Performance of Coarse Matrix High Binder Hot-Mix Asphalt Materials in the State of Texas

DHT- 42

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16. Abstract

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PERFORMANCE
of
COARSE MATRIX HIGH BINDER HOT-MIX ASPHALT MATERIALS
in the
STATE OF TEXAS

PREPARED
for
TEXAS DEPARTMENT OF TRANSPORTATION
and
TEXAS HOT-MIX ASPHALT PAVEMENT ASSOCIATION

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INTRODUCTION

Increased traffic volumes, greater truck weights and higher tire pressures have created the need to develop more rut resistant hot-mix asphalt mixtures. The introduction of stone mastic asphalt (SMA) into the United States from Europe in 1991; the results from the Strategic Highway Research Program (SHRP) on asphalt and asphalt mixtures (Superpave) in 1993; and the introduction of coarse matrix, high binder (CMHB) asphalt mixtures in Texas in 1993 have provided the engineer in the United States with hot-mix asphalt materials that provide stone-to-stone (aggregate-to-aggregate) contact to help resist permanent deformation or rutting in pavements. By the end of the construction season in 1996, over 100 SMA projects and over 100 Superpave projects had been placed in the United States.

The Texas Department of Transportation (TxDOT) has placed over 100 CMHB mixtures in Texas to date. In 1993, 12,000 tons of CMHB were placed by TxDOT. In 1994, an additional 300,000 tons and in 1995, a total of 1,700,000 tons were placed by TxDOT.

The early life performance results from SMA projects has mostly been good. A 1997 report on over 100 projects with SMA mixtures indicates that only 4 percent of the pavements had rut depths greater than 6 mm (0.25 in).[1] Longitudinal joint problems exist on some of the projects. The SMA mixtures appear to have better resistance to reflection cracking than conventional dense-graded hot-mix asphalt. Raveling and segregation do not appear to be a major problem. The greatest performance problem with SMA are "fat" spots caused by fines segregation, draindown, high asphalt binder content, and improper amounts of fibers or fines.

The early life performance of Superpave coarse-graded mixtures (mixtures which contain a relatively high percent of coarse aggregate) has not been documented. The limited information currently available suggests that performance has been good with these types of mixtures.

Performance of coarse matrix, high binder asphalt mixtures in Texas has in general been good. Some of the projects, however, have experienced poor performance and have been removed. Concerns for some of these early performance problems has resulted in a series of studies to define the performance of CMHB mixtures in Texas. A performance study conducted by TxDOT in 1995[2] indicated that the majority of the CMHB projects are perform ing satisfactorily. The CMHB mixtures are rut resistant and resistant to segregation during construction. Flushing was identified as the single largest problem by the performance review team. Mixture design and inadequate construction quality control were suggested as likely causes of flushing. Industry and a joint industry-TxDOT performance studies followed the initial TxDOT study in 1996.[3,4] Results of these studies, plus the collection and synthesis of other information from TxDOT files, are the basis for the study reported herein.

BACKGROUND

COARSE-GRADED MIXTURES

The three most popular coarse-graded hot-mix asphalt mixtures presently used in the United States are SMA, Superpave, and CMHB. All of these mixtures were developed to provide stone-to-stone contact within the aggregate of the hot-mix asphalt. Theory suggests that this stone-to-stone or aggregate-to-aggregate contact will carry the loads imposed by traffic without significant permanent deformation or rutting in the hot-mix asphalt layer. These types of mixtures do not significantly depend on the quality and quantity of the intermediate and fine aggregate to prevent rutting.

Coarse-graded mixtures in general have higher voids in the mineral aggregate (VMA) and thus, higher asphalt binder contents. The higher asphalt binder contents provide thicker films of asphalt on the aggregate and a more durable hot-mix asphalt mixture results. Since the relative amount of coarse aggregate is large and the amount of fine aggregate is small, segregation is generally not a problem with the coarse-graded mixtures.

Most SMA mixture use stabilizers (fibers or mineral filler) to prevent draindown of asphalt binder in the mixtures during construction. Superpave coarse-graded and CMHB mixtures in general do not have a draindown problem during construction and do not use fibers or mineral fillers.

Typical gradations for the coarse-graded mixtures presently used in the United States are shown in Table 1. SMA mixtures typically used in the United States have more coarse aggregate (retained on 4.75 mm (No. 4 sieve) than CMHB mixtures at approximately the same nominal maximum aggregate size. In general, the percent passing the 0.075 mm (No. 200) sieve is larger for the SMA mixtures than the typical CMHB mixture.

The Superpave coarse aggregate mixtures typically have lower percentages passing the 0.075 mm (No. 200) sieve fraction than the CMHB mixtures as the Superpave mixtures must satisfy the dust to asphalt binder ratio.

Figures 1 through 6 show gradation comparison among these types of coarse aggregate mixtures. The typical SMA gradation, as presently used in the United States is shown in Figures 1 and 2. Figure 1 shows the SMA compared to the 9.5 mm nominal maximum size Superpave mixture, while Figure 2 shows the SMA compared to the 12.5 mm nominal maximum size Superpave mixture. SMA mixtures have more coarse aggregate (retained on 4.75 mm (No. 4 sieve) and a higher percent passing the 0.075 mm (No. 200) sieve than Superpave mixtures.

Figures 3 and 4 compare the fine CMHB mixture with the Superpave 9.5 mm and 12.5 mm nominal maximum size aggregate mixtures. Figures 5 and 6 compare the coarse CMHB mixture with the Superpave 12.5 mm and 19 mm nominal maximum size aggregate mixtures. CMHB mixtures have more coarse aggregate (retained on the No.10 sieve than the Superpave mixtures.

SCOPE AND OBJECTIVES

The scope of the study is limited to the performance of CMHB on TxDOT projects. The objectives of the study are to review and evaluate CMHB mixture design procedures, specifications, construction records, and performance studies; to make visual inspections of pavements and interview TxDOT and industry personnel; and to recommend changes in the design method, specifications, and construction methods. TxDOT and Texas Hot-Mix Asphalt Pavement Association (THMAPA) have been charged with providing design procedures, specifications, construction records, performance studies, traffic data, and other information. Visual inspections of pavements and interviews with TxDOT and industry personnel have been performed in previous studies and by a current Federal Highway Administration effort. Pavement condition surveys and interviews were therefore not conducted in this study.

Information supplied by TxDOT and THMAPA is contained in appendices A through I as described by the title of the appendix as given below:

- Appendix A — Asphalt Binder Type and Properties
- Appendix B — Aggregate Sources and Properties
- Appendix C — Mixture Properties
- Appendix D — Traffic Characteristics
- Appendix E — Quality Control-Quality Assurance
- Appendix F — Joint TxDOT Industry Performance Study

Appendix G — Pavement Rating Scores

Appendix H — Comparison of Performance Surveys and Date Project Completed

Appendix I — Comparison of Variability Among Lots

Recommendations are based on the supplied data and the collective experience of the research team, including representatives from the consultant, TxDOT, and THMAPA. Reviews and evaluations are first presented for the mixture design method, specifications, and construction information. Performance information is summarized and analyzed. Recommendation relative to changes in mixture design, specifications, and construction are provided.

MIXTURE DESIGN METHOD

Specifications and test methods associated with the use of CMHB mixtures in Texas are shown in Table 2 (See references 5 through 18). The laboratory mixture design method for CMHB was developed by TxDOT. References 15 through 17 describe this procedure in detail. The documents describing the development of the mixture design method and basis for the criteria in the mixture design procedure have not been supplied and have not been reviewed.

In earlier versions of the mixture design method, the Texas gyratory compactor was utilized to compact mixtures to determine the optimum amount of material retained on the No. 10 sieve. The optimum percent of the aggregate retained on the No.10 sieve was determined by compacting mixtures with different percentages retained on the No.10 sieve at 4 percent asphalt binder. A graph of the compacted density versus percent by volume retained on the No.10 sieve was used to select the optimum percent retained on the No. 10 sieve (at maximum density). Once the percent retained on the No. 10 sieve was determined, 2.5 percent by volume of No. 10 was added to this number to allow for aggregate breakdown during the construction operation. Currently, this optimization procedure for the No.10 sieve is not used.

At present, design asphalt binder content is determined by using the Texas gyratory compactor to compact samples at various asphalt binder percentages. The binder percent that provides a compacted mixture at 3.5 percent air voids is considered optimum. Minimum VMA criteria are specified as well as parameters from the static creep test (creep stiffness, permanent strain, and creep slope).

The static creep test is performed on 100 mm (4 inches) diameter by 50 mm (2 inch) thick samples. Samples are preconditioned with three load cycles prior to applying a fixed or creep load to the sample. The load is held for 60 minutes and released for 10 minutes. Permanent strain, creep stiffness, and the slope of the steady state creep strain-time curve is calculated. Stiffness is defined at the load divided by the total strain during the 60-minute creep test. Criteria for mixture acceptance is based on these parameters.

SPECIFICATIONS

Specifications associated with the use of CMHB mixtures in Texas are shown in Table 2 (See references 5 through 14). The first specification was issued in December of 1993 after the placement of an experimental CMHB section in the Austin district of TxDOT in the summer of 1993. The specification for CMHB has been revised several times with the latest specification issued in April of 1996.

Tables 3A and 3B provides a summary history of the changes in specifications for CMHB. Changes in aggregate gradation, laboratory mixture design, trial mixture, and operational tolerances are summarized.

The specifications contain a fine and coarse gradation for CMHB mixtures. Gradation changes in the fine CMHB mixtures include: allowing higher percentages of 9.5 mm (3/8 inch) aggregate; increasing the range on the 4.75 mm (No. 4) sieve; placing controls on the No.10, No. 40 and No. 80 sieves; and increasing the amount passing the 0.075 mm (No. 200 sieve).

The laboratory molded density for selection of the optimum asphalt binder content during the mixture design process has changed from 3 percent to 4 percent to 3 percent to 3.5 percent in the various specifications.

The requirement for creep slope has increased while the creep stiffness has remained unchanged and the permanent strain criteria has increased.

At the start of a paving project, a trial hot-mix asphalt mixture is produced and tested. The laboratory molded density of the plant produced mixture is specified. The acceptable range has changed from 1.5-4.0 percent air voids to 3.0-4.0 percent air voids to 2.0-4.0 percent air voids to 2.5-3.5 percent air voids to 2.5-4.5 percent air voids. Similar changes in air void requirements were made in the specifications for mixtures produced during the paving operation.

During the implementation of the CMHB technology, the hot-mix asphalt specification was changing from a method type of specification to a quality control-quality assurance type of specification. Control and acceptance criteria for CMHB were added to the quality control-quality assurance specification near the end of the development process. Controlled trial projects using CMHB mixtures were not conducted prior to inclusion of CMHB in the new quality control-quality assurance specification. The various specification changes noted above were made based on field experience to improve performance of the CMHB mixtures as well as to include statistically significant criteria into the new quality control-quality assurance specification.

CONSTRUCTION INFORMATION

Construction information for several projects was supplied by TxDOT. A statistical summary of the data available is shown in Tables 4 through 11 and contained in Appendix E. Asphalt binder type, aggregate type, mixture properties, and quality control-quality assurance information is reviewed below.

ASPHALT BINDERS

The type of asphalt binder used on the CMHB projects was provided by TxDOT and is summarized in Appendix A. Reference 18 contains the specification that describes the physical property requirements of the various binders. Table 4 provides the specification for latex-modified asphalt cement.[18] Neat asphalt cements, latex modified asphalt cement, SBS modified asphalt cement, and crumb rubber modified asphalt cement were utilized on the CMHB projects. Physical properties for binders used on specific projects were not supplied by TxDOT.

AGGREGATES

The general type of aggregate used on the projects is summarized in Appendix B. The source of the aggregate was provided for only a few of the projects. References 5 through 14 contain the physical requirements for the aggregates. The specification designation used for particular projects and aggregate test properties were not identified by TxDOT for the majority of the projects and thus, the aggregate requirements for a particular project are not summarize. Aggregate property requirements have not changed historically with specification changes.

The surface texture, shape, and durability of the coarse and fine aggregate are important when selecting aggregates for use with CMHB mixtures. Crushed dolomite, crushed granite, crushed limestone, crushed sandstone, and crushed gravel were used as coarse aggregate. Dolomite screenings, field sand, and limestone screenings were used as fine aggregate. Most of the projects utilized crushed limestone as coarse aggregate and limestone screenings as the fine aggregate.

MIXTURE PROPERTIES

Mixture properties and mixture design information was available on 15 projects. A summary of available information is shown in Appendix C. Stiffness, permanent strain, and slope of the strain-time curve information from laboratory creep tests are reported and statistics for these parameters are reported when sufficient information was available.

QUALITY CONTROL / QUALITY ASSURANCE DATA

Quality control-quality assurance (QC-QA) information was supplied by TxDOT for 17 projects. These data are summarized in appendix E and Table 5. Statistics have been calculated for each project by job mix formula (JMF) for contractor performed tests. Information is available for asphalt binder content, percent retained on the (No. 10) sieve, percent passing the 0.075 mm (No. 200) sieve, field mixed-laboratory compacted density, and field air void content. Statistics reported are mean, standard deviation, and number of test results.

Comparison with Target Values

Appendix E contains a comparison among contractor quality control mean values for asphalt binder content, percent retained on the 2.0 mm (No. 10) sieve and percent passing the 0.075 mm (No. 200) sieve and target values for 17 CMHB projects. Fifty-five different job mix formula were used on these 17 projects. Higher than target asphalt contents were obtained on 54 percent of the data sets. A higher percent retained on the 2.0 mm (No. 10) sieve was obtained on 55 percent of the data sets and a higher percent passing the 0.075 mm (No. 200) sieve was obtained on 44 percent of the data sets. These data suggest that the projects were controlled without bias to the high or low side of the targets for asphalt binder content, retained on the 2.0 mm (No. 10) sieve, and percent passing the 0.075 mm (No. 200) sieve.

The magnitude of the variation of the contractor quality control tests from the target values are shown in Appendix E and Table 11. Fifty-two percent of the data sets have variability associated with asphalt binder content less than 0.09 percentage points. Only 9 percent of the data sets have variability greater than 0.3 percentage points for asphalt binder content.

Fifty-five percent of the data sets have variability associated with retained on the No. 10 sieve less than 0.9 percentage points. Only 13 percent of the data sets have variability greater than 2.0 percentage points.

Fifty-three percent of the data sets have variability associated with passing the 0.075 mm sieve (No. 200) sieve less than 0.4 percentage points. Only 1 percent of the data sets have variability greater than 2.0 percentage points. With the exception of a few projects, the quality control information suggest that asphalt binder and aggregate gradations were near targets and the projects were well controlled.

A general relationship between asphalt binder content and percent passing the 0.075 mm (No. 200) sieve is not apparent when reviewing the data in Appendix E. In general, field mixed-laboratory compacted and field mixed-field compacted air voids can be controlled by decreasing asphalt binder content and increasing percent passing the 0.075 mm (No. 200) sieve material or by increasing the asphalt binder content and decreasing the 0.075 mm (No. 200) sieve material. With the exception of a few of the 17 projects, this trend was not evident.

Comparisons of Lots

Appendix I contains a comparison of means and variability among lots for specific job mix formula for six projects. Sufficient data were available for analysis purposes from projects in Atlanta (US 59 and IH 20), Odessa (US 385), and Waco (IH 35W, SH 171 and LP 340). Contractor quality control test data were available from all five projects and TxDOT quality assurance test data were available from two projects.

A review of the data presented in the figures in Appendix I suggests that only a few lots are statistically significantly different (95 percent confidence interval) from other lots for specific job mix formula and for either contractor or TxDOT data sets. Data are available for asphalt binder content, percent retained on the No. 10 sieve, percent passing the 0.075 mm (No. 200) sieve, field mixed-laboratory compacted density, and in-place air voids.

Typical Construction Variability

Appendix E contains statistical information (standard deviation) that describes construction variability as measured by contractor quality control tests. Table 5 contains a summary of these data for lots with larger data sets associated with these 17 projects. The average standard deviation for asphalt binder content is 0.19, for percent retained on the 2.0 mm (No. 10) sieve the standard deviation is 1.5, for percent passing the 0.075 mm (No. 200) sieve the standard deviation is 0.55, for field mixed, laboratory molded density the standard deviation is 0.53, and for in-place air voids, the standard deviation is 1.02.

Typical variability (expressed as a standard deviation) for dense-graded hot-mix asphalt construction projects in the United States for asphalt binder content is about 0.30, for the 2.0 mm (No. 10) sieve about 2.5 to 3.0, for percent passing the 0.075 mm (No. 200) sieve about 1.0, for field mixed-laboratory molded density about 0.8 to 1.0, and for in-place air voids about 1.0 to 1.5. With the exception of a very few jobs (Table 5), the construction variability was below or within normally accepted ranges.

Comparison of TxDOT and Contractor Test Results

Tables 6 through 10 contain a summary of a comparison of contractor and TxDOT quality control-quality assurance test results. Sufficient data was supplied on eight projects by TxDOT to allow for this statistical comparison for asphalt binder content (Table 6), percent retained on the No. 10 sieve (Table 7), percent passing the 0.075 mm (No. 200) sieve (Table 8), field mixed-laboratory molded density (Table 9), and in-place air void content (Table 10). The "F" and "t" statistical tests were utilized to compare variance and mean values of contractor and TxDOT companion data sets for specific projects and specific job mix formula.

Comparisons for asphalt binder content (Table 6) indicate that six of the eight comparisons are not statistically significantly different at a level of confidence of 95 percent. Comparisons for percent retained on the No. 10 sieve (Table 7) indicate that none of the eight data sets were statistically significantly different. Comparisons for percent passing the 0.075 mm (No. 200) (Table 8) indicate that six of eight comparisons are not statistically significantly different.

Data sets for the field mixed-laboratory compacted density comparisons are not statistically significantly different for all eight projects. Data comparisons are possible for only two projects for in-place air void contents (Table 10). The means of the two data sets are not statistically significantly different.

PERFORMANCE INFORMATION

TxDOT and the THMAPA have collected performance information on CMHB mixtures. Information from these studies is contained in references 2 through 4. TxDOT has performed limited forensic studies on two projects which are contained in references 19 and 20. An industry partner has performed a study on one project.[21] Information is summarized from these studies and presented below.

TXDOT STUDY[2]

In the fall of 1995, a team of TxDOT engineers visited 21 districts and reviewed information on 77 CMHB projects. This study indicated that the majority of the projects are performing satisfactorily and that the mixtures are rut resistant and have reduced aggregate segregation. Flushing and permeability were noted as the major problem that existed in the projects.

Of the 80 projects with reported performance information, 23 percent reported some level of flushing. Five percent of the projects reported rutting at some level and 3 percent reported slippage types of problems. In general, Abilene, Amarillo, Austin, Brownwood, Bryan, Dallas, El Paso, Houston, Lubbock, San Angelo, San Antonio, and the Yoakum districts reported good performance. The Atlanta, Childress, Ft. Worth, Lufkin, Odessa, Pharr, Tyler, Waco, and Wichita Falls districts reported some performance problems with CMHB mixtures.

The TxDOT review team indicated that the excessive asphalt binder content was largely due to erroneous mixture design and/or inadequate construction quality control. Suggested revisions in the mixture design process and specifications were suggested in the study. Summaries of the visits were presented by district in the report.

INDUSTRY STUDY[3]

In the spring of 1996, the THMAPA conducted a survey of 15 construction firms that reported placing 54 CMHB mixtures in 14 TxDOT districts. The responses of this survey indicated that most projects are in fairly good condition with flushing being the major problem. Rough riding surfaces, degradation of aggregate during compaction, inability to hand rake, draindown on long hauls, and rapid loss of temperature were other problems mentioned in the survey. Some sections of pavement were also removed during and relatively shortly after construction.

The construction community favors the use of the QC/QA specification for conventional mixtures, but does not feel that the QC/QA specification allows sufficient flexibility necessary to adjust for the sensitivity of CMHB mixtures. The consensus of the respondents was that CMHB should be considered experimental until design and construction problems are resolved.

Based on this survey and other information gathered, the THMAPA indicated that CMHB are good in concept and will result in a valuable paving material. However, THMAPA suggests that TxDOT restrict the use of CMHB to selective projects for performance evaluation. The THMAPA also indicates that the QC/QA problems that have been experienced in Texas are not CMHB problems and, therefore, the problems with CMHB and the QC/QA specification should be initially separated.

JOINT TXDOT-INDUSTRY STUDY[4]

A joint TxDOT-Industry survey was conducted in the fall of 1996.[4] A CMHB pavement performance evaluation form was used to evaluate the condition of CMHB mixtures placed state-wide. The performance surveys were to be performed by a joint team of TxDOT-Industry representatives at the local level. Results of the pavement condition surveys were summarized by TxDOT and are shown in Appendix F. Recorded information included cracking, rutting, flushing, friction, performance comparisons between conventional dense-graded and CMHB, planned future use of CMHB, and general comments.

Based on information from the author's files, two of the projects evaluated were misrepresented by the joint TxDOT-Industry survey (Childress IH-40 and Tyler LP 323). CMHB was not used in Childress on IH-40 and the CMHB was placed on intersections on LP 323 in Tyler. The intersections in the he Tyler district were removed shortly after placement. The Tyler LP 323 project was therefore assigned a pavement rating score of 40.

Relative Performance

Table 12 contains a summary by district of the relative performance of CMHB mixtures as compared to conventional dense-graded hot-mix asphalt materials. This summary was prepared from Appendix F and Appendix G and is based on the joint TxDOT-Industry performance survey. The Abilene, Lubbock, Odessa, San Antonio, and Yoakum districts report generally favorable results. The Brownwood, El Paso, and Wichita Falls districts report relatively poor performance as compared to conventional dense-graded hot-mix asphalt. Some districts reported mixed performance.

A total of 96 projects are summarized in Table 12. CMHB mixtures were judged to be performing better on 30 projects, about the same on 15 projects, and not as good on 20 projects as compared to conventional dense-graded mixtures. Relative performance information was not reported on 31 projects. These data indicate that relative performance is not clearly evident in the opinion of the TxDOT engineers and the contractor personnel.

Pavement Rating Score

Based on the joint TxDOT-Industry survey, a numeric score was determined to allow for analysis of the performance information. Table 13 shows the deduct points associated with the various types and the extent of distress. Some interpretation of the information was necessary to determine the Pavement Rating Score (PRS) which is 100 minus the sum of the deduct points shown in Table 13. Appendix G shows the PRS for the pavements evaluated.

Appendix H provides a table to allow for the comparison of the TxDOT study[2] reported in December 1995, the industry survey reported in June of 1996,[3] and the joint survey reported in November of 1996.[4] The performance reported by TxDOT in December 1995 and industry in June 1996 are identical as one was copied from the other. With the exception of one pavement (Waco-IH 35W), all pavements that were identified with good performance in the December 1995 TxDOT survey had pavement rating scores above 80 based on the joint TxDOT-Industry survey of November 1996. The Waco-IH 35W project has mainly localized areas of flushing and rutting and mostly in the northbound lane.

FORENSIC INVESTIGATIONS

Two forensic types of investigation reports were supplied by TxDOT.[19,20] TxDOT[19] and an asphalt binder supplier[21] both performed forensic type reports on IH 20 in the Fort Worth district. The third forensic report prepared by TxDOT was for Kemp Street in the Wichita Falls district.[20] The forensic reports will be briefly summarized below.

Fort Worth District-IH 20[19,21]

The TxDOT report on the IH 20 project[19] indicates that several factors contributed to the flushing and rutting experienced on the project. Two binders were used on this project; a latex-modified asphalt cement and a multigrade asphalt. Evaluation of mix design information and the performance of the mixture suggests that a slightly lower asphalt binder content (0.2 percent) could have been used on the project. During construction, the asphalt binder content was increased from 5.5 to 5.6 percent. In addition, the project experienced higher than normal variability in asphalt binder content.

The percent passing the 0.075 mm (No. 200) sieve increased during the conduct of the project in the multigrade asphalt section. Field mixed, laboratory molded densities were high on several samples of mix taken during the project. Low in-place air voids were also experienced on the project.

Another factor contributing to the flushing of the mixture was the high moisture content of the aggregate as it entered the plant. Factors contributing to rutting of the mixture include the number of fracture faces on the aggregate, the over asphalting of the mixture, and the loss of bond between the overlay and the existing pavement.

The asphalt supplier report prepared for the IH 20 project[21] indicates that the major causes of the distress were associated with the high moisture content in the hot-mix asphalt. An increase in the minus 0.075 mm (No. 200) was also identified as a problem. An increase of 2.5 percent in minus 0.075 mm (No. 200) material decreased the air voids 2 percentage points in a laboratory study. Minus 0.075 mm (No. 200) material was consistently 2 to 3 percent higher than the laboratory design or target for this sieve.

Wichita Falls District Kemp Street[20]

Kemp Street experienced premature rutting and reflection cracking. The report did not investigate the materials aspect of the distress problems noted on Kemp Street.

DATA ANALYSIS

This section of the report provides an analysis of data available at the time of the preparation of the report. Project traffic information and project age were obtained for analysis purposes. Data sets were prepared project by project and statistical analyses were performed on grouped data. A summary of this effort is provided below.

TRAFFIC DATA

Equivalent 18 kip axle load data for the design life of the pavement was obtained by TxDOT. Average daily traffic, percent trucks, and design life 18,000 lb single axle load (ESALs) were provided for some of the CMHB projects. These data are contained in Appendix D.

PROJECT AGE

The date the project was competed was provided by TxDOT for most of the CMHB projects. Appendix H shows the completion date for these projects. Table 14 shows the pavement age at the time of the performance survey based on these completion dates.

SUMMARY OF DATA SETS

Table 14 shows a listing of available information on the CMHB mixtures evaluated in the November 1996 joint TxDOT-Industry survey. Binder type, aggregate type, traffic (ESAL), and the age of the project types of data are available for most of the projects. Mix design, QC/QA, specification, and forensic investigation types of information are not available on most of the projects. The absence of these detailed data sets limits the analysis.

Projects with Greater than 7 Million ESALs

Table 15 shows available information of CMHB projects with in excess of 7 million ESALs (34 projects). Since the life of the CMHB projects is short, the higher traffic facility pavements will provide the best indication of the long-term performance of this type of coarse-graded mixture.

Projects with Greater than 7 Million ESALs and PRS Below 80

Table 16 shows data for pavements with CMHB mixtures with traffic volumes greater than 7 million ESALs and with pavement rating scores 80 and below. As discussed previously, almost all pavements that were rated as good performers had scores of 80 and above. Available information on 13 pavements are summarized in Table 16 and will be briefly discussed below.

Of the 13 projects identified in Table 16, only two (Fort Worth IH 20 and Waco IH 35W) have QC/QA data available. The likely causes of the distress experienced in the pavement in the Fort Worth district has been discussed previously under the forensic analysis section of the report.

Tables E17 and E18 in Appendix E contain a summary of QC/QA data for the Waco IH 35W project. The standard deviation of the asphalt binder content is higher than expected on four of the nine job mix formulas used to construct the project. Laboratory compacted density measurements on field produced mix indicates that the air voids were less than 3 percent on five of the nine job mix formulas used on the project. In-place air void data have not been reported for the project.

Table E18 indicates that the asphalt content was greater than the target for all of the data sets reported. Some of the data indicate an average deviation from target of 0.2 to 0.3 percentage points. The percent passing the 0.075 mm (No. 200) sieve was high on five of the nine reported data sets. The percent retained on the No. 10 sieve was greater than the target

on all but three of the nine reported data sets. Higher than design asphalt binder contents and higher than target percent passing the 0.075 mm (No. 200) sieve probably contributed to the severe localized rutting and flushing reported on the project.

Four of 13 projects used crushed gravel and seven of the projects used crushed limestone. The type of aggregate was not identified on two of the projects.

The type of asphalt used on the eight projects includes: AC-20, AC-20 plus latex, crumb rubber modified asphalt, and multigrade asphalt. AC-20 was used on nine of the projects. AC-10 or AC-20 plus latex was used on three of the projects. A crumb rubber modified asphalt binder was used on one project. Based on these data, aggregate type and asphalt type by themselves do not explain the relatively poor performance of these pavements.

PAVEMENT PERFORMANCE AND AGE

Pavement performance as indexed by the pavement rating score is plotted versus age of the pavement in Figure 7 for all traffic volumes. A general relationship between pavement performance and pavement age is not evident. Figures 8 through 11 show the same relationship between pavement performance and age with the level of traffic identified. Traffic levels of 0 million to 7 million, 7 million to 20 million, and greater than 20 million ESALs were selected for use in this study. Figure 8 identifies several of the projects on the graph for ease of reference. Figures 9 through 11 are plots of performance versus age for individual traffic volume groups. A general performance curve cannot be established for age based on traffic level.

PAVEMENT PERFORMANCE AND DESIGN ESAL

Pavement performance as indexed by the pavement rating score is plotted versus design ESAL for the projects in Figure 12. A general performance curve cannot be obtained from these data. Figure 12 identifies several of the projects on the graph for ease of reference.

Figures 9 through 12 indicate in general that the higher design traffic volume pavements are experiencing more distress than the lower traffic volume facilities (Figure 9 in contrast to Figures 10 and 11). Figure 12 indicates that, in general, a relatively high percent of the pavements are experiencing relatively poor performance when the traffic volumes are above about

7.5 million ESALs. However, if the Ft. Worth IH-20 and the Waco IH-35W projects are removed from the plots (as their poor relative performance has been mostly attributed to high asphalt content and high minus 0.075 mm (No. 200) sieve materials); the relationship between performance and design ESAL is not clear. If QC/QA records were available on more of the mixtures with PRS 80 and below, the presence or lack of a relationship between performance and design ESAL would more likely be evident.

PAVEMENT PERFORMANCE AND ACCUMULATIVE ESAL

Pavement performance as indexed by the pavement rating score is plotted versus accumulative ESALs for the projects in Figures 13 through 16. Accumulative ESALs were calculated from the design ESAL data and the age of the pavement assuming that the design ESALs were for a 20-year life.

A general performance curve cannot be obtained from these data. Figures 13 through 16, however, indicate in general that the higher accumulative traffic, the poorer the performance. Figure 13 indicates that a relatively high percent of the pavements are experiencing relatively poor performance when the accumulative ESALs exceed about 1 million. However, if the Ft. Worth IH-20 and the Waco IH-35W projects are removed from the plots (as their poor relative performance has been mostly attributed to high asphalt content and high minus 0.075 mm (No. 200) sieve material); the relationship between performance and accumulative ESALs is not as clear. If QC/QA records were available on more of the mixtures with PRS 80 and below, the presence or lack of a relationship between performance and accumulative ESALs would more likely be evident. In addition, as time and traffic increases for the projects with relatively low accumulative ESALs, the performance trend should become more evident.

PAVEMENT PERFORMANCE AND ASPHALT CONTENT

Pavement performance as indexed by the pavement rating score is plotted versus asphalt binder content in Figures 17 to 20 for various traffic levels. Project designations are identified in the figures for ease of reference.

Only a general relationship exists between pavement condition and asphalt content. Since asphalt content is relative to the characteristics of a particular mixture, Table 17 was prepared to define the deviation from target values for the projects with QC/QA data as provided in Table 5 and Appendix E. A plot of pavement performance versus the deviation of asphalt content from the target is shown in Figure 21. A relationship is not apparent. Pavement age, accumulative traffic, and percent passing the 0.075 mm (No. 200) sieve (among other factors) compound the establishment of this general relationship.

PAVEMENT PERFORMANCE AND MINUS 0.075 MM (NO. 200)

Pavement performance as indexed by the pavement rating score is plotted versus percent passing the 0.075 mm (No. 200) sieve in Figures 22 through 25 for various traffic levels. Project designations are identified in the figures for ease of reference.

Only a very general relationship exists between pavement condition and percent passing the 0.075 mm (No. 200) sieve (Figure 22). For percent passing the 0.075 mm sieve (No. 200) sieve greater than approximately 6 percent, problems with pavement performance are more likely. Note that only three projects have minus 0.075 mm (No. 200) less than about 5.9 percent. Additional QC/QA data are needed to define the existence of a possible relationship.

Since percent passing the 0.075 mm sieve (No. 200) is related to the characteristics of a particular mixture, Table 17 was prepared to define the deviation from target values for the projects with QC/QA data as provided in Table 5 and Appendix E. A plot of pavement performance versus the deviation of percent passing the 0.075 mm (No. 200) sieve from the target is shown in Figure 26. A general relationship does not exist between performance and deviation from the target value. Pavement age, accumulative traffic, and asphalt content confound the establishment of this relationship.

PAVEMENT PERFORMANCE AND LABORATORY MOLDED DENSITY OF FIELD MIX

Pavement performance, as indexed by the pavement rating score, is plotted versus the laboratory molded density obtained on field or plant produced hot-mix asphalt in Figures 27 through 30 for various levels of traffic. Project designations are identified in the figures for ease of reference.

Only a very general relationship exists between pavement performance and laboratory molded density of field-produced mixtures. In general, when the laboratory molded density exceeds about 97 percent relative density or 3 percent air voids, pavement performance problems are more likely. Note that only three projects have relative densities above 97 percent. Additional QC/QA data are needed to define the existence of a possible relationship.

PAVEMENT PERFORMANCE AND FIELD AIR VOID CONTENTS

Pavement performance as indexed by the pavement rating score is plotted versus the field or in-place air voids in Figures 31 through 34 for various levels of traffic. Project designations are identified in the figures for ease of reference.

Only a very general relationship exists between pavement performance and in-place air voids for this very limited data. In general, when the in-place air voids are less than about 6.5 percent, pavement performance problems are more likely. This criteria may be indirect evidence that if CMHB mixtures are relatively easy to compact in the field, performance problems are more likely.

PAVEMENT PERFORMANCE AND LABORATORY MIXTURE PROPERTIES

Pavement performance as indexed by the pavement rating score is plotted versus laboratory mixture properties in Figures 35 through 37. Mixture properties obtained from laboratory mixed and laboratory compacted samples during the mixture design process are shown in Appendix C. Improved resistance to rutting can be obtained with mixtures with high creep stiffness, low permanent strain, and low creep slopes. Mixture properties currently specified are given below:

creep stiffness	minimum	6,000	psi
permanent strain	maximum	6×10^{-4}	in/in
creep slope	maximum	4×10^{-8}	in/in/s

A summary of the changes that have been made in the specification for these mixture properties are shown in Tables 3A and 3B.

A plot of pavement performance and creep stiffness is shown in Figure 35. If the Waco SH 7 project is removed from the data set, a general relationship exists which suggests that an increase in stiffness will result in relatively poor performance. The limited database, and the fact that these are laboratory produced and not field produced mixture properties, contribute to the poor agreement between the data trends and theory.

A plot of pavement performance and permanent strain is shown in Figure 36. A general relationship does not exist in this graph. The limited database, and the fact that these are laboratory-produced and not field-produced mixture properties, contribute to poor agreement between the data and theory.

A plot of pavement performance and creep slope is shown in Figure 37. A general relationship does not exist on this graph. The limited database, and the fact that these are laboratory-produced and not field-produced mixture properties, contribute to poor agreement between the data and theory. A larger database and longer term performance information is needed to resolve the differences between expected theoretical behavior and observed field performance as many compounding effects are possible.

RECOMMENDATIONS

Performance, traffic and pavement age information is available on nearly 100 CMHB pavements placed by TxDOT during the period 1993 through 1996. Construction quality control-quality assurance information is available on 17 of these projects. These data, the analysis of these data, and TxDOT specifications and test methods are the basis for the recommendations provided below under the headings of mixture design, specifications, construction methods, and use of CMHB mixtures. The availability of additional QC/QA data would greatly improve the basis for the recommendations given below. The recommendations are based on a very conservative evaluation of the available information and information available from other coarse-graded mixtures (SMA and Superpave).

The recommendations are intended to improve the performance of CMHB mixtures by reducing the relatively frequently reported incidents of flushing and rutting. The occasional problems of slippage, ride, degradation of aggregate, inability to hand rake, and draindown are generally not considered in the recommendations.

DESIGN PROCEDURE

The mixture design procedure is based on volumetrics and material characterization tests. The current recommended laboratory mixed-laboratory compacted air void criteria for selection of the optimum asphalt content is 3.5 percent based on theoretical maximum specific

gravity. Based on the very limited information obtained in this study and from a nationwide evaluation of SMA mixture, it is recommended that this criteria remain at the 3.5 to 4.0 level. An increase above this level is not warranted even though SMA studies indicate levels above 4.0 will provide improved performance. SMA mixtures are typically designed using 50 blow Marshall compaction which results in a mixture with about 4 percent air voids when the Texas gyratory compactor will produce a mixture at about 2 percent air voids. An increase in the air void content criteria will reduce the asphalt binder content and could cause durability problems.

The mixture characterization test is a creep test and is performed on 50 mm (2 in) by 100 mm (4 in) gyratory compacted samples or cores from the field. While the sample size is convenient, considerable end loading effects are likely with this size sample. In addition, creep testing has not been well accepted in the research community as a predictor of permanent deformation of hot-mix asphalt.

Unfortunately, a universally acceptable test to predict permanent deformation is not presently available. The dynamic shear test developed in the SHRP research effort and research that has been initiated at the University of Maryland offer some promise. The University of

Maryland study will likely investigate a creep test.

The basis for the test method and the acceptance criteria for creep stiffness, permanent stain and slope of the strain-time plot should be better defined. Information describing the development of the test method and the establishment of the acceptance criteria was not supplied. Thus, an evaluation of the test method or the acceptance criteria was not made. It should be noted that the test temperature is 50 C (104 F) which is considerably lower than maximum pavement temperature in Texas.

It is recommended that the present testing technique for CMHB not be altered at this time as a more suitable technique is presently not available for implementation. The research effort at the University of Maryland should be completed prior to TxDOT performing an extensive research project to address this problem. The effort should develop suitable tests for both dense-graded and CMHB mixtures.

To address the sensitivity of CMHB mixtures to asphalt binder content and percent passing the 0.075 mm (No. 200) sieve, it is recommended that a mixture design curve be performed not only at the desired fines content, but also at 1.5 percentage points above and below the desired content. This additional testing will allow for the determination of the sensitivity of these types of mixtures to variation in asphalt binder content and fines.

SPECIFICATION

The early performance of CMHB mixtures indicates that they may be very sensitive to changes in asphalt binder content and percent passing the 0.075 mm (No. 200) sieve. Changes in the specification shown in Tables 3A and 3B reflect this concern.

The amount of change in asphalt content and percent passing the 0.075 mm (No. 200) sieve allowed in the specification between job mix formula 1 (laboratory mixture design) and

subsequent job mix formula should be reduced if possible. The asphalt binder content can change up to 0.5 percentage points from the laboratory mixture design (JMF 1) to subsequent JMFs under the existing specification. This limit should be reduced if possible.

The percent passing the 0.075 mm (No. 200) sieve can change up to plus or minus 3 percentage points from the laboratory mixture design (JMF 1) to subsequent JMFs under the existing specification. This limit should be reduced if possible.

