inches (75 mm), new material added, and the layer shall be blended and recompacted to bring it to grade. If the finished surface is above plan grade, it shall be cut back to grade and rerolled.

209-3.7 SURFACE TOLERANCES. The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 16-foot (4.8 m) straightedge applied parallel with or at right angles to the centerline. Any deviation in excess of this amount shall be corrected by the Contractor at the Contractor's expense.

209-3.8 THICKNESS CONTROL. The completed thickness of the base course shall be within 1/2 inch (12 mm) of the design thickness. Four determinations of thickness shall be made for each lot of material placed. The lot size shall be consistent with that specified in paragraph 3.5. Each lot shall be divided into four equal sublots. One test shall be made for each sublot. Sampling locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Where the thickness is deficient by more than 1/2 inch (12 mm), the Contractor shall correct such areas at no additional cost by excavating to the required depth and replacing with new material. Additional test holes may be required to identify the limits of deficient areas.

209-3.9 MAINTENANCE. The base course shall be maintained in a condition that will meet all specification requirements until the work is accepted. Equipment used in the construction of an adjoining section may be routed over completed portions of the base course, provided no damage results and provided that the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

METHOD OF MEASUREMENT

209-4.1 The quantity of crushed aggregate base course to be paid for will be determined by measurement of the number of [**square yards (square meters)**][**cubic yards (cubic meters)**] of material actually constructed and accepted by the Engineer as complying with the plans and specifications. [**On individual depth measurements, thicknesses more than 1/2 inch (12 mm) in excess of the design thickness shall be considered as the specified thickness, plus 1/2 inch (12 mm) in computing the number of cubic yards (cubic meters) for payment.**]

BASIS OF PAYMENT

209-5.1 Payment shall be made at the contract unit price per [**square yard (square meter)**][**cubic yard (cubic meter)**] for crushed aggregate base course. This price shall be full compensation for furnishing all materials, for preparing and placing these materials, and for all labor, equipment tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-209-5.1	Crushed Aggregate Base Course — per [**square yard (square meter)**][**cubic yard (cubic meter)**]

TESTING REQUIREMENTS

ASTM C 29	Unit Weight of Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Materials Finer than 75um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM D 75	Sampling Aggregate
ASTM D 693	Crushed Stone, Crushed Slag, and Crushed Gravel for Dry- or Water-Bound Macadam Base Courses and Bituminous Macadam Base and Surface Courses of Pavements.
ASTM D 698	Moisture-Density Relations of Soils and Soil - Aggregate Mixtures Using 5.5-lb (2.49-kg) Rammer and 12-in (305mm) Drop
ASTM D 1556	Density of Soil in Place by the Sand - Cone Method
ASTM D 1557	Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.5kg) Rammer and 18 in (457 mm) Drop
ASTM D 2167	Density of Soil in Place by the Rubber-Ballon Method
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2922	Density of Soil and Soil-Aggregate in Place by Nuclear Methods
ASTM D 3017	Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils

APPENDIX C

ITEM P-208 AGGREGATE BASE COURSE

DESCRIPTION

208-1.1 This item shall consist of a base course composed of [**crushed**][**uncrushed**] coarse aggregate bonded with either soil or fine aggregate or both. It shall be constructed on a prepared underlying course in accordance with these specifications and shall conform to the dimensions and typical cross section shown on the plans.

MATERIALS

208-2.1 UNCRUSHED COARSE AGGREGATE. The base course material shall consist of hard, durable particles or fragments of stone or gravel mixed or blended with sand, stone dust, or other similar binding or filler materials produced from approved sources. All oversized stones, rocks and boulders occurring in the pit or quarry material shall be wasted; those of acceptable quality may be crushed and become a part of the base material, provided the blend meets the specified gradations. The aggregate shall be free from vegetation, lumps, or excessive amounts of clay and other objectionable substances. The coarse aggregate shall have a percent of wear not more than 45 at 500 revolutions as determined by ASTM C 131.

208-2.2. CRUSHED COARSE AGGREGATE. The aggregates shall consist of both fine and coarse fragments of crushed stone, crushed slag, or crushed gravel mixed or blended with sand, screenings, or other similar approved materials. The crushed stone shall consist of hard, durable particles or fragments of stone and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter.

The crushed slag shall be air-cooled, blast furnace slag and shall consist of angular fragments reasonably uniform in density and quality and shall be reasonably free from thin, elongated, or soft pieces, dirt, and other objectionable matter. It shall weigh not less than 70 pounds per cubic foot (1.12 Mg/cubic meter) as determined by ASTM C 29.

The crushed gravel shall consist of hard, durable stones, rock, and boulders crushed to specified size and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter. The method used in production of crushed gravel shall be such that the fractured particles occurring in the finished product shall be as nearly constant and uniform as practicable and shall result in at least the specified percentage of material retained on a No. 4 mesh (4.75 mm) sieve having one or more fractured faces.

If necessary to meet this requirement or to eliminate an excess of fine, uncrushed particles, the gravel shall be screened before crushing. All stones, rocks, and boulders of inferior quality in the pit shall be wasted.

The crushed coarse aggregate shall have a percent of wear not more than 50 at 500 revolutions as determined by ASTM C 131.

All material passing the No. 4 mesh (4.75 mm) sieve produced in the crushing operation of either stone, slag, or gravel shall be incorporated in the base material to the extent permitted by the gradation requirements.

208-2.3 GRADATION. The gradation of the uncrushed or crushed material shall meet the requirements of one of the gradations given in Table 1 when tested in accordance with ASTM C 117 and C 136.

TABLE 1. REQUIREMENTS FOR GRADATION OF AGGREGATE

Sieve Designation (square openings)	Percentage by weight passing sieves		
	2" maximum	1½" maximum	1" maximum
2 inch (50.0 mm)	100	—	—
1½ inch (37.0 mm)	—	100	—
1 inch (25.0 mm)	55-85	70-95	100
¾ inch (13.0 mm)	50-80	55-85	70-100
No. 4 (4.75 mm)	30-60	30-60	35-65
No. 40 (0.45 mm)	10-30	10-30	15-30
No. 200 (0.075 mm)	5-15	5-15	5-15

The gradations in the table represent the limits which shall determine suitability of aggregate for use from the sources of supply. The final gradations decided on within the limits designated in the table shall be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves, or vice versa.

The amount of the fraction of material passing the No. 200 mesh (0.075 mm) sieve shall not exceed one-half the fraction passing the No. 40 mesh (0.45 mm) sieve.

The portion of the filler and binder, including any blended material, passing the No. 40 mesh (0.45 mm) sieve have a liquid limit not more than 25 and a plasticity index not more than 6 when tested in accordance with ASTM D 4318.

The selection of any of the gradations shown in the table shall be such that the maximum size aggregate used in any course shall be not more than two-thirds the thickness of the layer of the course being constructed.

208-2.4 FILLER FOR BLENDING. If filler, in addition to that naturally present in the base course material, is necessary for satisfactory bonding of the material, for changing the soil constants of the material passing the No. 40 mesh (0.45 mm) sieve, or for correcting the gradation to the limitations of the specified gradation, it shall be uniformly blended with the base course material at the crushing plant or at the mixing plant. The material for such purpose shall be obtained from sources approved by the Engineer and shall be of a gradation necessary to accomplish the specified gradation in the finally processed material.

The additional filler may be composed of sand, but the amount of sand shall not exceed 20% by weight of the total combined base aggregate. All the sand shall pass a No. 4 mesh (0.45 mm) sieve and not more than 5% by weight shall pass a No. 200 mesh (4.75 mm) sieve.

CONSTRUCTION METHODS

208-3.1 OPERATIONS IN PITS AND QUARRIES. All work involved in clearing and stripping pits and quarries, including handling of unsuitable material, shall be performed by the Contractor. All material shall be handled in a manner that shall secure a uniform and satisfactory base product. The base course material shall be obtained from sources that have been approved.

208-3.2 PREPARING UNDERLYING COURSE. The underlying course shall be checked and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft, yielding places due to improper drainage conditions, hauling, or any other cause, shall be corrected and rolled to the required density before the base course is placed thereon.

To protect the underlying course and to ensure proper drainage, the spreading of the base shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope.

208-3.3 METHODS OF PRODUCTION

a. Plant Mix. When provided in the proposal, or when selected by the Contractor and approved by the Engineer, the base material shall be uniformly blended or mixed in an approved plant. The mixing plant shall include bins for storage and batching of the aggregate, pump and tanks for water, and batch mixers of either the pugmill or drum type. All mineral aggregates shall be batched into the mixer by weight. The agitation shall be such that a thorough dispersion of moisture is obtained. The size of the batch and the time of mixing shall be fixed by the Engineer and shall produce the results and requirements specified. The base course material produced by combining two or more materials from different sources shall be mixed in a mixing plant described herein. The mixture material shall be at a satisfactory moisture content to obtain maximum density.

b. Travel Plant. When the use of a traveling plant is allowed, the plant shall blend and mix the materials to meet these specifications. It shall accomplish a thorough mixing in one trip. The agitation shall be such that the dispersion of the moisture is complete. The machine shall move at a uniform rate of speed and this speed shall be regulated to fix the mixing time. If a windrow-type of travel plant is employed for mixing, the aggregate shall be placed in windrows parallel to the pavement centerline.

The windrow volume shall be sufficient to cover exact areas as planned. The windrow contents shall produce a mixture of the required gradation and bonding qualities. If a travel plant is used which is of the type that mixes previously spread aggregates in-place, the material shall have been spread in such thickness and proportions as may be handled by the machine to develop a base course of the thickness of each layer and of the gradation required. With either type of equipment, the mixed material shall be at a satisfactory moisture content to obtain the maximum density.

c. Proportioning or Blending In-Place. When the base materials are to be proportioned and mixed or blended in-place, the different layers shall be placed and spread with the relative proportions of the components of the mixture being designated by the Engineer. The base aggregate shall be deposited and spread evenly to a uniform thickness and width. Then the binder or filler shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the Engineer may direct to obtain the required gradation and layer thickness. When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of approved graders, discs, harrows, rotary tillers, or a machine capable of combining these operations, supplemented by other suitable equipment if necessary. The mixing shall continue until the mixture is uniform throughout and accepted by the Engineer. Areas of segregated material shall be corrected by the addition of needed material and by remixing. Water shall be uniformly applied, prior and during the mixing operation if necessary to maintain the material at the proper moisture content. When the mixing and blending have been completed, the material shall be bladed and dragged, if necessary, until a smooth uniform surface is obtained, true to line and grade.

d. Materials of Proper Gradation. When the entire base course material from coarse to fine is secured in a uniform and well-graded condition and contains approximately the proper moisture, such approved material may be handled directly to the spreading equipment. The material may be obtained from gravel pits, stockpiles, or produced from a crushing and screening plant with the proper blending. The materials from these sources shall meet the requirements for gradation, quality, and consistency. The intent of this section of these specifications is to secure materials that will not require further mixing. The base material shall be at a satisfactory moisture content to obtain maximum density. Any minor deficiency or excess of moisture may be corrected by surface sprinkling or by aeration. In such instances some mixing or manipulation may be required immediately preceding the rolling to obtain the required moisture content. The final operation shall be blading or dragging, if necessary, to obtain a smooth uniform surface true to line and grade.

208-3.4 PLACING.

a. The aggregate base material that is correctly proportioned, or has been processed in a plant, shall be placed on the prepared underlying course and compacted in layers of the thickness shown on the plans. The depositing and spreading of the material shall commence where designated and shall progress continuously without breaks. The material shall be deposited and spread in lanes in a uniform layer and without segregation of size to such loose depth that, when compacted, the layer shall have the required thickness. The base aggregate shall be spread by spreader boxes or other approved devices having positive thickness controls that shall spread the aggregate in the required amount to avoid or minimize the need for hand manipulation. Dumping from vehicles in piles which require rehandling shall not be permitted. Hauling over the uncompacted base course shall not be permitted.

b. The aggregate base material that has been processed in a traveling plant, or mixed and blended in-place, shall be spread in a uniform layer of required depth and width and to the typical cross section. The spreading shall be by a self-powered blade grader, mechanical spreader, or other approved method. In spreading, care shall be taken to prevent cutting into the underlying layer. The material shall be bladed until a smooth, uniform surface is obtained, true to line and grade.

c. The base course shall be constructed in a layer not less than 3 inches (75 mm) nor more than 6 inches (150 mm) of compacted thickness. The aggregate as spread shall be of uniform grading with no pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the Engineer, shall not be spread more than 2,000 square yards (1700 square meters) in advance of the rolling. Any necessary sprinkling shall be kept within these limits. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

During the mixing and spreading process, sufficient caution shall be exercised to prevent the incorporation of subgrade, subbase, or shoulder material in the base course mixture.

208-3.5 COMPACTION. Immediately upon completion of the spreading operations, the aggregate shall be thoroughly compacted. The number, type, and weight of rollers shall be sufficient to compact the material to the required density.

The moisture content of the material during placing operations shall not be below, nor more than 1-1/2 percentage points above, the optimum moisture content as determined by ASTM [ ].

208-3.6 ACCEPTANCE SAMPLING AND TESTING FOR DENSITY. Aggregate base course shall be accepted for density on a lot basis. A lot will consist of one day's production where it is not expected to exceed 2400 square yards (2000 square meters). A lot will consist of one-half day's production where a day's production is expected to consist of between 2400 and 4800 square yards (2000 and 4000 square meters).

Each lot shall be divided into two equal sublots. One test shall be made for each sublot. Sampling locations will be determined by the Engineer on a random basis in accordance with statistical procedures contained in ASTM D 3665.

Each lot will be accepted for density when the field density is at least 100 percent of the maximum density of laboratory specimens prepared from samples of the material delivered to the jobsite. The specimens shall be compacted and tested in accordance with ASTM [ ]. The in-place field density shall be determined in accordance with ASTM D 1556 or D 2167. If the specified density is not attained, the entire lot shall be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached.

* *

The Engineer shall specify ASTM D 698 for areas designated for aircraft with gross weights of 60,000 pounds (27 200 kg) or less and ASTM D 1557 for areas designated for aircraft with gross weights greater than 60,000 pounds (27 200 kg).

* *

208-3.7 SURFACE TEST. After the course has been completely compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified, reshaped, recompacted, and otherwise manipulated as the Engineer may direct until the required smoothness and accuracy are obtained. The finished surface shall not vary more than 3/8 inch (9 mm) from a 16-foot (4.8 m) straightedge when applied to the surface parallel width, and at right angles to, the centerline.

208-3.8 THICKNESS. The thickness of the base course shall be determined by depth tests or cores taken at intervals in such manner that each test shall represent no more than 300 square yards (250 square meters).

When the base deficiency is more than 1/2 inch (12 mm), the Contractor shall correct such areas by scarifying, adding satisfactory base mixture, rolling, sprinkling, reshaping, and finishing in accordance with these specifications. The Contractor shall replace, at his/her expense, the base material where borings have been taken for test purposes.

208-3.9 PROTECTION. Work on the base course shall not be accomplished during freezing temperatures nor when the subgrade is wet. When the aggregates contain frozen materials or when the underlying course is frozen, the construction shall be stopped.

Hauling equipment may be routed over completed portions of the base course, provided no damage results and provided that such equipment is routed over the full width of the base course to avoid rutting or uneven compaction. However, the Engineer in charge shall have full and specific authority to stop all hauling over completed or partially completed base course when, in his/her opinion, such hauling is causing damage. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the Contractor at his/her own expense.

208-3.10 MAINTENANCE. Following the completion of the base course, the Contractor shall perform all maintenance work necessary to keep the base course in a condition satisfactory for priming. After priming, the surface shall be kept clean and free from foreign material. The base course shall be properly drained at all times. If cleaning is necessary, or if the prime coat becomes disturbed, any work or restitution necessary shall be performed at the expense of the Contractor.

Before preparations begin for the application of a surface treatment or for a surface course, the base course shall be allowed to partially dry until the average moisture content of the full depth of base is less than 80% of the optimum moisture of the base mixture. The drying shall not continue to the extent that the surface of the base becomes dusty with consequent loss of binder. If during the curing period the surface of the base dries too fast, it shall be kept moist by sprinkling until such time as the prime coat is applied as directed.

METHOD OF MEASUREMENT

208-4.1 The quantity of **[uncrushed][crushed]** aggregate base course to be paid for shall be the number of cubic yards (cubic meters) of base course material placed, bonded, and accepted in the completed base course. The quantity of base course material shall be measured in final position based upon depth test, or cores taken as directed by the Engineer, or at the rate of 1 depth test for each 300 square yards (250 square meters) of base course, or by means of average end areas on the complete work computed from elevations to the nearest 0.01 foot (3 mm). On individual depth measurements, thicknesses more than 1/2 inch (12 mm) in excess of that shown on the plans shall be considered as specified thickness plus 1/2 inch (12 mm) in computing the yardage for payment. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

208-5.1 Payment shall be made at the contract unit price per cubic yard (cubic meter) for aggregate base course. This price shall be full compensation for furnishing all materials and for all operations, hauling, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-208-5.1	**[Uncrushed][Crushed]** Aggregate Base Course—per cubic yard (cubic meter)

TESTING REQUIREMENTS

ASTM C 29	Unit Weight of Aggregate
ASTM C 117	Materials Finer than 75um (No. 200) Sieve in Mineral Aggregates by Washing

ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM D 698	Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 5.5 lb (2.49 kg) Rammer and 12-in (305 mm) Drop
ASTM D 1556	Density of Soil in Place by the Sand-Cone Method
ASTM D 1557	Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.5 kg) Rammer and 18-in (457 mm) Drop
ASTM D 2167	Density of Soil in Place by the Rubber-Ballon Method
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils

APPENDIX D

ITEM 247

FLEXIBLE BASE

247.1. Description. This Item shall govern for the delivery, stockpiling and/or the construction of foundation or base courses as herein specified and in conformity with the typical sections and to the lines and grades shown on the plans or established by the Engineer.

247.2. Materials. The flexible base material shall be crushed or uncrushed as necessary to meet the requirements herein, and shall consist of durable coarse aggregate particles and binding materials.

(1) General. When off-right-of-way sources are involved, the Contractor's attention is directed to Item 7, "Legal Relations and Responsibilities to the Public".

(2) Physical Requirements.

(a) General. All types shall meet the physical requirements for the specified grade(s) as set forth in Table 1.

Additives, such as, but not limited to, lime, cement or fly ash, shall not be used to alter the soil constants or strengths shown in Table 1, unless otherwise shown on the plans.

Unless otherwise shown on the plans, the base material shall have a minimum Bar Linear Shrinkage of 2 percent as determined by Test Method Tex-107-E, Part II.

The flexible base shall be one of the following types, as follows:

(b) Type A. Type A material shall be crushed stone produced from oversize quarried aggregate, sized by crushing and produced from a naturally occurring single source. Crushed gravel or uncrushed gravel shall not be acceptable for Type A material. No blending of sources and/or additive materials will be allowed in Type A material.

(c) Type B. Type B material shall be crushed or uncrushed gravel.

(d) Type C. Type C material shall be crushed gravel. Unless otherwise shown on the plans, crushed gravel shall have a minimum of 60 percent of the particles retained on the No. 4 sieve with two (2) or more crushed faces as determined by Test Method Tex-460-A, Part I.

(e) Type D. As shown on the plans.

TABLE 1
PHYSICAL REQUIREMENTS

GRADE 1		GRADE 2		GRADE 3	
Triaxial Class 1: Min. compressive strength, psi: 45 at 0 psi lateral pressure and 175 at 15 psi lateral pressure		Triaxial Class 1 to 2.3: Min. compressive strength, psi: 35 at 0 psi lateral pressure and 175 at 15 psi lateral pressure		Triaxial Class - Unspecified	
Master Grading		Master Grading		Master Grading	
1-3/4"	0	2-1/2"	0	2-1/2"	0
7/8"	10-35	1-3/4"	0-10	1-3/4"	0-10
3/8"	30-50	No. 4	45-75	No. 4	30-75
No. 4	45-65	No. 40	60-85	No. 40	50-85
No. 40	70-85				
Max LL	35	Max LL	40	Max LL	40
Max PI	10	Max PI	12	Max PI	12
Wet Ball Mill Max	40	Wet Ball Mill Max	45	Wet Ball Mill Max	50
Max increase in passing No. 40	20	Max increase in passing No. 40	20	Max increase in passing No.	4020

GRADE 4	GRADE 5	GRADE 6
Triaxial Class Unspecified Master Grading 1-3/4" . . . . 0 No. 4 . . . . 45-75 No. 40 . . . . 50-85 Max LL . . . . 40 Max PI 12	Triaxial Class Unspecified Master Grading 1-3/4" . . . . 0 No. 40 . . . . 50-85 Max LL . . . . 40 Max PI 12	As Shown on the Plans

Notes:

1. Gradation requirements are percent retained on square sieves.
2. When a magnesium soundness value is shown on the plans the material will be tested in accordance with Test Method Tex-411-A.
3. When lightweight aggregates are used, the wet ball mill requirements will not apply and the lightweight aggregate shall meet the Los Angeles Abrasion, Pressure Slaking and Freeze Thaw requirements of Item 303, "Aggregate for Surface Treatment (Lightweight)".

(3) Pilot Grading. When pilot grading is required on the plans, the flexible base shall not vary from the designated pilot grading of each sieve size by more than five (5) percentage points. However, the flexible base grading shall be within the master grading limits as shown in Table 1. The pilot grading may be varied by the Engineer as necessary to insure that the base material produced will meet the physical requirements shown in Table 1.

(4) Testing. Testing of flexible base materials shall be in accordance with the following Department standard laboratory test procedures:

Moisture Content	Tex-103-E
Liquid Limit	Tex-104-E
Plasticity Index	Tex-106-E
Bar Linear Shrinkage	Tex-107-E, Part II

Sieve Analysis	Tex-110-E
Moisture-Density Determination	Tex-113-E
Roadway Density	Tex-115-E
Wet Ball Mill	Tex-116-E
Triaxial Tests (Part I or II as selected by the Engineer)	Tex-117-E
Particle Count	Tex-460-A, Part I

Samples for testing the base material for triaxial class, soil constants, gradation and wet ball mill will be taken prior to the compaction operations.

(5) Tolerances. Unless otherwise shown on the plans, the limits establishing reasonably close conformity with the specified gradation and plasticity index are defined by the following:

(a) Gradation. The Engineer may accept the material, providing not more than one (1) out of the most recent five (5) consecutive gradation tests performed are outside the specified limits for master grading or pilot grading, as applicable, on any individual sieve by no more than five (5) percentage points.

(b) Plasticity Index. The Engineer may accept the material providing not more than one (1) out of the most recent five (5) consecutive plasticity index samples tested are outside the specified limit by no more than two (2) percentage points.

(6) Material Sources. The flexible base material shall be furnished by the Contractor. When a non-commercial source is utilized, it shall be opened in such manner as to immediately expose the vertical faces of all the various strata of acceptable material. Unless otherwise approved by the Engineer, the material shall be secured and processed by successive vertical cuts extending through all of the exposed strata.

Unless otherwise shown on the plans, the flexible base material shall be temporarily stockpiled prior to delivery to the roadway. Unless otherwise shown on the plans, the stockpile shall not be less than 10 feet in height and shall be made up of layers not greater than two (2) feet in thickness. After a sufficient stockpile has been constructed the Contractor may proceed with loading from the stockpile for delivery. In loading from the stockpile for delivery, the material shall be loaded by making successive vertical cuts through the entire depth of the stockpile.

When temporary stockpiles are to be tested for acceptance prior to delivery to its intended use, any stockpile that has been sampled and accepted shall not have material added or removed unless otherwise approved by the Engineer. The Contractor will be charged for additional sampling and testing required as a result of material being removed from a previously approved stockpile without the approval of the Engineer. Such charges will be deducted from the Contractor's estimates.

Blending of materials from more than one (1) source to produce Type B, C or D flexible base will be allowed when approved by the Engineer.

247.3. Construction Methods.

(1) Complete In Place

(a) Preparation of Subgrade or Existing Roadbed. Prior to delivery of the base material, the subgrade or existing roadbed shall be shaped to conform to the typical sections, shown on the plans or established by the Engineer. This work shall be done in accordance with the provision of the applicable bid items.

When shown on the plans and directed by the Engineer, the Contractor shall proof roll the roadbed in accordance with Item 216, "Rolling (Proof)". Soft spots shall be corrected as directed by the Engineer.

(b) First Course. It shall be the responsibility of the Contractor to deliver the required amount of base material to each 100 foot station. Base material shall be spread uniformly and shaped the same day as delivered. In the event inclement weather or other unforeseen circumstances render this impractical, the material shall be shaped as soon as practical.

Prior to compacting the flexible base, the flexible base material shall be bladed and shaped to conform to the typical sections as shown on the plans. All areas of segregated coarse or fine material shall be corrected or removed and replaced with well graded material, as directed by the Engineer and at the Contractor's expense.

The Contractor shall sprinkle for dust control as directed by the Engineer.

(c) **Succeeding or Finish Courses.** Construction methods shall be the same as required for the first course. Throughout this entire operation, the shape of each course shall be maintained by blading. Upon completion, the surface shall be smooth and in conformity with the typical section as shown on the plans and the established lines and grades. Prior to placing the surfacing on the completed base, the base shall be cured to the extent directed by the Engineer.

(d) **Compaction Method.** The flexible base shall be compacted by "Density Control" as shown on the plans. Water used for compaction shall conform to the material requirements of Item 204, "Sprinkling".

The flexible base shall be sprinkled as required and compacted to the extent necessary to provide not less than 100 percent density as determined by Test Method Tex-113-E, unless otherwise shown on the plans. After each section of flexible base is completed, tests as necessary will be made by the Engineer in accordance with Test Method Tex-115-E. When the material fails to meet the density requirements, or it loses the required stability, density or finish before the next course is placed or the project is completed, it shall be reworked and retested in accordance with Section 247.3.(1)(e).

(e) **Reworking a Section.** Should the base course, due to any reason or cause, lose the required stability, density or finish before the surfacing is complete, it shall be reworked, recompacted and refinished at the sole expense of the Contractor.

(f) **Tolerances.** Tolerances shall conform to the following:

(i) **Density Tolerances.** The Engineer may accept the work providing not more than one (1) out of the most recent five (5) consecutive density tests performed is below the specified density, and providing that the failing test is no more than three (3.0) pounds per cubic foot below the specified density.

