ESTABLISHING LAYER COEFFICIENTS FOR

CTB, PMBB, AND RAP

(HPR NO. 5282)

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16. Abstract

In 1988, the Oregon State Highway Division adopted the 1986 AASHTO guide for pavement thickness design. Currently the OSHD uses a layer coefficient of .22 to .24 for cement treated base (CTB), and .32 for plant mix bituminous base (PMBB). Recycled asphalt pavement grindings (RAP) have been given the same layer coefficient as that used for aggregate base. This study was conducted to determine more specific values which take into account local materials and specifications. Through the use of laboratory triaxial, diametral, and unconfined compressive strength testing equipment, the strength properties of the CTB, PMBB, and RAP were characterized and correlated to AASHTO layer coefficients. The results of the testing for CTB were modified to take into account the new OSHD specification and the unrecoverable cores. The modified data resulted in project average layer coefficients for CTB ranging from .21 to .30. The PMBB project averages for layer coefficients ranged from .3 to .47. The range in these values is considerable. The current design practice of using layer coefficients of .22 to .24 for CTB and .32 for PMBB will be continued until additional data and specification changes are made to justify a change. The use of RAP in lieu of untreated aggregate base appears to be a good alternate on some projects.

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DISCLAIMER

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1.0 INTRODUCTION

1.1 Background

The Oregon State Highway Division (OSHD) has long been designing with dense graded, treated aggregate bases. Both cement-treated base (CTB) and plant-mix bituminous base (PMBB) have been used. In addition, recycled asphalt pavement (RAP) grindings have been used as base material. Some of the first PMBB used in Oregon was placed under the original construction of the interstate while the CTB came into heavy use during the 1970's. During this time the design procedures used gave equal structural credit to CTB and PMBB. Consequently, since CTB is generally less expensive on a per inch basis, most jobs were built with CTB.

In 1988 OSHD adopted the 1986 AASHTO guide for pavement thickness design. The guide recommends layer coefficients for CTB based on compressive strength and for PMBB based on resilient modulus. Using the AASHTO approach and considering other factors such as constructability and cracking resistance, OSHD tended toward constructing more projects with PMBB.

While AASHTO has identified broad guidelines for selecting layer coefficients for use in pavement design, it is appropriate to determine more specific values which take into consideration local materials and specifications.

1.1.1 Current OSHD Design Practices

Currently, the OSHD designs CTB with an AASHTO layer coefficient of between 0.22 and 0.24. PMBB is designed with an AASHTO layer coefficient of 0.32. These design values were determined after a search of appropriate literature and past laboratory testing.

To determine an appropriate AASHTO layer coefficient to use in CTB design, laboratory analysis was performed on field CTB mixes. The field inspectors prepared briquettes of the CTB used on each project. These samples were shipped to the lab where they were cured and tested. The spread of the resulting unconfined compressive strengths from these tests is illustrated in Figure 4.1. The average unconfined compressive strength of the lab controlled samples was 938 psi (length to diameter correction made-AASHTO T-24), with a corresponding AASHTO layer coefficient of 0.24 from the AASHTO Design Guide, Section II. Due to field variability in construction, the CTB layer coefficient may be less than 0.24. A range of layer coefficients of between 0.22-0.24 are generally used depending on the type of job and potential for variability.

To determine an appropriate PMBB AASHTO layer coefficient for design, a literature review of appropriate studies was performed. According to the AASHTO Road Test results of studies on bituminous treated aggregate, a layer coefficient value of 0.34 was determined for a modulus of 400,000 psi. The typical PMBB used by OSHD is of high quality and it is believed that a layer coefficient value of 0.34 may be too conservative. However, without the benefit of full laboratory testing and study, the decision was made to design OSHD PMBB with an AASHTO layer coefficient of 0.32.

1.2 Purpose

This project is intended to determine appropriate layer coefficients for CTB, PMBB, and RAP from actual field samples. Through the use of laboratory triaxial, diametral, and unconfined compressive strength testing equipment, the strength properties were characterized for each of the test materials. These values were correlated to AASHTO layer coefficients and will be incorporated into the OSHD pavement design procedure.

A better knowledge of structural layer coefficients will allow for fine-tuning of the design procedure. This could result in more economical pavements which will perform well under the anticipated traffic loadings. In addition, a better understanding of the characteristics of recycled material will allow its use in pavements with a higher degree of confidence. By utilizing recycled materials in pavements, less new material will be

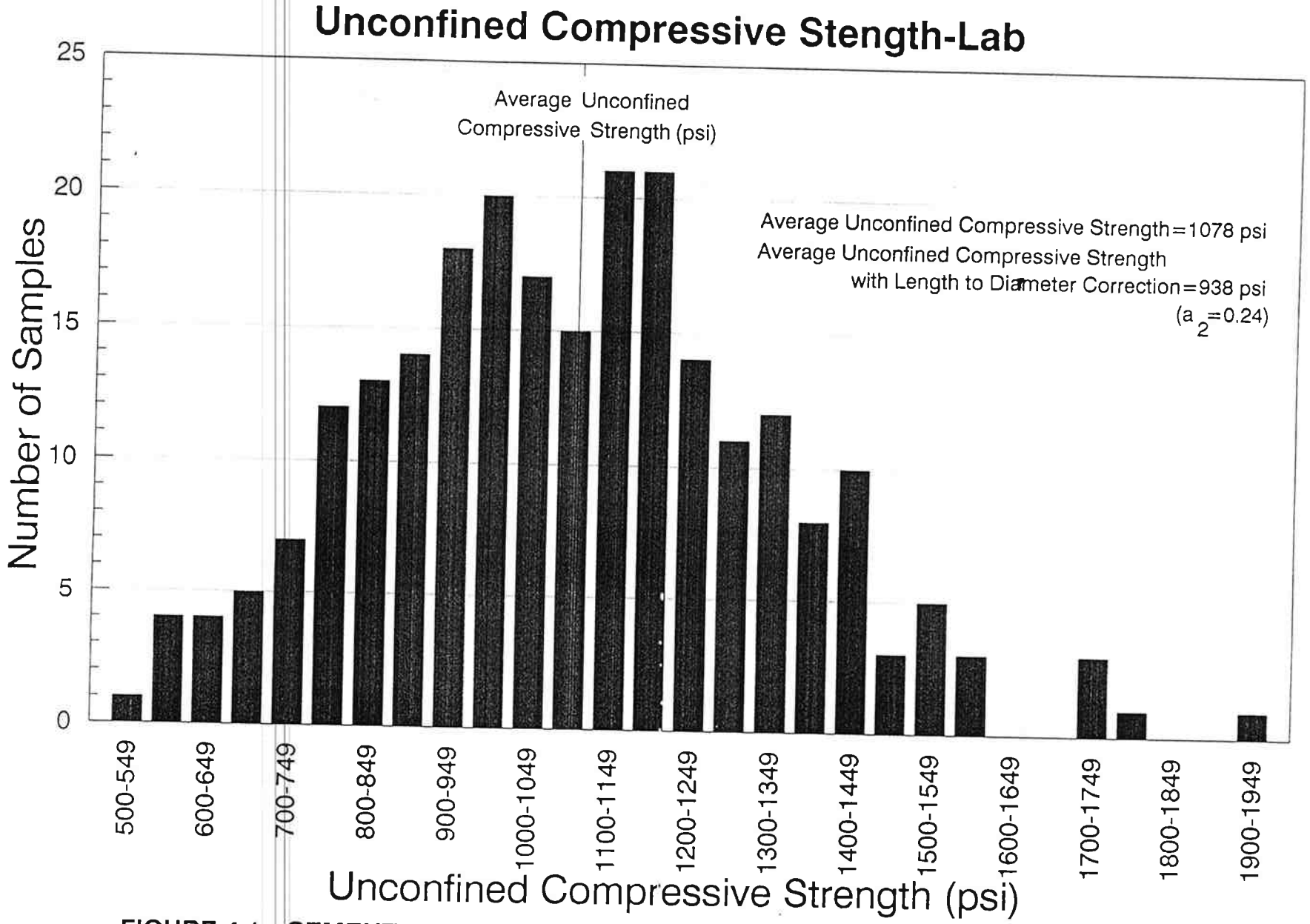

FIGURE 4.1: CEMENT-TREATED BASE UNCONFINED COMPRESSIVE STRENGTH-LAB

needed and more economical designs obtained. The expected findings may be immediately incorporated into the existing design procedure. If the research study indicates the need for new or revised specifications, further study may be required.