Information contained in this report and general observation of Superpave mixtures indicates that the 0.075 mm (No. 200) sieve material need to be controlled in the mix design process and the construction process. CMHB limits for mix design purposes are currently set at 6 to 10 percent. Improved performance at high traffic levels will likely occur in CMHB mixes if these limits are lowered.

A decrease in the 0.075 mm (No. 200) sieve will increase the draindown of the asphalt binder in the he CMHB during construction. A fiber or other suitable material (perhaps polymer-modified asphalt) may have to be used to control draindown.

Mixes with higher percentages of coarse aggregate than CMHB mixtures (for example SMA mixtures) may require relative high percentages of 0.075 mm (No. 200) sieve material for good performance. The higher percentages of this fine material increases the stiffness of the asphalt binder and improves the rut resistance of the hot-mix asphalt.

Field mixed-laboratory compacted density for trial mixtures and field operation are presently established between 2.5 and 4.5 percent air voids. This criteria implies a target value of 3.5 percent. Very limited data suggests that this target value could be increased slightly to 4.0 percent. If the criteria is changed to 4 percent, a decrease in asphalt content will occur and durability could be an issue. In addition, field compaction will become more difficult. A compromise may be needed and should be based on a study that continues to monitor the performance of CMHB mixtures.

In-place air voids appear to be somewhat related to performance of the CMHB mixture (Figures 31 to 34). If in-place air voids are less than about 6.0 percent, the CMHB mixtures probably compacted easily in the he field. The low in-place air void content may be an indication of potential performance problems. A change in the present specification may be needed as more performance and QC/QA data is obtained.

The characteristics of the aggregate shape and surface texture appears to be somewhat important for good performance of CMHB mixtures. A change in the specification for fractured faces or the percent of fractured faces appears to be premature at this time as little data is available relating this aggregate property to performance.

Based on the information presented in this study, the changes suggested above will improve the performance of CMHB mixtures. The exact numbers to recommend for the specification changes should be based on a database larger than 17 projects so that statistical variability can be more adequately considered. In the absence of additional data, the following is recommended:

1. Change the allowable range between laboratory mixture design (JMF 1) and subsequent JMFs as follows.

    a. asphalt binder content 0.3

    b. passing 0.075 mm (No. 200) sieve 2.0

2. Revise the master gradation band for percent passing the 0.075 mm (No. 200) sieve to 3.0-7.0 percent.

3. Alter Table 7 in the specification with a note that indicates that in-place air voids below about 6.5 percent can cause performance problems (rutting) with CMHB mixtures.

The above recommendations are based on the limited database and literature reviewed as part of this project.

CONSTRUCTION

The information presented in Tables 5 and 11 and in Appendix E indicates that the majority of the projects had good quality control and agreement of test results was generally obtained between the contractor's results and TxDOT's results. On two of the projects with the most performance problems (Fort Worth-IH 20 and Waco-IH 35W), both experienced quality control problems. The data suggest that the asphalt binder, percent passing the 0.075 mm (No. 200) sieve, and laboratory compacted voids of field mixtures need to be carefully controlled during the construction operation. Training in quality control-quality assurance techniques for project managers may be needed to improve the construction control.

Draindown may be a problem with the CMHB mixtures at reduced percentages passing the 0.075 mm (No. 200) sieve. If the suggested specification changes are made, draindown should be carefully monitored.

Recent experience gained on coarse aggregate mixtures suggests that larger than typical variability may occur in the quality control-quality assurance operation. Variability needs to be more carefully defined for CMHB mixtures using TxDOT sampling and testing techniques.

Insufficient information is available to address the construction issues of ride quality, joint construction, temperature loss, and other workability related issues. The issue of permeability of CMHB mixtures is presently being studied by the Texas Transportation Institute.

USE OF CMHB

Coarse-graded, hot-mix asphalt mixtures appear to be sensitive to changes in asphalt binder content, gradation, laboratory compacted density and in-place density. Good construc tion practices including good QC/QA practices involving the meeting of the target values of JMF 1 and low variability during construction (uniform mixture) are needed on all projects, but particularly on higher traffic volume facilities. The limited data reported in this study suggests that the greatest opportunity for good performance of CMHB mixtures will be on highways with design ESALs below 7.5 million (Figures 9 to 12) and on highways that expect less than 1 million accumulative ESALs (Figures 13 to 16) over their intended life. The use of CMHB mixtures on higher traffic volume facilities may provide adequate performance provided the precautions identified above are incorporated into design and specification requirements. The use of CMHB mixtures is, therefore, encouraged on higher traffic volume facilities as more rut resistant mixtures are needed and information collected in this study suggests that CMHB mixtures can provide the desired performance.

A formalized research project should be established to collect QC/QA and performance data on CMHB projects. This information should be used to revise and extend the recommendations contain in this report.

Table 1: Typical gradations for coarse-graded mixtures

Sieve Size, mm	Typical SMA in U.S.	Superpave Coarse			CMHB (3006.03)	CMHB (April 96)
		9.5 mm	12.5 mm	19 mm	Fine	Coarse
25 (1 in)				100		
22.5 (7/8 in)						100
19 (3/4 in)			100	90-100		
16 (5/8 in)						95-100
12.5 (1/2 in)	94-100	100	90-100		100	
9.5 (3/8 in)		90-100			85-100	50-70
4.75 (No. 4)	20-35				40-60	30-45
2.36 (No. 8)		32.0-47.2	28.0-39.1	23.0-34.6		
(No. 10)					15-25	15-25
1.18 (No. 16)		Max. 31.6	Max. 25.6	Max. 22.3		
0.600 (No. 30)		Max. 23.5	Max. 19.1	Max. 16.7		
(No. 40)					6-20	6-20
0-300 (No. 50)	12-14	Max. 18.7	Max. 15.5	Max. 13.7		
(No. 80)					6-18	6-18
0.150 (No. 100)						
0.075 (No. 200)	7-11	2-10	2-10	2-8	6-10	6-10

Table 2: TxDOT Specifications and Test Methods

Specification/Test Method		Date	Projects	Reference No.
Item	**Title**			
3007.000	Special Specification Quality Control/Quality Assurance of Hot-Mix Asphalt	Dec. 1993		5
3036.000	Special Provision Coarse Matrix High Binder (CMHB) Hot-Mix Asphaltic Concrete Pavement	April 1994		6
3036.000	Special Provision to Special Specification Item 3036 Coarse Matrix High Binder (CMHB) Hot-Mix Asphaltic Concrete Pavement			7
3007.001	Special Provision to Special Specification Item 3007-Quality Control/Quality Assurance of Hot-Mix Asphalt	June 1994		8
3007.002	Special Provision to Specific Specification Item 3007-Quality Control/Quality Assurance of Hot-Mix Asphalt	August 1994		9
3063.000	Special Specification Quality Control/Quality Assurance of Hot-Mix Asphalt	Jan. 1995		10
3063.001	Special Provision to Special Specification Item 3063-Quality Control/Quality Assurance of Hot-Mix Asphalt	Nov. 1995		11
3063.002	Special Provision to Special Specification Item 3063-Quality Control/Quality Assurance of Hot-Mix Asphalt	Jan. 1996		12
3063.003	Special Provision to Special Specification Item 3063-Quality Control/Quality Assurance of Hot-Mix Asphalt	April 1996		13
3063.002	Supplement to Special Provision 3063.002 (Explanation for Special Provision)	Feb. 1996		14
Tex-204-F	Design of Bituminous Mixtures	Sept. 1995		15
Tex-234-F	Mixture Design Procedure for Coarse Matrix High Binder Asphaltic Concrete	Feb. 1994		16
Tex-231-F	Static Creep Test	Sept. 1995		17

Table 3A. Requirements for CMHB Mixtures.

Property		Specification No. and Date							
		3007.000(Dec. '93)*		3007.001(June '94)**		3007.002(Aug. '94)***			
		Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Sieve Analysis	7/8 in	100		100					
	5/8 in	98-100		95-100					
	½ in		100		100				
	3/8 in	55-75	98-100	50-70	85-100				
	¼ in								
	No. 4	35-45	40-50	30-45	40-60				
	No. 10	15-25	15-25						
	No. 40								
	No. 80								
	No. 200	4-8	4-8	6-10	6-10				
(JMF 1) Laboratory Mixture Properties	Optimum Lab Molded Density, %	97±1	97±1						
	VMA, % Min.	13	14						
	Creep Slope, in/in/s	3.5x10-8	3.5x10-8						
	Creep Stiffness, psi	6,000	6,000						
	Permanent Strain in/in	5x10-4	5x10-4						
Trial Mixture (JMF2)	Laboratory Molded Density, % Range	96.0-98.5	96.0-98.5	96.0-97.0	96.0-97.0				

*Same Requirements as Item 3036.000, April 1994
**Only Changes Shown
***No Change From 3007.001

Table 3A. Requirements for CMHB Mixtures (cont'd).

Property		Specification No. and Date							
		3007.000(Dec. '93)*		3007.001(June '94)**		3007.002(Aug. '94)***			
		Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Operational Tolerances(JMF3)	Laboratory Molded Density, % Range	96.0-98.5	96.0-98.5	96.0-97.0	96.0-97.0				
	MINS								
	MAX	99.0	99.0	97.5	97.5				

*Same Requirements as Item 3036.000, April 1994
**Only Changes Shown
***No Change From 3007.001

Table 3B. Requirements for CMHB Mixtures.

Property		Specification No. and Date							
		3063.000(Jan. '95)		3063.001(Nov. '95)*		3063.002(Jan. '96)*		3063.003(Apr. '96)**	
		Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Sieve Analysis	7/8 in	100							
	5/8 in	95-100							
	½ in		100						
	3/8 in	50-70	85-100						
	¼ in								
	No. 4	30-45	40-60						
	No. 10	15-25	15-25						
	No. 40	6-20	6-20						
	No. 80	6-18	6-18						
	No. 200	6-10	6-10						
(JMF 1) Laboratory Mixture Design	Optimum Lab Molded Density, %	96.0	96.0	97.0	97.0	96.5	96.5		
	VMA, % Min.	14	15						
	Creep Slope, in/in/s	4x10-8	4x15-8						
	Creep Stiffness, psi	6,000	6,000						
	Permanent Strain, in/in	6x10-4	6x10-4						
Trial Mixture (JMF2)	Laboratory Molded Density, % Range	96.0-98.0	96.0-98.0	96.5-97.5	96.5-97.5	95.5-97.5	95.5-97.5		

*Only Change Shown
**No Change From 3063.002

Table 3B. Requirements for CMHB Mixtures (cont'd).

Property		Specification No. and Date							
		3063.000(Jan. '95)		3063.001(Nov. '95)*		3063.002(Jan. '96)		3063.003(Apr. '96)**	
		Coarse	Fine	Coarse	Fine	Coarse	Fine	Coarse	Fine
Operational Tolerances(JMF3)	Laboratory Molded Density, % Range	96.0-98.0	96.0-98.0	96.5-97.5	96.5-97.5	95.5-97.5	95.5-97.5		
	MIN					95.0	95.01		
	MAX	98.5	98.5		98.0	98.0	98.0		

*Only Change Shown
**No Change From 3063.002

Table 4. TxDOT Specification for Latex-Modified Asphalt Cement.

Type - Grade / Property	AC-5 + 2% Latex Solids	AC-10 + 2% Latex Solids	AC-10 + 3% Latex Solids	AC-10 + 3% Latex (High Viscosity Blend)
Minimum SBR content, percent by wt. solids (IR determination) *	2.0	2.0	3.0	3.0
Penetration, 100g, 5 sec, 77 F, minimum	120	80	75	75
Viscosity, 140 F, poises, minimum	700	1,300	1,600	2,300
Viscosity, 275 F, poises, maximum	7.0	8.0	12.0	12.0
Ductility, 39.2 F, 1 cm/min, cm, minimum	-	-	100	100
Ductility, 39.2 F, 5 cm/min, cm, minimum	70	60	-	-
Separation of Polymer after 48 hrs. at 325 F	None	None	None	None
Separation of Polymer after 5 hrs. at 325 F **	None	None	None	None

*The asphalt supplier shall furnish the Department samples of the asphalt cement and latex emulsion used in making the finished product.

**Applies in lieu of the 48-hour requirement when the latex modified asphalt is to be used in asphaltic concrete and the latex additive is introduced separately at the mix plant, either by injection into the asphalt line or into the mixer.

Table 5. Representative QC/QA Data.

County	JMF	High-way	CSJ	Asphalt Content, % Mean	Asphalt Content, % Std. Dev.	Asphalt Content, % n	Dev	No. 10, % Passing Mean	No. 10, % Passing Std Dev	No. 10, % Passing n	Dev	No. 200, % Mean	No. 200, % Std Dev	No. 200, % n	Dev	Lab Molded Density, % Mean	Lab Molded Density, % Std Dev	Lab Molded Density, % n	Dev	Field Air Voids % Mean	Field Air Voids % Std Dev	Field Air Voids % n	Dev	PRS	Age (mo)	Traffic (ESALs X 10^6)
ATLANTA DISTRICT																										
Harrison	4	IH-20	495-09-038	4.81	0.10	90	0.01	76.7	1.53	90	0.2	7.50	0.48	90	-0.10	97.00	0.38	23		5.60	1.14	72		90	13	33.1
Harrison	3	US 59	63-01-055	4.73	0.12	24	-0.07	77.6	1.98	24	1.1	6.80	0.40	24	-0.50	97.10	0.28	6		7.00	0.67	12		95	13	8.1
BRYAN DISTRICT																										
Milam	3	US 79	204-05-024	5.75	0.22	17	0.55	77.6								96.90	0.51	10		7.95	1.50	16			4	5.6
CHILDRESS DISTRICT																										
Childress	3	US 287	42-12-36	4.85	0.16	11	0.05	75.9	1.76	19	-3.4	5.27	0.57	19	0.27	97.70	0.50	6		7.37	1.47	11		95	28	6.4
FORT WORTH DISTRICT																										
Palo Pinto	6	IH-20	314-02-042	5.70	0.17	24	0.10	77.8	1.60	24	-0.1	6.03	0.40	24	-0.47	97.20	0.95	6		5.95	1.34	24		40	14	22.0
Palo Pinto	7	IH-20	314-02-042	5.63	0.14	32	0.03	77.9	1.23	32	0	6.17	0.42	32	0.17	97.20	0.44	8		6.30	1.06	32		40	14	22.0
ODESSA DISTRICT																										
Crane	4A	US 385	229-03-28	5.96	0.19	99	0.06	80.3	1.71	103	1.2	7.42	0.69	91	-0.48	97.30	0.34	27		8.51	1.06	76		80	14	2.7
WACO DISTRICT																										
Bell	4	SH 317	15-05-03	6.18	0.08	8	0.18	77.5	0.96	8	0	7.51	0.52	8	0.01	96.40	0.64	2		9.66	0.68	8		100	4	2.5
Falls	4	SH 7	382-07-039	5.25	0.16	12	-0.05	79.6	0.99	12	0.6	5.54	0.41	12	-0.26	97.40	0.39	4		6.87	0.50	6		95	12	1.2
Hill	4	IH-35W	14-23-022	5.52	0.20	36	0.02	76.5	1.07	36	0.5	6.22	0.46	32	-0.28	97.20	0.33	9						35	13	18.7

Table 5. Representative QC/QA Data (cont'd).

				Asphalt Content, %				No. 10, % Passing				No. 200, %				Lab Molded Density, %				Field Air Voids %						
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Dev	Mean	Std Dev	n	Dev	Mean	Std Dev	n	Dev	Mean	Std Dev	n	Dev	Mean	Std Dev	n	Dev	PRS	Age (mo)	Traffic (ESALs X 10^6)
WACO DISTRICT																										
Hill	7	IH-35W	14-23-022	5.73	0.29	25	0.23	76.1	1.74	21	0.1	5.88	0.42	21	-0.12	97.70	0.74	6						35	13	18.7
Limestone	8	SH 171	419-02-032	6.55	0.36	10	-0.05	75.3	1.67	10	-0.1	7.05	0.54	10	0.05	97.90	0.45	3						62	17	2.0
McLennan	4	LP 340	56-1-25	6.03	0.28	24	0.03	78.3	2.14	24	-0.7	5.29	0.64	24	-0.21	97.60	0.52	7						100	17	6.9
McLennan	9	US 84	56-1-25	6.05	0.25	19	0.05	77.3	0.21	19	-0.1	5.94	0.48	19	-0.06	97.50	0.34	6						80	16	2.2
WICHITA FALLS DISTRICT																										
Clay	3	US 287	224-02-03	5.01	0.17	16	-0.19	77.7	1.73	16	1.5	8.31	0.72	16	1.14	97.70	1.03	5		7.50	1.10	16		70	17	14.7
Montague	3A	US 82	44-04-04	5.14	0.19	20	0.04	77.6	1.68	20	-1	7.83	0.54	20	0.93	97.50	0.58	5		5.95	0.81	11		72	4	2.1
Montague	3B	US 82	44-04-04	4.81	0.14	32	0.01	77.4	1.89	32	-1.6	8.31	0.57	32	1.41	97.20	0.54	8		6.54	1.01	28		72	4	2.1
Montague	3	US 82	44-04-04	5.14	0.15	34	-0.36	76.5	1.06	34	-2.1	8.80	0.46	34	1.60	97.60	0.66	11		5.65	0.70	16		72	4	2.1
Wichita	3	US 287	43-09-08	4.89	0.17	60	0.09	76.2	2.09	60	-0.6	7.31	1.20	60	0.61	96.60	0.48	15		5.75	1.22	52		100	17	12.0
Average					0.19				1.50				0.55				0.53				1.02					
Std Dev.					0.07				0.48				0.18				0.20				0.30					
n					19				18				18				19				14					

Table 6. Statistical Comparison of QC/QA Tests (Asphalt Binder Content).

				Contractor			TxDOT											
				Asphalt Content, %			Asphalt Content, %			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
ATLANTA DISTRICT																		
Harrison	4	IH-20	495-09-038													90	13	33.1
Harrison	3	US 59	63-01-055	4.73	0.12	24	4.79	0.10	6	-1.01	0.32	Yes	1.51	0.69	Yes	95	13	8.1
BRYAN DISTRICT																		
Milam	3	US 79	204-05-024														4	
CHILDRESS DISTRICT																		
Childress	3	US 287	42-12-36													95	28	6.4
FORT WORTH DISTRICT																		
Palo Pinto	6	IH-20	314-02-042													40	14	22.0
Palo Pinto	7	IH-20	314-02-042													40	14	22.0
ODESSA DISTRICT																		
Crane	4A	US 385	229-03-28	5.96	0.19	99	6.00	0.26	25	-0.87	0.39	Yes	0.53	0.03	No	80	14	
WACO DISTRICT																		
Bell	4	SH 317	15-05-03	6.18	0.08	8	6.02	0.09	5	3.43	0.01	No	0.85	0.80	Yes	100	4	
Falls	4	SH 7	382-07-039	5.24	0.16	12	5.11	0.18	3	1.26	0.23	Yes	0.81	0.66	Yes	95	12	
Hill	4	IH-35W	14-23-022													35	13	
Hill	7	IH-35W	14-23-022	5.72	0.28	25	5.47	0.21	6	2.03	0.05	Yes	1.79	0.53	Yes	35	13	
Limestone	8	SH 171	419-02-032	6.55	0.36	10	6.28	0.49	7	1.34	0.20	Yes	0.56	0.41	Yes	62	17	

Table 6. Statistical Comparison of QC/QA Tests (Asphalt Binder Content) (cont'd).

				Contractor Asphalt Content, %			TxDOT Asphalt Content, %			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
WACO DISTRICT																		
McLennan	4	LP 340	56-1-25	6.03	0.28	24	6.38	0.58	12	-2.40	0.02	No	0.23	0.00	No	100	17	
McLennan	9	US 84	56-1-25	6.05	0.25	19	6.14	0.36	12	-0.78	0.48	Yes	0.46	0.14	Yes	80	16	
WICHITA FALLS																		
Clay	3	US 287	224-02-03													70	17	14.7
Montague	3A	US 82	44-04-04													72	4	2.1
Montague	3B	US 82	44-04-04													72	4	2.1
Montague	3	US 82	44-04-04													72	4	2.1
Wichita	3	US 287	43-09-08													100	17	12.0

Table 7. Statistical Comparison of QC/QA Tests (Percent Passing No. 10 Sieve).

				Contractor			TxDOT											
				No. 10, % Retained			No. 10, % Retained			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
ATLANTA DISTRICT																		
Harrison	4	IH-20	495-09-038													90	13	33.1
Harrison	3	US 59	63-01-055	77.60	1.98	24	78.00	2.07	6	-0.04	0.67	Yes	0.92	0.79	Yes	95	13	8.1
BRYAN DISTRICT																		
Milam	3	US 79	204-05-024														4	
CHILDRESS DISTRICT																		
Childress	3	US 287	42-12-36													95	28	6.4
FORT WORTH DISTRICT																		
Palo Pinto	6	IH-20	314-02-042													40	14	22.0
Palo Pinto	7	IH-20	314-02-042													40	14	22.0
ODESSA DISTRICT																		
Crane	4A	US 385	229-03-28	80.42	1.70	100	80.14	2.05	26	0.70	0.48	Yes	0.69	0.90	Yes	80	14	
WACO DISTRICT																		
Bell	4	SH 317	15-05-03	77.50	0.96	8	77.76	1.02	5	-0.44	0.67	Yes	0.89	0.83	Yes	100	4	
Falls	4	SH 7	382-07-039	79.58	0.99	12	80.10	1.01	3	-0.87	0.40	Yes	0.96	0.77	Yes	95	12	
Hill	4	IH-35W	14-23-022													35	13	
Hill	7	IH-35W	14-23-022	76.07	1.74	21	75.46	1.22	5	0.74	0.47	Yes	2.04	0.51	Yes	35	13	
Limestone	8	SH 171	419-02-032	75.30	1.67	10	75.26	1.98	8	0.04	0.97	Yes	0.71	0.62	Yes	62	17	

Table 7. Statistical Comparison of QC/QA Tests (Percent Passing No. 10 Sieve) (cont'd).

				Contractor			TxDOT											
				No. 10, % Retained			No. 10, % Retained			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
WACO DISTRICT																		
McLennan	4	LP 340	56-1-25	78.28	2.14	24	77.34	2.60	9	1.05	0.36	Yes	0.67	0.43	Yes	100	17	
McLennan	9	US 84	56-1-25	77.31	2.11	19	77.53	1.97	11	-0.27	0.79	Yes	1.15	0.85	Yes	80	16	
WICHITA FALLS DISTRICT																		
Clay	3	US 287	224-02-03													70	17	14.7
Montague	3A	US 82	44-04-04													72	4	2.1
Montague	3B	US 82	44-04-04													72	4	2.1
Montague	3	US 82	44-04-04													72	4	2.1
Wichita	3	US 287	43-09-08													100	17	12.0

Table 8. Statistical Comparison of QC/QA Tests (Percent Passing No. 200 Sieve).

				Contractor			TxDOT											
				No. 200, % Retained			No. 200, % Retained			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
ATLANTA DISTRICT																		
Harrison	4	IH-20	495-09-038													90	13	33.1
Harrison	3	US 59	63-01-055	6.80	0.40	24	6.78	0.96	6	0.07	0.95	Yes	0.18	0.00	No	95	13	8.1
BRYAN DISTRICT																		
Milam	3	US 79	204-05-024														4	
CHILDRESS DISTRICT																		
Childress	3	US 287	42-12-36													95	28	6.4
FORT WORTH DISTRICT																		
Palo Pinto	6	IH-20	314-02-042													40	14	22.0
Palo Pinto	7	IH-20	314-02-042													40	14	22.0
ODESSA DISTRICT																		
Crane	4A	US 385	229-03-28	7.44	0.62	87	7.73	1.14	23	-1.62	0.11	Yes	0.29	0.00	No	80	14	
WACO DISTRICT																		
Bell	4	SH 317	15-05-03	7.51	0.52	8	7.82	1.71	5	-0.48	0.64	Yes	0.09	0.01	No	100	4	
Falls	4	SH 7	382-07-039	5.54	0.40	12	5.27	0.06	3	1.13	0.28	Yes	44.40	0.04	Yes	95	12	
Hill	4	IH-35W	14-23-022													35	13	
Hill	7	IH-35W	14-23-022	5.88	0.42	21	4.84	0.40	5	4.99	0.00	No	1.09	0.95	Yes	35	13	
Limestone	8	SH 171	419-02-032	7.05	0.54	10	7.39	0.40	8	-1.47	0.16	Yes	1.80	0.45	Yes	62	17	

Table 8. Statistical Comparison of QC/QA Tests (Percent Passing No. 200 Sieve) (cont'd).

				Contractor No. 200, % Retained			TxDOT No. 200, % Retained			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
WACO DISTRICT																		
McLennan	4	LP 340	56-1-25	5.29	0.64	24	5.90	1.07	11	-2.09	0.04	No	0.36	0.04	No	100	17	
McLennan	9	US 84	56-1-25	5.94	0.48	19	5.75	0.39	11	1.13	0.27	Yes	1.46	0.55	Yes	80	16	
WICHITA FALLS DISTRICT																		
Clay	3	US 287	224-02-03													70	17	14.7
Montague	3A	US 82	44-04-04													72	4	2.1
Montague	3B	US 82	44-04-04													72	4	2.1
Montague	3	US 82	44-04-04													72	4	2.1
Wichita	3	US 287	43-09-08													100	17	12.0

Table 9. Statistical Comparison of QC/QA Tests (Field Mixed, Laboratory Molded Density).

				Contractor			TxDOT											
				Lab Molded Density, %			No. 200, % Retained			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
ATLANTA DISTRICT																		
Harrison	4	IH-20	495-09-038													90	13	33.1
Harrison	3	US 59	63-01-055	97.08	0.28	6	97.27	0.43	6	-0.87	0.41	Yes	0.42	0.36	Yes	95	13	8.1
BRYAN DISTRICT																		
Milam	3	US 79	204-05-24														4	
CHILDRESS DISTRICT																		
Childress	3	US 287	42-12-36													95	28	6.4
FORT WORTH DISTRICT																		
Palo Pinto	6	IH-20	314-02-042													40	14	22.0
Palo Pinto	7	IH-20	314-02-042													40	14	22.0
ODESSA DISTRICT																		
Crane	4A	US 385	229-03-28	97.28	0.34	26	97.13	0.62	24	1.05	0.30	Yes	0.31	0.01	Yes	80	14	
WACO DISTRICT																		
Bell	4	SH 317	15-05-03	96.45	0.64	2	96.36	0.40	5	0.24	0.82	Yes	2.56	0.37	Yes	1004		
Falls	4	SH 7	382-07-039	97.40	0.39	4	97.20	0.72	3	0.54	0.61	Yes	0.29	0.33	Yes	95	12	
Hill	4	IH-35W	14-23-022													35	13	
Hill	7	IH-35W	14-23-022	97.55	0.46	6	97.65	0.82	6	-0.26	0.80	Yes	0.32	0.24	Yes	35	13	

Table 9. Statistical Comparison of QC/QA Tests (Field Mixed, Laboratory Molded Density) (cont'd).

				Contractor			TxDOT											
				Lab Molded Density, %			No. 200, % Retained			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
WACO DISTRICT																		
Limestone	8	SH 171	419-02-032	97.87	0.45	3	98.03	0.27	6	-0.71	050	yes	2.72	0.32	Yes	62	17	
McLennan	4	LP 340	56-1-25	97.64	0.52	7	97.62	0.72	9	0.06	0.95	Yes	0.53	0.45	Yes	100	17	
McLennan	9	US 84	56-1-25	97.52	0.34	6	97.50	0.76	9	0.05	0.96	Yes	0.20	0.10	Yes	80	16	
WICHITA FALLS DISTRICT																		
Clay	3	US 287	224-02-03													70	17	14.7
Montague	3A	US 82	44-04-04													72	4	2.1
Montague	3B	US 82	44-04-04													72	4	2.1
Montague	3	US 82	44-04-04													72	4	2.1
Wichita	3	US 287	43-09-08													100	17	12.0

Table 10. Statistical Comparison of QC/QA Tests (In-Place Air Voids).

				Contractor			TxDOT											
				Field Air Voids %			Field Air Voids %			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
ATLANTA DISTRICT																		
Harrison	4	IH-20	495-09-038													90	13	33.1
Harrison	3	US 59	63-01-055	7.00	0.67	12	6.38	1.97	4	0.99	0.34	Yes	0.12	0.01	No	95	13	8.1
BRYAN DISTRICT																		
Milam	3	US 79	204-05-024														4	
CHILDRESS DISTRICT																		
Childress	3	US 287	42-12-36													95	28	6.4
FORT WORTH DISTRICT																		
Palo Pinto	6	IH-20	314-02-042													40	14	22.0
Palo Pinto	7	IH-20	314-02-042													40	14	22.0
ODESSA DISTRICT																		
Crane	4A	US 385	229-03-28													80	14	
WACO DISTRICT																		
Bell	4	SH 317	15-05-03	9.66	0.68	8	10.03	0.83	8	-0.96	0.35	Yes	0.67	0.61	Yes	100	4	
Falls	4	SH 7	382-07-039													95	12	
Hill	4	IH-35W	14-23-022													35	13	
Hill	7	IH-35W	14-23-022													35	13	
Limestone	8	SH 171	419-02-032													62	17	

Table 10. Statistical Comparison of QC/QA Tests (In-Place Air Voids) (cont'd).

				Contractor			TxDOT											
				Field Air Voids %			Field Air Voids %			Means Test			Std. Dev. Test					
County	JMF	High-way	CSJ	Mean	Std. Dev.	n	Mean	Std. Dev.	n	t	P-value	Same ?	F	P-value	Same ?	PRS	Age (mo)	Traffic (ESALs X 10^6)
WACO DISTRICT																		
McLennan	4	LP 340	56-1-25													100	17	
McLennan	9	US 84	56-1-25													80		
WICHITA FALLS DISTRICT																		
Clay	3	US 287	224-02-03													70	17	14.7
Montague	3A	US 82	44-04-04													72	4	2.1
Montague	3B	US 82	44-04-04													72	4	2.1
Montague	3	US 82	44-04-04													72	4	2.1
Wichita	3	US 287	43-09-08													100	17	12.0

Table 11. Variability from Target Values for Contractor Quality Control Tests, Percent of Data.

Variation from Target Value	Asphalt Binder Content, Percent	Retained on No. 10 Sieve, Percent	Passing on No. 200 Sieve, Percent
0.00 - 0.09	52		
0.10 - 0.19	30		
0.20 - 0.29	9		
Greater than 0.30	9		
0.0 - 0.4		26	53
0.5-0.9		29	22
1.0 - 1.4		16	15
1.5 - 1.9		16	9
Greater than 2.0		13	1

Table 12. Relative Performance of CMHB Versus Dense-Graded Hot-Mix Asphalt.

District	Relative Performance				Total
	Better	About Same	Not As Good	Not Designated	
Abilene	4	0	0	2	6
Amarillo	0	1	0	0	1
Atlanta	1	3	1	5	10
Austin	1	0	0	2	3
Beaumont	0	1	0	0	1
Brownwood	0	0	3	0	3
Bryan	1	1	0	2	4
Childress	0	2	0	1	3
Dallas	0	0	0	1	1
El Paso	1	0	2	0	3
Ft. Worth	0	0	1	0	1
Houston	0	0	0	5	5
Lubbock	2	0	0	0	2
Lufkin	1	1	0	0	2
Odessa	4	1	1	2	8
Pharr				2	2
San Angelo	1	0	0	0	1
San Antonio	7	3	3	3	16
Tyler	0	0	0	1	1
Waco	3	1	4	3	11
Wichita Falls	1	1	5	2	9
Yoakum	3	0	0	0	3
Total	30	15	20	31	96

Table 13. Deduct Points for Pavement Rating Score Calculation.

Type of Distress	Rating of Extent*			
	None	Slight	Moderate	Severe
Cracking	0	5	15	30
Rutting	0	5	15	30
Flushing	0	5	15	30

*Performed by TxDOT and Contractor Team.

Table 14. Summary of Available Information.

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggregate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
ABILENE DISTRICT											
IH-20	Callihan	0006-07-061	75	AC-20	CL			20.5			16
SH-36	Callihan	0181-02-021	90	CRM	CL	Y		2.7		Y	38
US-87	Howard	69-1-40	95	AC-20	CL			3.4			26
US 83/84	Jones	33-5-070	85	AC-20	CL			3.8			28
IH-20	Taylor	6-04-057	95	AC-20	CL			19.8			6
US-83	Taylor	34-2-27	100	AC-20	CL			1.5			7
AMARILLO DISTRICT											
IH-40	Gray	275-8-025	80	AC-20	CG-L5			30.3	3036		29
ATLANTA DISTRICT											
SH-8	Bowie	61-1-019	90	AC-20 + latex	CGR-FS			6.6			16
US-59	Bowie Harrison	218-0-065 STP 95 (548)	65	AC-20 + latex	CGR-FS			9.7			15
IH-20	Harrison	495-09-038 495-10-	90	AC-20 + latex	CGR-LS		Y	33.1			13
SH-154	Harrison	402-2-30	100	AC-20 + latex	CGR-LS			1.0			15
US-59	Harrison	63-1-55	95	AC-20 + latex	CGR-LS		Y	8.1			13
SH-149	Panola	0394-01-047	100	AC-10 + 3% latex	CGR-LS			1.2			16
SH-149	Panola	0063-11-024	100	AC-20 + latex	CGR-LS			11.4			16

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggregate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
ATLANTA DISTRICT											
SH-315	Panola	0462-03-030	100	AC-10+3% latex	CGR-LS			9.3			28
US-79	Panola	0247-02-032	80	AC-20+ others	CGR			7.9			28
US-79	Panola	0247-03-015	95	AC-20+3% latex	CG			7.9			12
AUSTIN DISTRICT											
IH-35	Travis	0015-13-240	100	AC-20	CL-CS-LS			45.5			14
Loop 1	Travis	3136-01-?	100	AC-20	CL-CS-LS			4.6			38
US-290	Travis	114-2-43	95	AC-20	CL-CS-LS			4.2			40
BEAUMONT DISTRICT											
US-96	Hardin	65-5-117	100	CRM	CD			9.2			23
BROWNWOOD DISTRICT											
IH-20	Eastland	7-3-65	97	SBS Modified	CL-LS			22.1			5
IH-20	Eastland	7-6-060	87	SBS Modified	CL-LS			22.4			5
US-180	Stephens	11-7-39	87	SBS Modified	CL-LS			1.8			5
BRYAN DISTRICT											
SH-21	Brazos	116-4-080	95	AC-20	CL-LS			5.2			13
SH-36	Washington	186-5-27	95	AC-20	CL-LS	Y		4.8	3036	Y	11
US-290	Washington	186-6-050	95	AC-20	CL-LS	Y		6.6	3063	Y	16

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggre-gate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
BRYAN DISTRICT											
US-79	Milam	204-5-24		AC-20	CL-LS		Y	5.6	3007	Y	4
CHILDRESS DISTRICT											
US-287	Childress	43-1-049 42-12-36	95	AC-20	CL-CS		Y	6.4			28
US-287	Childress/	43-1-049	90	AC-20	CL-CS			6.4			15
US-287	Hardeman		90	AC-20	CL-CG			6.4			15
I-40*	Wheeler	IM 40-2(20)146 275-12-53	70	AC-20				26.8			25
DALLAS DISTRICT											
IH-45	Navarro	92-06-82		CRM	CL			28.2			24
EL PASO DISTRICT											
FM-659	El Paso	1046-1-14	85	CRM-Dry	CD	Y		7.1		Y	25
IH-10 (West)	Hudspeth	2-8-042	80	AC-20+ latex	CD			19.1			11
IH-10 (East)	Hudspeth	2-8-042	90	AC-20+ latex	CD			19.1			11
FORT WORTH DISTRICT											
IH-20	Palo Pinto	0314-02-042	40	AC-20+latex Multi-grade	CGR-LS	Y	Y	22.0		Y	14

*Not a CMHB project

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggre-gate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
HOUSTON DISTRICT											
FM-1301	Brazoria	1412-2-11		CRM	CL-LS			0.3			25
FM-360	Ft. Bend	527-6		CRM	CL-LS			1.0			24
FM-442		838-2		CRM	CL-LS			0.3			24
FM-1994		1965-1-5		CRM	CL-LS			0.6			24
FM-1458	Waller	527-2-13		CRM	CL-LS			0.2			28
LUBBOCK DISTRICT											
98th St.	Lubbock	905-06-024	100	AC-10+ latex	CG						13
FM-2255	Lubbock	2256-01-014	95	AC-10+ latex	CG						11
LUFKIN DISTRICT											
SH-63	Angelina	0244-01-040	90	CRM				3.1			24
US-259	Nacogdoches	0138-06-033	65	CRM				12.1			26
ODESSA DISTRICT											
US-385	Crane/Upton	228-3-28 229-3-28	80	AC-20+ latex	CL-LS		Y	2.7			14
IH-20	Ector	4-7-87	95	AC-10	CL-LS			19.5			30
FM-1882	Ector	2005-8-1				Y		1.2	3006	Y	30
IH-20	Ector	4-7-88	65	AC-10	CL-LS						28
IH-20	Ector	5-13-037		CRM	CL-LS			19.9			30

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggre-gate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
ODESSA DISTRICT											
BI-10-G	Pecos	0140-17-004	72	AC-20+ latex	CGR-LS			1.0			20
IH-20	Ward/Reeves	?	90	AC-20+ latex	CGR-LS						13
SH-137	Martin	0494-03-023	100	AC-20+ latex	CL-LS			1.2			4
LP-250	Midland	1188-02-046	95	AC-20	CL-LS			1.2			18
PHARR DISTRICT											
US-281	Hidalgo	255-12-2		AC-20	CGR						16
US-281	Hidalgo	255-09-66		AC-20	CGR			2.7			4
SAN ANGELO DISTRICT											
US-277 RM-915 US-190E	Schleicher	0159-04-025	90	AC-20	CL-LS			1.7			12
SAN ANTONIO DISTRICT											
Loop 13	Bexar	0521-01-039	90	AC-20	CL-LS			1.6			16
Poplar St.	Bexar	0915-12-098	100	AC-20	CL-LS						12
Wetmore	Bexar	915-12-112	100	AC-20	CL-LS						15
Callaghn	Bexar	521-4-224	95	AC-20	CL-LS			12.0			19
IH-10	Kerr	0142-14-041	85	AC-20	CD-DS			10.9			4
IH-10	Bexar	72-7-43		CRM	CL-LS			11.1			4

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggre-gate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
SAN ANTONIO DISTRICT											
IH-10	Kerr	0142-12-12	95	AC-20	CL-LS			10.2			15
Water St.	Kerr	0915-15-012	55	AC-20	CL-LS						16
IH-35	Frio	0017-06-059	25	AC-20	CL-LS			17.9			0
IH-35	Frio	0017-07-070	25	AC-20	CL-LS			19.7			10
IH-35	Bexar	17-03-49	95	AC-20	CL-LS			17.0			63
SP-537	Bexar	253-04-103	100	AC-20	CL-LS			2.4			5
36th & Culebr	Bexar	?	95	AC-20	CL-LS						28
Old Castroville Road	Bexar	?	95	AC-20	CL-LS						28
SP-422	Bexar	613-01-047	100	AC-20	CL-LS			2.0			5
LP-1604	Bexar	2452-4-103	100	AC-20	CL-LS			0.7			
TYLER DISTRICT											
LP-323	Smith	2075-02-040	40	AC-10 + latex	CS or CL-LS	Y		6.7	3063	Y	15
WACO DISTRICT											
SH-317	Bell	0398-04-051 0015-05-03	100	AC-20	CL-LS	Y	Y	2.5			4

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggregate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
WACO DISTRICT											
SH-7	Falls	382-01-039	95	AC-20	CL-LS	Y	Y	1.2			12
IH-35W	Hill	14-23-022	35	AC-20	CL-LS	Y	Y	18.7			13
IH-35FR	McLennan	14-8-64			CL-LS			38.5			28
SH-22	Hill	0121-03-049		AC-20	CL-LS			1.6			25
SH-171	Limestone	419-2-032	62	AC-20	CL-LS	Y	Y	2.0			17
FM-3051	McLennan	2311-01-22	60	AC-20	CL-LS			3.0			30
Loop 340	McLennan	258-9-106	100	AC-20	CL-LS		Y	6.4			17
US-84	McLennan	56-1-025	80	AC-20	CL-LS		Y	2.2			16
US-84	McLennan	55-7-048		AC-20	CL-LS			2.3			4
FM-1633	Limestone	1664-1-13	95	AC-20	CL-LS			0.1	3063		14
WICHITA FALLS DISTRICT											
US-287	Clay	224-1-44 224-01-04	50	AC-20	CL-LS	Y	Y	13.8	3007	Y	25
US-287	Clay	224-2-34 224-02-03	90	AC-20	CL-LS		Y?	14.3			12
US-287	Clay	224-2-35 224-02-03	70	AC-20	CL-LS		Y?	14.7			17

Table 14. Summary of Available Information (cont'd).

