FINAL REPORT

EVALUATION OF POROUS PAVEMENTS USED IN OREGON

Volume II - Appendices

by

Krey Younger
Graduate Research Assistant

and

R.G. Hicks
Professor

Department of Civil Engineering
Oregon State University
Corvallis, OR 97331

and

Jeff Gower
Pavements Engineer

Oregon Department of Transportation
Salem, OR 97310

for

Oregon Department of Transportation
Research Section

December 1994

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-OR-RD-95-13B		

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code
EVALUATION OF POROUS PAVEMENTS USED IN OREGON Volume II - Appendices	5. Report Date: December 1994 6. Performing Organization Code:
7. Author(s) Krey Younger, R.G. Hicks, and Jeff Gower	8. Performing Organization Report No. TRI #94-17
9. Performing Organization Name and Address Oregon State University, Dept. of Civil Engineering, Corvallis, OR 97331-2302 ODOT - Pavements Section, 2950 State St., Salem, OR 97310	10. Work Unit No. (TRAIS) 11. Contract or Grant No. SP&R 5298
12. Sponsoring Agency Name and Address Oregon Department of Transportation, Research Section 2950 State St. Salem, OR 97310	13. Type of Report and Period Covered Final Report (February 17 to December 31, 1994) 14. Sponsoring Agency Code

15. Supplementary Notes

Body of report available in Volume I

16. Abstract

Porous pavements or open-graded asphalt mixtures have been in use in Oregon since the late 1960s. The use of this pavement type has increased over the years because the pores in the mat provide an efficient way for water to drain from the pavement surface. This greatly increases safety in the areas of skid resistance and splash and spray. An added benefit from these pavements is that tire noise is partly absorbed into the voids of the pavement.

The purpose of this study was to evaluate porous pavements, especially the F-mix, as they are used in Oregon. The input from inside (i.e., contractors, ODOT personnel, asphalt experts) and outside (i.e., literature published over the years from agencies in the U.S. and abroad) Oregon was used to study open-graded mixes. This information was then used for improving porous pavements in Oregon.

Laboratory and field studies were performed on Oregon's open-graded mixtures. These tests were designed to understand how the mixture types performed with Oregon's conditions. These tests included texture depth, permeability, accident analysis, skid testing, rutting, splash and spray, noise, core gradation, asphalt properties, and tack coat shear testing.

A number of findings resulted from this study. Porous pavements provide a 1-2 dB A-weighted roadside noise improvement when compared to B-mix pavements. This difference would not be perceptible to an individual with average hearing. However, noticeable improvements for the F-mix did occur in the 500-4000 Hz range. Splash and spray visibility is improved, and safety on the roadway is improved. Potential problems with porous pavements include post-construction skid resistance, construction difficulties, and clogging of the pavement mat. Suggestions have been made in this study in terms of solving these problems and increasing the benefits.

17. Key Words	18. Distribution Statement
Porous mixtures, asphalt pavements, noise, splash and spray	No restrictions

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	104	

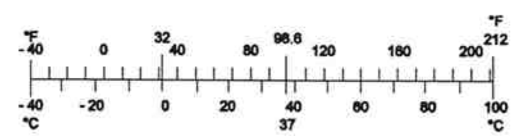
SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	millimeters squared	mm^2
ft^2	square feet	0.093	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	kilometers squared	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3
NOTE: Volumes greater than 1000 L shall be shown in m^3.				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
ha	hectares	2.47	acres	ac
km^2	kilometers squared	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.102	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8 + 32	Fahrenheit	°F



* SI is the symbol for the International System of Measurement

(4-7-94 jbp)

EVALUATION OF POROUS PAVEMENTS
USED IN OREGON
VOLUME II

LIST OF APPENDICES

APPENDIX B

ODOT Asphalt Concrete Specification

SECTION 00745 - ASPHALT CONCRETE PAVEMENT

Delete this Section in the Standard Specifications and substitute the following:

SECTION 00745 - ASPHALT CONCRETE PAVEMENT

Description

(Obtain the type of AC for the project from Pavement Design.)

00745.00 Scope - This work consists of constructing one or more courses of (Light, Standard, Heavy) Duty asphalt concrete (AC) pavement, 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 or as established.

00745.01 Abbreviations:

- IRM_R - Index of Retained Resilient Modulus
- IRS - Index of Retained Strength
- MAMD - Moving Average Maximum Density
- MDT - Maximum Density Test
- T - Tolerance
- TV - Target Value

00745.02 Definitions:

Heavy Duty AC - AC for use on highways and streets with high volume and heavy loads. Usually used on freeway projects.

Light Duty AC - AC for use on highway and streets with low volume and average loads.

Standard Duty AC - AC for use on highways and streets with average volume and average loads.

Mixture - Asphalt concrete.

00745.03 Reclaimed Asphalt Pavement (RAP) Material - Reclaimed AC pavement (RAP) material used in the production of new AC pavement is optional. No more than 20 percent RAP material will be allowed in the new pavement. Asphalt in the RAP material, when blended with other material, shall provide properties equivalent to asphalt specified in Section 02710. RAP material will not be permitted in open-graded (Class "E" or "F") mixtures or Heavy Duty AC mixtures.

00745.04 Modification of Mixes - Modify and proportion specified mixes for special purposes as directed. Modified mixes shall be consistent with the gradation and separation of the aggregate produced and accepted for use in the specified mix. Modifications of mix may require changes in the plan of operations. Such change in mix and plan shall be covered by the unit bid prices.

00745.05 Precrushing and Prepaving Conferences:

(a) Precrushing Conference - Supervisory personnel of the Contractor and any subcontractor who are to be involved in aggregate crushing of Standard and Heavy Duty AC aggregates shall meet with the Project Manager at a mutually agreed time, to discuss methods of accomplishing all phases of the crushing work. The crusher foreman and the Contractor's process control tester shall be at the meeting.

(b) Prepaving Conference - Supervisory personnel of the Contractor and any subcontractor who are to be involved in the paving work, shall meet with the Project Manager at a mutually agreed time to discuss methods of accomplishing all phases of the paving work.

Materials

00745.10 Aggregate - Produce and stockpile aggregate as follows:

(a) Light Duty AC - Provide new aggregates for Light Duty AC which are hard, sound, and durable, with at least 75 percent (by weight) of particles retained on the #10 sieve having one fractured face and free from all harmful substances as visually determined.

Use RAP aggregates for Light Duty AC according to 02680.40.

Stockpile Light Duty AC aggregates according to 02680.50.

(b) Standard Duty and Heavy Duty AC - Provide new aggregates, RAP aggregates and stockpile aggregates for Standard Duty and Heavy Duty AC according to Section 02680.

00745.11 Asphalt Cement, Additives, and Aggregate Treatment - Provide the following:

(a) Light Duty AC:

(1) Asphalt Cement - Use PBA-2 or PBA-5 grade asphalt that meets the requirements of Section 02710.

(2) Asphalt Cement Additives - When specified, add antistripping additives meeting the requirements of Section 02710.

Accompany each shipment of asphalt and additives with a quality compliance certificate, as required in 00165.60, and a copy of the weight receipt for each delivery.

(b) Standard Duty and Heavy Duty AC:

(Use one of the following asphalt cement specs as directed by Pavement Design.)

(1) Asphalt Cement - Use PBA-2 or PBA-5 grade asphalt for dense graded AC and PBA-5 grade asphalt for open graded AC, meeting the requirements of Section 02710.

(1) Asphalt Cement - Use PBA-3 or PBA-6 grade asphalt for dense graded AC and PBA-6 grade asphalt for open graded AC, meeting the requirements of Section 02710.

(2) Asphalt Cement Additives - When specified, add antistripping additives meeting the requirements of Section 02710 and satisfying the Index of Retained Strength (IRS) and the Index of Retained Resilient Modulus (IRM_R), as specified in 00745.13(b-1).

(Use the following 00745.11(b-3) lime treatment subsection when directed by Pavement Design.)

(3) Aggregate Treatment - Treat new crushed aggregates, except those in RAP materials, with dry hydrated lime meeting the requirements of 02090.20. Treat each size of aggregate as follows:

a. General:

1. Mix the hydrated lime, water, and aggregate thoroughly in a pugmill, or other approved mechanical mixer.

2. Demonstrate to the Engineer's satisfaction, the quantity of lime in aggregate for each sublot. If the rates of application are not met, remove the deficient AC mixture from the AC pavement.

b. Stockpiled Aggregates:

1. Lime treat and stockpile each size aggregate separately after treatment (See 02680.50).

2. Proportions of Hydrated Lime and Aggregate Moisture (Percents by weight of dry aggregates):

	Coarse Aggregate	1/4"-0	1/4"-No. 10	10-0
Hydrated Lime (%)	0.4	1.5	1.0	2.0
Lime Tolerance (%)	±0.2	±0.2	±0.2	±0.2
Moisture Content of Aggregate (%)	2.5 min.	5.0 min.	5.0 min.	5.0 min.

3. Treat the aggregate with lime no earlier than February 1 of the same calendar year as its final use in the AC mixture.

4. Retreat any lime treated aggregate remaining from a previous construction season before use in AC mixture.

c. Treatment During AC Mixture Production:

1. Mix dry lime and aggregates before they enter the paving plant dryer.

2. Proportions of hydrated lime and aggregate moisture (Percents by weight of dry aggregates):

Hydrated Lime (%)	1.0-1.5
Moisture Content of Aggregate (%)	4.00 for Class A, B and C mixes 3.50 for Class E mix 3.00 for Class F mix

00745.12 Mix Class and Broadband Limits - Mix class and broadband limits for Light Duty, Standard Duty and Heavy Duty AC shall meet the following:

(a) Mix Class - Furnish the class(es) of AC shown or as directed. The broadband limits for each of the mix classes are specified in (b) below. When the plans allow an option of two classes for a course of pavement, use only one class throughout the course.

(b) Broadband Limits - Provide mixture for the specified mix class within the:

- JMF of 00745.13,
- Tolerances of 00745.14, and
- Broadband limits below.

Do not exceed these limits without a contract change order. Specified aggregate proportions are given in percentages by weight of the total aggregates including hydrated lime and mineral filler material.

Broadband Limits

Sieve Size Passing	Dense Graded Class "A"	Class "B"	Class "C"	Class "D"	Class "M"	Open Graded Class "E"	Class "F"
1-1/2"	99-100						
1-1/4"	95-100						
1"	-	99-100				-	99-100
3/4"	74-87	92-100	99-100			99-100	85-96
1/2"	-	75-91	90-100	99-100		95-100	60-71
1/4"	46-56	50-70	52-80	85-100	99-100	52-72	17-31
No. 10	22-30	21-41	21-46	37-57	75-90	5-15	7-19
No. 40	6-18	6-24	8-25	13-29	25-40	-	-
No. 200	2-6	2-7	3-8	4-9	3-12	1-5	1-6
Asphalt Cement*	4-8	4-8	4-8	4-8	7-11	4-9	4-8

*Percent of total mix (by weight).

00745.13 Job Mix Formula (JMF) and Adjustments - Do not begin production of AC for use on the project until the JMF is provided or approved by the Materials Unit Engineer.

(a) Light Duty AC and Temporary Surfacing:

(1) JMF - Develop and use a JMF according to one of the following options:

a. On File With The Department - If the JMF is approved and on file with the Department for the source(s) to be used, no more than 2 years shall have lapsed since the JMF was last used or verified using submitted AC mixture. The Materials Unit Engineer will verify that the JMF has produced acceptable AC before it may be used on this project.

b. Developed From AC Test Data - If the JMF is developed from AC test data, provide the Project Manager with:

- A 25 pound sample of mixture for the Department's Materials Laboratory to analyze, and
- At least 5 test results, not older than the previous paving season, of asphalt content and aggregate gradation for the same class mixture produced from the source.

The average of each constituent will be the JMF, if approved by the Materials Unit Engineer.

c. Submitted by the Contractor - If the JMF is submitted by the Contractor, it shall be for a well-graded, uniform, durable mix substantially conforming to FHWA Technical Advisory T5040.27 for the Marshall mix design method or the current OSHD Asphalt Concrete Mix Design Guidelines for the Hveem mix design method. Submit the JMF with laboratory test results to the Project Manager for approval or rejection by the Materials Unit Engineer.

6-94

d. Provided by the Department - If a new JMF is developed by the Department, the costs of development will be at the Contractor's expense, subject to the terms and conditions on file at the Department's Materials Laboratory.

(b) Standard Duty and Heavy Duty AC:

(1) JMF for Permanent Courses - Take representative, composite samples of aggregate after 1,000 tons or 10 percent, whichever is less, of each separated size of specification aggregate material produced.

For each JMF requested, furnish representative samples of materials to be used in the mixture on the project to the Project Manager as follows:

Material	Amount
New Aggregate	300 pounds of each separated size (6 bags)
Reclaimed Asphalt Concrete	200 pounds from each stockpile (4 bags)
Hydrated Lime	20 pounds
Asphalt Cement (without Antistrip)	2 gallons in 1 quart metal containers
Antistripping Additive	1 pint in metal container

Provide these representative samples so they can be shipped to and received at the Department's Materials Laboratory in Salem at least 21 calendar days before anticipated use in the AC pavement. This 21-day period begins when samples of all materials complying with specifications have been received at the Department's Materials Laboratory.

a. JMF Materials Testing - These JMF representative materials samples may be tested for conformance with specifications. If these and other materials are acceptable, the proportions of the constituents to be used in the mixture will be determined and established. 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 establish a new JMF. If the materials are not acceptable, furnish additional samples as required by 00745.13(b).

Materials used in dense-graded AC pavement shall achieve an IRS of at least 75 percent (OSHD TM 308C), and an IRM_R of at least 70 percent (OSHD TM 315), when at the JMF target value with antistrip additives, if needed.

6-94

b. JMF Cost Responsibility - The Department will provide one JMF for each class of mix specified, with and without RAP, at no cost to the Contractor. The cost of development of additional JMF requested by the Contractor will be borne by the Contractor.

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

Aggregate Passing Sieve Size	(%) From JMF
1/4"	±2
No. 10	±1
No. 200	±0.5

Field adjustments will not be made unless the change produces material of equal or better quality. Adjustments beyond these limits will require development of a new JMF according to 00745.13(b). The adjusted JMF, plus or minus the allowed tolerances, shall be within the broadband limits specified in 00745.12(b).

00745.14 Tolerances and Limits - Produce and place the AC in final position within the following JMF tolerances and limits:

Constituent of Mixture	Light Duty AC, Temporary Surfacing, and Leveling Course All Courses	Standard Duty AC All Courses	Heavy Duty AC All Courses
Aggregate (Sieve Size Passing):			
1/2", 1-1/4", 1", 3/4" and 1/2"	Within the broadband limits of 00745.12(b)	Within the broadband limits of 00745.12(b)	
1/4"	± 6%	± 6%	± 5%
No. 40 and No. 10	± 5%	± 5%	± 4%
No. 200	± 2.0%	± 2.0%	± 2.0%
6-94 Asphalt Cement - OSHD TM 319 (Nuclear)	± 0.50%	± 0.50%	± 0.40%
Asphalt Cement - OSHD TM 321 (Cold Feed/Meter)	± 0.20%	± 0.20%	± 0.20%
Temperature of mixture after adjustment for 00745.43(d) at time placed in final position	± 20°F	± 20°F	± 20°F
Moisture content at time of discharge from the mixing plant 6-94 AASHTO T 255	0.80% Max.	0.80% Max.	0.70% Max.
Compaction Density	See 00745.49(b,c,e)	See 00745.49	See 00745.49

The base and wearing course tolerances for Standard Duty and Heavy Duty AC apply to the entire panel when a panel consists of both temporary and permanent courses.

00745.15 Process Control - Be responsible for quality control of AC as required by 00165.10. Perform process control sampling and testing for Standard Duty and Heavy Duty AC as follows:

(a) Aggregate - Sample each size aggregate during production (before treating with hydrated lime, when lime is required) 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	Aggre-gates	Minimum Frequency Schedule: Start of Production	One Per 5 Shifts*	One Per Shift*
Fracture of Gravel	TM 213		Coarse/ Fine	X	X	-
Friable Particles		T 112	Coarse/ Fine	X	X**	-
Wood Particles	TM 225		Coarse	X	X**	-
Dust or Clay Coating	TM 226		Coarse	X	X**	-
Elongated Pieces	TM 229		Coarse	X	X**	-
Sieve Analysis		T 27 with T 11	Coarse/ Fine	X	-	X***
Sand Equivalent	TM 101		Fine	X	-	X**

*A shift means: a production shift or 500 tons, whichever results in the greatest sampling frequency.
**May be waived after first five shifts, if allowed by the Materials Unit Engineer.
***Perform at least three tests.

(2) Split Samples - Provide split samples of all required samples to the Project Manager.

(3) Engineer Testing - The Engineer may perform any of the tests required in 00745.15(a-1), and any additional tests, such as lightweight pieces, plasticity index, soundness, degradation, and abrasion.

6-94

(4) Removal of Failing Material - Immediately perform a second test from Contractor's portion of split sample whenever a test result, other than sieve analysis, does not meet specifications. If the second test result confirms the material does not meet specification, make the appropriate operational adjustments before continuing production and remove all failing material from the stockpile. Refer to 00745.16(b-1) relative to nonspecification aggregate gradation.

(5) Preproduced Aggregate - Compliance of aggregates produced and stockpiled before the award date of this contract will be determined by the following:

- Continuing production records meeting the requirements of 00745.15(a-1), (a-3), and (a-4), or
- Sample according to AASHTO T 2 and furnish records of testing for the entire stockpile for the tests required in 0745.15(a) except change the sampling frequency schedule to:
  - "Start of Production" means "One Set of Tests Per Stockpile".
  - "One Per 5 Shifts" means "One Set of Tests Per 2,500 Tons".

- "One Per Shift" means "One Set of Tests Per 500 Tons" with a minimum of three sets of Sieve Analysis tests per project.

One stockpile sample shall be required for each set of tests required above.

(b) AC Production:

(1) Calibration - Determine the proper proportioning of the materials at the cold feed or hot bins. Do not begin production until calibration tests indicate that the specified proportions can be obtained.

In calibrating for mixtures containing RAP, determine gradation and asphalt content after blending and mixing at the plant.

(2) Mixture Control with RAP - Sample and test RAP cold feed material for gradation once for each sublot of AC mixture produced. Sample on a random basis according to 00745.16(b-2-c). Immediately test according to OSHD TM 309. Furnish the test results to the Project Manager within 24 hours for use in acceptance of the AC mixture according to 00745.16(b-2-h-2). If results are not furnished within 24 hours, the Project Manager will submit the split sample of RAP material for use in acceptance of the AC mixture to the Materials Laboratory for gradation testing. If this occurs, pay the cost of testing.

a. Asphalt Antistrip Additive - (if not preblended by the asphalt supplier):

- Metering and Weighing - From the plant's asphalt metering or weighing system, and confirm by invoices and tank stickings.

00745.16 Acceptance of AC - Acceptance sampling and testing will be performed by the Engineer, according to 00165.40 and the following:

(a) Light Duty AC:

6-94 (1) Acceptance Sampling - Take samples in accordance with OSHD TM 368 when directed by the Engineer as follows:

a. Random Sampling - The Engineer will determine when and where to sample on a random basis. A sample will not be required from the first 25 tons of mixture produced each day.

b. Aggregate Gradation and Asphalt Cement Content - When directed, take one sample from each sublot, from the discharge of the paving plant mixer.

c. Moisture - Take samples for each sublot from the discharge of the paving plant mixer to match samples taken in b. above, as directed.

(2) Frequency:

a. Lot Size - Lot size for Light Duty AC shall conform to 00745.16(b-2-f).

b. Sublot Size - Sublot size for Light Duty AC shall conform to 00745.16(b-2-g).

(3) Acceptance Testing - Testing will be conducted in the Department's Materials Laboratory in Salem or in the field as deemed appropriate.

a. Aggregate Gradation and Asphalt Content - Samples will be tested using OSHD TM 309.

If gradation or asphalt content test results varies from the JMF by 1-1/2 times or more than the tolerance limits specified in 00745.14, a backup sample from the random sample will be tested. The test result which yields the highest CPF through that sublot will be used. If original and backup test results yield the same CPF, original test results will be used.

6-94

b. Moisture - Samples will be tested according to AASHTO T 255.

c. Compaction - Acceptance testing for compaction will be according to 00745.49(a), (b) and (c).

(b) Standard Duty and Heavy Duty AC:

(1) Aggregate - Compliance of material will be based on the Contractor's process control testing, as required in 00165.10, 00745.15(a), and 00745.16(b-1), and verified by other tests performed by the Engineer.

a. Aggregate Gradation - A stockpile contains specification aggregate when the QL for each sieve size calculated according to 00165.30, is equal to or greater than the QL indicated in Table 00165-2 for a PF of 1.00. Each required sample represents a sublot. When the QL indicated in Table 00165-2 yields a PF of less than 1.00 for any sieve size, the material is nonspecification.

b. Nonspecification Aggregate Gradation - The Engineer will reject any stockpile of aggregate containing material not conforming to the gradation specifications, unless the nonspecification material is removed from the stockpile. Do not add additional material to such a stockpile until enough nonspecification material is removed so the QL for each sieve size is equal to or greater than the QL in Table 00165-2 for a 1.00 PF.

Stockpiled aggregates not conforming to the gradation specification may be accepted if the Contractor can demonstrate that materials from other stockpiles can be combined with those in the rejected stockpile so the combined materials meet all specifications with QL at the 1.00 PF. Materials shall be combined with a controlled blending system synchronized to furnish each separate aggregate size at an established rate of flow. Such materials, if found acceptable, will be subject to a contract change order.

c. Verification Testing - Compliance will be verified by check tests and other tests performed by the Engineer. If the difference between the Engineer's check tests and the Contractor's tests are not within the allowable differences given in the Department's Manual of Field Test Procedures, the Contractor shall work immediately with the Engineer to resolve the difference to avoid having this material rejected for not meeting specification. Material not meeting specifications based on other tests performed by the Engineer will be rejected.

d. Materials on Hand - Payment for stockpiled materials on hand may be allowed as described in 00195.60, subject to meeting 00745.15(a), 00745.16(b-1), and Section 02680.

Payment for nonspecification materials will not be allowed.

6-94 (2) AC Mixture - Take samples in accordance with OSHD TM 368 when directed by the Engineer as follows:

a. Random Sampling - The Engineer will determine when and where to sample on a random basis. A sample will not be required from the first 25 tons of mixture each day.

b. Aggregate Gradation - Take one sample from each sublot using an approved mechanical sampling device as required by 00745.21(o) when directed as follows:

- Drum Plants - After lime treatment from the cold feed prior to entering the dryer.
- Batch Plants - If no aggregate is rejected from the storage bins, cold feed, or hot feed prior to screening. Otherwise sample from the hot bins.
- When converted to the OSHD TM 309 method of acceptance according to 00745.16(b-2-h-2) from the discharge of the plant.

c. RAP Gradation - Take one sample from each sublot using an approved mechanical sampling device, when directed, from the RAP cold feed prior to entering the plant. Provide a split sample to the Project Manager. Test each sample according to 00745.15(b-2). The first and fifth sample, and every fifth sample thereafter will be tested by the Materials Laboratory using OSHD TM 309 to verify process control testing.

If check test results are within accepted tolerance, original results will be used in acceptance according to 00745.16(b-2-h-2).

If check test results are not within accepted tolerance, all split samples will be tested by the Materials Laboratory back to the previous check test that was within tolerance. The Department test results will be used for acceptance until the Contractor's tests are within accepted tolerance.

d. Asphalt Cement Content, Moisture, and Asphalt Aging - Take one sample from each sublot, when directed, from the discharge of the paving plant mixer prior to incorporation into the storage hopper or silo. Use an approved mechanical sampling device as required by 00745.21(o). For batch plants that discharge directly into trucks, the sample may be taken directly from the truck.

e. Compaction - Sampling for compaction will be according to 00745.49.

f. Lot Size - A lot is the total quantity of material or work produced per JMF with the same specification limits of all constituents. Increase sampling frequency of lots with two or less sublots according to 00165.30.

g. Sublot Size - A sublot is 500 tons of AC, except when sampled at an increased frequency according to 00745.16(b-2-f) or when a terminated sublot.

h. Acceptance Testing:

1. General - The Engineer will furnish copies of test results on the morning of the next workday after sampling, except for where differences in process control testing and Department testing require acceptance tests to be performed by the Materials Laboratory. Department test results include the following:

- Acceptance testing performed in the field.
- Acceptance testing performed in the Materials Laboratory.
- The CPF of the completed sublots after three sublots have been produced.

For RAP gradation acceptance testing performed by the Materials Laboratory according to 00745.16(b-2-c), test results from the first and fifth sample and every fifth sample thereafter will be made available on the morning of the first workday 4 days after the sample is received in the Materials Laboratory. Test results from intervening samples, if tested, will be available within 21 days after the sample is received in the Materials Laboratory.

For AC mixture acceptance testing performed by the Materials Laboratory according to 00745.16(b-2-h-2), test results from the first and fifth sample and every fifth sample thereafter will be made available on the morning of the first workday 4 days after the sample is received in the Materials Laboratory. Test results from intervening samples, if tested, will be available within 21 days after the sample is received in the Materials Laboratory.

6-94

2. Aggregate gradation - Except as noted below, aggregate samples will be tested using AASHTO T 27 and T 11.

- For batch plants, if hot bin samples are used, separated size test results will be mathematically combined in the same proportions as batched.
- For mixture with RAP, cold feed, hot feed, or hot bin aggregate test results will be mathematically combined with the process control extraction gradation results for RAP, except as required in 00745.16(b-2-c).

If aggregate complies with all gradation constituent specifications according to 00745.16(b-1-b), except the stockpiles cannot be combined to comply with the P#200 specifications, an attempt may be made to remove the excess P#200 in the plant as follows:

- Request in writing for conversion to acceptance of aggregate gradation by testing the AC mixture using OSHD TM 309.
- If the conversion to the TM 309 method of gradation acceptance is approved by contract change order, conversion back to the cold feed method of acceptance will not be allowed. No cold feed testing will be performed. All gradation constituents will be accepted by using TM 309.
- Take one sample of AC mixture from each sublot when directed. Provide a split portion to the Project Manager.
- Immediately test every sample of AC mixture by OSHD TM 309.
- Furnish the test results to the Project Manager on the morning of the next workday after sampling for acceptance of the AC mixture. If results are not furnished within 24 hours, the Project Manager will submit the split sample to the Materials Laboratory for testing by OSHD TM 309 for acceptance of the aggregate gradation. If this occurs, pay the cost of testing.

- The first and fifth sample, and every fifth sample thereafter will be check tested by the Materials Laboratory using OSHD TM 309 to verify Contractor's testing. If the check test results are not within accepted check test tolerance, all split samples will be tested by the Materials Laboratory back to the previous check test that was within check test tolerance. Contractor's results will be used in acceptance if check test results are within accepted check test tolerance. Pay the cost of testing.

- For AC mixture including RAP, testing of RAP according to 00745.16(b-2-c) is not required.

3. Asphalt Content - Asphalt content will be tested using:

   - Dense Graded Mix - OSHD TM 319 (Asphalt Content of Bituminous Mixtures by Nuclear Method).

   - Open Graded Mix - OSHD TM 319, or if elected, OSHD TM 321 (Asphalt Content by Cold Feed/Meter Procedure) from the continuous or drum mix plant's asphalt metering/weighing system and confirm by invoices and tank stickings.

     If OSHD TM 321 is used, perform an initial plant calibration according to OSHD TM 322 (Asphalt Concrete Plant Calibration) before the start of paving and then once a week thereafter, or any time there is a breakdown or change in plant equipment.

6-94 4. Moisture - Samples will be tested using AASHTO T 255.

6-94 5. Backup Testing - If the gradation test result of the 1/4", #10, #40 and #200 sieves vary from the JMF by 1-1/2 times or more the tolerance limits specified in 00745.14, a backup sample from the random sample will be tested. The test result which yields the highest CPF through that sublot will be used. If the original and backup test results yield the same CPF, the original test results will be used.