2.0 PROCEDURE

Five projects were selected statewide to study CTB, six projects to study PMBB, and one project to study RAP. In the case of the CTB, one project was selected from each of the five regions in the state, while for PMBB one project was selected in each region with an additional project in the local region. These projects were selected to provide the broad range of pavement construction conditions and materials found throughout the state. The projects tested are listed in Table 2.1.

Samples were obtained in the field by coring. The recovered cores from the various project sites were brought to the lab where specified tests were performed. A great deal of difficulty was encountered in coring the CTB. Many times it was not possible to retrieve a core because the material crumbled. It is assumed the unrecovered cores crumbled due to low strength. Table 2.2 shows the percentage of recovered cores per project. The CTB was tested for dry density and unconfined compressive strength (ASTM 2166). The values determined were corrected for the length to diameter ratio of the core sample (AASHTO T-24). The PMBB was tested for bulk specific gravity (ASTM D2726), gradation (ASTM D2172), asphalt content (ASTM D2172), and resilient modulus (OSHD 315A). The values determined were corrected from the test temperature of 72°F to the AASHTO layer coefficient chart (Section II of the AASHTO Design Guide) temperature of 68°F using the "Asphalt modulus temperature adjustment factor" graph from the AASHTO Design Guide, Section L. The RAP was tested for density and optimum moisture content (AASHTO T99A) as well as resilient modulus (OSHD 315A).

BASE MATERIAL	PROJECT NAME	OREGON STATE HIGHWAY #
CTB	Murphy Road-Lava Butte Section	004
	Camas Mt Wayside-Muns Creek Section	035
	Wildwood-Zigzag Section	026
	Kuebler Blvd-Cordon Road	Salem
	John Logan Lane-Pine Creek Road Section	007
PMBB	Longwood Drive-Winchester Bay Section	009
	Simmons Creek-Pleasant Valley Section	009
	Farewell Bend POE	006
	Austin Avenue-Eastside Bypass	020
	Greeley Ramps-North Banfield Interchange	001 & 002
	Mill City-Gun Creek	162
RAP	Hayesville-Battlecreek Inlay	001

TABLE 2.1: Base material and project name.

PROJECT NAME	NUMBER OF CORES ATTEMPTED	NUMBER OF CORES RECOVERED	PERCENT OF CORES RECOVERABLE
Camas Mt Wayside-Muns Cr	8	1	12.5
John Logan Ln-Pine Creek Rd	13	8	61.5
Kuebler Blvd-Cordon Rd	20	13	65.0
Murphy Rd-Lava Butte	14	12	85.7
Wildwood-Zigzag	9	6	66.7

TABLE 2.2: Percent CTB cores recoverable.

3.0 PROJECT DATA

The CTB material was tested for unconfined compressive strength. These strength results were converted to AASHTO layer coefficients. The unconfined compressive strength, modified unconfined compressive strength and AASHTO layer coefficient are presented by project and with the project average in Appendix A. The PMBB material was tested for modulus of elasticity. These modulus and corresponding AASHTO layer coefficients are presented by project and with the project average in Appendix B. The RAP material was tested for resilient modulus at a bulk stress. The resulting values are presented in Appendix C.

4.0 ANALYSIS

Analysis of lab results was performed to determine the layer coefficients for use in the AASHTO design procedure. The results of the analysis follow.

4.1 CEMENT-TREATED BASE

The current construction specifications used by the OSHD for CTB design are provided in Appendix A. All CTB designed under the present and future specifications will be subject to an upper limit on unconfined compressive strength. This is necessary to minimize uncontrolled cracking. This limit will force the CTB strengths to be less than 1800 psi. With this limitation, the data gathered from the five projects tested were shifted to meet this criteria. By modifying the results of the data tested, a representation of future project samples can be made. In addition, any unrecovered cores were assigned an unconfined compressive strength corresponding to that of the weakest core recovered, 682 psi (Kuebler-Cordon Rd). Since the 682 psi value is relatively high, an analysis was also performed assuming 300 psi strength, this was done to evaluate the sensitivity of the results of the strength of the unrecovered cores.

The unmodified results of the CTB field sample testing are shown in Appendix A, Table A-1. The unconfined compressive strength of each sample is shown by project and with the project average. In addition, the average unconfined compressive strength of all of the projects (1423 psi) is shown. To make this data conform to the latest specification, it was shifted so that 95% of the core strengths by project fall below 1800 psi. The modified values of unconfined compressive strength are shown in Appendix A, Table A-1, and as Modification A in Figure 4.1.

Once the modified unconfined compressive strength was known, AASHTO layer coefficients were determined from Section II of the AASHTO Design Guide. These layer coefficients are shown in Appendix A, Table A-1. Once the data had been modified to consider the upper limit of strength, the unrecovered cores were accounted for. For each unrecovered core, an unconfined compressive strength of 682 psi and 300 psi was assigned. Table 4.1 summarizes the modified average compressive strength for modification B (682 psi) and modification C (300 psi), and the average AASHTO layer coefficient, taking the unrecovered cores into account.

PROJECT	AVERAGE UNCONFINED COMPRESSIVE STRENGTH (PSI)			AVERAGE AASHTO LAYER COEFFICIENT (a_2)	
	MOD A	MOD B	MOD C	MOD B	MOD C
Murphy Rd-Lava Butte	1745	1337	1282	0.30	0.30
Camas Mt Wayside-Muns Cr	1057	729	395	0.21	0.15
Wildwood-Zigzag	1524	1237	1109	0.29	0.27
Kuebler-Cordon Rd	1190	1012	939	0.26	0.24
John Logan Ln-Pine Cr Rd	1598	1104	957	0.27	0.24
AVERAGE		**1084**	**935**	**0.27**	**0.24**

TABLE 4.1: Average unconfined compressive strength and AASHTO layer coefficient for each CTB Project.

4.2 PLANT-MIX BITUMINOUS BASE

The OSHD design and specification for PMBB more closely approximates the dense graded asphalt concrete from the AASHTO road test than it does the asphalt base. Therefore, in this analysis PMBB AASHTO layer coefficients were determined from AASHTO Figure 2.5 (Section II), "Chart for estimating structural layer coefficient of dense-graded asphalt concrete based on the elastic (resilient) modulus". Appendix B, Table B-1 lists the modulus of elasticity and AASHTO layer coefficient for each sample. Table 4.2 summarizes the average modulus of elasticity and AASHTO layer coefficient for each project.

PROJECT	AVERAGE MODULUS OF ELASTICITY ($x10^5$ PSI)	AVERAGE AASHTO LAYER COEFFICIENT (a_1)
Longwood-Winchester	2.37	0.32
Simmons-Pleasant	2.06	0.30
Farewell Bend POE	1.17	0.21
Austin Ave-Eastside	3.82	0.41
Greeley Ramps	5.20	0.47
Mill City-Gun Creek	2.16	0.30
AVERAGE	**2.80**	**0.34**

TABLE 4.2: Average resilient modulus and AASHTO layer coefficient for each PMBB project.

It should be noted that of the field projects tested, only two were constructed under the current specifications, Greeley Ramps-N. Banfield and Mill City-Gun Creek. The projects not meeting current specifications were constructed using specifications very similar to the current with the only exception being Farewell Bend. This project was constructed several years ago using specifications dramatically different from the current. The gradation used in Farewell Bend provided a finer base material than the current specification. If the average AASHTO layer coefficient is recalculated without the Farewell Bend results, the a_1 value is 0.36. However, designing with an average AASHTO layer coefficient would not encompass the projects yielding acceptable but lower layer coefficients. The AASHTO layer coefficients range from 0.30

to 0.47.

4.3 RECYCLED ASPHALT PAVEMENT

The data from the field sample testing of the RAP are shown in Appendix C. The test results yielded an equation relating bulk stress to resilient modulus for each RAP sample.