Highway	County	CSJ	Pavement Rating Score	Binder Type	Aggre-gate Type	Mix Design Information	QC/QA Information	Traffic ESAL X 10^6	Specs	TxDOT Inves-tigation	Age
WICHITA FALLS DISTRICT											
US-82	Montague	0044-04-040	72	AC-20 (Kerr-McGee) AC-20 (FINA)	CL-LS		Y?	2.1			4
US-82	Montague	0044-04-041	72	AC-20	CL-LS		Y?	3.6			4
US-82	Montague	CPM44-4-42	95	AC-20	CL-LS			4.2			13
US-287	Wichita	43-9-80 0043-09-08	100	AC-20	CL-LS		Y	12.0			17
Kemp St.	Wichita	903-03-027 413-01-047 903-03-02		AC-20	CL-LS	Y	Y			Y	4
IH-44	Wichita	156-07-048				Y		6.9	3063	Y	5
US-287	Wilbarger	0043-06-062	80	AC-20	CL-LS			12.5			8
YOAKUM DISTRICT											
FM-1093	Wharton	0446-05-008	100	AC-20	CL-LS			0.5			16
FM-1093	Colorado	0446-04-011	100	AC-20	CL-LS			0.7			16
FM-3013	Colorado	3205-02-012	100	AC-20	CL-LS			4.0			17

<u>Aggregate Type</u>
1. CD - Crushed Dolomite
2. CG - Crushed Granite
3. CL - Crushed Limestone
4. CS - Crushed Sandstone
5. CGR - Crushed Gravel
6. DS - Dolomite Screenings
7. FS - Field Sand
8. LS - Limestone Screenings

Table 15. CMHB Pavements with ESAL Above 7 X 10^6 with Age and Performance Data Available.

County	Highway/CSJ	Pavement Rating Score	Age, Months	Traffic, ESAL X 10^6	Asphalt Type	Aggregate Type	QC/QA Data
ABILENE DISTRICT							
Callihan	IH-20 0006-07-061	75	16	20.5	AC-20	CL	N
Taylor	IH-20 6-04-057	95	6	19.8	AC-20	CL	N
AMARILLO DISTRICT							
Gray	IH-40 275-8-025	80	29	30.3	AC-20	CG-LS	N
ATLANTA DISTRICT							
Bowie Harrison	US 57 218-0-065	65	15	9.7	AC-20 + latex	CGR & FS	N
Harrison	IH-20 459-09-038	90	13	33.1	AC-20 + latex	CGR-LS	Y
Harrison	US 59 63-1-55	95	13	8.1	AC-20 + latex	CGR- LS	Y
Panola	SH 149 0063-11-024	100	16	11.4	AC-20 + latex	CGR - LS	N
Panola	SH 315 0462-03-030	100	28	9.3	AC-10 + 3% latex	CGR - LS	N
Panola	US 79 247-02-032	80	28	7.9	AC-20 + others	CGR	N
Panola	US 79 247-03-015	95	12	7.9	AC-10 + 3% latex	CG	N

Table 15. CMHB Pavements with ESAL Above 7 X 10^6 with Age and Performance Data Available (cont'd).

County	Highway/CSJ	Pavement Rating Score	Age, Months	Traffic, ESAL X 10^6	Asphalt Type	Aggregate Type	QC/QA Data
AUSTIN DISTRICT							
Travis	IH-35 0015-13-240	100	14	45.5	AC-20	CL-CS-LS	N
BEAUMONT DISTRICT							
Hardin	US 96 65-5-117	100	23	9.2	CRM	CD	N
BROWNWOOD DISTRICT							
Eastland	IH-20 7-3-65	97	5	22.1	SBS modified	CL-LS	N
Eastland	IH-20 7-6-060	87	5	22.4	SBS modified	CL-LS	N
CHILDRESS DISTRICT							
Wheeler*	IH-40 2(20)146	70	25	26.8	AC-20		N
EL PASO DISTRICT							
El Paso	FM-659 1046-1-14	85	25	7.1	CRM-DRY	CD	N
Hudspeth	IH-10W 2-8-042	80	11	19.1	AC-10 + latex	CD	N
Hudspeth	IH-10E 2-8-042	90	11	19.1	AC-10 + latex	CD	N

*Not a CMHB project

Table 15. CMHB Pavements with ESAL Above 7 X 10^6 with Age and Performance Data Available (cont'd).

County	Highway/CSJ	Pavement Rating Score	Age, Months	Traffic, ESAL X 10^6	Asphalt Type	Aggregate Type	QC/QA Data
FORT WORTH DISTRICT							
Palo Pinto	IH-20 0314-02-042	40	14	220	AC-10 + latex multigrade	CGR-LS	Y
LUFKIN DISTRICT							
Nacogdoches	US 259 0138-06-033	65	26	12.1	CRM		N
ODESSA DISTRICT							
Ector	IH-20 4-7-87	95	30	19.5	AC-10	CL-LS	N
Ector	IH-20 5-13-037	?	30	19.9	CRM	CL-LS	N
SAN ANTONO DISTRICT							
Bexar	IH-35 17-03-49	95	63	17.0	AC-20	CL-LS	N
Bexar	Callaghn 521-4-224	95	19	12.0	AC-20	CL-LS	N
Frio	IH-35 0017-06-059	25	0	17.9	AC-20	CL-LS	N
Frio	IH-35 0017-07-070	25	10	19.7	AC-20	CL-LS	N
Kerr	IH-10 142-14-041	85	4	10.9	AC-20	CD-DS	N

Table 15. CMHB Pavements with ESAL Above 7 X 10^6 with Age and Performance Data Available (cont'd).

County	Highway/CSJ	Pavement Rating Score	Age, Months	Traffic, ESAL X 10^6	Asphalt Type	Aggregate Type	QC/QA Data
SAN ANTONIO DISTRICT							
Kerr	IH-10 142-12-12	95	15	10.2	AC-20	CL-LS	N
WACO DISTRICT							
Hill	IH-35W 14-23-022	35	13	18.7	AC-20	CL-LS	Y
WICHITA FALLS DISTRICT							
Clay	US 287 224-1-44	50	25	13.8	AC-20	CL-LS	N
Clay	US 287 224-2-34	90	12	14.3	AC-20	CL-LS	Y?
Clay	US 287 224-2-35	70	17	14.7	AC-20	CL-LS	Y?
Wichita	US 287 43-09-80	100	17	12.0	AC-20	CL-LS	Y
Wilbarger	US 287 0043-06-062	80	8	12.5	AC-20	CL-LS	N

Table 16. CMHB Pavements with ESAL Above 7 X 10^6 with PRS Scores 80 and Below.

County	Highway/CSJ	Pavement Rating Score	Age, Months	Traffic, ESAL X 10^6	Asphalt Type	Aggregate Type	QC/QA Data
ABILENE DISTRICT							
Callihan	IH-20	75	16	20.5	AC-20	CL	N
AMARILLO DISTRICT							
Gray	IH-40	80	29	30.3	AC-20	CG-LS	N
ATLANTA DISTRICT							
Bowie Harrison	US 50	65	15	9.7	AC-20 + latex	CGR-FS	N
Panola	US 79	80	28	7.9	AC-20 + others	CGR	N
CHILRESS DISTRICT							
Wheeler*	IH-40	70	25	26.8	AC-20		N
FORT WORTH DISTRICT							
Palo Pinto	IH-20	40	14	22.0	AC - 10 + latex multigrade	CGR-LS	Y
LUFKIN DISTRICT							
Nacogdoches	US 259	65	26	12.1	CRM		N
SAN ANTONIO DISTRICT							
Frio	IH-35 0017-06-059	25	0	17.9	AC-20	CL-LS	N
Frio	IH-35 0017-07-070	25	10	19.7	AC-20	CL-LS	N

*Not a CMHB project

Table 16. CMHB Pavements with ESAL Above 7 X 10^6 with PRS Scores 80 and Below (cont'd).

County	Highway/CSJ	Pavement Rating Score	Age, Months	Traffic, ESAL X 10^6	Asphalt Type	Aggregate Type	QC/QA Data
WACO DISTRICT							
Hill	IH-35W 14-23-022	35	13	18.7	AC-20	CL-LS	Y
WICHITA FALLS DISTRICT							
Clay	US 287	50	25	13.8	AC-20	CL-LS	N
Clay	US 287 224-235	70	17	14.7	AC-20	CL-LS	Y?
Wilbarger	US 287 00438-06-062	80	8	12.5	AC-20	CL-LS	N

Table 17. Peformance and QC/QA Data.*

Project Identification			Asphalt Content, Percent				Passing No. 200 Sieve, Percent					
County	Highway	JMF	Representative Avg. Value	Range of Average Values	Representative Deviation from Target	Range of Deviations from Target	Representative Avg. Value	Range of Average Values	Representative Deviation from Target	Range of Deviations from Target	PRS	Traffic ESAL
ATLANTA DISTRICT												
Harrison	IH-20	4	4.8	4.7-5.0	+0.01	-0.08 to +0.01	7.2	6.5-7.4	-0.1	-1.1 to -0.1	90	33.1
Harrison	US 59	3	4.7	4.7-4.8	-0.07	-0.13 to +0.02	6.8	6.1-7.0	-0.5	-1.2 to -0.2	95	8.1
BRYAN DISTRICT												
Milam	US 79	3	5.8	5.8	+0.55	+0.55						5.6
CHILDRESS DISTRICT												
Childress	US 287	3	4.9	4.9	+0.05	+0.05	5.3	5.3	+0.27	+0.27	95	6.4
FORT WORTH DISTRICT												
Palo Pinto	IH-20	7	5.6	5.5-5.7	+0.03	-0.12 to +0.16	6.2	6.0-6.4	+0.17	-0.47 to + 0.35	40	22.0
ODESSA DISTRICT												
Crane	US 385	4A	6.0	5.5 to 6.6	+0.06	-0.67 to +0.06	7.4	5.2-7.5	-0.48	-2.68 to -0.40	80	2.7
WACO DISTRICT												
Bell	SH-317	4	6.2	6.2	+0.18	+0.18	7.5	7.5	+0.01	+0.01	100	2.5
Falls	SH-7	4	5.3	5.3	-0.05	-0.05	5.5	5.5	-0.26	-0.26	95	1.2
Hill	IH-35W	7	5.7	5.3-7.0	+0.23	-0.05 to +0.30	5.9	4.9-7.3	-0.12	-1.1 to + 0.78	35	18.7
Limestone	SH-171	8	6.6	6.5-6.9	-0.05	-0.05 to +0.30	7.1	6.0-7.1	+0.05	-0.97 to +0.70	62	2.0
McLennan	LP-340	4	6.0	5.8-6.0	+0.03	-0.10 to +0.15	5.3	4.6-5.3	-0.21	-0.34 to + 0.03	100	6.9

Table 17. Peformance and QC/QA Data* (cont'd).

Project Identification			Asphalt Content, Percent				Passing No. 200 Sieve, Percent					
County	Highway	JMF	Represen-tative Avg. Value	Range of Average Values	Represen-tative Deviation from Target	Range of Deviations from Target	Represen-tative Avg. Value	Range of Average Values	Represen-tative Deviation from Target	Range of Deviations from Target	PRS	Traffic ESAL
WACO DISTRICT												
McLennan	US 84	9	6.1	6.1-6.2	+0.05	+0.05 to +0.22	5.9	5.9-6.2	-0.06	-0.32 to -0.06	80	2.2
WICHITA FALLS DISTRICT												
Clay	US 287	3	5.0	4.9-5.1	-0.19	-0.22 to -0.10	8.3	8.0-8.8	+1.41	+1.05 to +1.88	70	14.7
Montague	US 82	3	5.1	4.8-5.1	+0.04	-0.36 to +0.04	8.8	7.8-8.8	+0.93	+0.93 to +1.4	72	2.1
Wichita	US 287	3	4.9	4.9	+0.19	+0.19	7.3	7.3	+0.61	+0.61	100	12.0

*Summarized from Table 5 and Appendix E.

REFERENCES

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2 "Review of Coarse Matrix High Binder (CMHB) Projects," Materials and Test Division and Construction and Maintenance Division, Vol. 1, December 1995, prepared by CMHB Review Team.

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4 "Joint TxDOT-THMAPA Review of Coarse Matrix High Binder (CMHB) Projects," Preliminary Summary of Data, November 25, 1996.

5 "Special Specification-Quality Control/Quality Assurance of Hot-Mix Asphalt" - Item 3007.000, December 1993.

6 "Special Specification Item 3036-Coarse Matrix High Binder (CMHB) Hot-Mix Asphaltic Concrete Pavement" - Item 3036.00, April 1994.

7 "Special Provision to Special Specification Item 3036-Coarse Matrix High Binder (CMHB) Hot-Mix Asphaltic Concrete Pavement."

8 "Special Provision to Special Specification - Item 3007-Quality Control/Quality Assurance of Hot-Mix Asphalt" - Item 3007.001, June 1994.

9 Special Provision to Specific Specification "Item 3007-Quality Control/Quality Assurance of Hot-Mix Asphalt" - Item 3007.002, August 1994.

10 "Special Specification-Quality Control/Quality Assurance of Hot-Mix Asphalt," Item 3063, January 1995.

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15 "Design of Bituminous Mixtures," Tex-204-F, Manual of Testing Procedure, Vol. 1, September 1995.

16 "Mixture Design Procedure for Coarse Matrix High Binder Asphaltic Concrete-Draft," Tex-234-F, February 1994.

17 "Static Creep Test," Tex-231-F, September 1995.

18 "Standard Specifications for Construction of Highway Streets and Bridges," Texas Department of Transportation.

19 "Forensic Investigation on IH20, Palo Pinto County," prepared by M. Tahmoressi for M. McEndree, Stephenville Area Office, November 20, 1995.

20 "Forensic Investigation on US 82 from Kell Blvd. to 9th Street, Wichita County," prepared by R. Wilson for D. Peeples, District Engineer, Wichita Falls, March 31, 1994.

21 "Interstate Highway 20 Investigation of Premature Distress," Heritage Research Group, June 16, 1995.

APPENDIX A

ASPHALT BINDER TYPE AND PROPERTIES

Table A1. Asphalt Binder Properties.

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
ABILENE DISTRICT										
IH-20	Callihan	0006-07-061	AC-20							
SH-36	Callihan	0181-02-021	CRM							
US-87	Howard	69-1-40	AC-20							
US 83/84	Jones	33-5-070	AC-20							
IH-20	Taylor	6-04-057	AC-20							
US-83	Taylor	34-2-27	AC-20							
AMARILLO DISTRICT										
HI-40	Gray	275-8-025	AC-20							
ATLANTA DISTRICT										
SH-8	Bowie	61-1-029	AC-20+ latex							
US-59	Bowie Harrison	218-0-065 STP 95 (548)	AC-20+ latex							
IH-20	Harrison	495-09-038 495-10-	AC-20+ latex							
SH-154	Harrison	402-2-30	AC-20+ latex							
US-59	Harrison	63-1-55	AC-20+ latex							
SH-149	Panola	0394-01-047	AC-10+ 3% latex							
SH-149	Panola	0063-11-024	AC-20+ latex							

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
ATLANTA DISTRICT										
SH-315	Panola	0462-03-030	AC-10 + 3% latex							
US-79	Panola	0247-02-032	AC-20 CRM AC-20 + 3% latex							
US-79	Panola	0247-03-015	AC-10 + 3% latex							
AUSTIN DISTRICT										
IH-35	Travis	0015-13-240	AC-20							
Loop 1	Travis	3136-01-?	AC-20							
US 290	Travis	114-2-43	AC-20							
BEAUMONT DISTRICT										
US-96	Hardin	65-5-117	CRM							
BROWNWOOD DISTRICT										
IH-20	Eastland	7-3-65	SBS modified							
IH-20	Eastland	7-6-060	SBS modified							
US-180	Stephens	11-7-39	SBS modified							
BRYAN DISTRICT										
SH-21	Brazos	116-4-080	AC-20							
SH-36	Washington	186-5-27	AC-20							
US-290	Washington	186-6-050	AC-20							

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
BRYAN DISTRICT										
US-79	Milam	204-5-24	AC-20							
CHILDRESS DISTRICT										
US-287	Childress	43-1-049 42-12-36	AC-20							
US-287	Childress	43-1-049	AC-20							
US-287	Hardeman		AC-20							
I-40*	Wheeler	IM 40-2(20)146 275-12-52	AC-20							
DALLAS DISTRICT										
IH-45	Navarro	92-06-82	CRM							
EL PASO DISTRICT										
FM-659	El Paso	1046-1-14	Crumb Rubber Dry							
IH-10 (West)	Hudspeth	2-8-042	AC-20 + latex							
IH-10 (East)	Hudspeth	2-8-042	AC-20 + latex							

*Not a CMHB project

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
FORT WORTH DISTRICT										
IH-20	Palo Pinto	0314-02-042	Multi-grade, AC-10 + latex							
HOUSTON DISTRICT										
FM-1301	Brazoria	1412-2-11	CRM							
FM-360	Ft. Bend	527-6-16	CRM							
FM-442	Ft. Bend	838-2-16	CRM							
FM-1994	Ft. Bend	1965-1-5	CRM							
FM-1458	Waller	527-2-13	CRM							
LUBBOCK DISTRICT										
98th St.	Lubbock	905-06-024	AC-10 + latex							
FM-2255	Lubbock	2256-01-014	AC-10 + latex							
LUFKIN DISTRICT										
SH-63	Angelina	0244-01-040	Crumb Rubber Wet							
US-259	Nacogdoches	0138-06-033	Crumb Rubber Wet							

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
Loop 59										
ODESSA DISTRICT										
US-385	Crane/Upton	228-3-28 229-3-28	AC-20 + latex							
IH-20	Ector	4-7-87	AC-10							
FM-1882	Ector	2005-8-1								
IH-20	Ector	4-7-88	AC-10							
IH-20	Ector	5-13-037	CRM							
BI-10-G	Pecos	0140-17-004	AC-20 + latex							
IH-20	Ward/Reeves	?	AC-20 + latex							
SH-137	Martin	0494-03-023	AC-20 + latex							
LP-250	Midland	1188-02-046	AC-20							
PHARR DISTRICT										
US-281	Hidalgo	255-12-2	AC-20							
US-281	Hidalgo	255-09-66	AC-20							
SAN ANGELO DISTRICT										
US-277 RM-915 US-190E	Schleicher	0159-04-025	AC-20							

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
SAN ANTONIO DISTRICT										
Loop 13	Bexar	0521-01-039	AC-20							
Poplar St.	Bexar	0915-12-098	AC-20							
Wetmore	Bexar	915-12-112	AC-20							
Callaghn	Bexar	521-4-224	AC-20							
IH-10	Kerr	0142-14-041	AC-20							
IH-10	Bexar	72-7-43	CRM							
IH-10	Kerr	0142-12-12	AC-20							
Water St.	Kerr	0915-15-012	AC-20							
IH-35	Frio	0017-06-059	AC-20							
IH-35	Frio	0017-07-070	AC-20							
IH-35	Bexar	17-03-49	AC-20							
SP-537	Bexar	253-04-103	AC-20							
36th & Culebr	Bexar	?	AC-20							
Old Castroville Road	Bexar	?	AC-20							

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
SAN ANTONIO DISTRICT										
SP-422	Bexar	613-01-047	AC-20							
LP-1609	Bexar	2452-4-103	AC-20							
TYLER DISTRICT										
LP-323	Smith	2075-02-040	AC-10 + latex							
WACO DISTRICT										
SH-317	Bell	0398-04-051	AC-20							
SH-7	Falls	382-01-039	AC-20							
IH-35W	Hill	14-23-022	AC-20							
IH-35FR	McLennan	14-8-64								
SH-22	Hill	0121-03-049	AC-20							
SH-171	Limestone	419-2-032	AC-20							
FM-3051	McLennan	2311-01-22	AC-20							
Loop 340	McLennan	258-9-106	AC-20							
US-84	McLennan	56-1-025	AC-20							
US-84	McLennan	55-7-048	AC-20							
FM-1633	Limestone	1664-1-13	AC-20							

Table A1. Asphalt Binder Properties (cont'd).

Highway	County	CSJ	Asphalt Grade	Original Properties					TFOT Properties	
				Viscosity 140°F	Viscosity 275°F	PEN 77°F	Ductility 39.2 F		Viscosity 140°F	Ductility 77°F
							1 CM/MIN	5 CM/MIN		
WICHITA FALLS DISTRICT										
US-287	Clay	224-1-44 224-01-04	AC-20							
US-287	Clay	224-2-34 224-02-03	AC-20							
US-287	Clay	224-02-03 224-2-35	AC-20							
US-82	Montague	0044-04-040	AC-20							
US-82	Montague	0044-04-041	AC-20							
US-82	Montague	CPM44-4-42	AC-20							
US-287	Wichita	43-9-80 0043-09-08	AC-20							
Kemp St.	Wichita	903-03-027	AC-20							
IH-44	Wichita									
US-287	Wilbarger	0043-06-062	AC-20							
YOAKUM DISTRICT										
FM-1093	Wharton	0446-05-008	AC-20							
FM-1093	Colorado	0446-04-011	AC-20							
FM-3013	Colorado	3205-02-012	AC-20							

APPENDIX B

AGGREGATE SOURCES AND PROPERTIES

Table B1. Aggregate Sources.

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
ABILENE DISTRICT									
IH-20	Callihan	0006-07-061	CL						
SH-36	Callihan	0181-02-021	CL						
US-87	Howard	69-1-40	CL						
US-83/84	Jones	33-5-070	CL						
IH-20	Taylor	6-04-057	CL						
US-83	Taylor	34-2-27	CL						
AMARILLO DISTRICT									
IH-40	Gray	275-8-025	CG			LS			
ATLANTA DISTRICT									
SH-8	Bowie	61-1-019	CGR				FS		
US-59	Bowie Harrison	218-0-065 STP 95 (548)	CGR				FS		
IH-20	Harrison	495-09-038	CGR			LS			
SH-154	Harrison	402-2-30	CGR			LS			
US-59	Harrison	63-1-55	CGR			LS			
SH-149	Panola	0394-01-047	CGR			LS			
SH-149	Panola	0063-11-024	CGR			LS			
SH-315	Panola	0462-03-030	CGR			LS			

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
ATLANTA DISTRICT									
US-79	Panola	0247-02-032	CGR						
US-79	Panola	0247-03-015	CG						
AUSTIN DISTRICT									
IH-35	Travis	0015-13-240	CL	CS		LS			
Loop 1	Travis	3136-01-?	CL	CS		LS			
US-290	Travis	114-2-43	CL	CS		LS			
BEAUMONT DISTRICT									
US-96	Hardin	65-5-117	CD						
BROWNWOOD DISTRICT									
IH-20	Eastland	7-3-65	CL			LS			
IH-20	Eastland	7-6-060	CL			LS			
US-180	Stephens	11-7-39	CL			LS			
BRYAN DISTRICT						LS			
SH-21	Brazos	116-4-080	CL			LS			
SH-36	Washington	186-5-27	CL			LS			
US-290	Washington	186-6-050	CL			LS			
US-79	Milam	204-5-24	CL			LS			

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
CHILDRESS DISTRICT									
US-287	Childress	43-1-049 42-12-36	CL	CS					
US-287	Childress	43-1-049	CL	CG					
US-287	Hardeman	43-2-049	CL	CG					
1-40*	Wheeler	IM 40-2(20)146 275-12-52							
DALLAS DISTRICT				CS		LS			
IH-45	Navarro	92-06-82	CL						
EL PASO DISTRICT									
FM-659	El Paso	1046-1-14	CD						
IH-10 (West)	Hudspeth	2-8-042	CD						
IH-10 (East)	Hudspeth	2-8-042	CD						
FORT WORTH DISTRICT						LS			
IH-20	Palo Pinto	0314-02-042	CGR			LS			
HOUSTON DISTRICT						LS			
FM-1301	Brazoria	1412-2-11	CL			LS			
FM-360	Ft. Bend	527-6-16	CL			LS			

*Not a CMHB project

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
HOUSTON DISTRICT									
FM-442	Ft. Bend	838-2-16	CL			LS			
FM-1994	Ft. Bend	1965-1-5	CL			LS			
FM-1458	Waller	527-2-13	CL			LS			
LUBBOCK DISTRICT									
98th St.	Lubbock	905-06-024	CG						
FM-2255	Lubbock	2256-01-014	CG						
LUFKIN DISTRICT									
SH-63	Angelina	0244-01-040							
US-259	Nacogdoches	0138-06-033							
ODESSA DISTRICT									
US-385	Crane/Upton	228-3-28 229-3-28	CL			LS			
IH-20	Ector	4-7-87	CL			LS			
IH-20	Ector	4-7-88	CL			LS			
IH-20	Ector	5-13-037	CL			LS			
BI-10-G	Pecos	0140-17-004	CGR			LS			
IH-20	Ward/Reeves	?	CGR			LS			
SH-137	Martin	0494-03-023	CL			LS			

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
ODESSA DISTRICT									
LP-250	Midland	1188-02-046	CL			LS			
PHARR DISTRICT						LS			
US-281	Hidalgo	255-12-2	CGR						
US-281	Hidalgo	255-09-66	CGR						
SAN ANGELO DISTRICT									
US-277 RM-915 US-190E	Schleicher	0159-04-025	CL			LS			
SAN ANTONIO DISTRICT									
Loop 13	Bexar	0521-01-039	CL			LS			
Poplar St.	Bexar	0915-12-098	CL			LS			
Wetmore	Bexar	915-12-112	CL			LS			
Callaghn	Bexar	521-4-224	CL			LS			
IH-10	Kerr	0142-14-041	CD			DS			
IH-10	Bexar	72-7-43	CL			LS			
IH-10	Kerr	0142-12-12	CL			LS			
Water St.	Kerr	0915-15-012	CL			LS			
IH-35	Frio	0017-06-059	CL			LS			
IH-35	Frio	0017-07-070	CL			LS			

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
SAN ANTONIO DISTRICT									
IH-35	Bexar	17-03-49	CL			LS			
SP-537	Bexar	253-04-103	CL			LS			
36th & Culebr	Bexar	?	CL			LS			
Old Castroville Road	Bexar	?	CL			LS			
SP-422	Bexar	613-01-047	CL			LS			
LP-1609	Bexar	2452-4-103	CL			LS			
TYLER DISTRICT									
LP-323	Smith	2075-02-040	CS or CL			LS			
WACO DISTRICT						LS			
SH-317	Bell	0398-04-051	CL			LS			
SH-7	Falls	382-01-039	CL			LS			
IH-35W	Hill	14-23-022	CL			LS			
IH-35FR	McLennan	14-8-64	CL			LS			
SH-22	Hill	0121-03-049	CL			LS			
SH-171	Limestone	419-2-032	CL			LS			
FM-3051	McLennan	2311-01-22	CL			LS			

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
WACO DISTRICT									
Loop-340	McLennan	258-9-106	CL			LS			
US-84	McLennan	56-1-025	CL			LS			
US-84	McLennan	55-7-048	CL			LS			
FM-1633	Limestone	1664-1-13	CL			LS			
WICHITA FALLS DISTRICT						LS			
US-287	Clay	224-1-44 224-01-04	CL			LS			
US-287	Clay	224-2-34 224-02-03	CL			LS			
US-287	Clay	224-02-03 224-2-35	CL			LS			
US-82	Montague	0044-04-040	CL			LS			
US-82	Montague	0044-04-041	CL			LS			
US-82	Montague	CPM44-4- 42	CL			LS			
US-287	Wichita	43-9-80 0043-09-08	CL			LS			
Kemp St.	Wichita	903-03-027 903-03-02	CL			LS			
US-287	Wilbarger	0043-06-062	CL			LS			

Table B1. Aggregate Sources (cont'd).

Highway	County	CSJ	Coarse Aggregate Size A	Coarse Aggregate Size B	Intermediate Aggregate	Fine Aggregate Crushed	Fine Aggregate Not Crushed	Other Aggregate	
								A	B
YOAKUM DISTRICT									
FM-1093	Wharton	0446-05-008	CL			LS			
FM-1093	Colorado	0446-04-011	CL			LS			
FM-3013	Colorado	3205-02-012	CL			LS			

1) CD - Cracked Dolomite
2) CG - Crushed Granite
3) CL - Crushed Limestone
4) CS - Crushed Sandstone
5) CGR - Crushed Gravel
6) DS - Dolomite Screenings
7) FS - Field Sand
8) LS - Limestone Screenings

APPENDIX C

MIXTURE PROPERTIES

Table C1. Mixture Properties.

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
ABILENE DISTRICT															
IH-20	Callihan	0006-07-061													
SH-36	Callihan	0181-02-021	6218	1134	2	0.47	0.12	2	3.3	0.42	2			90	2.7
US-87	Howard	69-1-40													
US-83/84	Jones	33-5-070													
IH-20	Taylor	6-04-057													
US-83	Taylor	34-2-27													
AMARILLO DISTRICT															
IH-40	Gray	275-8-025													
ATLANTA DISTRICT															
SH-8	Bowie	61-1-019													
US-59	Bowie Harrison	218-0-065 STP 95(548)													
IH-20	Harrison	495-09-038 495-10-											C		
SH-154	Harrison	402-2-30													
US-59	Harrison	63-1-55											C		
SH-149	Panola	0394-01-047													

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
ATLANTA DISTRICT															
SH-149	Panola	0063-11-024													
SH-315	Panola	0462-03-030													
US-79	Panola	0247-02-032													
US-79	Panola	0247-03-015													
AUSTIN DISTRICT															
IH-35	Travis	0015-13-240													
Loop 1	Travis	3136-01-?													
US-290	Travis	114-2-43													
BEAUMONT DISTRICT															
US-96	Hardin	65-5-117													
BROWNWOOD DISTRICT															
IH-20	Eastland	7-3-65													
IH-20	Eastland	7-6-060											C		
US-180	Stephens	11-7-39													
BRYAN DISTRICT													C		
SH-21	Brazos	116-4-080													
SH-36	Washington	186-5-27	7879	1876	3	0.19	0.087	3	1.77	0.12	3	16.2	C	95	
US-290	Washington	186-6-050	7794	1709	3	0.36	0.07	3	3.37	0.58	3	114.5	C	95	

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
BRYAN DISTRICT															
US-79	Milam	204-5-24	6450			0.46			3.0			14.1	C		
CHILDRESS DISTRICT															
US-287	Childress	43-1-049 42-12-36											C		
US-287	Childress/ Hardeman	43-1-049													
I-40*	Wheeler	IM40- 2(20)146 275-12-52													
DALLAS DISTRICT															
IH-45	Navarro	92-06-82													
EL PASO DISTRICT															
FM-659	El Paso	1046-1-14	11979	3330	3	0.41	0.20	3	3.8	1.19	3				
IH-10 (West)	Hudspeth	2-8-042													
IH-10 (East)	Hudspeth	2-8-042													
FORT WORTH DISTRICT													C		
IH-20	Palo Pinto	0314-02-042	8008	1206	3	0.19	0.08	3	2.7	0.45	3		C	40	22.0

*Not a CMHB project

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
HOUSTON DISTRICT															
FM-1301	Brazoria	1412-2-11													
FM-360	Ft. Bend	527-6-6													
FM-442	Ft. Bend	838-2-16													
FM-1994	Ft. Bend	1965-1-5													
FM-1458	Waller	527-2-13													
LUBBOCK DISTRICT															
98th St.	Lubbock	905-06-024													
FM-2255	Lubbock	2256-01-014													
LUFKIN DISTRICT															
SH-63	Angelina	0244-01-040													
US-259	Nacogdoches	0138-06-033													
ODESSA DISTRICT															
US-385	Crane/Upton	228-3-28 229-3-28											C		
IH-20	Ector	4-7-87													
FM-1882	Ector	2005-3-1	7006			0.38			3.1				F		
IH-20	Ector	4-7-88											F		

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
ODESSA DISTRICT															
IH-20	Ector	5-13-037													
BI-10-G	Pecos	0140-17-004													
IH-20	Ward/ Reeves	?													
SH-137	Martin	0494-03-023													
LP-250	Midland	1188-02-046													
PHARR DISTRICT															
US-281	Hidalgo	255-12-2													
US-281	Hidalgo	255-09-66													
SAN ANGELO DISTRICT															
US-277 RM-915 US-190E	Schleicher	0159-04-025													
SAN ANTONIO DISTRICT															
Loop 13	Bexar	0521-01-039													
Poplar St.	Bexar	0915-12-098													
Wetmore	Bexar	915-12-112													
Callaghn	Bexar	521-4-224													

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
SAN ANTONIO DISTRICT															
IH-10	Kerr	0142-14-041													
IH-10	Bexar	72-7-43													
IH-10	Kerr	0142-12-12													
Water St.	Kerr	0915-15-012													
IH-35	Frio	0017-06-059													
IH-35	Frio	0017-07-070													
IH-35	Bexar	17-03-49													
SP-537	Bexar	253-04-103													
36th & Culebr	Bexar	?													
Old Castroville Road	Bexar	?													
SP-422	Bexar	613-01-047													
LP-1609	Bexar	2452-4-103													
TYLER DISTRICT															
LP-323	Smith	2075-02-040	9320			0.26			3.2			18.6	C	40	6.7

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
WACO DISTRICT															
SH-317	Bell	0398-04-051 15-06-03	7515			0.36			3.1			17	F	100	
SH-7	Falls	382-01-039	15088			.025			2.6			15	C	95	
IH-35W	Hill	14-23-022	9543			0.18			2.3			16	C	35	
IH-35FR	McLennan	14-8-64													
SH-22	Hill	0121-03-049													
SH-171	Limestone	419-2-032	6515			0.4			3.7			16	C	62	
FM-3051	McLennan	2311-01-22													
Loop 340	McLennan	258-9-106													
US-84	McLennan	56-1-025											C		
US-84	McLennan	55-7-048													
FM-1633	Limeston	1664-1-13													
WICHITA FALLS DISTRICT															
US-287	Clay	224-1-44 224-01-04	6907	791	2	0.34	0.08	2	3.0	0.21	2	17.7	F	50	13.8
US-287	Clay	224-2-34 224-02-03										15.4	C		
US-287	Clay	224-02-03 224-2-35										16.3	C		

Table C1. Mixture Properties (cont'd).

Highway	County	CSJ	Stiffness, PSI			Perm. Strain, in/in X 10^{-4}			Slope in/in Per Sec. X 10^{-8}			VMA	Gradation	PRS	Traffic ESAL X106
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n				
WICHITA FALLS DISTRICT															
US-82	Montague	0044-04-040										14.3	C		
US-82	Montague	0044-04-041										14.8	C		
US-82	Montague	CPM44-4-42													
US-287	Wichita	43-9-80 0043-09-08										14.3	C		
Kemp St.	Wichita	903-03-02 903-03-027 413-01-027	11943			0.19			2.6				C		
IH-441	Wichita	156-07-048	9896			0.28			1.9				C		
US-287	Wilbarger	0043-06-062													
YOAKUM DISTRICT															
FM-1093	Wharton	0446-05-008													
FM-1093	Colorado	0446-04-011													
FM-3013	Colorado	3205-02-012													

APPENDIX D

TRAFFIC CHARACTERISTICS

Table D1. Traffic Characteristics.

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
ABILENE DISTRICT							
IH-20	Callihan	0006-07-061	6.7	17,320	27.8	20.5	
SH-36	Callihan	0181-02-021	6.2	3,200	22.4	2.7	
US-87	Howard	69-1-40				3.4	
US-83/84	Jones	33-5-070	36.9	9,060	11.9	3.8	
IH-20	Taylor	6-04-057				19.8	
US-83	Taylor	34-2-27				1.5	
AMARILLO DISTRICT							
IH-40	Gray	275-8-025				30.3	
ATLANTA DISTRICT							
SH-8	Bowie	61-1-019	1.2	6,000	24.8	6.6	
US-59	Bowie	218-0-065	17.0	15,000	16.0	9.7	Control and section does not match (218-01)
IH-20	Harrison	495-09-038 495-10-	20.3	21,270	34.7	33.1	
SH-154	Harrison	402-2-30	7.7	1,950	14.4	1.0	Control and section does not match (402-03)
US-59	Harrison	63-1-55	5.6	14,600	13.3	8.1	
SH-149	Panola	0394-01-047	10.9	4,700	9.4	1.2	
SH-149	Panola	0063-11-024	6.4	4,400	35.5	11.4	
SH-315	Panola	0462-03-030	11.0	5,200	33.5	9.3	
US-79	Panola	0247-02-032	16.0	5,800	27.4	7.9	

Table D1. Traffic Characteristics (cont'd).