6-94 6. Compaction - Acceptance testing for compaction will be according to 00745.49. New nuclear gage tests will be obtained for any failing sublot of pavement, at the same randomly selected sites used for the original nuclear gage tests, if a new test is requested in writing on the same day nuclear gage tests are provided. The average of these five new density tests will constitute the "in place" density of the sublot of pavement and will prevail over the original nuclear results.

The Engineer may test any area that appears defective in compaction and require further compaction of any area that does not meet specifications.

7. Asphalt Aging - Open-graded AC, leveling courses, temporary surfacing, and AC containing RAP will be excluded from asphalt aging testing.

   The asphalt aging C Value test, OSHD TM 425, (see 00745.43(c)), will be made on the first sublot of each project. If there is an AC pavement tenderness problem, tests will also be made on the first and fifth sublot of each lot, and every fifth sublot thereafter, until the tenderness problem is resolved.

   C Value test results will be valid only if tested within 2 weeks of the date sampled. When a C Value test result is less than 30 and there is a pavement tenderness problem, make appropriate plant adjustments.

   When the low C Value and tenderness is due to contamination from burner fuel, 00150.25 applies.

i. Minimum Pay Factor for Each Constituent - Stop production when the pay factor for any constituent with a weighing factor greater than 1 falls below 0.75. Resume production when a plan for correction is accepted by the Engineer.

Equipment

00745.20 Lime Treated Aggregate Plant - When lime treated aggregate is specified, provide a mixing plant that includes:

(a) Mechanical Mixer - A mechanical mixer or pug mill that mixes the aggregate and lime until the aggregate is uniformly coated, and the lime is distributed throughout the aggregate.

(b) Belt Scales - Belt scales that comply with 00745.21(b-2).

(c) Lime Metering Device - A lime metering or weighing device that displays the accumulated amount of lime incorporated within any selected time period. It shall be accurate within 0.5 percent by weight.

00745.21 Asphalt Concrete Mixing Plant - Provide AC plants that comply with the following:

(a) DEQ Permits - Before producing AC for this contract at a new or revised plant location, provide the Engineer with copies of permits according to 00160.70.

(b) Scales - Provide required scales to assure a uniform mixture. Check and adjust scales according to 00190.20.

(1) Plant Scales - In batch plants, provide plant scales to weigh rescreened aggregates.

(2) Belt Scales - On plants without screens, provide belt scales on the conveyor belt:

- For each separated size aggregate, or
- Conveying all the new aggregates to the mixer, and
- Conveying RAP to the mixer.

Zero belt scales before starting each day during production.

(c) Storage Bins - Provide storage bins for each separate material to prevent intermingling of aggregate when operating mixer at full capacity.

(d) Aggregate Proportioning - Proportion aggregate with a controlled blending system synchronized to furnish each separate aggregate size at an established rate of flow.

(e) Weight Calibration of Aggregate Feed - Calibrate aggregate feed gate openings according to 00745.15(b-1) by weighing test samples.

(f) Vibratory Scalping Devices - Provide vibratory scalping devices ahead of the mixer to reject aggregate, RAP, and lumps of cemented material larger than 1 inch, or the nominal maximum aggregate size, if larger.

(g) Dryers - Provide dryers that do the following to the aggregate during mixing:

- Agitate it continuously.
- Heat it uniformly to specified temperature.
- Dry it uniformly to specified moisture content.
- Leave no unburned oil or carbon residue on it.

(h) Screens - If screens are provided, they shall do the following to the aggregate:

- Separate the coarse from the fine.
- Separate the fine into two sizes.

(i) Tanks - Provide storage tanks that do the following to the asphalt:

- Circulate it continuously when operating.
- Heat and hold it at the specified temperatures.
- Allow for convenient measurement of its quantity.

(j) Asphalt Control - Provide a means to weigh or meter the asphalt into the mixture at rates that produce the product specified. The measuring device shall be accurate to plus or minus 0.5 percent.

(k) Asphalt Antistrip Additive Metering Device - When asphalt antistrip additive is added into the asphalt at the AC mixing plant, provide a means to weigh or meter the additive at a specified rate. The measuring device shall be accurate to plus or minus 0.5 percent.

6-94

(l) Thermometers - Provide the following:

- A direct reading, full operating range, thermometer in the asphalt feed line near the mixer unit.

- A thermometric instrument, that registers or indicates automatically the temperature of the materials at the discharge of the mixer.

(m) Synchronization of Aggregate Feed and Asphalt Feed - Provide a means to synchronize and maintain a uniform flow of proportioned aggregates from the bins with the flow of asphalt from the meter.

(n) Sampling Devices - Provide a mechanical sampling device, as described in 00165.20(b), in the final conveyor to the mixer, and a similar sampling device at the discharge of the mixer and for each hot bin used in batch plants.

(o) Dust Collector - Equip the plant with dust collectors that conform to the air pollution laws.

6-94 00745.22 Hauling Equipment - Provide hauling vehicles in good operating condition with tight, clean, smooth beds.

Coat the beds with a minimum amount of an approved material to keep the AC from sticking to the beds. Do not use diesel oil, unless approved. Drain excess coating material before loading by raising the truck bed, opening belly dump gates, or operating the conveyor belt, as appropriate.

00745.23 Asphalt Concrete Pavers - Pavers shall comply with the following::

(a) Power and Support - Self-contained, self-propelled, supported on tracks or wheels, none of which contact the mixture being placed.

(b) Augers and Screed - Equipped with augers and an activated screed or strike-off assembly, heated if necessary, which:

- Provide extensions used on travel lanes, with the same augering, screeding, and heating equipment as the rest of the paver.

- Can spread and finish AC in the specified widths, thicknesses, lines, grades, and cross sections.

- Will not segregate, tear, shove, or gouge the AC.

- Produce a finished surface to specified evenness and texture.

(c) Control System - Equipped with a paver control system which:

- Controls AC placement to specified slope and grade.
- Maintains the paver screed in proper position.
- Provide specified results through mechanical sensors and sensor-directed devices actuated from independent line and grade control references.

00745.24 Compactors - Provide specified self-propelled rollers capable of reversing without backlash, as follows:

(a) Steel-Wheeled Rollers - Steel-wheeled rollers shall have:

- A gross static weight of at least 8 tons.
- A static weight on the drive wheel of at least 250 pounds per inch of width.

If used for finish rolling, shall have:

- A gross static weight of at least 6 tons.
- No drive wheel static weight requirement.

(b) Vibratory Rollers - Vibratory rollers shall be:

- Equipped with amplitude and frequency controls.
- Specifically designed to compact AC.
- Capable of at least 2,000 vibrations per minute.

If used for pavement thickness less than 1-1/2 inches or open graded AC, shall:

- Have a gross static weight of at least 8 tons.
- Have a static weight on the drive wheel of at least 250 pounds per inch of width.
- Not be operated in vibratory mode.

If used for finish rolling, shall:

- Have a gross static weight of at least 6 tons.
- Not be operated in the vibratory mode.

(c) Pneumatic-tired Rollers - Pneumatic-tired rollers shall:

- Be tandem, or multiple axle, multiple wheel type.

- Have smooth-tread, pneumatic tires of equal size.
- Have tires staggered on the axles, spaced and overlapped to provide uniform compacting pressure for the full compacting width.
- Be capable of exerting ground pressure of at least 80 pounds per square inch of tire contact area with a minimum total load of 2,800 pounds per tire.
- Be fully skirted to reduce tire heat loss and mixture pick up.

Construction

00745.40 Season and Temperature Limitations - Place AC during the dates indicated, and when the air temperature in the shade is not less than:

Nominal Compacted Thickness of Individual Lifts and Courses as shown on the typical section of the plans	Air Temp.	Light Duty All Courses	Standard Duty and Heavy Duty Travel Lane Wearing Course From	To Inclusive	All Other Courses From	To Inclusive
Open Graded Mixes						
Less than 2 "	60°F	—	3/15	9/15	3/15	9/15
2" and Over	50°F	—	3/15	9/15	3/15	9/15
Dense Graded Mixes						
Less than 1-1/2"	60°F*	All Year	3/15	9/30	All Year	
1-1/2" to 2-1/2"	50°F*	All Year	3/15	9/30	All Year	
2-1/2" and Over	40°F*	All Year	3/15	9/30	All Year	
Temporary	45°F	All Year	All Year		All Year	

*Air temperature for All Courses, other than travel lane wearing courses, in Light Duty AC, and for All Other Courses in Standard Duty and Heavy Duty AC may be lowered 5°F between March 15 and September 30.

00745.41 Rate of Progress and Scheduling - Schedule operations when placing all courses of Standard Duty and Heavy Duty AC:

- So the mixture is placed as continuously and uniformly as possible.
- So the mixing plant produces AC for the contract only, unless otherwise permitted.
- For periods of continuous paving at least 1 hour in duration.

Provide sufficient plant, equipment, labor, and materials to place the AC at a rate of at least 100 tons per hour when paving travel lanes with Standard Duty and Heavy Duty AC.

00745.42 Preparation of Underlying Surfaces:

(a) Overlays Only - Recondition existing base and foundations according to Section 00610. Trim broken or ragged edges to firm material.

(b) All Projects - Finish bases and foundations on which the AC is to be placed to the condition specified for its construction.

Treat all paved surfaces on which AC is to be placed with an asphalt tack coat, according to Section 00730.

Level and compact depressed areas with AC. The leveling work shall be a separate operation, performed at the locations and to the extent shown or directed. Leveling material shall be spread by a paving machine, unless otherwise directed.

00745.43 Drying and Heating Aggregates and AC:

(a) Drying - Dry aggregates so that any remaining moisture complies with 00745.14, and does not produce visible defects in the AC.

(b) Burner Fuel - Furnish a written statement describing the burner fuel to be used on the project. Use the same burner fuel for heating the aggregates throughout production of the AC, unless otherwise approved.

(c) Burner Operation - Operate the burner used to heat the aggregates to completely burn the fuel so the aggregate and asphalt are not contaminated and the asphalt is suitably aged.

(d) Heating Temperatures - Heat the asphalt to at least 250°F, but not more than 350°F, when it enters the mixer. The maximum temperature of the AC at discharge from the mixer and minimum placement temperature behind the paver shall be as follows:

	AC Temperature (°F)	
Grading	Maximum at Mixer	Minimum Behind Paver
Dense	325	240
Open	265	205

The required mixture placement temperature behind the paver will be established by the JMF. Within the above limits, the Project Manager may adjust this temperature in 10°F increments as follows:

- Up - If the aggregate coating, moisture content, workability, or compaction requirements are not attained.
- Down - If the aggregate coating, moisture content, workability, and compaction requirements are attained.

00745.44 Mixing - Utilize the required components of the AC mixing plant. Heat and mix the materials so the RAP material is broken down, the particles are uniformly coated, and the asphalt is thoroughly distributed throughout the mixture.

6-94

00745.45 AC Storage - Do not store or hold hot AC in open stockpiles.

Temporary storing or holding of hot AC in storage silos will be permitted if the Contractor complies with the following:

(a) Flow Diverter - Provides a device to divert the flow of AC away from the silo when starting or stopping plant production, or at any other time necessary, so improperly proportioned mixture or incompletely mixed portions of the mixture do not enter the silo.

(b) Segregation - Equips storage silos with a batcher, rotating chute, or similar device to prevent segregation of the AC as it enters the silo.

(c) Unheated Silos - Stores AC in unheated silos only when the total elapsed time from the mixing to placing is less than 6 hours.

(d) Heated Silos - Stores AC in heated insulated silos no more than 72 hours only if an inert gas atmosphere is maintained in the silos at all times.

(e) Discharging AC and Loading Trucks - Discharges AC and loads trucks so segregation is prevented. If the AC is segregated, dispose of the unsuitable AC at the Contractor's expense, and stop temporary storage of the AC.

00745.46 Control of Line and Grade - The Engineer will establish references at reasonable intervals for line and grade control of the placing operations. Use a floating beam device of adequate length and sensitivity to control the grade of the paver. Where this method is impractical, manual control of grade will be permitted after approval.

00745.48 Hauling, Depositing, and Placing:

(a) Hauling - Cover the AC if rain or cold air temperatures are encountered any time between loading and placement.

The AC will be rejected before placing if one or more of the following is found:

- Below specified placing temperature limit.
- Slumping or separating.
- Solidifying or crusting.
- Absorbing moisture.

Dispose of rejected loads at the Contractor's expense.

Deliver the mixture to the paving machine at a rate that provides continuous operation of the paving machine, except for unavoidable delay or breakdown. If excessive stopping of the paving machine occurs during paving operations, the Engineer may suspend paving operations until the mixture delivery rate matches the paving machine operation.

(b) Depositing - Deposit the AC from the hauling vehicles so segregation is prevented.

When AC is windrowed, the pick-up equipment shall:

- Pick up substantially all of the AC deposited on the roadway.
- Be self-supporting, not exerting any vertical load on the paving machine, nor causing vibrations or other motions which could have a harmful effect on the riding quality of the completed pavement.

(c) Placing - Place AC on dry, prepared surfaces with pavers conforming to 00745.23. When approved, place AC with other equipment and means where irregularities or obstacles make the use of specified equipment impractical. Provide adequate lighting at Contractor's expense, when permitted to place AC other than during daylight hours.

Do not place AC:

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

AC 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 are met.

When leveling irregular surfaces and raising low areas, the actual compacted thickness of any one lift shall not exceed 2 inches except the actual compacted thickness of intermittent areas of 1,000 square feet or less may exceed 2 inches, but not 4 inches. This may require portions of the mixture to be laid in 2 or more lifts.

Place the mixture in the number of lifts and courses, and to the compacted thickness per lift and course, shown. Place each course in one lift unless otherwise specified. The compacted thickness for any lift, other than leveling, shall not exceed 3 inches.

Do not intermingle AC produced from more than one JMF. Each base course panel placed during a working shift shall conform to a single JMF. The wearing course shall conform to a single JMF, except for adjustments in the JMF according to 00745.13(b-3).

00745.49 Compaction - Compact the AC as follows:

(a) General - Immediately after the AC has been spread, struck off, and surface irregularities and other defects remedied, roll it uniformly until compacted as specified.

(1) Temperature - Complete compaction before the AC temperature drops below 180°F, unless otherwise directed. When the rolling causes tearing, displacement, cracking, or shoving, make necessary changes in compaction temperature, type of compaction equipment, and rolling procedures.

(2) Rolling - Compact the AC with rollers conforming to 00745.24. Provide sufficient rollers of type and weight to compact the mixture while it is still within the specified temperature. Do not use equipment which crushes the aggregate. Do not displace the line and grade of edges. Moisten steel roller wheels with a least amount of water, or other approved material, necessary to prevent the AC from sticking to them and spotting or defacing the AC.

Operate rollers at a slow, uniform speed recommended by the manufacturer. Drive rolls or wheels shall be nearest the paver unless otherwise approved. Operate pneumatic rollers no faster than 5 MPH. Operate vibratory rollers at frequencies of at least 2,000 vibrations per minute.

Begin rolling at the sides and proceed longitudinally, parallel to the road centerline, gradually progressing to the center, unless otherwise directed. On super-elevated curves, begin rolling at the low side and progress to the high side. When paving in echelon, or when abutting a previously placed lane, roll the longitudinal joint first, followed by the regular rolling pattern. Do not make sharp turns or park rollers on the hot AC. Stop each pass at least 5 feet longitudinally from preceding stops.

Perform finish rolling with rollers meeting the requirements of 00745.24(a) or 00745.24(b), and continue until all roller marks are eliminated.

(3) Maximum Pay Factor - The PF for compaction will be:

Type/Method	PF	Maximum PF
Light Duty AC	1.00	
Standard Duty and Heavy Duty AC:		
Normal Pavement		
Control Strip Method		1.00
MAMD Method		1.05
Thin Pavement	1.00	
Open-Graded AC	1.00	
Other Areas	1.00	

(b) Normal Pavement (Nominal Thickness 1-1/2 Inches or Greater):

(1) Light Duty AC - Compacting Light Duty AC to a specified density will not be required. Continue breakdown and intermediate rolling until the entire surface has been compacted by at least 4 coverages of the roller(s). Perform additional coverages, as directed and as necessary, to obtain thorough compaction and finish rolling of the AC.

(2) Standard Duty and Heavy Duty AC:

a. General - Compliance with the density specifications for dense graded pavement courses will be determined by random testing of the compacted road surface with nuclear gauges. The Contractor is encouraged to have a representative observe the density tests. The control strip method of compaction measurement will be used.

Use at least one pneumatic-tired roller conforming to 00745.24(c) in the breakdown or intermediate compaction sequences. Otherwise, the type of rollers and their relative position in the compaction sequence is optional, provided specified densities are attained.

b. Random Testing - The density of each sublot will be determined by acceptance tests at random locations with the nuclear gauge operated in the backscatter mode. Lots and sublots will correspond with those for the AC mixture in 00745.16(b-2-f) and 00745.16(b-2-g).

1. Taking Tests - After completion of the finish rolling, tests will be taken according to OSHD TM 306C. The center of a density test will not be located less than 1 foot from the panel edge.

2. Core Correlations of Nuclear Gauge Readings - Correlation of nuclear gauge densities with core densities will be required for projects with the following dense graded mixes:

- Heavy Duty AC - Within 4 inches of the finish grade of all project paving.

- Standard Duty AC - Within 2 inches of the finish grade of all project paving.

- Standard and Heavy Duty AC - When requested by the Contractor.

One correlation is required for each nuclear density gauge used on a project. An additional correlation is required if the aggregate source or the asphalt cement source changes. Correlations will be applied to all nuclear gauge readings for all dense graded mixtures placed on the project, including plant mix bituminous base.

Cutting of cores and the filling of core holes with dense graded mixture shall be by the Contractor at the Contractor's expense. Core correlation test sites may be at different random locations than the 00745.49(b-2-b) acceptance test sites. The Contractor shall cut ten 6-inch pavement cores, per FOP for AASHTO T 166, at locations as directed. Cut cores directly over randomly selected nuclear density test sites the same day as the nuclear tests. Do not cut cores until a valid nuclear density gauge reading has been obtained at the test location.

The density of the cores and the nuclear gauge correlation factor will be determined per OSHD TM 306C. Correlation results will be provided to the Contractor by noon of the next workday after coring.

c. Control Strip Method - This method consists of constructing and testing a designated strip to establish optimum rolling procedures and target density.

1. Construction of Control Strip - When beginning work on each lift of pavement, construct one or more control strips that are:

6-94

- 500 feet long (Maximum length of rolling pattern).
- Part of the roadway.
- Placed to the specified width and thickness.
- Composed of the same materials as the rest of the lift.
- Compacted with the same equipment as the rest of the lift.

The first valid target density for each lift of pavement will represent previously placed pavement with the same JMF.

A target density is not valid if it is less than the following percent of the MAMD (OSHD TM 306B):

Course of Construction	Standard Duty	Heavy Duty
First Lift of First Course	91.0	92.0
Single	91.0	92.0
All Other	92.0*	92.0

*If any part of a lift requires 91.0 percent, the entire lift shall be 91.0 percent.

A new control strip shall be constructed when:

- There is a new JMF.
- There is a major change in equipment or rolling pattern.
- 10 days of production have been accepted without construction of a new control strip.
- A new lift of pavement is started.
- The target density being used is suspect.

2. Establishing Target Density - The target density of the control strip will be determined according to OSHD TM 306C by averaging the final results of 5 density tests taken with a nuclear gauge at randomly selected sites within the control strip.

3. Compaction Requirement - Compact the AC mixture to a density of at least 98.0 percent of target density.

   Standard Duty AC material in the first lift of the first course, and represented by a valid target density, will be placed in a separate lot from subsequent lifts for statistical analysis.

4. Control of Operations - Stop paving if 3 consecutive control strips fail to achieve specified target density. Take all necessary actions to resolve compaction problems. Do not resume paving without approval of the Project Manager.

d. Converting Test Method - The Contractor may request, in writing, to change from control strip method 00745.49(b-2-c) to MAMD method 00745.49(b-2-e). After converting, the Contractor must compact the AC to the density of at least the percent of MAMD specified in 00745.49(b-2-e) for succeeding sublots.

If a succeeding sublot fails compaction requirements, construct a new control strip on the next possible sublot according to 00745.49(b-2-c). The new control strip method results will be used for succeeding sublots, unless the Contractor again requests in writing to change methods. The results from the MAMD method elected on the previous sublot(s) that failed will not be changed.

e. Moving Average Maximum Density (MAMD) Method - The MAMD is the average of the current MDT and, if available, the 4 previous MDTs for the JMF used. Each MDT and MAMD will be determined by the Engineer according to OSHD TM 306B.

If the Contractor requests to use this method, according to 00745.49(b-2-d), compact the AC to at least the percent of MAMD shown in the table in 00745.49(b-2-c-1).

MDTs will be determined:

1. At the beginning of each production shift.

2. Whenever a new JMF is established.

3. Whenever a MDT result varies more than 3 pounds per cubic foot (pcf) from the last MAMD. Whichever MDT result is closest to the last MAMD will be used to determine the new MAMD.

f. Test Results - Density results for completed sublots will be made known to the Contractor as soon as possible.

(c) Thin Pavement:

(1) Light Duty AC - Compaction to a specified density will not be required for lifts of pavement less than 1-1/2 inches thick.

Continue the breakdown and intermediate rolling until the entire surface has been compacted by at least 4 coverages of the roller(s). Perform additional coverages, as directed and necessary, to obtain thorough compaction and finish rolling of the AC.

(2) Standard Duty and Heavy Duty AC - Compaction to a specified density will not be required for leveling, patches, or where the nominal compacted thickness of a course of dense graded mixtures will be less than 1-1/2 inches thick.

Use only pneumatic-tired rollers for breakdown compaction. Continue the breakdown and intermediate rolling until the entire surface has been compacted by at least 4 coverages of the roller(s). Perform additional coverages, as directed and as necessary, to obtain thorough compaction and finish rolling of the AC.

(d) Open Graded AC - Compaction of open graded AC to a specified density will not be required.

Use only steel-wheeled roller(s) for compaction. Continue the breakdown and intermediate rolling until the entire surface has been compacted with at least 4 coverages by the roller(s). Perform additional coverages, as directed and as necessary, to obtain thorough compaction and finish rolling of the AC.

(e) Other Areas:

(1) Compaction to a specified density will not be required on temporary surfacing (see 00745.50), guardrail flares, mailbox turnouts, road approaches, and areas of restricted width (less than 8 feet wide) or limited length, regardless of thickness.

Continue the breakdown and intermediate rolling until the entire surface has been compacted with at least four coverages by the roller(s). Perform additional coverages, as directed and as necessary, to obtain thorough compaction and finish rolling of the AC.

(2) Along curbs and walls, on walks, irregular areas, and other areas not practically accessible to rollers conforming to 00745.24 compact the mixture with small self-propelled rollers, mechanical tampers, hot hand tampers, or hand rollers. On depressed areas, a trench roller may be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Temporary

00745.50 Temporary Surfacing Course - AC for temporary surfacing shall be a well-graded, uniform, durable commercial mix. All new materials, or a combination of new materials and reclaimed materials, may be used, according to 00745.03, except no more than 20 percent RAP materials will be allowed in the wearing course of the travel lanes.

The requirements of 00165.10(b), 00745.15, and 00745.16(b-1) do not apply to temporary surfacing. As stated in 00745.16(b-2-h-7), the requirements for asphalt aging do not apply. The Contractor is responsible for the quality of material furnished according to 00165.10(a).

(a) Job Mix Formula (JMF) - Establish the JMF according to 00745.13(b-2). The constituents of the AC shall be within the broadband limits according to 00745.12(b).

(b) Sampling and Testing - Acceptance sampling and testing will be according to 00745.16(a) except acceptance of compaction will be according to 00745.49(e).

Maintenance

00745.60 Correction of Defects - Correct any defects in material and work, as directed, at the Contractor's expense, except as noted. These include segregation of materials, nonuniform texture, fouled surfaces preventing full bond between successive spreads of mixture, and (a) through (d) below. No adjustment in contract time will be made for corrective work.

(a) Boils and Slicks - Remove and replace boils and slicks immediately with suitable materials.

(b) Roller Damage to Surface - Correct any displacement immediately with rakes and addition of fresh mixture, when required, regardless of thickness or course.

(c) Nonspecification Compaction - Take corrective measures immediately, when it is determined specified compaction density is not achieved.

(d) Other Defects - Remove, replace with fresh, hot AC, and compact to conform to the surrounding area any AC that:

- Is loose, broken, or mixed with dirt.
- Shows visually too much or too little asphalt.
- Is defective in any way.

Remove and replace AC with defects, excesses, or deficiencies at the Contractor's expense.

00745.61 Longitudinal Joints - At longitudinal joints, bond, compact, and finish the new AC, equal to the AC against which it is placed.

(a) Location - Place the AC in panel widths which hold the number of longitudinal joints to a minimum. Offset the longitudinal joints in one panel by at least 6 inches from the longitudinal joints in the panel immediately below.

(1) Base Course - Place base course longitudinal joints within 12 inches of the edge of a lane, or within 12 inches of the center of a lane, except in irregular areas, unless otherwise shown.

(2) Wearing Course - Longitudinal joints shall not occur in the wearing course within the area or width of a traffic lane. On median lanes and on shoulder areas such joints shall occur only at lane lines or at points of change in the transverse slopes, as shown or as directed.

(b) Drop-offs:

- Provide warning signs and markings according to Section 00225 where abrupt or sloped edge drop-offs 1 or more inches in height occur.

- Protect edges from being broken down.

If unable to complete the pavement without drop-offs according to 00745.61(c):

- Construct and maintain a wedge of AC at a slope of 10:1 or flatter along the exposed longitudinal joint.

- Remove and dispose of the wedge before continuing paving operations.

- Construct, maintain, remove, and dispose of the temporary wedge at no expense to the Department, except the AC for the temporary wedge will be paid for at the bid item price.

(c) Placing AC Under Traffic - When placing AC pavement under traffic, schedule work for the nominal thickness being laid as follows:

(1) More Than 2 Inches - Schedule work so at the end of each working shift the full width of the area being paved, including shoulders, is completed to the same elevation with no longitudinal drop-offs.

(2) More Than 1 Inch But Not More Than 2 Inches - Schedule work so at the end of each working shift one panel of new travel lane pavement does not extend beyond the adjoining panel of new travel lane pavement more than the distance normally covered by each shift. At the end of each workweek complete the full width of the area to be paved, including shoulders, to the same elevation with no longitudinal drop-offs.

(3) 1 Inch and Less - No wedge is required.

00745.62 Transverse Joints:

(a) Travel Lanes - Construct transverse joints on the travel lane portion of all specified pavement courses, except leveling courses, as follows:

(1) Temporary End Panel - Maintain pavement depth, line, and grade at least 4 feet beyond the selected transverse joint location, and wedge down from that point on a 50:1 slope (length to depth) from the surface of the AC being laid to the surface beneath the hot AC. A 2-inch course requires a taper about 8-1/2 feet long. This wedge and the 4-foot or longer panel form the "temporary end panel".

(2) Vertical Face - After the mixture has reached the required density:

- Saw or cut the full depth of the course being laid to provide a smooth, vertical face at the location selected for the joint.

- Remove the AC material from the joint to the end of the panel. If removed before resuming paving beyond the joint, reconstruct the temporary end panel immediately by placing a bond-breaker of paper, dust, or other suitable material against the vertical face and on the surface to be occupied by the temporary end panel. Construct a full-depth panel at least 4 feet long, beginning at the sawed or cut joint, and taper it on a 50:1 slope (length to depth) to zero thickness.

(3) Excess AC - After completing a temporary end panel as specified, dispose of the unused remainder of AC as directed. Payment will be made for the entire load of AC, but will be limited to one load only per joint per panel.