Currently, OSHD allows construction of a RAP base in place of an aggregate base if a 1:1 conversion of inches required is used. The resilient modulus equations resulting from the testing are plotted with an average aggregate base resilient modulus equation in Figure 4.2. Since the AASHTO Road Test did not consider RAP, it is not possible to convert the resilient modulus to an AASHTO layer coefficient for these materials. Even though it is not possible to directly convert the values to an AASHTO layer coefficient, some typical values have been converted to illustrate the difference in designing with untreated aggregate base and RAP as seen in Table 4.3.. It can be seen that the RAP materials do yield a higher resilient modulus than aggregate base materials at the same bulk stress.

EQUATION	STRESS STATE (PSI)	RESILIENT MODULUS (PSI)	AASHTO LAYER COEFFICIENT
AASHTO Aggregate	7	16,070	0.075
	9	18,686	0.085
AVERAGE		17,378	0.080
RAP #1	7	41,689	0.175
	9	48,304	0.200
AVERAGE		44,997	0.188
RAP #2	7	25,004	0.115
	9	27,669	0.135
AVERAGE		26,337	0.125

TABLE 4.3: Layer Coefficients for typical stress states in RAP.

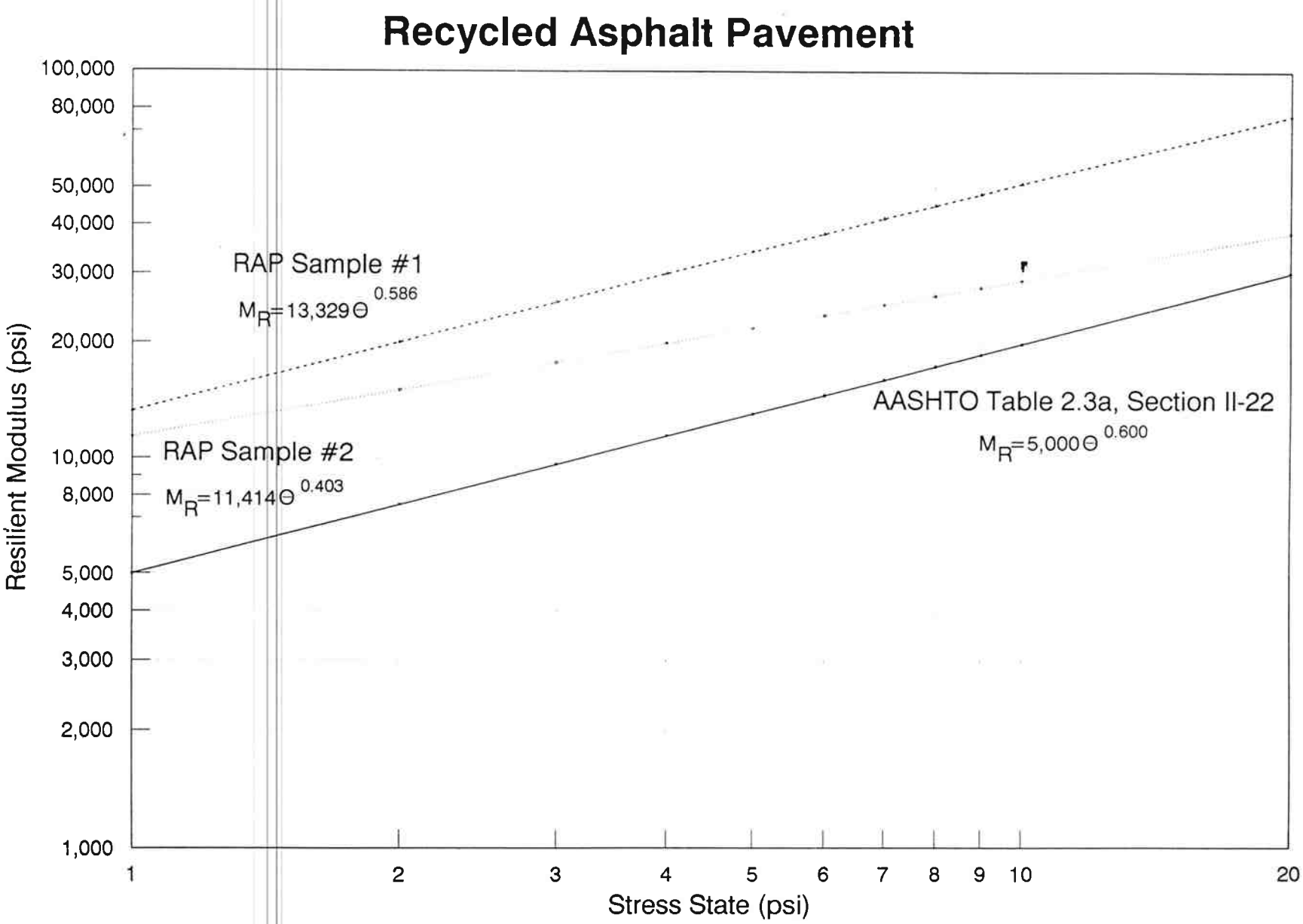

FIGURE 4.2: RECYCLED ASPHALT MODULUS OF ELASTICITY

5.0 CONCLUSIONS

Based on the results of this work, it is clear that considerable variability exists in the as constructed properties of treated base materials.

For CTB, the compressive strength of recovered cores varied from 682 psi to over 2,251 psi with project averages ranging from 1190 to 1745 psi and a pooled standard deviation of 353 psi. However, approximately 30 percent of the cores attempted for CTB could not be recovered. It is believed that CTB that cannot be cored is low strength however, in this project there was no way to determine the actual strength limit associated with the inability to core. For the purpose of this analysis, two compressive strengths were assumed for the unrecovered cores (680 psi ,and 300 psi). These assumptions resulted in adjusted average CTB strengths varying from 936 to 1,084. The AASHTO layer coefficients associated with these values are 0.24 and 0.27. In the case of the PMBB, the resilient modulus of recovered cores ranged from 114,000 to 830,000 psi excluding the Farewell Bend project. With project averages ranging from 206,000 to 520,000 psi and a pooled standard deviation of 88,000 psi. The AASHTO layer coefficient from the PMBB cores ranged from .25 to above .48 with project averages ranging from 0.3 to 0.47. These values are comparable to those currently used in design however, the amount of variability found in the field is surprising.

6.0 RECOMMENDATIONS

Steps should be taken to minimize the amount of variability in treated base materials. For CTB, the construction specifications need to be evaluated and amended to assure a more uniform product. If this is done, it appears that a more cost-effective layer coefficient of 0.27 might be appropriate. Also, some additional analysis and study should be performed prior to implementing use of 0.27 for CTB. This would include a design check for fatigue failure using a mechanistic analysis and a detailed performance evaluation of several "older" CTB jobs in Oregon.

The current design practice of using 0.22 to 0.24 for CTB and 0.32 for PMBB should be continued until additional data and specification changes are made to justify a change.

Use of RAP in lieu of untreated aggregate base appears to be a good alternate on some jobs. To account for the increased stiffness provided by the RAP, a mechanistic design should be performed. In the AASHTO design procedure, the use of a higher modulus for the base material would reduce the minimum AC thickness substantially.

The Division should develop and implement an ongoing program to evaluate "as built" material properties. The program should include coring, lab testing and deflection testing. The results would be used to further evaluate and adjust design values, mix designs and specifications. Failure to do so will result in overly conservative designs, premature failures, or both.

7.0 REFERENCES

1. **AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES**. Published by the American Association of State Highway and Transportation Officials, 1986.

2. Van Till, C.J., McCullough, B.F., Vallerga, B.A. and Hicks, R.G., "**Evaluation of AASHTO Interim Guides for Design of Pavement Structures**", NCHRP Report 128, 1972.