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
ATLANTA DISTRICT							
US-79	Panola	0247-03-015	8.8	6,200	26.6	7.9	
AUSTIN DISTRICT							
IH-35	Travis	0015-13-240	21.6	153,620	7.3	45.5	
Loop 1	Travis	3136-01-?	16.4	98,980	1.8	4.6	
US-290	Travis	114-2-43	7.0	27,000	4.7	4.2	
BEAUMONT DISTRICT							
US-96	Hardin	65-5-117				9.2	
BROWNWOOD DISTRICT							
IH-20	Eastland	7-3-65	12.3	14,060	35.7	22.1	
IH-20	Eastland	7-6-060	4.0	13,500	36.4	22.4	
US-180	Stephens	11-7-39	9.6	4,400	12.6	1.8	
BRYAN DISTRICT							
SH-21	Brazos	116-4-080				5.2	
SH-36	Washington	186-5-27				4.8	
US-290	Washington	186-6-450				6.6	
US-79	Milam	204-5-24				5.6	
CHILDRESS DISTRICT							
US-287	Childress	43-1-049	6.9	6,700	24.0	6.4	

Table D1. Traffic Characteristics (cont'd).

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
CHILDRESS DISTRICT							
US-287	Childress/ Hardeman	43-1-049	10.9	6,800	23.7	6.4	Control and section does not match (43-02)
1-40*	Wheeler	IM 40-2(20)146	14.1	12,010	50.4	26.8	Cotrol and section does not match (275-12)
DALLAS DISTRICT							
IH-45	Navarro	92-06-82	25.7	25,580	25.8	28.2	For control and section 92-06
EL PASO DISTRICT							
FM-659	El Paso	1046-1-14				7.1	
IH-10 (West)	Hudspeth	2-8-042				19.1	
IH-10 (East)	Hudspeth	2-8-042				19.1	
FORT WORTH DISTRICT							
IH-20	Palo Pinto	0314-02-042	17.3	14,010	35.7	22.0	
HOUSTON DISTRICT							
FM-1301	Brazoria	1412-2-11				0.3	
FM-360	Ft. Bend	527-6-16				1.0	
FM-442	Ft. Bend	838-2-16				0.3	
FM-1994	Ft. Bend	1965-1-5				0.6	
FM-1458	Waller	527-2-13				0.2	

*Not a CMHB project

Table D1. Traffic Characteristics (cont'd).

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
LUBBOCK DISTRICT							
98th St.	Lubbock	905-06-024					
FM 2255	Lubbock	2256-01-014					
LUFKIN DISTRICT							
SH-63	Angelina	0244-01-040	2.7	3,200	22.2	3.1	
US-259	Nacogdoches	0138-06-033	6.3	10,100	24.9	12.1	
ODESSA DISTRICT							
US-385	Crane/Upton	228-3-28				2.7	
IH-20	Ector	4-7-87				19.5	
IH-20	Ector	5-13-037				19.9	
IH-20	Ector	4-7-88					
BI-10-G	Pecos	0140-17-004				1.0	
IH-20	Waco/ Reeves	?					
SH-137	Martin	0494-03-023				1.2	
LP-250	Midland	1188-02-046				1.2	
PHARR DISTRICT							
US-281	Hidalgo	255-12-2					
US-281	Hidalgo	255-09-66	42.8	12,500	6.4	2.7	

Table D1. Traffic Characteristics (cont'd).

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
SAN ANGELO DISTRICT							
US-277 RM-915 US-190E	Schleicher	0159-04-025	16.7	3,500	17.8	1.7	
SAN ANTONIO DISTRICT							
Loop 13	Bexar	0521-01-039	3.0	16,600	4.2	1.6	
Poplar St.	Bexar	0915-12-098					
Wetmore	Bexar	915-12-112					
Callaghn	Bexar	521-4-224				12.0	
IH-10	Kerr	0142-14-041	18.8	9,770	27.0	10.9	
IH-10	Bexar	72-7-43	5.3	27,000	10.8	11.1	
IH-10	Kerr	0142-12-12	15.5	7,300	30.5	10.2	
Water St.	Kerr	0915-15-012					
IH-35	Frio	0017-06-059				17.9	
IH-35	Frio	0017-07-070				19.7	
IH-35	Bexar	17-03-49	8.1	21,480	16.5	17.0	
SP-537	Bexar	253-04-103	22.0	44,000	2.2	2.4	
36th & Culebr	Bexar	?					
Old Castroville Road	Bexar	?					

Table D1. Traffic Characteristics (cont'd).

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
SAN ANTONIO DISTRICT							
SP-422	Bexar	613-01-047	2.8	23,990	3.0	2.0	
LP-1604	Bexar	2452-4-103	7.0	3,800	5.9	0.74	
TYLER DISTRICT							
LP-323	Smith	2075-02-040	3.5	36,000	6.1	6.7	
WACO DISTRICT							
SH-317	Bell	0398-04-051				2.5	
SH-7	Falls	382-01-039				1.2	
IH-35W	Hill	14-23-022				18.7	
IH-35FR	McLennan	14-8-64				38.5	
SH-22	Hill	0121-03-049				1.6	
SH-171	Limestone	419-2-032				2.0	
FM-3051	McLennan	2311-01-22				3.0	
Loop-340	McLennan	258-9-106				6.4	
US-84	McLennan	56-1-025				2.2	
US-84	McLennan	55-7-048				2.3	
FM-1633	Limestone	1664-1-13				0.1	
WICHITA FALLS DISTRICT							
US-287	Clay	224-1-44	16.8	13,430	25.2	13.8	
US-287	Clay	224-2-34	11.8	13,500	25.2	14.3	

Table D1. Traffic Characteristics (cont'd).

Highway	County	CSJ	MP	ADT	Percent Trucks	ESAL X 10^6	Comments
WICHITA FALLS DISTRICT							
US-287	Clay	224-2-35	17.1	14,300	24.4	14.7	
US-82	Montague	0044-04-040	9.6	3,000	18.6	2.1	
US-82	Montague	0044-04-041	15.6	6,800	13.9	3.6	
US-82	Montague	CPM44-4-42	16.1	8,200	13.3	4.2	
US-287	Wichita	43-9-80	20.2	13.400	21.8	12.0	
Kemp St.	Wichita	903-03-027					
US-287	Wilbarger	0043-06-062				12.5	
YOAKUM DISTRICT							
FM-1093	Wharton	0446-05-008				0.5	
FM-1093	Colorado	0446-04-011	4.0	610	24.2	0.68	
FM-3013	Colorado	3205-02-012	7.8	2,700	28.5	4.0	

APPENDIX E

QUALITY CONTROL/QUALITY ASSURANCE

Table E1. Field QC/QA Statistics - Atlanta District, Harrison County, Highway IH20, CSJ 495-09-038.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3A	1-4	C	4.91	0.07	9	78.0	1.11	10	7.0	0.42	10	96.7	0.46	4	6.0	0.69	16
3B	5	C	5.02	0.08	3	78.3	1.44	3	6.5	0.26	3				6.1	0.95	4
1	6	C	4.71	9.06	4	77.6	2.80	4	7.4	0.79	4						
4	7-29	C	4.87	0.10	90	76.7	1.53	90	7.2	0.48	90	97.0	0.38	23	5.6	1.14	72

Table E2. Field QC/QA Deviation From Job Mix Formula LA Atlanta District, Harrison County, Highway IH20, CST 495-09-038.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3A	1-4	C	+0.01	+0.9	-0.6
3B	5	C	-0.08	+1.2	-1.1
1	6	C	+0.01	+0.5	-0.2
4	7-29	C	+0.01	+0.2	-0.1

Table E3. Field QC/QA Statistics Atlanta District, Harrison County, Highway US 59, CSJ 63-01-055.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			x̄	s	n	x̄	s	n	x̄	s	n	x̄	s	n	x̄	s	n
3	1	C	4.70	0.06	4	76.9	0.96	4	7.0	0.36	4				7.5	0.91	4
3	2	C	4.69	0.08	4	75.9	1.44	4	7.0	0.31	4				6.8	04.8	4
3	3	C	4.67	0.07	4	78.0	3.28	4	6.9	0.15	4				6.6	0.25	4
3	4	C	4.73	0.12	4	77.9	1.19	4	6.8	0.35	4						
3	5	C	4.82	0.09	4	78.9	1.76	4	6.1	0.21	4						
3	6	C	4.79	0.21	4	78.2	2.06	4	7.1	0.17	4						
3	1-6	C	4.73	0.12	24	77.6	4.98	24	6.8	0.40	24	97.1	0.28	6	7.0	0.67	12

Table E4. Field QC/QA Deviation From Job Mix Formula LA Atlanta District, Harrison County, Highway US 59, CSJ C3-01-055.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1	C	-0.10	+0.4	-0.3
3	2	C	-0.11	-0.6	-0.3
3	3	C	-0.13	+1.5	-0.4
3	4	C	-0.07	+1.4	-0.5
3	5	C	+0.02	+2.4	-1.2
3	6	C	-0.01	+1.7	-0.2
3	1-6	C	-0.07	+1.1	-0.5

Table E5. Field QC/QA Statistics Bryan District, Milam County, Highway US79, CSJ 204-05624.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	6-10	C	5.75	0.22	17							96.9	0.51	10	7.95	1.50	16

Table E6. Field QC/QA Deviation From Job Mix Formula Bryan District, Milam County, Highway US79, CSJ 204-05-024.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	6-10	C	+0.55		

Table E7. Field QC/QA Statistics Childress District, Childress County, Highway US287, CSJ 42-12-36.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	1-5	T	4.85	0.16	11	75.9	1.76	19	5.27	0.57	19	97.7	0.50	6	7.37	1.47	11

Table E8. Field QC/QA Deviation From Job Mix Formula Childress District, Childress County, Highway US297, CSJ 42-2-36.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1-5	T	+0.05	-3.4	+0.27

Table E9. Field QC/QA Statistics Ft. Worth District, Palo Pinto County, Highway IH20, CSJ 314-02-042.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
4	1-2	C	5.66	0.21	8	77.6	2.02	89	6.10	0.70	89	97.6	0.42	2	6.06	1.46	8
5	3-6	C	5.58	0.16	16	78.4	1.98	16	5.96	0.85	16	96.4	0.89	5	6.19	0.94	16
6	7-12	C	5.70	0.17	24	77.8	1.60	24	6.03	0.40	24	97.2	0.95	6	5.95	1.34	24
7	13-20	C	5.63	0.14	32	77.9	1.23	32	6.17	0.42	32	97.2	0.44	8	6.30	1.06	32
8	21-22	C	5.48	0.17	4	77.5	1.37	4	6.35	0.51	4	96.8		1	6.35	2.65	4

Table E10. Field QC/QA Deviation From Job Mix Formula Ft. Worth District, Palo Pinto County, Highway IH20, CSJ 314-02-042.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
4	1-2	C	+0.16	0.00	+0.10
5	3-6	C	-0.02	+0.5	-0.04
6	7-12	C	+0.10	-0.1	-0.47
7	13-20	C	+0.03	0.0	+0.17
8	21-22	C	-0.12	-1.5	+0.35

Table E11. Field QC/QA Statistics Odessa District, Crane County, Highway US 385, CSJ 229-03-28.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
2A	1	C	6.55	0.92	2	80.4	1.87	6	5.22	1.21	6	98.5	0.57	4	8.40	0.55	4
2B	2	C	6.45	0.53	4	81.2	1.47	4	6.03	0.79	4	97.7	0.94	4	7.85	0.65	4
3A	3	C	5.53	0.10	6	80.6	1.39	6	7.50	0.42	6	96.3	0.32	4	10.4	0.84	4
3B	4-6	C	5.77	0.27	12	80.7	3.32	12	7.23	0.61	11	97.0	0.38	4	10.5	0.43	12
4A	7-33	C	5.96	0.19	99	80.3	1.71	103	7.42	0.69	91	97.3	0.34	27	8.51	1.06	76

Table E12. Field QC/QA Deviation From Job Mix Formula Odessa District, Crane County, Highway US 385, CSJ 229-03-28.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
2A	1	C	-0.15	+0.4	-2.68
2B	2	C	+0.05	+1.2	-1.87
3A	3	C	-0.67	+0.6	-0.40
3B	4-6	C	-0.13	+0.7	-0.67
4A	7-33	C	+0.06	+1.2	-0.48

Table E13. Field QC/QA Statistics Waco District, Bell County, Highway SH317, CSJ 15-05-03.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
4	1-2	C	6.18	0.08	8	77.5	0.96	8	7.51	0.52	8	96.4	0.64	2	9.66	0.68	8

Table E14. Field QC/QA Deviation From Job Mix Formula Waco District, Bell County, Highway SH317, CSJ 15-05-13.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
4	1-2	C	+0.18	0.0	+0.01

Table E15. Field QC/QA Statistics Waco District, Falls County, Highway SH7, CSJ 382-01-037.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
4	1-3	C	5.25	0.16	12	79.6	0.99	12	5.54	0.41	12	97.4	0.39	4	6.87	0.50	6

Table E16. Field QC/QA Deviation From Job Mix Formula Waco District, Falls County, Highway SH 7, CSJ 382-01-039.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
4	1-3	C	-0.05	+0.6	-0.26

Table E17. Field QC/QA Statistics Waco District, Hill County, Highway IH35W, CSJ 14-23-022.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	0	C	6.40	0.20	3	81.4	0.20	3	6.50	1.73	3						
4	1	C	6.97	0.43	4	80.5	1.56	4	7.28	0.90	4	97.2	0.29	4			
5	2.5	C	6.69	0.47	16	81.8	3.01	16	6.69	0.59	16	96.2	0.55	7			
6	6	C	7.17	0.63	4	82.7	1.30	4	7.08	0.67	4	96.8		1			
7	7-9	C	6.85	0.31	12	82.2	1.97	12	6.90	0.59	12	96.7	0.89	3			
4(?)5	11-19	C	5.52	0.20	36	76.5	1.07	36	6.22	0.46	32	97.2	0.33	9			
6	20	C	5.34	0.25	4	75.7	1.02	4	4.90	0.64	4	97.1		1			
7	22-28	C	5.73	0.29	25	76.1	1.74	21	5.88	0.42	21	97.7	0.74	6			
8	29	C	6.19	0.36	4	75.5	1.29	4	6.30	0.14	4	97.1	0.99	2			

Table E18. Field QC/QA Deviation From Job Mix Formula Waco District, Hill County, Highway IH35W, CSJ 14-23-022.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
5	0	C	+0.30	+2.4	0.0
4	1	C	+0.17	+1.5	+0.78
5	2-5	C	+0.09	+0.8	+0.19
6	6	C	+0.27	+0.7	+0.58
7	7-9	C	-0.05	+0.2	+0.40
4(?)5	11-19	C	+0.02	+0.5	-0.28
6	20	C	+0.14	-0.3	-1.1
7	22-28	C	+0.23	+0.1	-0.12
8	29	C	+0.19	-0.5	+0.30

Table E19. Field QC/QA Statistics Waco District, Limestone County, Highway SH171, CSJ 419-02-032.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
4	1-3	C	6.47	0.55	12	74.1	1.17	12	6.84	0.54	12	97.5	0.93	3			
5	4	C	6.70	0.33	4	74.4	0.55	4	6.18	0.21	4	96.5	0.14	2			
6	5-6	C	6.63	0.18	8	73.6	1.26	8	6.03	0.24	8	96.4	0.35	2			
7	7-8	C	6.86	0.23	8	74.9	1.44	8	6.30	0.44	8	97.8		1			
8	9-11	C	6.55	0.36	10	75.3	1.67	10	7.05	0.54	10	97.9	0.45	3			

Table E20. Field QC/QA Deviation From Job Mix Formula Waco District, Limestone County, Highway SH171, CSJ 419-02-032.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
4	1-3	C	+0.07	-1.3	-0.16
5	4	C	+0.30	-1.0	-0.82
6	5-6	C	+0.03	-1.8	-0.97
7	7-8	C	-0.04	-1.5	+0.70
8	9-11	C	-0.05	-0.1	+0.05

Table E21. Field QC/QA Statistics Waco District, McLennan County, Highway LP340/305, CSJ 56-1-25.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			x̄	s	n	x̄	s	n	x̄	s	n	x̄	s	n	x̄	s	n
3	1	C	5.93	0.23	4	77.5	2.22	4	5.40	0.54	4	98.4	0.21	2			
4	2-7	C	6.03	0.28	24	78.3	2.14	24	5.29	0.64	24	97.6	0.52	7			
5	8	C	5.95	0.13	4	77.9	0.47	4	5.03	0.66	4	97.5		1			
6	9-10	C	5.90	0.21	8	79.0	2.28	8	5.03	0.43	8	97.8	0.00	2			
7	11-12	C	5.75	0.58	5	80.6	0.90	5	4.66	0.59	5	97.0	0.57	2			

Table E22. Field QC/QA Deviation From Job Mix Formula Waco District, McLennan County, Highway LP340/305, CSJ 56-1-25.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1	C	-0.07	-3.50	-0.10
4	2-7	C	+0.03	-0.7	-0.21
5	8	C	-0.05	-0.1	+0.03
6	9-10	C	-0.10	0.0	+0.03
7	11-12	C	+0.15	+0.6	-0.34

Table E23. Field QC/QA Statistics Waco District, McLennan County, Highway US84, CSJ 56-1-25.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
8	13	C	6.22	0.08	4	76.6	0.96	4	6.18	0.49	4	97.1		1			
9	14-18	C	6.05	0.25	19	77.3	0.21	19	5.94	0.48	19	97.5	0.34	6			

Table E24. Field QC/QA Deviation From Job Mix Formula Waco District, McLennan County, Highway US84, CSJ 56-1-25.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
8	13	C	+0.22	-1.9	-0.32
9	14-18	C	+0.05	-0.1	-0.06

Table E25. Field QC/QA Statistics Wichita Falls District, Clay County, Highway US87, CSJ 224-02-03.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	1	C	5.10	0.23	4	78.4	1.68	4	7.95	0.87	4				8.3	0.55	4
3	2	C	5.08	0.17	4	78.3	1.49	4	7.95	0.60	4				6.7	1.03	4
3	3	C	5.00	0.14	4	77.6	1.43	4	8.58	0.51	4				7.3	1.70	4
3	4	C	4.88	0.10	4	76.4	2.10	4	8.78	0.71	4				7.8	0.00	4
3	1-4	C	5.01	0.17	16	77.7	1.73	16	8.31	0.72	16	97.7	1.03	5	7.5	1.10	16

Table E26. Field QC/QA Deviation From Job Mix Formula Wichita Falls District, Clay County, Highway US87, CSJ 224-02-03.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1	C	-0.10	+2.2	+1.05
3	2	C	-0.12	+2.1	+1.05
3	3	C	-0.20	+1.4	+1.68
3	4	C	-0.22	+0.2	+1.88
3	1-4	C	-0.19	+1.5	+1.41

Table E27. Field QC/QA Statistics Wichita Falls District, Clay County, Highway US287, CSJ 224-02-03 (Type C).

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	1-8	C	5.53	0.12	32	77.9	1.87	32	7.75	0.60	32	97.4	0.46	9	5.95	1.49	16

Table E28. Field QC/QA Deviation From Job Mix Formula Wichita Falls District, Clay County, Highway US 287, CSJ 224-02-03 (Type C).

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1-8	C	-0.07	-0.7	+0.85

Table E29. Field QC/QA Statistics Wichita Falls District, Montague County, Highway US82, CSJ 44-04-04.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3A	1-6	C	5.14	0.19	20	77.6	1.68	20	7.83	0.54	20	97.5	0.58	5	5.95	0.81	11
3B	1-8	C	4.81	0.14	32	77.4	1.89	32	8.31	0.57	32	97.2	0.54	8	6.54	1.01	28

Table E30. Field QC/QA Deviation From Job Mix Formula Wichita Falls District, Montague County, Highway US 82, CSJ 44-04-04.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3A	1-6		+0.04	-1.0	+0.93
3B	1-8		+0.01	-1.6	+1.4

Table E31. Field QC/QA Statistics Wichita Falls District, Montague County, Highway US 82, CSJ 44-04-04.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	1-10	C	5.14	0.15	34	76.5	1.06	34	8.80	0.46	34	97.6	0.66	11	5.65	0.70	16

Table E32. Field QC/QA Deviation From Job Mix Formula Wichita Falls District, Montague County, Highway US 82, CSJ 44-04-04.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1-10	C	-0.36	-2.1	+1.6

Table E33. Field QC/QA Statistics Wichita Falls District, Wichita County, Highway US 287, CSJ 43-09-08.

JMF	Lot	Tester	Asphalt Content, %			+No. 10, %			-No. 200, %			Lab Molded Density, %			Field Air Voids, %		
			$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n	$\bar{x}$	s	n
3	1-15	C	4.89	0.17	60	76.2	2.09	60	7.31	1.20	60	96.6	0.43	15	6.75	1.22	52

Table E34. Field QC/QA Deviation From Job Mix Formula Wichita Falls District, Wichita County, Highway US 287, CSJ 43-09-08.

JMF	Lot	Tester	Asphalt Content %	+ No. 10	- No. 200
3	1-15	C	+0.09	-0.6	+0.61

APPENDIX F

JOINT TxDOT — INDUSTRY PERFORMANCE STUDY
NOVEMBER 1996

Table F1. Joint TxDOT Industry Performance Study.

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
ABILENE DISTRICT									
IH-20	Callihan	0006-07-061	Slight	Slight	Moderate	No	Less rutting w/CHMB	Some	
SH-36	Callihan	0181-02-021	Slight	None	Slight	No	Better than Type D	Some	Job holding up well.
US-87	Howard	69-1-40	None	None	slight	No	Very Good	Some	Mix was placed 7/96.
US-83/84	Jones	33-5-070	Moderate	None	None	N/A	Better than ACP "D"	Some	
IH-20	Taylor	6-04-057	None	None	Slight	No		Some	Finished w/Pneumatic Roller, Ride is poor.
US-83	Taylor	34-2-27	None	None	None	No	Not in place long	Some	CMHB is harder to get established rolling pattern.
AMARILLO DISTRICT									
IH-40	Gray	275-8-025	None	Slight	Moderate	No	About equal	None planned	
ATLANTA DISTRICT									
SH-8	Bowie	61-1-019	None	Slight	Slight	No	Appears comparable to "C"	None	
US-59	Bowie	218-0-065	None	Severe	Slight	No	Comparable to "C" other than rutting	None	
IH-20	Harrison	495-09-038 495-10-	Slight	None	Slight	No	Looks slightly "Older" than conventional mix designs	None (Evaluating)	Pavement is discolored & has slight visual irregularities throughout project.
SH-154	Harrison	402-2-30	None	None	None	N/A	Good in relation to dense-graded mixes	None (Evaluating)	
US-59	Harrison	63-1-55	None	None	Slight	None yet	Similar to dense-graded mixes	None (Evaluating)	

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
ATLANTA DISTRICT									
SH-149	Panola	0394-01-047	None	None	None	No	Usually Type "C" surface	None	GH Little River Coarse Agg. w/TCS limestone screenings. AC-10+3% latex**
SH-149	Panola	0063-11-024	None	None	None	No	Type "C" surface usual	None	Isolated places cracked & failed. Underlying problems suspected to be cause.
SH-315	Panola	0462-03-030	None	None	None	No	Type "C" surface usual	None (Evaluating)	**same
US-79	Panola	0247-02-032	None	Moderate	Slight	No	Type "C" surface usual	None (Evaluating)	GH Little River agg. w/ various asphalts-AC-20, AC-15-5TR, AC-10+3% latex. Planning microsurface project.
US-79	Panola	0247-03-015	None	None	Slight	No	Type "C" surface usual	None (Evaluating)	Mid-Stages Agg. w/AC 10+3% latex.
AUSTIN DISTRICT									
IH-35	Travis	0015-13-240	None	none	None	N/A	Performing well.	Some-rural (no C&G)	Project not been exposed to extended freezing wet weather. Contractor feels mix not as forgiving during paving operations.
Loop 1	Travis	3131-01-?	None	None	None	N/A	Performing well.	Some-rural (no C&G)	Limited exposure to extended periods of freezing weather. Construction operations more difficult.
US-290	Travis	114-2-43	Slight	None	None	N/A	Noticeably less cracking.	None planned.	

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
BEAUMONT DISTRICT									
US-96	Hardin	65-5-117	None	None	None	N/A	No appreciable difference w/Type C ACP w/SBS	Some	
BROWNWOOD DISTRICT									
IH-20	Eastland	7-3-65	None to Slight	Slight	Slight	Yes, Skid scores 26-35*	Not as good	Maybe some	Ratings not strictly due to CMHB, but combination of CMHB, existing pavement conditions, construction & production irregularities.**
IH-20	Eastland	7-6-060	None to Slight	Slight	Slight	Yes*	Not as good	Maybe some	**
US-180	Stephens	11-7-39	None to Slight	Slight	Slight	Yes*	Not as good	Maybe some	**
BRYAN DISTRICT									
SH-21	Brazos	116-4-080	None	Slight	None	No	Too early to form opinion	Some	Contraction feels we need to try an F design.
SH-36	Washington	186-5-27	None	None	Slight	No	Comparable for down time.	Some	Department may need to restrict aggregate sources to insure quality product.
US-290	Washington		None	None	Slight	No	Equal to or better for time it has been down.	Some	May need to restrict aggregate sources to insure quality product.
CHILDRESS DISTRICT									
US-287	Childress	43-1-049	None	None	slight	Yes	CMHB is more permeable. Performing about same D.	None	CMHB is more suited to climates without freeze/thaw cycles. Need to control permeability.

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
CHILDRESS DISTRICT									
US-287	Childress/ Hardeman	43-1-049	None	None	Slight to Moderate	No	CMHB is more permeable. Performing about the same.	None	Feel CMHB is more suitable to climates without freeze/thaw cycles.
I-40*	Wheeler	IM 40-2(20)146	None	Severe	None	No	Slippage problems would have happened no matter what mix was used.	Not my decision	Some slippage problems caused by hot rubber asphalt underseal. Would have happened no matter what mix was used.
DALLAS DISTRICT									
IH-45									
EL PASO DISTRICT									
FM-659	El Paso	1046-1-14	None	None	Moderate	Yes	Equal if not better	None	
IH-10 (West)	Hudspeth	2-8-042	Slight	Moderate	None	No	Poor performance-suspect tack not applied at proper rate.	None	
IH-10 (East)	Hudspeth	2-8-042	Slight	Slight	None	No	Poor performance-suspect tack not applied at proper rate	None	
FORT WORTH DISTRICT									
IH-20	Palo Pinto	0314-02-042	N/A	N/A	N/A	N/A	Refer to MT's Forensic Investigation	None	Theory of CMHB is sound and shows great promise. My opinion is it may require tighter control in design & production than now allowed under current QC/QA spec.

*Not a CMHB project

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
HOUSTON DISTRICT									
FM-1301	Brazoria	1412-2-11							
FM-360	Ft. Bend	527-6-16							
FM-442	Ft. Bend	838-2-16							
FM-1994	Ft. Bend	1965-1-5							
FM-1458	Ft. Bend	527-2-13							
LUBBOCK DISTRICT									
98th St.	Lubbock	905-06-024	None	None	None	N/A	Much more stable mix, very high skid resistance, no sign of nay type failure to date, excellent performance.	Some (all projects, except thin lift overlays)	
FM-2255	Lubbock	2256-01-014	None	None	Slight	No	Initial performance is excellent. Very stable mix.	Some (all new construction, except Curb & Gutter	Very pleased with CMHB
LUFKIN DISTRICT									
SH-63	Angelina	0244-01-040	None	Slight	Slight	No	Looks good. Looks like hot-mix job	None programmed at this time	
US-259	Nacogdoches	0138-06-033	Slight	Moderate	Moderate	No	Holding better than D mix	None	

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
ODESSA DISTRICT									
US-385	Crane/Upton	228-3-28	Moderate	Slight	None	N/A	D would have been better due to water penetrating CMHB	Some(not over base due to water problems)	Let hot-asphalt rubber seal contract to eliminate water penetrating mix.
IH-20	Ector	4-7-87	None	Slight	None	N/A	CMHB-F(rubber asphalt)held up quite well. Prior D was cracking immediately.	Some - hot asphalt rubber in next CHMB-F 140,000 T	First project we'd added additive to asphalt.
IH-20	Ector	4-7-88	None	Slight	Severe - 1st in state	Yes - milled travel lanes	Used AC-10 high asphalt content; air temp 110-118F. Held up better than D	Some	First project--high learning curve. New surface in excellent condition.
BI-10-G	Pecos	0140-17-004	None	Slight	Moderat e-severe	Yes-marginal skid resistance	Mix did not rut or push like D would have on approaches to signals. Concerned about water penetration.	Some - D on some urban projects	Covered with microseal in July 96 to correct flushing & minor rutting. Looks very good now.
IH-20	Waco/ Reeves	?	None	Slight	Slight	No	As good or perhaps slightly better than D. More texture.	Selectively as budget allows	
SH-137	Martin	0494-03-023	None	None	None	N/A	Very good performance	Some	Depends on project specifics for future projects.
LP-250	Midland	1188-02-046	Slight	None	None	N/A	Good condition	Some	Depends on project specifics for future projects.
PHARR DISTRICT									
US-281									

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
PHARR DISTRICT									
US-281									
SAN ANGELO DISTRICT									
US-277 RM-915 US-190E	Schleicher	0159-04-025	None	Slight	Slight	No	CMHB stands heavier traffic than D has rougher surface texture; rides as smooth.	All	Still in overall good condition since overlay completion 11/95. Rating lanes had more distresses, if any.
SAN ANTONIO DISTRICT									
Loop 13	Bexar	0521-01-039	None	Slight	Slight	No	Performed relatively well.	Some	Use Type E on project. Will not use F on urban projects in future, but on higher speed facilities.
Poplar St.	Bexar	0915-12-098	None	None	None	No	Very pleased at time of placement and now.	Some	Will use CMHB-C on urban streets, not on higher speed facilities. Rutting would have occurred at major intersections if not using CMHB-C.
Wetmore	Bexar	915-12-112	None	None	None	N/A	As good, if not better.	Most	
Callaghn	Bexar	21-4-224	None	None	Slight	No	Good	Most	
IH-10	Kerr	0142-14-041	None	None	Moderate	No	Equal to or better	Some	Mix design used low AC(4.5%). Oxidized and retains water in patches throughout. Flushing in wheelpaths at isolated locations.
IH-10	Kerr	0142-12-12	Slight	None	None	No	Short time-can't make comparisons	Some	Will be selected on projects using CMHB on.

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
SAN ANTONIO DISTRICT									
Water St.	Kerr	0915-15-012	None	Severe	Moderate	Yes	Very Poor	Not until Type F improvement made in design procedures	Severe rutting in wheel paths maybe due to subgrade/base problems; moderate rutting at intersections.
IH-35	Frio	0017-06-059	Moderate	Severe	Severe	Yes	CMHB-F mix performance lower	None, too many problems with mix design*	Cracking where shoving & flushing located. Rutting very severe day or 2 after shoving & flushing begin. Flushing in 20% of roadway.**
IH-35	Frio	0017-07-070	Moderate	Severe	Severe	Yes	CMHB-F mix performance lower	*Same	**Same
IH-35	Bexar	17-03-49	None	None	Slight	No	Fair	Most	Type F CMHB. Recommend not using on high truck routes.
SP-537	Bexar	253-04-103	None	None	None	No	Good	Most	
36th & Culebr	Bexar	?	None	None	Slight	No	Good	Most	Flushed at start but not gotten worse. In place 3 years.
Old Castroville Road	Bexar	?	None	None	Slight	No	Good	Most	
SP-422	Bexar	613-01-047	None	None	None	No	Good	Most	
LP-1609	Bexar	2452-4-103	None	None	None	No	Good	Most	

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
TYLER DISTRICT									
LP-323	Smith	2075-02-040	None	Slight	None	N/A	Too early to tell	None at this time but idea not rejected.	Placed 8/95 and flushed immediately. Remixed 11/95. Added dry CMHB to lower asphalt content. Doing well now- 1 place to be remilled. Problems more with QC/QA.
WACO DISTRICT									
SH-317	Bell	0398-04-051	None	None	None	No	Comparable- Difficulties in lab testing. Mix is very sensitive. Must handle with extreme care.	Some	Could experience some failure potential due to drainage. Not sure what precautions should have been taken to prevent fines at top.
SH-7	Falls	382-01-039	None	None	Slight	No	Good	None (Evaluating)	Mix probably performing better than other materials evaluated by this group. Completed 11/95.
IH-35W	Hill	14-23-022	Slight	Severe	Severe	No	Holds water. Flushes fines to surface.	None	Can be quality non-rutting, high caliber. Hill County experience not lend to future consideration. Ruts in SB using TC5 performs better than NB. It has excessive shoving, slippage & holds water.
SH-22	Hill	0121-03-049							Due to pushing, shoving, rutting & other problems, been resurfaced. Severe overall problems were present.
SH-171	Limestone	419-2-032	None	Moderate	Moderate to Severe	Yes	Dense-graded D would not have flushed like CMHB.	None (Evaluating)	Requires maintenance work earlier than normal. Completed 6/95.

Table F1. Joint TxDOT Industry Performance Study (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
WACO DISTRICT									
FM-3051	McLennan	2311-01-22	Slight	Slight	Severe	No	D mix (dense-graded)would not have allowed underseal to move up to surface.	None (Evaluating)	Intersection at Lake Shore Drive rutted to extent CMHB had to be removed & replaced. Completed 12/94.
Loop-340	McLennan	258-9-106	None	None	None	N/A	Performance is good.	None (Evaluating)	Completed 9/94
US-84	McLennan	56-1-025	None	Slight	Moderate	No	Dense-graded D would not have flushed and allowed underseal asphalt to migrate up through mat.	None (Evaluating)	Completed 7/95
FM-1633	Limestone	1664-1-13	None	None	Slight	No	Performance is good.	None (Evaluating)	Completed 11/95
WICHITA FALLS DISTRICT									
US-287	Clay	224-1-44	Slight	Moderate to Severe	Moderate to Severe	Probably Not	A lot less than expected.	Some	Needs immediate attention. Some stripping in underlying layers.
US-287	Clay	224-2-34	None	Slight	Slight	No	Less than to be expected	Some	1 year old and looks fair. No major distress apparent.
US-287	Clay	224-2-35	None	Moderate	Moderate	No	Poorer than conventional mix	Some	Poorer ride quality
US-82	Montague	0044-04-040	None	Slight	Moderate to Severe	No	Poorer than convention mix in all areas but reflective crack resistance	Some	Ride quality is poorer than typical C-D mixes

Table F1. Joint TxDOT Idustry Prformance Sudy (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Planned Use	Comments
WICHITA FALLS DISTRICT									
US-82	Montague	0044-04-041	None	Slight	Moderate to Severe	No	Poorer than convention mix in all areas but reflective cracking	Some	Ride quality poorer than typical D-C mixes
US-82	Montague	CPM44-4-42	None	None	Slight	No	As good or equal to D or conventional mixes	Some	Best looking CMHB project I know of.
US-287	Wichita	43-9-80	None	None	None	N/A	Same	Some	Would expect more reflective cracking with HMAC.
Kemp St.	Wichita	903-03-027						Some	Flushing & slight rutting appeared during construction. Remilled to concrete & Type C used to replace CMHB.
US-287	Wilbarger	0043-06-062	None	Slight	Moderate	No	Too soon to make evaluation	Some	Mix placed 5/96
YOAKUM DISTRICT									
FM-1093	Wharton	0446-05-008	None	None	None	N/A	Performs well for high volume truck traffic on road	Some	Future projects depending on further review of existing projects.*
FM-1093	Colorado	0446-04-011	None	None	None	N/A	Performs well for high volume truck traffic on road	Some	*Same review. Had to patch where surface shoved. Mat thickness was marginally thin - less than 1" in these areas.
FM-3013	Colorado	3205-02-12	None	None	None	N/A	Performs well for high volume truck traffic on road	Some	*Same review.

APPENDIX G

PAVEMENT RATING SCORES

Table G1. Pavement Rating Scores.