(4) Resume Paving - When permanent paving resumes, remove the temporary end panel and any bond-breakers. Clean that surface of all debris. Then apply a tack coat to the vertical edge and the surface to be paved.

(5) Joint Requirements - Compact both sides of the joint to specified density. When tested with the straightedge placed across the joint, the joint surface shall conform to the specified surface tolerances.

(b) Abutting Bridge Ends - Compact AC abutting bridge ends, and other rigid type structures, in the transverse and/or diagonal direction, as well as longitudinally, as directed.

(c) Bridge Deck Overlays - Saw cut the wearing course of pavement directly over the joints in bridge decks, bridge end joints, and end panel end joints when applicable as soon as practical but within 48 hours of paving each stage of the wearing course. The saw cut shall be 3/8 inch wide, plus or minus 1/8 inch, and 1/2 inch less than the thickness of the panel of pavement to a maximum depth of 1-1/2 inches.

Flush the saw cut thoroughly with a high-pressure water stream immediately after the cut has been made. Before the cut drys out, blow it free of water and debris with compressed air. Fill the joint with a poured filler from the Department's Qualified Products Listing (QPL). No separate payment will be made for this work.

Finishing

00745.70 Pavement Smoothness - Furnish a 12-foot straightedge or a 12-foot rolling straightedge, and test as specified. Additional testing may be required. Mark areas not meeting the surface tolerance.

(a) Light Duty AC - Test with 12-foot straightedge parallel to and perpendicular to the centerline, as directed. The pavement surface shall not vary by more than 0.02 foot.

(b) Standard Duty and Heavy Duty AC:

(1) Single Course Construction - Test with the 12-foot straightedge parallel to and perpendicular to the centerline, as directed. The pavement surface shall not vary by more than 0.02 foot.

(2) Multiple Course Construction - Test the surface of the course on which the wearing course is placed according to (a) above.

Test the wearing surface with the rolling straightedge in the designated wheel path of a 500-foot strip of each travel lane per mile, where directed, and on each transverse joint throughout the project. Operate the rolling straightedge parallel to the centerline. The surface shall not vary more than 0.015 foot.

Also test the wearing surface with a 12-foot straightedge placed perpendicular to the centerline at least once within the above-mentioned 500-foot strip. It shall not vary by more than 0.02 foot.

If the 500-foot testing strip meets the specifications, no further testing of the mile represented by the testing strip will be required, except at the transverse joints. If any part of the testing strip does not meet the specifications, both wheel paths of the entire mile shall be tested.

(c) Utility Appurtenances - If the Contractor is required to construct or adjust utility appurtenances, such as manhole covers and valve boxes, the tolerances stated in (a) and (b) above apply. These tolerances do not apply at utility appurtenances adjusted by others.

(The following Smoothness Testing provision is to be included in provisions of projects identified for experimental testing.)

00745.71 Special Smoothness Testing - Test the finished surface of the wearing course of the Asphalt Concrete Pavement. This testing is to provide information only. The acceptance of the pavement will be in accordance with subsection 00745.70 herein.

Perform tests in accordance with the following:

(a) Equipment - Profilograph - Provide a California type profilograph complete with recorder for determining the profile index of the pavement according to OSHD TM 770.

The profilograph shall be on the project, calibrated, in good working condition, and ready for operation before construction of the wearing course of asphalt concrete pavement begins. The operator shall be competent and experienced in operation of the equipment.

California type profilographs are available from the following sources:

James Cox & Sons, Inc.
P.O. Box 674
Colfax, CA 95713
Telephone: (916) 346-8322
FAX (916) 346-6854

The Gilson Co., Inc.
P.O. Box 677
Worthington, Ohio 43085
Telephone: 1-800-444-1508
FAX (614) 548-5314

International Concrete Pipe Machinery Co.
P.O. Box 1708
Sioux City, Iowa 51102-1708
Telephone: (712) 277-8111

Ames Profilograph
200 Rockwell Avenue
Ames, Iowa 50010
Telephone: (515) 292-8194

(b) Testing - Profiles shall be made for each wheelpath for each travel lane in accordance with OSHD TM 770. Do not test ramps, bridges, pavement on horizontal curves with centerline radii of less than 1000 feet, and pavement within the superelevation transition of such curves, or pavement on horizontal curves with a superelevation rate of 0.100 ft/ft or greater.

Obtain profiles on the pavement surface along lines parallel to and approximately 3 feet from each edge and longitudinal joint(s) in the travel lanes. The intent is to obtain a profile in each wheelpath. The thirteen feet on either end of the project and on either end of bridges will not be profiled.

Run the profiles for each day's production as soon as possible. The daily profiles shall initially be analyzed by the Contractor as described in (c) below. The profiles and results will be given to the Engineer within 24 hours of the conclusion of the day's paving.

(c) Determination of the Profile Index:

1. General - Determine the profile index of pavement in 0.1 mile segments and partial segments. A segment will end as a partial segment and a new segment will begin when the segment sequence is interrupted by stage construction or by areas excluded from these smoothness requirements.

2. Method of Analysis - Determine the profile index and individual deviations of 0.3 inches or more by analyzing the profile charts according to OSHD TM 770 and provide the profile charts and results to the Engineer for review.

3. Profile Index - The profile index is the inches per mile in excess of the 0.2 inch blanking band. The formula for converting counts to profile index is:

$$\text{Profile Index} = \frac{\text{Total Count} * 0.10}{\text{Length of full 0.10 mile segment or partial segment*}}$$

*Report to the nearest one hundredth of a mile.

(Use the following on all projects.)

00745.75 Correction of Pavement Roughness - Correct equipment or paving operation procedures immediately, when tests show the pavement smoothness is not according to 00745.70. In addition:

(a) Methods - Correct surface roughness to the required tolerances, using one of the following methods as approved.

- Remove and replace the wearing surface lift.
- Grind the pavement surface to a maximum depth of 0.3 inch, and apply an emulsion fog seal as directed.

(b) Time Limit - Complete correction of all surface roughness within 14 calendar days following notification, unless otherwise directed.

Measurement

(Obtain the specific gravity for the project from the Materials Section.)

00745.80 General - The quantities of AC shown in the Bid Schedule were computed on the basis of aggregates having a Specific Gravity of _______.

When the Contractor notifies the Engineer what source is to be used to produce AC aggregates, the Engineer will recompute the quantities of AC to be used, and inform the Contractor in writing. The pay quantities of AC will be adjusted accordingly with no adjustment in contract unit prices. The provisions of 00140.20 and 00195.20 will apply.

00745.81 AC and Asphalt - The quantities of AC and asphalt in the mixture will be measured for payment as follows:

(a) AC - The quantity of each class of AC used in the accepted work will be measured for payment by the ton. No deduction will be made for the weight of the asphalt, lime, or any other additive used in the mixture as required by the specifications or as ordered. Weigh each pay load of AC on vehicle scales conforming to 00190.20.

(b) Asphalt - Unless there is a bid item "Asphalt in Mixture", no measurement of the quantity of asphalt used in the mixture will be made.

If there is an item "Asphalt in Mixture" the quantity of asphalt used in the accepted work will be measured for payment by the ton, according to Section 00190. Measurement will be based on acceptance tests averaged to the nearest 0.01 percent, if, in the opinion of the Engineer, invoice and tank stickings are not appropriate, such as when RAP is used or when mixture is furnished to others.

6-94 (c) Lime - There will be no separate measurement of this material.

00745.82 Other Bid Items - When indicated by appropriate pay items in the Bid Schedule, extra or additional measurement will be made for AC work in approaches, driveways, walks, and other miscellaneous structures, according to Section 00749.

(Delete the following subsection if not applicable.)

00745.83 Measurement - Profilograph Testing - There will be no measurement of this work.

Payment

00745.90 General - Work described in 00745.42 will be paid for according to the sections applicable to the work performed. Reconditioning of the old roadway will not be paid for separately, unless an appropriate pay item is given in the Bid Schedule. When extra or additional payment is to be made for AC approaches, driveways, walks and other miscellaneous structures, according to 00745.82, payment will be made according to Section 00749. When a panel consists of both temporary and permanent courses, payment for the entire panel will be based on the permanent course.

Payment for all acceptable AC incorporated into the project, whether or not recycled materials are used, will be made under applicable pay items and pay units, as follows:

(Include the word "Mixture" in item (a) and (b) when item (c) is a bid item. Delete item (b) when not required.)

Pay Item	Unit of Measurement
(a) _____ Class ____ _______ Asphalt Concrete (Mixture)	Ton
(b) _____ Class ____ _______ Asphalt Concrete (Mixture) in (Leveling, Temporary, Leveling and Temporary)	Ton
(c) _____ Asphalt in Mixture	Ton

In items (a) and (b), the types of AC, (Light Duty, Standard Duty, or Heavy Duty), will be inserted in the first blank. The respective class(es) of AC will be inserted in the second blank. The words "Lime Treated" will be inserted in the third blank when applicable.

In item (c), the performance based asphalt binder grades will be inserted in the blank. This item applies to all asphalt used in the mixtures, including residual asphalt in RAP.

(Delete the paragraph below if there is no lime on the project.)

There will be no separate payment for hydrated lime; it will be incidental to the other bid items.

Antistripping additives, other than lime, will be paid for at the Contractor's actual documented costs with no percentage allowance or markup allowed.

Each CPF, calculated according to 00165.30, 00745.16, and 00745.95, will be applied to the contract unit price for pay items (a), (b), and (c) above, and to the applicable lot quantities.

The following words and their abbreviations are listed in order to standardize and shorten pay item names when necessary:

Words	Abbreviations
Standard	Std.
Heavy	Hvy.
Asphalt Concrete	AC
Mixture	Mix
and	&
Temporary	Temp.

(Delete the following subsection when not applicable.)

00745.91 Payment - Profilograph Testing - Payment will be for the item "Profilograph Testing." Payment for profilograph testing at the lump sum amount will include payment in full for all materials, equipment and labor required to complete the work described.

00745.95 AC Price Adjustments - Use the following table to determine price adjustments in the CPF for constituents of AC:

Constituent	Weighing Factor "f"
All aggregate passing 1-1/2", 1-1/4", 1", 3/4", and 1/2" sieves according to 00745.12	1 Each
All aggregate passing 1/4"	5
All aggregate passing No. 10	5
All aggregate passing No. 40	3
Aggregate passing No. 200 sieve	10
Asphalt	26
Moisture content	8
Compaction (Density)	40

Those AC constituents statistically evaluated will be eligible for a maximum PF of 1.05 (see 00165.40(b-1)), unless otherwise specified.

When the CPF is greater than 1.000 for Light Duty AC and for material used in temporary surfacing and leveling courses for Standard Duty and Heavy Duty AC, it will be reduced as follows:

Reduction in CPF = (CPF-1) x 0.5

If these specifications do not require measurement of a constituent, its individual PF will be considered 1.00 in calculating the CPF according to 00165.30.

A price adjustment will be determined by the following formulas:

When in bonus for Light Duty AC and for temporary surfacing and leveling courses for Standard Duty and Heavy Duty AC:

[(CPF-1)x0.5]x[(JMF % ÷ 100 x Asphalt Bid Price)+(AC Bid Price)]x(LQ) = ____

All other instances:

(CPF-1) x [(JMF % ÷ 100 x Asphalt Bid Price)+(AC Bid Price)] x (LQ) = ____

Where:

JMF % is the asphalt cement % from the JMF. LQ is the quantity of mixture in the lot.

APPENDIX C

Field Survey Data

a) Field Survey

Table C.1. August 1993 field results for Marquam - N. Tigard

Section:	Marquam - N. Tigard		north
Milepost:	296.5		

RUTTING		
Outside	IWP	1/4" - 1/8"
	OWP	none

PERMEABILITY	MP 296.4		
Shoulder	2.23	1.93	1.67	1.79
IWP				
OWP	0.93	0.89		
BWP	0.81	0.84		
	MP 296.5			
Shoulder	1.38	1.42		
IWP	1.21	1.27		
OWP	1.06	0.79	0.76	
BWP	1.06	1.23	1.15	1.21

SAND PATCH		
Shoulder	7.7	7.8
IWP	7.5	7
BWP	6.8	6.8
OWP	6.5	6.5

Note: pavement in good condition, but bad spot was noticed in pavement a
see picture numbers 001 and 002

Table C.2. August 1993 field results for Hayesville - BattleCreek

SECTION:	Hayesville - Battlecreek	South
MILEPOST:	250.8	

RUTTING		
Outside	IWP	1/4"
	OWP	1/8"

PERMEABILITY		
Shoulder	1.50	1.54
IWP	0.98	1.02
OWP	0.77	0.74
BWP	1.00	0.97
B-mix taper	6.63	6.70

SAND PATCH		
Shoulder	7	7
IWP	6.1	6.2
BWP	6.2	6.3
OWP	6.5	6.3
B-mix taper	11.5	11.7

Table C.3. August 1993 field results for Jumpoff Joe - N. Grants Pass

SECTION: J.O. Joe - N. Grants Pass		North
MILEPOST: 64.7		

RUTTING		
Outside	IWP	0- 1/8"
	OWP	0

PERMEABILITY		
Shoulder	0.85	0.80
IWP	0.65	0.67
BWP	1.00	0.96
OWP	1.28	1.23

Note: Timer for permeameter did not work for this location. Manual stop watch had to be used.

SAND PATCH		
Shoulder	5.2	5.3
IWP	5.5	5.7
BWP	6.2	6.3
OWP	6.7	6.8

Note: For this site much of the sand escaped into the voids

Table C.4. August 1993 field results for E. Pendleton - Emigrant Hill

SECTION: E. Pendleton - Emigrant Hill		East
MILEPOST: 64.7		

RUTTING		
Outside	IWP	0
	OWP	0

PERMEABILITY			
Shoulder	1.12	1.25	1.18
IWP	0.96	0.77	0.80
BWP	1.30	1.34	1.33
OWP	0.96	0.97	0.84

SAND PATCH		
Shoulder		
IWP		
BWP		
OWP		

Note: Pavement was wet at this site so sand patch was unatainable

Table C.5. August 1993 field results for Murphy Road - Lava Butte

SECTION: Murphy Road - Lave Butte	South
MILEPOST: 146.7	

RUTTING		
Outside	IWP	1/4
	OWP	1/8 - 1/4

PERMEABILITY			
Shoulder	2.21	2.02	2.03
IWP	1.00	1.02	1.01
BWP	1.45	1.37	1.51
OWP 1	1.41	1.41	
OWP 2	0.80	0.96	0.96

SAND PATCH		
Shoulder	7.5	8.0
IWP	7.2	7.5
BWP	7.7	8.0
OWP	7.0	7.0

Note: Permeability for outside wheelpath conpleted twice, because the pavement had spots where aggregate had been picked out of the mat. This made a difference on the permeability as can be seen.

Table C.6. August 1993 field results for Oregon 138 project

SECTION: Oregon 138 Diamond Lk	North
MILEPOST: 82.3	

RUTTING		
Outside	IWP	1/8 - 3/8"
	OWP	1/4 - 1/2"

PERMEABILITY			
Shoulder	2.77	2.55	
IWP	2.87	2.92	
BWP	2.03	1.99	
OWP 2	1.51	1.44	

SAND PATCH		
Shoulder	7.7	7.5
IWP	7.2	7.5
BWP	8.2	8.0
OWP	8.0	7.7

Note: This section was badly deteriorated. Mumerous tranverse and fatigue cracks were evident. This made testing difficult.

Table C.7. September 1994 field results for Jumpoff Joe - N. Grants Pass

JumpOff Joe - N. Grants Pass		North	
MILEPOST: 64.7			

RUTTING		
Outside	IWP	1/8" -1/4"
	OWP	0-1/8"

PERMEABILITY			
Shoulder	0.75	0.74	7.10
IWP	0.83	0.97	0.96
OWP	1.61	1.45	1.49
BWP	0.71	0.71	0.77

SANDPATCH		
Shoulder		
IWP		
BWP		
OWP		

NOTE: Sandpatch measurements were not taken at this site
High pavement voids caused sand to run into pavement
and scew results

Table C.8. September 1994 field results for E. Pendleton - Emigrant Hill

E. Pendleton - Emigrant Hill		East	
MILEPOST: 214.2			

RUTTING		
Outside	IWP	1/8"
	OWP	0-1/8"

PERMEABILITY			
Shoulder	1.56	1.32	1.40
IWP	0.87	0.88	0.77
OWP	0.93	0.96	0.98
BWP	0.94	0.83	0.88

SANDPATCH		
Shoulder	7.0	6.7
IWP	6.5	6.2
BWP	6.5	6.3
OWP	6.7	6.2

Table C.9. September 1994 field results for Murphy Road - Lava Butte

Murphy Road - Lava Butte	South
MILEPOST: 146.8	

RUTTING		
Outside	IWP	1/8" - 1/4
	OWP	1/4"

PERMEABILITY			
Shoulder	1.68	1.50	1.20
IWP	1.32	1.37	1.35
OWP	1.08	1.06	1.02
BWP	1.67	1.73	1.83

SANDPATCH		
Shoulder	7.5	8.0
IWP	7.0	7.1
BWP	8.0	8.3
OWP	7.0	7.5

Table C.10. Interstate 5 traffic volume information

MP	1986	1987	1988	1989	1990	1991	1992
291.8	88400	94000	102400	103100	108800	109900	115000
293	58400	63900	69200	78200	70150	73900	79000
293.52	57800	63300	68500	67200	69200	73200	78000
294.74	72100	75800	82100	81900	83800	88200	93000
295.43	76800	81300	86900	86000	87850	90400	96000
296.24	75500	79600	85100	84100	85900	88200	94000
296.45	80700	84700	90600	89300	9100	94300	100000
297.08	87300	92100	99600	98900	100650	103600	10800
298.24	96000	101500	108300	108200	109900	113100	118000
299.13	93600	98800	106100	105000	106700	109600	114000
299.46	82800	87200	95100	92600	94100	95200	100000
300.37	87100	99900	107000	104400	101900	88100	94000
AVE	79708	85175	91742	91575	85671	93975	90983

MP	1986	1987	1988	1989	1990	1991	1992
251.03				36850	39600	40300	45000
253.48	32000	34000	39800	47050	48300	49800	52000
255.98	42800	45500	56200	59400	58750	59750	62000
258.26	42900	45600	54400	57450	56900	57950	56000
AVE	39233	41700	50133	50188	50888	51950	53750

MP	1986	1987	1988	1989	1990	1991	1992
71.29	13850	14300	15250	15800	16300	16250	17000
75.73	13350	13800	14750	14751	15900	15900	16000
76.5	12300	12700	13550	15300	14650	14650	15000
77.91	13350	13800	14700	15300	15600	15550	16000
80.3	13450	13900	14800	15400	15750	15700	16000
83.06	13600	14000	14450	15100	15600	15550	16000
85.84	13450	13600	14100	14800	15100	15050	16000
87.79	13450	13900	14350	15100	15500	15400	16000
AVE	13350	13750	14494	15194	15550	15506	16000

MP	1986	1987	1988	1989	1990	1991	1992
61.05	21150	21900	23950	24800	24650	24050	28000
64.2	14250	14800	15750	16300	16800	16800	17000
AVE	17700	18350	19850	20550	20725	20425	22500

U.S. 97 Traffic Volumes

MP	1986	1987	1988	1989	1990	1991	1992
141	15900	16500	19800	20600	23700	25400	25000
141.5	13700	14200	18300	19000	28500	30500	29000
142.27	11500	12000	13200	13800	15700	16900	18000
143.47	10200	10600	9800	10200	13600	14600	15000
AVE	12825	13325	15275	15900	20375	21850	21750

Interstate 84 Traffic Volumes

MP	1986	1987	1988	1989	1990	1991	1992
213.45	6000	6400	5151	6650	7300	7400	8800
216.44	5350	5700	46000	6150	6650	6650	8300
AVE	5675	6050	25576	6400	6975	7025	8550

Table C.11. Jumpoff Joe - N. Grants Pass accident data

	Fatal	Non-Fatal	Property Damage	Total	Killed	Injured
	Accident Data					
Intersection						
1986	0	0	0	0	0	0
1987	0	1	1	2	0	1
1988	0	0	1	1	0	0
1989	0	0	0	0	0	0
1990	0	0	1	1	0	0
1991	0	0	0	0	0	0
1992	0	1	1	2	0	1
1993	0	0	0	0	0	0
TOTAL	0	2	4	6	0	2
Non-Intersection						
1986	0	9	6	15	0	16
1987	1	6	7	14	2	10
1988	1	7	9	17	1	15
1989	1	10	18	29	1	15
1990	1	7	15	23	1	12
1991	0	7	12	19	0	10
1992	0	9	7	16	0	13
1993	0	5	4	9	0	9
TOTAL	4	60	78	142	5	100

Table C.12. Hayesville - BattleCreek accident data

	Fatal	Non-Fatal	Property Damage	Total	Killed	Injured
	Accident Data					
Intersection						
1986	0	6	4	10	0	8
1987	0	5	1	6	0	7
1988	0	4	1	5	0	5
1989	0	2	3	5	0	2
1990	0	5	3	8	0	5
1991	0	4	5	9	0	6
1992	0	3	4	7	0	5
1993	0	3	2	5	0	5
TOTAL	0	32	23	55	0	43
Non-Intersection						
1986	2	23	19	44	2	29
1987	0	26	27	53	0	43
1988	1	17	20	38	1	24
1989	0	32	24	56	0	62
1990	1	30	38	69	1	54
1991	3	23	22	48	4	42
1992	1	29	32	62	1	57
1993	2	25	30	57	2	36
TOTAL	10	205	212	427	11	347

Table C.13. Marquam Bridge - N. Tigard Interchange accident data

	Accident Data					
	Fatal	Non-Fatal	Property Damage	Total	Killed	Injured
Intersection						
1986	1	14	14	29	1	19
1987	1	11	14	26	1	21
1988	0	9	15	24	0	12
1989	0	18	19	37	0	27
1990	0	15	20	35	0	23
1991	0	18	17	35	0	25
1992	0	12	11	23	0	18
1993	0	4	9	13	0	12
TOTAL	2	101	119	222	2	157
Non-Intersection						
1986	1	14	14	29	1	19
1987	1	11	14	26	1	21
1988	0	9	15	24	0	12
1989	0	18	19	37	0	27
1990	0	15	20	35	0	23
1991	0	18	17	35	0	25
1992	0	12	11	23	0	18
1993	0	4	9	13	0	12
TOTAL	2	101	119	222	2	157

Table C.14. E. Pendleton - Emigrant Hill accident data

	Accident Data					
	Fatal	Non-Fatal	Property Damage	Total	Killed	Injured
Intersection						
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	0	0	0	0	0	0
1992	0	0	0	0	0	0
1993	0	0	0	0	0	0
TOTAL	0	0	0	0	0	0
Non-Intersection						
1986	0	1	5	6	0	1
1987	1	1	3	5	1	2
1988	0	1	0	1	0	2
1989	0	0	1	1	0	0
1990	0	2	1	3	0	3
1991	2	1	2	5	3	6
1992	0	2	3	5	0	5
1993	0	0	1	1	0	0
TOTAL	3	8	16	27	4	19

Table C.15. Murphy Road - Lava Butte accident data

	Accident Data					
	Fatal	Non-Fatal	Property Damage	Total	Killed	Injured
Intersection						
1986	**	**	**	**	**	**
1987	**	**	**	**	**	**
1988	0	3	6	9	0	4
1989	0	5	2	7	0	7
1990	0	8	5	13	0	16
1991	0	4	6	10	0	6
1992	0	17	10	27	0	43
1993	0	5	8	13	0	6
TOTAL	0	42	37	79	0	82
Non-Intersection						
1986	**	**	**	**	**	**
1987	**	**	**	**	**	**
1988	0	11	11	22	0	19
1989	3	10	14	27	4	32
1990	2	8	9	19	2	26
1991	0	5	14	19	0	9
1992	1	8	13	22	1	18
1993	1	7	11	19	1	11
TOTAL	7	49	72	128	8	115

** No data availiable for 1986 and 1987.

b) Noise Study Data

Table C.16. Traffic data for exterior noise study

			N	S	N	S	N	S	Pavement	Width
MP 34 S BND (I-	3/22/94	2:00 PM	773	701	72	44	116	110	PCC	76 Feet
		3:02 PM	884	622	66	39	143	115		
		4:04 PM	947	675	57	28	134	102		
		5:06 PM	930	548	50	23	95	90		
MP 34 N BND (I-	3/23/94	9:18 AM	531	691	65	34	140	102	PCC	76 Feet
		10:19 AM	606	772	78	44	140	94		
		11:20 AM	660	747	72	24	122	91		
		12:22 PM	740	723	55	29	143	94		
MP 208 S BND (	3/24/94	10:43 AM	817	795	89	46	205	143	B - North	77 Feet
		11:44 AM	841	757	87	42	173	164	F- South	
		12:45 AM	806	732	94	55	163	131		
		1:49 AM	880	806	71	41	178	148		
MP 208 N BND (	3/24/94	3:39 PM	919	911	81	48	151	133	B - North	77 Feet
		4:40 PM	903	1013	62	28	140	115	F- South	
		5:44 PM	737	851	45	18	165	98		
		6:46 PM	540	567	26	13	134	101		
MP 248 S BND (	3/25/94	8:28 AM	1195	1058	65	76	166	132	B	Barrier
		9:30 AM	1506	1086	86	74	189	188		
		10:34 AM	1519	1250	110	131	160	131		
		11:35 AM	1456	1215	92	60	199	178		
MAY TESTING										
Measurement Lo	Date	Time	Autos		Medium Trucks		Heavy Trucks		Existing	Median
			N	S	N	S	N	S	Pavement	Width
MP 34.52 S BN	05/11/94	01:45	734	600	47	34	127	101	B-mix	76 feet
		02:48	934	582	45	37	127	103		
		03:51	962	676	35	44	94	108		
		04:53	996	700	42	39	93	93		
MP 34 N BND	05/12/94	08:22	496	676	54	29	120	83	Bmix	76 feet
		09:26	537	717	56	44	109	97		
		10:31	579	736	61	55	114	101		
		11:33	646	684	38	56	120	93		
JULY TESTING										
Measurement Lo	Date	Time	Autos		Medium Trucks		Heavy Trucks		Existing	Median
			N	S	N	S	N	S	Pavement	Width
MP 34 N BND	07/27/94	08:10	536	754	57	51	118	108	F-mix	76 feet
		09:12	617	737	58	44	122	121		
		10:15	672	755	53	65	117	134		
		11:18	728	743	57	62	112	102		
MP 34.52 S BND	07/26/94	01:38	809	727	73	46	118	134	F-mix	76 feet
		02:45	916	736	54	62	114	134		
		03:47	1033	790	48	63	106	103		
		04:58	1084	624	45	35	105	112		
MP 208 N BND	07/22/94	12:59	1059	1055	76	81	135	145	F-mix	77 feet
		02:06	1175	1193	75	88	122	159		
		03:10	1267	1203	77	86	109	137		
		04:13	1208	1380	76	71	112	137		
MP 248 S BND	07/28/94	07:48	1150	1090	76	99	208	143	F-mix	Barrier
		08:52	1198	990	95	130	248	197		
		09:56	1191	1112	92	144	251	216		
		11:00	1226	1155	116	114	220	204		