APPENDIX A: CEMENT-TREATED BASE

TABLE A-1: CEMENT-TREATED BASE
PROJECT LAB TEST RESULTS AND LAYER COEFFICIENT

PROJECT NAME	SAMPLE #	UNCONFINED COMPRESSIVE STRENGTH (PSI)		AASHTO LAYER COEFFICIENT for MOD A
		LAB	MOD A	
Murphy Rd-Lava Butte	1	2068	1768	0.37
	2	2051	1751	0.37
	3	2091	1791	0.37
	4	1985	1685	0.36
	5	1826	1526	0.33
	6	1741	1441	0.32
	7	1464	1164	0.27
	8	1085	785	0.22
	9	1813	1513	0.33
	12	1161	861	0.23
	13	1411	1111	0.27
	14	2251	1951	0.40
PROJECT AVERAGE (without unrecovered cores)		**1745**	**1445**	**0.32**
Camas Mt Wayside-Muns	1	1057		0.26
PROJECT AVERAGE (without unrecovered cores)		**1057**		**0.26**
Wildwood-Zigzag	1	1400	1390	0.31
	2	1100	1090	0.26
	3	1762	1752	0.37
	4	1606	1596	0.34
	5	1810	1800	0.37
	8	1468	1458	0.32
PROJECT AVERAGE (without unrecovered cores)		**1524**	**1514**	**0.33**

TABLE A-1: CEMENT-TREATED BASE
PROJECT LAB TEST RESULTS AND LAYER COEFFICIENT

PROJECT NAME	SAMPLE #	UNCONFINED COMPRESSIVE STRENGTH (PSI)		AASHTO LAYER COEFFICIENT for MOD A
		LAB	MOD A	
Kuebler-Cordon Rd	1	1378		0.31
	2	1726		0.36
	3	682		0.20
	3A	1659		0.35
	8	1680		0.36
	10	1432		0.32
	11	884		0.23
	12	1076		0.26
	13	1017		0.25
	14	1807		0.38
	15	1147		0.27
	16	1141		0.27
	17	1044		0.26
PROJECT AVERAGE (without unrecovered cores)		**1190**		**0.29**
John Logan Ln-Pine Cr Rd	1	1826	1596	0.34
	3	1620	1390	0.31
	6	1341	1111	0.27
	7	2023	1793	0.37
	8	1287	1057	0.26
	10	2030	1800	0.37
	11	1602	1372	0.31
	13	1059	829	0.22
PROJECT AVERAGE (without unrecovered cores)		**1598**	**1368**	0.31
AVERAGE OF PROJECTS (without unrecovered cores)		**1423**	**1314**	**0.30**

Oregon State Highway Division
Cement-Treated Base
Specifications-1984

Section 308 - Plant Mix Cement Treated Base

Description

Subsection 308.01 Scope - This work consists of constructing a cement treated base composed of aggregate, cement and water, plant mixed at a central mixing plant into a uniform mixture, spread on a prepared base, compacted, and cured. The cement treated base, hereinafter referred to as CTB, shall be constructed in reasonably close conformity to the lines, grades, thicknesses and cross sections indicated on the plans or established by the Engineer.

Materials

308.11 Composition of Mixture - The CTB mixture shall be comprised of aggregate the portland cement and water in the proportions and amounts established by the Engineer. The cement content normally is to be between 4-1/2% and 5-1/2% of the dry weight of aggregate. The proportions of the materials will be subject to change from time to time.

In all plants, the weights or rates of feed of aggregates and water shall be within 5% of the amounts of each material designated by the Engineer. The weights or rates of feed of cement shall be such that the variations in cement content shall not have a variation above or below the established cement content of more than 0.5 of a percentage point.

308.12 Acceptance of Materials - Aggregate will be subject to acceptance preceding addition of portland cement at the mixer. Plant mixed mixtures will be subject to final acceptance after blending and mixing either at the plant or at the place of delivery. Acceptance will be based on periodic sampling of the materials.

308.13 Aggregate - The aggregate shall meet the requirements of subsection 703.05.

308.14 Portland Cement and Water - The portland cement and water shall conform to the requirements of Section 701.

308.15 Asphalt Material - The asphalt used in the curing seal shall be either CRS-1 or CRS-2 emulsified asphalt as designated. The emulsified asphalt shall conform to the applicable requirements of Section 702.

Construction

308.31 Weather Limitations - The CTB shall be constructed in accordance with the weather limitations as set for portland cement concrete pavement construction in subsection 450.31.

308.32 Plant and Equipment:

(a) Mixing plant - The CTB mixture shall be mixed at a centrally located plant of the batch type or of the continuous mixing type, capable of providing a mix of aggregate, cement and water of uniform proportions and consistency as designated by the Engineer.

Batch type plants shall conform to the requirements of subsections 450.32(b-1), 450.32(c-1) and 450.32(c-3), modified with respect to the use of a single aggregate size and mixing plant location.

Continuous mixing plants shall be equipped with feeding devices that will feed aggregate, cement and water into the mixer in specified proportions and feeding devices for aggregate and cement shall be interlocked and synchronized to maintain consistent proportions in the mixture. The plant shall be equipped with the following:

(a-1) An approved water meter which will accurately determine the rate of flow of water to the mixer.

(a-2) An approved device for accurate determination of rate of flow of cement to the mixer. This device shall include scales under cement storage bins.

(a-3) An approved belt weighing device for accurate determination of the rate of flow of aggregates to the mixer.

(a-4) An approved facility for obtaining aggregate samples just prior to mixing with cement and water.

The Engineer may order immediate discontinuance of the use of any metering, feeding or mixing equipment which does not, in his opinion, produce a uniform mixture of aggregate, cement and water in the established proportions.

(b) Hauling equipment - Vehicles for hauling the CTB mixture shall be watertight, nonagitating and capable of discharging the mix without waste and with a practicable minimum of segregation.

(c) Spreading equipment - Spreading of the CTB mixture shall be by equipment which is capable of spreading the material without segregation, dragging or fracture of material.

Spreading equipment which rides on freshly spread material and produces tracks or partially compacted areas thereon will be acceptable provided no displacement of material or filling of the tracks occur, and provided further that the tracks are not of such depth as to be visible after compaction is completed.

The spreading equipment may be provided with a control system automatically controlling the laying of the mix to specified transverse slope and longitudinal grade by means of actuation from an independent line and grade control reference, if the contractor so elects.

(d) Compacting equipment - Compaction shall be with vibrating type, pneumatic tire type or steel wheel type compactors, as the contractor may elect; provided, however, that compactors with lugs, projections or other features

that would leave ruts, holes, grooves, or uneven surfaces in the CTB after compaction or which loosen the mixture while operating will not be permitted.

Either a pneumatic tire roller or a smooth steel wheel roller shall be provided for the final rolling and compacting of the mixture.

(e) Other equipment - Equipment shall be provided to apply water by spray method to the CTB mixture during its compaction, the spray attachments being of a type that will produce a uniform and controlled fine spray. Equipment for application of the bituminous curing seal shall provide application by pressure spray method in a uniform and controlled application. Motor graders shall be available for correction of unavoidable segregation at edges of the mix.

(f) Capacities of plant and equipment - The plant and equipment furnished on the work shall be adequate at all times to provide for efficient and continuous operations.

308.33 Mixing - The charging of the materials into the mixer shall be by means whereby the quantities of the several materials are accurately controlled. Unless otherwise approved, mixers shall be charged and operated at not more than 80% of their rated capacity. Mixing shall continue until a uniform and homogeneous mixture of aggregate, cement and water has been obtained. In batch plants the time of mixing shall not be less than 30 seconds, except that the time may be reduced when tests indicate that the requirement for the variation of cement content, as specified in subsection 308.11, can be consistently complied with.

308.34 Preparation of Base - The base constructed under the contract and on which the CTB is to be constructed shall be in or brought to the finished condition prescribed under the applicable specification for its construction. Old base and foundations constructed under other contracts shall be brought by the Contractor to the applicable condition prescribed in Section 306.

Just prior to placing the CTB mixture, the prepared base shall be thoroughly moistened with water and kept moist, but not excessively wet, until covered with the mixture.

308.35 Hauling and Placing - The CTB mixture shall be delivered and deposited without delay which would modify moisture content to an appreciable extent. Mixture which has begun to harden or take an initial set prior to placement, or which has been retempered in transit with water, will be rejected and shall be wasted.

The mixture shall be delivered to the spreading machine by direct deposit in the receiving hopper, by placing in windrows in front of the machine, or by other means acceptable to the Engineer. If material is placed in windrows it shall be deposited on the roadbed at a uniform quantity per linear foot, which quantity shall be sufficient to provide the required compacted thickness without resorting to excess spotting, picking-up or otherwise shifting of the mixture.

The mixture shall be spread and screeded by specified equipment in one or more layers to provide the compacted thickness called for by the plans, or as otherwise designated by the Engineer. Placing shall be in strip widths which will hold the number of longitudinal joints to a practicable minimum, normally not less than one lane width. Longitudinal construction joints shall be within one foot of traffic lane lines.