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
ABILENE DISTRICT									
IH-20	Callihan	0006-07-061	Slight	Slight	Moderate	No	Less rutting w/CHMB +	75	
SH-36	Callihan	0181-02-021	Slight	None	Slight	No	Better than Type D +	90	
US-87	Howard	69-1-40	None	None	Slight	No	Very Good +	95	
US-83/84	Jones	33-5-070	Moderate	None	None	N/A	Better than ACP "D" +	85	
IH-20	Taylor	6-04-057	None	None	Slight	No		95	
US-83	Taylor	34-2-27	None	None	None	No	Not in place long	100	
AMARILLO DISTRICT									
IH-40	Gray	275-8-025	None	Slight	Moderate	No	About equal o	80	
ATLANTA DISTRICT									
SH-8	Bowie	61-1-019	None	Slight	Slight	No	Appears comparable to "C" o	90	
US-59	Bowie	218-0-065	None	Severe	Slight	No	Comparable to "C" other than rutting o	65	
IH-20	Harrison	495-09-038 495-10-	Slight	None	Slight	No	Looks slightly "Older" than conventional mix designs -	90	
SH-154	Harrison	402-2-30	None	None	None	N/A	Good in relation to dense-graded mixes +	100	
US-59	Harrison	63-1-55	None	None	Slight	None yet	Similar to dense-graded mixes o	95	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
ATLANTA DISTRICT									
SH-149	Panola	0394-01-047	None	None	None	No	Usually Type "C" surface	100	
SH-149	Panola	0063-11-024	None	None	None	No	Type "C" surface usual	100	
SH-315	Panola	0462-03-030	None	None	None	No	Type "C" surface usual	100	
US-79	Panola	0247-02-032	None	Moderate	Slight	No	Type "C" surface usual	80	
US-79	Panola	0247-03-015	None	None	Slight	No	Type "C" surface usual	95	
AUSTIN DISTRICT									
IH-35	Travis	0015-13-240	None	None	None	N/A	Performing well.	100	
Loop 1	Travis	3136-01-?	None	None	None	N/A	Performing well.	100	
US-290	Travis	114-2-43	Slight	None	None	N/A	Noticeably less cracking	95	
BEAUMONT DISTRICT									
US-96	Hardin	65-5-117	None	None	None	N/A	No appreciable difference with Type C ACP w/SBS	100	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
BROWNWOOD DISTRICT									
IH-20	Eastland	7-3-65	None to Slight	Slight	Slight	Yes, Skid scores 26-35*	Not as good -	97	
IH-20	Eastland	7-6-060	None to Slight	Slight	Slight	Yes*	Not as good -	87	
US-180	Stephens	11-7-39	None to Slight	Slight	Slight	Yes*	Not as good -	87	
BRYAN DISTRICT									
SH-21	Brazos	116-04-080	None	Slight	None	No	Too early to form opinion	95	
SH-36	Washington	186-5-27	None	None	Slight	No	Comparable for down time o	95	
US-290	Washington	186-6-050	None	None	Slight	No	Equal to or better for time it has been down +	95	
US-79	Milam	204-5-24							
CHILDRESS DISTRICT									
US-287	Childress	43-1-049	None	None	Slight	Yes	CMHB is more permeable. Performing about same D o	95	
US-287	Childress/ Hardeman	43-1-049	None	None	Slight to Moderate	No	CMHB is more permeable. Performing about the same o	90	
I-40*	Wheeler	IM 40-2(20)146	None	Severe	None	No	Slippage problems would have happened no matter what mix was used.	70	

*Not a CMHB project

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
DALLAS DISTRICT									
IH-45									
EL PASO DISTRICT									
FM-659	El Paso	1046-1-14	None	None	Moderate	Yes	Equal if not better +	85	
IH-10 (West)	Hudspeth	2-8-042	Slight	Moderate	None	No	Poor performance - suspect tack not applied at proper rate -	80	
IH-10 (East)	Hudspeth	2-8-042	Slight	Slight	None	No	Poor performance - suspect tack not applied at proper rate -	90	
FORT WORTH DISTRICT									
IH-20	Palo Pinto	0314-02-042	N/A	N/A	N/A	N/A	Refer to MT's Forensic Investigation	40 (estimated)	
HOUSTON DISTRICT									
FM-1301	Brazoria	1412-2-11					Very Good (MT)		
FM-360	Ft. Bend	527-6-16					Good (MT)		
FM-442	Ft. Bend	838-2-16					Good (MT)		
FM-1994	Ft. Bend	1965-1-5					Good (MT)		
FM-1458	Ft. Bend	527-2-13					Good (MT)		

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
LUBBOCK DISTRICT									
98th St.	Lubbock	905-06-024	None	None	None	N/A	Much more stable mix, very high skid resistance, no sign of any type failure to date, excellent performance. +	100	
FM-2255	Lubbock	2256-01-014	None	None	Slight	No	Initial performance is excellent. Very stable mix. +	95	
LUFKIN DISTRICT									
SH-63	Angelina	0244-01-040	None	Slight	Slight	No	Looks good. Looks like hot mix job. o	90	
US-259	Nacogdoches	0138-06-033	Slight	Moderate	Moderate	No	Holding better than D mix +	65	
ODESSA DISTRICT									
US-385	Crane/Upton	228-3-28	Moderate	Slight	None	N/A	D would have been better due to water penetrating CMHB -	80	
IH-20	Ector	4-7-87	None	Slight	None	N/A	CMHB-F(Rubber asphalt) held up quite well. Prior D was cracking immediately +	95	
IH-20	Ector	4-7-88	None	Slight	Severe - 1st in state	Yes - milled travel lanes	Used AC-10 high asphalt content; air temp 110-118F. Held up better than D +	65	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
ODESSA DISTRICT									
BI-10-G	Pecos	0140-17-004	None	Slight	Moderate - Severe	Yes - milled travel lanes	Mix did not rut or push like D would have on approaches to signals. Concerned about water penetration. +	72	
IH-20	Waco/Reeves	?	None	Slight	Slight	No	As good or perhaps slightly better than D. More texture. o	90	
SH-137	Martin	0494-03-023	None	None	None	N/A	Very good performance +	100	
LP-250	Midland	1188-02-046	Slight	None	None	N/A	Good condition	95	
PHARR DISTRICT									
US-281									
US-281									
SAN ANGELO DISTRICT									
US-277 RM-915 US-190E	Schleicher	0159-04-025	None	Slight	Slight	No	CMHB stands heavier traffic than D; has rougher surface texture; rides as smooth. +	90	
SAN ANTONIO DISTRICT									
Loop 13	Bexar	0521-01-039	None	Slight	Slight	No	Performed relatively well. o	90	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
SAN ANTONIO DISTRICT									
Poplar St.	Bexar	0915-12-098	None	None	None	No	Very pleased at time of placement and now.	100	
Wetmore	Bexar	915-12-112	None	None	None	N/A	As good, if not better. +	100	
Callaghn	Bexar	521-4-224	None	None	Slight	No	Good +	95	
IH-10	Kerr	0142-14-041	None	None	Moderate	No	Equal to or better o	85	
IH-10	Kerr	0142-12-12	Slight	None	None	No	Short time-can't make comparisons	95	
Water St.	Kerr	0915-15-012	None	Severe	Moderate	Yes	Very Poor -	55	
IH-35	Frio	0017-06-059	Moderate	Severe	Severe	Yes	CMHB-F mix performance lower -	25	
IH-35	Frio	0017-07-070	Moderate	Severe	Severe	Yes	CMHB-F mix performance lower -	25	
IH-35	Bexar	17-03-49	None	None	Slight	No	Fair o	95	
SP-537	Bexar	253-04-103	None	None	None	No	Good +	100	
36th & Culebr	Bexar	?	None	None	Slight	No	Good +	95	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
SAN ANTONIO DISTRICT									
Old Castroville Road	Bexar	?	None	None	Slight	No	Good +	95	
SP-422	Bexar	613-01-047	None	None	None	No	Good +	100	
LP-1609	Bexar	2452-4-103	None	None	None	No	Good +	100	
TYLER DISTRICT									
LP-323	Smith	2075-02-040	None	Slight	None	N/A	Too early to tell	40	
WACO DISTRICT									
SH-317	Bell	0398-04-051	None	None	None	No	Comparable - Difficulties in lab testing. Mix is very sensitive. Must handle with extreme care. o	100	
SH-7	Falls	382-01-039	None	None	Slight	No	Good +	95	
IH-35W	Hill	14-23-022	Slight	Severe	Severe	No	Holds water. Flushes fines to surface. -	35	
SH-22	Hill	0121-03-049							
SH-171	Limestone	419-2-032	None	Moderate	Moderate to Severe	Yes	Dense-graded D would not have flushed like CMHB -	62	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
WACO DISTRICT									
FM-3051	McLennan	2311-01-22	Slight	Slight	Severe	No	D mix (dense-graded) would not have allowed underseal to move up to surface. -	60	
Loop-340	McLennan	258-9-106	None	None	None	N/A	Performance is good. +	100	
US-84	McLennan	56-1-025	None	Slight	Moderate	No	Dense-graded D would not have flushed and allowed underseal asphalt to migrate up through mat. -	80	
FM-1633	Limestone	1664-1-13	None	None	Slight	No	Performance is good. +	95	
WICHITA FALLS DISTRICT									
US-287	Clay	224-1-44	Slight	Moderate to Severe	Moderate to Severe	Probably Not	A lot less than expected. -	50	
US-287	Clay	224-2-34	None	Slight	Slight	No	Less than to be expected. -	90	
US-287	Clay	224-2-35	None	Moderate	Moderate	No	Poorer than conventional mix. -	70	
US-82	Montague	0044-04-040	None	Slight	Moderate to Severe	No	Poorer than convention mix in all areas but reflective crack resistance. -	72	
US-82	Montague	0044-04-041	None	Slight	Moderate to Severe	No	Poorer than convention mix in all areas but reflective cracking. -	72	
US-82	Montague	CPM44-4-42	None	None	Slight	No	As good or equal to D or conventional mixes. +	95	

Table G1. Pavement Rating Scores (cont'd).

Highway	County	CSJ	Cracking	Rutting	Flushing	Skid Problems	Performance Comparison	Pavement Rating Score	
WICHITA FALLS DISTRICT									
US-287	Wichita	43-9-80	None	None	None	N/A	Same. o	100	
Kemp St.	Wichita	903-03-027							
US-287	Wilbarger	0043-06-062	None	Slight	Moderate	No	Too soon to make evaluation.	80	
YOAKUM DISTRICT									
FM-1093	Wharton	0446-05-008	None	None	None	N/A	Performs well for high volume truck traffic on road. +	100	
FM-1093	Colorado	0446-04-011	None	None	None	N/A	Performs well for high volume truck traffic on road. +	100	
FM-3013	Colorado	3205-02-012	None	None	None	N/A	Performs well for high volume truck traffic on road. +	100	

APPENDIX H

COMPARISON OF PERFORMANCE SURVEYS AND DATE PROJECT COMPLETED

Table H1. Comparison of Performance Surveys and Date Project Completed.

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
ABILENE DISTRICT										
IH-20	Callihan	0006-07-061	Stephens Martin	Moderate Flushing	Moderate Flushing	75				July 95
SH-36	Callihan	0181-02-021	Duininck Bros.	Good	Good	90				November 93
US-87	Howard	69-1-40				95				September 94
US-83/84	Jones	33-5-070	Contract Paving	Good	Good	85				
IH-20	Taylor	6-04-057				95				
US-83	Taylor	34-2-27				100				
AMARILLO DISTRICT										
IH-40	Donley Gray	275-8-025	Gilvin - Terrill	Good	Good	80				June 94
US-59	Harrison	63-1-55	Madden	Good	Good	95				October 95
SH-149	Panola	0394-01-047	Madden	Good	Good	100				July 95
SH-149	Panola	0063-11-024	Earnest	Good	Good	100				July 95
SH-315	Panola	0462-03-030	James	Good	Good	100				July 94
US-79	Panola(S)	0247-02-032	Earnest	Good	Good	80				July 94
US-79	Panola(N)	0247-03-015	Earnest	Some Rutting	Some Rutting	95				November 95

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
ATLANTA DISTRICT										
SH-8	Bowie	61-1-019	Caver	Good	Good	90				July 95
US-59	Bowie	218-0-065	Texarxana Asphalt	NB-Good SB-Rutted	NB-Good SB-Rutted	65				August 95
IH-20	Harrison	495-09-038 495-10-	Madden	Good	Good	90				October 95
SH-154	Harrison	402-2-30	Howard & Sons	Good - Slight Flushing	Good - Slight Flushing	100				August 95
AUSTIN DISTRICT										
IH-35	Travis	0015-13-240	Pool & Rogers	Good	Good	100				September 95
Loop 1	Travis	3136-01-?	Hunter Industries	Good	Good	100				September 93
US-290	Travis	11-2-43	Austin Road	Good	Good	95				July 93
BEAUMONT DISTRICT										
US-96	Hardin	65-5-117	Apac - Texas	Good	Good	100				January 95
BROWNWOOD DISTRICT										
IH-20	Eastland	7-3-65	Price	Good	Good	97				December 95
IH-20	Eastland	7-6-060	Price	Good	Good	87				June 96

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
BROWNWOOD DISTRICT										
US-180	Stephens	11-7-39	Price	Good	Good	87				December 95
BRYAN DISTRICT										
SH-21	Brazos	116-4-080	Young	Good	Good	95				October 95
SH-36	Washington	186-5-27	Young	Good	Good	95				December 95
US-290	Washington	186-6-050	Hunter	Good	Good	95				July 95
US-79	Milam	204-5-24	Hunter	Good	Good					July 96
CHILDRESS DISTRICT										
US-287	Childress	43-1-049		Good	Good	95				94
US-287	Childress/ Hardeman	43-1-049	Duininck	Good Flushed	Good Flushed	90				August 95
I-40*	Wheeler	IM 40-2(20)146 275-12-53	Millkan	Good	Good	70				October 94
DALLAS DISTRICT										
IH-45	Navarro	92-6-82	Duininck	Good	Good					November 94
EL PASO DISTRICT										
FM-659	El Paso	1046-1-14	Abrams	Test Sections	Test Sections	85				October 94

*Not a CMHB project

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
EL PASO DISTRICT										
IH-10 (West)	Hudspeth	2-8-042	Williams	Good	Good	80				December 95
IH-10 (East)	Hudspeth	2-8-042	Williams	Good	Good	90				December 95
FORT WORTH DISTRICT										
IH-20	Palo Pinto	0314-02-042	Stephens Martin	Flushed & Rutted	Flushed & Rutted	40				September 95
HOUSTON DISTRICT										
FM-1301	Brazoria	1412-2-11	Durwood Greene	Good	Good					October 94
FM-360	Ft. Bend	527-6	Durwood Greene	Good	Good					November 94
FM-442		838-2	Durwood Greene	Good	Good					November 94
FM-194		1965-1-5	Durwood Greene	Good	Good					November 94
FM-1458	Waller	527-2-13	Duininch	Good-Base Failure	Good-Base Failure					July 94
LUBBOCK DISTRICT										
98th St.	Lubbock	905-06-024	Williams & Peters	Good	Good	100				October 95

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
LUBBOCK DISTRICT										
FM-2255	Lubbock	2256-01-014	Gilbert Texas	Good	Good	95				December 95
LUFKIN DISTRICT										
SH-63	Angelina	0244-01-040	Moore Bros.	Good	Good	90				November 94
US-259	Nacogdoches	0138-06-033	C.C.E.	Some Minor Flushing	Some Minor Flushing	65				September 94
ODESSA DISTRICT										
US-385	Crane/Upton	228-3-28 229-3-28	Jones Bros.	Good	Good	80				September 95
IH-20	Ector	4-7-87				95				
IH-20	Ector	5-13-037	Jones Bros.	Good	Good					July 94
IH-20	Ector	4-7-88	Jones Bros.	Severely Flushed	Severely Flushed	65				July 94
BI-10-G	Pecos	0140-17-004	Price	Flushing Throughout	Flushing Throughout	72				March 95
IH-20	Ward/Reeves	4-2-047	Gilbert Texas	Good	Good	90				October 95
SH-137	Martin	0494-03-023	Jones Bros.	Good	Good	100				July 96

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
ODESSA DISTRICT										
LP-250	Midland	1188-02-046	Jones Bros.	Good	Good	95				May 95
PHARR DISTRICT										
US-281	Hidalgo	255-12-2	Foremost Paving	Rutted Intersection	Rutted Intersection					July 95
US-281	Hidalgo	255-09-66	Foremost Paving	Good	Good					July 96
SAN ANGELO DISTRICT										
US-277 RM-915 US-190E	Schleicher	0159-04-025	Reece Albert	Good	Good	90				November 95
SAN ANTONIO DISTRICT										
Loop 13	Bexar	0521-01-039	Clark	Good	Good	90				July 95
Poplar St.	Ector	0915-12-098	Bay Maint.	Good	Good	100				November 95
Wetmore	Bexar	915-12-112	Word	Good	Good	100				August 95
Callaghn	Bexar	521-4-224	Capital Excavation	Good	Good	95				April 95
IH-10	Kerr	0142-14-041	Hood & Son		Good	85				July 96
IH-10	Bexar	72-7-43		Good	Good					

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
SAN ANTONIO DISTRICT										
IH-10	Kerr	0142-12-12	Word	Good	Good	95				August 95
Water St.	Kerr	0915-15-012	Capital Excavation	Moderate Flushed Wheelpath	Moderate Flushed Wheelpath	55				July 95
IH-35	Frio	0017-06-059				25				
IH-35	Frio	0017-07-070				25				
IH-35	Bexar	17-03-49				95				
SP-537	Bexar	253-04-103				100				
36th & Culebr	Bexar	?				95				
Old Castroville Road	Bexar	?				95				
SP-422	Bexar	613-01-047				100				
LP-1609	Bexar	2452-4-103				100				
TYLER DISTRICT										
LP-323	Smith	2075-02-040		Flushed	Flushed	40				
WACO DISTRICT										
SH-317	Bell	0398-04-051	Young	Good	Good	100				July 96

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
WACO DISTRICT										
SH-7	Falls	382-01-039	Young	Good	Good	95				November 95
IH-35W	Hill	14-23-022	Young	Good	Good	35				October 95
IH-35FR	McLennan	14-8-64	Young	Good-Some Slippage	Good-Some Slippage					July 94
SH-22	Hill	0121-03-049	Young	Good-Some Slippage	Good-Some Slippage					October 94
SH-171	Limestone	419-2-032	Young	Minor Rutting	Minor Rutting	62				June 95
FM-3051	McLennan	2311-01-22	Young	Flushing of Underseal	Flushing of Underseal	60				May 94
Loop-340	McLennan	258-9-106	Fuquay	Good	Good	100				June 95
US-84	McLennan	56-1-025	Young	Good-Flushed Area	Good-Flushed Area	80				July 95
US-84	McLennan	55-7-098	Young	Good	Good					July 96
FM-1633	Limestone	1664-1-13				95				
WICHITA DISTRICT										
US-287	Clay	224-1-44	Duininck	Moderate Flushing	Moderate Flushing	50				October 94
US-287	Clay	224-2-34	Zack Burkett	Moderate Flushing	Moderate Flushing	90				November 95

Table H1. Comparison of Performance Surveys and Date Project Completed (cont'd).

Highway	County	CSJ	Contractor	TxDOT Survey Dec. 95	Industry Survey June 96	Joint Survey Nov. 96				Date Project Completed
WICHITA DISTRICT										
US-287	Clay	224-2-35	Duininck	Some Flushing	Some Flushing	70				June 95
US-82	Montague	0044-04-040	Zack Burkett	Moderately Flushed/ Fat Spots	Moderately Flushed/ Fat Spots	72				January 96
US-82	Montague	0044-04-041	Zack Burkett	Moderate Flushing	Moderate Flushing	72				July 96
US-82	Montague	CPM44-4-42	Duininck	Good-Flushed Intersection	Good-Flushed Intersection	95				October 95
US-287	Wichita	43-9-80	Zack Burkett	Moderate Flushing	Moderate Flushing	100				June 95
Kemp St.	Wichita	903-03-027	Zack Burkett	Moderate Flushed Area	Moderate Flushed Area					July 96
US-287	Wilbarger	0043-06-062				80				
YOAKUM DISTRICT										
FM-1093	Wharton	0446-05-008		Good	Good	100				
FM-1093	Colorado	0446-04-011				100				
FM-3013	Colorado	3205-02-012		Good	Good	100				

APPENDIX I

COMPARISON OF VARIABILITY AMONG LOTS

Figure 1. Comparison of SMA and Superpave 9.5 mm mixtures.

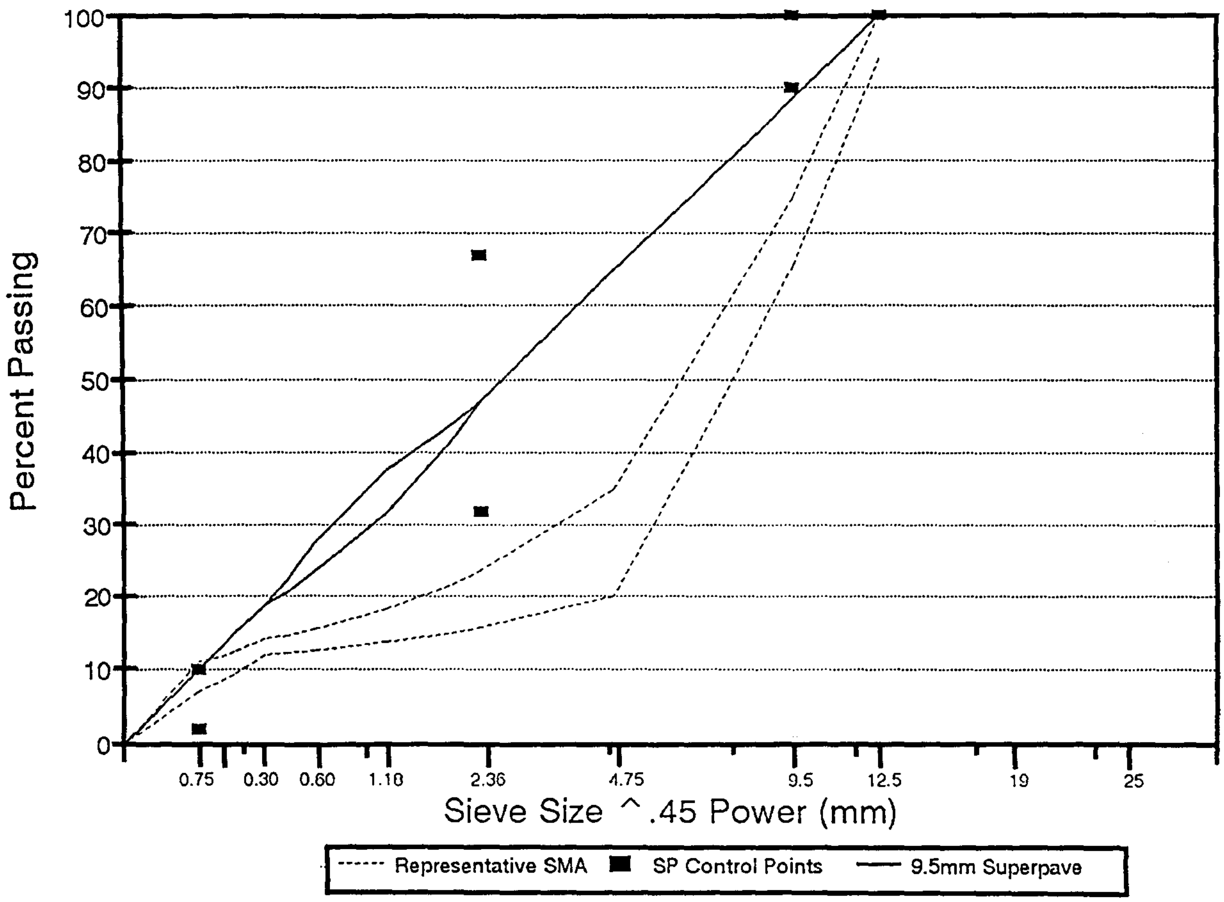


Figure 2. Comparison of SMA and Superpave 12.5 mm mixtures.

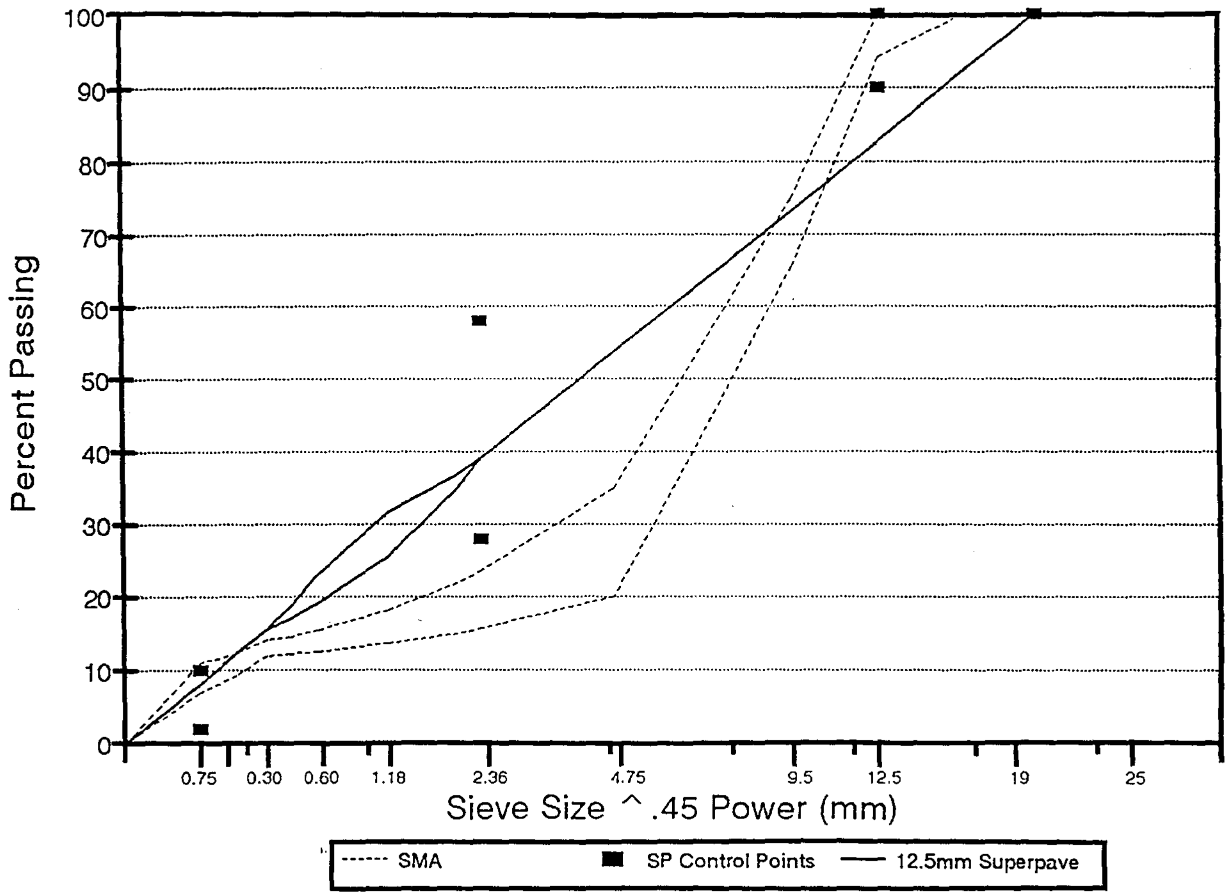


Figure 3. Comparison of fine CMHB and Superpave 9.5 mm mixtures.

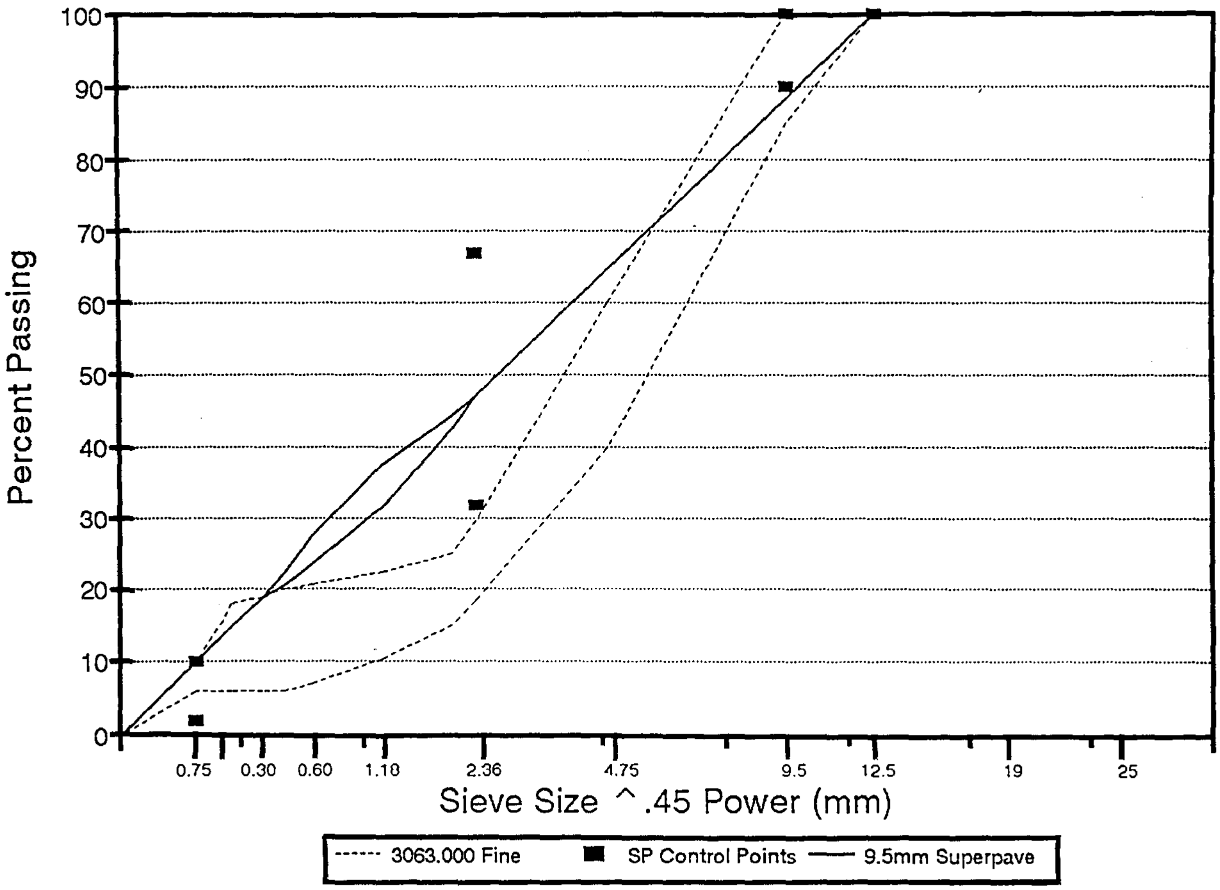


Figure 4. Comparison of fine CMHB and Superpave 12.5 mm mixtures.

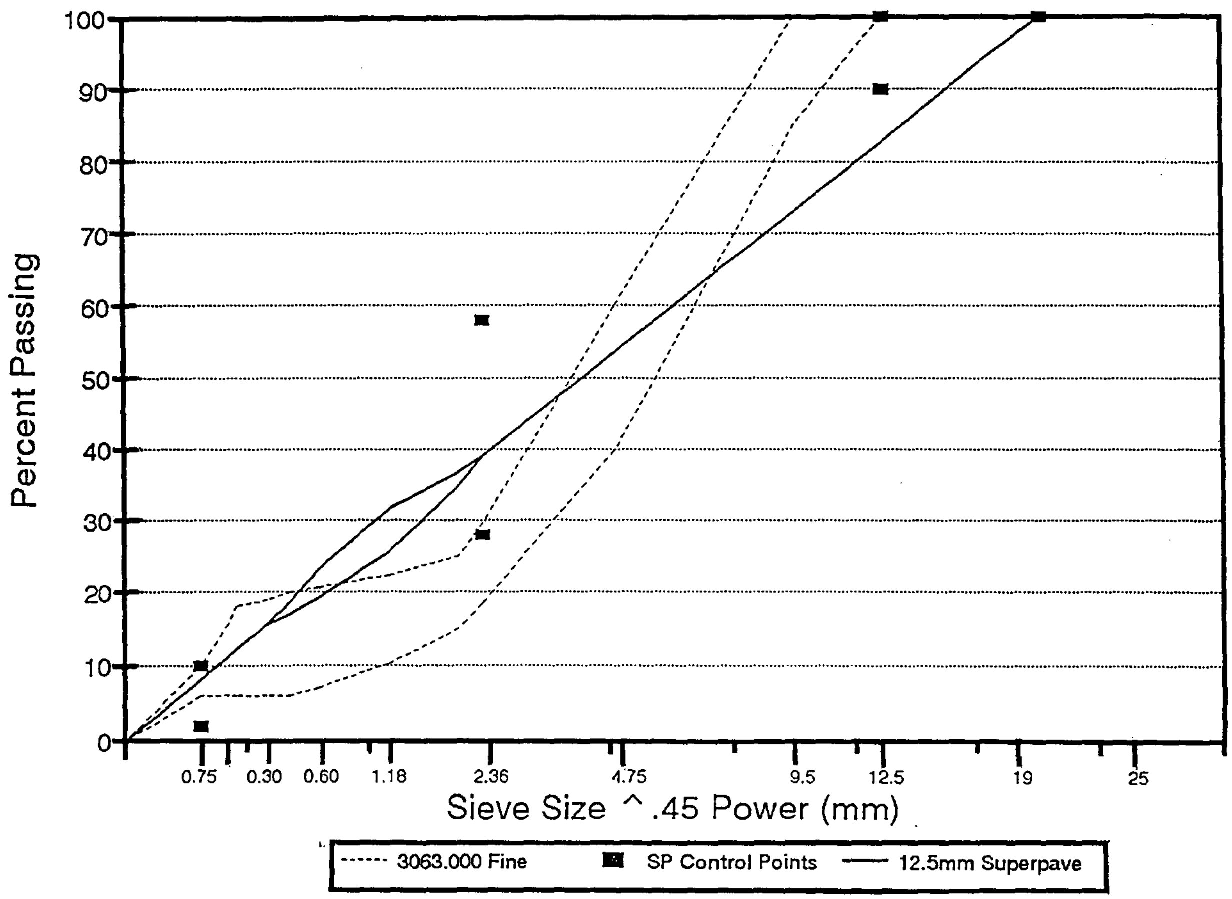


Figure 5. Comparison of coarse CMHB and Superpave 12.5 mm mixtures.

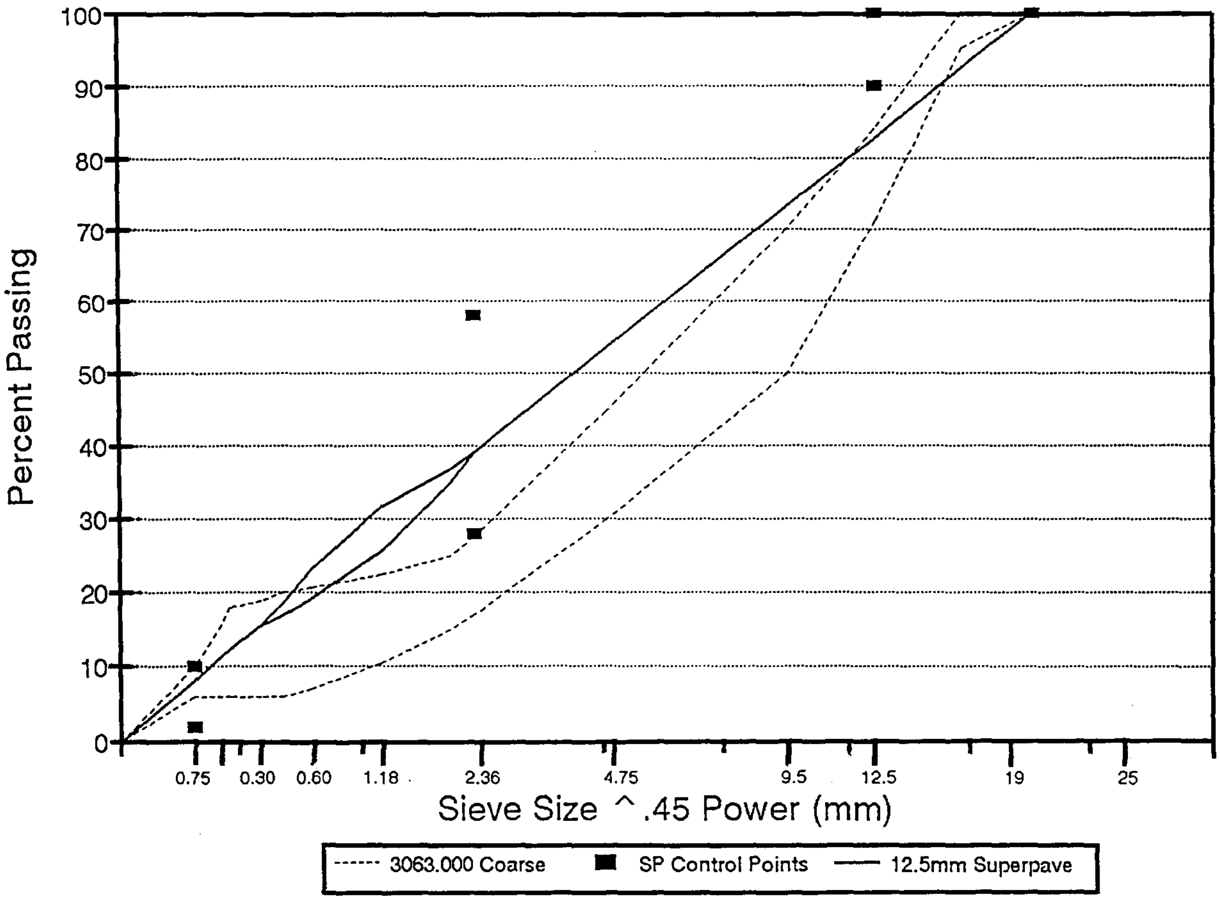


Figure 6. Comparison of coarse CMHB and Superpave 19 mm mixtures.

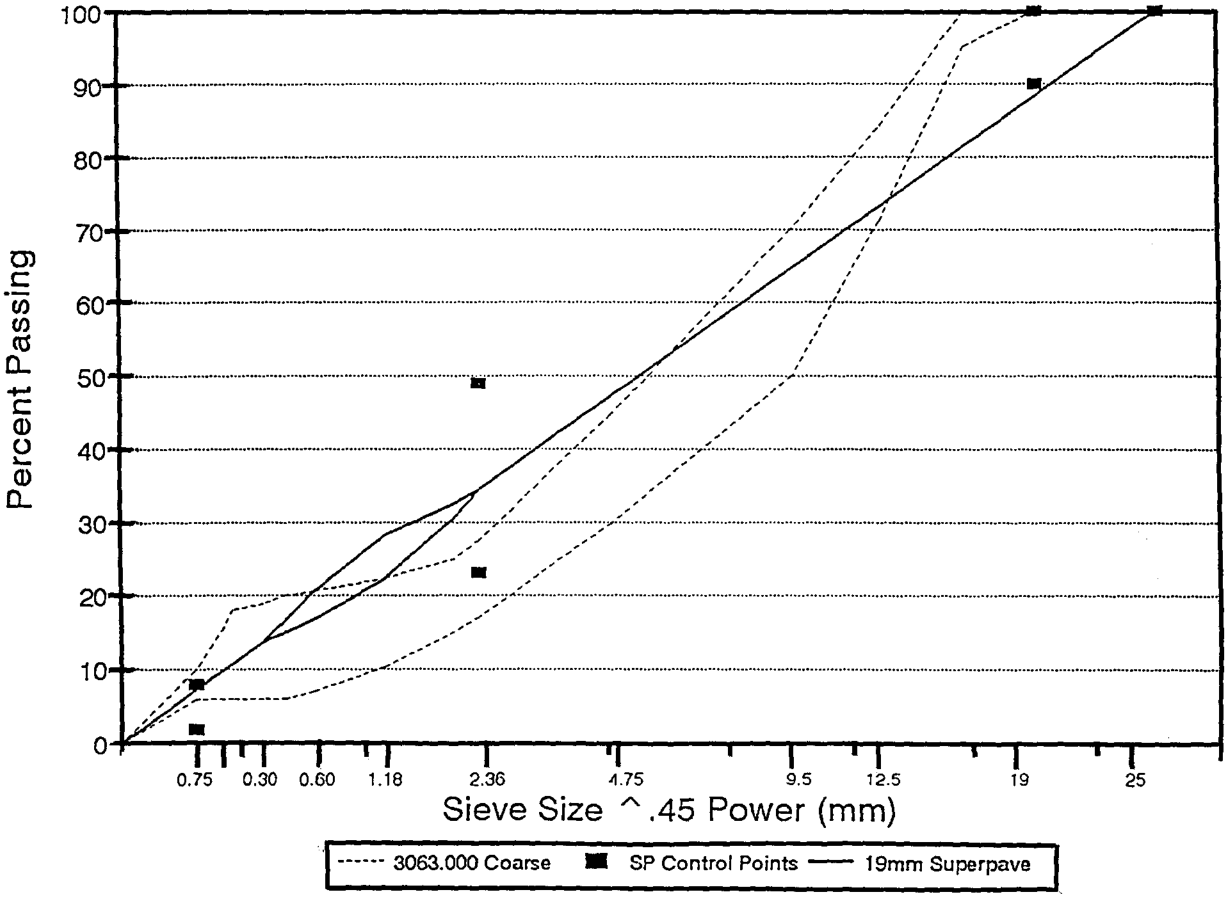


Figure 7. Pavement rating score (PRS) versus age for all available projects.