Table C.17. BattleCreek - N. Jefferson 1-year-old B-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	111.7	SEL	112.4	SEL	111.9	SEL	112.1
Leq	76.1	Leq	76.8	Leq	76.3	Leq	76.5
SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25		25	39.6	25	40.0	25	40.0
31.5	39.2	31.5	39.3	31.5	39.4	31.5	39.3
40	39.8	40	40.8	40	41.3	40	41.2
50	41.6	50	42.3	50	42.8	50	42.6
63	47.2	63	47.5	63	47.6	63	48.2
80	52.4	80	53.7	80	53.2	80	54.0
100	53.0	100	54.5	100	54.4	100	55.5
125	53.3	125	54.3	125	54.5	125	54.1
160	54.8	160	56.7	160	55.9	160	56.7
200	56.8	200	58.1	200	57.3	200	58.1
250	57.3	250	59.3	250	58.2	250	58.8
315	59.1	315	60.8	315	60.2	315	60.6
400	61.4	400	62.7	400	62.2	400	62.5
500	64.8	500	65.8	500	65.0	500	65.4
630	67.3	630	67.9	630	67.3	630	67.6
800	69.4	800	69.9	800	69.4	800	69.5
1000	69.4	1000	69.9	1000	69.5	1000	69.6
1250	67.6	1250	68.1	1250	67.7	1250	67.8
1600	64.5	1600	65.0	1600	64.6	1600	64.6
2000	62.1	2000	62.7	2000	62.1	2000	62.5
2500	58.9	2500	59.7	2500	59.0	2500	59.5
3150	57.0	3150	57.4	3150	56.4	3150	57.4
4000	54.4	4000	54.9	4000	54.0	4000	55.3
5000	50.6	5000	51.3	5000	50.4	5000	51.8
6300	47.5	6300	48.3	6300	47.3	6300	47.8
8000	44.5	8000	45.1	8000	44.9	8000	44.9
10000	42.3	10000	42.1	10000	41.9	10000	42.0
12500	39.3	12500	39.3	12500	39.3	12500	39.2
16000	39.6	16000	39.4	16000	39.2	16000	39.3
20000	39.1	20000	39.1	20000	39.1	20000	39.1

Table C.18. BattleCreek - N. Jefferson new F-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	107.4	SEL	107.9	SEL	108.1	SEL	107.7
Leq	71.9	Leq	72.4	Leq	72.6	Leq	72.2
SEL-Leq	35.5	SEL-Leq	35.5	SEL-Leq	35.5	SEL-Leq	35.5
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	39.7	25	40.0	25	40.8	25	41.6
31.5	39.9	31.5	40.1	31.5	40.5	31.5	40.7
40	43.8	40	44.3	40	44.5	40	45.1
50	42.7	50	43.0	50	43.6	50	43.7
63	47.5	63	47.5	63	47.6	63	47.5
80	54.0	80	53.5	80	54.3	80	53.5
100	54.3	100	53.9	100	54.7	100	54.9
125	53.1	125	53.1	125	53.9	125	53.6
160	55.5	160	55.7	160	56.0	160	55.6
200	56.3	200	56.8	200	57.1	200	57.3
250	57.7	250	57.8	250	58.4	250	58.2
315	59.3	315	60.5	315	60.7	315	60.1
400	60.7	400	62.6	400	62.6	400	61.8
500	62.6	500	63.7	500	63.6	500	63.5
630	62.3	630	63.0	630	63.1	630	63.0
800	62.5	800	62.9	800	63.1	800	62.6
1000	62.9	1000	63.1	1000	63.3	1000	62.9
1250	62.6	1250	62.9	1250	63.0	1250	62.5
1600	60.5	1600	60.7	1600	61.0	1600	60.5
2000	59.1	2000	59.1	2000	59.5	2000	59.0
2500	57.4	2500	57.3	2500	57.8	2500	57.4
3150	55.2	3150	55.2	3150	55.6	3150	55.2
4000	53.6	4000	53.1	4000	53.8	4000	53.4
5000	51.5	5000	50.9	5000	51.6	5000	51.1
6300	47.6	6300	47.5	6300	48.1	6300	47.8
8000	45.7	8000	45.7	8000	46.1	8000	46.0
10000	42.4	10000	42.5	10000	42.9	10000	42.9
12500	39.7	12500	39.6	12500	39.7	12500	39.7
16000	39.5	16000	39.5	16000	39.5	16000	39.5
20000	39.5	20000	39.5	20000	39.5	20000	39.5

Table C.19. Halsey Interchange - Lane County Line (north) 1-year-old B-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	108.6	SEL	108.6	SEL	108.7	SEL	107.4
Leq	73	Leq	73	Leq	73.1	Leq	71.8
SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	39.9	25	39.9	25	39.8	25	39.4
31.5	39.4	31.5	39.3	31.5	39.3	31.5	39.3
40	41.4	40	40.8	40	40.7	40	40.3
50	42.5	50	42.1	50	42.2	50	41.3
63	46.0	63	46.5	63	46.7	63	45.3
80	53.2	80	52.7	80	53.1	80	52.6
100	53.5	100	53.7	100	53.7	100	52.6
125	53.0	125	53.5	125	54.6	125	51.7
160	54.7	160	54.4	160	54.8	160	52.8
200	55.1	200	55.8	200	55.5	200	54.4
250	53.9	250	53.9	250	54.1	250	52.8
315	55.1	315	54.9	315	56.5	315	53.7
400	57.2	400	57.3	400	57.5	400	55.9
500	62.0	500	62.0	500	62.2	500	61.3
630	63.7	630	63.6	630	63.8	630	62.5
800	65.9	800	65.9	800	65.9	800	64.7
1000	66.3	1000	66.5	1000	66.5	1000	65.2
1250	64.9	1250	64.8	1250	64.9	1250	63.5
1600	62.0	1600	61.8	1600	61.9	1600	60.6
2000	59.5	2000	59.3	2000	59.4	2000	58.3
2500	56.6	2500	56.4	2500	56.5	2500	55.3
3150	55.1	3150	54.9	3150	55.0	3150	54.1
4000	52.5	4000	52.3	4000	52.3	4000	51.7
5000	49.3	5000	49.1	5000	49.0	5000	49.1
6300	46.0	6300	46.1	6300	46.0	6300	45.8
8000	43.8	8000	43.8	8000	43.7	8000	43.5
10000	41.7	10000	41.8	10000	41.8	10000	41.6
12500	39.1	12500	39.2	12500	39.1	12500	39.2
16000	39.1	16000	39.1	16000	39.1	16000	39.1
20000	39.1	20000	39.1	20000	39.1	20000	39.1

Table C.20. Halsey Interchange - Lane County Line (north) new F-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	104.1	SEL	104	SEL	104.4	SEL	105
Leq	68.5	Leq	68.5	Leq	68.8	Leq	69.4
SEL-Leq	35.6	SEL-Leq	35.5	SEL-Leq	35.6	SEL-Leq	35.6
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	34.8	25	34.8	25	35.4	25	34.9
31.5	34.0	31.5	35.1	31.5	36.7	31.5	36.3
40	38.0	40	38.9	40	40.3	40	40.0
50	39.1	50	39.9	50	41.8	50	41.9
63	43.3	63	43.6	63	45.3	63	45.5
80	50.9	80	50.2	80	50.4	80	50.9
100	51.2	100	51.0	100	51.0	100	51.8
125	51.2	125	50.6	125	51.0	125	51.5
160	50.9	160	50.8	160	50.6	160	51.3
200	52.8	200	52.6	200	52.6	200	53.0
250	54.4	250	54.1	250	53.9	250	54.9
315	57.2	315	56.5	315	56.7	315	57.0
400	57.0	400	56.5	400	57.2	400	57.4
500	58.2	500	58.1	500	58.1	500	58.6
630	57.8	630	57.9	630	58.2	630	58.7
800	59.7	800	59.8	800	60.2	800	60.8
1000	60.4	1000	60.6	1000	61.1	1000	61.6
1250	59.1	1250	59.4	1250	59.8	1250	60.7
1600	56.5	1600	56.5	1600	57.0	1600	57.7
2000	55.0	2000	55.2	2000	55.5	2000	56.3
2500	54.7	2500	54.9	2500	55.1	2500	55.9
3150	52.7	3150	52.7	3150	52.5	3150	52.6
4000	50.5	4000	50.1	4000	50.6	4000	51.3
5000	48.1	5000	47.6	5000	47.5	5000	47.9
6300	43.9	6300	43.7	6300	43.9	6300	44.7
8000	40.8	8000	40.7	8000	40.8	8000	41.5
10000	36.8	10000	36.7	10000	37.0	10000	37.4
12500	31.0	12500	31.1	12500	31.2	12500	31.4
16000	30.0	16000	30.0	16000	30.1	16000	30.2
20000	29.5	20000	29.5	20000	29.5	20000	29.5

Table C.21. Halsey Interchange - Lane County Line (south) 1-year-old B-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	106.7	SEL	107.2	SEL		SEL	106.7
Leq	71.2	Leq	71.7	Leq	70.8	Leq	71.2
SEL-Leq	35.5	SEL-Leq	35.3	SEL-Leq		SEL-Leq	35.5
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	39.6	25	39.7	25	39.6	25	39.6
31.5	39.2	31.5	39.3	31.5	39.4	31.5	39.3
40	40.4	40	40.7	40	40.7	40	40.7
50	41.4	50	42.4	50	42.1	50	42.1
63	45.3	63	45.7	63	45.3	63	44.6
80	52.3	80	52.5	80	51.9	80	52.1
100	52.4	100	52.6	100	53.1	100	52.4
125	51.5	125	52.6	125	51.7	125	51.7
160	52.9	160	53.4	160	52.9	160	52.9
200	54.6	200	55.1	200	54.5	200	54.6
250	54.5	250	55.6	250	54.3	250	54.9
315	57.4	315	58.6	315	57.3	315	57.3
400	57.9	400	58.7	400	57.9	400	57.9
500	62.1	500	62.3	500	61.4	500	61.9
630	63.5	630	63.9	630	63.2	630	63.5
800	64.1	800	64.5	800	63.9	800	64.2
1000	62.7	1000	63.1	1000	62.3	1000	62.7
1250	59.9	1250	60.8	1250	59.6	1250	60.0
1600	57.4	1600	58.3	1600	57.4	1600	57.5
2000	56.5	2000	57.6	2000	57.0	2000	56.9
2500	52.2	2500	55.4	2500	54.1	2500	54.5
3150	52.9	3150	54.1	3150	53.1	3150	53.2
4000	51.5	4000	52.6	4000	51.7	4000	51.7
5000	48.6	5000	50.7	5000	48.3	5000	48.5
6300	45.5	6300	48.2	6300	45.3	6300	45.5
8000	43.5	8000	44.4	8000	43.4	8000	43.5
10000	41.5	10000	42.6	10000	41.8	10000	41.7
12500	39.2	12500	39.7	12500	39.3	12500	39.2
16000	39.4	16000	39.9	16000	39.6	16000	39.6
20000	39.1	20000	39.3	20000	39.1	20000	39.1

Table C.22. Seven Oaks - Jackson (south) old PCC exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	112	SEL	112.1	SEL	111.8	SEL	
Leq	76.4	Leq	76.5	Leq	76.2	Leq	74
SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	30.1	25	30.6	25	30.2	25	33.4
31.5	30.5	31.5	31.0	31.5	30.6	31.5	32.8
40	34.2	40	34.6	40	34.1	40	34.1
50	37.3	50	37.9	50	37.2	50	36.5
63	43.6	63	44.4	63	43.7	63	41.2
80	51.8	80	53.0	80	51.0	80	49.2
100	51.7	100	53.1	100	52.2	100	50.1
125	50.8	125	51.6	125	51.6	125	49.2
160	51.8	160	52.3	160	51.8	160	50.2
200	53.6	200	54.3	200	54.1	200	52.4
250	55.7	250	56.6	250	55.5	250	53.2
315	58.8	315	59.6	315	58.6	315	55.9
400	60.2	400	60.5	400	59.7	400	58.0
500	64.1	500	64.4	500	63.9	500	62.5
630	66.2	630	66.4	630	65.9	630	64.6
800	68.8	800	68.8	800	68.4	800	67.1
1000	69.7	1000	69.7	1000	69.4	1000	68.1
1250	68.6	1250	68.5	1250	68.4	1250	67.0
1600	66.6	1600	66.6	1600	66.6	1600	65.0
2000	64.5	2000	64.4	2000	64.4	2000	62.8
2500	61.1	2500	61.4	2500	61.2	2500	59.5
3150	58.4	3150	58.8	3150	58.4	3150	56.7
4000	55.3	4000	55.5	4000	55.3	4000	53.5
5000	51.6	5000	52.2	5000	51.7	5000	49.9
6300	46.9	6300	47.5	6300	47.1	6300	46.5
8000	42.1	8000	42.7	8000	42.3	8000	41.6
10000	37.1	10000	37.8	10000	37.3	10000	38.2
12500	30.5	12500	31.2	12500	30.5	12500	34.6
16000	29.1	16000	29.2	16000	29.1	16000	33.4
20000	29.1	20000	29.1	20000	29.1	20000	32.4

Table C.23. Seven Oaks - Jackson (south) new B-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	105.3	SEL	105	SEL	105.2	SEL	105.7
Leq	69.8	Leq	70	Leq	69.6	Leq	70.2
SEL-Leq	35.5	SEL-Leq	35	SEL-Leq	35.6	SEL-Leq	35.5
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	35.4	25	34.7	25	34.5	25	34.6
31.5	33.4	31.5	33.6	31.5	33.7	31.5	33.9
40	38.1	40	38.9	40	38.9	40	38.9
50	38.2	50	38.3	50	38.0	50	38.4
63	44.6	63	44.0	63	42.8	63	42.9
80	50.2	80	50.0	80	48.9	80	48.3
100	48.7	100	48.9	100	48.0	100	48.1
125	48.1	125	49.0	125	49.0	125	48.9
160	49.2	160	49.1	160	48.4	160	48.7
200	50.9	200	50.3	200	51.0	200	51.3
250	54.0	250	53.3	250	52.1	250	52.9
315	58.0	315	56.2	315	56.0	315	56.5
400	57.7	400	57.7	400	56.8	400	56.7
500	60.3	500	60.8	500	60.7	500	60.6
630	60.1	630	60.7	630	60.4	630	60.7
800	61.2	800	61.7	800	61.2	800	62.0
1000	61.7	1000	62.0	1000	61.8	1000	62.6
1250	60.4	1250	60.7	1250	60.6	1250	61.5
1600	58.6	1600	58.8	1600	58.4	1600	59.4
2000	57.3	2000	57.3	2000	57.1	2000	52.7
2500	54.6	2500	54.5	2500	54.6	2500	50.1
3150	52.9	3150	52.7	3150	52.4	3150	52.7
4000	50.6	4000	50.3	4000	50.0	4000	50.1
5000	47.0	5000	46.7	5000	46.5	5000	46.5
6300	43.5	6300	43.5	6300	43.1	6300	43.2
8000	40.2	8000	40.7	8000	40.3	8000	40.5
10000	36.8	10000	37.1	10000	36.9	10000	37.1
12500	32.6	12500	32.7	12500	32.6	12500	32.6
16000	32.2	16000	32.2	16000	32.2	16000	32.2
20000	32.2	20000	32.2	20000	32.2	20000	32.2

Table C.24. Seven Oaks - Jackson (south) new F-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	104.7	SEL	104.3	SEL	104.1	SEL	103.4
Leq	69.3	Leq	68.8	Leq	68.5	Leq	67.9
SEL-Leq	35.4	SEL-Leq	35.5	SEL-Leq	35.6	SEL-Leq	35.5
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	33.5	25	41.7	25	41.5	25	41.2
31.5	32.5	31.5	41.5	31.5	41.9	31.5	42.0
40	37.6	40	47.8	40	48.3	40	48.3
50	37.6	50	44.8	50	44.9	50	44.8
63	44.2	63	47.6	63	47.8	63	47.7
80	49.7	80	50.6	80	50.9	80	50.8
100	50.0	100	50.3	100	50.3	100	50.0
125	50.1	125	50.5	125	49.9	125	49.8
160	49.6	160	51.1	160	50.9	160	50.6
200	52.3	200	52.4	200	52.5	200	52.0
250	55.0	250	54.8	250	54.5	250	54.1
315	59.2	315	58.7	315	58.1	315	57.1
400	58.9	400	58.6	400	58.4	400	57.7
500	59.6	500	59.8	500	59.3	500	58.8
630	58.2	630	58.4	630	58.2	630	57.4
800	58.8	800	58.7	800	58.6	800	57.7
1000	60.4	1000	59.9	1000	59.7	1000	59.4
1250	60.2	1250	59.9	1250	59.5	1250	59.1
1600	58.1	1600	58.0	1600	57.8	1600	57.2
2000	56.4	2000	56.1	2000	56.0	2000	55.0
2500	54.9	2500	54.8	2500	54.7	2500	53.8
3150	52.8	3150	52.1	3150	52.0	3150	51.2
4000	51.0	4000	49.8	4000	49.9	4000	48.9
5000	47.3	5000	48.7	5000	49.0	5000	48.9
6300	42.9	6300	45.8	6300	46.1	6300	46.1
8000	39.1	8000	46.5	8000	47.0	8000	47.1
10000	35.6	10000	43.2	10000	43.6	10000	43.9
12500	30.3	12500	39.5	12500	39.5	12500	39.5
16000	29.5	16000	39.5	16000	39.5	16000	39.5
20000	29.5	20000	39.5	20000	39.5	20000	39.5

Table C.25. Seven Oaks - Jackson (north) old PCC exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	112.3	SEL	112.5	SEL	112.3	SEL	112.6
Leq	76.7	Leq	76.9	Leq	76.7	Leq	77.1
SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	36.5
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	30.4	25	32.1	25	33.0	25	32.7
31.5	30.7	31.5	33.3	31.5	34.2	31.5	33.4
40	33.4	40	36.4	40	37.1	40	36.5
50	37.2	50	39.6	50	40.1	50	39.5
63	44.1	63	45.1	63	44.9	63	44.9
80	51.9	80	51.2	80	51.6	80	51.7
100	52.2	100	52.0	100	52.2	100	52.5
125	52.4	125	52.6	125	52.7	125	53.1
160	54.1	160	54.5	160	53.9	160	54.5
200	57.1	200	57.2	200	56.8	200	57.4
250	58.3	250	58.2	250	58.0	250	58.8
315	60.4	315	60.0	315	59.8	315	60.5
400	60.8	400	60.4	400	60.1	400	60.6
500	63.7	500	63.9	500	53.6	500	64.1
630	65.6	630	65.8	630	65.5	630	66.0
800	68.3	800	68.7	800	68.4	800	68.8
1000	69.7	1000	70.2	1000	69.9	1000	70.2
1250	69.3	1250	69.5	1250	69.4	1250	69.6
1600	67.8	1600	67.8	1600	67.7	1600	68.0
2000	65.6	2000	65.4	2000	65.3	2000	65.7
2500	62.3	2500	61.8	2500	61.7	2500	62.0
3150	59.6	3150	58.9	3150	58.7	3150	58.9
4000	57.0	4000	56.3	4000	56.0	4000	56.3
5000	52.6	5000	51.7	5000	51.5	5000	51.8
6300	47.6	6300	46.9	6300	46.7	6300	47.1
8000	43.1	8000	42.7	8000	42.5	8000	43.0
10000	37.7	10000	37.3	10000	37.3	10000	37.5
12500	30.9	12500	30.7	12500	30.7	12500	30.8
16000	29.2	16000	29.1	16000	29.1	16000	29.1
20000	29.1	20000	29.1	20000	29.1	20000	29.1

Table C.26. Seven Oaks - Jackson (north) new B-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	106.2	SEL	105.9	SEL	105.8	SEL	105.6
Leq	70.6	Leq	70.3	Leq	70.2	Leq	70
SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	32.7	25	32.9	25	34.1	25	34.5
31.5	32.8	31.5	32.8	31.5	33.1	31.5	33.2
40	36.0	40	36.4	40	36.7	40	37.0
50	36.8	50	36.7	50	37.2	50	37.6
63	41.1	63	41.1	63	41.9	63	41.2
80	50.1	80	49.8	80	49.7	80	48.8
100	49.9	100	48.9	100	49.6	100	49.4
125	48.6	125	48.9	125	48.7	125	49.5
160	49.0	160	49.1	160	49.3	160	49.3
200	51.6	200	51.3	200	51.1	200	52.0
250	51.7	250	52.0	250	52.0	250	52.5
315	54.4	315	54.5	315	55.4	315	55.2
400	55.2	400	54.8	400	55.4	400	55.0
500	58.7	500	59.7	500	59.2	500	59.4
630	59.9	630	59.9	630	60.0	630	59.5
800	62.8	800	62.3	800	62.1	800	61.7
1000	63.5	1000	63.2	1000	62.8	1000	62.8
1250	62.4	1250	62.0	1250	61.9	1250	61.7
1600	60.5	1600	60.2	1600	60.0	1600	60.1
2000	58.7	2000	58.4	2000	58.3	2000	58.3
2500	56.2	2500	55.7	2500	55.9	2500	55.7
3150	54.6	3150	53.9	3150	53.8	3150	53.9
4000	51.5	4000	51.0	4000	50.9	4000	50.9
5000	48.4	5000	47.8	5000	47.7	5000	48.1
6300	44.0	6300	43.7	6300	43.7	6300	43.8
8000	40.4	8000	40.2	8000	40.5	8000	40.3
10000	36.8	10000	36.3	10000	36.5	10000	36.8
12500	32.6	12500	32.5	12500	32.5	12500	32.5
16000	32.2	16000	32.2	16000	32.2	16000	32.2
20000	32.2	20000	32.2	20000	32.2	20000	32.2

Table C.27. Seven Oaks - Jackson (north) new F-mix exterior noise data

First Hour		Second Hour		Third Hour		Fourth Hour	
SEL	104.1	SEL	103.9	SEL	104.1	SEL	104
Leq	68.5	Leq	68.3	Leq	68.5	Leq	68.4
SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6	SEL-Leq	35.6
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	39.7	25	40.0	25	42.1	25	42.3
31.5	39.8	31.5	39.8	31.5	40.8	31.5	41.4
40	43.1	40	44.0	40	45.6	40	47.1
50	41.8	50	42.1	50	43.5	50	44.2
63	43.3	63	43.5	63	45.3	63	46.5
80	50.4	80	49.9	80	50.3	80	50.2
100	51.2	100	50.9	100	50.9	100	51.2
125	51.0	125	50.8	125	50.9	125	51.5
160	50.3	160	51.0	160	51.3	160	52.0
200	51.7	200	52.4	200	52.3	200	53.1
250	53.7	250	53.6	250	54.2	250	54.2
315	58.2	315	58.0	315	58.4	315	58.2
400	58.8	400	58.9	400	59.0	400	58.7
500	59.4	500	59.6	500	59.6	500	61.0
630	57.9	630	58.0	630	58.3	630	58.4
800	58.4	800	58.2	800	58.6	800	58.5
1000	59.5	1000	59.0	1000	59.4	1000	59.4
1250	59.3	1250	58.9	1250	59.2	1250	58.9
1600	57.2	1600	56.9	1600	57.3	1600	57.0
2000	55.7	2000	55.4	2000	56.0	2000	55.8
2500	54.7	2500	54.2	2500	54.8	2500	54.5
3150	52.3	3150	52.2	3150	52.8	3150	51.9
4000	50.5	4000	50.5	4000	50.4	4000	50.2
5000	48.6	5000	48.5	5000	48.5	5000	48.8
6300	44.7	6300	44.6	6300	45.2	6300	45.7
8000	44.0	8000	44.2	8000	45.2	8000	46.2
10000	41.7	10000	41.5	10000	42.2	10000	43.1
12500	39.6	12500	39.5	12500	39.5	12500	39.5
16000	39.5	16000	39.5	16000	39.5	16000	39.5
20000	39.5	20000	39.5	20000	39.5	20000	39.5

Table C.28. Halsey Interchange - Lane County Line first run interior noise data

MP 216 - 214 SouthBound		MP 211 to 209 SouthBound		MP 208 - 205 SouthBound		MP 216 - 214 SouthBound		MP 216 - 214 SouthBound	
SEL	94	SEL	93.6	SEL	93	SEL	94.1	SEL	93.3
Leq	73.2	Leq	72.8	Leq	72.2	Leq	73.3	Leq	72.5
SEL-Leq	20.8	SEL-Leq	20.8	SEL-Leq	20.8	SEL-Leq	20.8	SEL-Leq	20.8
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	42.0	25	40.8	25	39.1	25	41.7	25	42.5
31.5	43.9	31.5	42.5	31.5	42.0	31.5	42.8	31.5	42.6
40	46.4	40	45.4	40	44.6	40	47.0	40	45.7
50	48.3	50	48.0	50	46.3	50	48.1	50	47.2
63	53.3	63	52.6	63	53.3	63	53.4	63	52.4
80	56.2	80	55.3	80	55.6	80	56.7	80	56.3
100	63.2	100	62.0	100	62.6	100	63.9	100	64.2
125	57.5	125	55.9	125	57.3	125	56.3	125	55.2
160	58.2	160	57.6	160	56.7	160	57.9	160	56.5
200	61.6	200	60.4	200	61.2	200	60.9	200	59.2
250	65.3	250	63.2	250	64.2	250	65.5	250	64.9
315	61.8	315	60.0	315	60.5	315	62.6	315	61.5
400	62.5	400	60.8	400	61.6	400	63.2	400	61.8
500	62.4	500	60.9	500	60.9	500	64.0	500	62.9
630	61.6	630	61.6	630	60.9	630	63.5	630	62.9
800	63.6	800	64.8	800	62.9	800	63.5	800	63.8
1000	60.9	1000	62.7	1000	59.6	1000	61.5	1000	60.0
1250	60.2	1250	62.9	1250	58.3	1250	59.5	1250	58.0
1600	57.4	1600	58.6	1600	55.7	1600	55.0	1600	53.2
2000	57.5	2000	56.9	2000	54.8	2000	52.8	2000	51.5
2500	55.6	2500	54.8	2500	53.2	2500	52.3	2500	50.4
3150	53.5	3150	52.8	3150	50.9	3150	51.5	3150	48.8
4000	50.6	4000	49.7	4000	48.1	4000	49.6	4000	46.6
5000	47.0	5000	46.3	5000	45.0	5000	48.2	5000	45.1
6300	42.5	6300	41.9	6300	40.6	6300	46.7	6300	42.5
8000	39.2	8000	38.7	8000	37.5	8000	44.7	8000	42.3
10000	35.9	10000	35.6	10000	34.6	10000	43.6	10000	41.1
12500	29.1	12500	29.3	12500	29.2	12500	41.8	12500	39.1
16000	29.1	16000	29.1	16000	29.6	16000	41.0	16000	39.4
20000	29.1	20000	29.1	20000	29.1	20000	40.3	20000	39.1

Table C.28. Halsey Interchange - Lane County Line first run interior noise data (continued)

MP 208 - 206 SouthBound		MP 206 - 204 SouthBound		MP 204 - 206 NorthBound		MP 207 - 209 NorthBound		MP 213 - 215 NorthBound	
SEL	92.8	SEL	92.7	SEL	92.7	SEL	93	SEL	91.6
Leq	72	Leq	72	Leq	72	Leq	72.2	Leq	70.8
SEL-Leq	20.8	SEL-Leq	20.7	SEL-Leq	20.7	SEL-Leq	20.8	SEL-Leq	20.8
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	42.8	25	43.3	25	42.1	25	42.3	25	42.1
31.5	43.3	31.5	43.2	31.5	42.5	31.5	42.7	31.5	42.7
40	46.1	40	46.0	40	44.4	40	44.3	40	45.4
50	47.7	50	47.6	50	47.2	50	47.1	50	46.0
63	52.5	63	52.1	63	51.5	63	51.6	63	52.1
80	56.2	80	55.9	80	53.8	80	53.6	80	53.9
100	63.7	100	63.2	100	62.9	100	63.0	100	62.8
125	55.5	125	55.1	125	56.1	125	56.5	125	54.7
160	56.5	160	56.1	160	56.1	160	55.9	160	55.7
200	59.3	200	59.0	200	61.7	200	61.5	200	60.2
250	64.8	250	64.2	250	63.4	250	63.8	250	61.6
315	61.4	315	61.0	315	59.3	315	59.7	315	57.9
400	61.7	400	61.3	400	61.0	400	61.5	400	60.0
500	62.9	500	62.0	500	60.2	500	60.7	500	58.8
630	64.0	630	62.6	630	61.1	630	61.8	630	59.9
800	64.7	800	63.4	800	63.5	800	63.9	800	61.9
1000	60.6	1000	59.8	1000	61.1	1000	61.3	1000	59.3
1250	58.7	1250	57.4	1250	59.5	1250	59.4	1250	58.2
1600	53.7	1600	53.3	1600	56.6	1600	56.2	1600	56.0
2000	51.7	2000	51.5	2000	53.4	2000	53.1	2000	53.0
2500	50.4	2500	50.3	2500	51.6	2500	51.3	2500	51.0
3150	48.7	3150	48.6	3150	50.3	3150	49.7	3150	49.6
4000	46.4	4000	46.2	4000	48.1	4000	47.5	4000	47.4
5000	44.5	5000	44.3	5000	46.1	5000	45.5	5000	45.5
6300	42.2	6300	42.1	6300	43.5	6300	42.9	6300	42.9
8000	42.1	8000	42.1	8000	42.3	8000	42.0	8000	42.0
10000	41.0	10000	40.9	10000	41.2	10000	41.1	10000	41.1
12500	39.1	12500	39.1	12500	39.1	12500	39.1	12500	39.1
16000	39.3	16000	39.3	16000	39.1	16000	39.1	16000	39.1
20000	39.1	20000	39.1	20000	39.1	20000	39.1	20000	39.1