(ii) **Grade Tolerances.** In areas on which surfacing is to be placed, any deviation in excess of 1/4 inch in cross section or 1/4 inch in a length of 16 feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling.

(g) **Thickness Measurement.** When the measurement is by the square yard, the flexible base will be measured for depth in units of 4000 square yards, or fraction thereof. The measurements will be at location(s) determined by the Engineer and performed in accordance with Test Method Tex-140-E. In any unit where flexible base is deficient by more than 1/2 inch in thickness, the deficiency shall be corrected by scarifying, adding material as required, reshaping, recompacting and refinishing at the Contractor's expense.

(2) **Roadway Delivery.** It shall be the responsibility of the Contractor to deliver the required amount of base material to each 100 foot station. All processing or manipulations will be in accordance with the applicable bid items.

(3) **Stockpile Delivery.** It shall be the responsibility of the Contractor to prepare the stockpile site, to provide and deliver the required amount of base material to the designated stockpile site and to construct the stockpile. Unless otherwise shown on the plans, the stockpile shall not be less than ten (10) feet in height and shall be made up of layers not to exceed two (2) feet in thickness.

247.4. **Measurement.** This Item will be measured by either Measurement Class 1, 2, 3, 4, or 5 as shown on the plans:

(1) **Measurement Class 1.** Measurement will be by the cubic yard in vehicles of uniform capacity.

(2) **Measurement Class 2.** Measurement will be by the ton of 2000 pounds dry weight in vehicles as delivered. A set of standard platform truck scales conforming to the requirements of Item 520, "Weighing and Measuring Equipment", shall be furnished by the Contractor and placed at a location approved by the Engineer. When the material is weighed during mixing or batching, reweighing will not be necessary. The dry weight will be determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The moisture in the material will be determined in accordance with Test Method Tex-103-E at least once each day and more often if conditions warrant.

(3) Measurement Class 3. Measurement will be by the cubic yard in the final stockpile position. The volume of flexible base will be computed in place between the natural ground and the top of the stockpile by the method of average end areas.

(4) Measurement Class 4. Measurement will be by the cubic yard in the completed and accepted final position. The volume of base course will be computed in place between the original subgrade or subbase surfaces, and the lines, grades and slopes of the accepted base course as shown on the plans by the method of average end areas.

Measurement Class 4 is plan quantity measurement Item and the quantity to be paid for will be that quantity shown in the proposal and on the "Estimate and Quantity" sheet of the contract plans, except as may be modified by Article 9.8. If no adjustment is required, additional measurements or calculations will not be required. No payment will be made for thickness or width exceeding that shown on the typical section or provided on the plans.

(5) Measurement Class 5. Measurement will be by the square yard of surface area in the completed and accepted position. The surface area of the base course will be based on the width of flexible base as shown on the plans.

Measurement Class 5 is a plans quantity measurement Item and the quantity to be paid for will be that quantity shown in the proposal and on the "Estimate and Quantity" sheet of the contract plans, except as may be modified by Article 9.8. If no adjustment is required, additional measurements or calculations will not be required. No payment will be made for thickness or width exceeding that shown on the typical section or provided on the plans.

247.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Flexible Base (Complete in Place)" of the type, grade and measurement class specified; for "Flexible Base (Roadway Delivery)" of the type, grade and measurement class specified; and for "Flexible Base (Stockpile Delivery)" of the type, grade and measurement class specified. This price shall be full compensation for securing and furnishing all materials, including royalty and freight involved; for furnishing scales and labor involved in weighing the material when required; for loosening, blasting, excavating, screening, crushing and temporary stockpiling when required; for loading all materials; for all hauling and delivering and for all manipulations; sprinkling; for rolling, except for proof rolling; sprinkling for dust control, for labor, tools and incidentals necessary to complete the work except as follows:

When the plans specify "Flexible Base (Complete in Place)", the unit price bid shall be full compensation for shaping and fine grading the roadbed; and for spreading, mixing, blading, compacting, shaping, finishing, and curing the base material.

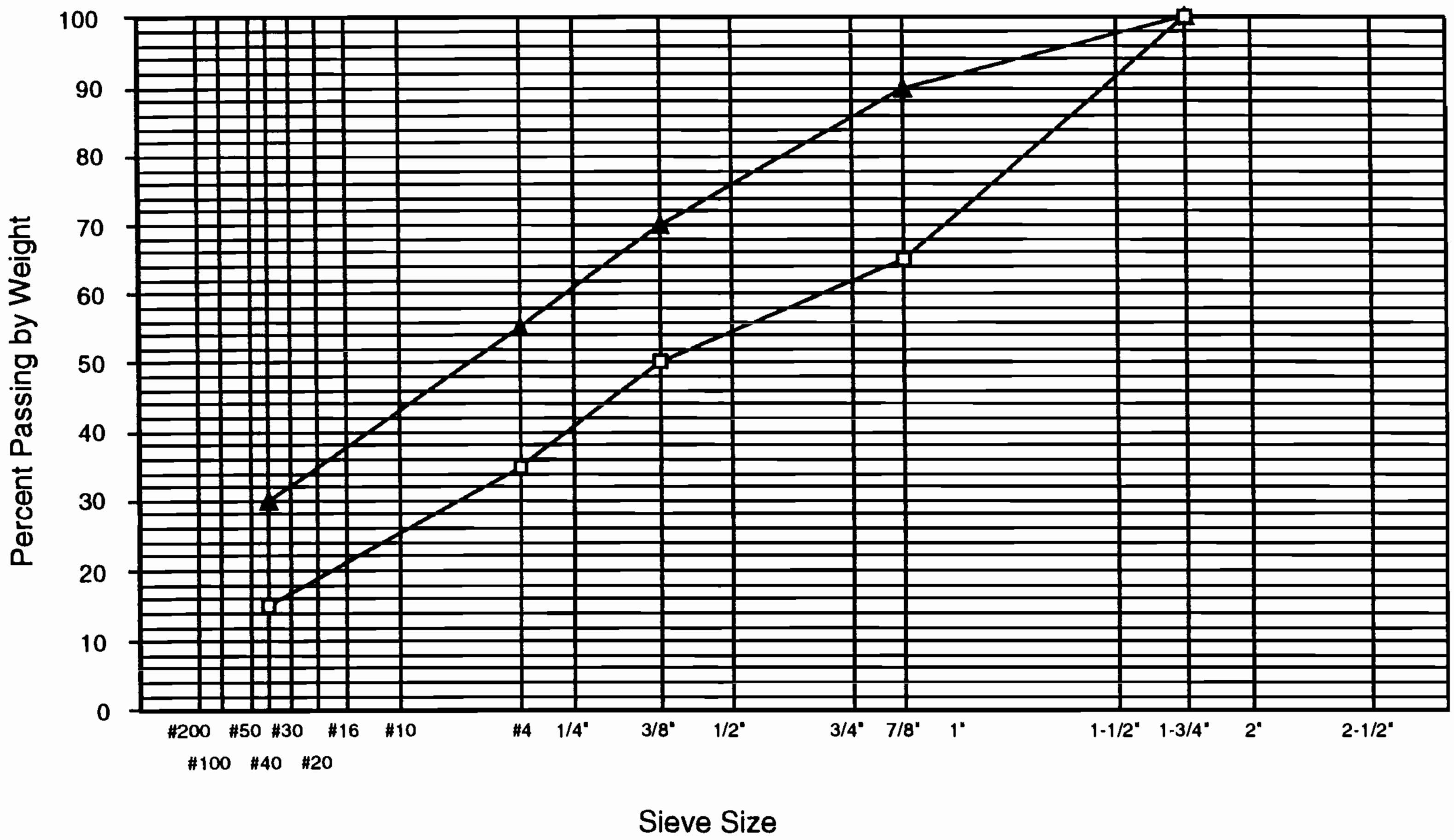
When the plans specify "Flexible Base (Roadway Delivery)", the unit price bid will not include processing at the roadway. Measurement will be only by Measurement Class 1 or 2.

When the plans specify "Flexible Base (Stockpile Delivery)", the unit price bid also will be full compensation for preparing the stockpile area and for spreading and shaping the material in the stockpile. Measurement will be only by Measurement Class 1, 2, or 3.

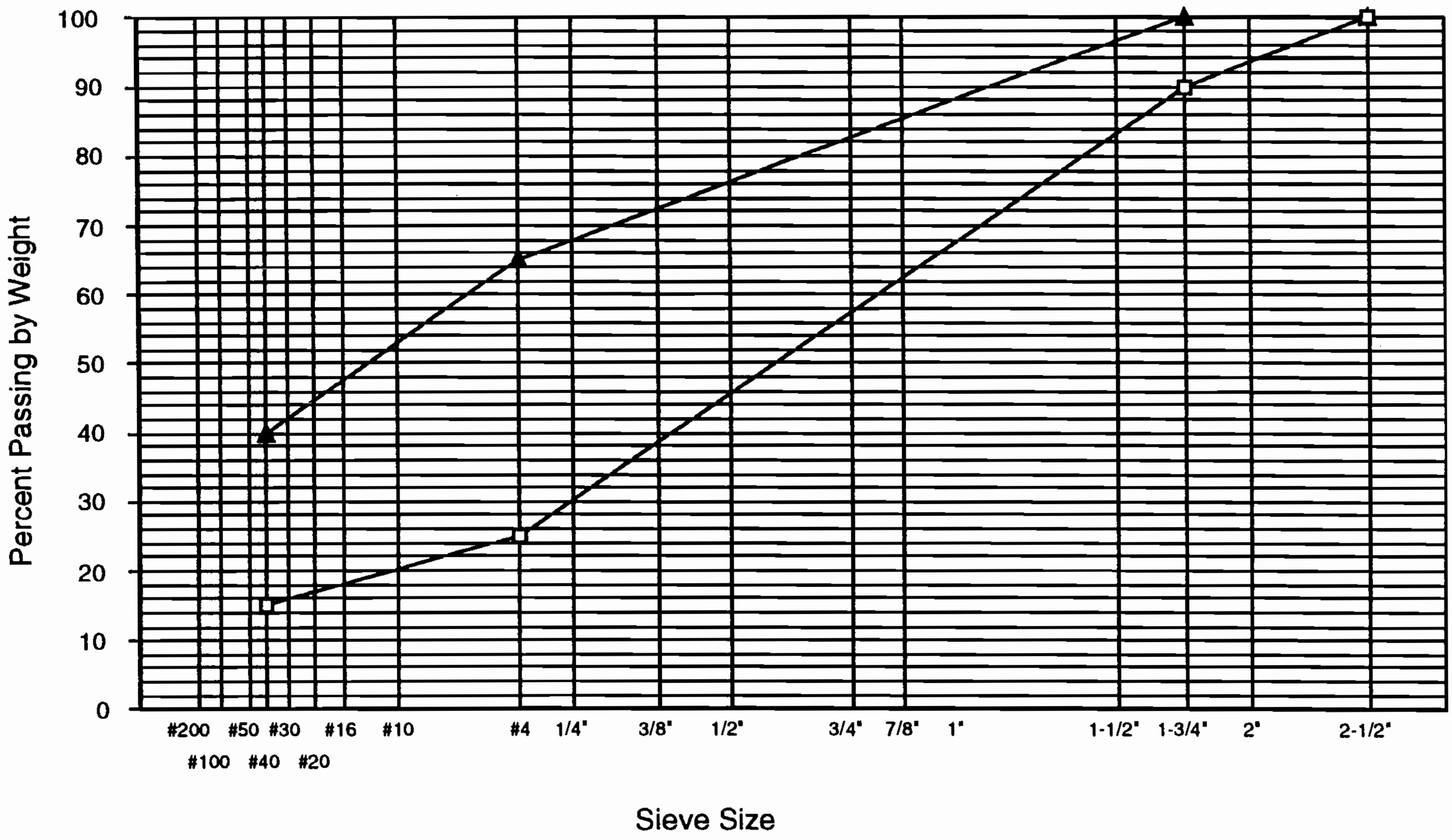
When proof rolling is shown on the plans, and when directed by the Engineer, it will be paid for in accordance with Item 216, "Rolling (Proof)".

When subgrade is constructed under this project, correction of soft spots will be at the Contractor's expense. When subgrade is not constructed under this project, correction of soft spots in the subgrade or existing roadbed will be in accordance with Article 4.3.

Item 247, Flexible Base
Grade 1



Item 247, Flexible Base
Grade 2



APPENDIX E

TEXAS TEST METHOD TEX-103-E, "DETERMINATION OF MOISTURE CONTENT IN SOIL MATERIALS"
(ASTM D 2216)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
Table 1, sample size is slightly greater. Allow use of microwave oven (proposed Part II)	Smaller sample size. Does not allow use of microwave oven. ASTM D4643 is a separate test method to determine water content using the microwave oven.	Greater sample size more accurate.	More restrictive

TEXAS TEST METHOD TEX-104-E, "DETERMINATION OF LIQUID LIMIT OF SOILS"
(ASTM D4318)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
Requires wet preparation.	Allows wet or dry preparation.	Wet preparation necessary to separate all minus No. 40 particles from the plus No. 40.	More Restrictive.
Does not allow plastic grooving tool.	Allows plastic grooving tool.	No portable measuring device to determine if the grooving tool is within tolerance. Plastic tool would require too much time spent on checking a large number of items.	More Restrictive.
Provides for a one blow method and hand method for cohesion-less soils.	Not allowed.	Allows differentiation of non-plastic soils into incremental groups. D4318 states that if the soil pat slides in the cup or if the number of blows required to close the groove is always less than 25, the sample is nonplastic, without performing the plastic limit test. Our procedure allows differentiation of nonplastic soils.	More Restrictive.

TEXAS TEST METHOD TEX-106-E, "METHOD OF CALCULATING THE PLASTICITY INDEX OF SOILS" (ASTM D4318)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
Addresses plastic and nonplastic condition.	Addresses a plastic condition. Does not test a nonplastic material.	Need to address plastic and nonplastic condition.	More restrictive.

TEXAS TEST METHOD TEX-107-E, "DETERMINATION OF SHRINKAGE FACTORS OF SOILS"
(AASHTO T92, ASTM D 427)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
<u>Part I</u>			
		Essentially the same as AASHTO/ASTM.	Equivalent.
<u>Part II</u>			
Provides a procedure to determine linear shrinkage by the bar method.	Does not provide a procedure to determine linear shrinkage by the bar method.	We need the bar linear shrinkage to test cohesionless soils when a liquid limit cannot be obtained.	

TEST METHOD TEX-110-E, "DETERMINATION OF PARTICLE SIZE ANALYSIS OF SOILS"

(AASHTO T88-90/ASTM D 422-63)

Texas Method	AASHTO/ASTM	Why Different	Effect on Results
•Materials separated on #40 sieve for test.	Materials separated on #10 sieve.	Separate soil particles larger than #40 sieve may not require much mechanical sieving after the hydrometer test.	Equivalent.
•Soak sample in dispersing agent for at least 12 hours, same as AASHTO.	ASTM required soaking of at least 16 hours.	Unknown.	Equivalent.
•Air-Tube Dispersing equipment which applies 25 psi pressure.	Air-jet Dispersing cup using 20 psi pressure.	ASTM recognizes "disbursing tube" developed by iowa State University, it's similar to Texas' Air-Tube.	Equivalent.
•Use individual correction factors KL, KG and Kn.	Use composite correction factor K.	Mathematically the same.	Equivalent.

TEXAS TEST METHOD TEX-113-E, "DETERMINATION OF MOISTURE-DENSITY RELATIONS OF SOILS AND BASE MATERIALS (AASHTO T180, AASHTO 599)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
Uses 2 inch thick layers to accommodate 1 3/4 inch particle size (6 inch dia. by 8 inch high).	Method C and D can accommodate up to 3/4 inch.	The total sample should be tested.	More accurate because our method allows the use of larger size aggregate. This test method has been used approximately 40 years with satisfactory performance.
Compactive effort of 13.26 ft. #/in^3.	Compactive effort of 29.8 ft. #/in^3 and 6.4 ft. #/in^3.		
Requires a fresh sample for each trial.	Reuses the same sample with additional moisture content for each trial.	Reusing same sample is not acceptable when the material contains aggregate.	

TEX-115-E, "FIELD METHOD FOR DETERMINATION OF IN-PLACE DENSITY OF SOIL AND BASE MATERIALS (PART I)
(AASHTO T205-86/ASTM D 2167-84)

Texas Method	AASHTO/ASTM	Why Different	Effect on Results
Does not discuss calibration procedures.	Includes calibration procedures. Recommend performing calibration check tests annually.	Equipment routinely calibrated.	Equivalent.
No requirement on the minimum test hole, volume and quantity of moisture content sample.	AASHTO and ASTM both contain requirements for minimum test hole volume. AASHTO has a minimum size of moisture content sample.	Per Tex-115-E, the entire soil mass excavated from the test hole is used for wet weight and moisture content determination.	Equivalent.

TEXAS PROCEDURE SHOULD address the MINIMUM VOL. OF Test HOLE

TEX-115-E, "FIELD METHOD FOR DETERMINATION OF IN-PLACE DENSITY OF SOIL AND BASE MATERIALS (PART II)
(AASHTO T238-86/ASTM D 2922-91)

Texas Method	AASTO/ASTM	Why Different	Effect on Results
Tolerance of standardization - Each one-minute standard count must be within $\pm 1.96 \sqrt{\text{Average Count Rate}}$.	The acceptable limits are set by $\lvert Ns-No \rvert \leq 2.0 \sqrt{No/F}$	Don't know why it differs between 1.96 and 2.0.	Equivalent.
Trench condition is not defined by a certain distance from a vertical mass.	Trench condition is defined as any vertical mass within 10 inches of the gauge.	Depends on gauge manufacturer's recommendations.	Equivalent.
Hole depth should be 2" deeper than the probe depth.	No requirement.	2" additional penetration will prevent tilting of instrument due to insufficient penetration.	Equivalent.
No requirement on air gap between the base of the gauge and soil surface.	Maximum 1/8" air gap.	Tex-115-E requires that the bottom of the gauge is firmly seated on full contact with the soil or base material.	Equivalent.

Test Method Tex-200-F, "Sieve Analysis of Fine and Coarse Aggregate"
(AASHTO T27-88, ASTM C 136-84): Dry Method
(AASHTO T11-90, ASTM C 117-87): Washed Method
No Equivalent Procedures for Volumetric Method

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
<u>Dry Method</u>: Dry sample between 100 and 300F.	Dry sample at 230±9F.	Unnecessary restriction. Limestone rock asphalt loses bitumen at 230F.	None.
Action of mechanical shaker is not specified.	Action of mechanical shaker is specified.	Unnecessary restriction.	None.
Requires that thoroughness of sieving be checked by hand. No additional aggregate should pass. No limit on size of sample.	Requires that thoroughness be determined by weighing the additional material passing a sieve in 1 minutes. Up to 0.5 percent allowed. Limits on sample sizes during test.	It is not practical to hand shake every sieve for 1 additional minute. If too large a sample is tested, the hand shake check should catch the fact that sieving is not complete.	None.
Allows up to 1 percent difference between original and final sample weights. More than 1 percent requires a new test.	Allows up to 0.3 percent difference. More than 0.3 percent disallows use as an acceptance test.	A different interpretation of what is a significant impact on test results. Our specification requirements are rounded to whole numbers. Same.	Almost Never.

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Washed Method:			
Same oven drying difference as above.	Same.	Same.	None.
Uses No. 10 sieve above the No. 200 sieve.	Uses No. 16 sieve above the No. 200 sieve.	No. 16 sieve is not common in Texas.	None.
Material is slaked for 10 minutes.	No slaking.	Allows clay to soften.	Our test method is more restrictive. Passing No. 200 may be higher.
Volumetric Method:			
200-F, Part III	No equivalent methods.	Allows rapid volumetric analysis.	

Test Method Tex-201-F, "Bulk Specific Gravity and Water Absorption of Aggregate"
(AASHTO T85-88, ASTM C 127-88)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
1,500 to 2,000 gram sample.	2,000 gram sample, minimum.	Practicality of sample handling.	None.
24-hour sample soak.	15-hour sample soak (AASHTO).	15 hours is not long enough for absorptive aggregates.	Texas method more accurate.
Half-gallon pycnometer is used.	Wire basket and bucket used for volume measurement.	Long standing difference in preference.	None known.
Water temperature is 73±2 F, or other temperatures so long as the calibration and test temperatures do not differ by more than 4F.	Water temperature is 73.4±3F.	Want to be more precise, and yet practical.	Very little.
Dry with towel and fan until sample looks like a washed and dried sample	Dry with towel and fan until all visible films of water are gone.	More description of the SSD condition is critical to test precision (See attached 1992 AAPT paper)	Texas results more accurate (heavier) and more precise.

Test Method Tex-202-F, "Apparent Specific Gravity of Material Finer than No. 80 Sieve"
(AASHTO T84-88, ASTM C128-88, ASTM D 854-83)

TEXAS METHOD	ASTM METHOD D 854	WHY DIFFERENT	EFFECT ON RESULTS
Sample passes No. 80 sieve.	Sample passes No. 4 sieve.	Different purpose for test.	None.
Sample boiled gently for 30 minutes of subjected to a partial vacuum.	Sample soaked for 12 hours, minimum.	12-hour soaking is both slow and inadequate for Passing No. 80 sieve material.	Texas results more accurate.
Allows air evacuation as above.	Allows air evacuation after soak.	Different approach.	None.

Note: Texas rejects AASHTO T84 and ASTM C 128 altogether as too inaccurate and imprecise for use in bituminous mixture design. See attached 1992 AAPT paper.

Test Method Tex-203-F, "Sand Equivalent Test"
(AASHTO T176-86 (1990), ASTM D2419-91)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Oven temperature 200 to 230 F and a minimum of 100 F for limestone rock asphalt.	230 ± 9 F.	Practicality.	None.
Pass the 3 oz. measuring can through large sample to obtain test sample. Run a pair of tests. Results must agree with 4 points.	Two different alternate methods allowed.	Unknown.	Method No. 1 and Texas Method should give same results.
Mechanical shake is for one minute.	Mechanical shake is for 45 seconds.	A one minute shake with our shaker equates best to the original handshake test results.	Unknown.
A clay reading seen within a clouded column may be read.	No discussion.	Allows for a situation that occasionally occurs.	Texas Method is more restrictive.

Test Method Tex-204-F, "Design of Bituminous Mixtures"
(AASHTO R 12-85)

AASHTO R12-85 refers to Marshall and Hveem mix design procedures. The Texas mixture design method is a unique combination of procedures that has been proven to be as effective as either the California Hveem Method or the Marshall Method.

Test Method Tex-205-F, "Laboratory Method of Mixing Bituminous Mixtures"

Neither ASTM nor AASHTO have a procedure that corresponds directly. AASHTO T246 has an abbreviated mixing procedure for use with Hveem stability testing.

Test Method Tex-206-F, "Method of Compacting Test Specimens of Bituminous Mixtures"
[ASTM D 4013-81 (1987)]

TEXAS METHOD	ASTM D4013	WHY DIFFERENT	EFFECT ON RESULTS
Specimen target height is 2 inches.	Target specimen height is not defined.	A specific height is necessary.	Probable.
Preheat mold and base plate in 250±5F oven for 15±2 minutes or a minimum of 4 hours in a 140±5F oven.	Preheat mold and base plate to 140 to 200F.	Better definition of desired heat in mold and base plate.	Higher heat in mold may cause higher specimen density.
No more than 3 minutes for filling mold with mixture.	No requirement.	For better test precision.	Cool mixture compacts less.
Includes a safety switch to keep left hand of operator away from moving parts.	No safety switch.	Safety.	None.
End point pump stroke speed is defined.	No definition.	Better precision.	Possible.

Tex-207-F "Determination of Density of Compacted Bituminous Mixtures"

(AASHTO T166-88, ASTM D2726) : Saturated Surface Dry Method
(AASHTO T275-89, ASTM D1188) : Paraffin-Coated Method
(No AASHTO Procedure, ASTM D2950) : Inplace-Nuclear Method

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Saturated Surface Dry Method and In-Place Nuclear Method	T166-88/D2726-89/ D29050-91	No significant differences.	None.
Paraffin Coated Method - Specify melting point of paraffin.	Does not specify melting point of paraffin.	Specifying melting point will affect uniformity of results and ensure purity level.	Different paraffins can give different results.
Specify method for measuring specific gravity of paraffin.	Does not give method.	Guidelines are needed on how to measure paraffin specific gravity.	Incorrect paraffin gravity can significantly affect results.

Test Method Tex-208-F, "Test for Stabilometer Value of Bituminous Mixtures"
(AASHTO T246-82, ASTM D 1560-81)

TEXAS METHOD	AASTHO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Requires specimen preparation by Texas Method Tex-206-F.	Requires kneading compaction.	Different theories.	Probable.
Requires 2.0 inch specimen height.	2.5 inch height.	2 inches is closer to actual paving depths.	Probable.
Specimen have a paper tape around circumference.	Bare specimen tested.	To protect diaphragm of stabilometer.	Very little.
Stabilometer is adjusted so that initial displacement is 0.070 to 0.080 inches.	Adjusted to 0.195 to 0.205 inches.	Our stabilometer is more sensitive in lateral pressure readings. Test is quicker and easier.	None.
Specimen is placed so that 3/16 inch of specimen is extended into the top metal ring.	Specimen is centered in diaphragm area.	California modified their procedures after some years of use.	Texas results will be higher.
Reading of lateral pressure at 5,000 pound load.	Readings at 500, 1,000, 2,000, 3,000, 4,000, 5,000 and 6,000 pounds.	Extra readings are not necessary.	None.
Stability corrected to a specimen height of 2 5/16 inches.	Stability corrected to 2 1/2 inches.	Unknown. It is believed that the original height was 2 5/16 inches.	None.

Note: The net effect of these differences is that Texas Hveem stability values are higher. This is based on AMRL reference sample test results.