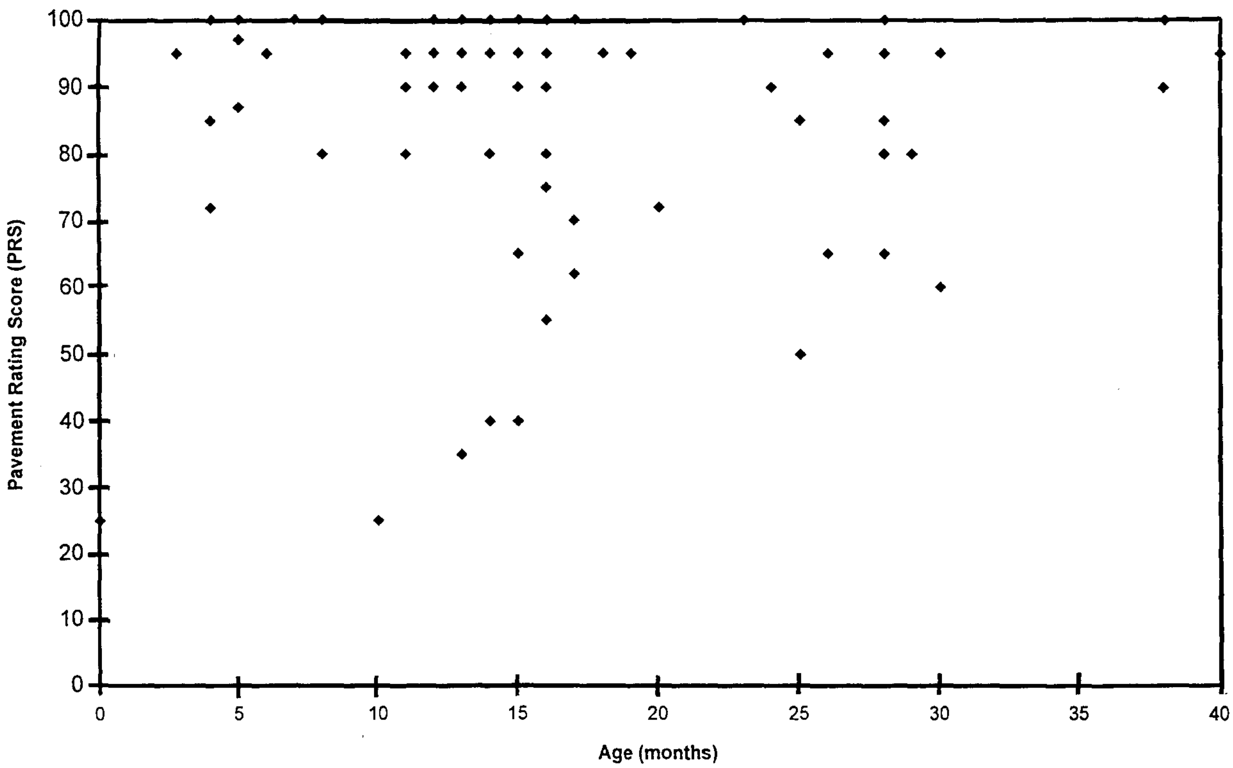


Figure 8. Pavement rating score vs. age by traffic level.

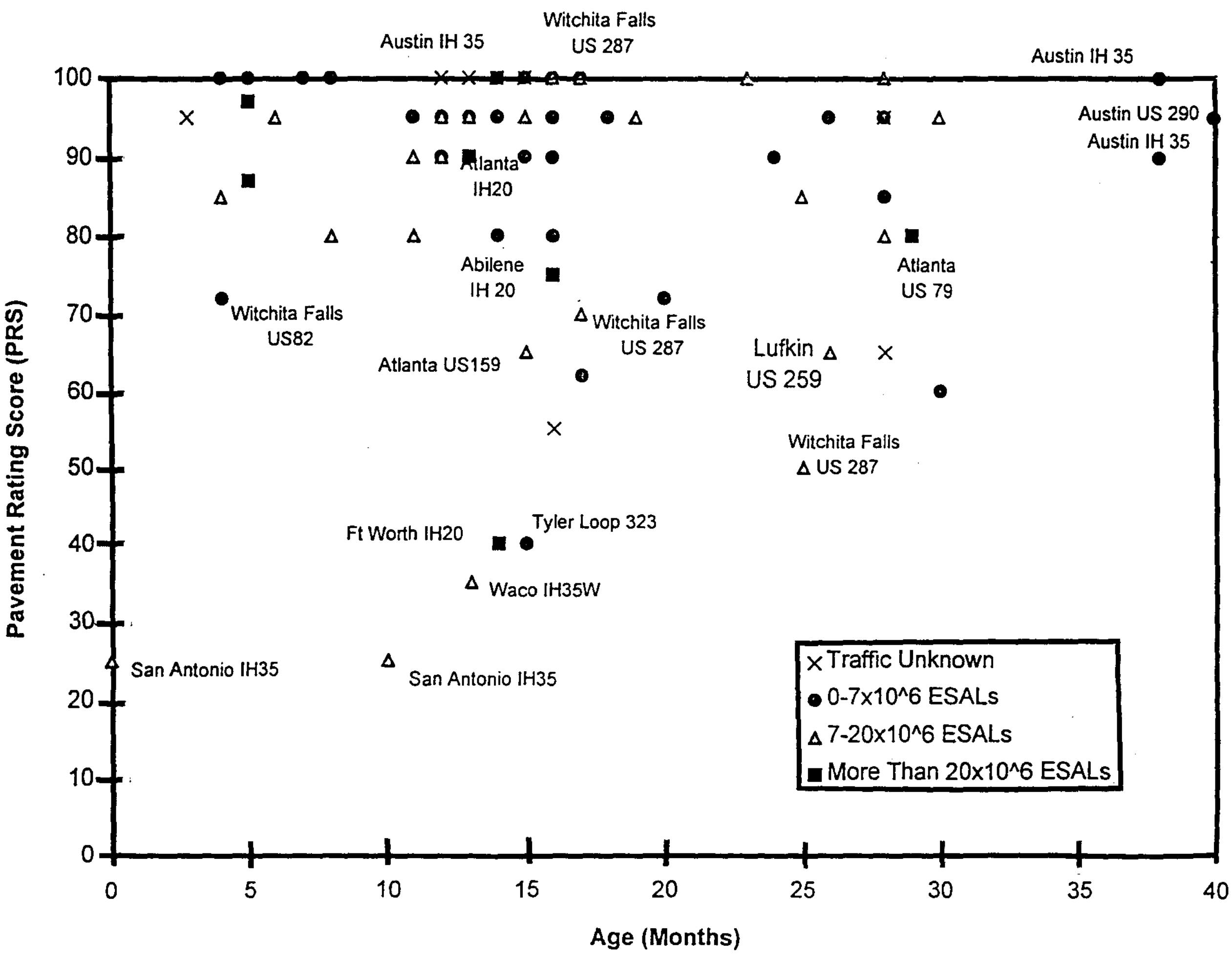


Figure 9. Pavement rating score vs. age by traffic level.

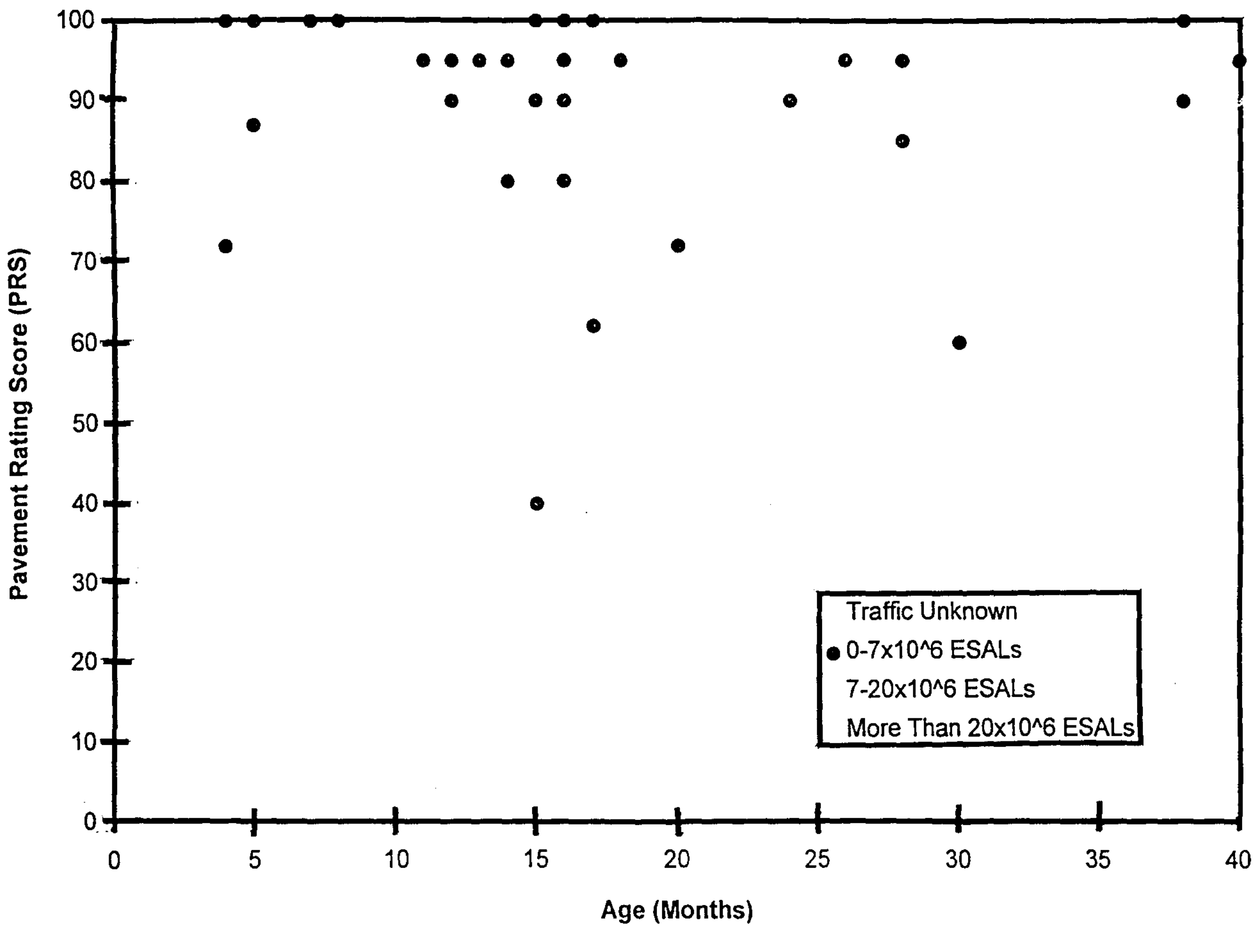


Figure 10. Pavement rating score vs. age by traffic level.

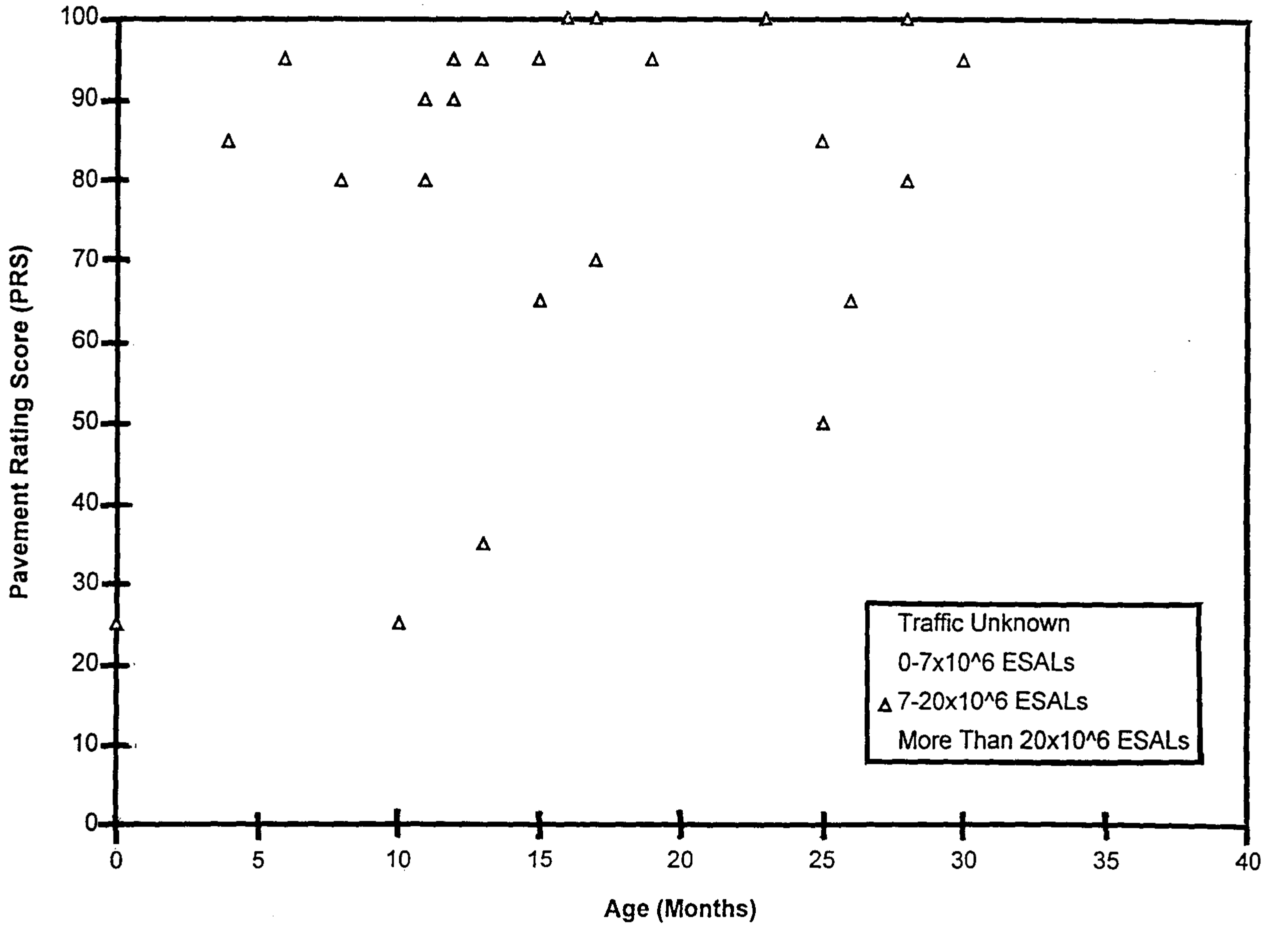


Figure 11. Pavement rating score vs. age by traffic level.

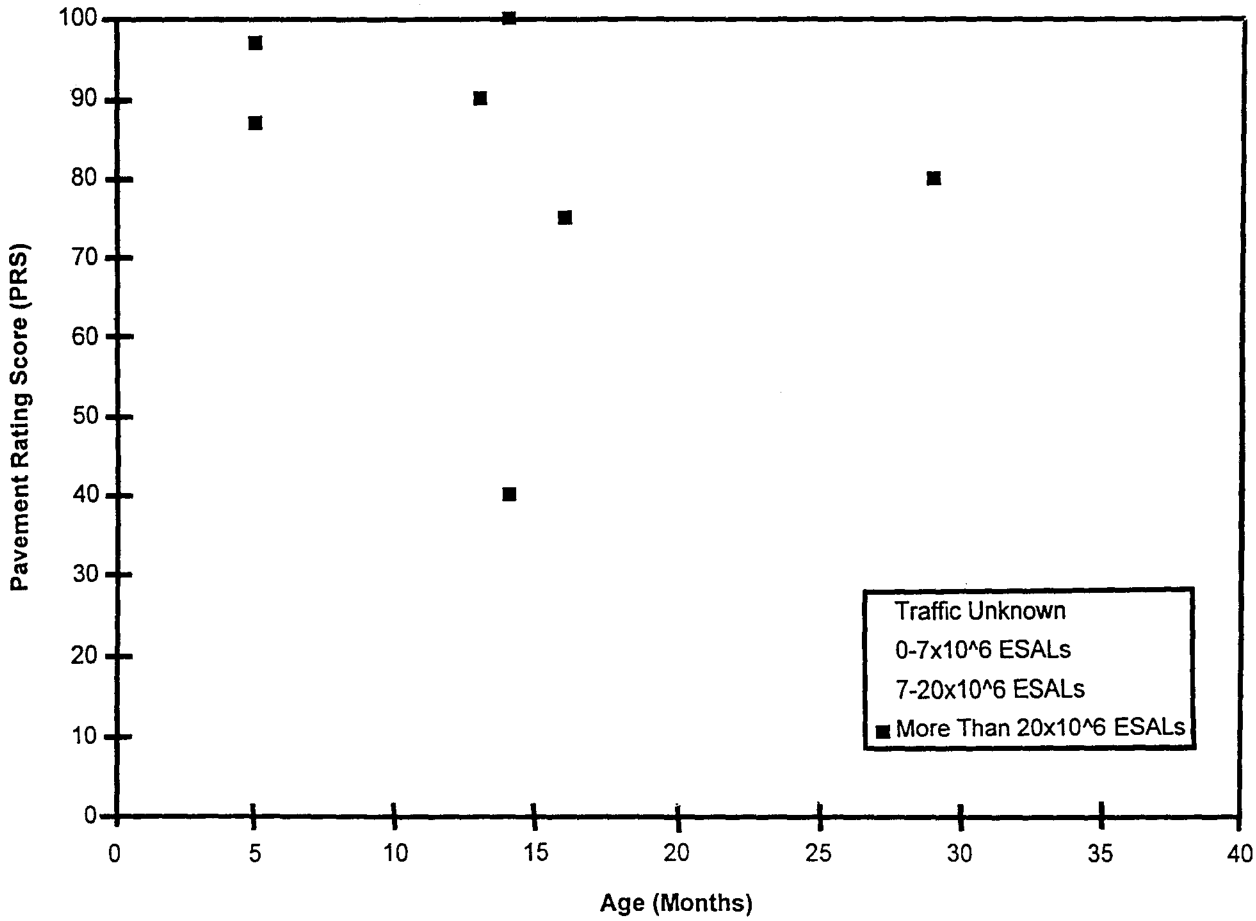


Figure 12. Pavement rating score (PRS) vs. traffic for all available projects.

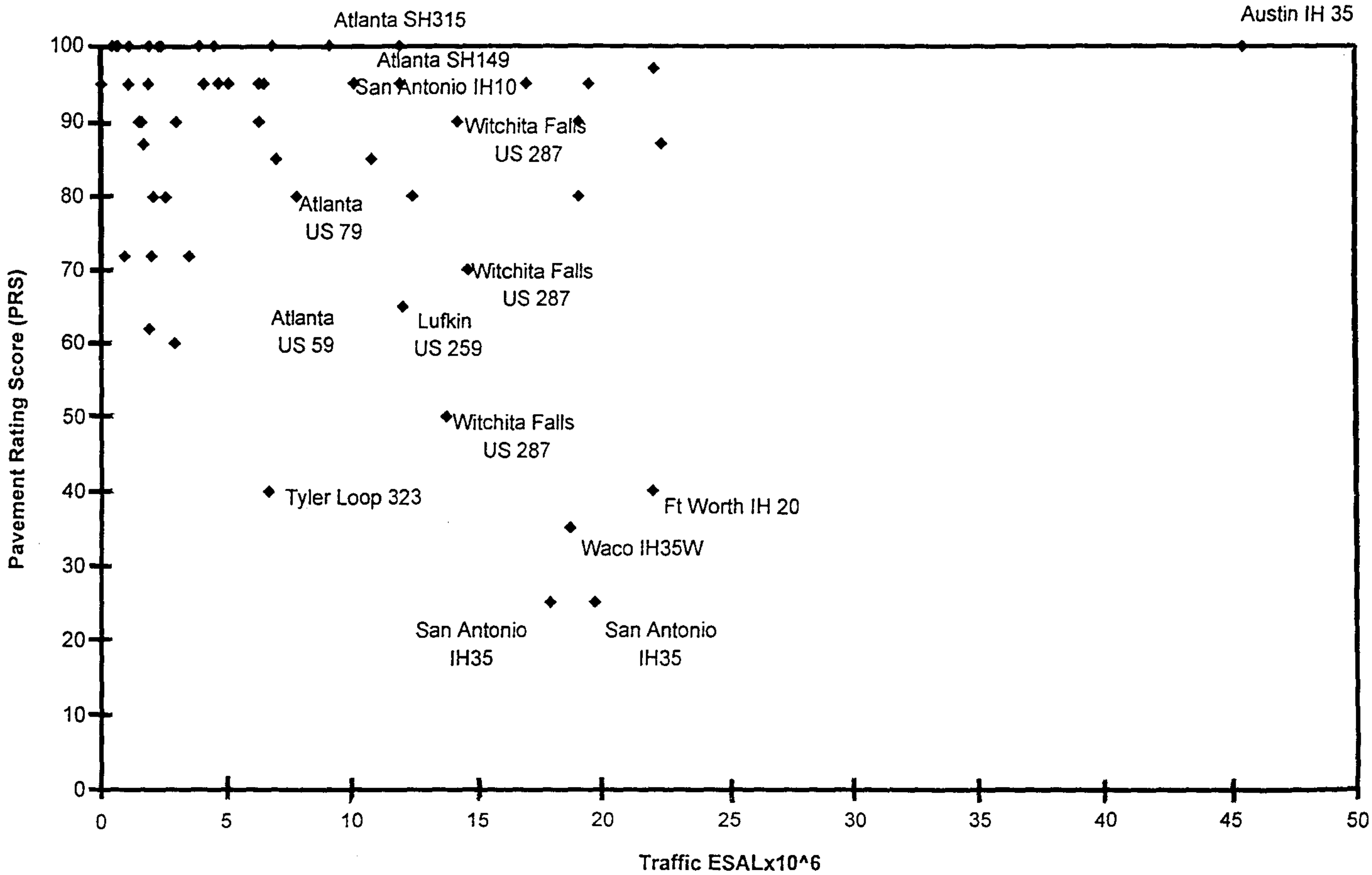


Figure 13. PRS vs. accumulated ESALs.

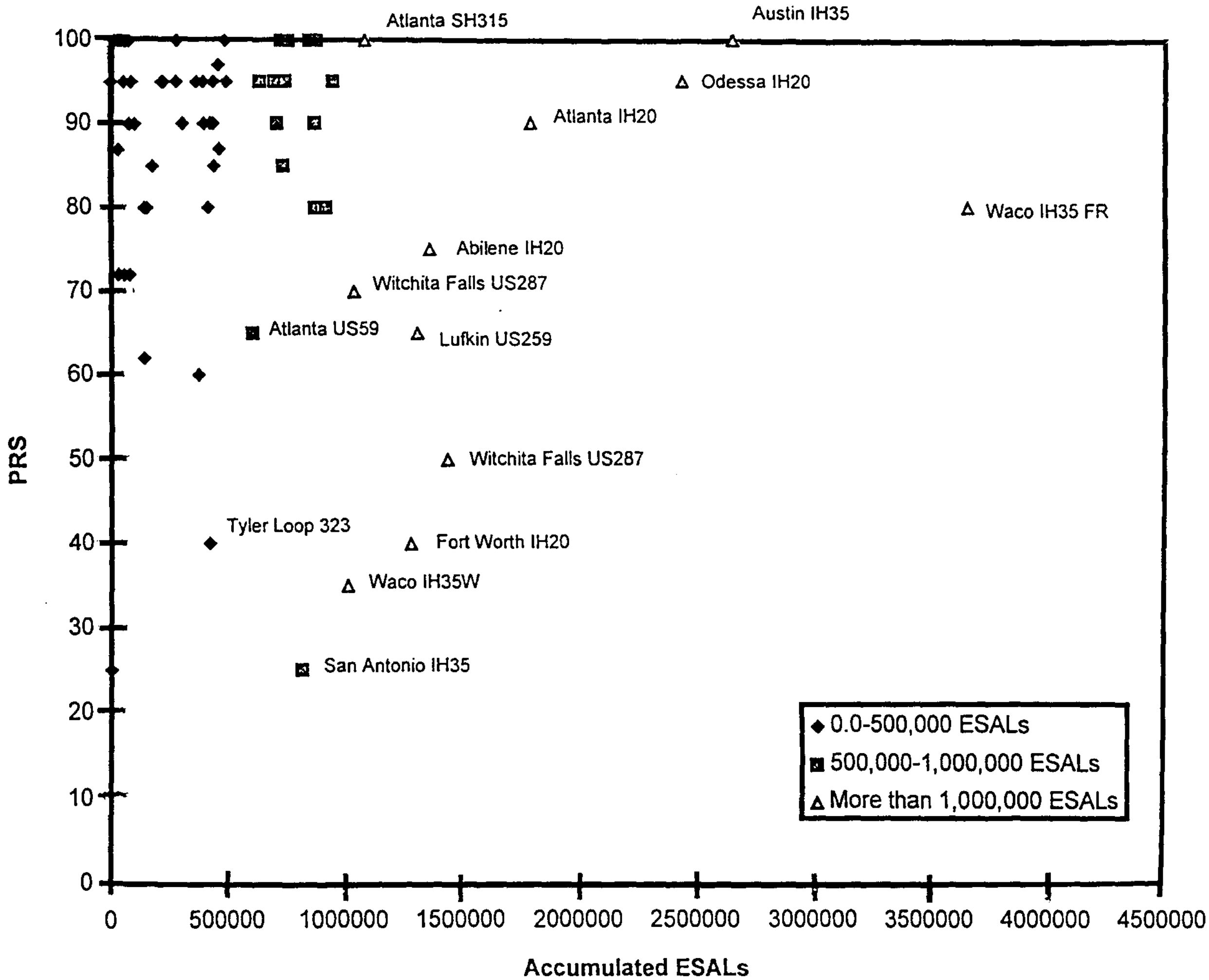


Figure 14. PRS vs. accumulated ESALs.

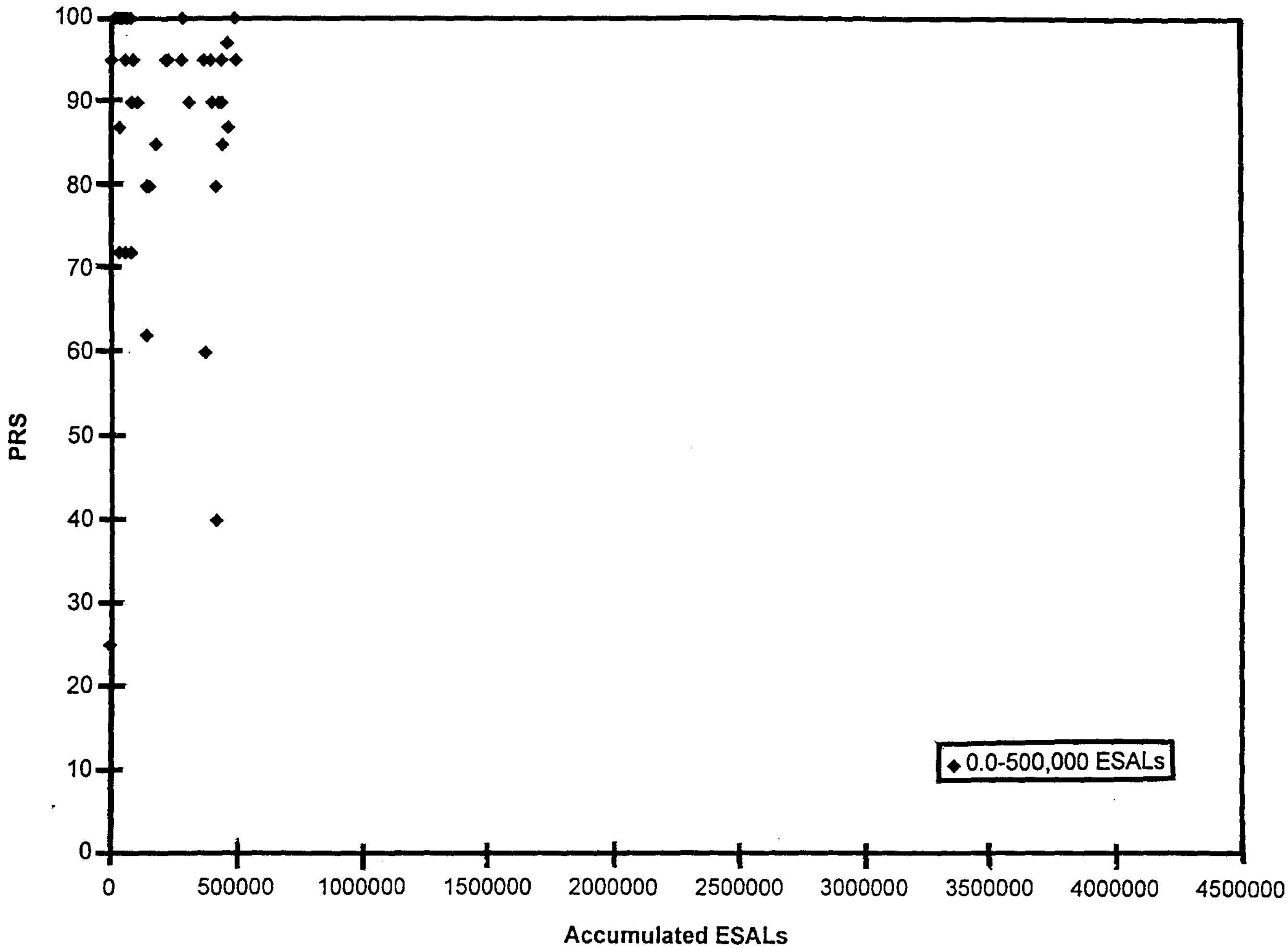


Figure 15. PRS vs. accumulated ESALs.

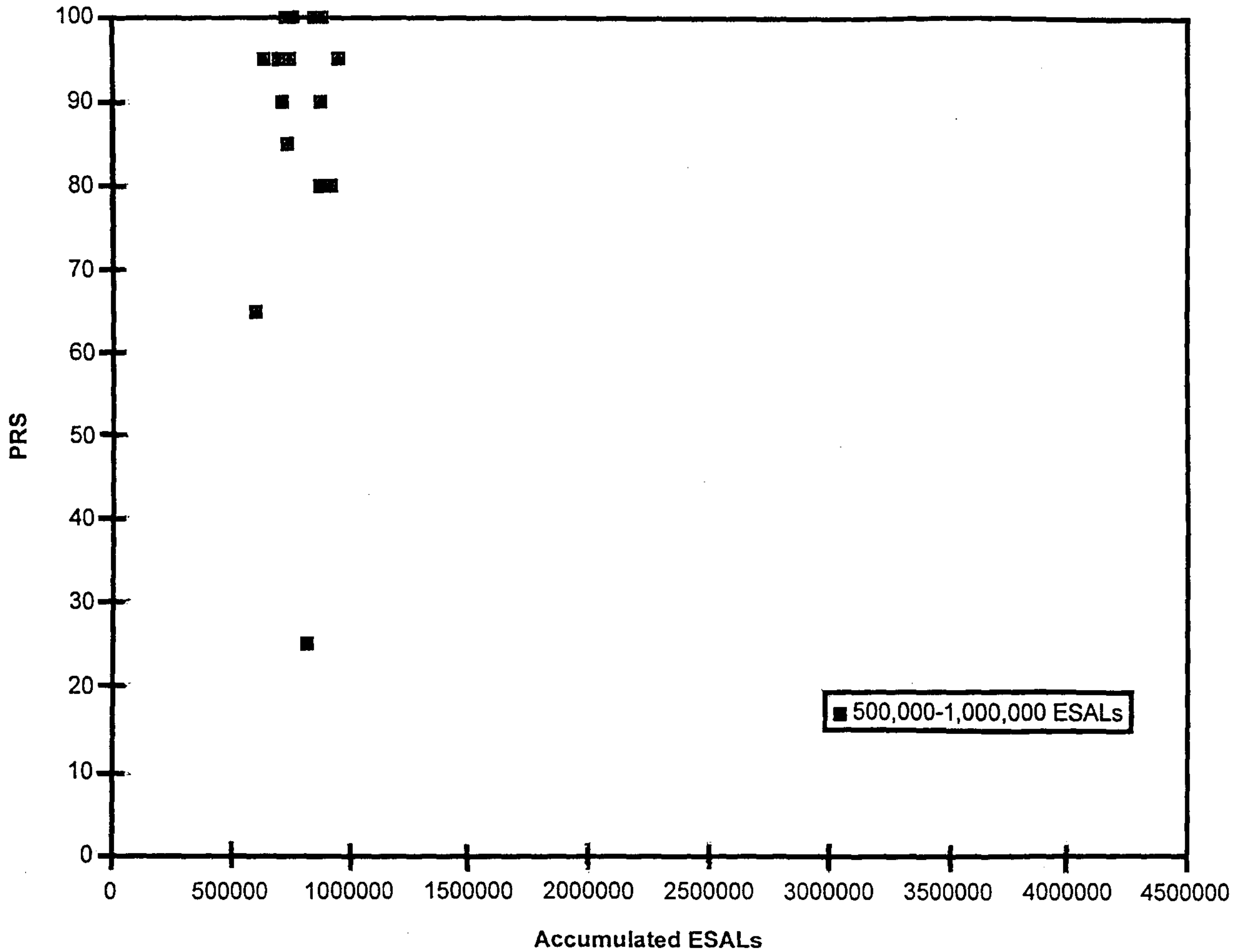


Figure 16. PRS vs. accumulated ESALs.

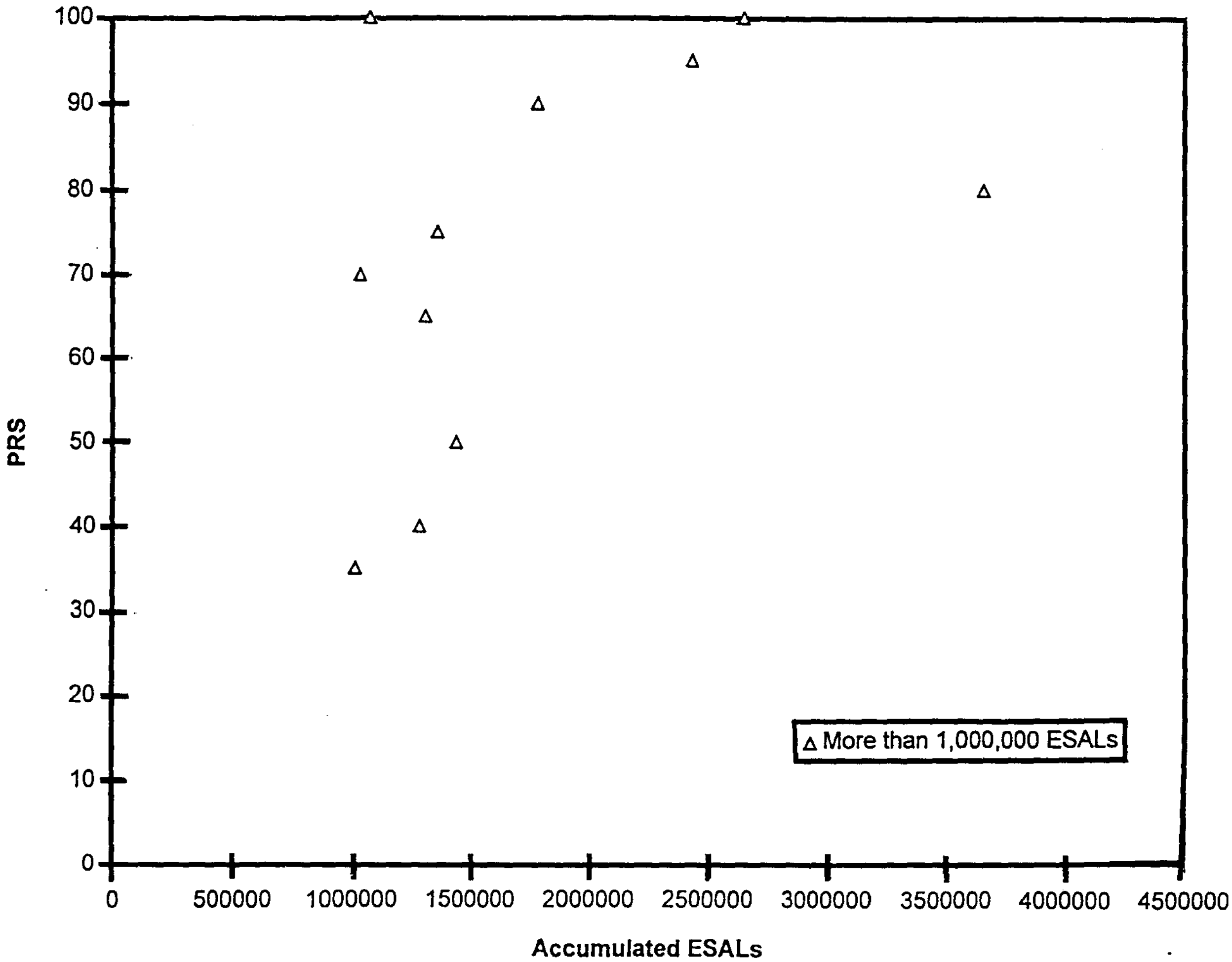


Figure 17. Pavement rating score vs. asphalt content by traffic level.