The depositing and spreading shall progress continuously without breaks insofar as is practicable. Should stoppage of operations be of such duration as to allow the mixture to take its initial set, the Contractor shall construct a transverse construction joint as hereinafter provided.

The mixture shall be spread and screeded to required thickness and to designated line, grade and transverse slope without segregation, dragging or fracture of the components of the mixture.

The Contractor shall correct unavoidable segregation at edges and remove and replace areas of deficiency.

308.36 Thickness and Number of Layers - If the required compacted depth of CTB exceeds 6 inches, it shall be constructed in two or more layers of approximately equal thickness unless the Contractor can demonstrate on a test section that the compaction requirements can be met with his equipment on material placed in lifts exceeding 6 inches. In such case the material may be placed in thicknesses approved by the Engineer.

308.37 Construction Joints - When it is necessary, to discontinue placing the mixture for a period of time which will allow the placed mixture to take its initial set, the Contractor shall construct a temporary transverse construction joint near the point at which CTB construction stopped. The joint shall be normal to the direction of CTB construction and shall be at a slope of 2:1 or steeper with the face of the joint free of loose material. The joint shall be constructed immediately prior to suspending operations on the day of placement.

308.38 Compaction - Compaction of the CTB mixture with specified compactors shall begin as soon as it has been spread and shall be continuous until completion. Not more than 60 minutes shall elapse between the start of the mixing and the time of starting compaction of the CTB mixture on the prepared subgrade. Compaction shall begin at edges and shall be controlled to prevent breakdown at the sides of a strip. Successive passes of the compactor shall be so spaced that no more than 75% of the compactive width of the compactor shall be on an uncompacted area at any time.

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During compaction, sprinkling with water by fine spray application shall be done at the times and in the amounts designated by the Engineer. Surfaces of uncompacted, partially compacted and completely compacted mixture shall be kept moist at all times until a subsequent layer of material or the bituminous seal has been placed thereon.

Compaction requirements on the completed CTB shall be a minimum of 95% of the maximum density as specified by the method of determination of relative maximum density set forth by the Materials Laboratory for the cement treated base materials used.

308.39 Surface Finish - The finished surface of the CTB shall not vary more than 0.04 foot from established grade and cross section at any point. Also the finished surface of the CTB when tested with a 10-foot straightedge laid in any direction, shall not vary from the testing edge by more than 0.03 foot at any point. When portland cement concrete pavement is to be placed on the CTB, the surface of the CTB at any point shall not extend above the grade established by the Engineer. The specified finish shall be attained by one or another or a combination of the following methods.

(a) After compaction of the final lift, the surface of the CTB shall be brought within the specified tolerances by trimming with a subgrade planer, by motor grader equipped with an electronic controlled blade or by grinding. Areas on which trimming or grinding is performed shall be rolled until a smooth surface is attained.

The excess material resulting from trimming or grinding may be placed as aggregate for shoulder construction subject to the following conditions:

(a-1) The shoulder subgrade shall be prepared as specified.

(a-2) Hardened chunks of trimmed material shall be removed or reduced to the maximum size specified for shoulder aggregate prior to spreading additional shoulder aggregate.

(a-3) The amount of trimmed material incorporated into the shoulder shall not exceed 25 percent of the planned volume of shoulder aggregate per linear foot of shoulder. When trimmings exceed this amount, the excess shall be removed and may be placed in other shoulder areas, in conformance to the 25 percent limit.

(a-4) The excess material shall be uniformly distributed in the shoulder area prior to spreading additional shoulder aggregate.

The excess material may also be used at other locations in the work area provided said excess material complies with applicable specification requirements.

(b) Plant mix bituminous base mixture, meeting the requirements of Section 301, may be substituted for the upper portion of the CTB and used as a leveling course. The bituminous base mixture shall be placed and compacted in such a manner as to attain the specified surface tolerance.

308.40 Curing of CTB - As soon as possible after each layer of the CTB is constructed, and while it is still moist, the surface and exposed edges shall be covered with an asphalt curing seal. The emulsified asphalt shall be applied by pressure spray method at a uniform rate between 0.25 gallon and 0.35 gallon per square yard of surface, the exact rate to be as designated and as necessary to provide a continuous, unbroken curing membrane.

After the curing seal has been applied, the CTB shall cure for a period of 4 days unless otherwise permitted. During the curing period no vehicle shall be permitted to use the section except as set forth in subsection 308.43. In case of damage to the CTB or the curing seal, after application and during the curing period, the damaged section shall be repaired by the Contractor immediately by reconstructing the CTB and/or resealing at his own expense.

The curing seal on any lift of CTB may be omitted if, within 2 hours after the start of mixing of the preceeding lift of CTB, a succeeding lift of material (CTB, bituminous base or asphalt concrete) is placed over the preceding lift. Vibratory rollers will not be permitted in the compaction of any succeeding lift of CTB, bituminous base or asphalt concrete during the period of time from 2 hours to 96 hours after the mixing of any of the underlying lifts of CTB.

308.41 Modification of Equipment and Methods - On tapers and other areas of irregular shape, limited length, restrictive width or other condition where the Engineer determines that full compliance with the above equipment and construction requirements is not practicable, the specified equipment and construction requirements may be modified, subject to approval by the Engineer.

308.42 Timing of Operations, Adequacy of Organization, and Rejection of Mixture - All operations involved in constructing the CTB shall be so timed and coordinated that regardless of daily or seasonal variations in weather, temperature and humidity, such work shall result in a finished CTB conforming in all respects to specified requirements.

In this respect, the Contractor shall provide and have readily available at all times adequate equipment, tools, material and labor and shall achieve the hauling, spreading, compacting and trimming of the CTB mixture within 2 hours after mixing.

Any CTB mixture not placed and trimmed within this 2-hour period shall be subject to rejection, wasting, removal and replacement as the Engineer determines to be applicable, and all costs involved in such removal, wasting and replacement shall be borne by the Contractor.

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308.43 Handling Traffic Over Cement Treated Base - At locations where highway traffic must be routed over the cement treated base, the CTB mixture shall be made with Type III or Type IIIA (high early strength) cement to expedite development of strength at an early date. Any extra costs of using high early strength cement shall be considered as incidental, with payment therefor covered in the pay item "Portland Cement in CTB Mixture".

On selected areas of the project where it would be advantageous to the Contractor and when approved by the Engineer, the Contractor may substitute plant mix bituminous base mixture meeting the requirements of Section 301.

If the Engineer so directs, traffic over recently constructed CTB shall be controlled as to speed and routing and the Contractor shall provide a pilot car when the engineer determines it to be necessary. Flaggers and pilot car operator will be compensated as set forth in Section 111. The cost of furnishing the pilot car shall be borne by the Contractor.

Measurement

308.81 General - The quantity of plant mix cement treated base mixture to be paid for will be the number of tons, to the nearest 0.1 ton, of the mixture used in the accepted work as specified, weighed after mixing as set forth in Section 109.

The quantity of portland cement in the CTB mixture will be separately measured by the ton, to the nearest 0.01 ton of portland cement actually incorporated in the mixture used in the accepted work as specified. The pay tonnage of portland cement will be determined either by (a) bulk cement separately weighed as provided in Section 109, or by (b) actual count of whole sacks and weighing of partial sacks. Correction of cement measurement shall be made for cement that is wasted, lost, rejected, or otherwise not actually incorporated in the accepted cement treated base.

The quantity of CTB material which is removed by trimming or grinding and is not incorporated into the project as permitted in subsection 308.39(a) will be deducted from the pay quantity. The quantity of CTB material which is removed by trimming or grinding and is incorporated into the project as permitted in subsection 308.39(a) will not be deducted from the pay quantity under the provisions. However, it is understood that the quantity of material for which it is substituted will be reduced accordingly.

Watering work required in the preparing of the base upon which the CTB is constructed will be measured as set forth under Section 233.