Test Method Tex-210-F, "Determination of Asphalt Content of Bituminous Mixtrues by Extraction" (AASHTO T164-90, ASTM D 2172-92)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Allows non-chlorinated solvent following seperate procedures.	Only chlorinated solvent.	AASHTO/ASTM have slow revision processes.	None.
Warm and dry sample at minimum of 200°F.	Warm and dry sample at 230 plus or minus 9°F.	Texas allows cooler temperature, better for Abson recovery.	None.
Minimum sample size of 1,000g.	AASHTO min.= 500g ASTM min. = 650g Larger minimums for larger aggregate.	Standardize minimum sample size at larger size.	None.
Minimum temperature for drying aggregate and filter is 140°F.	AASHTO and ASTM temperature = 230 plus or minus 9°F	Allow lower temperature if time is not critical.	None.
Weigh ignition dish to 0.01 gram.	Weigh ignition dish to 0.001 gram.	Not practical anywhere except a research lab.	None.
Includes determination of an asphalt retention factor.	Does not have this method.	Some highly absorptive aggregates never give up all asphalt.	Texas Method more accurate.

Test Method Tex - 212 - F, "Determination of Moisture Content of Bituminous Mixtures"

(AASHTO T110-88, ASTM D 1461-85)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Condenser jacket approx. 400 mm long	Condenser not less than 400mm long	Condensor availability.	None.
Trap = 25 ml	Trap = 10 or 25 ml	Want larger trap capacity for samples with more water.	None.
Gasoline or kerosene-gasoline combination.	Aromatic solvents preferred. Xylene recommended.	We experimented with Xylene and found that Xylene is not as desirable.	Texas Method more accurate.
Gasket not moistened with water.	Gasket moistened with water.	Believe this introduces more error potential, on high side, than allowing gasket to pick up a little moisture.	Texas Method more accurate.
Allows simple oven - dry method as alternate when hydrocarbon volatiles not present.	No alternate.	Practicality.	None.

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Heat set so that condensation in lower portion of condenser tube.	Heat set so reflux- ing starts in 5 to 10 minutes and solvent drips in trap at 85 to 90 drips/minute.	Different methods of achieving same goal. Don't want to run too fast. Technician doesn't have to count drips or watch timer.	None.
Test until trapped moisture level is constant.	Test until 3 readings at 15 minute inter- vals are constant.	On occasion, end point may exceed 45 minute constant period.	No significant difference.

Test Method Tex-222-F, "Method of Sampling Bituminous Mixtures"

(AASHTO T168-90, ASTM D979-87)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Sample size not less than 10 pounds or, for truck sample, 20 pounds	Sample size of 4 to 35 pounds, dependent on size of aggregate.	Standardize size of sample. AASHTO requires only 8 to 12 pounds for most common Texas mixes.	None.
Sample from a minimum of two points when sampling from truck.	Sample from four points.	Safety.	None.

Test Method Tex-225-F, "Random Selection of Bituminous Mixture Samples"

(ASTM D 3665-92)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Uses drawing of numbers for tonnage, production time and truckload sample selections.	Uses random number table.	Based on an Asphalt Institute Method, as I recall, easier.	None
Does not sample trucks by randomly selecting a sampling quadrant.	Randomly selects a quadrant for sampling.	Want to sample entire truck to better represent production.	None

Test Method Tex-226-F, "Indirect Tensile Strength Test"

(AASHTO - T283-89, ASTM D4867-92)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Test @ 77±2F	ASTM @ 77±1.8F AASHTO @ 77F	Rounded tolerance	None
Seperate test method.	Part of moisture-induced damage test procedure.	Preference	None

Test Method Tex-227-F, "Theoretical Maximum Specific Gravity of Bituminous Mixtures"
(AASHTO T209-90, ASTM D2041-91)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Three types, sizes of vacuum containers.	AASHTO-glass or metal bowl or flask ASTM-6 container types.	Standardize within state.	None.
Thermometer with 1F accuracy.	AASHTO 0.2F ASTM 0.9F	Practicality.	None.
1,000 g minimum sample size	AASHTO-500 to 2,500g ASTM requires manometer in line during test.	Standardize. Most common Texas mixes require 1,000 or 1,500g.	None.
Does not require manometer in line during test of sample. Includes 102F boil test to check pump adequacy.	ASTM require manometer in line during test.	Not practical.	None.
Requires test and calibration temperature within 2F. No pyc calibration curve.	Allows use of calibration curve for pycnometer.	Simpler.	None.

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Residual pressure of 50mm required during test.	Residual pressure of 30mm required.	Our tests show no significant difference. Less expensive pumps allowed. Less boiling, therefore easier to see end point and less evaporative cooling of water.	Not Significant.
Pull vacuum until obvious endpoint.	AASHTO - 15±2 minutes. ASTM - 5 to 15 minutes.	Less wasted time than with AASHTO. Pulling vacuum longer than necessary may pull air out of aggregate.	None.
May take final reading right away.	Reading after 10± 1 minute.	Have not found any Texas mixes where this makes a difference. Saves time.	None.
Supplemental procedure required on mix to determine if water was absorbed.	Break large rock and visually determine if water was absorbed.	You can't find absorbed water by ASTM/AASHTO method.	Texas Method gives more accurate results.

Test Method Tex-228-F "Determination of Asphalt Content of Bituminous Mixtures by the Nuclear Method"

(No AASHTO Method, ASTM D4125-92)

TEXAS METHOD	AASHTO/ASTM METHOD	WHY DIFFERENT	EFFECT ON RESULTS
Load pans in 2 layers.	Load pans in 3 layers.	Not recommended by gauge manufacturer	None known
Determine "base" wt. using mixture	Determine base wt. using dry aggregate	Not recommended by gauge manufacturer	None
Spade 20-30 times around perimeter with trowel or spatula.	Drop pan 2 or 3 from height of 20-50 mm to reduce voids	Texas method is more efficient at reducing void around perimeter	None known
Sample weight must be within plus or minus 1.0 gram of "base" wt.	Sample must be within plus or minus 10 grams of "base" ie dry aggregate weight	To reduce testing error	Improved accuracy

TEXAS TEST METHOD TEX-400-A, "METHOD OF SAMPLING STONE, GRAVEL AND MINERAL AGGREGATES" (AASHTO T2)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
Sample size is reduced (50% or more). Sampling procedures not clearly defined, i.e. sampling from hot bins, etc.	Larger sample size does not cover all situations.	To sample smaller samples and to cover situations not in AASHTO.	Less restrictive on sample size.

TEST METHOD TEX-411-A, "SOUNDNESS OF AGGREGATE BY USE OF SODIUM SULFATE OR MAGNESIUM SULFATE"

(AASHTO T104/ASTM C 88)

Texas Method	AASHTO/ASTM	Why Different	Effect on Results
Test solution prepared about 130°F.	Test solution prepared at 77 to 86°F.	Salt is dissolved better at higher temperature.	Equivalent.
Provides for alternate method to remove sulfate salt when barium chloride indicates presence of salt in clear tap water.	Requires use of barium chloride to determine sulfate presence.	Austin tap water shows presence of sulfate.	Equivalent.
Final sieve for fine aggregate is by hand.	Final sieve for fine aggregate same as used in preparation.	To minimize particle degradation by machine.	Less restrictive.
Obtain specific gravity of solution prior to stirring solution.	Obtain specific gravity of solution after stirring solution.	When obtaining specicfic gravity of solution before stirring, there are no particles in suspension.	More restrictive.
Allowable temperature of solution is 68-75°F.	Allowable temperature of solution is 70±2°F.	When specific gravity is in spec, tight temperature is not critical.	Equivalent when specific gravity is same.

(AASHTO T104/ASTM C 88)

TEXAS METHOD	AASHTO/ASTM	WHY DIFFERENT	EFFECT ON RESULTS
For HMAC/Surface Treatment, the smallest size tested is on No. 8 sieve.	When coarse aggregate has less than 10% - No. 4, assume - No. 4 has same loss as 3/8 - No. 4.	AASHTO/ASTM is written around concrete aggregates. Texas expands to include bituminous aggregates.	More restrictive.
Requires any size that has 5% or more to be tested.	Allows up to 10% + 3/8 Fine aggregate and up to 10% - No. 4 Coarse aggregate not to be tested and assume same loss as adjacent size.	AASHTO/ASTM is written around concrete aggregates. Texas expands to include bituminous aggregates.	More restrictive.

TEST METHOD TEX-438-A, "ACCELERATED POLISH TEST FOR COARSE AGGREGATE"

(AASHTO T 279/T 278; ASTM D3319/E303)

Texas Method	AASHTO/ASTM	Why Different	Effect on Results
Slider rubber Type A shore durometer 71±3.	Slider rubber Type A shore durometer 58±2.	Our 20 year historical data base is using 71±3.	Texas method produces lower test values.
Test 7 specimens.	Test 5 specimens.	The wheel holds 14 specimens.	7 specimens produce better quality statistical results.
Initial friction not required.	Specify initial friction.	Not needed.	Not used.
Provides differential wear procedure.	Does not have differential wear procedure.	Unknown.	Not equivalent.

APPENDIX F

Texas Department of Transportation

Division of Materials and Tests

BALL MILL METHOD FOR DETERMINATION OF THE DISINTEGRATION OF FLEXIBLE BASE MATERIAL

Scope

This test method describes a procedure for determining the resistance of the aggregate in flexible base material to disintegration in the presence of water. The test provides a measure of the ability of the material to withstand degradation in the road base and detects soft aggregate which is subject to weathering. This test is known as the Wet Ball Mill (W.B.M.) value.

Apparatus

1. Wet Ball Mill: The machine consists of a watertight steel cylinder, closed at one end, having inside dimensions of 10 3/16 ± 1/8 inches in diameter and 10 3/4 ± 1/8 inches in length. The cylinder is fitted with a removable lid with watertight gasket attached. The cylinder is mounted in a rigid support in such a manner that it is rotated about the central axis in a horizontal position. A steel baffle, projecting radially 3 1/4 ± 1/8 inches into the cylinder and 10 3/4 ± 1/8 inches in length, is welded along one element of the interior surface of the cylinder. The baffle shall be of such thickness and so mounted as to be rigid. The machine should be operated at a uniform speed of 58-62 rpm.

2. Metallic Spheres: The abrasive charge consists of six (6) steel spheres approximately 1-7/8 inches in diameter, weighing between 390 and 445 grams.

3. A balance with a minimum capacity of 15 Kg with a readability of no greater than 1 g and accuracy of at least 0.5 grams.

4. A set of Standard U.S. Sieves containing the following sizes: 1-3/4", 1-1/4", 7/8", 5/8", 3/8", No. 4, No. 10 and No. 40 which meet the requirements of Test Method Tex-907-K.

5. Oven, an air-dryer with temperature set to 140 ± 9°F.

6. Crusher.

7. Miscellaneous equipment includes large pans, wash bottles, etc.

Test Record Form

Each sample shall be given an identification number and a card bearing the number should be placed with each portion of the sample throughout the processing and testing of the material.

PART I
DETERMINATION OF DISINTEGRATION

Procedure

1. Secure a representative sample of the total material, approximately 12,000 grams.

2. Air dry the sample at 140°F.

3. Prepare sample according to Tex-101-E, Part II.

4. Recombine a 5000 gram sample for soil constants testing as shown in the governing specifications if needed.

5. Replace oversize particles retained on the 1-3/4 inch sieve with particles passing the 1-3/4 and retained on the 1-1/4 inch sieve.

6. Recombine a 3500 gram (± 50 grams) of air dried sample, weigh and record to the nearest whole gram. Place sample in pan and cover with water for one hour (one-half gallon is usually sufficient).

   Note: Use the dry sieve analysis as a rough check for specification compliance for grading prior to testing for soil constants and Wet Ball Mill.

7. Decant all free water from sample into a one-half gallon container, finish filling container with clear water and use to wash sample into the mill.

8. Place the six steel spheres in the mill, fasten the watertight lid securely and rotate 600 revolutions at the uniform speed of 58-62 rpm.

9. When the 600 revolutions are completed, remove the cover and carefully empty the cylinder contents into a pan.

10. Remove the steel spheres and separate the sample by washing over the No. 40 sieve.

11. Dry the aggregate portion retained on the No. 40 sieve to a constant weight at 140°F. Rescreen over the No. 40 sieve and weigh to the nearest whole gram. Additional sieves may be utilized here to determine particle size degradation due to the test.

Calculations

Calculate the percentage of the soil binder from the Wet Ball Mill test as follows:

$$\text{Wet Ball Mill Value} = \frac{A - B}{A} \times 100$$

Where:

A = dry weight of total sample (Step 6)

B = weight of retained material (Step 11)

PART II
DETERMINATION OF INCREASE OF MINUS NO. 40

If required, the increase in the percent of Minus No. 40 material should be determined as follows:

1. Secure approximately 3000 grams of the original prepared sample from Step 3, Part I by recombining.
2. Weigh to the nearest whole gram and record the weight as C.
3. Wash the sample over a No. 40 sieve.
4. Dry the aggregate portion retained on the No. 40 sieve to a constant weight at 140°F. Rescreen over the No. 40 sieve and weigh to the nearest whole gram. Record the weight as D.

Calculations

Calculate the original percentage of Minus No. 40 material as follows:

$$\text{Original \% Minus No. 40} = \frac{C - D}{C} \times 100$$

% increase Minus No. 40 = W.B.M. Value - Original % Minus No. 40

Reporting Test Results

Report to the nearest whole percent.

Precautions

1. Always use dry material in performing test.

2. Avoid the loss of portions of sample in transferring into or out of cylinder.

3. Use only 1/2 gallon of water in cylinder with wet sample from which free water has been decanted.

4. Check weight of steel spheres periodically for loss due to wear.

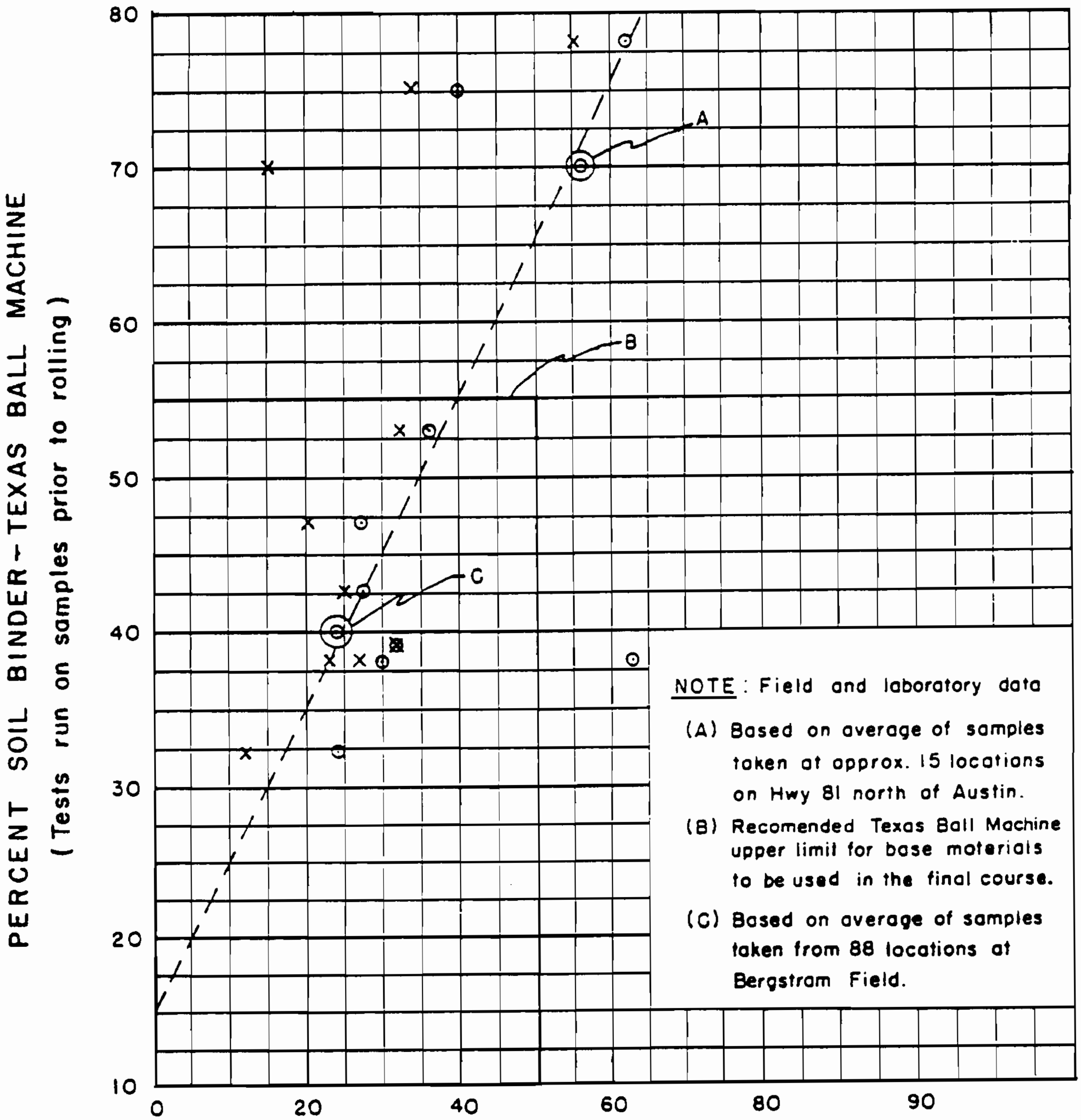
Reporting Test Results

Report the Wet Ball Mill value to the nearest whole number.

Notes

This test furnishes valuable supplementary data pertaining to the quality of the aggregate portion of flexible base material. The Wet Ball Mill test is more reliable than the Los Angeles abrasion test in evaluating the quality of base materials.

RELATION BETWEEN PERCENT SOIL BINDER FROM TEXAS BALL MACHINE AND PERCENT SOIL BINDERS BEFORE AND AFTER ROLLING



PERCENT SOIL BINDER

× = Before Rolling
⊙ = After Rolling

Figure 1

State Department of Highways and Public Transportation

Materials and Tests Division

TRIAXIAL COMPRESSION TESTS FOR DISTURBED SOILS AND BASE MATERIALS

Scope

This method of procedure provides for the determination of the shearing resistance, water absorption and expansion of soils or soil aggregate mixtures. The test consists of applying an axial load to cylindrical specimens of definite dimensions, supported by various known lateral pressures until failure occurs. The test method is applied in Part I to laboratory compacted specimens of disturbed soil or material containing aggregate with the largest size particle passing the 1-3/4 inch sieve. Part II describes an accelerated procedure which has been carefully correlated with the standard method of Part I. It is intended to use the accelerated method to control the quality of materials with low absorption during construction.

Definitions

1. Triaxial Test: A test in which force is applied in three mutually perpendicular directions.

2. Axial Load: This force is the sum of the applied load and dead load which includes the weight of the top porous stone, metal block and bell housing and is applied along the vertical axis of the test specimen.

3. Lateral Pressure: The force supplied by air in the cell and is applied in a radial or horizontal direction.

4. Unit Stress: This term is defined as the axial load divided by the end area of the cylindrical specimen.

5. Strain: Strain is unit deformation and is equal to deformation of specimen divided by the original height often expressed as a percentage.

6. Mohr's Diagram: A graphical construction used in analyzing data from tests on bodies acted on by combined forces in static equilibrium which shows more information as to physical properties of the material than other methods in common use.

7. Mohr's circle of failure: A stress circle constructed from principal stresses acting on the specimen at failure.

8. Mohr's envelope of failure: The envelope of failure is the common tangent to a series of failure circles constructed from different pairs of principal stresses required to fail the material. The envelope is generally curved, its curvature depending on the factors related to the characteristics of the material.

Apparatus

1. Apparatus used in Test Methods Tex-101-E and Tex-113-E.

2. Axial Cells, lightweight stainless steel cylinders; 6-3/4 inches inside diameter and 12 inches in height, fitted with standard air valve and tubular rubber membrane 6 inches in diameter (Figure 1).

3. Aspirator or other vacuum pump.

4. Air Compressor.

5. Damp room or moist cabinet equipped with shelves and regulated air pressure.

6. Screw jack press and assembly (Figure 3).

7. Pressure regulator, gauges and valves.

8. Micrometer dial gauge, calibrated in 0.001 inch, with support to measure deflection of specimen.

9. Dial housing and loading block to transmit load to cylindrical specimen.

10. Ring dynamometer which has been calibrated in accordance with Test Method Tex-902-K.

11. Circumference measuring device, special made metal tape measure (Figure 5).

12. Lead weights for surcharge loads.

13. Rectangular stainless steel pans 9 × 16 × 2-1/4 inches deep equipped with porous plates.

Test Record Forms

Record test data on Form No. 1062, Figure 10, M/D and Triaxial Test Work Sheets, Figure 9, and Triaxial Compression Test Capillary Wetting Data, Figure 8. After test and calculations are completed, summarize results on Triaxial Test Summary Sheet, Figure 15.

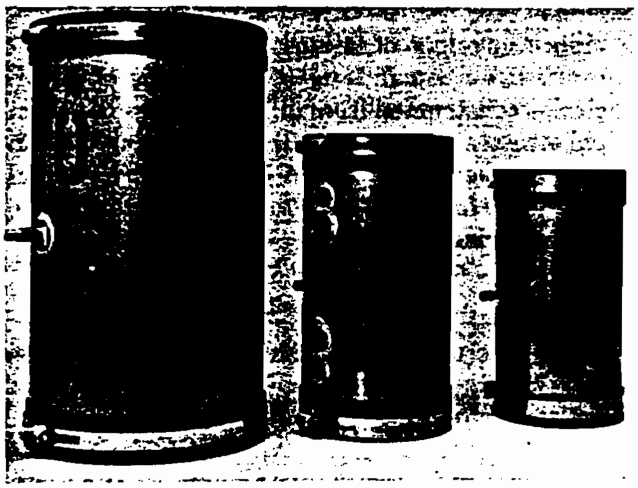


Figure 1
Axial Cells of Various Sizes

Figure 2
Capillary Wetting of Triaxial Specimens

Preparation of Sample

Prepare approximately 200 pounds of material according to the procedure given in Part II of Test Method Tex-101-E. See General Notes.

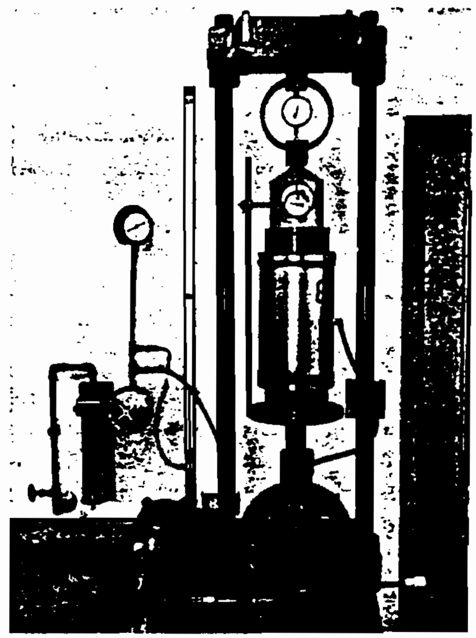


Figure 3
Press Assembly with Specimen in Place

PART I
STANDARD TRIAXIAL COMPRESSION TEST

Procedure

A. Determining Moisture-Density Relations

Determine the optimum moisture and maximum density as outlined in Test Method Tex-113-E, using the compactive effort specified for the type of material being tested.

B. Compaction of Test Specimens

1. Follow Steps 1 through 12 under procedure of Test Method Tex-113-E and mold at optimum moisture a total seven specimens, including the specimen from the peak of the M-D Curve for all materials containing aggregates (base and subbase materials). For fine grain soils or those containing small amounts of aggregates, mold a total of six specimens at optimum moisture and density conditions. These specimens should be six inches in diameter and 8 inches in height to the nearest 1/4 pound of dry material. These test specimens should be wet, mixed, molded and finished as nearly identical as possible. Identify each test specimen by laboratory number and specimen number.

2. Immediately after extruding the specimen from the mold, enclose the specimen in a tri-

axial cell, with top and bottom porous stones in place and allow all the specimens to remain undisturbed at room temperature until the entire set of test specimens has been molded. Record data on M-D and Triaxial Work Sheet shown in Figure 9.

Notes: When a different compactive effort is desired, a complete new M-D Curve and test specimens must be molded.

C. Curing Test Specimens

After the entire test set has been completed, remove the triaxial cells and dry cure the specimens according to the type of material. To avoid excessive cracking which will damage the specimen the dry curing is accomplished as follows:

1. For flexible base materials and select granular soils with little or no tendency to shrink, place specimens in the oven air dryer and remove 1/3 to 1/2 of the molding moisture content at a temperature of 140°F. (This will require 3 to 6 hours depending on the material, the optimum moisture content and the load of other wet material in the oven.) Allow the specimens to return to room temperature before preparation for and subjection to capillarity.

2. Very plastic clay subgrade soils subject to large volume change crack badly while shrinking. Air dry these soils at room temperature inspecting the specimens frequently by looking at the sides of the specimens and raising the top porous stones to examine the extent of cracking at the top edges of the specimens. When these cracks have formed to a depth of approximately 1/4 inch, replace the triaxial cell and prepare the specimens for capillary wetting.

3. For moderately active soils that might crack badly if placed in an air dryer for full curing time, dry at 140°F and check frequently for the appearance of shrinkage cracks. If cracks appear, examine the extent of cracking as described under Step 2, and allow some air drying at room temperature during the cooling period before enclosing specimens in cells.

D. Subjecting Test Specimens to Capillary Absorption

1. The specimens are now ready to be prepared for capillary wetting. Do not change the porous stones or remove them until the specimens have been tested. Weigh each specimen and its accompanying stones and record weight. Cut a piece of filter paper 10 in. by 20 in. fold to 5 in. by 20 in. and make several cuts with scissors (Jack-o-lantern fashion). These cuts will prevent any restriction by the paper. Wrap the filter paper around the specimen and stones, allowing the bottom of the paper to be near the bottom of the bottom porous stone, and fasten with a piece of tape. Replace cell by applying a partial vacuum to the cell, deflating the rubber membrane, then place the cell over the specimen and release the vacuum.

2. Transfer the specimens to the damp room and place them into the rectangular pans provided for capillary wetting shown in picture of damp room, Figure 2. Adjust the water level on the lower porous stones to approximately 1/2 inch below the bottom of the specimens. Add water later to the pans, as necessary, to maintain this level. Note schematic arrangement, Figure 4.