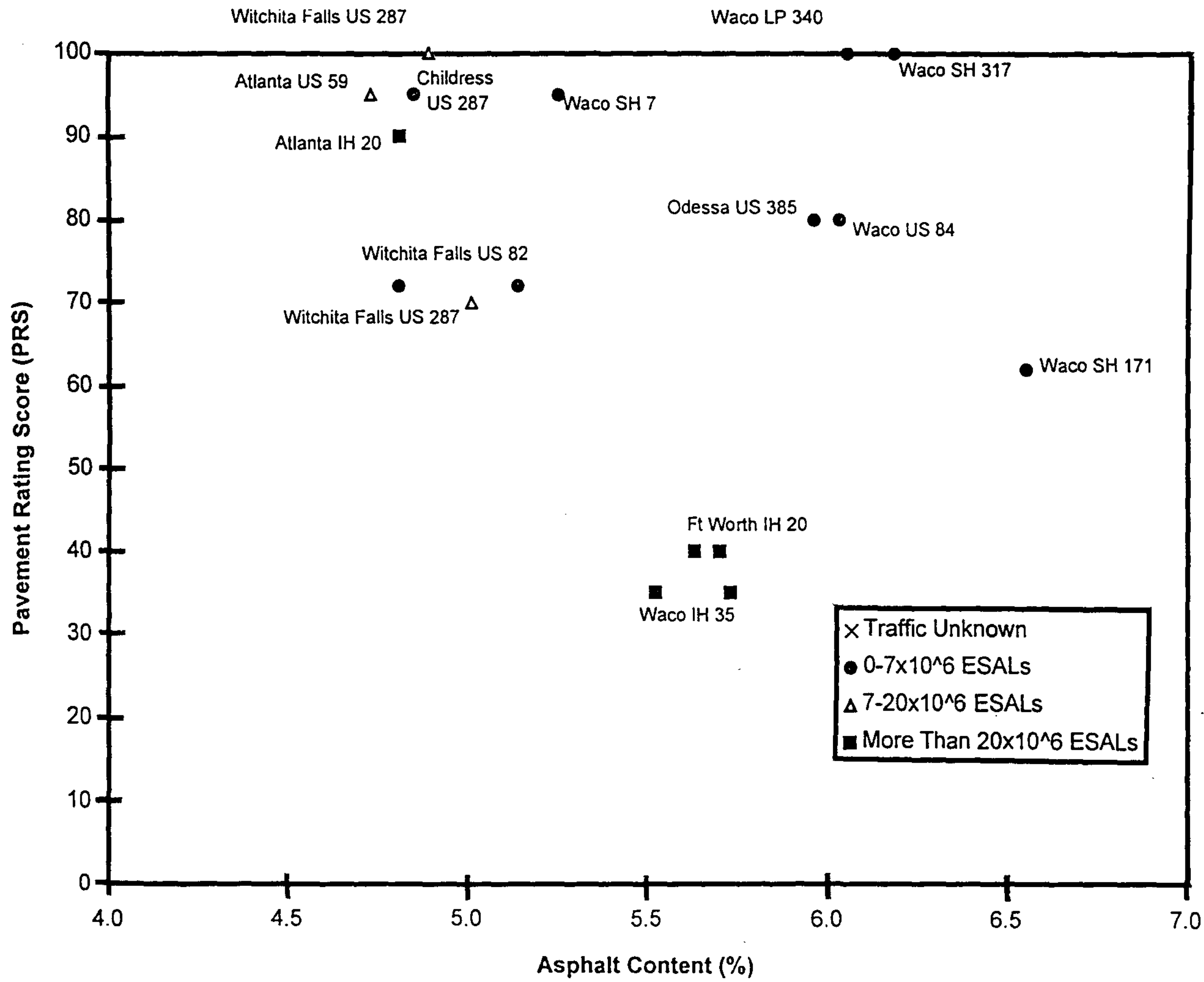


Figure 18. Pavement rating score vs. asphalt content by traffic level.

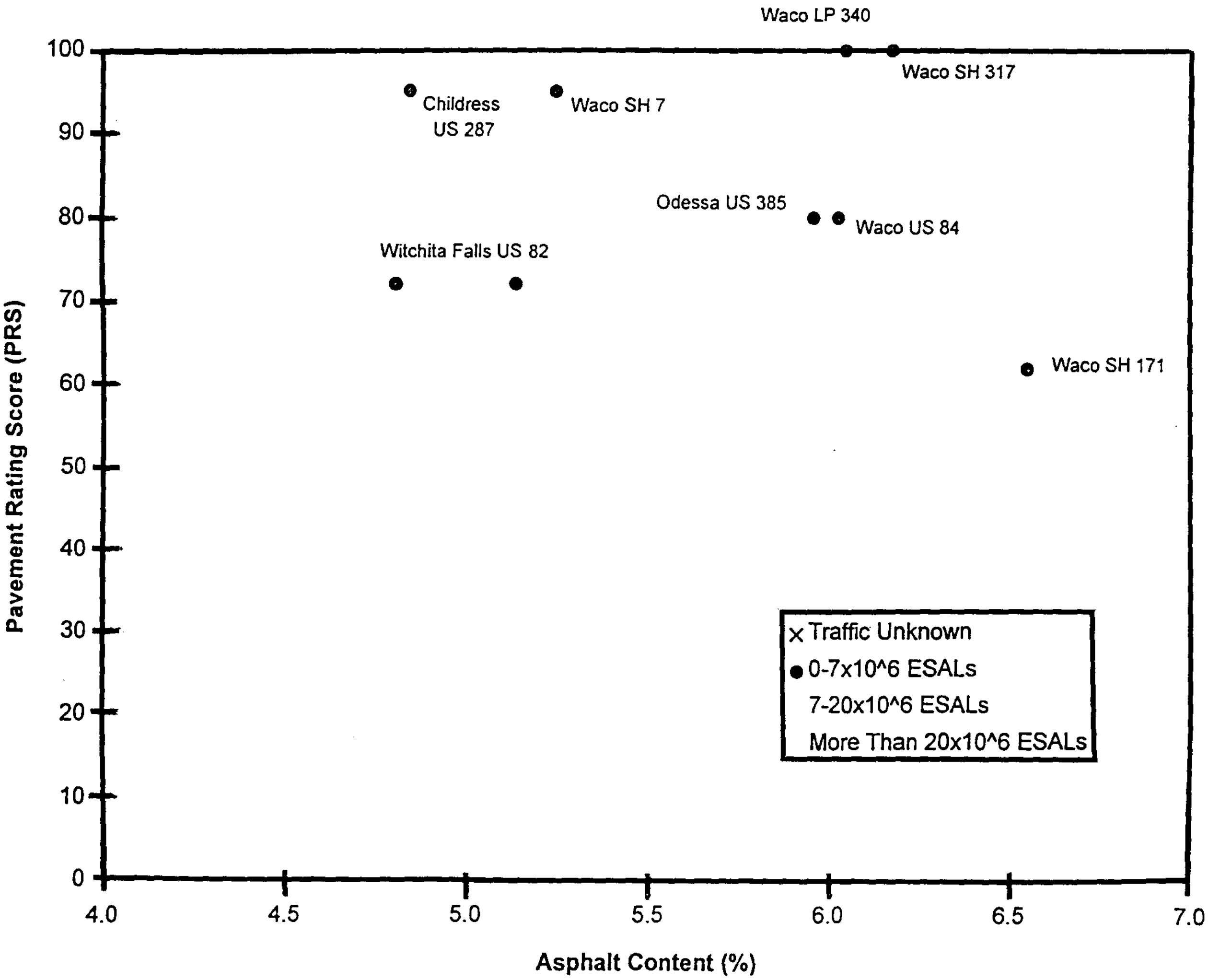


Figure 19. Pavement rating score vs. asphalt content by traffic level.

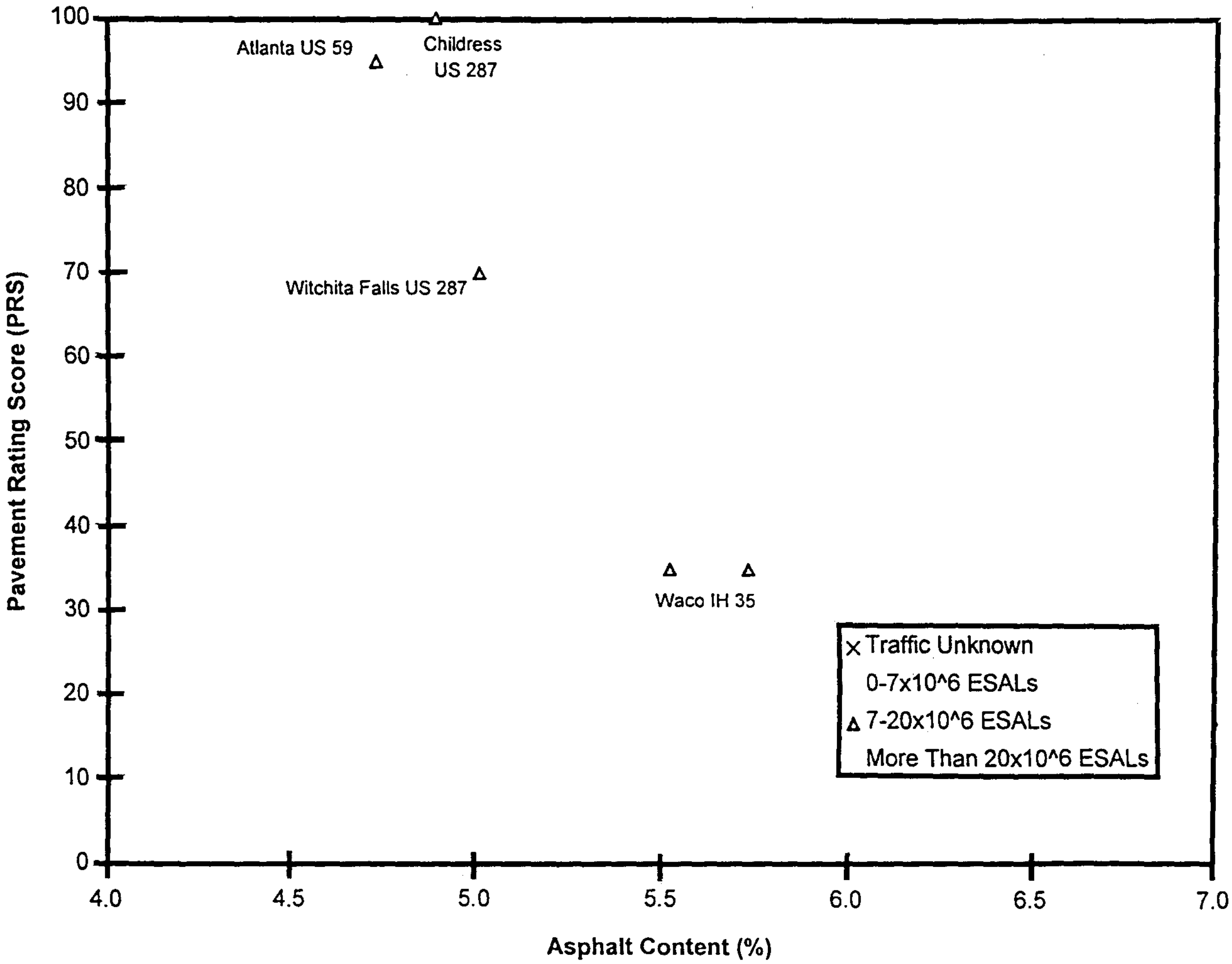


Figure 20. Pavement rating score vs. asphalt content by traffic level.

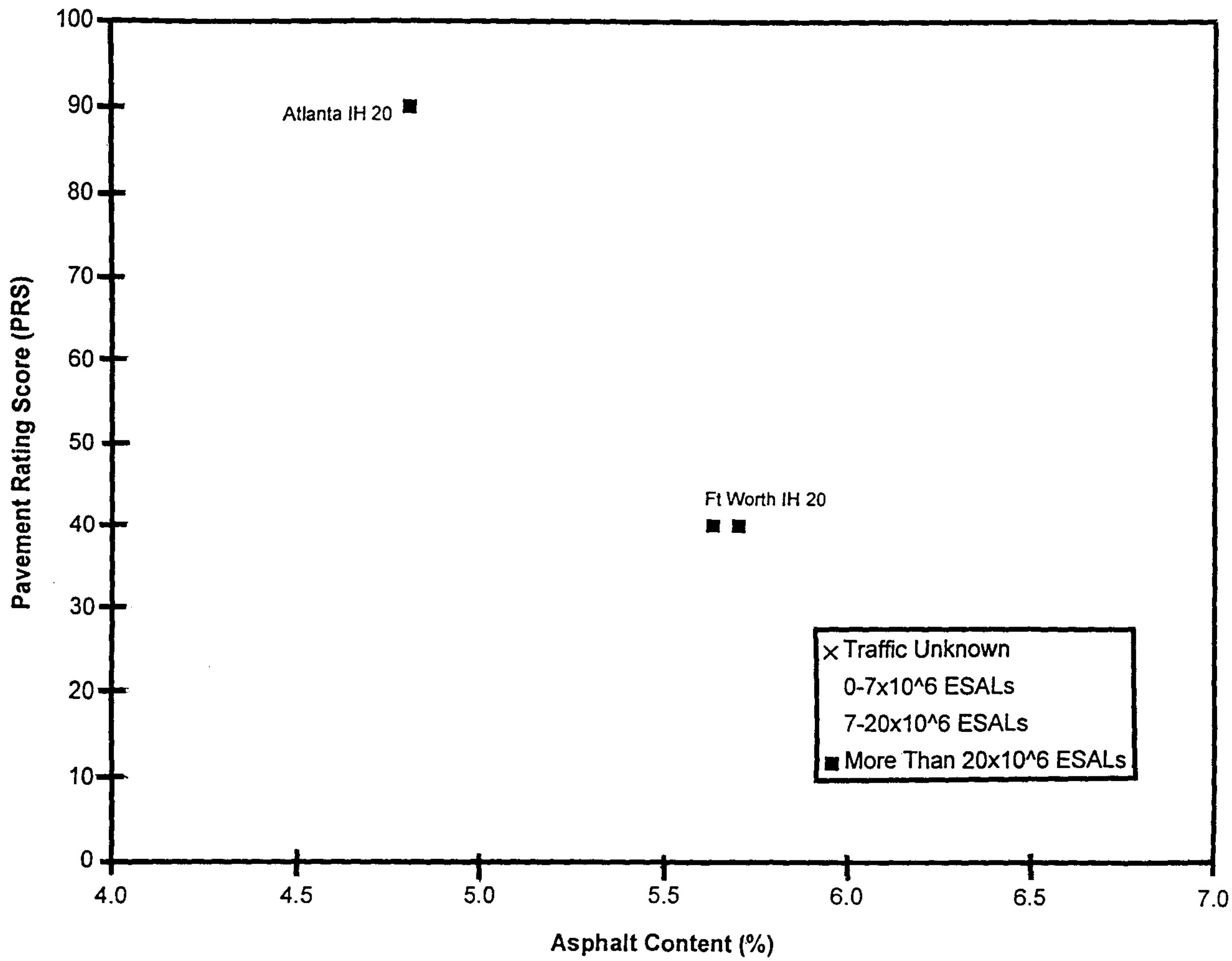


Figure 21. Pavement performance and relative asphalt content.

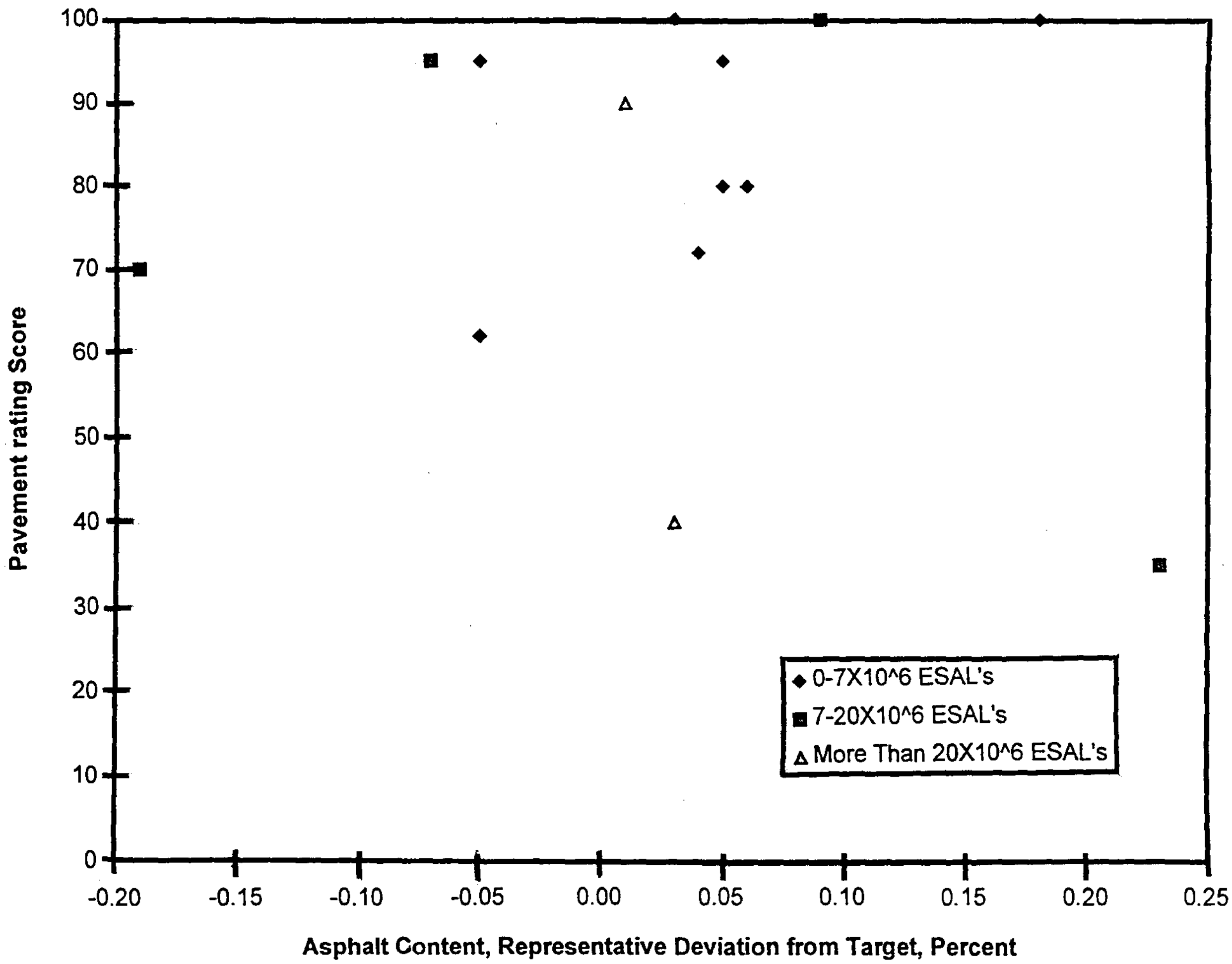


Figure 22. Pavement rating score vs. -#200 sieve by traffic level.

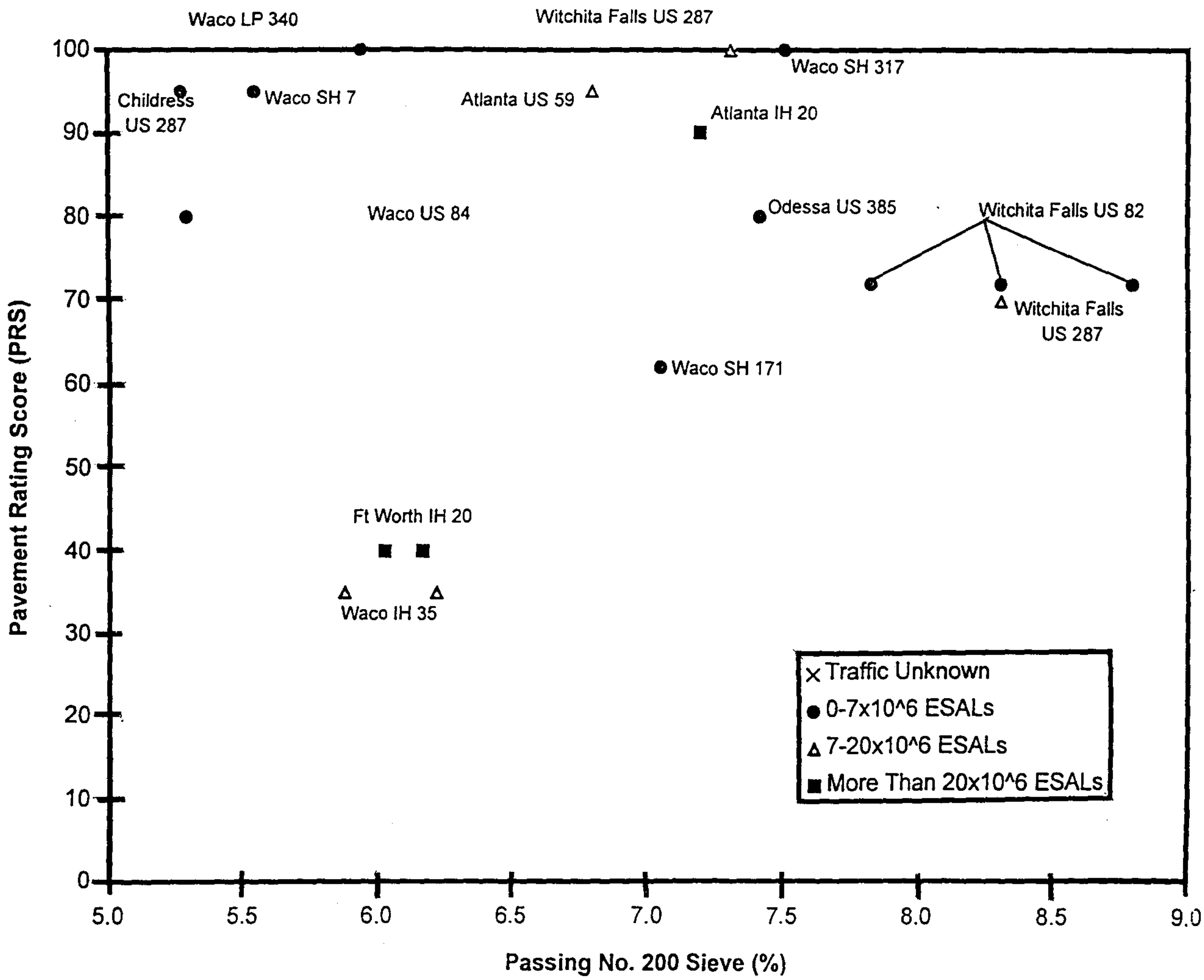


Figure 23. Pavement rating score vs. -#200 sieve by traffic level.

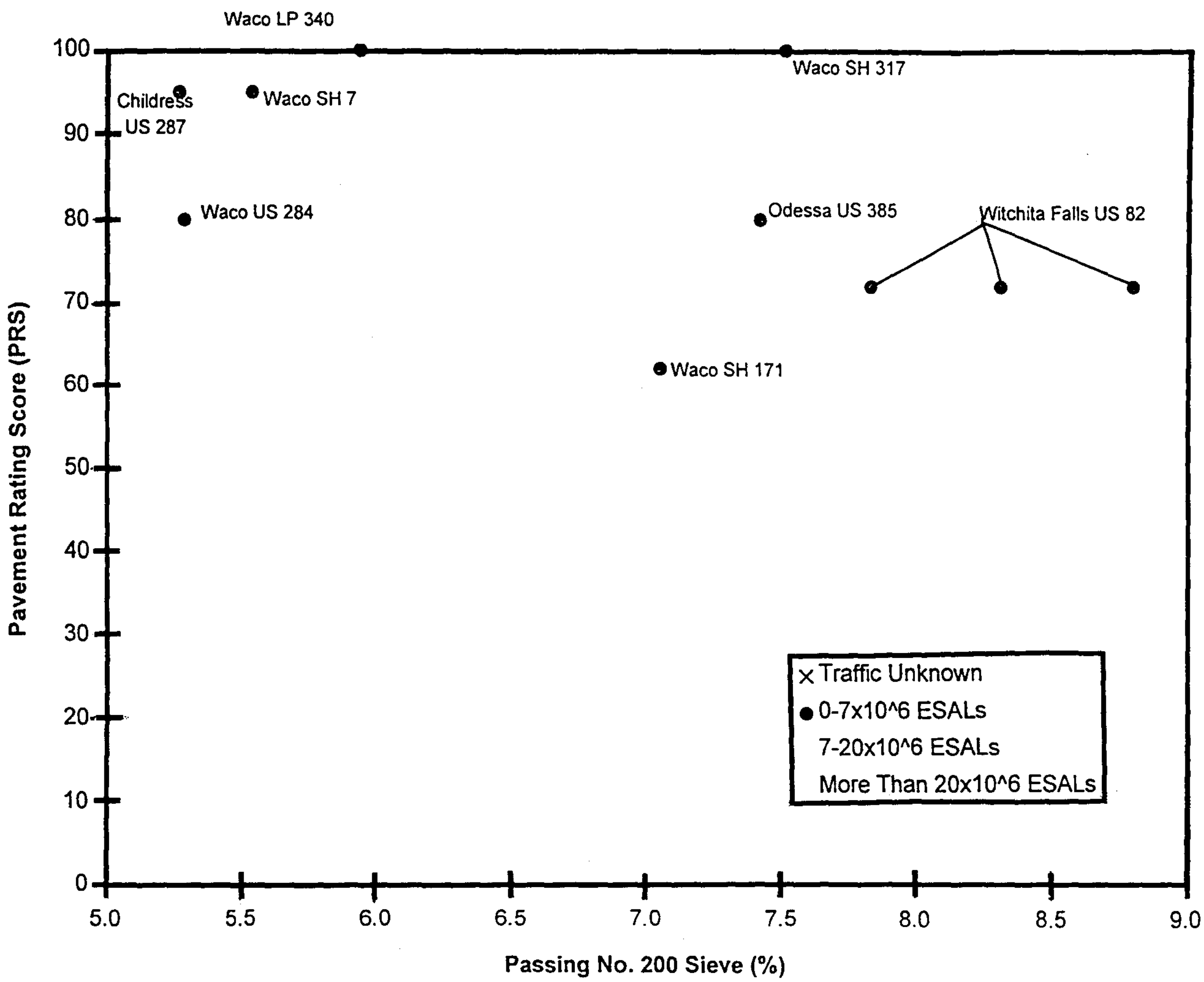


Figure 24. Pavement rating score vs. -#200 sieve by traffic level.

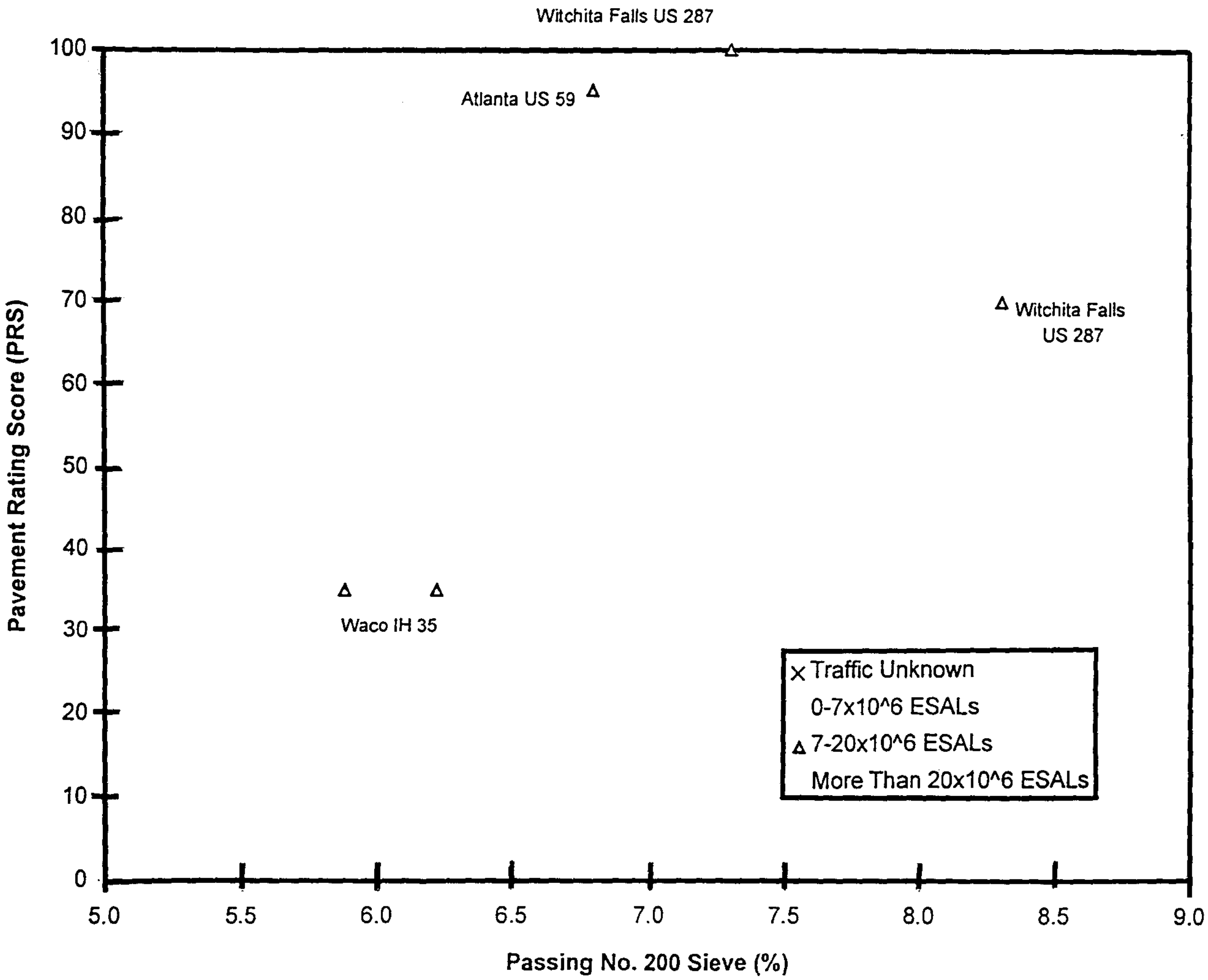


Figure 25. Pavement rating score vs. -#200 sieve by traffic level.

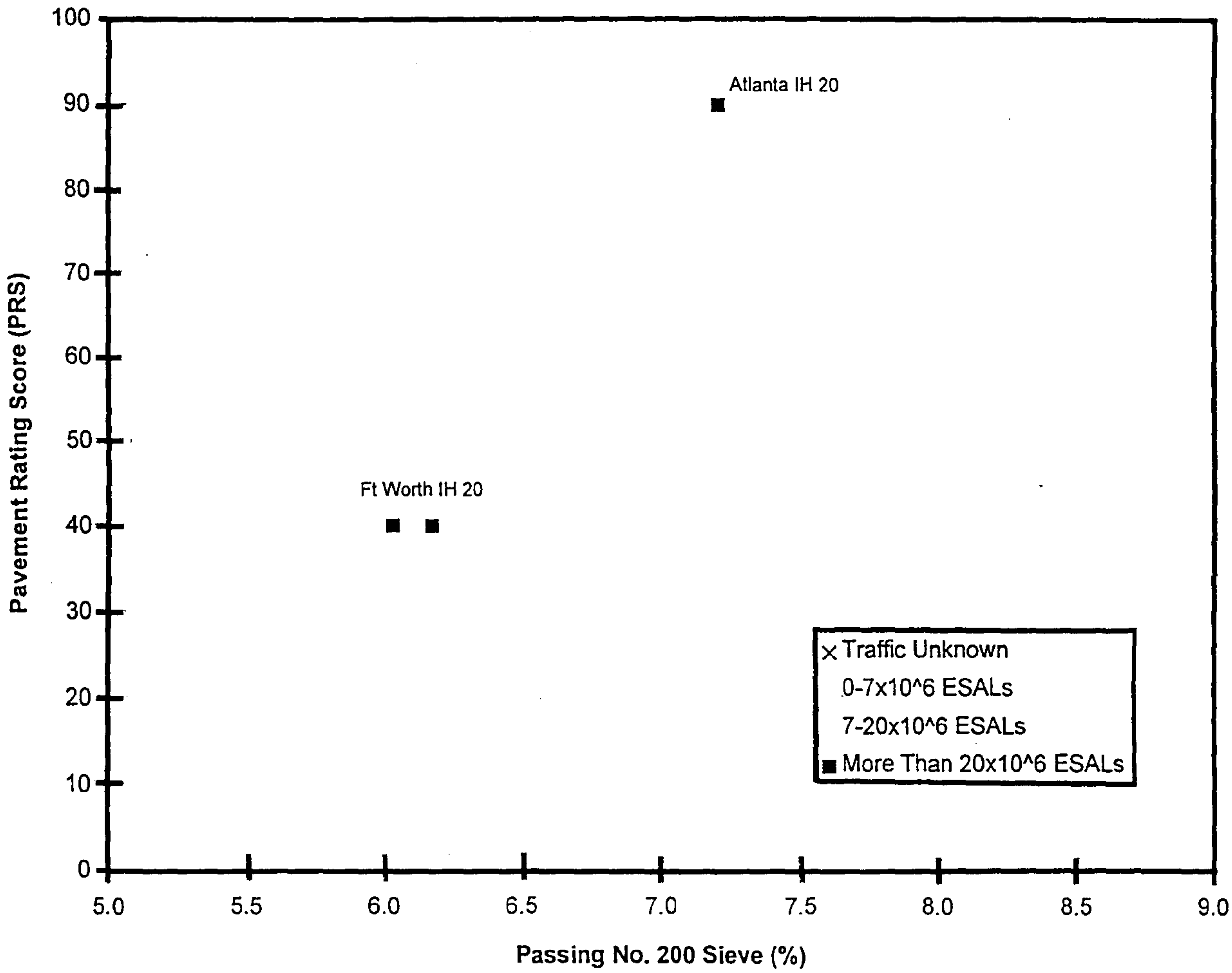


Figure 26. Pavement performance and relative fines content.

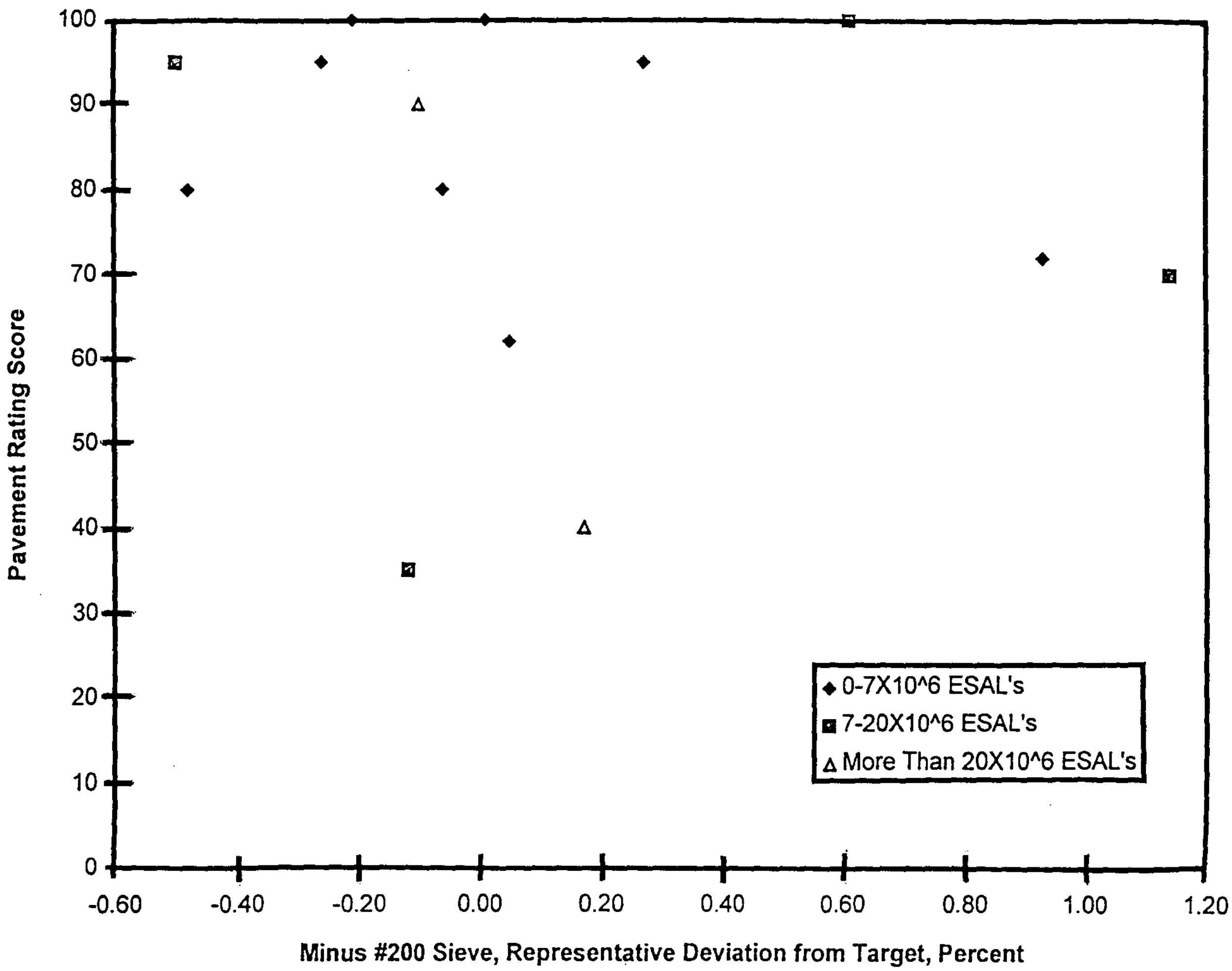


Figure 27. Pavement rating score vs. laboratory molded density by traffic level.

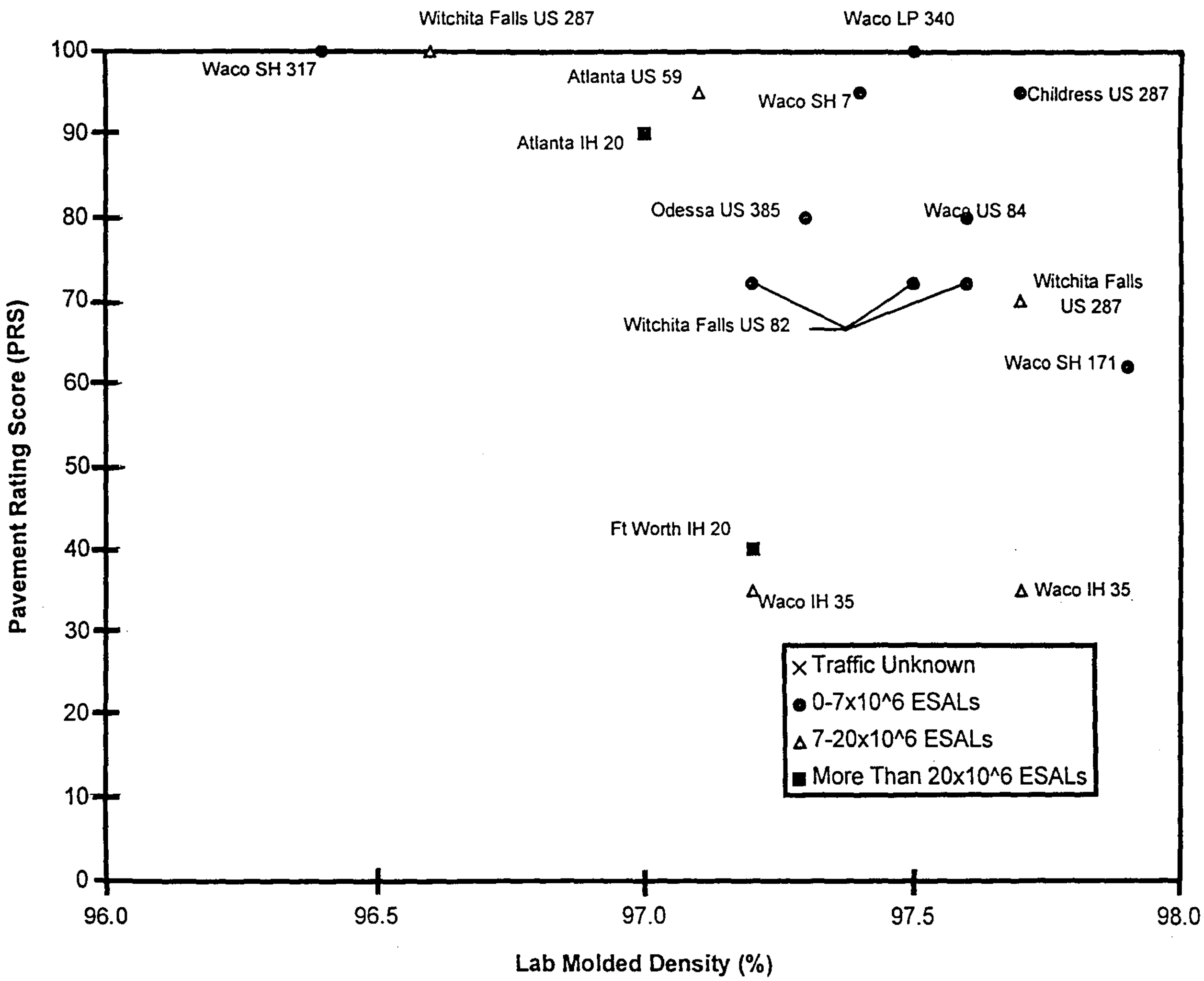


Figure 28. Pavement rating score vs. laboratory molded density by traffic level.