Payment

308.91 General - The accepted quantities will be paid for at the contract unit price per ton for the following items as given in the bid schedule:

Pay Item	Unit of Measurement
(a) Cement Treated Base Mixture	Ton
(b) Portland Cement in CTB Mixture	Ton

Payment at the applicable contract unit prices will be full and complete compensation for providing all materials in final position, including the curing seal and all labor, equipment, tools and incidentals necessary to complete the work as specified; except that watering in connection with preparing the base upon which the plant mix cement treated mixture is placed will be separately paid for as set forth in Section 233.

Plant mix bituminous base mixture placed in lieu of cement treated base in accordance with subsection 308.43 and 308.39(b) will be paid for at the contract unit price per ton for the item "Cement Treated Base Mixture" and the asphalt cement contained in the mixture will be separately paid for at the contract unit price per ton for the item "Portland Cement in CTB Mixture".

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703.05 Aggregate for Plant Mix Cement Treated Bases - The aggregate in the plant-mix cement treated base shall be crushed rock or gravel, including sand conforming to the requirements of subsection 703.07 for aggregate base and the following:

(a) Size - The aggregate shall be one or another of the following sizes: 2"-0, 1-1/2"-0, 1"-0 or 3/4"-0.

(b) Soundness - When aggregates are subjected to five alternations of the sodium sulfate soundness test (OSHD TM 206) the average loss shall not be more than 18% by weight.

703.07 Aggregate for Aggregate Shoulders and Base - Aggregates shall be crushed gravel or crushed rock, including sand.

(a) Fracture of gravel - Material produced from gravel shall have at least one mechanically fractured face based on the following percentage of particles retained on the 1/4" sieve for the designated size:

Designated Size	Min. % of Fractured Particles (by weight) of Material Retained on 1/4" Sieve
1-1/2"-0 and larger	50
Smaller than 1-1/2"-0 (Base)	70
Smaller than 1-1/2"-0 (Shoulders)	50

The fractured particles shall be reasonably well distributed in proportion to the component fractions of the aggregate larger than the 1/4" sieve as set forth in the table entitled "Grading Requirements Base and Shoulder Aggregates" in subsection 703.07(e).

(b) Durability - The source material from which aggregate materials are obtained, produced or manufactured and also the produced aggregates shall meet the following qualifying test requirements:

Test	Test Method	Requirements (Base)	(Shoulder)
Degradation:			
Passing No. 20 sieve	OSHD TM 208	30% Max.	35% Max.
Sediment Height	OSHD TM 208	3" Max.	6" Max.
Abrasion	OSHD TM 211	35% Max.	45% Max.

(c) Sand equivalent - When tested in conformance with OSHD TM 101, base aggregates shall have a sand equivalent of not less than 30; shoulder aggregates shall have a sand equivalent of not less than 25.

(d) Liquid limit and plasticity - Aggregate shall meet the following requirements:

Quality	Test Method	Requirements (Base)	(Shoulder)
Liquid Limit	OSHD TM 102	NP or 33 Max.*	NP or 35 Max
Plasticity Index	OSHD TM 103	NP or 6 Max.*	NP or 6 Max.

*When base aggregate is tested as specified and both the liquid limit and plasticity index are reportable with a numerical value, the pertinent quality requirements will be met when the numerical values of the test results conform to the following table:

Liquid Limit and Plasticity Index Values

Percent of Material Passing No. 40 Sieve	Liquid Limit (Max.)	Plasticity Index (Max.)
	OSHD TM 102	OSHD TM 103
0.0 to 5.0, incl.	33	6
5.1 to 10.0, incl.	30	5
10.1 to 15.0, incl.	27	4
15.1 to 20.0, incl.	24	3
20.1 to 25.0, incl.	21	2
Over 25.0	21	0 or N.P.

(e) Grading - The aggregates shall be uniformly graded from coarse to fine and shall conform to one or another of the grading requirements set forth in the following table:

GRADING REQUIREMENTS
BASE AND SHOULDER AGGREGATES

Sieve Size Passing	Separated Sizes 2-1/2"-0	2"-0	1-1/2"-0	1"-0	3/4"-0
	Percentages (by weight)				
3"	100				
2-1/2"	95-100	100			
2"		95-100	100		
1-1/2"			95-100	100	
1-1/4"	55-75				
1"		55-75		90-100	100
3/4"			55-75		90-100
1/2"				**55-75	
3/8"					**55-75
*1/4"	30-45	30-45	35-50	40-55	40-60

Where a tolerance range is set forth in the above grading requirements, the midpoint of the tolerance range is the target value and the product shall conform as closely as realistically possible to this target value. The purpose of the tolerance range is only to permit occasional minor variations from the target value that are, for practical reasons, unavoidable.

The determination of sizes and grading shall be in conformance with OSHD TM 204.

The grading to be furnished and used shall be as called for in subsection 304.12, by the special provisions, or as indicated by the pay item in the bid schedule.

*For base aggregates only, of the fraction passing the 1/4-inch sieve 40% to 60% shall pass the No. 10 sieve.

**Does not apply to shoulder aggregate.

APPENDIX B: PLANT-MIX BITUMINOUS BASE

TABLE B-1: PLANT-MIX BITUMINOUS BASE
PROJECT LAB TEST RESULTS AND LAYER COEFFICIENT

PROJECT NAME	SAMPLE #	LIFT #	MODULUS OF ELASTICITY (X10^5 PSI)	AASHTO LAYER COEFFICIENT a_1
Longwood-Winchester	3	3	2.62	0.34
	3	4	2.15	0.31
	5	3	2.59	0.34
	5	4	3.44	0.39
	8	3	1.87	0.28
	8	5	2.00	0.30
	10	4	1.76	0.27
	10	5	1.44	0.25
	12	5	3.23	0.38
	12	6	2.65	0.34
PROJECT AVERAGE			**2.37**	**0.32**
Simmons-Pleasant	1	3	1.88	0.28
	1	4	2.25	0.31
	5	3	2.94	0.36
	5	4	2.32	0.32
	8	3	2.24	0.31
	8	4	1.47	0.25
	10	3	1.93	0.30
	10	4	1.85	0.28
	12	3	1.71	0.27
	12	4	1.99	0.30
PROJECT AVERAGE			**2.06**	**0.30**

TABLE B-1: PLANT-MIX BITUMINOUS BASE
PROJECT LAB TEST RESULTS AND LAYER COEFFICIENT

PROJECT NAME	SAMPLE #	LIFT #	MODULUS OF ELASTICITY (X10^5 PSI)	AASHTO LAYER COEFFICIENT a_1
Farewell Bend POE	2	3	1.15	0.20
	2	4	.94	
	4	4	1.65	0.26
	4	6	1.36	0.23
	5	4	.94	
	5	8	1.05	0.20
	6	5	1.16	0.21
	6	7	1.18	0.21
	9	4	1.29	0.22
	9	6	.98	
PROJECT AVERAGE			**1.17**	**0.21**
Austin Ave-Eastside	2	3	4.87	0.45
	2	4	3.30	0.38
	5	4	2.68	0.34
	5	5	2.74	0.35
	6	4	2.14	0.31
	6	5	4.62	0.45
	11	3	4.97	0.46
	11	5	4.31	0.43
	9	3	4.84	0.45
	9	4	3.72	0.41
PROJECT AVERAGE			**3.82**	**0.41**

TABLE B-1: PLANT-MIX BITUMINOUS BASE PROJECT LAB TEST RESULTS AND LAYER COEFFICIENT

PROJECT NAME	SAMPLE #	LIFT #	MODULUS OF ELASTICITY (X10^5 PSI)	AASHTO LAYER COEFFICIENT a_1
Greeley Ramps	1	3	4.78	0.45
	1	4	5.34	0.48
	3	3	3.84	0.41
	3	4	6.58	
	5	3	8.30	
	5	4	4.24	0.43
	8	3	2.62	0.34
	8	4	6.25	
	12	4	4.41	0.44
	12	5	5.60	
PROJECT AVERAGE			**5.20**	**0.47**
Mill City-Gun Creek	1	3	1.87	0.28
	1	4	1.96	0.30
	2	3	2.81	0.36
	2	4	2.39	0.32
	3	3	3.07	0.37
	3	4	1.99	0.30
	4	3	1.12	0.20
	4	4	2.16	0.31
	7	3	2.67	0.34
	7	4	1.56	0.26
PROJECT AVERAGE			**2.16**	**0.30**
AVERAGE OF PROJECTS			**2.80**	**0.34**