3. Connect each cell to the air manifold and open valve to apply a constant lateral pressure of 1 psi. Maintain this constant pressure throughout the period of absorption.

4. Next, place a suitable vertical surcharge load (which will depend upon the proposed use or location of the material in the roadway) on the top porous stone. For flexible base use 1/2 pound per square inch and for subgrade soils use 1 pound per square inch of end area of the specimen. Consider the weight of the top porous stone as part of the surcharge weight, Figure 4.

5. Subject all flexible base materials and soils with plasticity index of 15 or less to capillary absorption for 10 days. Use a period of time in days equal to the plasticity index of the material for subgrade soils with PI above 15. Keep the specimens in the damp room, equipped with spray system, during the period of capillary absorption.

E. Preparing Specimens for Testing

1. Disconnect air hose from cell, remove surcharge weight and return specimens to labo-

ratory for testing. Use a vacuum and deflate the rubber membrane to aid in removing the cell from specimens and discard filter paper. If any appreciable material clings to paper, carefully press it back into the available holes along the side of the specimen.

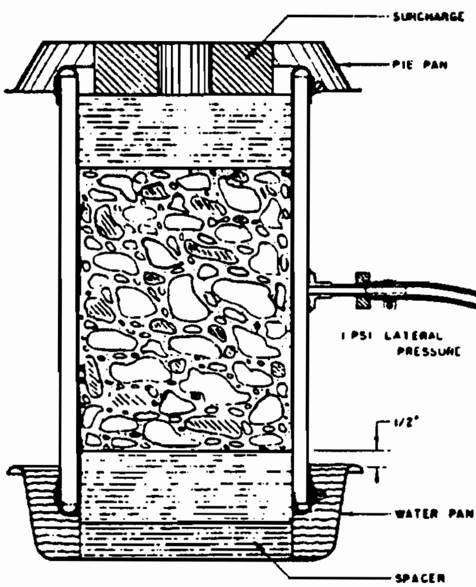


Figure 4
Schematic Arrangement for Capillary Wetting

2. Weigh the specimens and record as total weight after capillary absorption. Note that the wet weight of stones is obtained after the specimens are tested. Record on Figure 8.

3. Measure the circumference of each specimen by means of the metal measuring tape. Measure the height of the specimen including the stones, and enter on data sheet as height over stones. Also record the height of each stone (Figures 5 and 6).

4. Replace the axial cell on the specimen, release the vacuum, and the specimen is ready to be tested. The cell is replaced to eliminate any moisture loss of the specimen waiting to be tested. When a specimen is designated to be tested at zero lateral pressure, the cell is removed just before testing. It is important to keep the proper identification on the specimens at all times because weights, measurements, test values and calculations are determined for each individual specimen.

F. Testing Specimens

In brief, the specimens are tested in compression while being subjected to their assigned constant lateral pressure. The motorized press is geared to travel at the rate of 0.135 inches per minute plus or minus 0.015 inches per minute. Simultaneous readings of load and deformation are taken at intervals of 0.02 inch deformation until specimen fails, Figure 7.

1. Disengage the worm gear drive and crank the press down far enough to have room to place specimen, metal loading blocks and the special bell dial housing in the press.

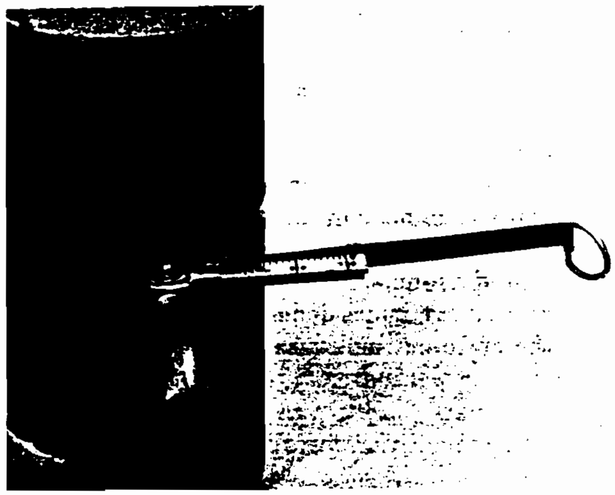


Figure 5
Circumference Measuring Device

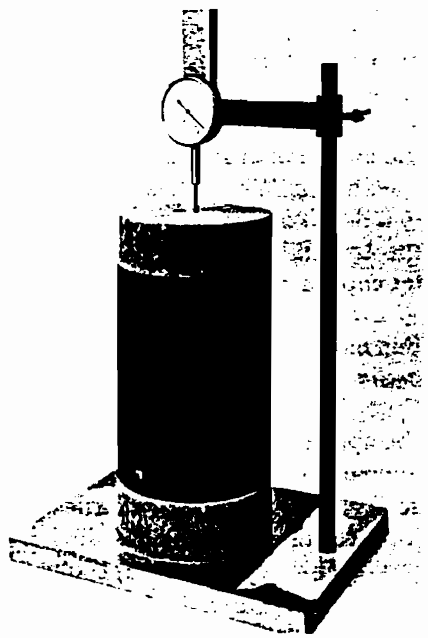


Figure 6
Measuring Overall Height of Specimen and Stones

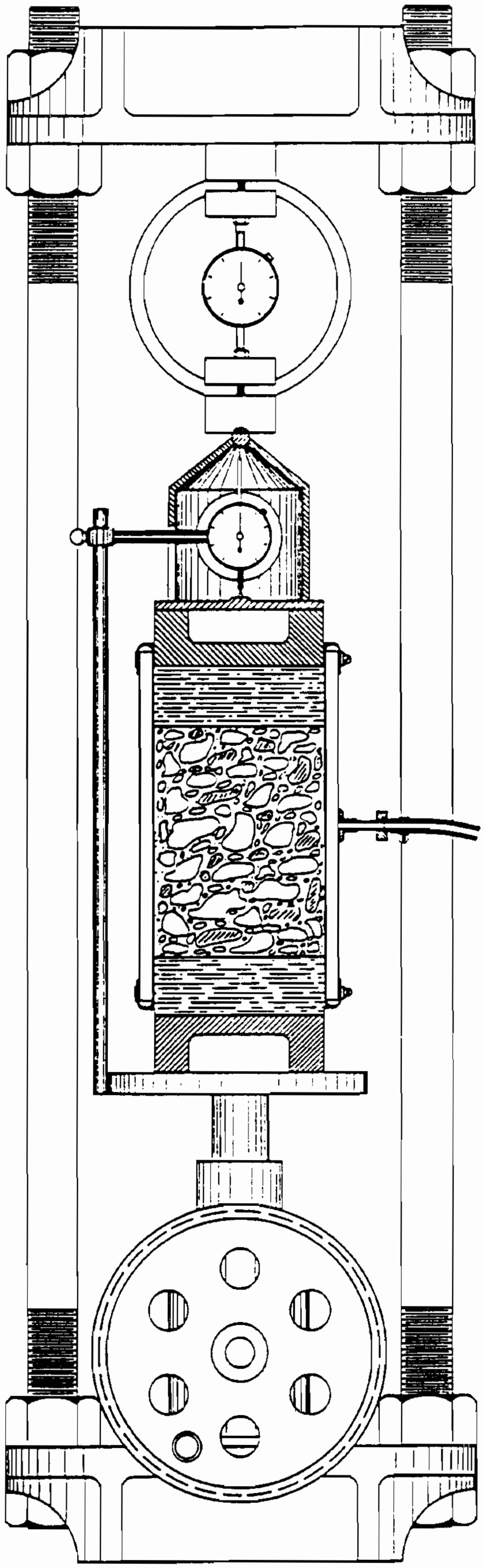


Figure 7a

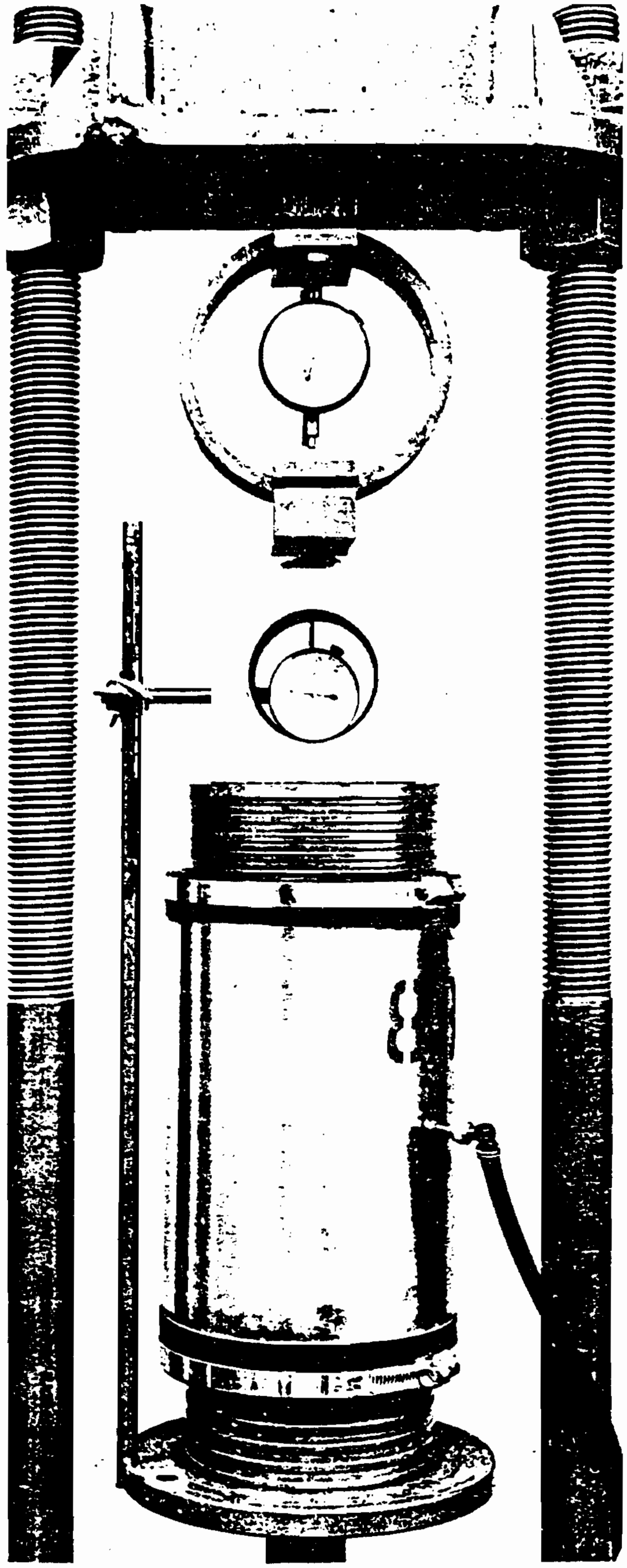


Figure 7b

Press Assembly for Triaxial Test

2. Center the specimen with upper and lower metal loading blocks in place in the press. Adjust the deformation gauge in such a manner that it will be down against the center of the top spacer block and also compressed for almost the length of travel of the stem. The gauge must be placed in this position since the specimen moves away from the gauge during the compression. Set the dial of the strain gauge to read zero.

3. Next, set the bell housing over the deformation gauge and adjust so that it does not touch the gauge or its mounting. At this point it should be noted that the compressive stress will necessarily be applied along a vertical line through the center of the ball that is mounted in the top of the bell housing. Since it is desirable to apply the compressive force along the vertical axis of the test specimen, shift the bell housing laterally to bring the ball directly over the axis of the specimen. Raise the press by means of the motor, align and seat the ball on the bell housing into the socket in the proving ring. Then apply just enough pressure to obtain a perceptible reading on the proving ring gauge. Read the deformation gauge and record as deformation under dead load.

4. Connect the air line to the axial cell and apply lateral pressure to the specimen. The usual lateral pressures used for a series of tests are 0,3,5,10,15 and 20 psi. In cases where the load or stress is high (175-180 psi) for the specimen tested at 15 psi lateral pressure, use 7 psi instead of 20 psi for the last specimen. The lateral pressure applied by the air will tend to change the initial reading of the gauge. As the air pressure is adjusted, start the motor momentarily to compress the specimen until the deformation gauge reads the same as recorded in Step 3. Read the proving ring gauge and enter in load column opposite the initial deformation reading (Figure 10).

5. The test is ready to be started. Turn on the motor and read the proving ring dial at each 0.02 inch deformation of the specimen. Continue readings until 0.60 inch of deformation has occurred unless failure occurs earlier. Failure is reached when the proving ring dial readings remain constant or decrease with further increments of deformation. In testing specimens with aggregates, the slipping and shearing of aggregates will cause temporary decreases in proving ring readings. The test should be continued until true failure is reached. After 0.60 inch of deformation the cross sectional area of the specimen has increased so that the subsequent small increase in load readings is little more than the increase in tension of the membrane acting as lateral pressure.

6. All of the above procedure applies to the unconfined specimen except that no air or axial cell is used. For materials which contain a large amount of aggregate, compact and test two specimens at zero lateral pressure. Use average of test results unless large rocks appear to have created point bearing; in this care use highest value.

G. Obtaining Dry Weight of Specimens and Stones.

1. The specimen and stones are removed from the cell over a flat tared drying pan. Use a spatula to clean the material from the inside of cell and stones. Break up the specimen taking care to lose none of the material and place the identification tag in the tray.

2. Dry the material to constant weight at a temperature of 230°F and determine the dry weight.

3. The damp stones are weighed, dried at 140°F and the dry weight obtained. This weight completes the test procedure.

Calculations

1. Volume of compacted specimen = volume per inch of mold × height of specimen.

2. Calculate dry density of specimen as follows:

$$\text{Dry Density} = \frac{\text{Dry weight of specimen in pounds}}{\text{Volume of specimen in cu. ft.}}$$

3. Molding moisture =

$$\frac{\text{Weight of specimen wet} - \text{weight of specimen dry}}{\text{weight of specimen dry}} \times 100$$

4. Calculate the percentage of volumetric swell by the expression:

$$V_S = \frac{V_A - V_M}{V_M} \times 100$$

Where:

V_S = Percentage volumetric swell
V_A = Volume of specimen after capillary absorption
V_M = Volume of specimen as molded

5. Calculate the moisture before and after capillarity as follows:

Where:

M_C = Percent moisture in specimen after capillarity
M_B = Percent moisture in specimen before capillarity

$$M_C = \frac{W_A - W_B - W_D}{W_D} \times 100$$

$$M_B = \frac{W_C - W_S - W_D}{W_D} \times 100$$

W_A = Wet weight of specimen and stones after absorption
W_B = Wet weight of stones
W_C = Weight of specimen and stones before capillarity
W_D = Correct oven-dry weight of specimen
W_S = Dry weight of stones

6. Calculate the values of stress and strain for each individual specimen from the following relations:

$$S = \frac{d}{h} \times 100$$

Where:

S = Percent strain
d = Total vertical deformation at the given instant, measured in inches by deformation gauge.
h = The height of the specimen in inches, measured after specimen is removed from capillarity.

$$p = \frac{P}{A}\left(1 - \frac{S}{100}\right)$$

Where:

p = The corrected vertical unit stress in pounds per square inch

A correction is necessary because the area of the cross-section increases as the specimen is reduced in height. The assumption is made that the specimen deforms at constant volume.

P = The total vertical load on the specimen at any given deformation expressed in pounds. It is the sum of the applied load measured by the proving ring plus the dead weight of the upper stone, loading block and dial housing.

A = The end area of cylindrical specimen expressed in square inches at the beginning of test.

Graphs and Diagrams

1. Plot the moisture-density curve shown in Figure 8 of Test Method Tex-113-E.

2. Plot the stress-strain diagram as shown in Figure 12 when requested.

3. The Mohr's diagram of stress (Figure 13) is constructed upon coordinate axes in which ordinates represent shear stress and abscissas represent normal stress, both expressed as pounds per square inch to the same scale.

   L = Minor principal stress which is the constant lateral pressure applied to the specimen during an individual test.

   V = The major principal stress which is the ultimate compressive strength or the highest value of p determined at the given lateral pressure.

   Each individual test will be shown by one stress circle drawn as follows:

Plot L and V on the base line of normal stress. Locate the center of each circle a distance of (V + L)/2 from the origin and construct a semi-circle with its radius equal to (V - L)/2 intersecting the base line at V and L. Repeat these steps for each specimen tested at different lateral pressures to provide enough stress circles to define the failure envelope on the Mohr's diagram.

Draw the failure envelope tangent to all of the stress circles. Since it is practically impossible to avoid compacting an occasional specimen that is not identical with the other specimens in the same set, disregard any stress circle that is obviously out of line when drawing the tangent line.

TRIAXIAL COMPRESSION TEST CAPILLARY WETTING DATA

LAB NO. ______________________

Sample No.												
Cell No.												
Lbs. of Added Surcharge												
Date Molded												
Date in Air Dryer												
Date in Capillarity												
Date out Capillarity												
Height in Capillarity												
Height out Capillarity												
Weight after Air Dry												
Dry Weight Stones												
Dry Weight Sample												
Weight Moisture in Sample												
% Moisture to Capillarity												
Weight after Capillarity												
Wet Weight Stones												
Wet Weight Sample												
Dry Weight Sample												
Weight Moisture in Sample												
% Moisture after Capillarity												
Remarks:												

Figure 8

M/D & TRIAXIAL WORK SHEET

LAB NO. ____________________

__________% HYGRO ALLOWED

Date Molded												
Sample No.												
Compactive Effort												
Total % Water												
Pounds Material												
Pounds Water Desired												
Pounds Hygroscopic Water												
Pounds Water Added												
Tare Weight of Jar												
Weight Jar and Water												
Mold No.												
Wet Wt. Specimen & Mold												
Tare Weight Mold												
Wet Wt. Specimen												
Height of Mold												
Dial Reference												
Dial Reading												
Height Specimen												
Vol. per Linear inch												
Vol. of Specimen												
Wet Density Specimen												
Dry Weight Pan & Specimen												
Tare Weight Pan												
Dry Weight Material												
Weight Water												
Percent Water on Total												
Dry Density												
Guestimated Dry Density												

Figure 9

Form 1082 TRIAXIAL TEST DATA SHEET

Lab. No.__________ Area__________ Circumference__________ Ht./Stones__________
Specimen No._______ l/A__________ Avg. Dia.__________ Stones_______ & _____
Lat.Pressure_______ *______/A______ Strain Rate = .15"/min. New Height
Date Molded_______ ______ft. lbs./cu. in. Compaction
Date Tested_______ Initial Vol.______ Final Vol.__________ % Vol. Swell________
No. Days in Cap._____
*Ring Factor_______
Dead Load______ Lbs.
DL/A__________ Psi Strain = $\frac{.01}{\text{New Ht.}}$ = .01 = ________________

Deformation	Load	Uncorr'd Stress	I-Strain	% Strain	Corrected Stress	Deformation	Load	Uncorr'd Stress	I-Strain	% Strain	Corrected Stress
.01						.31					
.02						.32					
.03						.33					
.04						.34					
.05						.35					
.06						.36					
.07						.37					
.08						.38					
.09						.39					
.10						.40					
.11						.41					
.12						.42					
.13						.43					
.14						.44					
.15						.45					
.16						.46					
.17						.47					
.18						.48					
.19						.49					
.20						.50					
.21						.51					
.22						.52					
.23						.53					
.24						.54					
.25						.55					
.26						.56					
.27						.57					
.28						.58					
.29						.59					
.30						.60					

Figure 10

Classification of Material

Transfer the envelope of failure onto the chart for classification of subgrade and flexible base materials (Figure 14) and classify the material to the nearest one-tenth of a class. When the envelope of failure falls between class limits, select the critical point or weakest condition on the failure envelope. Measure the vertical distance down from a boundary line to the point to obtain the exact classification (3.7) as shown in Figure 14.

Reporting Test Results

Report the soil constants, grading and Wet Ball Mill Value for the aggregate on Form 476-A. Summarize test results on Triaxial Test Summary Sheet, Figure 15, and strength classification plotted as given in Figure 14.

PART II
ACCELERATED METHOD FOR TRIAXIAL COMPRESSION OF SOILS

This accelerated procedure is based on a correlation with the standard method for Triaxial Compression Test, Part I, performed on a large number of different types of soils. Generally it is intended to use the accelerated test to control the quality of base materials with low absorption in group (d) during stockpiling and in such cases roadway samples will not necessarily be considered to be representative.

Procedure

1. Prepare all materials in accordance with Test Method Tex-101-E, Part II.

2. Determine the optimum moisture and maximum density as outlined in Test Method Tex-113-E with the following addition that materials having a PI of 20 or above and containing aggregate; wet the portion passing the No. 10 sieve and retained on the No. 20 sieve with the aggregate.

3. Group the soils into five general types of materials and treat as follows:

   a. Fine granular materials with plasticity index less than 5.

   b. Very low swelling soils with plasticity index of 5 through 11.

   c. Swelling subgrade soils, plasticity index of 12 or more.

   d. Flexible base and subbase materials with considerable amounts of aggregate.

   e. Combination soil types.

Group (a)

Fine Granular Materials with Plasticity Index Less Than 5

1. Mold 6 specimens 6 inches in diameter and 8 inches in height at the optimum moisture and density, using the same compactive effort that was specified in Test Method Tex-113-E.

2. Cover the specimen (with stones in place) with a triaxial cell immediately after removing from mold and allow to set overnight undisturbed at room temperature. Do not dry cure or subject specimens to capillary absorption.

3. Test the specimens at the usual lateral pressures

4. Calculate unit stress, plot diagrams and classify material.

Group (b)

Very Low Swelling Soils with Plasticity Index of 5 through 11

1. Compact a set of 6 identical specimens at the optimum moisture and density condition.

2. Use filter paper, lead surcharge weights and air pressure for lateral support and subject the specimens to capillary absorption overnight as described in Section D of Part I.

3. The next morning, remove filter paper and test the specimens at the usual lateral pressure shown above. Calculate unit stress, plot diagrams and classify material.

Group (c)

Swelling Subgrade Soils, Plasticity Index of 12 or More

1. Obtain the plasticity index and hygroscopic moisture of these soils in advance of molding specimens.

2. Determine the optimum moisture and dry density of the materials as outlined in Test Method Tex-113-E, using the compactive effort specified

in Test Method Tex-113-E under Compactive Effort.

3. Calculate the molding moisture to use as follows: Percent Molding Moisture = (1.4 × optimum moisture) – 22.

4. Obtain the desired molding density from the following expression:

$$\text{Molded Dry Density} = \frac{\text{Optimum dry density (Step 2)}}{1 + \frac{\text{percent volumetric swell}}{100}}$$

To determine the percent volumetric swell to be expected, use average condition in charge shown in Figure 11 or soil pressure Slide Rule. If Slide Rule is available, use A_2 Scale, an infinite thickness of layer and the plasticity index of the soil. It is important to modify the percent volumetric swell by multiplying by percent soil binder divided by 100 to obtain the percent volumetric swell to be expected.

5. Use the moisture content (Step 3), vary the compactive effort (usually 25 blows per layer will suffice on most materials) until the desired density (Step 4) is obtained and mold a set of six specimens. Where this moisture content is too great to permit the desired density, reduce the molding water slightly (usually about 1%) and continue molding. The specimens, being in capillarity overnight, will pick up this moisture that was left out.

6. When the six specimens have been molded, they are put to capillary absorption (as in Part I) overnight. Test at the usual lateral pressures and classify.

Group (d)

Flexible Base and Subbase Materials with Aggregate

1. When classification is required, weigh out enough material to mold 6 or more specimens, in individual pans, keeping the portion passing the No. 10 sieve separate. Sprinkle all the soaking water on the + No. 10 aggregate portion in the mixing pan and allow to soak for four or more hours. Overnight is recommended. The soaking water is the optimum moisture as determined in Tex-113-E except, where the flat top curve exists, then the soaking water should be the amount of the left side or dry side of the flat portion.

2. When desired in testing base and subbase materials with aggregates, the following procedure may be used where strengths are required. Begin the M-D curve as outlined in Test Method Tex-113-E and mold at least 2 specimens on the dry side of optimum moisture with the second specimen being slightly below optimum moisture. Weigh out the plus No. 10 portion of 9 specimens in individual pans and sprinkle the water as determined to be just below optimum moisture on each specimen then stir so as to wet the aggregates thoroughly. As each pan is wet, weigh the contents to obtain the weight of pan + soil + water and record. Cover with a lid or suitable cover and stir contents every hour (or 3 times). Continue molding the M-D curve until optimum moisture and density are determined. The difference between optimum moisture and the water the specimens were sprinkled with must be added to the +10 material in the pans. If in the event the specimens have been wet with only slightly more than optimum, they may be dried back at room temperature, by stirring, to the desired weight.

3. Replace any evaporated water, add in the material passing No. 10 sieve, mix and compact. Materials which can be compacted to the desired density without the addition of more water, should be molded at optimum moistures ± 0.1%. Many materials require the addition of small amounts of moisture to obtain the desired density. If needed, add in the required amounts of additional water (by trial and error method) until the desired density is obtained and compact a set of eight specimens using 13.26 ft. lbs. per cu. in. effort. The intent of this technique is to use the minimum amount of moisture equal to or above optimum moisture that will produce a set of accelerated test specimens whose average density is within 1/2 lb per cu. ft. of the maximum cubic foot density of the original moisture density curve. It should be noted that excessive densities can sometimes be obtained in the accelerated set but these are almost always very wet specimens and their resultant strengths can be misleading.

4. Subject specimens to overnight capillarity.

5. Test and if required classify in accordance with Part I. If strengths at zero and 15 lb lateral pressures are specified, test five specimens at zero lateral confinement and three of 15 lb lateral confinement and average the three highest values for each state of confinement for the control values.