Table C.29. Halsey Interchange - Lane County Line new F-mix, second run interior noise data

MP 249 SouthBound		MP 246 NorthBound		MP 248 - 250 SouthBound		MP 247 NorthBound	
SEL Leq SEL-Leq	72	SEL Leq SEL-Leq	71.5	SEL Leq SEL-Leq	71.9	SEL Leq SEL-Leq	72
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	41.8	25	42.4	25	42.0	25	41.6
31.5	45.0	31.5	44.6	31.5	45.1	31.5	45.8
40	47.0	40	46.6	40	46.7	40	46.7
50	47.7	50	47.2	50	47.5	50	48.8
63	53.0	63	52.2	63	51.9	63	52.5
80	57.3	80	55.0	80	57.3	80	56.9
100	60.9	100	60.7	100	51.2	100	61.0
125	55.3	125	54.3	125	55.1	125	55.9
160	58.5	160	58.4	160	58.7	160	57.7
200	59.0	200	58.4	200	58.7	200	59.1
250	63.9	250	63.2	250	63.1	250	63.4
315	61.3	315	60.6	315	61.1	315	60.3
400	62.7	400	61.9	400	61.9	400	62.2
500	63.4	500	62.5	500	62.3	500	62.5
630	61.3	630	60.9	630	61.4	630	61.3
800	61.1	800	61.4	800	62.0	800	61.9
1000	59.7	1000	60.1	1000	60.9	1000	60.8
1250	58.1	1250	58.4	1250	59.4	1250	59.1
1600	54.2	1600	53.9	1600	55.2	1600	55.1
2000	53.9	2000	53.2	2000	54.6	2000	54.6
2500	52.1	2500	51.3	2500	53.5	2500	52.7
3150	49.2	3150	48.5	3150	50.4	3150	50.0
4000	45.9	4000	45.2	4000	46.9	4000	47.7
5000	43.0	5000	42.7	5000	43.7	5000	45.0
6300	39.8	6300	39.3	6300	40.3	6300	41.0
8000	37.7	8000	37.5	8000	38.1	8000	38.5
10000	34.9	10000	34.5	10000	35.1	10000	35.2
12500	29.5	12500	39.8	12500	29.5	12500	29.8
16000	30.1	16000	30.0	16000	30.0	16000	30.0
20000	29.5	20000	29.5	20000	29.5	20000	29.5

Table C.30. Medford old PCC first run interior noise data

MP 35 - 33 SouthBound		MP 33.5 - 35 NorthBound	
SEL	94.2	SEL	94.2
Leq	74.9	Leq	73.4
SEL-Leq	19.3	SEL-Leq	20.8
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	45.5	25	41.6
31.5	46.2	31.5	43.5
40	48.5	40	46.3
50	52.4	50	50.4
63	55.4	63	54.1
80	60.2	80	59.1
100	67.6	100	66.8
125	58.9	125	56.4
160	60.2	160	58.1
200	61.7	200	60.3
250	65.0	250	62.9
315	62.2	315	59.6
400	61.3	400	59.1
500	61.3	500	59.3
630	63.1	630	61.2
800	65.8	800	64.8
1000	64.1	1000	62.3
1250	64.0	1250	62.2
1600	61.3	1600	60.5
2000	58.6	2000	54.6
2500	56.8	2500	51.5
3150	54.4	3150	50.4
4000	51.5	4000	48.0
5000	48.0	5000	45.7
6300	44.8	6300	43.0
8000	43.2	8000	41.5
10000	41.9	10000	41.5
12500	39.1	12500	39.1
16000	39.1	16000	39.1
20000	39.1	20000	39.1

Table C.31. Medford new B-mix second run interior noise data

MP 35.75 SouthBound		MP 32 NorthBound		MP 35.75 SouthBound		MP 32 NorthBound		MP 35.75 SouthBound	
SEL	88.4	SEL	91.2	SEL	87.4	SEL	90.8	SEL	84.7
Leq	68.8	Leq	70.4	Leq	68.8	Leq	70	Leq	66.9
SEL-Leq	19.6	SEL-Leq	20.8	SEL-Leq	18.6	SEL-Leq	20.8	SEL-Leq	17.8
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	39.0	25	42.0	25	39.3	25	41.9	25	38.4
31.5	39.6	31.5	42.5	31.5	40.8	31.5	42.6	31.5	41.6
40	43.1	40	45.0	40	44.2	40	45.9	40	43.3
50	45.5	50	48.0	50	45.4	50	48.3	50	44.5
63	48.9	63	50.1	63	48.0	63	49.5	63	47.0
80	52.2	80	53.1	80	52.1	80	52.7	80	52.2
100	60.0	100	59.2	100	59.5	100	59.7	100	52.9
125	52.1	125	54.1	125	51.8	125	54.9	125	56.6
160	56.9	160	57.3	160	55.7	160	57.4	160	51.9
200	55.9	200	57.3	200	58.7	200	58.1	200	55.7
250	58.5	250	59.7	250	58.6	250	59.3	250	58.8
315	56.1	315	58.2	315	56.2	315	57.9	315	54.8
400	57.2	400	59.0	400	57.3	400	58.7	400	55.5
500	57.3	500	58.7	500	57.2	500	58.3	500	56.7
630	58.5	630	60.2	630	58.1	630	59.5	630	56.4
800	59.1	800	61.0	800	58.9	800	60.4	800	56.7
1000	58.3	1000	60.2	1000	58.2	1000	59.5	1000	55.8
1250	58.0	1250	59.9	1250	57.7	1250	59.2	1250	55.3
1600	53.6	1600	56.8	1600	53.7	1600	56.1	1600	51.0
2000	52.1	2000	56.0	2000	52.2	2000	55.5	2000	48.1
2500	50.2	2500	54.6	2500	50.3	2500	53.8	2500	46.3
3150	48.1	3150	51.9	3150	48.1	3150	51.1	3150	44.3
4000	45.0	4000	49.0	4000	45.4	4000	48.3	4000	41.7
5000	42.3	5000	45.7	5000	42.8	5000	45.2	5000	40.0
6300	38.8	6300	42.0	6300	39.4	6300	41.5	6300	37.2
8000	37.1	8000	39.5	8000	37.7	8000	39.2	8000	37.0
10000	35.0	10000	37.0	10000	35.4	10000	36.8	10000	34.7
12500	32.2	12500	32.2	12500	32.2	12500	32.2	12500	32.2
16000	32.7	16000	32.6	16000	32.5	16000	32.5	16000	32.5
20000	32.2	20000	32.2	20000	32.2	20000	32.2	20000	32.2

Table C.32. Medford new F-mix third run interior noise data

MP 35.75 SouthBound		MP 33 - 35 NorthBound		MP 35.75 SouthBound		MP 33 - 35 NorthBound	
SEL		SEL		SEL		SEL	
Leq	71.7	Leq	71.9	Leq	71.3	Leq	72.6
SEL-Leq		SEL-Leq		SEL-Leq		SEL-Leq	
Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)	Freq. (Hz)	Sound Level db(A)
25	41.4	25	41.5	25	41.0	25	41.9
31.5	42.8	31.5	43.4	31.5	42.8	31.5	43.9
40	44.1	40	43.4	40	43.9	40	44.3
50	47.0	50	47.8	50	47.0	50	47.7
63	49.7	63	50.3	63	49.4	63	51.5
80	55.5	80	56.0	80	57.4	80	56.3
100	60.6	100	61.3	100	60.8	100	61.5
125	55.5	125	54.9	125	59.0	125	55.3
160	61.9	160	61.1	160	61.0	160	61.2
200	57.7	200	59.0	200	58.0	200	58.8
250	63.7	250	63.6	250	62.2	250	64.6
315	60.9	315	61.1	315	59.7	315	61.9
400	62.1	400	62.3	400	61.4	400	62.6
500	62.5	500	63.1	500	61.9	500	64.6
630	60.9	630	62.2	630	60.7	630	63.6
800	59.8	800	60.0	800	59.1	800	60.6
1000	59.4	1000	58.8	1000	58.6	1000	58.5
1250	57.4	1250	57.1	1250	56.9	1250	56.5
1600	54.3	1600	53.9	1600	54.6	1600	54.0
2000	54.1	2000	53.4	2000	54.0	2000	54.1
2500	52.4	2500	51.5	2500	52.3	2500	51.9
3150	49.5	3150	48.9	3150	49.1	3150	49.0
4000	46.3	4000	46.2	4000	46.2	4000	46.1
5000	43.4	5000	43.3	5000	43.4	5000	42.9
6300	39.8	6300	39.4	6300	39.7	6300	39.3
8000	37.6	8000	37.3	8000	37.7	8000	37.4
10000	34.7	10000	34.4	10000	34.8	10000	34.4
12500	29.5	12500	29.5	12500	29.5	12500	39.5
16000	29.5	16000	29.5	16000	29.5	16000	39.5
20000	29.5	20000	29.5	20000	29.5	20000	39.5

APPENDIX D

Laboratory Data

a) ECS Air Permeability Data

Table D.1. Air permeability calculations for samples P1PP to P8PP

P1PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	5.5	0	4.3E-05	4.5E-05	1.9E-05	0.00811	3.845	0.09766	8.1E-05	9.3E-05	1.3E-08
40	13533	94558.5	7.75	0	6.1E-05	6.5E-05	1.9E-05	0.00811	3.845	0.09766	6.3E-05	6.8E-05	9.9E-09
60	20299.5	91175.3	9.75	0	7.7E-05	8.5E-05	1.9E-05	0.00811	3.845	0.09766	5.6E-05	5.9E-05	8.8E-09
80	27066	87792	11.5	0	9E-05	0.0001	1.9E-05	0.00811	3.845	0.09766	5.2E-05	5.4E-05	8.2E-09
100	33832.5	84408.8	13	0	0.0001	0.00012	1.9E-05	0.00811	3.845	0.09766	4.9E-05	5.1E-05	7.8E-09
120	40599	81025.5	13.5	0	0.00011	0.00013	1.9E-05	0.00811	3.845	0.09766	4.5E-05	4.6E-05	7.1E-09
140	47365.5	77642.3	14.5	0	0.00011	0.00015	1.9E-05	0.00811	3.845	0.09766	4.3E-05	4.4E-05	6.8E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.845	0.09766			0

Average K	5.5E-05	5.9E-05

P2PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	6	0	4.7E-05	4.9E-05	1.9E-05	0.00811	3.874	0.0984	8.9E-05	0.0001	1.4E-08
40	13533	94558.5	8.25	0	6.5E-05	7E-05	1.9E-05	0.00811	3.874	0.0984	6.7E-05	7.2E-05	1.1E-08
60	20299.5	91175.3	10.5	0	8.3E-05	9.2E-05	1.9E-05	0.00811	3.874	0.0984	6.1E-05	6.4E-05	9.6E-09
80	27066	87792	12	0	9.4E-05	0.00011	1.9E-05	0.00811	3.874	0.0984	5.5E-05	5.7E-05	8.6E-09
100	33832.5	84408.8	13.5	0	0.00011	0.00013	1.9E-05	0.00811	3.874	0.0984	5.2E-05	5.3E-05	8.2E-09
120	40599	81025.5	15	0	0.00012	0.00015	1.9E-05	0.00811	3.874	0.0984	5E-05	5.1E-05	7.9E-09
140	47365.5	77642.3	15.5	0	0.00012	0.00016	1.9E-05	0.00811	3.874	0.0984	4.6E-05	4.7E-05	7.3E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.874	0.0984			0

Average K	6E-05	6.4E-05

P4PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	4.25	0	3.3E-05	3.5E-05	1.9E-05	0.00811	4.146	0.10531	6.7E-05	7.7E-05	1.1E-08
40	13533	94558.5	6.5	0	5.1E-05	5.5E-05	1.9E-05	0.00811	4.146	0.10531	5.7E-05	6.1E-05	9E-09
60	20299.5	91175.3	8.25	0	6.5E-05	7.2E-05	1.9E-05	0.00811	4.146	0.10531	5.1E-05	5.4E-05	8.1E-09
80	27066	87792	9.25	0	7.3E-05	8.4E-05	1.9E-05	0.00811	4.146	0.10531	4.5E-05	4.7E-05	7.1E-09
100	33832.5	84408.8	10.25	0	8.1E-05	9.7E-05	1.9E-05	0.00811	4.146	0.10531	4.2E-05	4.3E-05	6.6E-09
120	40599	81025.5	10.75	0	8.5E-05	0.00011	1.9E-05	0.00811	4.146	0.10531	3.8E-05	3.9E-05	6.1E-09
140	47365.5	77642.3	11	0	8.7E-05	0.00011	1.9E-05	0.00811	4.146	0.10531	3.5E-05	3.6E-05	5.6E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	4.146	0.10531			0

Average K	4.8E-05	5.1E-05

P5PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	6.25	0	4.9E-05	5.1E-05	1.9E-05	0.00811	3.98	0.10109	9.5E-05	0.00011	1.5E-08
40	13533	94558.5	9	0	7.1E-05	7.6E-05	1.9E-05	0.00811	3.98	0.10109	7.6E-05	8.1E-05	1.2E-08
60	20299.5	91175.3	12	0	9.4E-05	0.0001	1.9E-05	0.00811	3.98	0.10109	7.1E-05	7.5E-05	1.1E-08
80	27066	87792	13.5	0	0.00011	0.00012	1.9E-05	0.00811	3.98	0.10109	6.3E-05	6.6E-05	1E-08
100	33832.5	84408.8	15	0	0.00012	0.00014	1.9E-05	0.00811	3.98	0.10109	5.9E-05	6.1E-05	9.3E-09
120	40599	81025.5	16	0	0.00013	0.00016	1.9E-05	0.00811	3.98	0.10109	5.5E-05	5.6E-05	8.7E-09
140	47365.5	77642.3	16.5	0	0.00013	0.00017	1.9E-05	0.00811	3.98	0.10109	5.1E-05	5.2E-05	8E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.98	0.10109			0

Average K	6.7E-05	7.1E-05

Table D.1. Air permeability calculations for samples P1PP to P8PP (continued)

P6PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	4.25	0	3.3E-05	3.5E-05	1.9E-05	0.00811	4.09	0.10389	6.6E-05	7.6E-05	1E-08
40	13533	94558.5	5.75	0	4.5E-05	4.8E-05	1.9E-05	0.00811	4.09	0.10389	5E-05	5.3E-05	7.8E-09
60	20299.5	91175.3	7	0	5.5E-05	6.1E-05	1.9E-05	0.00811	4.09	0.10389	4.3E-05	4.5E-05	6.8E-09
80	27066	87792	8.25	0	6.5E-05	7.5E-05	1.9E-05	0.00811	4.09	0.10389	4E-05	4.1E-05	6.3E-09
100	33832.5	84408.8	9.25	0	7.3E-05	8.7E-05	1.9E-05	0.00811	4.09	0.10389	3.7E-05	3.8E-05	5.9E-09
120	40599	81025.5	9.75	0	7.7E-05	9.6E-05	1.9E-05	0.00811	4.09	0.10389	3.4E-05	3.5E-05	5.4E-09
140	47365.5	77642.3	10.5	0	8.3E-05	0.00011	1.9E-05	0.00811	4.09	0.10389	3.3E-05	3.4E-05	5.2E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	4.09	0.10389			0

Average K	4.3E-05	4.6E-05

P7PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	6.25	0	4.9E-05	5.1E-05	1.9E-05	0.00811	4.052	0.10292	9.6E-05	0.00011	1.5E-08
40	13533	94558.5	9	0	7.1E-05	7.6E-05	1.9E-05	0.00811	4.052	0.10292	7.7E-05	8.3E-05	1.2E-08
60	20299.5	91175.3	12	0	9.4E-05	0.0001	1.9E-05	0.00811	4.052	0.10292	7.3E-05	7.6E-05	1.1E-08
80	27066	87792	13.5	0	0.00011	0.00012	1.9E-05	0.00811	4.052	0.10292	6.4E-05	6.7E-05	1E-08
100	33832.5	84408.8	15.5	0	0.00012	0.00015	1.9E-05	0.00811	4.052	0.10292	6.2E-05	6.4E-05	9.8E-09
120	40599	81025.5	16.5	0	0.00013	0.00016	1.9E-05	0.00811	4.052	0.10292	5.7E-05	5.9E-05	9.1E-09
140	47365.5	77642.3	17.5	0	0.00014	0.00018	1.9E-05	0.00811	4.052	0.10292	5.5E-05	5.6E-05	8.7E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	4.052	0.10292			0

Average K	6.9E-05	7.4E-05

P8PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	5.75	0	4.5E-05	4.7E-05	1.9E-05	0.00811	3.738	0.09495	8.2E-05	9.4E-05	1.3E-08
40	13533	94558.5	8.25	0	6.5E-05	7E-05	1.9E-05	0.00811	3.738	0.09495	6.5E-05	7E-05	1E-08
60	20299.5	91175.3	10.25	0	8.1E-05	9E-05	1.9E-05	0.00811	3.738	0.09495	5.7E-05	6E-05	9E-09
80	27066	87792	12.25	0	9.6E-05	0.00011	1.9E-05	0.00811	3.738	0.09495	5.4E-05	5.6E-05	8.5E-09
100	33832.5	84408.8	13.5	0	0.00011	0.00013	1.9E-05	0.00811	3.738	0.09495	5E-05	5.1E-05	7.9E-09
120	40599	81025.5	15	0	0.00012	0.00015	1.9E-05	0.00811	3.738	0.09495	4.8E-05	4.9E-05	7.6E-09
140	47365.5	77642.3	15.5	0	0.00012	0.00016	1.9E-05	0.00811	3.738	0.09495	4.5E-05	4.6E-05	7.1E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.738	0.09495			0

Average K	5.7E-05	6.1E-05

Table D.2. Air permeability calculations for samples J1PP to J8PP

J1PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	3.75	0	2.9E-05	3.1E-05	1.9E-05	0.00811	3.902	0.09911	5.6E-05	6.4E-05	8.8E-09
40	13533	94558.5	5	0	3.9E-05	4.2E-05	1.9E-05	0.00811	3.902	0.09911	4.1E-05	4.4E-05	6.5E-09
60	20299.5	91175.3	6.25	0	4.9E-05	5.5E-05	1.9E-05	0.00811	3.902	0.09911	3.6E-05	3.8E-05	5.8E-09
80	27066	87792	7.5	0	5.9E-05	6.8E-05	1.9E-05	0.00811	3.902	0.09911	3.4E-05	3.6E-05	5.4E-09
100	33832.5	84408.8	8.75	0	6.9E-05	8.3E-05	1.9E-05	0.00811	3.902	0.09911	3.4E-05	3.5E-05	5.3E-09
120	40599	81025.5	9.75	0	7.7E-05	9.6E-05	1.9E-05	0.00811	3.902	0.09911	3.3E-05	3.4E-05	5.2E-09
140	47365.5	77642.3	10.5	0	8.3E-05	0.00011	1.9E-05	0.00811	3.902	0.09911	3.2E-05	3.2E-05	5E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.902	0.09911			0

Average K	3.8E-05	4E-05

J2PP impermeable

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
40	13533	94558.5		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
60	20299.5	91175.3		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
80	27066	87792		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
100	33832.5	84408.8		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
120	40599	81025.5		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
140	47365.5	77642.3		0	0	0	1.9E-05	0.00811	3.965	0.10071	0	0	0
160	54132	74259		0	0	0	1.9E-05	0.00811	3.965	0.10071			0

Average K	0	0

J3PP IMPERMEABLE

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
40	13533	94558.5		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
60	20299.5	91175.3		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
80	27066	87792		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
100	33832.5	84408.8		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
120	40599	81025.5		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
140	47365.5	77642.3		0	0	0	1.9E-05	0.00811	3.744	0.0951	0	0	0
160	54132	74259		0	0	0	1.9E-05	0.00811	3.744	0.0951			0

Average K	0	0

J4PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	2.5	0	2E-05	2E-05	1.9E-05	0.00811	3.634	0.0923	3.5E-05	4E-05	5.5E-09
40	13533	94558.5	3.25	0	2.6E-05	2.7E-05	1.9E-05	0.00811	3.634	0.0923	2.5E-05	2.7E-05	3.9E-09
60	20299.5	91175.3	4.25	0	3.3E-05	3.7E-05	1.9E-05	0.00811	3.634	0.0923	2.3E-05	2.4E-05	3.6E-09
80	27066	87792	5	0	3.9E-05	4.5E-05	1.9E-05	0.00811	3.634	0.0923	2.1E-05	2.2E-05	3.4E-09
100	33832.5	84408.8	5.5	0	4.3E-05	5.2E-05	1.9E-05	0.00811	3.634	0.0923	2E-05	2E-05	3.1E-09
120	40599	81025.5	5.75	0	4.5E-05	5.7E-05	1.9E-05	0.00811	3.634	0.0923	1.8E-05	1.8E-05	2.8E-09
140	47365.5	77642.3	6	0	4.7E-05	6.2E-05	1.9E-05	0.00811	3.634	0.0923	1.7E-05	1.7E-05	2.7E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.634	0.0923			0

Average K	2.3E-05	2.4E-05

Table D.3. Air permeability calculations for samples J1PP to J8PP (continued)

J5PP Impermeable

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
40	13533	94558.5		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
60	20299.5	91175.3		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
80	27066	87792		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
100	33832.5	84408.8		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
120	40599	81025.5		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
140	47365.5	77642.3		0	0	0	1.9E-05	0.00811	3.766	0.09566	0	0	0
160	54132	74259		0	0	0	1.9E-05	0.00811	3.766	0.09566			0

Average K	0	0

J6PP

CHANGE

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	5.75	0	4.5E-05	4.7E-05	1.9E-05	0.00811	3.975	0.10097	8.7E-05	0.0001	1.4E-08
40	13533	94558.5	8	0	6.3E-05	6.7E-05	1.9E-05	0.00811	3.975	0.10097	6.7E-05	7.2E-05	1.1E-08
60	20299.5	91175.3	9.75	0	7.7E-05	8.5E-05	1.9E-05	0.00811	3.975	0.10097	5.8E-05	6.1E-05	9.1E-09
80	27066	87792	11	0	8.7E-05	1E-04	1.9E-05	0.00811	3.975	0.10097	5.1E-05	5.3E-05	8.1E-09
100	33832.5	84408.8	13	0	0.0001	0.00012	1.9E-05	0.00811	3.975	0.10097	5.1E-05	5.3E-05	8.1E-09
120	40599	81025.5	14	0	0.00011	0.00014	1.9E-05	0.00811	3.975	0.10097	4.8E-05	4.9E-05	7.6E-09
140	47365.5	77642.3	15.5	0	0.00012	0.00016	1.9E-05	0.00811	3.975	0.10097	4.8E-05	4.9E-05	7.5E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.975	0.10097			0

Average K	5.9E-05	6.2E-05

J7PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	5	0	3.9E-05	4.1E-05	1.9E-05	0.00811	3.946	0.10023	7.5E-05	8.6E-05	1.2E-08
40	13533	94558.5	8	0	6.3E-05	6.7E-05	1.9E-05	0.00811	3.946	0.10023	6.7E-05	7.2E-05	1.1E-08
60	20299.5	91175.3	9.75	0	7.7E-05	8.5E-05	1.9E-05	0.00811	3.946	0.10023	5.7E-05	6E-05	9.1E-09
80	27066	87792	11.5	0	9E-05	0.0001	1.9E-05	0.00811	3.946	0.10023	5.3E-05	5.5E-05	8.4E-09
100	33832.5	84408.8	13	0	0.0001	0.00012	1.9E-05	0.00811	3.946	0.10023	5.1E-05	5.2E-05	8E-09
120	40599	81025.5	13.75	0	0.00011	0.00014	1.9E-05	0.00811	3.946	0.10023	4.7E-05	4.8E-05	7.4E-09
140	47365.5	77642.3	15	0	0.00012	0.00015	1.9E-05	0.00811	3.946	0.10023	4.6E-05	4.7E-05	7.2E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.946	0.10023			0

Average K	5.6E-05	6E-05

J8PP

Press In. Hg	Press N/m2	Ave P. N/m2	Flow SCFH	flow ccm	Flow m3/s	Flow a.p m3/s	Viscosity N-s/m2	Area m2	Height in.	hEIGHT M	K (CM/S		k (cm2)
20	6766.5	97941.8	5.75	0	4.5E-05	4.7E-05	1.9E-05	0.00811	3.884	0.09865	8.5E-05	9.8E-05	1.3E-08
40	13533	94558.5	8	0	6.3E-05	6.7E-05	1.9E-05	0.00811	3.884	0.09865	6.6E-05	7E-05	1E-08
60	20299.5	91175.3	9.5	0	7.5E-05	8.3E-05	1.9E-05	0.00811	3.884	0.09865	5.5E-05	5.8E-05	8.7E-09
80	27066	87792	11.5	0	9E-05	0.0001	1.9E-05	0.00811	3.884	0.09865	5.3E-05	5.5E-05	8.3E-09
100	33832.5	84408.8	12.5	0	9.8E-05	0.00012	1.9E-05	0.00811	3.884	0.09865	4.8E-05	4.9E-05	7.6E-09
120	40599	81025.5	13.5	0	0.00011	0.00013	1.9E-05	0.00811	3.884	0.09865	4.5E-05	4.6E-05	7.1E-09
140	47365.5	77642.3	15	0	0.00012	0.00015	1.9E-05	0.00811	3.884	0.09865	4.5E-05	4.6E-05	7.1E-09
160	54132	74259		0	0	0	1.9E-05	0.00811	3.884	0.09865			0

Average K	5.7E-05	6E-05

b) ECS Water Permeability Data

Table D.3. ECS water permeability for samples J1PP to J8PP

Sample: J1PP 22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	2.5	2.9083567
8	2.25	2.6587957
7	2	2.4092346
6	1.75	2.1596735
5	1.5	1.9101124
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	40598.096	2.90836	0	3.1E-06	0.00092
8	36140.52	2.6588	0	2.8E-06	0.00095
7	31682.944	2.40923	0	2.5E-06	0.00099
6	27225.368	2.15967	0	2.3E-06	0.00103
5	22767.792	1.91011	0	2E-06	0.0011
4	18310.216	1.66055	0	1.7E-06	0.0012
3	20508.596	0	0	0	0

ave K: 1.03E-03

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	1.75	2.15967
8	1.5	1.91011
7	1.5	1.91011
6	1.5	1.91011
5	1.25	1.66055
4	1	1.41099
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	45590.1	2.15967	0	2.3E-06	0.00061
8	41132.5	1.91011	0	2E-06	0.0006
7	35010.9	1.91011	0	2E-06	0.00071
6	28889.4	1.91011	0	2E-06	0.00086
5	24431.8	1.66055	0	1.7E-06	0.00089
4	19974.2	1.41099	0	1.5E-06	0.00093
3	20508.6	0	0	0	0

ave K: 0.000766

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	2.75	3.1579178
8	2.25	2.6587957
7	2.25	2.6587957
6	1.75	2.1596735
5	1.5	1.9101124
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	38934.107	3.15792	0	3.3E-06	0.00105
8	36140.52	2.6588	0	2.8E-06	0.00095
7	30018.955	2.6588	0	2.8E-06	0.00115
6	27225.368	2.15967	0	2.3E-06	0.00103
5	22767.792	1.91011	0	2E-06	0.0011
4	18310.216	1.66055	0	1.7E-06	0.0012
3	20508.596	0	0	0	0

ave K: 1.08E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	2.25	2.6588
8	2	2.40923
7	1.75	2.15967
6	1.5	1.91011
5	1.5	1.91011
4	1.25	1.66055
3	0	1.66055