TABLE B-2: PLANT-MIX BITUMINOUS BASE
PROJECT GRADATION AND ASPHALT CONTENT

PROJECT	PERCENT PASSING SIEVE SIZE								AC	FIELD OR MIX DESIGN (SIZE)*
	3/4	1/2	3/8	1/4	#4	#10	#40	#200		
GREELEY RAMPS-N.BANFIELD	69	49	45	40		21	9	5.1	3.9	M(1 1/2)
	83	56	48	41	35	23	13	7.1	5.6	FIELD
LONGWOOD DR-WINCHESTER DR	97	80	70	54	47	27	10	2.8	4.4	FIELD
SIMMONS CR-PLEASANT VALLEY	81	70	61	53		25	11	3.0	5.0	M(1)
	86	75	63	47	40	21	10	4.5	5.2	FIELD
	82	70	61	49	42	24	10	4.9	5.0	FIELD
	85	73	65	52	44	25	11	5.0	5.4	FIELD
	89	79	69	55	46	24	10	4.9	5.7	FIELD
AUSTIN AVE-EASTSIDE BYPASS	97	87	70	55		30	10	3.3	5.5	M(3/4)
	97	78	63	48		24	12	5.7	5.8	M(3/4)
	99	79	65	49	40	23	11	6.0	6.2	FIELD
	98	81	69	54	46	32	14	6.0	5.8	FIELD
	91	73	65	57	50	30	15	6.9	4.6	FIELD
	99	82	68	51	43	27	15	7.6	5.7	FIELD

*Specifies either mix (M) or field (FIELD) values. If mix values, nominal size given.

TABLE B-2: PLANT-MIX BITUMINOUS BASE
PROJECT GRADATION AND ASPHALT CONTENT

PROJECT	PERCENT PASSING SIEVE SIZE								AC	FIELD OR MIX DESIGN (SIZE)*
	3/4	1/2	3/8	1/4	#4	#10	#40	#200		
MILL CITY-GUN CREEK	70	52	42	35	28	15	8.5	5.0	5.0	FIELD
FAREWELL BEND P.O.E.	100	95	86	73	65	48	15	2.6	5.1	FIELD
	100	91		71		46	13	1.5	5.7	FIELD
	100	95		69		38	12	2.8	5.5	FIELD
	100	93		64		39	15	2.5	6.3	FIELD

*Specifies either mix (M) or field (FIELD) values. If mix values, nominal size shown.
Also, several lab (LAB) samples were prepared and tested.

TABLE B-3: PLANT-MIX BITUMINOUS BASE CURRENT GRADATION SPECIFICATIONS

SIZE	PERCENT PASSING SIEVE SIZE					
	3/4	1/2	1/4	#10	#40	#200
1 1/2"-0	55-75		35-50	14-30	0-14	0-5
1"-0		55-75	40-55	16-33	0-16	0-5

(Use with SP403 and SP403.A)

SECTION 301 - PLANT MIX BITUMINOUS BASE

Delete Section 301 of the 1984 Standard Specifications and substitute the following:

SECTION 301 - PLANT MIX BITUMINOUS BASE

Description

(Delete the words "open or dense" as appropriate.)

301.01 Scope - This work consists of constructing one or more courses of open or dense graded plant mixed bituminous base (PMBB), as specified, plant mixed into a uniformly coated mass, hot laid on a prepared foundation, compacted to specified density, and finished to a specified smoothness to the lines, grades, thicknesses, and cross sections shown on the plans or as established by the Engineer.

301.02 Definitions and Abbreviations - The following definitions and abbreviations are used in this Section:

(a) Definitions:

Asphalt - Asphalt cement.

Course - See Typical Section on plans.

Coverage - One pass over the entire surface designated.

Lift - The nominal compacted thickness of PMBB material placed by the paving machine in a single pass.

Mixture - Plant mix bituminous base.

Pass - The passing of a piece of equipment over a given spot.

Panel - The width of PMBB material being placed by the paving machine in a single pass.

(b) Abbreviations:

AC - Asphalt Concrete
IRS - Index of Retained Strength
JMF - Job Mix Formula

PMBB - Plant Mix Bituminous Base
RAP - Reclaimed Asphalt Concrete Pavement
TM - Test Method

(In 301.03 for open graded only, delete 1st paragraph for dense graded only, delete 2nd paragraph.)

301.03 Reclaimed Asphalt Pavement (RAP) Material - Using processed reclaimed AC material (RAP) in the production of new dense graded PMBB is optional. A maximum of 30 percent RAP material will be allowed in the new dense graded PMBB., Asphalt in the RAP material, when blended with other material, shall provide properties equivalent to asphalt specified in Section 702.

RAP material will not be allowed in open graded PMBB.

301.04 References to Section 403 - Any number references made to Section 403 or subsections of Section 403 shall be understood to refer to the Supplemental Standard Specifications. Where in Section 403 the term "AC" is used it shall be understood to mean "PMBB".

Materials

301.10 Aggregate - The Contractor shall do the following when producing and stockpiling aggregate:

(a) Stockpiling - Prepare the ground for the stockpile site to prevent contamination. Prevent segregation, as much as possible, when stockpiling and removing the aggregate.

(b) New aggregate - Provide new aggregates conforming to the requirements of 703.07 of the Standard Specifications for aggregate base, except delete the grading requirements under 703.07(e) and substitute the following:

(Delete dense graded or open graded grading requirements which are not applicable.)

Sieve Size Passing	Dense Graded Options 1-1/2"-0	Dense Graded Options 1"-0	Open Graded
	(Percentages by weight)		
2"	99-100	-	-
1-1/2"	95-100	99-100	-
1"	-	90-100	99-100
3/4"	55-75	-	85-95
1/2"	-	55-75	35-68
1/4"	35-50	40-55	5-20
#10	14-30	16-33	0-5
#40	0-14	0-16	-
#200	0-5	0-5	0-2

(For open graded only, delete the following (c).)

(c) RAP aggregates - Use RAP aggregate in dense graded PMBB mixture that is hard, sound and durable and no larger than 2 inches before entering the cold feed, as visually determined by the Engineer. Blend RAP material with new aggregate to provide a dense graded mixture conforming to one of the options in 301.10(b).

301.11 Asphalt Cement and Additives - The Contractor shall provide:

(a) Asphalt cement (asphalt) - New asphalt that meets the requirements of Section 702. One of the asphalt grades listed in the Division's Specifications for Asphalt Materials publication shall be used as established in the JMF. Other grades shall be used when directed by the Engineer.

(b) Asphalt cement additives - Antistripping additives meeting the requirements of Section 702 to add to the asphalt to satisfy the Index of Retained Strength (IRS) as specified in 301.13(a).

(For dense graded only, delete the following (c).)

(c) Mineral filler - One of the following:

Material	Specification
Fly Ash	701.07
Hydrated Lime	AASHTO M 216
Portland Cement	701.01
Other Inert Mineral Filler	AASHTO M 17-88I

Accompany each shipment with a quality compliance certificate, as required in 106.08, and a certified copy of the weight of each delivery.

301.12 Composition of Mixture - Provide a mixture of aggregate and asphalt cement meeting all specifications within the following ranges. The ranges are given in percentages by weight of the total mixture.

(For dense graded only, delete mineral filler.)

Component	Percentage by Weight
Aggregates	93.5 to 98.0 incl.
Asphalt Cement	2.0 to 6.5 incl.
*Mineral Filler	0.5 to 1.5 incl.

*Use with open graded only

301.13 Job Mix Formula (JMF) and Adjustments - Production of PMBB for use on the project shall not begin until the JMF is provided or approved by the Engineer of Materials and Research.

(a) JMF - The Contractor shall take representative, composite samples of aggregate after 1,000 tons or 10 percent of specification aggregate, whichever is less, has been produced.

Furnish representative samples of materials to be used in the mixture on the project to the Project Manager as follows:

(For dense graded only, delete mineral filler.)

Material	Amount
New Aggregate	250 pounds
Reclaimed Asphalt Concrete	200 pounds
Mineral Filler	20 pounds
Asphalt Cement	2 gallons in one quart containers
Antistripping Additive	1 pint

These samples shall be supplied so they can be shipped to and received at the Materials Laboratory in Salem at least 21 calendar days before anticipated use in the PMBB. This 21-day period will begin when samples of all materials complying with specifications have been recieved at the Materials Laboratory.