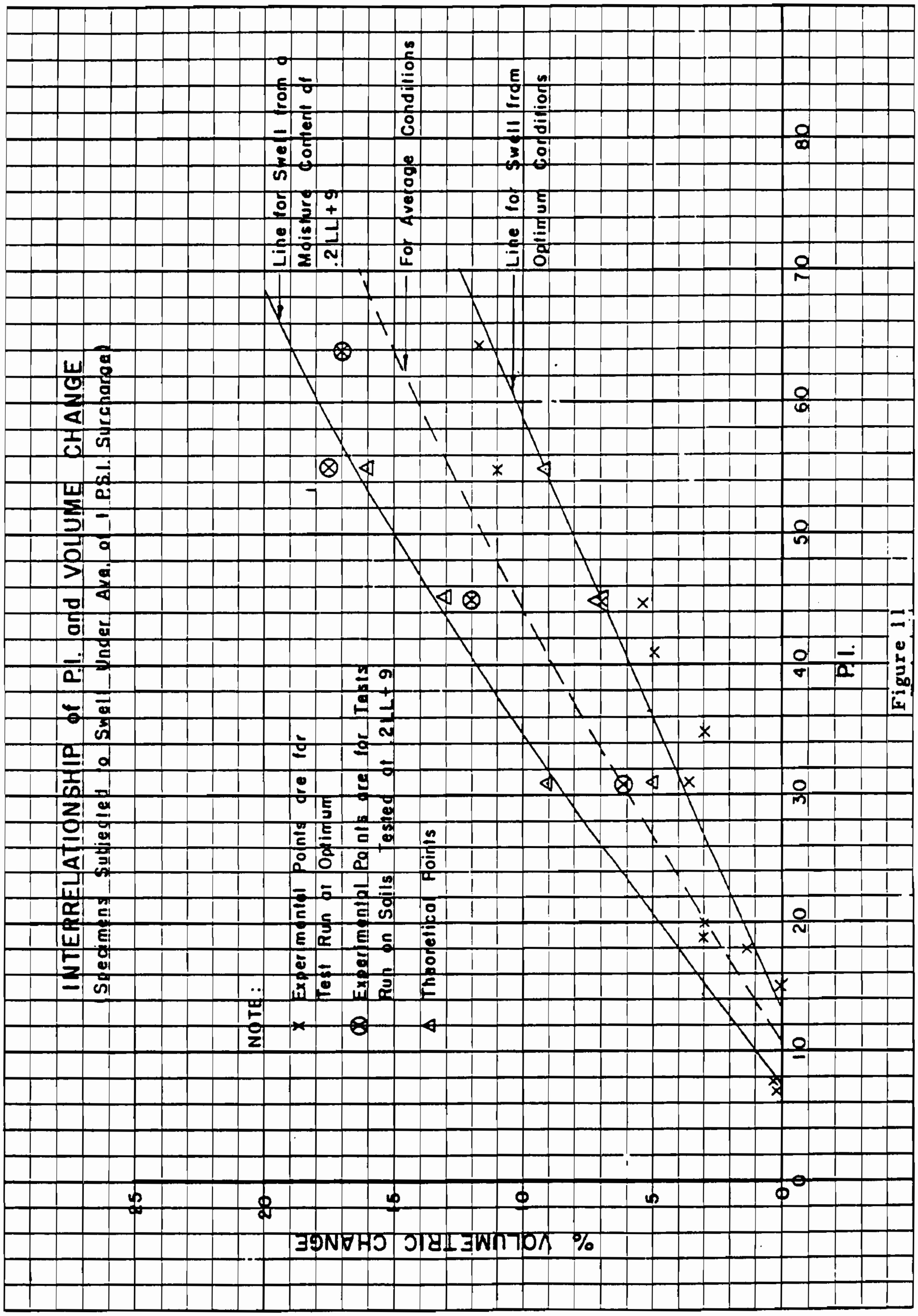

INTERRELATIONSHIP of P.I. and VOLUME CHANGE
(Specimens Subjected to Swell Under Ave. of 1 P.S.I. Surcharge)
NOTE:
× Experimental Points are for Test Run at Optimum
⊗ Experimental Points are for Tests Run on Soils Tested at .2LL+9
△ Theoretical Points
Line for Swell from a Moisture Content of .2LL+9
For Average Conditions
Line for Swell from Optimum Conditions
% VOLUMETRIC CHANGE
0
5
10
15
20
25
P.I.
0
10
20
30
40
50
60
70
80
Figure 11

Figure 11

Note: When strengths at zero and 15 psi lateral pressures are specified, it is permitted to run correlation tests on a given source of material.

The correlation shall be as follows: As soon as three satisfactory accelerated test specimens have been molded in accordance with Paragraph 2 above, two of them will be tested at zero lateral pressure and the results averaged as one test. The third specimen will be tested at 15 psi lateral pressure. If these specimens pass it is safe to assume the set to be tested the next day will pass.

Group (e)

Combination Soil Types

This group includes all materials with enough soil binder to separate the aggregate particles or overfill the voids of the compacted specimen. For example, if the material is a clay gravel with high plasticity index, treat the material as a swelling soil, and allow the + No. 20 material to soak a minimum of 4 hours as do aggregate materials. It should be noted that the total swelling is figured only for that part passing the No. 40 sieve. Other combinations must be recognized and tested in the proper group. Subject all specimens to overnight capillarity, test and classify.

Notes

When testing aggregate materials under Part II where classification is required, test two specimens at 0 psi and the others at 3, 5, 10 and 15 psi. Average the result of the zero lateral pressure tests as one value. Fine grain soils are classified using lateral pressures of 0, 3, 5, 10, 15 and 20 psi.

Reporting Test Results

The reports and forms are the same as given in Part I of this procedure.

Pavement Design Notes

After materials have been classified in accordance with Part I or Part II and cohesiometer values for stabilized layers and surfacing have been determined, the following steps should be followed for the thickness design:

1. Obtain from the Transportation Planning Division, D-10, the current and projected traffic data.

2. Select a design wheel load from D-10, traffic data, and known local conditions. Consideration should be given to increasing the design wheel load by 30 percent if traffic is anticipated to have over 50 percent tandem axles. Use Figure 16 to calculate total depth of pavement to protect the subgrade.

3. Reduce total depth of pavement by using Figure 17 whenever stabilized layers are used in the pavement structure. Enter above depth on ordinate of Figure 17 and follow across page until intersection of cohesiometer value selected (see below) for use is reached, then project to abscissa to read reduction in depth due to bridging effects.

   Standard cohesiometer values (corrected to represent values from 3-inch height specimens) are used with Figure 17 regardless of thickness of stabilized layer except where asphaltic mixtures are used. The modification of cohesiometer values for 3 inch high specimens for application to other thicknesses of asphaltic mixtures is obtained by the following formula:

   $$C_m = \frac{C \times t^2}{9}$$

   Where:

   C_m = Modified cohesiometer value

   C = Standard cohesiometer value for a 3-inch height specimen

   t = Proposed thickness of Bituminous Mixtures in inches

4. The load frequency design factor can be obtained from the tabulation in Figure 18. The depth obtained in Step 3 is then multiplied by this factor and used with the Flexible Base Design Chart in Figure 16 to design each course of the pavement structure.

5. Figure 19 presents data which was interpreted from good engineering practice supplemented by utilizing the AASHTO Road Test data and is a suggested method for determining the thickness of surface courses.

Limitations

1. For a 6 inch or greater layer thickness, use a value of 6 in. in the formula for t.

2. When adjacent layers of stabilization and asphaltic concrete are used, the cohesiometer value to be used with Figure 17 should be equal to the sum of the standard cohesiometer value for the

stabilized layer and the modified cohesiometer value of the asphaltic concrete. When two adjacent layers of stabilization are used, or if a layer of untreated flexible base material exists between asphaltic concrete and a stabilized layer only the greater of the two cohesiometer values should be used in Figure 17. Considerable caution and good engineering judgement should be used in selecting cohesiometer values for use in reduction of base depths. This is especially true in cases where hot mix-cold laid asphaltic concrete is bid as an alternate to hot mix asphaltic concrete laid hot. In the case of stabilized bases, subbases and subgrades, average values rather than highest values should be selected for use in Figure 17.

General Notes

1. Wetted stabilized materials taken from the roadway during construction should be screened over a No. 4 sieve at the field moisture content without drying. Each of these two sizes is mixed for uniformity and weighed. Specimens are then weighed and recombined with like amounts of plus No. 4 material. Moisture can be adjusted in each specimen by adding to the plus No. 4 material or removing from the minus No. 4 material by a fan, as needed.

2. See appropriate test method listed below for testing wetted stabilized materials taken from the roadway during construction.

   a. Cement Stabilization: Test Method Tex-120-E.

   b. Lime Stabilization: Test Method Tex-121-E.

   In any event, the stabilized material should not be completely air dried as outlined in Test Method Tex-101-E.

3. When molding a set of preliminary specimens for testing lime stabilized subgrades and base materials, refer to Figure 3 in Test Method Tex-121-E for the recommended amounts of lime to be used.

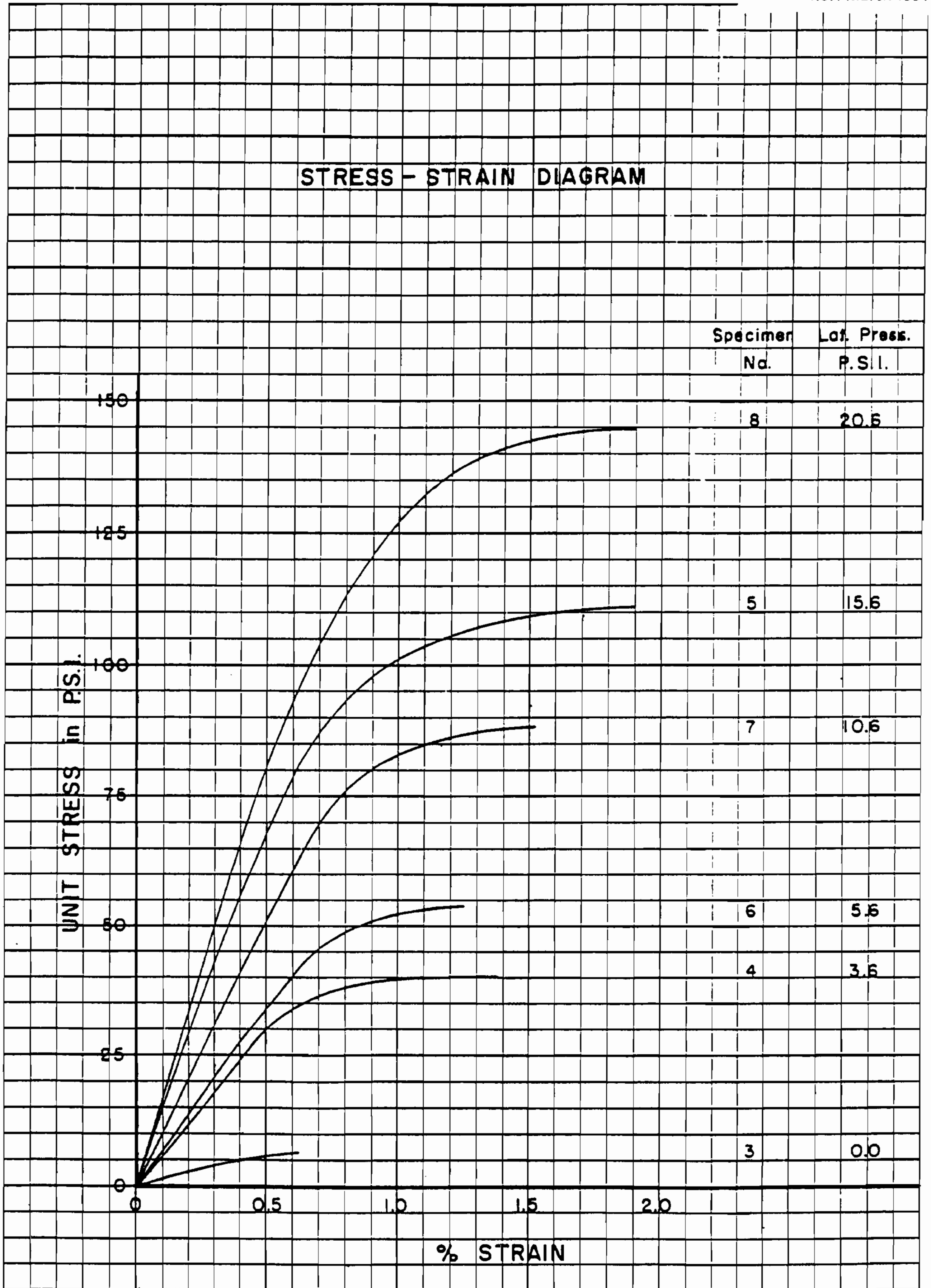

STRESS - STRAIN DIAGRAM
Specimen No.
Lat. Press. P.S.I.
8
20.6
5
15.6
7
10.6
6
5.6
4
3.6
3
0.0
UNIT STRESS in P.S.I.
150
125
100
75
50
25
0
0
0.5
1.0
1.5
2.0
% STRAIN

Figure 12

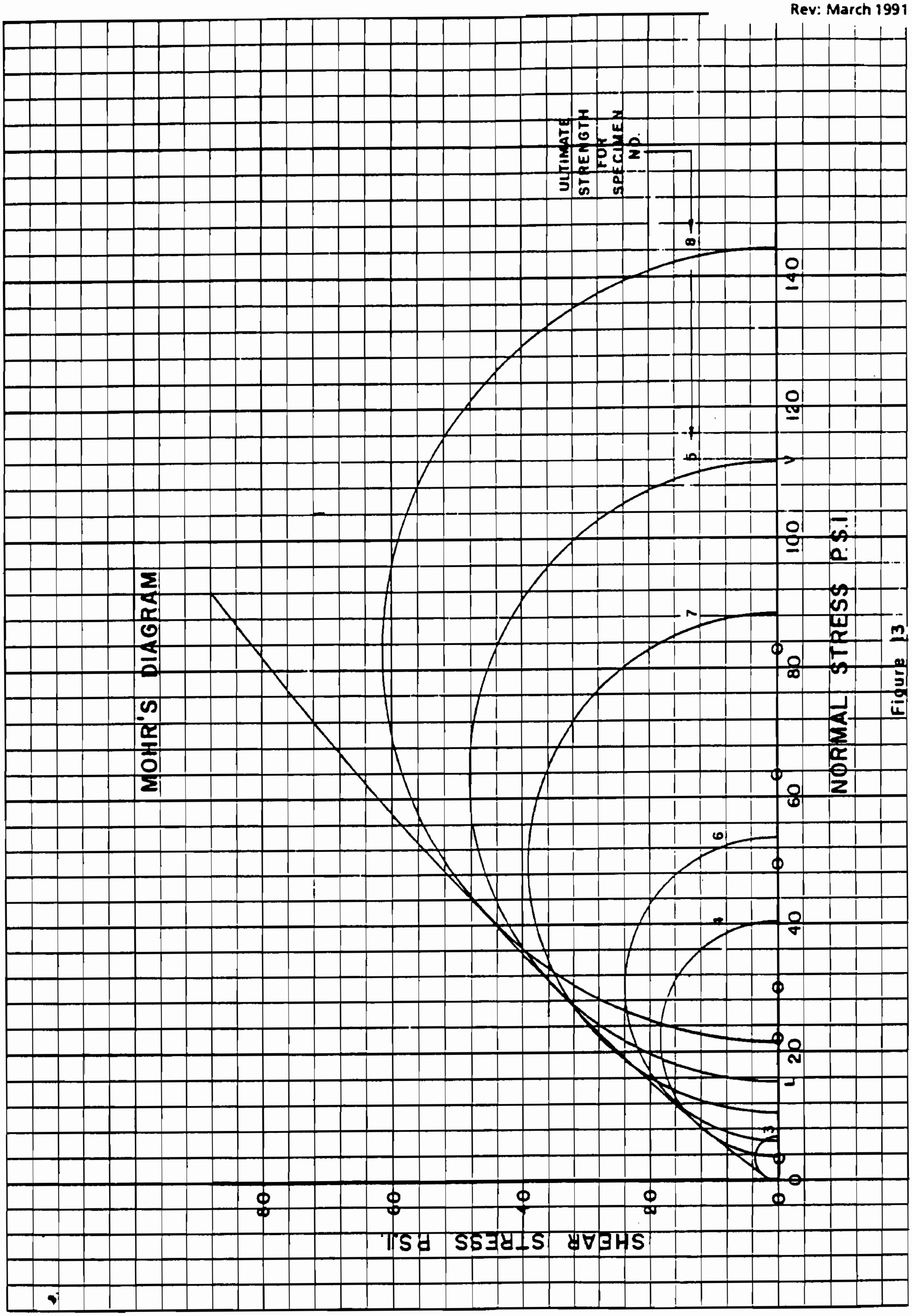

MOHR'S DIAGRAM
NORMAL STRESS P.S.I
SHEAR STRESS P.S.I.
ULTIMATE STRENGTH FOR SPECIMEN NO.
0
20
40
60
80
100
120
140
80
60
40
20
0
8
5
7
6
4
3

Figure 13

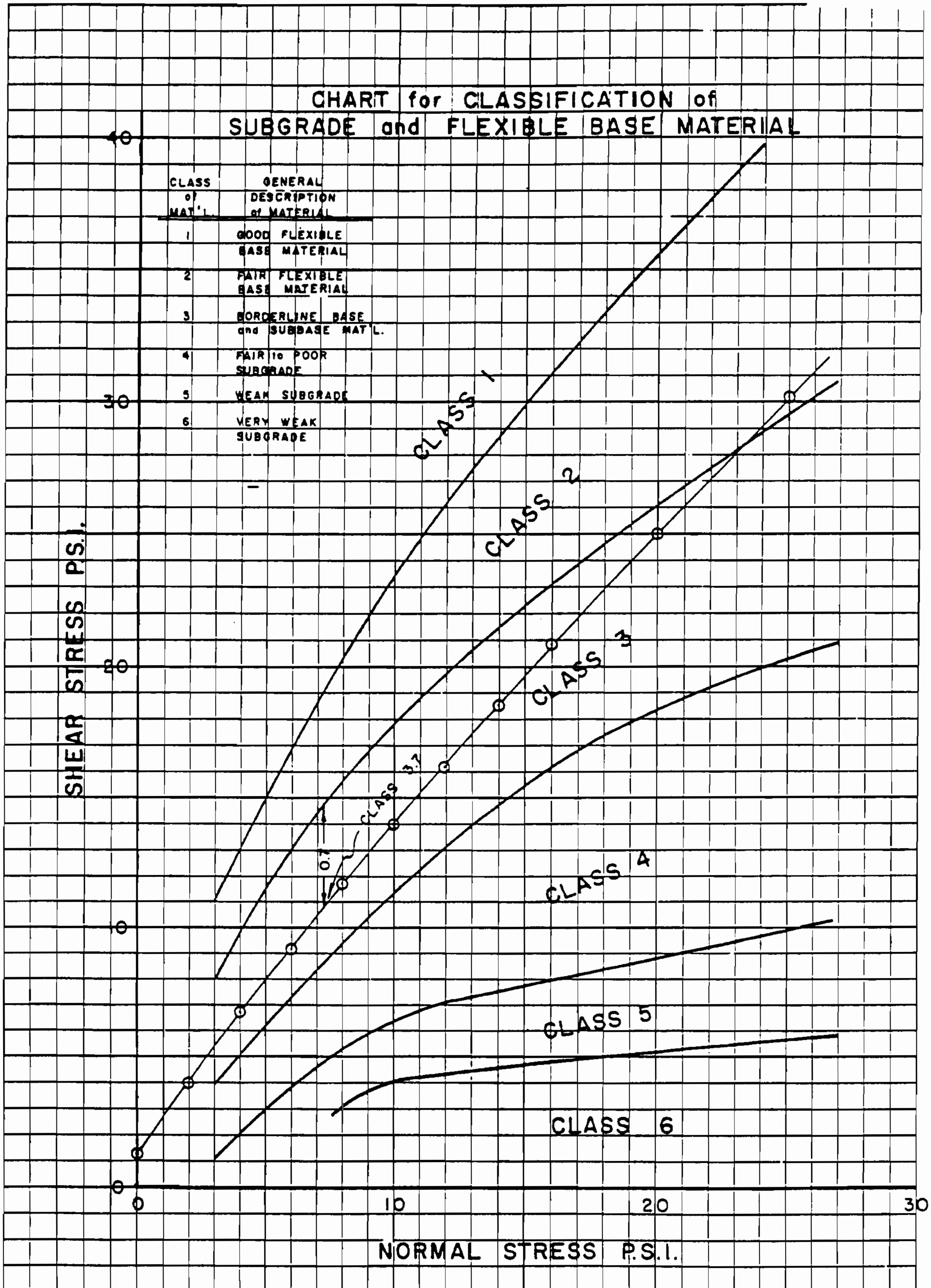


CHART for CLASSIFICATION of
SUBGRADE and FLEXIBLE BASE MATERIAL
CLASS of MAT'L.
GENERAL DESCRIPTION of MATERIAL
1 GOOD FLEXIBLE BASE MATERIAL
2 FAIR FLEXIBLE BASE MATERIAL
3 BORDERLINE BASE and SUBBASE MAT'L.
4 FAIR to POOR SUBGRADE
5 WEAK SUBGRADE
6 VERY WEAK SUBGRADE
CLASS 1
CLASS 2
CLASS 3
CLASS 3.7
0.7
CLASS 4
CLASS 5
CLASS 6
SHEAR STRESS P.S.I.
NORMAL STRESS P.S.I.
0
10
20
30
40

Figure 14

TRIAXIAL TEST SUMMARY SHEET

TABLE NO. ____

Lab No.____________________ County______________ Highway_____ Project______

Material__________________________________ Identification______________

Description____

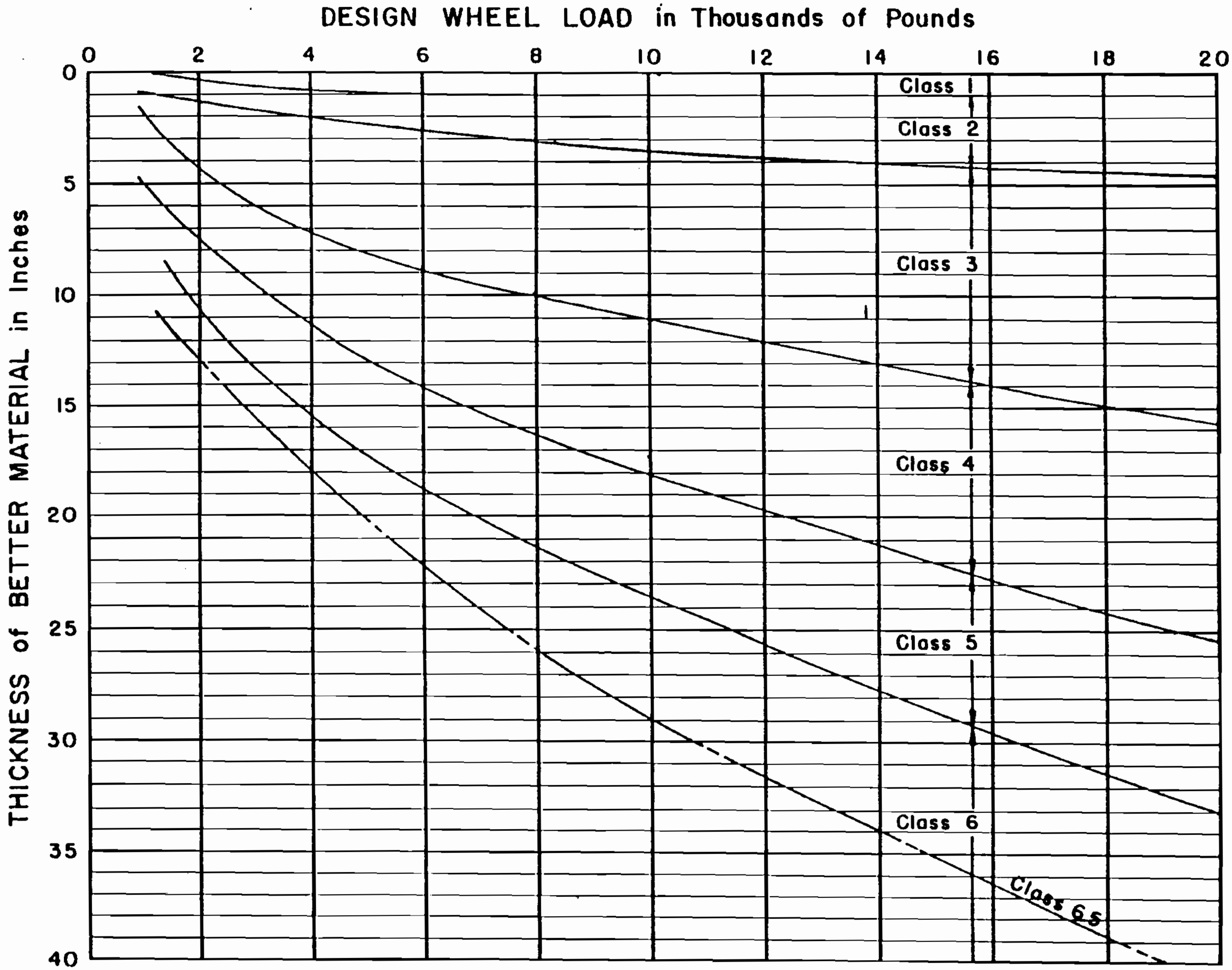
____

Opt. Moist. __________ Opt. Dry Density__________ at Comp. Effort________ ft.-lbs./cu. in.