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	42262.1	2.6588	0	2.8E-06	0.00081
8	37804.5	2.40923	0	2.5E-06	0.00082
7	33346.9	2.15967	0	2.3E-06	0.00084
6	28889.4	1.91011	0	2E-06	0.00086
5	22767.8	1.91011	0	2E-06	0.0011
4	18310.2	1.66055	0	1.7E-06	0.0012
3	20508.6	1.66055	0	1.7E-06	0.00107

ave K: 9.58E-04

Table D.3. ECS water permeability for samples J1PP to J8PP (continued)

Sample: J2PP   22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.013256

Pressure	Reading	Calibration
9	0	-0.175982
8	2.25	2.103843
7	2	1.850529
6	2	1.850529
5	1.75	1.597215
4	1.75	1.597215
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.14	0	0	0	0
8	56663.73	2.10384	0	2.2E-06	0.00048
7	49639.59	1.85053	0	1.9E-06	0.00048
6	41703.72	1.85053	0	1.9E-06	0.00057
5	34679.59	1.59722	0	1.7E-06	0.0006
4	26743.72	1.59722	0	1.7E-06	0.00078
3	25189.95	0	0	0	0

ave K: 5.80E-04

Cycle # 1

Regression Output for System B (gph)
Constant -0.176
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.176
8	2.5	2.35716
7	2.25	2.10384
6	2	1.85053
5	2	1.85053
4	1.75	1.59722
3		-0.176

Regression Output for System B (cc/min
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	55752	2.35716	0	2.5E-06	0.00054
7	48727.9	2.10384	0	2.2E-06	0.00055
6	41703.7	1.85053	0	1.9E-06	0.00057
5	33767.9	1.85053	0	1.9E-06	0.00071
4	26743.7	1.59722	0	1.7E-06	0.00078
3	25190	0	0	0	0

ave K: 0.000631

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.013256

Pressure	Reading	Calibration
9	0	-0.175982
8	3	2.863785
7	2.75	2.610471
6	2.5	2.357157
5	2.25	2.103843
4	2	1.850529
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.14	0	0	0	0
8	53928.54	2.86378	0	3E-06	0.00068
7	46904.41	2.61047	0	2.7E-06	0.00071
6	39880.27	2.35716	0	2.5E-06	0.00076
5	32856.13	2.10384	0	2.2E-06	0.00083
4	25831.99	1.85053	0	1.9E-06	0.00094
3	25189.95	0	0	0	0

ave K: 7.84E-04

Cycle # 3

Regression Output for System B (gph)
Constant -0.176
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.176
8	2	1.85053
7	1.75	1.59722
6	1.75	1.59722
5	1.5	1.3439
4	1.5	1.3439
3	0	-0.176

Regression Output for System B (cc/min
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.902

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	57575.5	1.85053	0	1.9E-06	0.00041
7	50551.3	1.59722	0	1.7E-06	0.00041
6	42615.5	1.59722	0	1.7E-06	0.00048
5	35591.3	1.3439	0	1.4E-06	0.00049
4	27655.4	1.3439	0	1.4E-06	0.00063
3	25190	0	0	0	0

ave K: 4.84E-04

Table D.3. ECS water permeability for samples J1PP to J8PP (continued)

Sample: J3PP   22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3	3.4074789
8	2.5	2.9083567
7	2	2.4092346
6	1.75	2.1596735
5	1.5	1.9101124
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.744

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	37270.118	3.40748	0	3.6E-06	0.00113
8	34476.531	2.90836	0	3.1E-06	0.00105
7	31682.944	2.40923	0	2.5E-06	0.00095
6	27225.368	2.15967	0	2.3E-06	0.00099
5	22767.792	1.91011	0	2E-06	0.00106
4	18310.216	1.66055	0	1.7E-06	0.00115
3	20508.596	0	0	0	0

ave K: 1.05E-03

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	1.25	1.66055
8	1.25	1.66055
7	1.1	1.51081
6	1	1.41099
5	0.8	1.21134
4	0.7	1.11152
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.744

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	48918	1.66055	0	1.7E-06	0.00042
8	42796.5	1.66055	0	1.7E-06	0.00048
7	37673.3	1.51081	0	1.6E-06	0.0005
6	32217.3	1.41099	0	1.5E-06	0.00054
5	27427	1.21134	0	1.3E-06	0.00055
4	21971	1.11152	0	1.2E-06	0.00064
3	20508.6	0	0	0	0

ave K: 0.000521

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3.25	3.65704
8	2.75	3.1579178
7	2.5	2.9083567
6	2	2.4092346
5	1.5	1.9101124
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.744

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	35606.129	3.65704	0	3.8E-06	0.00127
8	32812.542	3.15792	0	3.3E-06	0.0012
7	28354.966	2.90836	0	3.1E-06	0.00128
6	25561.379	2.40923	0	2.5E-06	0.00118
5	22767.792	1.91011	0	2E-06	0.00106
4	18310.216	1.66055	0	1.7E-06	0.00115
3	20508.596	0	0	0	0

ave K: 1.19E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	2.75	3.15792
8	2.25	2.6588
7	1.9	2.30941
6	1.6	2.00994
5	1.25	1.66055
4	1	1.41099
3	0	1.41099

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.744

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	38934.1	3.15792	0	3.3E-06	0.001
8	36140.5	2.6588	0	2.8E-06	0.00091
7	32348.5	2.30941	0	2.4E-06	0.00089
6	28223.8	2.00994	0	2.1E-06	0.00089
5	24431.8	1.66055	0	1.7E-06	0.00085
4	19974.2	1.41099	0	1.5E-06	0.00089
3	20508.6	1.41099	0	1.5E-06	0.00087

ave K: 9.01E-04

Table D.3. ECS water permeability for samples J1PP to J8PP (continued)

Sample: J4PP   22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	6	5.9035519
6	5	4.8902963
5	4.25	4.1303545
4	3.75	3.6237267
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.634

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	35051.947	5.90355	0	6.2E-06	0.00202
6	30762.992	4.8903	0	5.1E-06	0.00192
5	25562.31	4.13035	0	4.3E-06	0.00196
4	19449.9	3.62373	0	3.8E-06	0.00229
3	25189.95	0	0	0	0

ave K: 2.05E-03

Cycle # 1

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	6	5.90355
6	5.75	5.65024
5	5	4.8903
4	4	3.87704
3		-0.17598

Regression Output for System B (cc/min
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.634

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	35051.9	5.90355	0	6.2E-06	0.00202
6	28027.8	5.65024	0	5.9E-06	0.00244
5	22827.1	4.8903	0	5.1E-06	0.00261
4	18538.2	3.87704	0	4.1E-06	0.00257
3	25190	0	0	0	0

ave K: 0.002413

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	6	5.9035519
6	5.25	5.1436102
5	4.5	4.3836684
4	4	3.8770406
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.634

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	35051.947	5.90355	0	6.2E-06	0.00202
6	29851.265	5.14361	0	5.4E-06	0.00208
5	24650.583	4.38367	0	4.6E-06	0.00216
4	18538.173	3.87704	0	4.1E-06	0.00257
3	25189.95	0	0	0	0

ave K: 2.21E-03

Cycle # 3

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	6.5	6.41018
6	6.25	6.15687
5	5.25	5.14361
4	4.25	4.13035
3	0	-0.17598

Regression Output for System B (cc/min
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.634

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	33228.5	6.41018	0	6.7E-06	0.00232
6	26204.4	6.15687	0	6.5E-06	0.00285
5	21915.4	5.14361	0	5.4E-06	0.00287
4	17626.4	4.13035	0	4.3E-06	0.00289
3	25190	0	0	0	0

ave K: 2.73E-03

Table D.3. ECS water permeability for samples J1PP to J8PP (continued)

Sample: J5PP 22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	0	0.412746
8	0	0.412746
7	0	0.412746
6	0	0.412746
5	0	0.412746
4	0	0.412746
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	12	11.843663
7	8	8.2161487
6	7	7.3092701
5	4	4.5886343
4	2	2.7748772
3	0	0.96112

Height 3.766

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	57237.987	0	0	0	0
8	49850.63	0	11.8437	2E-07	4.7E-05
7	44150.996	0	8.21615	1.4E-07	3.7E-05
6	38134.913	0	7.30927	1.2E-07	3.8E-05
5	32329.796	0	4.58863	7.6E-08	2.8E-05
4	26419.196	0	2.77488	4.6E-08	2.1E-05
3	20508.596	0	0	0	0

ave K: 3.40E-05

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratic
9	0	0.41275
8	4.75	5.15441
7	4.5	4.90485
6	4	4.40572
5	3.25	3.65704
4	2.75	3.15792
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratior
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.766

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	57238	0	0	0	0
8	19500.6	5.15441	0	5.4E-06	0.00337
7	15043.1	4.90485	0	5.2E-06	0.00422
6	12249.5	4.40572	0	4.6E-06	0.00473
5	11119.9	3.65704	0	3.8E-06	0.00436
4	8326.28	3.15792	0	3.3E-06	0.00519
3	20508.6	0	0	0	0

ave K: 0.004372

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	0	0.412746
8	4.25	4.6552843
7	4	4.4057232
6	3.5	3.906601
5	3	3.4074789
4	2.25	2.6587957
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.766

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	57237.987	0	0	0	0
8	22828.608	4.65528	0	4.9E-06	0.00258
7	18371.032	4.40572	0	4.6E-06	0.00307
6	15577.445	3.9066	0	4.1E-06	0.00324
5	12783.858	3.40748	0	3.6E-06	0.00349
4	11654.26	2.6588	0	2.8E-06	0.00301
3	20508.596	0	0	0	0

ave K: 3.08E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratic
9	0	0.41275
8	5	5.40397
7	4.25	4.65528
6	3.75	4.15616
5	3.25	3.65704
4	2.25	2.6588
3	0	2.6588

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratior
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.766

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	57238	0	0	0	0
8	51116.4	5.40397	0	5.7E-06	0.00131
7	11715.1	4.65528	0	4.9E-06	0.00524
6	10585.5	4.15616	0	4.4E-06	0.00523
5	7791.89	3.65704	0	3.8E-06	0.00647
4	4998.3	2.6588	0	2.8E-06	0.00794
3	20508.6	2.6588	0	2.8E-06	0.00165

ave K: 4.64E-03

Table D.3. ECS water permeability for samples J1PP to J8PP (continued)

Sample: J6PP 22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	0	-0.175982
6	7.25	7.1701215
5	6.25	6.1568658
4	5	4.8902963
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.975

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	56933.412	0	0	0	0
6	22557.443	7.17012	0	7.5E-06	0.00426
5	18268.489	6.15687	0	6.5E-06	0.00456
4	14891.262	4.8903	0	5.1E-06	0.00451
3	25189.95	0	0	0	0

ave K: 4.44E-03

Cycle # 1

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	0	-0.17598
6	8.5	8.43669
5	7	6.91681
4	5.5	5.39692
3		-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.975

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	56933.4	0	0	0	0
6	17998.8	8.43669	0	8.9E-06	0.00635
5	15533.3	6.91681	0	7.3E-06	0.00609
4	13067.8	5.39692	0	5.7E-06	0.00572
3	25190	0	0	0	0

ave K: 0.006056

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	0	-0.175982
6	10	9.9565745
5	8.75	8.6900049
4	7.5	7.4234354
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.975

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	56933.412	0	0	0	0
6	12528.439	9.95657	0	1E-05	0.01105
5	9151.2117	8.69	0	9.1E-06	0.01364
4	5773.9849	7.42344	0	7.8E-06	0.01987
3	25189.95	0	0	0	0

ave K: 1.49E-02

Cycle # 3

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	9.5	9.44995
6	8	7.93006
5	7	6.91681
4	5.5	5.39692
3	0	-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.975

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	22287.8	9.44995	0	9.9E-06	0.00568
6	19822.3	7.93006	0	8.3E-06	0.00539
5	15533.3	6.91681	0	7.3E-06	0.00609
4	13067.8	5.39692	0	5.7E-06	0.00572
3	25190	0	0	0	0

ave K: 5.72E-03

Table D.3. ECS water permeability for samples J1PP to J8PP (continued)

Sample: J7PP 22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3.5	3.906601
8	3.25	3.65704
7	2.75	3.1579178
6	2.25	2.6587957
5	1.75	2.1596735
4	0.75	1.1614292
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.946

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	33942.14	3.9066	0	4.1E-06	0.00151
8	29484.564	3.65704	0	3.8E-06	0.00163
7	26690.977	3.15792	0	3.3E-06	0.00156
6	23897.39	2.6588	0	2.8E-06	0.00148
5	21103.803	2.15967	0	2.3E-06	0.00136
4	21638.194	1.16143	0	1.2E-06	0.00071
3	20508.596	0	0	0	0

ave K: 1.38E-03

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratic
9	3	3.40748
8	2.5	2.90836
7	2.25	2.6588
6	2	2.40923
5	1.75	2.15967
4	1.25	1.66055
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratior
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.946

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	37270.1	3.40748	0	3.6E-06	0.00119
8	34476.5	2.90836	0	3.1E-06	0.0011
7	30019	2.6588	0	2.8E-06	0.00116
6	25561.4	2.40923	0	2.5E-06	0.00125
5	21103.8	2.15967	0	2.3E-06	0.00136
4	18310.2	1.66055	0	1.7E-06	0.00122
3	20508.6	0	0	0	0

ave K: 0.001215

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	0.6	1.0116926
8	3	3.4074789
7	2.75	3.1579178
6	2.25	2.6587957
5	1.75	2.1596735
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.946

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	53244.414	1.01169	0	1.1E-06	0.00025
8	31148.553	3.40748	0	3.6E-06	0.00144
7	26690.977	3.15792	0	3.3E-06	0.00156
6	23897.39	2.6588	0	2.8E-06	0.00148
5	21103.803	2.15967	0	2.3E-06	0.00136
4	18310.216	1.66055	0	1.7E-06	0.00122
3	20508.596	0	0	0	0

ave K: 1.22E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratic
9	2.25	2.6588
8	2	2.40923
7	1.75	2.15967
6	1.5	1.91011
5	1.25	1.66055
4	1	1.41099
3	0	1.41099

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratior
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.946

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	57238	2.6588	0	2.8E-06	0.0006
8	36140.5	2.40923	0	2.5E-06	0.00087
7	31682.9	2.15967	0	2.3E-06	0.00089
6	27225.4	1.91011	0	2E-06	0.00093
5	22767.8	1.66055	0	1.7E-06	0.00097
4	18310.2	1.41099	0	1.5E-06	0.00104
3	20508.6	1.41099	0	1.5E-06	0.00092

ave K: 8.88E-04

Table D.4. ECS water permeability for samples P1PP to P8PP

Sample: J8PP 22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	7.75	7.6767493
6	6	5.9035519
5	5	4.8902963
4	4	3.8770406
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.884

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	28669.853	7.67675	0	8.1E-06	0.00347
6	27116.082	5.90355	0	6.2E-06	0.00283
5	22827.127	4.8903	0	5.1E-06	0.0028
4	18538.173	3.87704	0	4.1E-06	0.00276
3	25189.95	0	0	0	0

ave K: 2.96E-03

Cycle # 1

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	5.5	5.39692
6	5	4.8903
5	4	3.87704
4	3	2.86378
3		-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.884

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	36875.4	5.39692	0	5.7E-06	0.00188
6	30763	4.8903	0	5.1E-06	0.00205
5	26474	3.87704	0	4.1E-06	0.0019
4	22185.1	2.86378	0	3E-06	0.00169
3	25190	0	0	0	0

ave K: 0.001882

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	6.5	6.4101797
6	5.5	5.3969241
5	4.5	4.3836684
4	3.75	3.6237267
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.884

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	33228.492	6.41018	0	6.7E-06	0.00249
6	28939.537	5.39692	0	5.7E-06	0.00241
5	24650.583	4.38367	0	4.6E-06	0.00232
4	19449.9	3.62373	0	3.8E-06	0.00245
3	25189.95	0	0	0	0

ave K: 2.42E-03

Cycle # 3

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	8.5	8.43669
6	7.5	7.42344
5	6	5.90355
4	5	4.8903
3	0	-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.884

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	25934.7	8.43669	0	8.9E-06	0.00423
6	21645.7	7.42344	0	7.8E-06	0.00449
5	19180.2	5.90355	0	6.2E-06	0.00406
4	14891.3	4.8903	0	5.1E-06	0.0044
3	25190	0	0	0	0

ave K: 4.29E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continued)

Sample: P1PP 22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3	3.4074789
8	2.5	2.9083567
7	2	2.4092346
6	1.75	2.1596735
5	1.5	1.9101124
4	1	1.4109903
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.845

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	37270.118	3.40748	0	3.6E-06	0.00116
8	34476.531	2.90836	0	3.1E-06	0.00108
7	31682.944	2.40923	0	2.5E-06	0.00097
6	27225.368	2.15967	0	2.3E-06	0.00102
5	22767.792	1.91011	0	2E-06	0.00109
4	19974.205	1.41099	0	1.5E-06	0.00092
3	20508.596	0	0	0	0

ave K: 1.04E-03

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	3.5	3.9066
8	3.25	3.65704
7	2.75	3.15792
6	2.25	2.6588
5	1.75	2.15967
4	1.25	1.66055
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.845

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	33942.1	3.9066	0	4.1E-06	0.00147
8	29484.6	3.65704	0	3.8E-06	0.00159
7	26691	3.15792	0	3.3E-06	0.00152
6	23897.4	2.6588	0	2.8E-06	0.00144
5	21103.8	2.15967	0	2.3E-06	0.00133
4	18310.2	1.66055	0	1.7E-06	0.00119
3	20508.6	0	0	0	0

ave K: 0.001421

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3.75	4.1561621
8	3.25	3.65704
7	2.75	3.1579178
6	2.25	2.6587957
5	1.75	2.1596735
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	1	1.8679986
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.845

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	32278.151	4.15616	0	4.4E-06	0.00164
8	29484.564	3.65704	0	3.8E-06	0.00159
7	26690.977	3.15792	0	3.3E-06	0.00152
6	23897.39	2.6588	1.868	2.8E-06	0.00144
5	21103.803	2.15967	0	2.3E-06	0.00133
4	18310.216	1.66055	0	1.7E-06	0.00119
3	20508.596	0	0	0	0

ave K: 1.45E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	3.5	3.9066
8	3	3.40748
7	2.5	2.90836
6	2	2.40923
5	1.75	2.15967
4	1.25	1.66055
3	0	0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.845

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	33942.1	3.9066	0	4.1E-06	0.00147
8	31148.6	3.40748	0	3.6E-06	0.0014
7	28355	2.90836	0	3.1E-06	0.00132
6	25561.4	2.40923	0	2.5E-06	0.00121
5	21103.8	2.15967	0	2.3E-06	0.00133
4	18310.2	1.66055	0	1.7E-06	0.00119
3	20508.6	0	0	0	0

ave K: 1.32E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continued)

Sample: P2PP   22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	0	-0.175982
6	6.25	6.1568658
5	5	4.8902963
4	4	3.8770406
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.874

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	56933.412	0	0	0	0
6	26204.354	6.15687	0	6.5E-06	0.00305
5	22827.127	4.8903	0	5.1E-06	0.00279
4	18538.173	3.87704	0	4.1E-06	0.00275
3	25189.95	0	0	0	0

ave K: 2.86E-03

Cycle # 1

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	7	6.91681
6	5.5	5.39692
5	4.75	4.63698
4	3.75	3.62373
3		-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.874

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	31405	6.91681	0	7.3E-06	0.00284
6	28939.5	5.39692	0	5.7E-06	0.00241
5	23738.9	4.63698	0	4.9E-06	0.00254
4	19449.9	3.62373	0	3.8E-06	0.00245
3	25190	0	0	0	0

ave K: 0.002558

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	7.5	7.4234354
6	6	5.9035519
5	5	4.8902963
4	4	3.8770406
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.874

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	29581.581	7.42344	0	7.8E-06	0.00324
6	27116.082	5.90355	0	6.2E-06	0.00282
5	22827.127	4.8903	0	5.1E-06	0.00279
4	18538.173	3.87704	0	4.1E-06	0.00275
3	25189.95	0	0	0	0

ave K: 2.90E-03

Cycle # 3

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	5.5	5.39692
6	4.25	4.13035
5	4	3.87704
4	3	2.86378
3	0	-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 3.874

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	36875.4	5.39692	0	5.7E-06	0.00188
6	33498.2	4.13035	0	4.3E-06	0.00158
5	26474	3.87704	0	4.1E-06	0.0019
4	22185.1	2.86378	0	3E-06	0.00168
3	25190	0	0	0	0

ave K: 1.76E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continued)

Sample: P4PP   22-Jul

Cycle # ***Initial***

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	2.25	2.6587957
8	2	2.4092346
7	0.01333	0.4260559
6	1.5	1.9101124
5	1.25	1.6605514
4	1	1.4109903
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.146

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	42262.086	2.6588	0	2.8E-06	0.00086
8	37804.51	2.40923	0	2.5E-06	0.00088
7	44906.111	0.42606	0	4.5E-07	0.00013
6	28889.357	1.91011	0	2E-06	0.00092
5	24431.781	1.66055	0	1.7E-06	0.00095
4	19974.205	1.41099	0	1.5E-06	0.001
3	20508.596	0	0	0	0

ave K: 7.88E-04

Cycle # ***1***

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratic
9	2.5	2.90836
8	2.25	2.6588
7	2	2.40923
6	1.75	2.15967
5	1.5	1.91011
4	1.25	1.66055
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.146

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	40598.1	2.90836	0	3.1E-06	0.00098
8	36140.5	2.6588	0	2.8E-06	0.00101
7	31682.9	2.40923	0	2.5E-06	0.00105
6	27225.4	2.15967	0	2.3E-06	0.0011
5	22767.8	1.91011	0	2E-06	0.00117
4	18310.2	1.66055	0	1.7E-06	0.00128
3	20508.6	0	0	0	0

ave K: 0.001101

Cycle # ***2***

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	2.25	2.6587957
8	2	2.4092346
7	1.75	2.1596735
6	1.5	1.9101124
5	1.25	1.6605514
4	1	1.4109903
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	1	1.8679986
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.146

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	42262.086	2.6588	0	2.8E-06	0.00086
8	37804.51	2.40923	0	2.5E-06	0.00088
7	33346.933	2.15967	0	2.3E-06	0.00089
6	28889.357	1.91011	1.868	2E-06	0.00092
5	24431.781	1.66055	0	1.7E-06	0.00095
4	19974.205	1.41099	0	1.5E-06	0.001
3	20508.596	0	0	0	0

ave K: 9.15E-04

Cycle # ***3***

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratic
9	2.75	3.15792
8	2.5	2.90836
7	2	2.40923
6	1.75	2.15967
5	1.5	1.91011
4	1.25	1.66055
3	0	0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.146

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	38934.1	3.15792	0	3.3E-06	0.00111
8	34476.5	2.90836	0	3.1E-06	0.00116
7	31682.9	2.40923	0	2.5E-06	0.00105
6	27225.4	2.15967	0	2.3E-06	0.0011
5	22767.8	1.91011	0	2E-06	0.00117
4	18310.2	1.66055	0	1.7E-06	0.00128
3	20508.6	0	0	0	0

ave K: 1.15E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continued)

Sample: P5PP 22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3.5	3.906601
8	3.25	3.65704
7	2.75	3.1579178
6	2.25	2.6587957
5	1.75	2.1596735
4	1.25	1.6605514
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.980

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	33942.14	3.9066	0	4.1E-06	0.00152
8	29484.564	3.65704	0	3.8E-06	0.00165
7	26690.977	3.15792	0	3.3E-06	0.00158
6	23897.39	2.6588	0	2.8E-06	0.00149
5	21103.803	2.15967	0	2.3E-06	0.00138
4	18310.216	1.66055	0	1.7E-06	0.00123
3	20508.596	0	0	0	0

ave K: 1.47E-03

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	3.5	3.9066
8	3.25	3.65704
7	2.75	3.15792
6	2.25	2.6588
5	1.75	2.15967
4	1.25	1.66055
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.980

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	33942.1	3.9066	0	4.1E-06	0.00152
8	29484.6	3.65704	0	3.8E-06	0.00165
7	26691	3.15792	0	3.3E-06	0.00158
6	23897.4	2.6588	0	2.8E-06	0.00149
5	21103.8	2.15967	0	2.3E-06	0.00138
4	18310.2	1.66055	0	1.7E-06	0.00123
3	20508.6	0	0	0	0

ave K: 0.001473

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	3.25	3.65704
8	3	3.4074789
7	2.5	2.9083567
6	2	2.4092346
5	1.5	1.9101124
4	1	1.4109903
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.980

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	35606.129	3.65704	0	3.8E-06	0.00135
8	31148.553	3.40748	0	3.6E-06	0.00145
7	28354.966	2.90836	0	3.1E-06	0.00136
6	25561.379	2.40923	0	2.5E-06	0.00126
5	22767.792	1.91011	0	2E-06	0.00112
4	19974.205	1.41099	0	1.5E-06	0.00095
3	20508.596	0	0	0	0

ave K: 1.25E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	4	4.40572
8	3.5	3.9066
7	3.25	3.65704
6	2.75	3.15792
5	2.25	2.6588
4	1.75	2.15967
3	0	0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 3.980

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	30614.2	4.40572	0	4.6E-06	0.00191
8	27820.6	3.9066	0	4.1E-06	0.00187
7	23363	3.65704	0	3.8E-06	0.0021
6	20569.4	3.15792	0	3.3E-06	0.00207
5	17775.8	2.6588	0	2.8E-06	0.00203
4	14982.2	2.15967	0	2.3E-06	0.00198
3	20508.6	0	0	0	0

ave K: 1.99E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continued)

Sample: P6PP   22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	4	3.8770406
6	3.25	3.1170989
5	2.75	2.610471
4	2.25	2.1038432
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	42345.769	3.87704	0	4.1E-06	0.00124
6	37145.086	3.1171	0	3.3E-06	0.00114
5	31032.676	2.61047	0	2.7E-06	0.00115
4	24920.266	2.10384	0	2.2E-06	0.00116
3	25189.95	0	0	0	0

ave K: 1.17E-03

Cycle # 1

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibration
9	0	-0.17598
8	0	-0.17598
7	5	4.8903
6	4.25	4.13035
5	3.5	3.37041
4	2.75	2.61047
3		-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	38698.9	4.8903	0	5.1E-06	0.00171
6	33498.2	4.13035	0	4.3E-06	0.00168
5	28297.5	3.37041	0	3.5E-06	0.00163
4	23096.8	2.61047	0	2.7E-06	0.00156
3	25190	0	0	0	0

ave K: 0.001643

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	5.25	5.1436102
6	4.5	4.3836684
5	3.75	3.6237267
4	3	2.863785
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	37787.13	5.14361	0	5.4E-06	0.00184
6	32586.448	4.38367	0	4.6E-06	0.00183
5	27385.766	3.62373	0	3.8E-06	0.00181
4	22185.083	2.86378	0	3E-06	0.00178
3	25189.95	0	0	0	0

ave K: 1.82E-03

Cycle # 3

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibration
9	0	-0.17598
8	0	-0.17598
7	5.5	5.39692
6	4.5	4.38367
5	4	3.87704
4	3	2.86378
3	0	-0.17598