(For open graded only, delete the words "either (1)" and "or (2) a single percentage of new aggregate, RAP and asphalt" and delete the last sentence.)

(1) JMF materials testing - The JMF materials samples will be tested for conformance with specifications. If the materials are acceptable, the Engineer of Materials and Research will establish the JMF proportions comprising either (1) a single percentage of aggregate and asphalt or (2) a single percentage of new aggregate, RAP, and asphalt. These proportions shall be defined as the JMF and shall be changed only upon order of the Engineer. Any change or adjustment of the JMF will be defined as a new JMF. If the materials are not acceptable, the Contractor shall furnish additional samples as required by 301.13(a). Materials used in dense graded PMBB, when at the JMF target value with antistrip additives, if needed, shall achieve an IRS of at least 70 percent (OSHD TM 308).

(For open graded only, delete the words "with and without RAP,")

(2) JMF cost responsibility - The Division will provide one JMF for mix specified, with and without RAP, at no cost to the Contractor. The costs of development of any additional JMF requested by the Contractor shall be borne by the Contractor.

(b) Adjustments - Upon written request, field adjustments to the JMF may be approved within the following tolerances:

Component	Plus or Minus From JMF (%)
Aggregate	Within Broad Band Range
Asphalt	0.5

Field adjustments will not be made unless the change produces material of equal or better quality. A field adjustment will establish a new JMF. Adjustments beyond these limits will require development of a new JMF according to 301.13(a). The adjusted JMF, plus or minus the allowed tolerances, shall be within the ranges specified in 301.12.

301.14 Tolerances - The Contractor shall produce and place the PMBB in final position within the following tolerances and limits:

Constituent of Mixture	Plus or Minus Tolerance from JMF
Aggregates	Within 301.10(b) limits.
Asphalt Cement	0.5%
Temperature of mixture after adjustment for 403.34(d) at time placed in final position . . .	20°F
Moisture content at time of discharge from the mixing plant*. .	0.60% Max.
Compaction Density**	See 301.39

*Upper Specification Limit
**Lower Specification Limit

301.15 Process Control - The provisions of 403.15 shall apply except:

Change 403.15(a) and 403.15(a-1) to read as follows:

(a) Aggregate - Sample aggregate during production and test as follows:

(1) Required tests - Perform each of the following tests at the sampling frequency indicated:

Test	Test Method OSHD	Test Method AASHTO	Start of Production	One Per 5 Shifts*	One Per Shift*
Fracture of Gravel	TM 213		X	X	-
Sieve Analysis		T 27 with T 11	X	-	X**
Sand Equivalent	TM 101		X	-	X***

*A shift means: a production shift or 1,000 cubic yards (1,500 tons), whichever results in the greatest sampling frequency.
**Perform at least three tests per project.
***May be waived after first week, if allowed by the Engineer of Materials and Research.

Change 403.15(a-3) to read as follows:

(3) Additional testing - The Engineer may perform any of the tests required in 301.15(a-1) and additional tests, such as liquid limit, plasticity, degradation and abrasion.

Change the last two provisions of 403.15(a-5b) to read as follows:

- "One per 5 shifts" tests meaning one set of tests per 5,000 cubic yards.
- "One per shift" tests meaning one set of tests per 1,000 cubic yards with a minimum of three sets of tests per project.

301.16 Acceptance Sampling and Testing - The provisions of 403.16 shall apply except:

- Delete 403.16(a-1).
- Change the reference in 403.16(a-5) from 403.10 to 301.10 and 403.15(a) to 403.15(a) as modified by 301.15(a).
- Delete 403.16(b-2) and substitute the following:

  (2) Aggregate gradation and asphalt content - Take one sample from each sublot, when directed, from the discharge of the paving plant mixer.

- Change the reference in 403.16(b-4) to 301.39.
- Delete 403.16(b-5).
- Delete 403.16(b-6) and substitute the following:

  (6) Sublot size - A sublot is a maximum of 1,000 tons of PMBB.

- Delete the sentence in 403.16(b-7a) which begins "- The Composite Pay Factor ....".
- In 403.16(b-7b) delete the second paragraph.
- Delete 403.16(b-8) and substitute the following:

  (8) Nonspecification materials - The Engineer will determine the appropriate price reduction or order its removal from the work in accordance with 105.03.

Equipment

301.21 Bituminous Base Mixing Plant - The provisions of 403.21 shall apply except the scalping device called for under (f) shall reject material larger than 2 inches.

301.22 Hauling Equipment - The provisions of 403.22 shall apply.

301.23 Bituminous Pavers - The provisions of 403.23 shall apply.

301.24 Compactors - The provisions of 403.24 shall apply.

Construction

(For open graded only, delete the last sentence.)

301.31 Weather Limitations - Bituminous base mixture shall be placed on dry prepared surfaces when the air temperature in the shade is not less than 40°F. For dense graded mixture only, the air temperature in the shade may be lowered 5°F between April 1 and September 30.

Do not place PMBB:

- During rain or other adverse weather conditions.
- When the underlying layer is frozen.
- When existing or expected weather conditions which will prevent its proper handling, finishing, or compacting.

PMBB in transit at the time adverse conditions occur may be placed if:

- It has been covered during transit.
- Its temperature is satisfactory.
- Placed on a foundation free from pools or flow of water.
- All other requirements of these specifications are met.

301.32 Rate of Progress and Scheduling - The provisions of 403.32 shall apply.

301.33 Preparation of Underlying Surfaces - The provisions of 403.33 shall apply.

301.34 Drying and Heating Aggregates and PMBB - The provisions of 403.34 shall apply, except change the reference in (a) from 403.14 to 301.14.

301.35 Mixing - The provisions of 403.35 shall apply.

301.36 PMBB Mixture Storage - The provisions of 403.36 shall apply.

301.37 Control of Line and Grade - The provisions of 403.37 shall apply.

301.38 Hauling, Spreading and Placing - The provisions of 403.38 shall apply, except:

- The nominal compacted thickness for any lift, other than leveling, shall not exceed 4 inches.

- Delete the last paragraph:

301.39 Compaction - The provisions of 403.39 shall apply, except:

- Delete 403.39(a-6).

(For open graded only, delete the following two paragraphs.)

- Delete the first paragraph of 403.39(b-2) and substitute the following:

  (2) Random testing - The density of each sublot of dense graded mixture will be determined by random acceptance tests with the nuclear gage operated in the backscatter mode. A sublot of pavement is the area constructed from about 1,000 consecutive tons of mixture. Sublots will correspond with those for the PMBB mixture in 301.16(b-6).

301.41 Longitudinal Joints - The provisions of 403.41 shall apply.

301.42 Transverse Joints - The provisions of 403.42 shall apply.

301.43 Surface Tolerance - The finished surface of PMBB shall parallel the cross section and grade established for the surface within 0.03 foot.

The Contractor shall furnish a 12-foot straightedge and test parallel to and perpendicular to the centerline as directed by the Engineer. The surface of each lift shall not vary from the testing edge by more than 0.02 foot. Areas not meeting surface tolerance shall be marked.

301.44 Correction of Defects - The provisions of 403.44 shall apply, except change the reference in (b) from 403.43(a), (b), or (c) to 301.43.

Measurement

301.81 General - The provisions of 403.81 shall apply. The quantity of PMBB mixture was computed on the basis of aggregates having a specific gravity of _____.

Payment

301.91 General - The provisions of 403.91 shall apply, except delete the paragraph which begins "Each COMPOSITE PAY FACTOR ...".

The pay items and pay units are as follows:

(Delete the pay items which are not applicable.)

	Pay Item	Unit of Measurement
(a)	Bituminous Base Mixture, Dense Graded	Ton
(b)	Bituminous Base Mixture, Open Graded	Ton
(c)	Asphalt in Bituminous Base Mixture	Ton
(d)	Mineral Filler in Bituminous Base Mixture	Ton

Item (c) applies to all asphalt used in the mixtures including old residual asphalt in recycled material if used in the dense graded mixture.

Item (d) applies to mineral filler added to open graded bituminous base mixture as a filler.

APPENDIX C: RECYCLED ASPHALT PAVEMENT