Molding Data **Curing Data** **Testing Data**

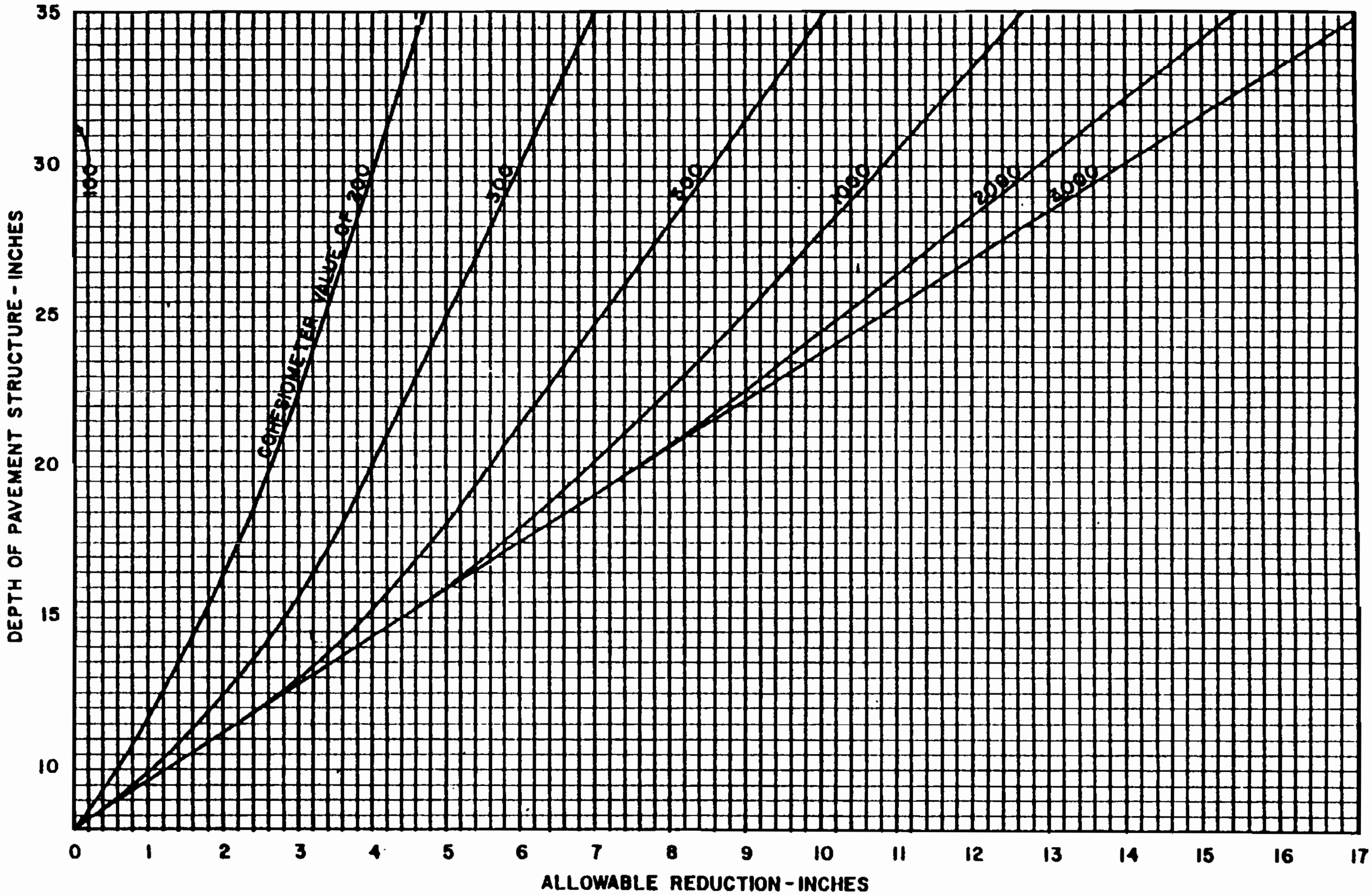
Specimen No.	Water Percent Dry Weight	Dry Density Lbs./Cu.Ft.	Capillary Moisture Time Days	Water Content		Applied Lateral Pressure PSI	Ultimate Compressive Strength PSI	Percent Strain at Ultimate	Percent Volumetric Swell
				After Drying Percent Dry Weight	After Capillary Absorption % Dry Weight				

Figure 15



FLEXIBLE BASE DESIGN CHART

Figure 16



THICKNESS REDUCTION CHART FOR STABILIZED LAYERS

Figure 17

CRITERIA FOR OBTAINING THE LOAD-FREQUENCY DESIGN FACTOR

Total Equivalent 18,000 Pound Single Axle Load Applications	Design Wheel Load in Pounds (ADTHWL)	*Load Frequency Design Factor
14,000	6,000	0.65
25,000	6,200	0.70
38,000	6,300	0.75
61,000	6,500	0.80
100,000	6,800	0.85
150,000	7,200	0.90
250,000	7,900	0.95
400,000	8,700	1.00
600,000	9,500	1.05
1,000,000	10,900	1.10
1,500,000	12,000	1.15
2,500,000	13,500	1.20
4,000,000	14,900	1.25
10,000,000	17,300	1.35

*A load-frequency design factor less then 1.0 is not recommended for the design of the main lanes of a controlled access highway.

Figure 18

SUGGESTED MINIMUM THICKNESS OF SURFACE COURSES INCHES

Total Equivalent 18 Kip Single Axle Load Applications	When Tests Show Materials to be Specifications Grades* of Base Materials			Item 248
	Grade 1	Grade 2	Grade	
14,000	ST	ST	ST	
25,000	ST	ST	ST	
38,000	ST	ST	ST	
61,000	ST	ST	1 1/2	
100,000	ST	1 1/2	2	
150,000	ST	1 3/4	2 1/2	
250,000	1 1/4	2	3	Not recommended for use except where availability of better base material is very expensive
400,000	1 1/2	2 1/4	3 1/2	
600,000	1 3/4	2 1/2	4	
1,000,000	2	3	4 1/2	
1,500,000	2 1/2	3 1/2	5	
2,500,000	3	4	5 1/2	
4,000,000	3 1/2	4 1/2	6	
10,000,000	4 1/2	5 1/2	7	

* It is assumed that the material in question is no better than the grade shown.

** Exclusive of Cohesionless Materials.

Notes: ST denotes surface treatments.
Stage construction of surfacing permitted if traffic studies indicate slow development of axle load equivalencies.

Figure 19

State Department of Highways and Public Transportation
Materials and Tests Division

LABORATORY METHOD OF MIXING BITUMINOUS MIXTURES

Scope

This test method covers the technique for combining various sizes of aggregates and blending them with asphalt under carefully controlled conditions to obtain uniform bituminous mixtures, the object being to prepare mixtures which, when compacted, will result in a series of test specimens as nearly identical as possible with respect to grading, asphalt content for each percentage used, density and arrangement of particles.

Apparatus

1. A balance with a minimum capacity of 4000 g which meets the requirements of Test Method Tex-901-K, Class III-D. When weighing large mixes in mechanical mixer bowls, a larger capacity balance with a sensitivity and readability of at least 0.5 grams is required.
2. Heating oven capable of attaining a temperature of 300°F, or more.
3. Hot plate (gas or electric).
4. Mixing equipment:
   a. Mechanical mixer and bowl, or
   b. Round pans of approximate 8-inch diameter and 3-inch depth dimensions.
5. Small masonry pointing trowels.
6. Thermometers, range of 100° to 400°F graduated in 5° intervals.
7. Tare weights consisting of tin cans with lids, and lead shot. Not required if electronic balances are used.
8. Miscellaneous items such as angle pliers and insulating gloves.

Materials

1. Supply of asphalt cement.
2. Supply of graded aggregate.

Test Record Forms

Identify each mixture with a laboratory number and indicate the percentage of asphalt. Record information on work card, Form No. D-9-F18.

Calibration of Apparatus

When the balance does not have an electronic tare feature, determine the weight of the small pan or mechanical mixing bowl and trowel. Place lead shot in a can to make a tare weight equal to the total weight of the pan or mixing bowl and trowel. Number the pan or mixing bowl, trowel, and the tare weight to correspond to each other. Prepare additional sets of pans, trowels and tare weights, as described above, if pans and trowels are to be used.

Procedure

1. Design the asphaltic concrete mixtures as described in Test Method Tex-204-F using the grading of aggregates and asphalt contents to satisfy the requirements of specifications.
2. To control the grading of the mixtures, separate the aggregates into the proper sizes as set forth by the governing specifications and recombine materials in the correct proportions. Since a minimum amount of segregation occurs in the materials passing the No. 10 sieve, this material need not be divided into smaller sizes unless segregation is apparent or absolute control is necessary.
3. Place the pan or mixer bowl with trowel on the balance and, if necessary, balance with correct numbered tare weight. Place the blade of the trowel in a flat position on top of each layer and pour the next smaller size aggregate to be weighed on the trowel. The blade of the trowel momentarily separates the aggregate being weighed from that portion which has previously been placed in the pan or bowl. The trowel is then used to retrieve any excess of aggregate.

Use the cumulative weight for each size aggregate calculated in the design of the mixture and weigh the various materials and size particles as the materials are combined. The fine aggregate (passing the No. 10 sieve) is weighed last because the final or total weight of the aggregate portion of the asphaltic mixture can be easily adjusted by adding or removing very small amounts of fines.

4. Place a quantity of the desired asphaltic material into a No. 2 can to facilitate handling and heat slowly to the minimum temperature shown in Table 1. Do not allow the asphaltic material to be heated to a temperature above the maximum temperature allowed for storage in the Item, "Asphalts, Oils and Emulsions."

5. Mix the dry aggregate weighed in Step 3 until all sizes are thoroughly blended being careful not to lose any of the aggregate. Place a quick-reading thermometer in the pan or bowl and cover the end of the thermometer with aggregate. Set the pan or bowl of aggregate in an oven maintained at a sufficient temperature to ensure that mixing will be done at the temperature listed in Table 1, ± 5°F. (Do not leave trowel in pan or bowl when heating materials.)

Table 1

Asphaltic Material Type-Grade	Minimum Asphaltic Material Temperature, °F	Mixing Temperature, °F
AC-3, 5, 10	275	275
AC-20, 30	290	290
RC-250	100	165
MC-250	100	165
MC-800	140	190
CMS-2	140	235
AES-300	140	235

Note: Mixtures containing asphaltic materials which are not listed above, or those containing viscosity modifying additives, may require considerably varied mixing temperatures from those shown above. The Asphalt Section will assist in determining appropriate mixing temperatures in these cases.

6. After the aggregate has reached proper temperature, remove the pan or bowl from the oven and remove the thermometer. Make a small depression in the aggregate at center of material to receive the asphaltic material without exposing the bottom of the pan or bowl. Use gloves and side angle pliers to handle hot containers to avoid burns to hands.

7. Place the pan or bowl of heated aggregate and trowel on scale, use the tare weight or the taring features of this balance, and weigh out the required amount of preheated asphaltic material. Pour the asphaltic material into the depression made in the aggregate and use a small piece of paper to remove excess asphalt, if necessary.

8. When mixing by hand, use trowel to blend in the aggregate around the side of the pan and mix thoroughly to blend the asphaltic material and dry materials. Care should be taken to prevent the free asphaltic material from coming in contact with the side or bottom of mixing pan (Figure 1). Mixing of aggregate and asphaltic material should continue until materials are thoroughly coated. Some mixtures require more than one cycle of heating and mixing to coat particles thoroughly. Every effort should be made to complete mixing in one cycle when using cutbacks and emulsions.

   When using a mechanical mixer, the speed of mixing, time of mixing and clearance between the mixing device and the bowl should be such to prevent abnormal degradation of the aggregate. Mix only until a uniform and complete coating of the aggregate is achieved.

9. The mixtures are now ready for heating or curing as required for subsequent testing or compaction. For mixtures containing an emulsion or cutback asphalt, cure to constant weight at a minimum temperature of 140°F and then heat to the temperature required for compacting test specimens in Test Method Tex-206-F. The samples prepared for film stripping tests are allowed to cool to the temperature specified.

Figure 1

Texas Department of Transportation

Materials and Tests Division

COMBINED HMAC COLD-BELT SAMPLING AND TESTING PROCEDURE

Scope

This procedure provides for the sampling and testing of combined aggregates from the hot mix asphaltic concrete plant cold feed belt. It also covers a correlation test procedure to verify the accuracy of cold-belt analysis as compared to solvent extraction analysis. It is intended that this procedure be used in conjunction with Test Method Tex-228-F, "Determination of Asphalt Content of Bituminous Mixtures by the Nuclear Method."

Apparatus

1. Sample template (Figure 1).
2. Sample-splitter or quartering machine.
3. Set of Standard U. S. Sieves which meets the requirements of Test Method Tex-907-K.
4. Mechanical sieve shaker.
5. Balance with a minimum capacity of 6000 g, readable to 0.1 gram and with an accuracy of 0.5 gram.
6. Drying oven capable of maintaining a temperature of 350°F or more or microwave oven.
7. Various pans, scoop, brushes, and spatulas.
8. Sink or other suitable device.
9. Source of potable water with pressurized (minimum 20 psi) spray attachment. (Example: standard sink with spray head attachment).

Sampling Procedure

1. The sample shall be secured from the combined belt feed after all of the required mineral aggregates (except mineral filler where used) have been deposited and just prior to introduction into the mixing plant or chamber.
2. When this method is used, the belt sample shall be taken with the belt stopped. The sample shall be taken across the entire width (cross section) of the belt for a minimum 1.5 foot length along the belt.
3. The sampling template is used to enclose a section of the aggregate on the belt. (Segregation of the sample is to be avoided.) All of the aggregate on the belt, including the fines, is to be taken for the sample. The belt section so sampled shall be relatively clean after sampling.
4. A greater cross-sectional area may be required for low plant production rates. This may be accomplished by repositioning of the template downstream of the original sample area. (Additional sampling shall be contiguous.) The intent is to secure a representative sample of 35 pounds (minimum) from the belt.
5. Other methods of securing representative, homogeneous samples may be approved by the Engineer.

Sample Preparation

1. The entire belt sample shall be thoroughly mixed to avoid segregation and then shall be quartered or split to yield a test sample of approximately 5.5 pounds (2500 g) minimum.
2. The test sample of approximately 2500 g (minimum) shall then be dried using either a conventional drying oven or microwave oven. (Adequate drying has resulted when a loss of less than 1.0 gram occurs in 5 minutes in a conventional oven at a minimum temperature of 250°F; the sample being no more than 1 inch deep in the pan. In a microwave oven, adequate drying is defined as less than 1.0 gram loss after an additional 2 minutes of high-setting heating in a microwave oven of minimum 700 watt capacity. *Caution:* When drying with a

microwave oven, do not heat so rapidly as to cause the sample to "pop" or "sputter" as it may result in loss of fines.)

Sample Testing

A. Dry Sieve Analysis – Weigh the dried and cooled (120°F or less) test sample to the nearest 0.1 gram and record as Original Dry Weight. Determine the Dry Sieve Analysis in accordance with Test Method Tex-200-F, Part I.

B. Washed Sieve Analysis – Weigh the dried and cooled (120°F or less) test sample to the nearest 0.1 gram and record as Original Dry Weight. Determine the Washed Sieve Analysis in accordance with Test Method Tex-200-F, Part II.

Correlation Testing

Correlation testing will be performed to determine if cold feed belt sieve analysis and extraction test results compare in an acceptable manner. This correlation also adjusts the acceptable range for percentage of aggregate passing the No. 200 sieve when cold feed belt samples are used for gradation control.

1. A minimum of three (3) correlation tests will be performed for each mix design being considered for cold feed belt sampling gradation control. For this procedure, one correlation test is defined as a comparison of one mixture aggregate gradation determined by Test Method Tex-210-F (Extraction Test) to one gradation test made on the combined cold feed aggregates using Test Method Tex-200-F, Part I or II (Dry or Washed Sieve Analysis Methods). Quantities of mineral filler (other than baghouse fines) introduced during mixing operations within the drum or mixing chamber shall be added proportionally to the samples taken from the cold feed belt.

2. The acceptability of the relationship between belt sample and extraction test results will be determined by the Engineer. Some degree of difference is to be expected when comparing test results from the two types of samples. Both the consistency of this difference between pairs of compared values and the amount of the difference should be considered in determining if an acceptable correlation exists. Additional correlation tests are recommended whenever the acceptability of the correlation is questionable. Cold feed belt sampling should not be used for mixtures containing aggregates prone to degradation during plant mixing.

3. When cold feed belt samples are used to reduce the required number of extraction tests, the gradation tolerances of the specifications are applied as follows to set allowable operating ranges for the belt sample test results.

   a. All size fractions larger than the No. 200 sieve:

      The tolerances are applied as prescribed by the specifications for gradation control based on extractions. Belt sample and extraction test results have the same operating range for each size fraction.

   b. The passing No. 200 size fraction:

      The method of applying the tolerance depends on the correlation test results. First, average the passing No. 200 percentages determined by extraction tests. Next, average the passing No. 200 percentages found in the cold feed belt samples. Compare these averages.

      When the average values differ by less than 1.0 percentage point, the tolerances are applied as prescribed by the specifications for gradation control based on extractions. As for the larger aggregate sizes, belt sample and extraction test results must meet the same requirement.

      When the average values differ by 1.0 or more percentage points, the allowable range for cold feed belt sample passing No. 200 will be adjusted from the range allowed for extraction results to account for this difference. It is the intent that the allowable range for cold feed belt sample test results will insure that the produced *asphaltic concrete mixture* meets the specifications for percentage passing the No. 200 sieve. Two examples follow which demonstrate the determination of the allowable range for passing No. 200 percentages under those circumstances.

EXAMPLE DETERMINATION OF ALLOWABLE RANGE FOR PASSING NO. 200 IN BELT SAMPLES

Correlation Test Results:

Job Mix Formula from Mix Design		Cold Feed Belt and Extraction Pairs CFB1	EXT1	CFB2	EXT2	CFB3	EXT3
Ret. 1/2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1/2 – 3/8	0.8	0.2	1.2	0.9	1.0	1.2	1.5
3/8 – #4	28.8	27.2	28.1	28.1	29.5	27.0	26.7
#4 – #10	29.7	28.7	29.4	29.1	30.4	29.0	31.5
Ret. #10	59.3	56.1	58.7	58.1	60.9	57.2	59.7
#10 – #40	15.5	16.8	16.0	14.7	14.1	15.0	13.7
#40 – #80	15.0	16.3	15.5	17.9	15.2	17.5	14.8
#80 – #200	5.9	7.5	4.3	6.9	5.5	7.8	8.0
Pass #200	4.3	3.3	5.5	2.4	4.3	2.5	3.8

The average cold feed belt and extraction passing No. 200 percentages are calculated.

	Cold Feed Belt	Extraction
	3.3	5.5
	2.4	4.3
	2.5	3.8
Average	2.7	4.5

From the correlation tests performed in this example, cold feed belt sample test results for passing No. 200 material may be expected to be approximately 1.8 percentage points (4.5 – 2.7) lower than corresponding extractions would find. First, the allowable range for extraction results must be found. Then, it will be adjusted based on the above comparison to derive the cold feed belt sample allowable range.

Since the extraction results are required to meet both the master gradation limits and tolerance limitations for the passing No. 200 sieve size, the operating range for extraction test results is 4.3% (the mix design percentage) plus or minus 3%, or 1.3% to 7.3%. However, should the prevailing specification require master gradation limits of 1 – 6%, then the extraction operating range is diminished to 1.3% to 6.0%.

The extraction operating range of 1.3% to 6.0% is then lowered by the 1.8 percentage points which was found to be the anticipated difference between extraction and cold feed belt sample results. This determines the allowable cold feed belt sample operating range for passing No. 200 material. Since the correlation test results indicate that approximately 1.8% of passing No. 200 sieve material would be the least amount to be expected in the produced mixture, and this exceeds the minimum extraction master limit of 1%, the lower master gradation limit is not applicable to the cold feed belt sample in this case. Therefore, the allowable operating range for cold feed belt samples in this example would be 0.0% to 4.2% for the passing No. 200 sieve size.

As a second example, should the above correlation test results be reversed and the extracted passing No. 200 percentage be expected to be lower than the amount found by testing cold feed belt samples by 1.8 percentage points, then the upper master gradation limit would not be applicable to the cold feed belt samples. While the extraction operating range would still be 1.3% to 6.0% (if the master limit was 1 – 6%), the cold feed belt sample operating range would be found by shifting the extraction range upward by 1.8 percentage points. An operating range of 3.1% to 7.8% can be allowed for the amount of passing No. 200 material in cold feed belt samples.

4. Later changes in plant production rate, draft, temperature, etc., that are believed to potentially alter the amount of degradation and/or fines loss should warrant one or more correlation tests at the time of the production change. Periodic checks of the established correlation should be made as may be required in the Guide Schedule of Minimum Sampling and Testing.

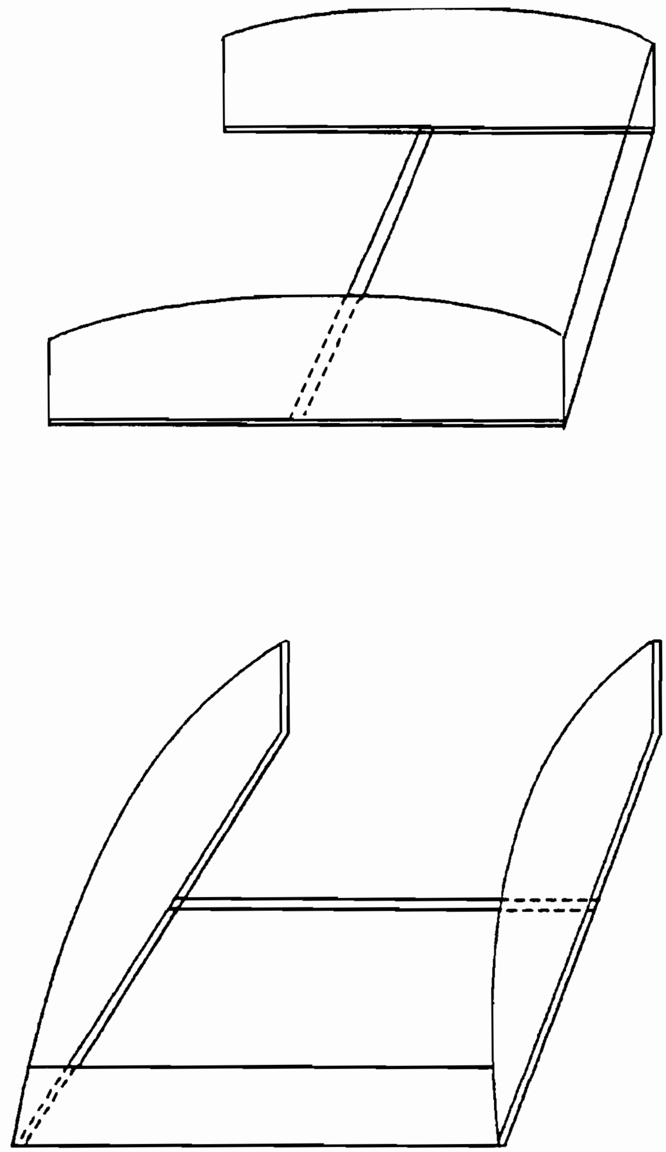


Figure 1

Texas Department of Transportation

Division of Materials and Tests

STATIC CREEP TEST

Scope

This test method covers the determination of creep characteristics in axial unconfined compression for a compacted bituminous specimen or pavement core.

Summary of Method

A static load of a specified magnitude is applied for a fixed duration of time along the centric longitudinal axis of a compacted bituminous specimen or pavement core. Prior to the initiation of creep testing, the specimen is subjected to a specified preconditioning load. During the conduct of the test, the axial deformation of the specimen is continuously measured and subsequently used to calculate creep properties such as stiffness, permanent strain and slope of the strain versus time plot.

When used in conjunction with other physical properties, the creep properties can be used to evaluate rutting susceptibility of bituminous mixtures.

Apparatus

1. Loading Press: Capable of applying a constant axial compressive load over a specified time period. The axial load measuring device shall be capable of measuring the axial load to an accuracy of plus or minus 1% of the applied axial load. The load cell shall be calibrated and/or checked prior to initiation of any program of creep testing, rechecked monthly thereafter, and recalibrated semiannually.

2. Temperature Control System: The temperature control system shall be capable of controlling temperature with a range of 104 to 140°F (40 to 60°C). The temperature shall be held to within ±2°F (±1.1°C) of the specified test temperature. The system should include a temperature controlled cabinet large enough to hold at least three specimens.

3. Measurement and Recording System: The measurement and recording system shall include sensors for measuring load and vertical deformation. The vertical deformation should be measured by Linear Variable Differential Transducers (LVDT). Resolution of each LVDT shall be better than .0001". The deformations can be recorded as real time computer generated plots or on a multichannel strip-chart recorder with minimal noise at the highest sensitivity setting. Load shall be measured with an electronic load cell capable of measuring vertical loads up to 500 pounds with an accuracy of ±1% of the load level being applied. The load and axial deformations should be continuously recorded and monitored during the test.

4. Loading platens: Smooth platens shall be used to minimize the effects of platen to sample end frictions, on creep deformation. The upper load platen shall be of the same diameter as the sample being tested to provide for positive centering of the specimen under load. The upper platen shall be of the floating compression type to account for minor deviations in specimen surface. The upper load platen should not be attached to load cell.

5. LVDT Attachments: Two LVDTs will be used for deformation measurement. LVDTs should be attached to the lower load platen and be positioned on the upper load platen for deformation measurements (Figure 1).

Specimen

1. Laboratory Molded Specimen: Prepare the laboratory molded specimen in accordance with Test Methods Tex-205-F and Tex-206-F. The specimen shall be 4" diameter and 2" ± 0.1" thick.

2. Core Specimens: Cores should have minimum of 2" thickness and should have relatively smooth, parallel surfaces.

Specimen Preparation

1. Measure relative density of specimens in accordance with Test Methods Tex-207-F and Tex-227-F. Cap both the top and bottom surface of the specimen using a mixture of high strength plaster capping compound in accordance with Test Method Tex-450-A. Care should be exercised to ensure top and bottom surfaces are parallel to each other and smooth.

2. Specimen shall be placed in a controlled temperature chamber and maintained at 104°F (40°C) for 3 to 5 hours prior to start of the test.

Procedure

1. Apply three cycles of a square wave preload for one minute intervals followed by a one minute rest period for each cycle. This will allow the loading platens to achieve more uniform contact with the specimen. The magnitude of the load applied at preload shall be 125 pounds.

2. After the last preload and rest cycle has been applied, apply 125 pounds load to the specimen. Maintain this load on the specimen for one hour. At the end of one hour, remove the load and allow the specimen to rebound for 10 minutes. During the entire loading and unloading time, monitor and record the load which is being applied and the resulting vertical deformations for each LVDT.

Calculations

A typical plot of load and deformation is shown in Figure 2.