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	36875.4	5.39692	0	5.7E-06	0.00198
6	32586.4	4.38367	0	4.6E-06	0.00183
5	26474	3.87704	0	4.1E-06	0.00201
4	22185.1	2.86378	0	3E-06	0.00178
3	25190	0	0	0	0

ave K: 1.90E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continued)

Sample: P7PP   22-Jul

Cycle # Initial

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	4	4.4057232
8	4	4.4057232
7	3.5	3.906601
6	3	3.4074789
5	2.5	2.9083567
4	1.75	2.1596735
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.052

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	30614.162	4.40572	0	4.6E-06	0.00194
8	24492.597	4.40572	0	4.6E-06	0.00245
7	21699.01	3.9066	0	4.1E-06	0.00247
6	18905.423	3.40748	0	3.6E-06	0.00249
5	16111.836	2.90836	0	3.1E-06	0.00251
4	14982.238	2.15967	0	2.3E-06	0.00202
3	20508.596	0	0	0	0

ave K: 2.31E-03

Cycle # 1

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	4.25	4.65528
8	3.75	4.15616
7	3.25	3.65704
6	2.75	3.15792
5	2.25	2.6588
4	1.5	1.91011
3		0.41275

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.052

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	28950.2	4.65528	0	4.9E-06	0.00218
8	26156.6	4.15616	0	4.4E-06	0.00216
7	23363	3.65704	0	3.8E-06	0.00214
6	20569.4	3.15792	0	3.3E-06	0.00211
5	17775.8	2.6588	0	2.8E-06	0.00207
4	16646.2	1.91011	0	2E-06	0.00159
3	20508.6	0	0	0	0

ave K: 0.00204

Cycle # 2

Regression Output for System A (gph)
Constant 0.412746
X Coefficient(s) 0.9982443

Pressure	Reading	Calibration
9	5.25	5.6535286
8	4.25	4.6552843
7	3.75	4.1561621
6	3.25	3.65704
5	2.75	3.1579178
4	2	2.4092346
3	0	0.412746

Regression Output for System A (cc/min)
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibration
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.052

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	22294.217	5.65353	0	5.9E-06	0.00347
8	22828.608	4.65528	0	4.9E-06	0.00279
7	20035.021	4.15616	0	4.4E-06	0.00285
6	17241.434	3.65704	0	3.8E-06	0.00294
5	14447.847	3.15792	0	3.3E-06	0.00307
4	13318.249	2.40923	0	2.5E-06	0.00256
3	20508.596	0	0	0	0

ave K: 2.95E-03

Cycle # 3

Regression Output for System A (gph)
Constant 0.41275
X Coefficient(s) 0.99824

Pressure	Reading	Calibratio
9	4.75	5.15441
8	4.25	4.65528
7	3.5	3.9066
6	3	3.40748
5	2.5	2.90836
4	1.75	2.15967
3	0	2.15967

Regression Output for System A (cc/min
Constant 0.96112
X Coefficient(s) 0.90688

Pressure	Reading	Calibratio
9	0	0.96112
8	0	0.96112
7	0	0.96112
6	0	0.96112
5	0	0.96112
4	0	0.96112
3	0	0.96112

Height 4.052

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	25622.2	5.15441	0	5.4E-06	0.00273
8	22828.6	4.65528	0	4.9E-06	0.00279
7	21699	3.9066	0	4.1E-06	0.00247
6	18905.4	3.40748	0	3.6E-06	0.00249
5	16111.8	2.90836	0	3.1E-06	0.00251
4	14982.2	2.15967	0	2.3E-06	0.00202
3	20508.6	2.15967	0	2.3E-06	0.00145

ave K: 2.35E-03

Table D.4. ECS water permeability for samples P1PP to P8PP (continuted)

Sample: P8PP   22-Jul

Cycle # Initial

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	7.5	7.4234354
6	6.5	6.4101797
5	5.5	5.3969241
4	4.25	4.1303545
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	29581.581	7.42344	0	7.8E-06	0.00343
6	25292.626	6.41018	0	6.7E-06	0.00348
5	21003.672	5.39692	0	5.7E-06	0.00356
4	17626.445	4.13035	0	4.3E-06	0.00328
3	25189.95	0	0	0	0

ave K: 3.44E-03

Cycle # 1

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	6.75	6.66349
6	5.5	5.39692
5	4.75	4.63698
4	3.75	3.62373
3		-0.17598

Regression Output for System B (cc/min
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	32316.8	6.66349	0	7E-06	0.00281
6	28939.5	5.39692	0	5.7E-06	0.00255
5	23738.9	4.63698	0	4.9E-06	0.00269
4	19449.9	3.62373	0	3.8E-06	0.00259
3	25190	0	0	0	0

ave K: 0.002659

Cycle # 2

Regression Output for System B (gph)
Constant -0.175982
X Coefficient(s) 1.0132557

Pressure	Reading	Calibration
9	0	-0.175982
8	0	-0.175982
7	5.5	5.3969241
6	4.75	4.6369823
5	4	3.8770406
4	3	2.863785
3	0	-0.175982

Regression Output for System B (cc/min)
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibration
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m3/s	K cm/sec
9	72805.142	0	0	0	0
8	64869.277	0	0	0	0
7	36875.402	5.39692	0	5.7E-06	0.00198
6	31674.72	4.63698	0	4.9E-06	0.00199
5	26474.038	3.87704	0	4.1E-06	0.00201
4	22185.083	2.86378	0	3E-06	0.00178
3	25189.95	0	0	0	0

ave K: 1.94E-03

Cycle # 3

Regression Output for System B (gph)
Constant -0.17598
X Coefficient(s) 1.01326

Pressure	Reading	Calibratio
9	0	-0.17598
8	0	-0.17598
7	6	5.90355
6	5.25	5.14361
5	4.5	4.38367
4	3.5	3.37041
3	0	-0.17598

Regression Output for System B (cc/min
Constant 2.17333
X Coefficient(s) 0.74461

Pressure	Reading	Calibratio
9	0	2.173328
8	0	2.173328
7	0	2.173328
6	0	2.173328
5	0	2.173328
4	0	2.173328
3	0	2.173328

Height 4.090

Pressure psi	Pressure N/m2	Q gph	Q ccm	Q m2/s	K cm/sec
9	72805.1	0	0	0	0
8	64869.3	0	0	0	0
7	35051.9	5.90355	0	6.2E-06	0.00229
6	29851.3	5.14361	0	5.4E-06	0.00235
5	24650.6	4.38367	0	4.6E-06	0.00244
4	20361.6	3.37041	0	3.5E-06	0.0023
3	25190	0	0	0	0

ave K: 2.34E-03

APPENDIX E

ECS Test Procedures

APPENDIX E

Standard Method of Test for

Determining Moisture Sensitivity Characteristics of Compacted Bituminous Mixtures Subjected to Hot and Cold Climate Conditions

SHRP Designation: M-006[1]

1. SCOPE

1.1 This method determines the water sensitivity or stripping characteristics of compacted asphalt concrete mixtures under warm and cold climatic conditions.

1.2 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.3 The values stated in SI units are to be regarded as the standard. The values in parentheses are for information only.

2. REFERENCED DOCUMENTS

2.1 *AASHTO Documents*

MP1	Method of Test for Performance-Graded Asphalt Binder
R 11	Practice for Indicating Which Places of Figures are to be Considered Significant in Specifying Limiting Values
T2	Method for Sampling Aggregates
T27	Method for Sieve Analysis of Fine and Coarse Aggregates
T40	Method for Sampling Bituminous Materials
T164	Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
T167	Method for Compressive Strength of Bituminous Mixtures
T168	Method of Sampling Bituminous Paving Mixtures
T247	Method for Preparation of Test Specimens of a Bituminous Mixture by Means of the California Kneading Compactor
T269	Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures

[1]This standard is based on SHRP Product 1024.

M-002 Preparation of Compacted Concrete Specimens of Modified and Unmodified Hot Mix Asphalt by Means of the SHRP Gyratory Compactor
M-008 Preparation of Test Specimens of Bituminous Mixtures by Means of Rolling Wheel Compaction
M-007 Short- and Long-Term Aging of Asphalt Concrete Mixtures

2.2 *ASTM Documents*

D 8 Standard Definitions of Terms Relating to Materials for Roads and Pavements
D 3497 Standard Test Methods for Dynamic Modulus of Asphalt Mixtures
D 3549 Method for Thickness or Height of Compacted Bituminous Paving Mixture Specimens
E 1 Specification for Thermometers

3. TERMINOLOGY

3.1 Definitions for many terms to asphalt are found in the following documents:

3.1.1 ASTM D8 Standard Definitions

3.1.2 AASHTO MP1 Performance-Graded Asphalt Binder

4. SUMMARY OF PRACTICE

4.1 Compacted asphalt concrete test specimens are subjected to a water and temperature conditioning process. The water sensitivity characteristics of the compacted mixtures are determined based upon measurements of percent stripping, the environmental conditioning system (ECS) modulus, and the coefficients of permeability for air and water flow.

5. SIGNIFICANCE AND USE

5.1 The measured water sensitivity characteristics may be used to evaluate or characterize asphalt concrete mixtures.

5.2 The water sensitivity characteristics of asphalt concrete mixtures can be used to determine their suitability for use as highway paving materials. This information may also be used to compare and select binders, modifiers, mixtures, additives, and aggregates for asphalt concrete.

6. APPARATUS

6.1 *Environmental Condition System (ECS)*—Any closed-loop computer-controlled test system that meets the minimum requirements outlined in table E.1. The ECS must be capable of within an asphalt concrete specimen increasing the temperature to 100°C *and* decreasing it to −20°C within 2 hours. It must be able to "pull" distilled water through a specimen at specified vacuum levels. The ECS must be able to apply axial load pulses (220 ± 5 N static and 6700 ± 25 N dynamic) in a haversine wave form with a load duration of 0.1 s and a rest period of 0.9 s between load pulses. The system must also be capable of measuring axial deformations and be equipped with computer software which can compute axial compressive stress and recoverable axial deformation strain at various load cycles. In addition, the ECS must be capable of applying loads sufficient to obtain deformations between 50 to 100 μstrain. The ECS is illustrated in figures E.1, E.2, and E.3.

Table E.1. Minimum Test System Requirements

Measurement and Control Parameters	Range	Resolution	Accuracy
Load (compression)	0 to 6700 N	≤ 2.5 N	± 5 N
Axial Deformation	0 to 6.5 mm	≤ 0.0001	± 0.0001
Chamber Temperature	−20 to 100°C	≤ 0.5°C	± 0.5°C
Vacuum Pressure	0 to 635 mm Hg	≤ 25 mm Hg	± 25 mm Hg
Air Flow	20 to 20,000 cm^3/min	≤ 20 cm^3/min	± 10 cm^3/min
Water Flow	0 to 2525 cm^3/min	≤ 2 cm^3/min	± 1 cm^3/min
Water Reserve Temperature	25 ± 3°C	≤ 0.5°C	± 0.5°C

6.2 *Testing Machine*—a pneumatic or hydraulic testing machine that meets the requirements outlined in section 4.3 of T167.

6.3 *Specimen End Platens*—Two aluminum end platens are shown in figure E.4. The end platens shall be 102 ± 2 mm diameter by 51 ± 2 mm thick. Each end platen will have a drainage hole at its center that is 4.76 ± 0.5 mm in diameter and one side of each end platen will be patterned with grooves as shown in figure E-4. In addition, the platen must have a groove around its perimeter at mid height which is of sufficient width and depth to hold the O-rings described in section 6.5.2.

6.4 *Perforated Teflon Disks*—As shown in figure E.4. The perforations must coincide with the grooving pattern in the specimen end platens.

6.5 *Miscellaneous Apparatus:*

6.5.1 150 mm of 100 mm diameter rubber membrane capable of covering the cylindrical surface area of the specimen.

6.5.2 Two 102 mm O-rings

6.5.3 Caulking gun

6.5.4 Calipers

6.5.5 Spatula

6.5.6 Vacuum source

7. MATERIALS

7.1 The following materials are required:

7.1.1 Clear silicone sealant (e.g., general household sealant, silicon rubber)

7.1.2 Compressed air

7.1.3 40 L of distilled water

8. SAMPLING

8.1 Asphalt binder shall be sampled in accordance with AASHTO T40.

8.2 Aggregate shall be sampled in accordance with AASHTO T2.

8.3 Asphalt concrete mixtures shall be sampled in accordance with AASHTO T168.

9. SPECIMEN PREPARATION

9.1 Prepare an asphalt concrete mixture sample in accordance with sections 9.1, 9.2, and 9.3 of T247. Prepare a sufficient amount of material to ensure that the final compacted test specimen is 102 $\pm$ 4 mm in diameter by 102 $\pm$ 4 mm in height.

9.2 Subject the asphalt concrete mixture prepared in section 9.1 to short-term aging in accordance with sections 10.1, 10.2, and 10.3 of T247.

NOTE 1.—Plant mixed asphalt concrete samples are not to be subjected to short-term aging as described in T247.

9.3 Heat or cool the asphalt concrete mixture to the described compaction temperature.

9.4 Compact the asphalt concrete mixture in accordance with T247. Compact a sufficient amount of material to ensure that the final compacted test specimen is 102 ± 4 mm in height.

9.5 Determine the air void of the specimen.

NOTE 2.—It is *not* recommended that the Marshall method of compaction (AASHTO T245-82 or ASTM D 1559-89) be used. If specimens are cored from the field or from a slab, the top and bottom of the specimen must *not* sustain a cut surface.

9.6 Measure the diameter and height or thickness of the specimen at three locations, at approximately one-third points and record the average measurement as the diameter and thickness of the specimen ± 1.0 mm in accordance with D 3549.

9.7 Place the specimen inside the 150-mm long rubber membrane, centering the specimen within the membrane so that there is a 25-mm overlap at each end. Inject a continuous line of silicone cement between the membrane and the specimen with a caulking gun. Use a spatula to smooth the silicone to a thick, uniform layer between the rubber membrane and the specimen. Allow the specimen to stand at room temperature, overnight or longer, until the silicone is dry.

10. PROCEDURE

10.1 *Specimen Setup*

10.1.1 Place a perforated Teflon disk on top of the grooved surface of the bottom end platen inside the load frame.

10.1.2 Place the specimen vertically on top of the Teflon disk and bottom end platen.

NOTE 3.—For cores removed from field pavements, it is important that the specimen be placed such that the top of the specimen corresponds to the top of the pavement.

10.1.3 Place a perforated Teflon disk on top of the specimen and place the top end platen on top of the disk, with the grooved surface facing the disk and specimen.

10.1.4 Seal the rubber membrane around the specimen platen assembly by placing an O-ring in each groove of the end platens, over the rubber membrane.

10.1.5 To ensure that the system is airtight, select vacuum with the water-vacuum-air valve. This closes the system to air and water. Open the vacuum valve until the inlet and outlet pressure reads 510 mm of Hg. Adjust the vacuum level with the vacuum regulator. Close the vacuum valve. Close the bypass valve so that the vacuum is drawn through the specimen. Wait for 5 minutes. If both gauge readings remain constant, the system is airtight and testing may continue. If the readings decrease, the system is not airtight and adjustments must be made to the system prior to continuing testing.

10.1.6 Attach the yoke with the spacers and the LVDTs to the specimen.

10.2 *Coefficient of Permeability for Air Flow*

10.2.1 Set and establish the temperature of the environmental control chamber to 25 ± 0.5°C.

10.2.2 Open the vacuum valve and select air flow from the water-vacuum-air valve. Apply the lowest differential pressure possible (typically 50 mm of Hg) by adjusting the vacuum regulator. Record the air flow through the test specimen. Record the pressure differential reading.

10.2.3 Repeat 10.2.2 for four different pressures. The pressures selected will vary depending on the void content of the specimen being tested. They may range from 50 to 400 mm of Hg. It is important that a range be selected that is consistent with the air void content. A constant interval between the pressures must be selected e.g., 20, 30, 40, and 50 kPa.

10.2.4 Calculate the coefficient of permeability for air flow of the test specimen as described in 11.2.1 for each of the pressures. Report the average of the four results.

NOTE 4.—Air flow measurements should be within 10% of each other.

10.2.5 Close the vacuum valve.

10.3 *ECS Modulus Test*

10.3.1 Maintain the temperature of the environmental chamber at 25 ± 0.5°C. Remove the spacers from the yoke.

10.3.2 Apply a static load of 130 ± 25 N and an axial compressive repeated load of 2200 ± 25 N to the test specimen. The repeated load should be in a haversine wave form with a load duration of 0.1 s and a rest period of 0.9 s between load pulses.

10.3.3 Adjust the specimen until the readings from the two LVDTs are within 15% of each other.

10.3.4 If the strain is less than 50 μstrain, *increase* the repeated load until a strain level between 50 and 100 μstrain is reached. If the strain is more than 100 μstrain, *decrease* the repeated load until a strain level between 50 and 100 μstrain is reached.

10.3.5 If using the ECS software, the load and deformation data for the last five cycles are collected and the ECS modulus automatically calculated when the [ESC] key is pressed. Otherwise, measure and record the peak axial load and recoverable vertical deformation for the load interval from the last five cycles. Then calculate the ECS modulus as outlined in section 11.3.3.

NOTE 5.—Typically, to achieve a strain level of 100 ± 5 μstrain, a dynamic load approximately 4000 N is required. Once the load has been adjusted, use the same loads for subsequent measurements for the *same* specimen after the conditioning cycles.

NOTE 6.—Do *not* exceed 250 load cycles when performing the ECS modulus test. This will damage the specimen.

10.3.6 Remove the load from the specimen after the last load cycle. Check that the inlet and outlet gauges are closed.

10.4 *Vacuum*

10.4.1 Check that the bypass valve is open. Select vacuum with the vacuum-water-air valve.

10.4.2 Open the vacuum valve and close the bypass valve. Apply a vacuum of 510 mm of Hg for 10 min.

10.4.3 Open the bypass valve.

10.5 *Wetting*

10.5.1 Maintain the temperature of the environment chamber at 25 ± 0.5°C. Establish the temperature of the distilled water source at 25 ± 3°C (room temperature). Open the bypass valve.

10.5.2 Select water flow from the vacuum-water-air valve. Turn on the vacuum and adjust using the vacuum regulator until a level of 510 ± 25 mm of Hg (as measured by the outlet gauge) has been reached.

10.5.3 Wait for one minute or until distilled water has been drawn into the tubing and the system. Close the bypass valve so that the distilled water is pulled through the test specimen for 30 ± 1 min.

10.6 *Coefficient of Permeability of Water Flow*

10.6.1 Decrease the vacuum level to approximately 40 kPa (5.8 psi) differential pressure by adjusting the vacuum regulator. Record the water flow through the test specimen. Record the pressure differential reading.

10.6.2 Repeat the procedure described in section 10.6.1 for four different pressures. The pressures selected will vary depending on the void content of the specimen being tested.

They may range from 20 to 40 kPa differential pressure. It is important that a range be selected that is consistent with the air void content.

10.6.3 Calculate the coefficient of permeability for water flow as described in section 11.5.1 for each pressure. Report the average result.

NOTE 7.—Water flow measurements should be within 10% of each other.

10.7 *Water Conditioning*

10.7.1 Conduct water conditioning for either the warm or cold climate conditions as described in sections 10.7.2 or 10.7.3, respectively. Table E.2 summarizes the procedures described in sections 10.7.2 and 10.7.3.

Table E.2. Conditioning Cycles for Warm and Hot Climates

	Conditioning Stage				
Conditioning Factor	**Wetting***	**Cycle-1**	**Cycle-2**	**Cycle-3**	**Cycle-4**
Vacuum Level (mm Hg)	510	250	250	250	250
Repeated Loading	NO	YES	YES	YES	NO
Ambient Temperature (°C)**	25	60	60	60	−18
Duration (hrs)	0.5	6	6	6	6

Conditioning Procedure for Warm Climates (Wetting through Cycle-3)

Conditioning Procedure for Cold Climate (Wetting through Cycle-4)

*Wetting the specimen prior to the conditioning cycles
**inside the environmental cabinet

Notes:
1. The conditioning procedure for a warm climate is wet, then 3 hot cycles.
2. The conditioning procedure for a cold climate is wet, then 3 hot cycles plus one cold cycle.

10.7.2 *Warm Climate Conditioning*

10.7.2.1 Reduce the vacuum pressure to 254 ± 25 mm Hg at the outlet gauge and reduce the water flow to 4 ± 1 cm^3/min.

10.7.2.2 Set the temperature of the environmental cabinet to 60 ± 0.5°C for 6 hours ± 5 min, followed by a temperature of 25 ± 0.5°C for at least 2 hours.

10.7.2.3 Apply a repeated axial compressive load of 90 ± 5 N static and 900 ± 25 N dynamic to the test specimen, in a haversine wave form with a load duration of 0.1 s and a rest period of 0.9 s between load pulses. Continuous application of the load is to occur throughout the hot conditioning cycle (i.e., 6 hours at 60°C).

NOTE 8.—For open-graded mixes, the loads may need to be reduced.

10.7.2.4 At the end of 8 hours, close the vacuum valve, open the bypass valve and open the system to atmospheric pressure. Continue to maintain the temperature setting of the environmental chamber at 25 ± 0.5°C. Determine the ECS modulus as described in section 10.3.

NOTE 9.—For the modulus test, use the same loads that were initially established in section 10.3.

10.7.2.5 Continue to maintain temperature setting of the environmental chamber at 25 ± 0.5°C and determine the coefficient of permeability of water flow as described in section 10.6.

NOTE 10.—If excessive deformation (5 to 10%) of the specimen is experienced after the first hot cycle, terminate the conditioning.

10.7.2.6 Begin a second hot conditioning cycle by repeating the procedure in sections 10.7.2.1 to 10.7.2.5.

10.7.2.7 Begin a third hot conditioning cycle by repeating the procedure in sections 10.7.2.1 to 10.7.2.5.

10.7.3 *Cold Climate Conditioning*

10.7.3.1 Complete the three hot conditioning cycles as described in sections 10.7.1. to 10.7.2.7.

10.7.3.2 Reduce the vacuum pressure to 250 ± 25 mm Hg at the outlet gauge and reduce the water flow to 4 ± 1 cm_3/min. Turn off the load.

10.7.3.3 Set the temperature of the environmental chamber to −18 ± 0.5°C for 6 hours ± 5 min followed by a temperature of 25 ± 0.5°C for at least 2 hours.

10.7.3.4 At the end of the 8 hours, close the vacuum valve, open the bypass valve and open the system to atmospheric pressure. Continue to maintain the temperature setting of the environmental chamber at 25 ± 0.5°C. Determine the ECS resilient modulus as described in section 10.3.

10.7.3.5 Continue to maintain the temperature setting of the environmental chamber at 25 ± 0.5°C and determine the coefficient of permeability of water flow as described in section 10.6.

10.8 *Stripping Evaluation*

10.8.1 At the conclusion of the last conditioning cycle, remove the specimen from the environmental chamber. Remove the membrane from the specimen and place it in a diametral position between two bearing plates of a loading jack on a mechanical or hydraulic testing machine.

10.8.2 Apply a load sufficient to induce a vertical crack in the specimen.

10.8.3 Remove the test specimen and pull the two halves apart. Estimate the percentage of stripping that has occurred by making a relative comparison to the standard patterns of stripping shown in figure E.6.

11. CALCULATIONS

11.1 Calculate the following:

11.1.1 *Cross Sectional Area (m^2)*:

$$A = \frac{\pi d^2}{40,000} \tag{1}$$

where

d = Average diameter of the test specimen, in cm
π = 3.14159

11.2 After conducting the air permeability testing outlined in section 10.2, calculate the following:

11.2.1 *Coefficient of Permeability of Air Flow (cm/s)*:

$$k_a = \frac{1.7937 \times 10^{-8} qL}{\Delta P} \tag{2}$$

where

k_a = Coefficient of permeability for air flow, in cm/s
q = Flow rate of air at mean pressure across specimen, in cm^3/min
L = Average height of the test specimen, in mm
ΔP = Pressure difference across the specimen, mm Hg

11.3 For the last five load cycles applied as specified in section section 10.3, calculate the following:

NOTE 11.—The ECS software should automatically make the computations described in sections 11.3, 11.4, and 11.6.1.

11.3.1 *Peak Stress (kPa) per load cycle:*

$$\sigma_{i-n} = \left[\frac{V_{i-n}}{A}\right] \tag{3}$$

where

V_{i-n} = Peak load applied by the vertical actuator over a load cycle, in N
i = Number of conditioning cycles applied (i.e., 0, 1...4)
n = Number of load cycles applied (i.e., 1, 2, 3, 4, 5)

11.3.2 *Recoverable Axial Strain (mm/mm) per load cycle*:

$$\epsilon_{i-n} = \frac{\delta_{ri-n}}{2h} \tag{4}$$

where

δ_{ri-n} = Peak recoverable vertical deformation over a load cycle, in mm
h = Gauge length, the distance over which deformations are measured (i.e, distance between yoke rings), in mm

NOTE 12.—The recoverable deformation is the position of the total deformation that disappears (or is recovered) upon unloading the specimen as shown in figure E.7.

11.3.3 *ECS Modulus (kPa) per load cycle:*

$$M_{Ri-n} = \left[\frac{\sigma_{i-n}}{\epsilon_{i-n}}\right] \tag{5}$$

11.4 After calculating ECS modulus for the last five load cycles, calculate the following:

11.4.1 *Average ECS Modulus (kPa) per conditioning cycle:*

$$M_{Ri} = \frac{\sum_{n=1}^{5} (M_{Ri-n})}{\Delta n} \tag{6}$$

where

Δn = the number of load cycle included in M_{Ri} calculation (for last five load cycles, $\Delta n = 5$)

11.5 After conducting the water permeability testing outlined in section 10.6, calculate the following:

11.5.1 *Coefficient of Permeability for Water Flow (cm/s):*

$$k_w = \frac{7.4075 \times 10^{-6} qL}{\Delta P} \tag{7}$$

where

k_w	=	Coefficient of permeability for water flow, in cm/s
q	=	Flow rate of water at mean pressure across specimen, in cm^3/min
L	=	Average height of the test specimen, in mm
ΔP	=	Pressure difference across the specimen, in kPa

11.6 After completing each conditioning cycle (i), compute the following:

11.6.1 *ECS Modulus Ratio:*

$$M_R R_i = \left[\frac{M_{Ri}}{M_{RO}}\right] \tag{8}$$

where

M_{R0}	=	Initial ECS resilient modulus, in kPa

11.6.2 *Water Permeability Ratio:*

$$k_{Rwi} = \left[\frac{k_{wi}}{k_{w0}}\right] \tag{9}$$

where

K_{w0}	=	Initial water permeability, in cm/s

12. REPORT

12.1 Report the following information:

12.1.1 *Asphalt Binder Grade*

12.1.2 *Asphalt Binder Content*—in percent to the nearest 0.1%

12.1.3 *Aggregate Type and Gradation*

12.1.4 *Mixing and Compaction Conditions*—the following information is applicable:

12.1.4.1 *Plant Mixing Temperature*—in degrees Celsius to the nearest 1°C

12.1.4.2 *Laboratory Mixing Temperature*—in degrees Celsius to the nearest 1°C

12.1.4.3 *Laboratory Compaction Temperature*—in degrees Celsius to the nearest 1°C

12.1.4.4 *Laboratory Compaction Method*

12.1.4.5 *Compacted Specimen Height*—in centimeters to the nearest 0.15 cm

12.1.4.6 *Compacted Specimen Diameter*—in centimeters to the nearest 0.15 cm

12.1.4.7 *Compacted Specimen Area*—in square centimeters to the nearest 0.02 cm^2

12.1.4.8 *Compacted Specimen Density*—in kilograms per square meter to the nearest 0.02 cm^2

12.1.4.9 *Compacted Specimen Air Voids*—in percent to the nearest 0.1%

12.1.5 *Coefficient of Permeability for Air Flow*—a table listing of the following results for each different pressure applied:

12.1.5.1 *Chamber Testing Temperature*—in degrees Celsius to the nearest 0.5°C

12.1.5.2 *Differential Pressure*—in mm of Hg

12.1.5.3 *Air Flow*—in cubic centimeters per second to the nearest 2 cm^3/s

12.1.5.4 *Coefficient of Permeability for Air Flow*—in cm/s to the nearest 2 cm/s

12.1.6 *ECS Modulus Results*—a table listing the following results for each load cycle (last five cycles) prior to any conditioning cycles and after each conditioning cycle:

12.1.6.1 *Chamber of Testing Temperature*—in degrees Celsius to the nearest 0.5°C

12.1.6.2 *Static Load Applied*—in newtons to the nearest 5 N

12.1.6.3 *Dynamic Load Applied*—in newtons to the nearest 5 N

12.1.6.4 *Peak Stress*—in kilopascals to the nearest 0.1 kPa

12.1.6.5 *Recoverable Axial Strain*—in millimeters per millimeter to the nearest 10^{-6} mm/mm

12.1.6.6 *ECS Modulus*—in kilopascals to the nearest 5 kPa

12.1.7 *Initial ECS Modulus*—in kilopascals to the nearest 5 kPa

12.1.8 *Coefficient of Permeability for Water Flow*—a table listing the following results for each differential pressure applied after each conditioning cycle:

12.1.8.1 *Chamber Testing Temperature*—in degrees Celsius to the nearest 0.5°C

12.1.8.2 *Water Temperature*—in degrees Celsius to the nearest 0.5°C

12.1.8.3 *Differential Pressure*—in kpa to the nearest 5 kpa

12.1.8.4 *Water Flow*—in cubic centimeters per minute to the nearest 2 cm^3/min

12.1.8.5 *Coefficient of Permeability of Water Flow*—in centimeters per second to the nearest 10^{-4} cm/s

12.1.9 *Water Conditioning Results*—a table listing the following results for each conditioning cycle:

12.1.9.1 *Average ECS Modulus*—in kPa to the nearest 5 kPa

12.1.9.2 *ECS Modulus Ratio*

12.1.9.3 *Water Permeability Ratio*

12.1.10 *Stripping Rate*—in percent to the nearest 5%

13. PRECISION

13.1 Data to support a precision statement for this test method are not available.

13.2 Since there is no accepted reference value, the bias for this test method cannot be determined.

14. KEYWORDS

14.1 Asphalt concrete, asphalt concrete permeability, bituminous mixtures, bituminous paving mixtures, moisture sensitivity, resilient modulus, stripping potential, water sensitivity.