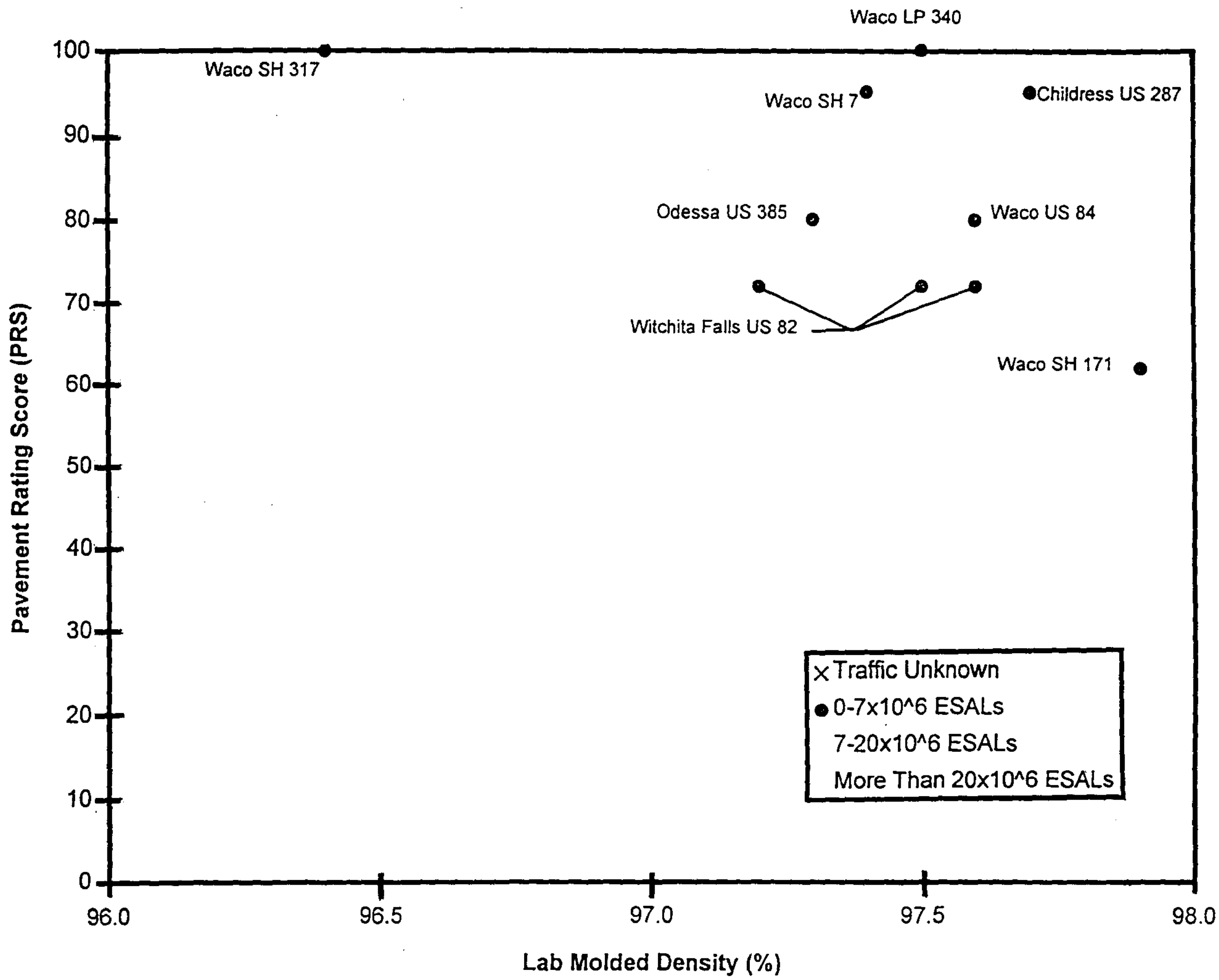


Figure 29. Pavement rating score vs. laboratory molded density by traffic level.

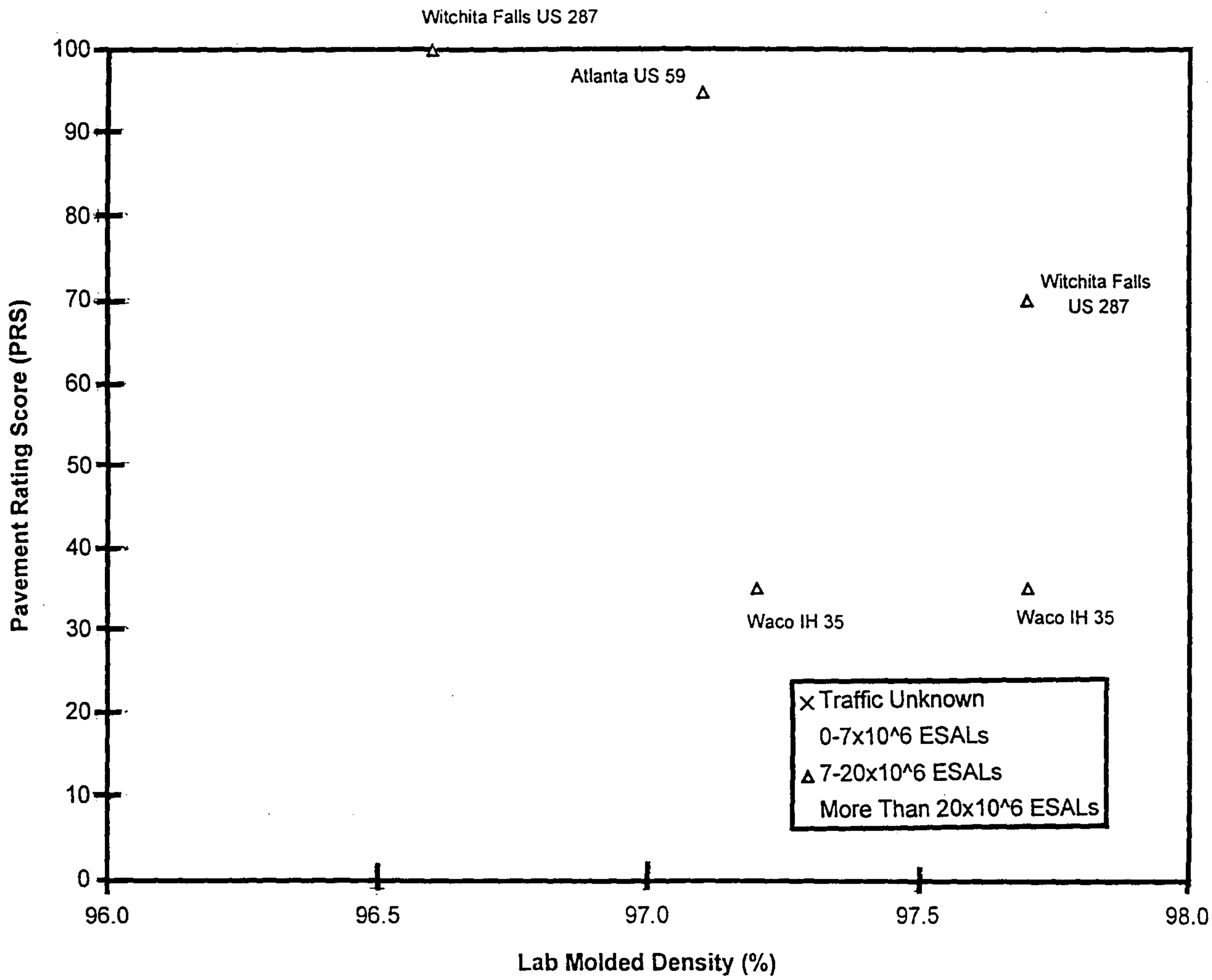


Figure 30. Pavement rating score vs. laboratory molded density by traffic level.

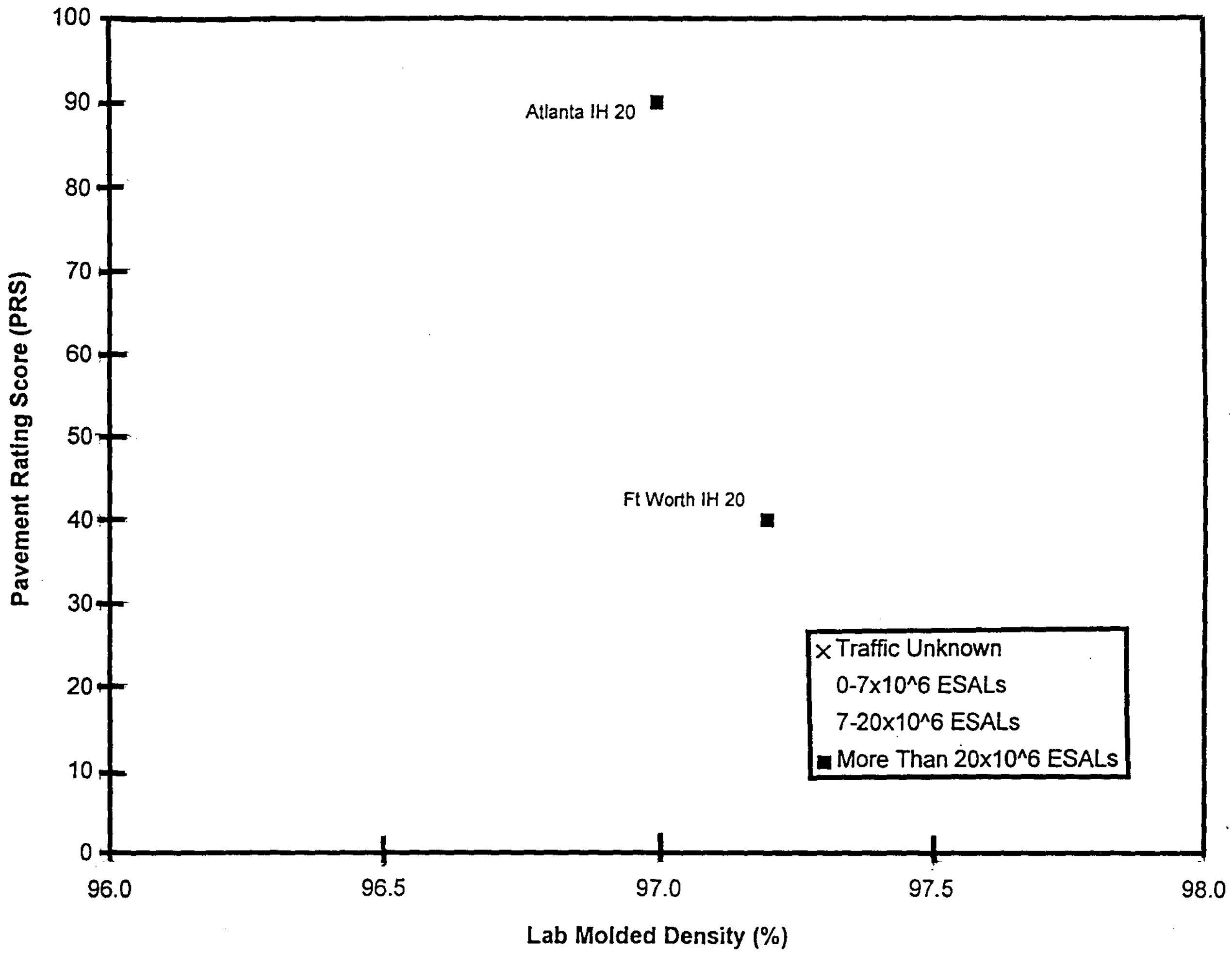


Figure 31. Pavement rating score vs. field air voids by traffic level.

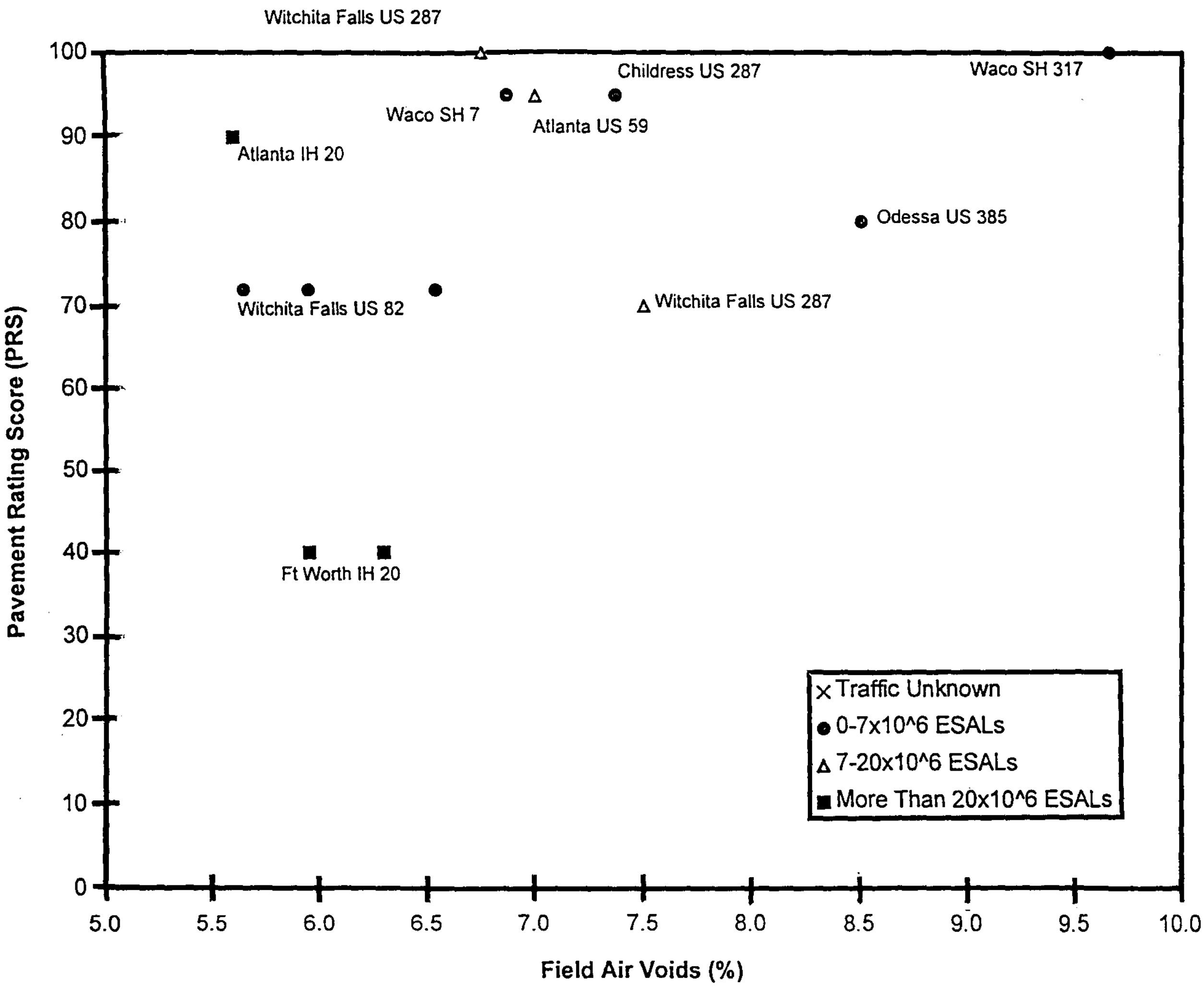


Figure 32. Pavement rating score vs. field air voids by traffic level.

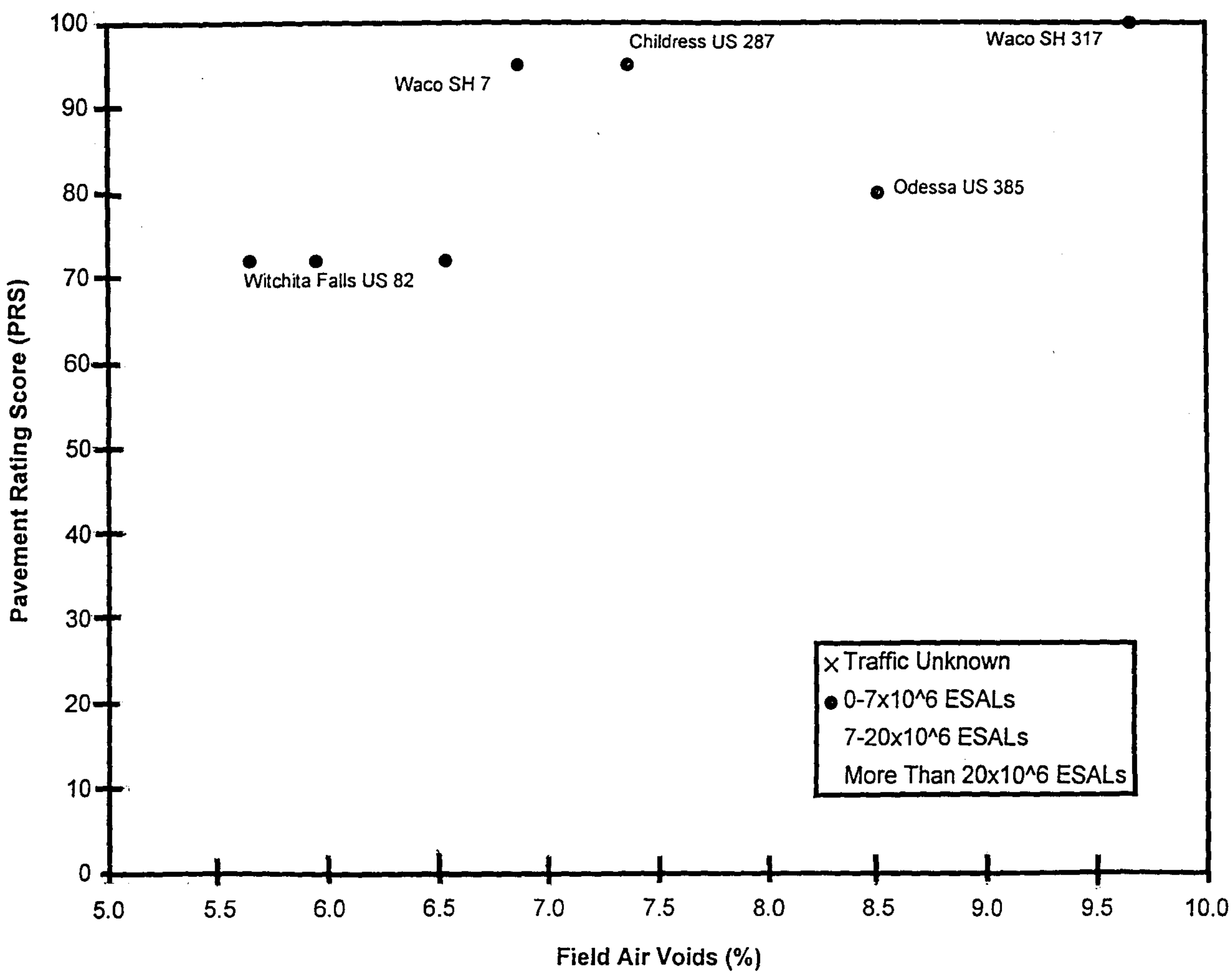


Figure 33. Pavement rating score vs. field air voids by traffic level.

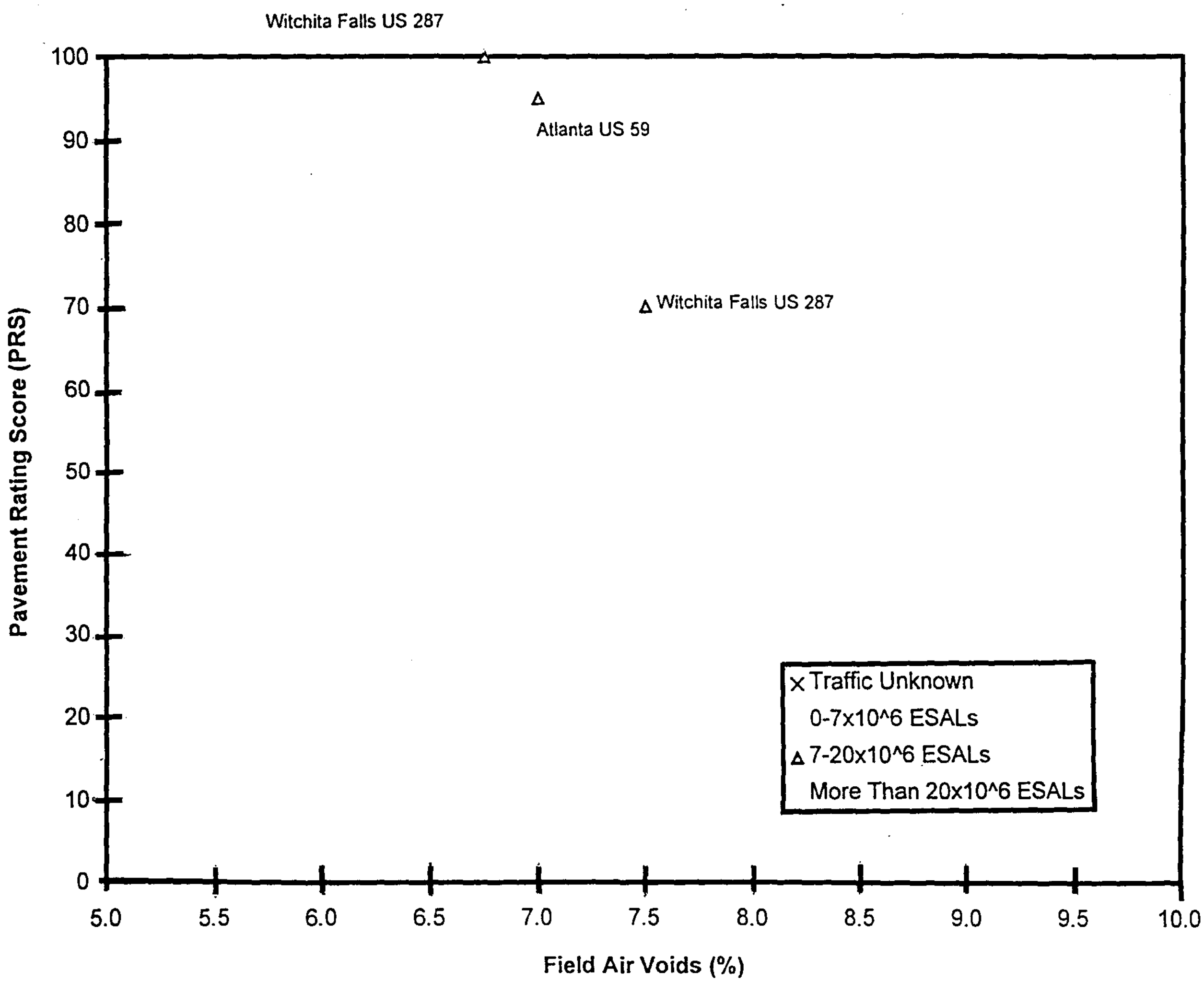


Figure 34. Pavement rating score vs. field air voids by traffic level.

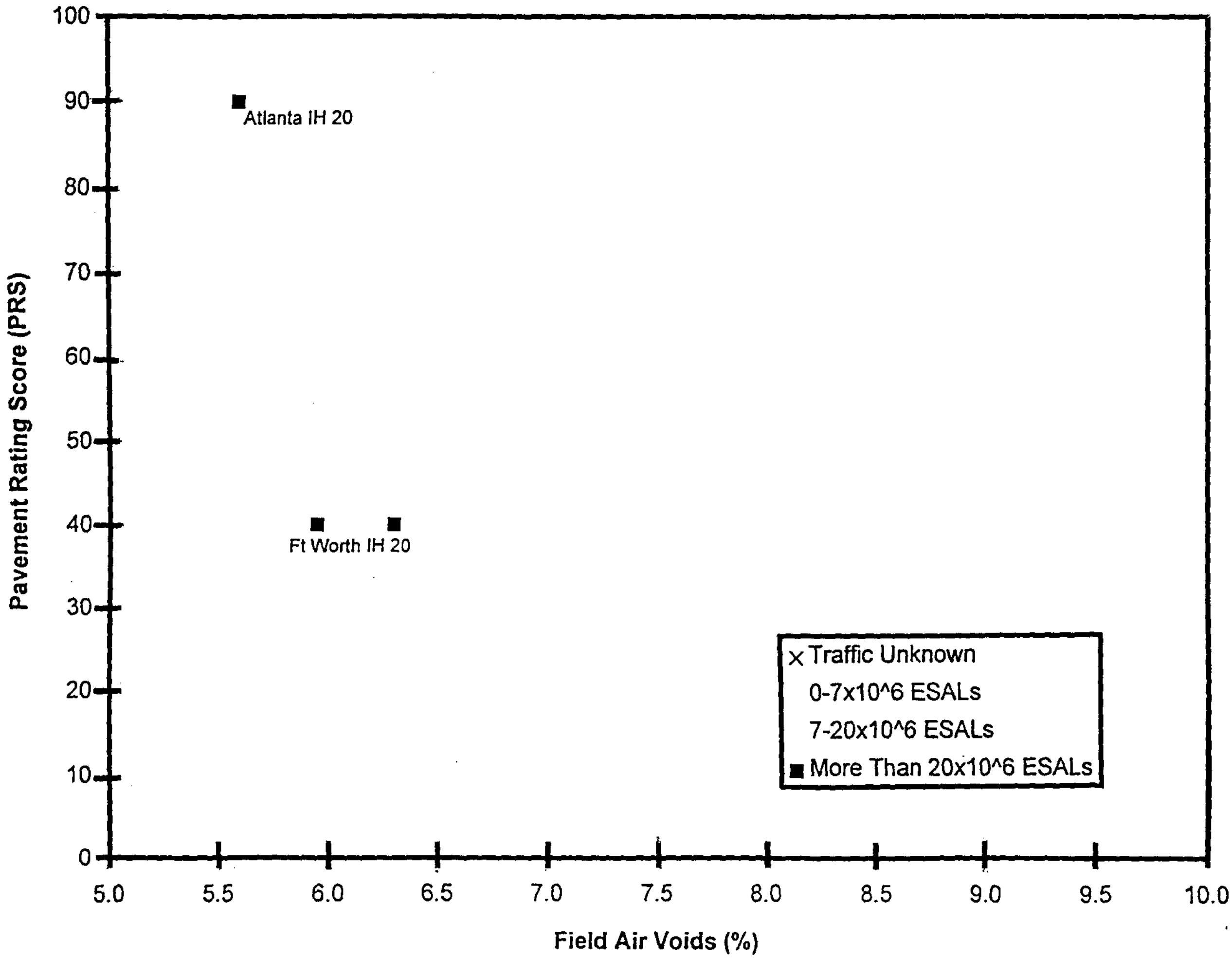


Figure 35. Pavement rating score vs. stiffness by traffic level.

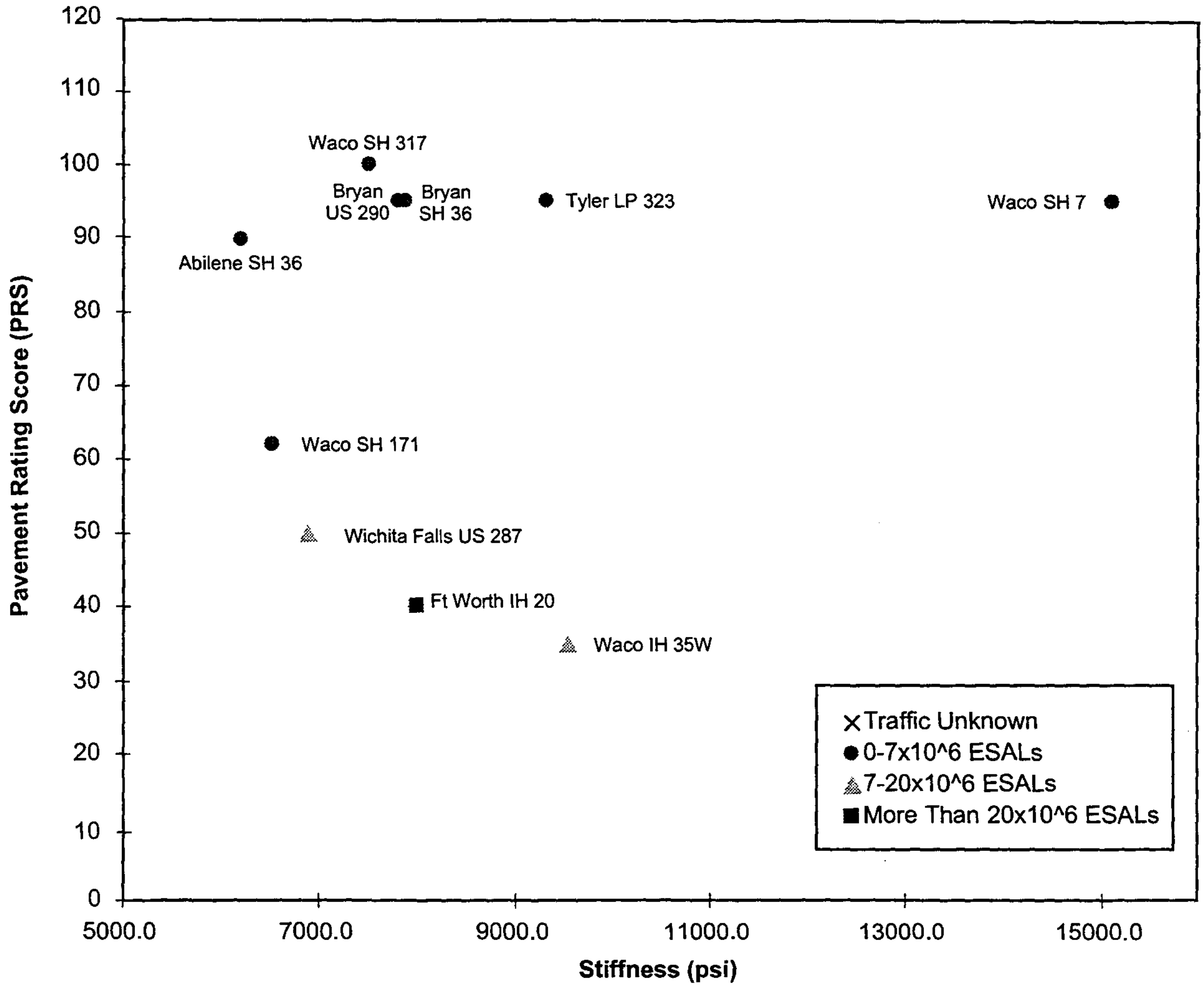


Figure 36. Pavement rating score vs. permanent strain by traffic level.

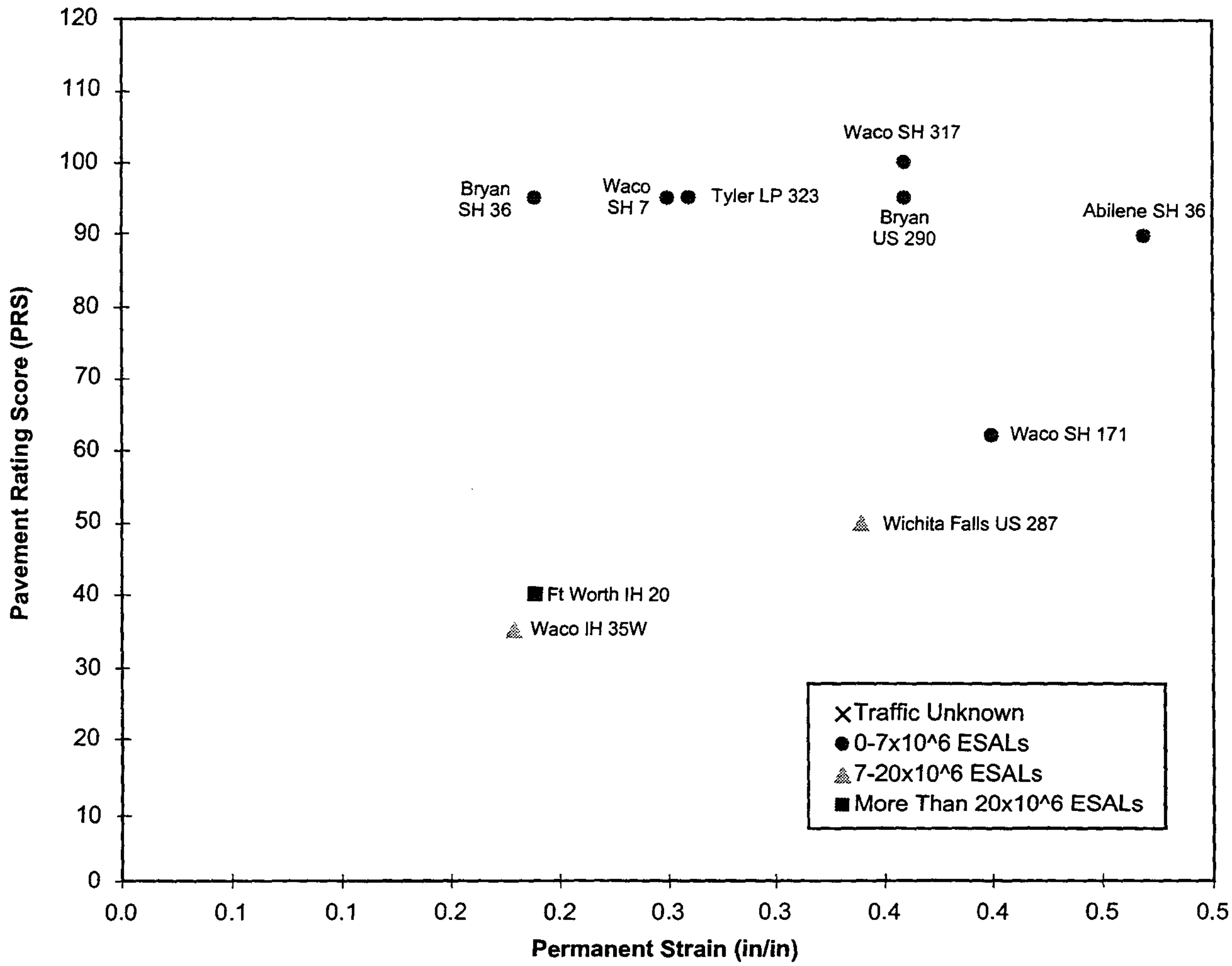
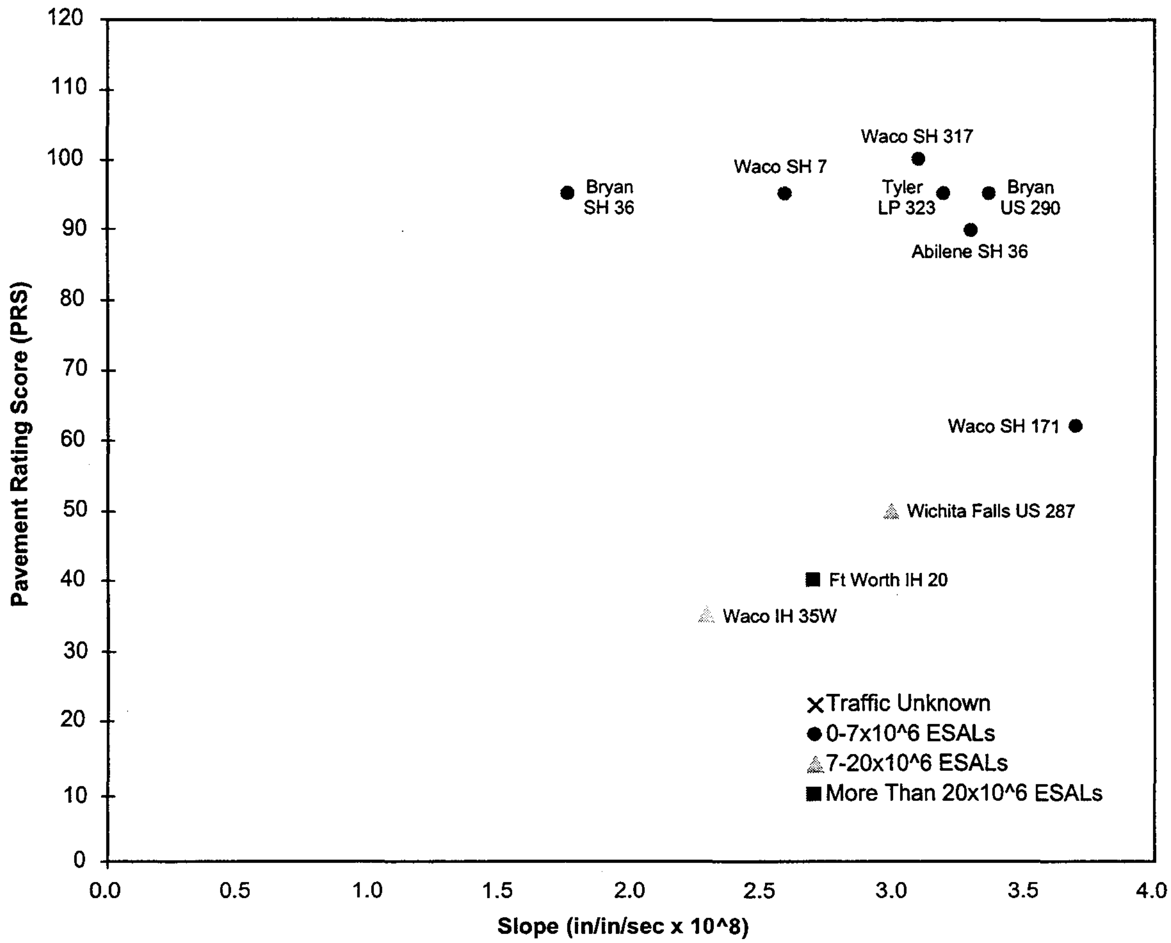


Figure 37. Pavement rating score vs. slope by traffic level.



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