1. For each specimen, calculate the average deformation by averaging the readings from the two LVDTs. Convert the average deformation values to strain using the following relationship:

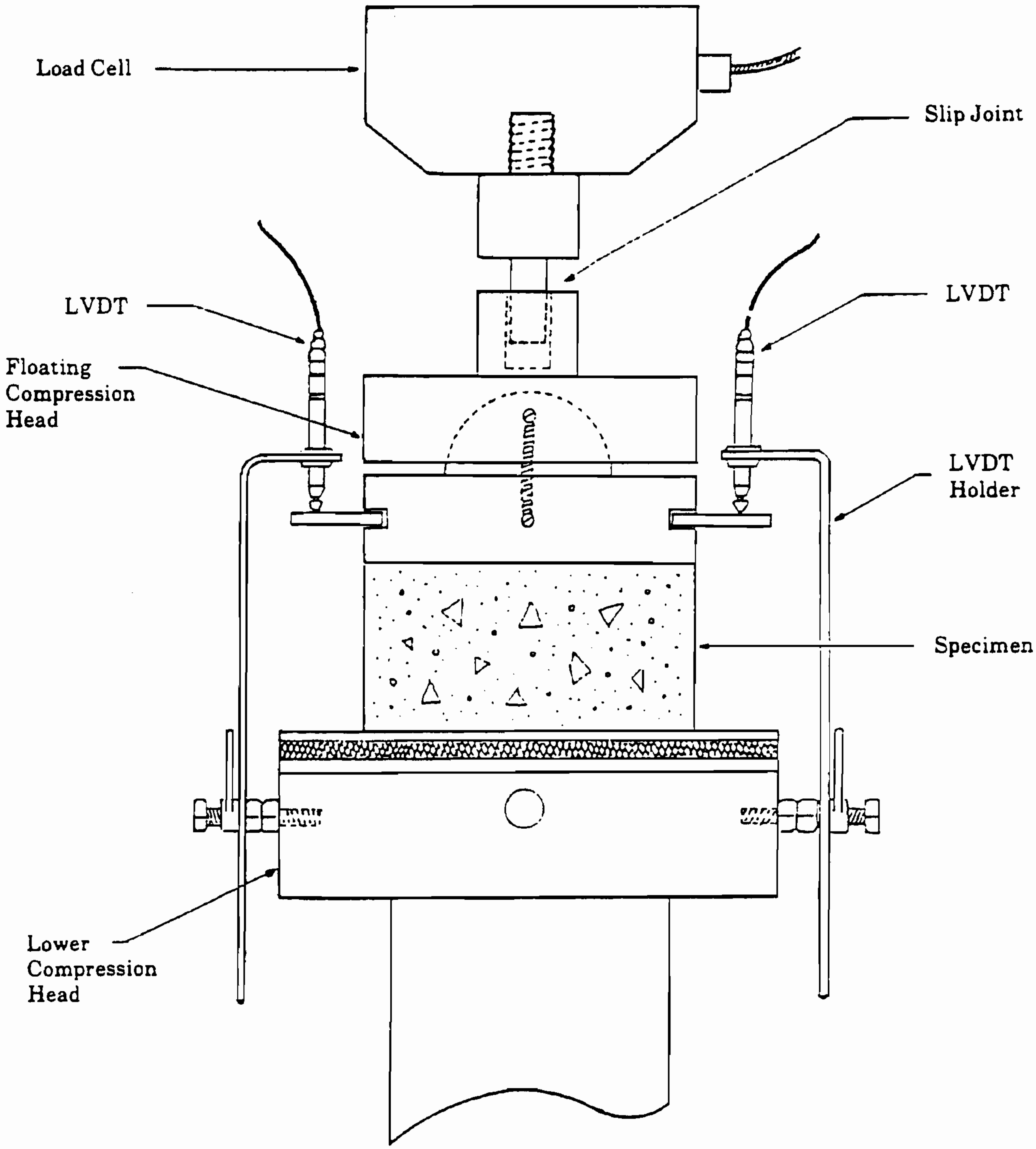
$$\text{Strain} = \frac{\text{Deformation}}{\text{Specimen Thickness}}$$

2. Plot strain versus time for each specimen, a typical plot is shown in Figure 3. This plot is referred to as creep curve. From this plot, obtain the following values:

   Total strain (In/In)
   Permanent strain (In/In)
   Slope of the steady-state portion of creep curve (In/In Sec)
   $$\text{Creep stiffness (PSI)} = \frac{\text{10 psi}}{\text{Total Strain}}$$

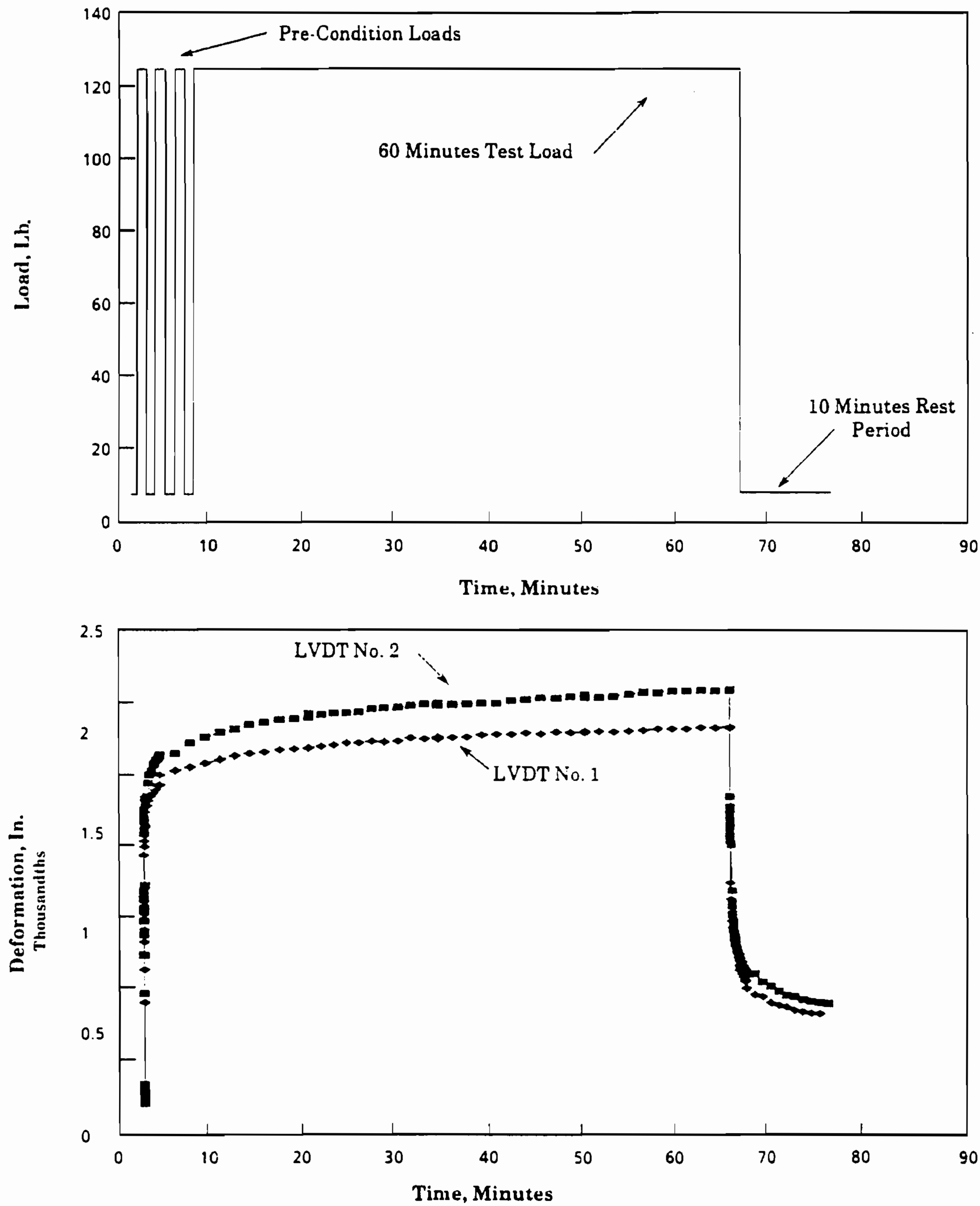
Report

For each specimen, report the air voids content, asphalt content, permanent strain, slope, and creep stiffness.



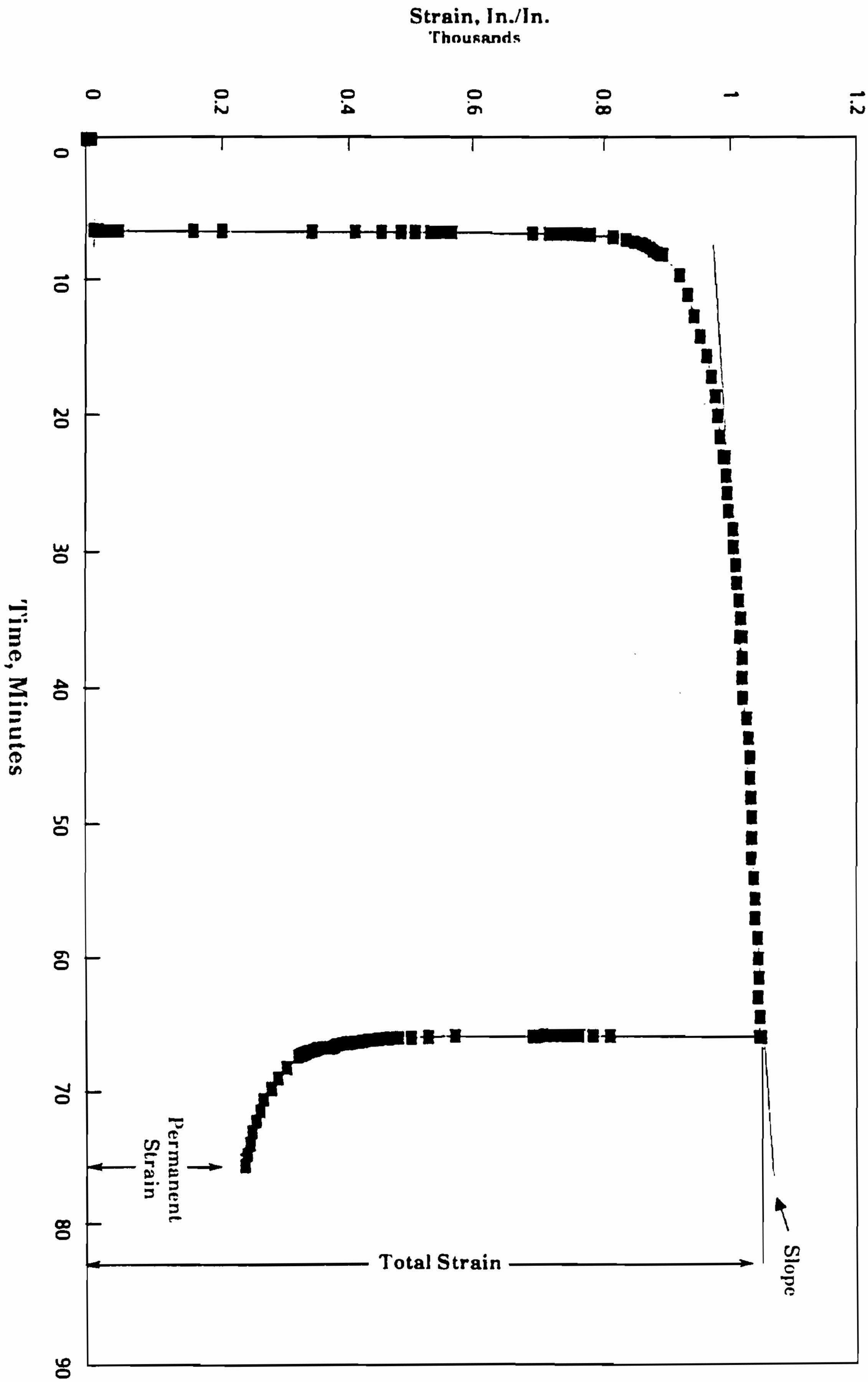
Configuration of Measurement System

Figure 1



Typical load and Deformation Plots

Figure 2


Strain, In./In.
Thousands
0
0.2
0.4
0.6
0.8
1
1.2
0
10
20
30
40
50
60
70
80
90
Time, Minutes
Slope
Permanent Strain
Total Strain

State Department of Highways and Public Transportation

Materials and Tests Division

PRESSURE-SLAKING TEST OF SYNTHETIC COARSE AGGREGATE

Scope

The test method described here is intended to be used to evaluate the amount of dehydration that has occurred in the production of synthetic aggregates fired in a Rotary Kiln.

Apparatus

The apparatus shall consist of the following:

1. Pressure cooker (common kitchen type with 6 quart capacity with 15 psi pressure regulator)

Note: Centrifuge bottles will require a pan depth of approximately 7 inches. Presto Stainless Steel Pressure Cooker Model C601A has been found to have a satisfactory inside height.

2. Centrifuge bottles - 500 ml Pyrex

3. A balance with a minimum capacity of 4000 g which meets the requirements of Test Method Tex-901-K, Class III D.

4. Heavy duty shaker - Equipoise Model No. 5855

5. Standard U.S. Sieves, sizes 3/4-inch, No. 10, and No. 40, which meet the requirements of Test Method Tex-907-K.

6. Drying oven capable of attaining a temperature of 200°F or more.

Sample

An unwashed representative sample of sufficient volume to half fill the centrifuge bottle should be chosen. The sample shall be dried and then sieved so that the material passes a 3/4" sieve and is retained on a No. 10 sieve. Any material retained on the 3/4" sieve should be crushed to pass this sieve using a minimum amount of crushing. Since synthetic aggregates vary widely as to specific gravity, a volumetric measure of the sample is used rather than weight. (A filled 250 ml beaker can serve as a convenient method of measuring the proper quantity of aggregate for the test sample.)

1. Place the sample into the centrifuge bottle and add 200 ml of distilled water. Measure the height of the water level in each centrifuge bottle to the nearest 1/16 inch.

2. Place the centrifuge bottles containing the aggregates into the pressure cooker, adding approximately 1/2" of distilled water to the pressure cooker and seal the lid tightly.

3. Heat the pressure cooker until full pressure is indicated by the pressure regulator.

4. Adjust heat to allow only a slight escape of steam and maintain pressure for 15 minutes.

5. Remove the source of heat from the pressure cooker after the 15-minute period. Immediately remove the regulator from the top of the pressure cooker with tongs or a gloved hand. *Extreme care should be used to insure that the high-pressure steam jet will not contact skin.* Allow the pressure to be completely released, then remove the pressure cooker lid. Remove the centrifuge bottles.

6. After cooling to approximately 100°F, again measure the height of the water level in each centrifuge bottle to the nearest 1/16-inch. If the water level is found to be more than 5/8-inch below the original level, add distilled water at approximately 100°F until the water level is restored to 1/2-inch below the original water level.

7. Place corks in the centrifuge bottles and place the bottles in the Equipoise shaker. Shake the aggregates for 15 minutes.

8. Upon removing the bottles from the shaker, wash the sample over a No. 40 sieve, taking care not to lose any of either fraction.

9. Dry both fractions to a constant weight and cool to room temperature.

10. Weigh the material retained on the No. 40 sieve and the material passing the No. 40 sieve to the nearest 0.1 gram.

ALTERNATE METHOD

Apparatus

1. Pressure cooker (common kitchen type with 6 quart capacity with 15 psi pressure regulator).

Note: Centrifuge bottles will require a pan depth approximately 7 inches. Presto Stainless Steel Pressure Cooker Model C601A has been found to have a satisfactory inside height.

2. Centrifuge bottles - 500 ml Pyrex.

3. A balance with a minimum capacity of 4000 g which meets the requirements of Test Method Tex-901-K, Class III-D.

4. Sieve Shaker - Tyler Portable Sieve Shaker or equivalent - motor driven. Shaker shaft speed = 260

± 25 rpm. (A 1725 rpm motor with a 1-1/2 inch pulley and a shaker shaft with a 10 inch pulley will usually meet this requirement.) See Figure 2.

5. Standard U.S. Sieves, sizes 3/4-inch, No. 10, and No. 40, which meet the requirements of Test Method Tex-907-K.

6. Drying oven capable of attaining a temperature of 200°F or more.

7. Bracket for clamping centrifuge bottles in a side-by-side, horizontal position in the Tyler sieve shaker (Figure 1).

Sample

An unwashed representative sample of sufficient volume to half fill the centrifuge bottle should be chosen. The sample material is that which passes a 3/4" sieve and is retained on a No. 10 sieve. Any material retained on the 3/4" sieve should be crushed to pass this sieve using a minimum amount of crushing. Since synthetic aggregates vary widely as to specific gravity, a volumetric measure of the sample is used rather than weight. (A filled 250 ml beaker can serve as a convenient method of measuring the proper quantity of aggregate for the test sample.)

Procedure

1. Place the sample into the centrifuge bottle and add 200 ml of distilled water. Measure the height of the water level in each centrifuge bottle to the nearest 1/16 inch.

2. Place the centrifuge bottles containing the aggregates into the pressure cooker, adding approximately 1/2" of distilled water to the pressure cooker and seal the lid tightly.

3. Heat the pressure cooker until full pressure is indicated by the pressure regulator.

4. Adjust heat to allow only a slight escape of steam and maintain pressure for 15 minutes.

5. Remove the source of heat from the pressure cooker after the 15-minute period. Immediately remove the regulator from the top of the pressure cooker with tongs or a gloved hand. ***Extreme care should be used to insure that the high-pressure steam jet will not contact skin.*** Allow the pressure to be completely released, then remove the pressure cooker lid. Remove the centrifuge bottles.

6. After cooling to approximately 100°F, again measure the height of the water level in each centrifuge bottle to the nearest 1/16-inch. If the water level is found to be more than 5/8-inch below the original level, add distilled water at approximately 100°F until the water level is restored to 1/2-inch below the original water level.

7. Place corks in the centrifuge bottles and place the bottles in the horizontal shaking bracket securely clamping them in place. (Prior to placing the bottles, make certain that the bracket is securely fastened to the Tyler sieve shaker.) See Figure 3.

8. Shake the samples in the Tyler sieve shaker horizontal bracket for 35 minutes at 260 ± 25 rpm (See Apparatus, 4., for shaker details).

9. Remove the bottles from the shaking bracket and wash the sample over a No. 40 sieve, taking care to lose none of either fraction.

10. Dry both fractions to a constant weight and cool to room temperature.

11. Weigh the material retained on the No. 40 sieve and the material passing the No. 40 sieve to the nearest 0.1 gram.

Calculations

The pressure slaking value is the material passing the No. 40 sieve expressed as a percentage of the total sample weight:

Pressure Slaking Value =

$$\frac{\text{Weight of minus No. 40 material}}{\text{Weight of minus No. 40 + Ret. No. 40}} \times 100$$

Note: If a Tyler sieve shaker is used, excessive wear of the vertical slot in the base of the sieve holder may cause erroneous test results.

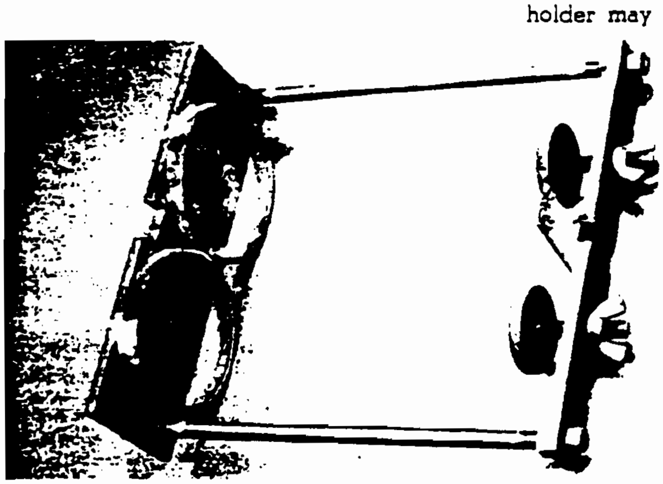


Figure 1

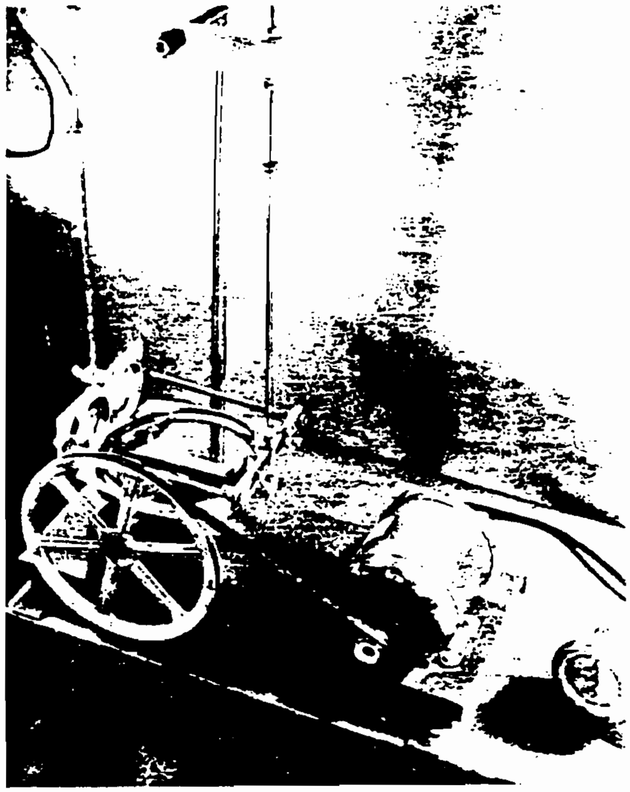


Figure 2

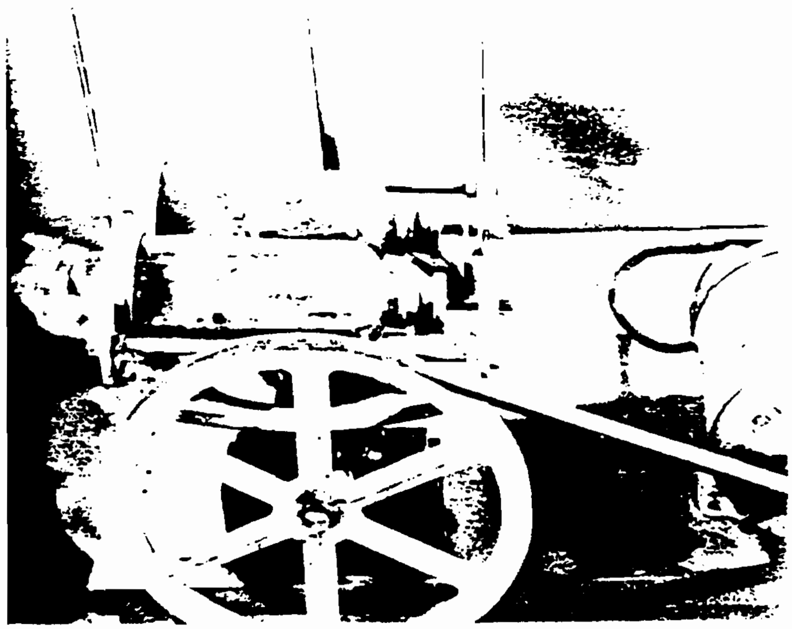


Figure 3

Texas Department of Transportation

Division of Materials and Tests

PARTICLE COUNT

Scope

This method provides procedures for determining the percent of particles meeting the crushed face requirement and the minimum percent of non-polishing aggregate when blending.

PART I DETERMINATION OF CRUSHED FACE COUNT

Definition

A crushed face is defined as the surface produced from the mechanical crushing of an aggregate. They are identified by fresh fractures and lack of evidence of weathering.

Purpose

This test procedure involves the manual separation of the particles with two or more crushed faces, and determining the percent based on the total number of particles in the test sample.

Procedure

1. Place aggregate sample in an oven and dry to constant weight at a temperature of 100 to 300°F. (Aggregates may be dried in a pan over open flame with frequent stirring.) Drying to a "constant weight" may be accomplished by drying for a specific period of time that has proven by experiment to be adequate or drying to the point that by observation, based on experience, the aggregate is sufficiently dry for testing.

   Remove sample from oven and allow the aggregate to cool to the point that it can be handled in the laboratory.

2. Carefully quarter the aggregate sample submitted for testing to obtain a representative portion of material so that the material retained on the No. 4 sieve will contain approximately 400 particles. Larger test samples may be taken to improve test accuracy.

3. Sieve the sample over the No. 4 sieve, discarding the material passing the No. 4 sieve. The material retained on the No. 4 sieve constitutes the test sample.

4. Spread the test sample of aggregate on a smooth surface. (A contrasting colored surface is helpful, if available.)

5. Closely examine the surface of each aggregate particle in the sample. Place those with two or more crushed faces in one pile and the particles with one or no crushed faces in a separate pile.

6. After completely separating the test sample into the two piles, count the number of particles in each pile. Record the number of particles in the pile having two (2) or more crushed faces as N_F. Record the number of particles with one or no crushed faces as N_U.

Calculations

Determine the percentage of crushed particles in the sample as follows:

$$\text{Percent crushed Particles} = \frac{N_F}{N_T} \times 100$$

Where:

N_F = number of particles equal to two (2) or more crushed faces than specified

N_U = number of particles with less crushed faces than specified

N_T = total number of particles in the test sample ($N_F + N_U$)

PART II
DETERMINATION OF PERCENT BY VOLUME OF NON-POLISHING AGGREGATES

Purpose

This test procedure involves the manual separation of particles by visual differences and determining the percent non-polishing aggregate by volume.

Procedure

1. Place aggregate sample in an oven and dry to constant weight at a temperature of 100 to 300°F. (Aggregates may be dried in a pan over open flame with frequent stirring.) Drying to a "constant weight" may be accomplished by drying for a specific period of time that has proven by experiment to be adequate or drying to the point that by observation, based on experience, the aggregate is sufficiently dry for testing.

   Remove sample from oven and allow the aggregate to cool to the point that it can be handled in the laboratory.

2. Carefully quarter the aggregate sample submitted for testing to obtain a representative portion of material so that the material retained on the No. 4 sieve will contain approximately 400 particles. Larger test samples may be taken to improve test accuracy.

3. Sieve the sample over the No. 4 sieve, discarding the material passing the No. 4 sieve. The material retained on the No. 4 sieve constitutes the test sample.

   NOTE: The No. 10 sieve may be substituted for the No. 4 sieve when the specification requires testing of the No. 10 size fraction.

4. Spread the test sample of aggregate on a smooth surface. (A contrasting colored surface is helpful, if available.)

5. Closely examine each particle in the sample. Separate by visual differences.

Calculations

Determine the percentage of non-polishing aggregates by volume as follows:

$$\text{Volume of Aggregate} = \frac{\text{weight}}{SG_A \times UW_w}$$

Where:

SG_A = bulk specific gravity of aggregate

UW_w = unit weight of water (gm/cu. cm or lb/cu. ft.)

$$\text{Percent Non Polishing Aggregate} = \frac{\text{Volume of Non Polishing Aggregate (100)}}{\text{Total Volume of Ret. No. 4}}$$

Texas Department of Transportation

Division of Materials and Tests

EFFECT OF WATER ON BITUMINOUS PAVING MIXTURES

Scope

This procedure may be used to evaluate the susceptibility of hot mix-hot laid (HMHL) or hot mix-cold laid (HMCL) paving mixtures to stripping of the asphalt from the aggregate by water.[1] It may also be used to evaluate the effectiveness of antistripping additives in a paving mixture.

Apparatus

1. Mixing Pan (round, approximately 8 inch dia., approximately 3 inch depth).
2. Mixing Trowel (ex: masonry pointing).
3. Thermometer, general use (ex: range 30 to 580°F, ASTM 1F).
4. Metal can (ex: 6-oz ointment can).
5. Spatula, approximately 4 inch metal blade.
6. Balance, with a minimum capacity of 2000 g, accuracy of 0.1 g and sensitivity of 0.1 g.
7. Oven, capable of attaining 300°F min.
8. Hot Oil Bath, controllable and able to maintain an oil temperature of 350°F min., sized to allow 2000-ml beaker to be supported min. of 1/4 inch above bottom when beaker submerged to 2/3 its depth. Oil not closer than 1 inch from top of bath when beaker is submerged.[2]
9. USP mineral oil, for oil bath, min. flash 420°F.
10. Beaker, 2000-ml (preferably stainless steel).[3]
11. White paper towels.
12. Utensils for handling hot containers (heat resistant gloves, beaker tongs, angle pliers).
13. Distilled or deionized water.
14. Timing device (ex: stopwatch or timing clock).

Addition of Antistripping Additives

If a commercial antistrip agent is to be evaluated, it must be blended with asphaltic material. Preheat the asphaltic material to the minimum asphaltic material temperature shown in Figure 1 of Test Method Tex-205-F. Weigh an amount of asphaltic material and antistrip agent into a metal can (6-oz) to yield approximately 100 grams of treated asphaltic material. A larger treated sample may be prepared using a larger container. Immediately mix the two materials by stirring with a small spatula for a minimum of two minutes. The concentration of antistrip agent is expressed as a percent of the treated asphaltic material.

If lime or lime slurry is to be evaluated, it should be blended and mixed well with the aggregate. Lime slurry-aggregate blends should then be oven dried at the temperature shown for mixing in Figure 1 of Test Method Tex-205-F. The concentration of lime is expressed as a percent of the aggregate.

Preparation of Mix

Using the designated asphaltic material and aggregates, prepare approximately 1000 grams of mix. The mixing procedure outlined in Test Method Tex-205-F shall be used, except the project aggregates need not be separated into various sizes. Instead, representative portions of each aggregate may be weighed together.

The mix then shall be allowed to cool to room temperature. Twenty-four ± two hours shall elapse between preparation of the mixture and performing the stripping test.

For HMCL mixtures which contain asphalt cement and primer, an asphalt-primer blend (no water) and any additional additives must be prepared in the ratio anticipated during plant production. This blend is mixed with the aggregate, as above, except that the blend and aggregate temperature shall be 200 ± 5°F.

HMCL mixtures will be subjected to the following curing process prior to testing. Immediately after mixing, spread the mixture no more than one coarse aggregate deep in a flat pan and place in a 190 ± 5°F oven for 3 hours ±15 minutes. The sample should be stirred at the midpoint of this period. Remove the sample from the oven and cool to room temperature for 2 hours ± 15 minutes. Immediately proceed with the stripping test.

If specified, HMCL material will be tested in the as-received condition. When tested in the as-received condition, a 200 gram representative sample shall be obtained and immediately tested.

Performing the Stripping Test

Bring the oil bath to a temperature between 325°F and 350°F. Obtain a 200 gram representative sample of the mix to be evaluated. Fill the 2000-ml beaker to approximately 1/2 capacity with distilled or deionized water and heat to boiling. Any convenient method may be used to heat the water, but the stripping test shall be performed in the oil bath. Add the 200 grams of mix to the boiling water and rotate the beaker to distribute the mix evenly over the bottom. Addition of the mix will temporarily cool the water below the boiling point. The beaker should be placed in the oil bath. The temperature of the oil bath should allow the water to begin boiling again within 3 minutes after addition of the mix. Maintain the water at medium boil for 10 minutes ± 30 seconds, then remove the beaker from the oil bath. Skim any asphalt from the surface of the water with a paper towel. Decant the water from the beaker and empty the wet mix onto a white paper towel.

Evaluation of the Mix

Visually estimate the degree of stripping present in the mixture. The mixture should also be examined after it has been allowed to dry for 24 ± 2 hours. Some mixes will evidence stripping of fine aggregate that is not apparent when the mix is wet.[4]

Report Test Results

The test results shall be reported as the estimated percent of stripping after the 24 hour drying period.

Precautions

Care should be taken not to get water in the oil bath, especially when it is hot. Observe the usual precautions in handling hot asphalt, aggregate, water, and oil.

Notes

1. Plant mixes may be tested by this procedure beginning with the cooling or curing requirements for HMHL or HMCL mixtures, respectively.

2. As an alternative to using an oil bath, the beaker may be heated with a Fisher Burner. The beaker should be supported on a ringstand (ring 4 1/4 inch I.D.) and a ceramic-centered iron wire gauze should be placed under the beaker and rested on the ring support. This will help distribute heat and produce more uniform boiling.

3. Metal beakers are recommended for use in the oil bath. Glass beakers may crack or break in the hot oil bath resulting in a safety hazard.

4. Examination of mix under slight magnification may aid in determining the extent of stripping.

APPENDIX G

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

JUL 31 1992
MATERIALS & TESTS

July 29, 1992

IN REPLY REFER TO

HB-TX

Texas Test Methods

Mr. Arnold W. Oliver
Executive Director
Texas Department of Transportation
Austin, Texas 78701

Attention: Mr. Billy R. Neeley

Dear Sir:

Please refer to your letter dated July 15, 1992. The test methods referenced in your letter substantially agree with the ASTM or AASHTO standard tests and thus are satisfactory to use for Federal Aid projects. Thank you for researching and listing these tests.

Sincerely yours,

J. W. Cravens, Jr.
Area Engineer

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

September 3, 1992

Subject: Texas Test Methods

Mr. Frank Mayer, P.E.
Attn: Mr. James Cravens, P.E.
Federal Highway Administration
826 Federal Office Building
Austin, TX 78701

Dear Sirs:

Reference is made to our letter of July 15, 1992, on the above subject.

Test Method Tex-314-D, Tex-427-A and Tex-428-A, which were listed in our letter of July 15, 1992, as being identical to either an ASTM or AASHTO Standard have been deleted from our Manual of Test Procedures.

The above is furnished for your information.

Sincerely,

Billy R. Neeley

Billy R. Neeley, P.E.
Director, Division of
Materials & Tests

LBC:co

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

July 15, 1992

Subject: Test Methods

Mr. Frank Mayer, P.E.
Attn: Mr. James Cravens, P.E.
Federal Highway Administration
826 Federal Office Building
Austin, TX 78701

Dear Sirs:

Reference is made to our letter of June 23, 1992, in which we transmitted a list of Texas Department of Transportation Test Methods which conform to either an ASTM or AASHTO standard. After future review, we have divided this list into test methods which are identical to either an ASTM or AASHTO standard and test methods which are technically identical to either an ASTM or AASHTO standard.

We have attached a list of the test methods which are identical and technically identical along with their corresponding ASTM or AASHTO standards for your review.

IDENTICAL

Test Method	Standard
Tex-301-D	ASTM C187
Tex-302-D	ASTM C266
Tex-303-D	ASTM C191
Tex-304-D	ASTM C190
Tex-305-D	ASTM C185
Tex-306-D	ASTM C305
Tex-307-D	ASTM C109
Tex-308-D	ASTM C151
Tex-309-D	ASTM C189 (Discontinued)
Tex-310-D	ASTM C115
Tex-311-D	ASTM C91
Tex-312-D	ASTM C359
Tex-313-D	ASTM C451
Tex-314-D	ASTM C114
Tex-410-A	ASTM C131

Identical Test Methods List - continued

IDENTICAL

Test Method	Standard
Tex-412-A	ASTM C123
Tex-427-A	ASTM E8, A370
Tex-428-A (Structural Steel, Wire)	ASTM A36, A82
Tex-443-A	ASTM E10, E18
Tex-446-A	ASTM C805
Tex-501-C	ASTM D95
Tex-502-C	ASTM D5
Tex-503-C	ASTM D113
Tex-504-C	ASTM D92
Tex-505-C	ASTM D36, D2398
Tex-506-C	ASTM D6
Tex-507-C	ASTM D2042
Tex-508-C	ASTM D70
Tex-509-C	AASHTO T102
Tex-510-C	ASTM D1754
Tex-512-C	ASTM D1310
Tex-513-C	ASTM D88
Tex-514-C	ASTM D244, D3142
Tex-515-C	ASTM D402
Tex-516-C	ASTM D1189 (Discontinued)
Tex-519-C	ASTM D139
Tex-520-C	ASTM D243
Tex-521-C	ASTM D244
Tex-523-C	ASTM D41, D146, D517, D1010
Tex-528-C	ASTM D2171
Tex-529-C	ASTM D2170
Tex-531-C	AASHTO T283
Tex-602-J	ASTM A90, A239

Technically Identical

Test Method	Standard
Tex-121-E	AASHTO T-220
Tex-124-E	AASHTO T-258
Tex-444-A	ASTM C457
Tex-445-A	ASTM C856

Test Methods Tex-402-A and Tex-809-B, which were included in our original list, have been omitted from this list because further review indicated these two test methods are modifications.

If you have any questions concerning the above or need additional information, please contact Lyt Callihan at 465-7629.

Sincerely,

Donald L. O'Connor

For Billy R. Neeley, P.E.
Director, Division of
Materials & Tests

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

DIVISION OF MATERIALS AND TESTS
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October 19, 1992

IN REPLY REFER TO
HB-TX

Texas Test Methods

Mr. Arnold W. Oliver
Executive Director
Texas Department of Transportation
Austin, Texas 78701

Attention: Mr. Billy R. Neeley

Dear Sir:

Please refer to your letter dated August 19,1992 which transmitted forty Texas Test Methods for our review.

The following Test Methods are approved for use on Federal Aid projects.

Tex-101-E	Tex-201-F	Tex 400-A	Tex-601-J
Tex-103-E	Tex-202-F	Tex-402-A	Tex-612-J
Tex-104-E Parts I & II	Tex-203-F	Tex-447-A	Tex-613-J
Tex-105-E	Tex-204-F	Tex-448-A	Tex-614-J
Tex-106-E	Tex-205-F	Tex-450-A	Tex-616-J
Tex-107-E	Tex-206-F	Tex-524-C	Tex-617-J
Tex-111-E	Tex-208-F	Tex-525-C	Tex-618-J
Tex-113-E	Tex-211-F	Tex-600-J	Tex-619-J
Tex-120-E	Tex-214-F		

It is our understanding that Tests Tex-518-C and Tex-610-J are to be deleted. Test Tex-615-J may be deleted since polyurethene waterproofing is seldom used at the present time. Test Tex-104-E Part III (Hand Method for Determining Liquid Limit) is to be phased out when the revised Standard Specifications are put into effect.

Tests Tex-200-F, Tex-449-A and Tex-500-C will be reconsidered after additional study and comparative tests have been completed by the Materials and Tests Division.

This has been discussed with Mr. Lyt Callihan of your office.

Sincerely yours,

J. W. Cravens, Jr.
Area Engineer

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

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January 22, 1993

IN REPLY REFER TO

Texas Test Methods

HB-TX

93 JAN 25 PM 2:41
DIVISION OF MATERIALS AND TESTS

Mr. Arnold W. Oliver
Executive Director
Texas Department of Transportation
Austin, Texas 78701

Attention: Mr. Billy R. Neeley

Dear Sir:

Please refer to your letter dated November 13, 1992 which transmitted twenty-eight Texas Test Methods for our review.

The following Test Methods are approved for use on Federal Aid projects:

Tex-110-E	Tex-411-A	Tex-424-A	Tex-901-K
Tex-118-E	Tex-415-A	Tex-438-A	Tex-902-K
Tex-135-E	Tex-416-A	Tex-439-A	Tex-903-K
Tex-407-A	Tex-419-A	Tex-900-K	Tex-907-K
Tex-409-A			

It is our understanding that TxDOT will be making the following revisions:

Tex-418-A, "Compressive Strength of Cylinder Concrete Test Specimens" will be revised to include the other pertinent information of ASTM C39/AASHTO T22. Tex-420-A, "Flexural Strength of Concrete" (Using Simple Beam with Carter-Paint Loading) will be phased out in favor of Tex-448-A (Using the Third Point Loading Method) when the new Standard Specifications are in effect. Tex-421-A, "Determination Modulus of Elasticity of Concrete" and Tex-423-A, "Resistance of Concrete to Rapid Freezing and Thawing" are essentially the same as ASTM C469 and ASTM C666/AASHTO T161 respectively. These two Test Procedures will be deleted from the Manuals of Testing Procedures during the next revision.

We offer the following recommendations:

Tex-108-E, "Determination of Specific Gravity of Soils" should require the weights of the soil samples be determined to the nearest 0.01 gram as outlined in AASHTO T100-90/ASTM U854-91.

Tex-115-E,"Field Method for Determination of In-Density of Soil and Base Materials (Part I)" should specify a minimum test hole volume as outlined in AASHTO T205-86/ASTM D2167-84.

Laboratory tests should be made comparing the results of Tex-127-E, "Fly Ash Compressive Strength Test Method" to the results of Test ASTM D5102-90, "Unconfined Compressive Strength of Compacted Soil-Lime Mixtures" (utilizing the specified mellowing of the soil-water lime mixture).

Tex-130-E, Part II, "Standard Test Method for Density of Drilling Slurries" should require the mud balance to be calibrated at 70°F as outlined in ASTM D4380.

Tex-401-A, "Sieve Analysis of Fine and Coarse Aggregate" should include a maximum weight requirement for aggregates to be sieved through the #4 and larger sieves as outlined in AASHTO T27-88/ASTM C136-84).

Laboratory tests should be made comparing the results of Tex-403-A, "Saturated Surface-Dry Specific Gravity and Absorption of Aggregates" utilizing a 1500 gram sample of coarse aggregate with the half-gallon glass pycnometer to the results of AASHTO T85/ASTM C127 utilizing a 4000 to 5000 gram sample of coarse aggregate weighed in a tank of water. Laboratory tests should be made comparing the results of Tex-403-A utilizing the Pan Tilt Method to the results of AASHTO T84/ASTM C128 utilizing the Sand Cone Method (to determine the Saturated Surface-Dry Condition of fine aggregates.) The fine aggregates should be weighed to the nearest 0.1 gram as outlined by AASHTO T84/ASTM C128.

Tex-417-A, "Weight Per Cubic Foot and Yield of Concrete" should specify that the concrete will be struck off with a glass or steel plate as outlined by ASTM C138/AASHTO T121.

This has been discussed with Mr. Lyt Callihan of your office.

Sincerely yours,

J. W. Cravens
Area Engineer

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

May 27, 1993

Mr. Frank Mayer, P.E.
Attn: Mr. James Cravens, P.E.
Federal Highway Administration
826 Federal Office Building
Austin, TX 78701

Subject: Texas Test Methods

Dear Mr. Mayer:

Reference your letter of May 3, 1993 on the above subject.

Test Method Tex-702-I has been revised to eliminate the reference to Test Method Tex-316-D. The revised test method will be included in our Manual of Testing Procedures.

Sincerely,

Billy R. Neeley

Billy R. Neeley, P.E.
Director
Division of Materials and Tests

/co

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

DIVISION OF
MATERIALS AND TESTS

93 MAY -5 AM 8:59

May 3, 1993

IN REPLY REFER TO

HTA-TX

Texas Test Methods

Mr. Arnold W. Oliver
Executive Director
Texas Department of Transportation
Austin, Texas 78701

Attention: Mr. Billy R. Neeley

Dear Sir:

Please refer to your letter dated February 17, 1993, which listed 142 Category C Texas Test Methods. There are no corresponding ASTM or AASHTO Standard Tests for the Category C Tests. These Texas Test Methods have been reviewed and are approved for use on Federal-aid projects. It is understood that Test Method Tex-702-I will be revised to correct the reference to Test Method Tex-316-D (which is being deleted).

Sincerely yours,

C L Chambers

C. L. Chambers
Technology Assistance Engineer

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

February 17, 1993

Mr. Frank Mayer, P.E.
Attn: Mr. James Cravens, P.E.
Federal Highway Administration
826 Federal Office Building
Austin, TX 78701

Subject: Texas Test Methods

Dear Mr. Mayer:

Attached please find a list of Texas Test Methods for which there is no corresponding ASTM or AASHTO Standards.

These Test Methods have been developed based upon military and other federal specifications, material manufacturer's data, equipment specifications and Department research. These Test Procedures have proven satisfactory in insuring that various materials meet specification requirements prior to incorporation into Department projects.

Questions concerning the above should be directed to Mr. Lyt Callihan at (512) 465-7629.

Sincerely,

Billy R. Neeley

Billy R. Neeley, P.E.
Director
Division of Materials and Tests

/co

Attachment

TEXAS TEST METHODS FOR WHICH THERE IS NO CORRESPONDING ASTM OR AASHTO STANDARD

Tex-102-E
Tex-109-E
Tex-112-E
Tex-114-E
Tex-116-E
Tex-117-E
Tex-119-E
Tex-122-E
Tex-123-E
Tex-126-E
Tex-132-E
Tex-140-E
Tex-205-F
Tex-209-F
Tex-215-F
Tex-216-F
Tex-217-F
Tex-220-F
Tex-223-F
Tex-224-F
Tex-229-F
Tex-409-A
Tex-422-A
Tex-429-A
Tex-430-A
Tex-431-A
Tex-433-A
Tex-434-A
Tex-436-A
Tex-440-A
Tex-441-A
Tex-442-A
Tex-460-A
Tex-517-C
Tex-522-C
Tex-526-C
Tex-530-C
Tex-532-C
Tex-533-C
Tex-534-C
Tex-535-C
Tex-604-J
Tex-605-J
Tex-606-J
Tex-607-J
Tex-608-J
Tex-611-J
Tex-620-J
Tex-700-I
Tex-701-I
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Tex-711-I
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Tex-920-K
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Tex-1010-S

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

July 29, 1993

Mr. Frank Mayer, P.E.
Attn: Mr. James Cravens, P.E.
Federal Highway Administration
826 Federal Office Building
Austin, TX 78701

Subject: Texas Test Methods

Dear Mr. Mayer:

Texas Test Methods which are modifications to ASTM or AASHTO Standards have been reviewed by your office and commented on in your letters of October 19, 1992, December 4, 1992, January 22, 1993, and May 3, 1993.

We offer the following comments regarding the modifications.

Tex-104-E - This test procedure will be revised to eliminate Part II and Part III.

Tex-108-E - This test procedure will be revised to require the weights of the soil samples to be determined to the nearest 0.01 grams as outlined in ASTM U854/AASHTO T100.

Tex-115-E - This test procedure will be revised to specify a minimum test hole volume as outlined in ASTM D2167/AASHTO T205.

Tex-130-E, Part II - This test procedure will be revised to require the mud balance to be calibrated at 70 ±2 F as outlined in ASTM D4380.

Tex-200-F - This test procedure will be revised to required the 0.3% tolerance on total weights as outlined in ASTM/AASHTO.

Tex-417-A - This test procedure will be revised to require the concrete be removed with a steel or glass plate as outlined in ASTM C183/AASHTO T121.

Tex-421-A - This test procedure will be deleted from the test procedures.

Tex-423-A - This test procedure will be deleted from the test procedures.

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

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Texas Test Methods

August 20, 1993

IN REPLY REFER TO
HTA-TX

Mr. Arnold W. Oliver
Executive Director
Texas Department of Transportation
Austin, Texas 78701

Attention: Mr. Billy R. Neeley

Dear Sir:

Please refer to your letter dated July 16, 1993, which transmitted thirteen Texas Test Methods for our review.

The following Test methods are approved for use on Federal-aid projects:

Tex-207-F	Tex-225-F
Tex-210-F	Tex-226-F
Tex-212-F	Tex-228-F
Tex-217-F, Part I	Tex-230-F
Tex-219-F	Tex-1000-S

We offer the following recommendations:

Comparative tests for Tex-213-F, "Determination of Hydrocarbon Volatile Content of Bituminous Mixtures," should be made with "water only" versus "water with 3 grams of Carbonate Sodium" as outlined in AASHTO T 110-88 and ASTM D 1461-85.

Tex-222-F, "Method of Sampling Bituminous Mixtures," should specify that the bituminous mixture shall be sampled from four points in a hauling vehicle, as outlined in AASHTO T 168-90.

Comparative tests for Tex-227-F, "Theoretical Maximum Specific Gravity of Bituminous Mixtures," should be made utilizing a residual pressure of 50 mm Hg versus a residual pressure of 30 mm Hg as outlined in AASHTO T 209-90 and ASTM D 2041-91.

This has been discussed with Mr. Lyt Callihan of your office.

Sincerely yours,

C L Chambers

C. L. Chambers
Technology Assistance Engineer

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

August 25, 1993

IN REPLY REFER TO

HTA-TX

93 AUG 26 AM 11 14
DIVISION OF MATERIALS & TESTS

Texas Test Methods

Mr. Arnold W. Oliver
Executive Director
Texas Department of Transportation
Austin, Texas 78701

Attention: Mr. Billy R. Neeley

Dear Sir:

Please refer to your letter dated July 29, 1993. The following revised Texas Test Methods are approved for use on Federal-aid projects:

- Tex-104-E
- Tex-108-E
- Tex-115-E
- Tex-130-E, Part II
- Tex-200-F
- Tex-417-A
- Tex-449-A
- Tex-806-B
- Tex-812-B

It is understood that Tests Tex-421-A and Tex-423-A are to be deleted. If you have questions concerning this, please contact Mr. Jim Cravens at 482-5966.

Sincerely yours,

C L Chambers

C. L. Chambers
Technology Assistance Engineer

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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
826 FEDERAL OFFICE BUILDING
AUSTIN, TEXAS 78701-3276

August 29, 1994

IN REPLY REFER TO

HTA-TX

MATERIALS AND TESTS DIVISION
94 AUG 31 AM 9:02

Texas Test Methods

Ms. Katherine H. Hargett, P.E.
Director of Materials and Tests Division
Texas Department of Transportation
Austin, Texas 78701-2483

Attention: Mr. Lyt Callihan

Dear Ms. Hargett:

Please refer to your letter dated August 3, 1994, which provided comments concerning previously reviewed Test Methods.

The following Texas Test Methods are approved for use on Federal-aid Projects:

Tex-213-F	Tex-401-A
Tex-222-F	Tex-404-A
Tex-227-F	

It is understood the other Test Methods listed in your letter will continue to be compared to the appropriate ASTM (or AASHTO) Test Procedures.

If you have questions concerning this, please contact me at 482-5966.

Sincerely yours,

James W. Cravens, Jr.
Materials Engineer

Texas Department of Transportation

DEWITT C. GREER STATE HIGHWAY BLDG. • 125 E. 11TH STREET • AUSTIN, TEXAS 78701-2483 • (512) 463-8585

August 3, 1994

Mr. Frank Mayer, P.E.
Attn: Mr. James Cravens, P.E.
Federal Highway Administration
826 Federal Office Building
Austin, TX 78701

Subject: Texas Test Methods

Texas test methods which are modifications to ASTM or AASHTO Standards have previously been reviewed and commented on by your office.

We offer the following comments regarding the modifications.

<u>Tex-213-F</u>
We have run some comparison tests to determine the effect of "water only" versus "water with 3 grams of carbonate sodium" as outlined in AASHTO T 110-88 and ASTM D 1461-85. Our comparison tests indicate that we consistently remove more hydrocarbon volatiles using our current procedure than when using the sodium carbonate. Therefore, we plan to leave our test method intact.

<u>Tex-222-F</u>
We shall revise this test procedure to specify sampling bituminous mixtures from four points in a hauling vehicle as outlined in AASHTO T 168-90.

<u>Tex-227-F</u>
This test procedure states "remove air which is entrapped around the sample by subjecting the contents of the pycnometer to a partial vacuum for 5 to 20 minutes. The residual pressure within the system must be lowered to 50 mm Hg or less absolute pressure before completion of the evacuation process." Manometer measurements at 50 mm Hg equates to a vacuum gauge reading of 27.9 inches Hg, and 30 mm Hg equates to a vacuum gauge reading of 28.8 inches Hg. The research work done during the development of our test procedure indicates that this difference does not affect the test results significantly. Therefore, we plan to leave our test method intact.

<u>Tex-100-E</u>
We will complete the evaluation as a part of our current test procedure revision effort by January 1995.

<u>Tex-127-E</u>
As an in-house research, we will complete this evaluation by July 1995.

<u>Tex-128-E</u>
We will complete this in-house research and comparison by January 1995.

<u>Tex-129-E</u>
We will complete this in-house research and comparison by July 1995.

<u>Tex-401-A</u>
The revised test method will include a sample size table identical to ASTM C 136.

<u>Tex-403-A</u>
The cone method for SSD determination has been added to the revised test method. We will complete the comparison of pycnometer versus basket and water for specific gravity determination by January 1995.

<u>Tex-404-A</u>
As part of our current test procedure revision effort, we will add the dry-rodded unit weight method (ASTM C 29) in the 400 series of the Manual of Test Procedures.

<u>Tex-432-A</u>
We will complete this comparison by July 1995.

Questions regarding the above may be directed to me at 512/465-7629.

Sincerely,

Lyt Callihan

Lyt Callihan
Internal Auditor
Materials and Tests Division

/co