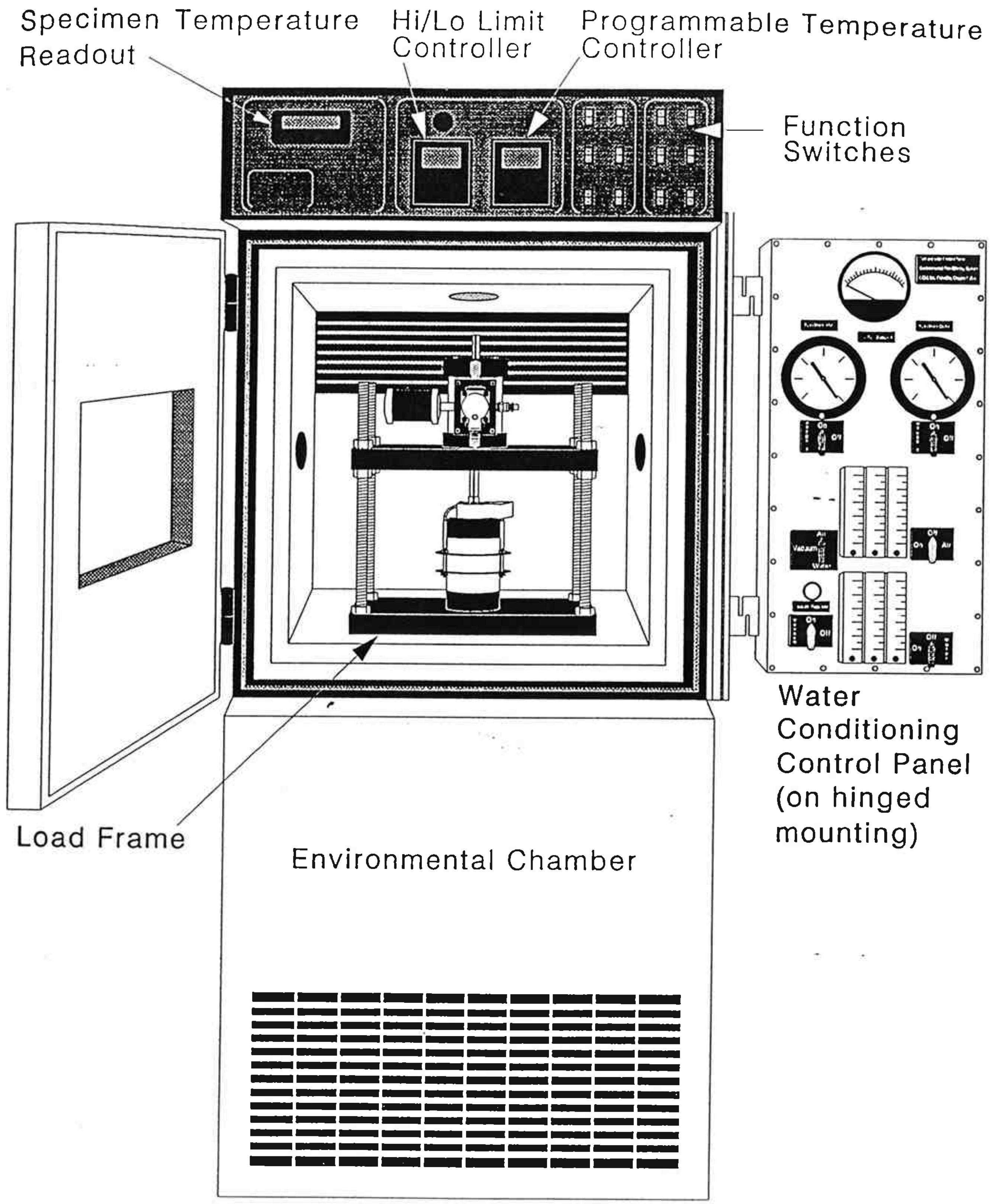


Figure E.1. Environmental Conditioning System (Front View)

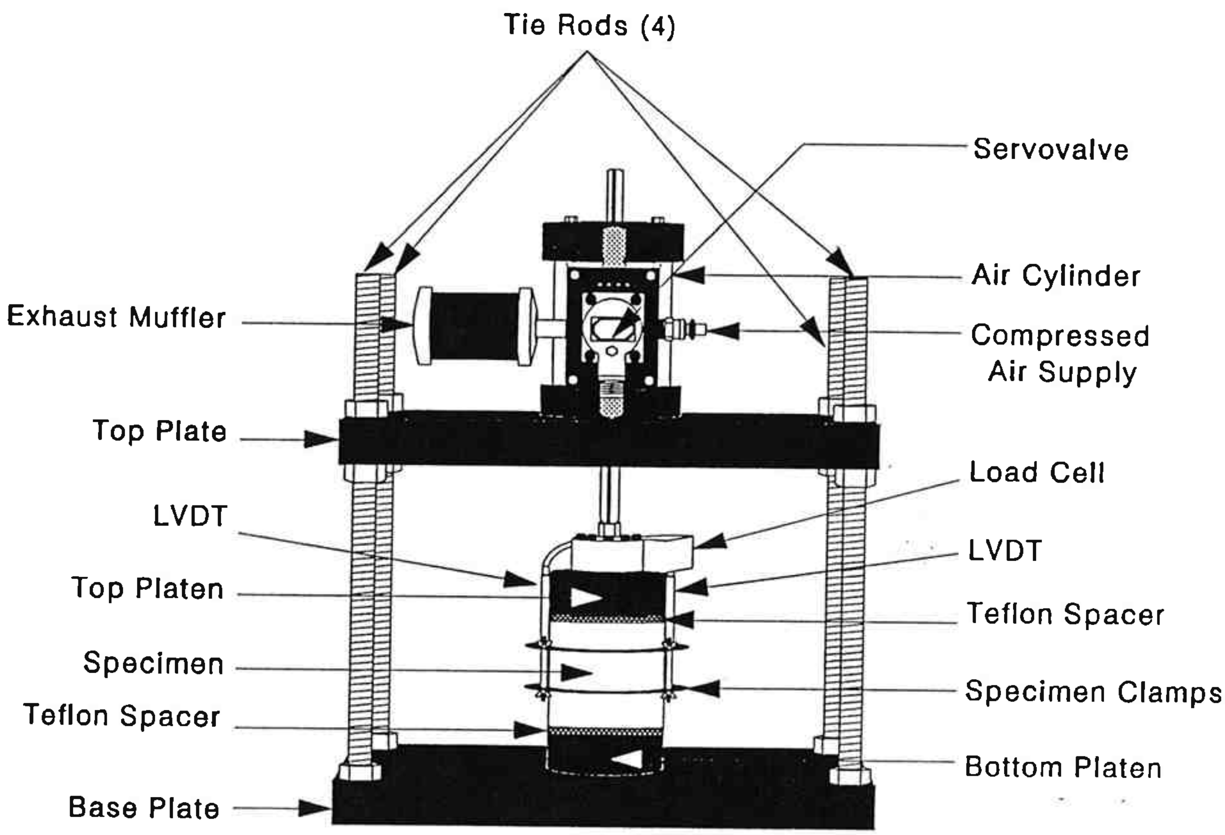


Figure E.2. Load Frame with Specimen

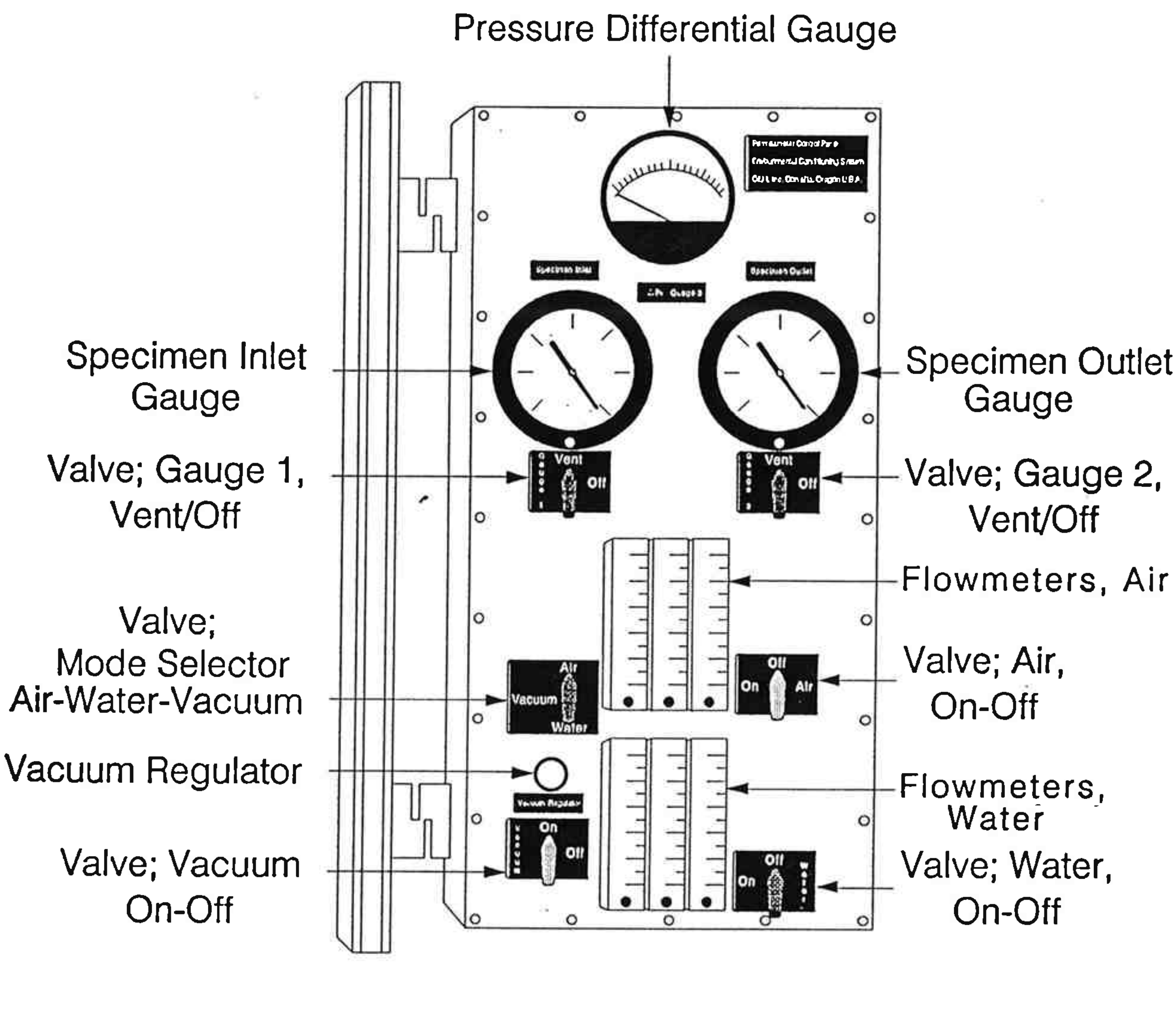


Figure E.3. Control Panel

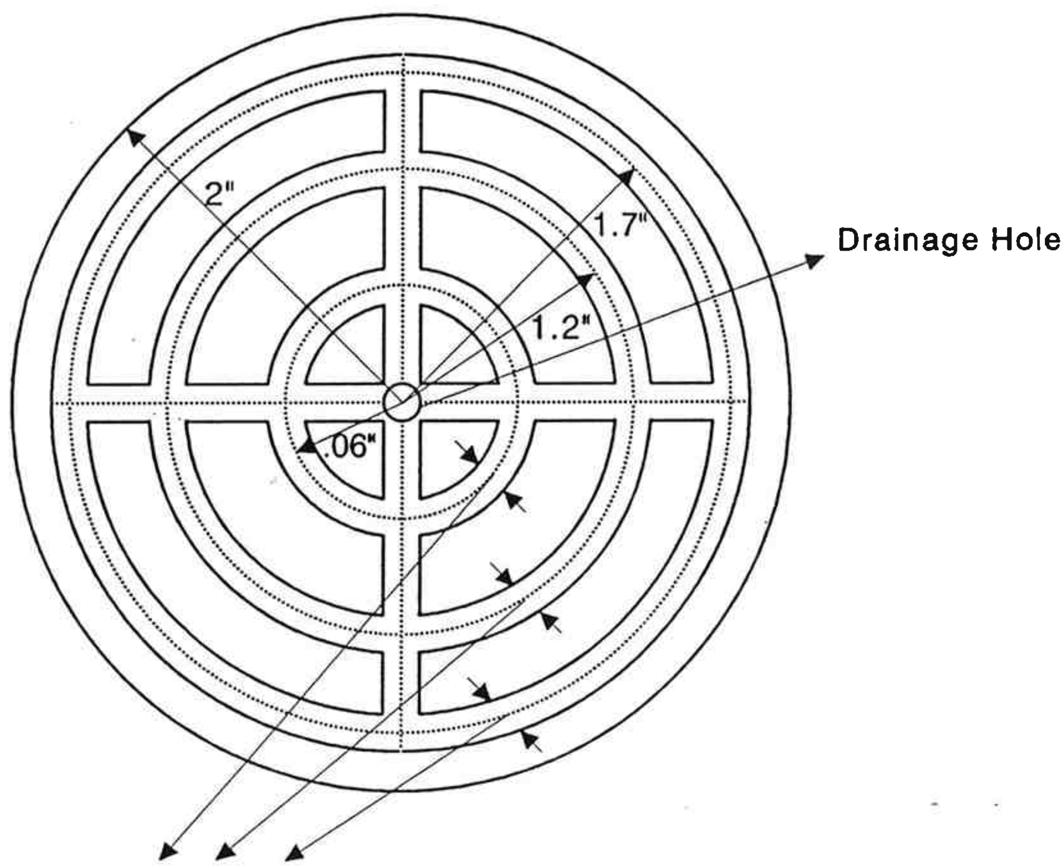


Figure E.4. Groove Pattern for End Platens

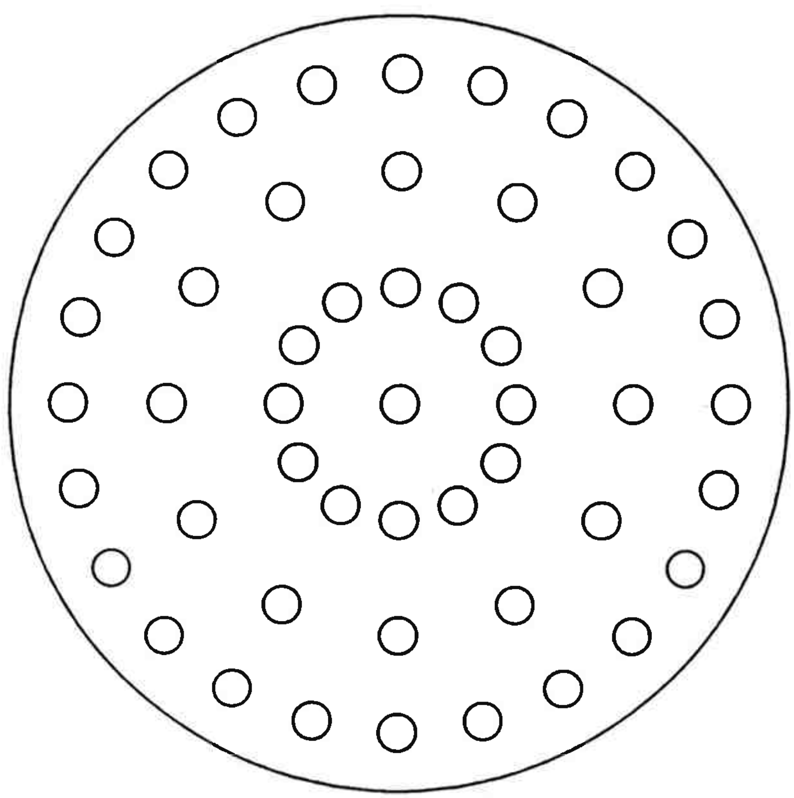


Figure E.5. Perforated Teflon Spacers

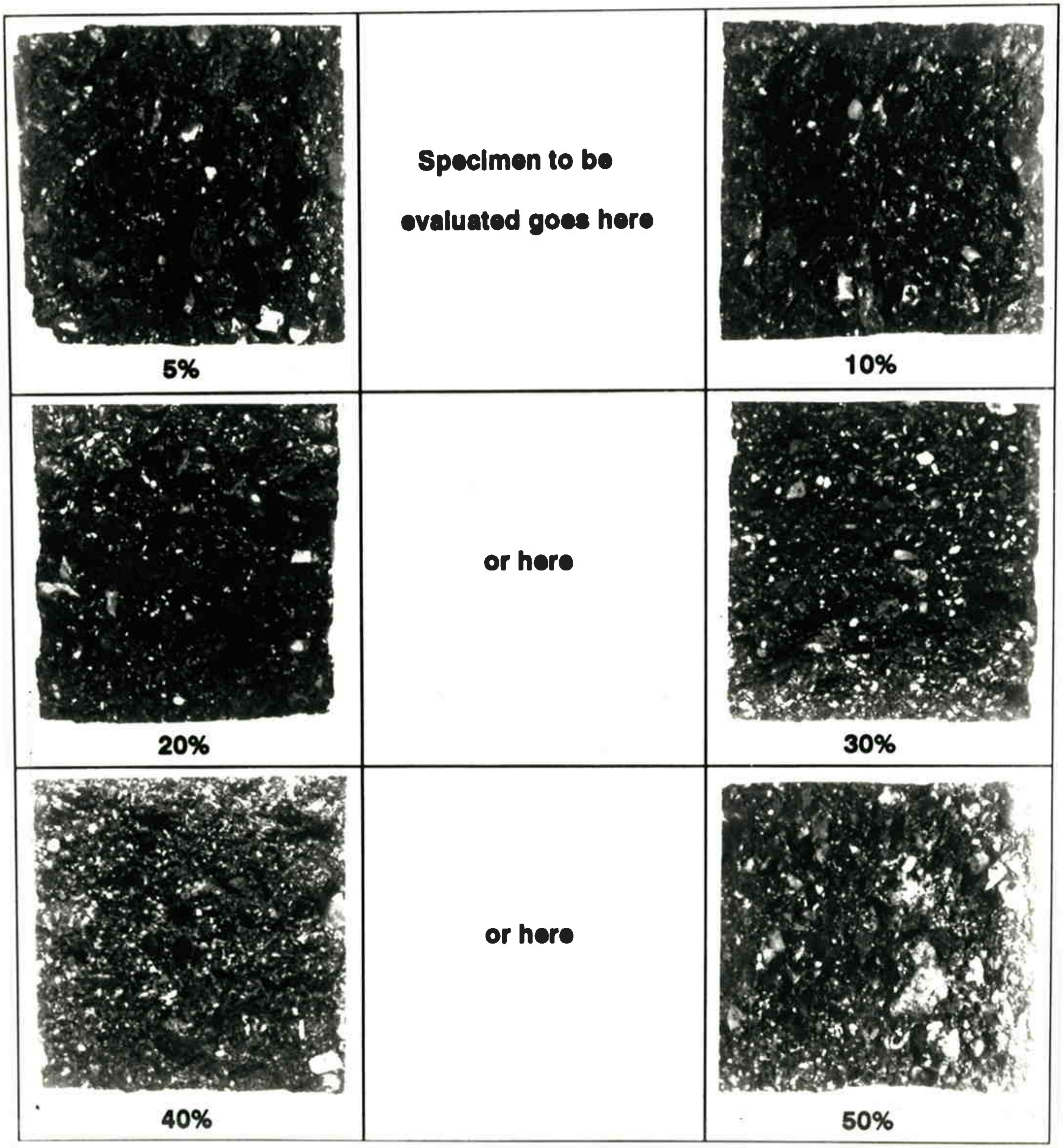


Figure E.6. Stripping Rate Standards

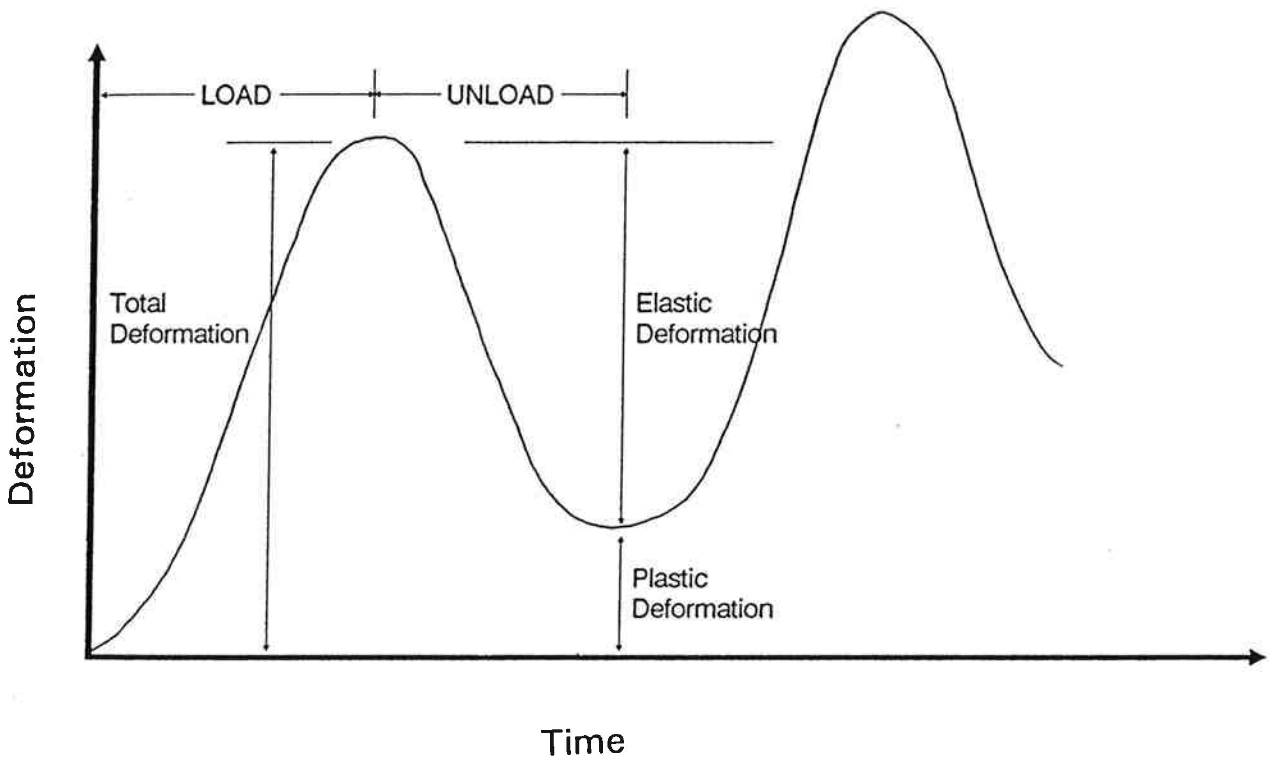


Figure E.7. Illustration of Specimen Deformation Resulting from Application of Load Cycles

APPENDIX F

STRESS DISTRIBUTIONS IN POROUS ASPHALT MIXES

by

Duhwoe Jung

Krey Younger

R.G. Hicks

Department of Civil Engineering
Oregon State University
Corvallis, OR 97331

June 1994

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Background

Porous pavements are currently used in Oregon (Class F-mix) as overlays on dense-graded asphalt mixes to increase safety. F-mixes are also being proposed for use on portland cement concrete pavements. The effect of porous mixes on pavement structural performance has yet to be evaluated. This is because most laboratory tests and analytical methods are not capable of evaluating the affects of these mix types.

Using a finite element method can allow one to estimate the stresses in a multi-layered system. A finite element program (ANSYS) was used in this study to evaluate the performance characterics of porous mix overlay on both an asphalt concrete and a portland cement concrete pavement (1-4).

1.2 Purpose

The purpose of this appendix is twofold:

1) To evaluate the stresses porous mixes are subjected to in actual pavements. This will permit development of appropriate stress conditions for evaluating the laboratory performance of such mixes.

2) To evaluate the effect of varying thicknesses of porous mixes on the critical stresses in portland cement concrete mixes.

2.0 APPROACH USED

The approach used in this study is summarized in Figure F-1. The following sections describe the selected process in detail.

2.1 Stresses in Porous Mixes

To determine the stresses in a porous mix placed over an asphalt concrete layer, a finite element program (ANSYS) was employed (1-4). Figure F-2 illustrates the cross sections employed while Figure F-3 identifies the finite element configuration. A tire pressure of 80 psi was employed for the analysis.

The material properties assumed for each layer were as follows:

1)	Porous mix:	500,000 psi (3,400 MPa)
2)	Existing ACP:	150,000 psi (1,000 MPa)
3)	Aggregate base:	20,000 psi (140 MPa)
4)	Subgrade:	3,000, 10,000 and 20,000 psi (21, 69, and 140 MPa)

Stresses in the porous mix were calculated along the left and right sides of the finite elements shown in Figure F-3b. Each of these elements is calculated as directly under the prospective wheel loads shown in the element diagram, Figure F-3a. Specification DLT, for example, stands for element beneath wheel load D, and on the top left corner. As it was necessary to try to determine what in field confining pressure exists, the pressure was determined by an average of the top, middle, and bottom corner stresses.

2.2 Stresses in PCC Pavements

A similar approach was used to calculate the critical stress reduction in portland cement concrete from the use of a porous overlay. The cross section employed is shown in Figure F-4. A

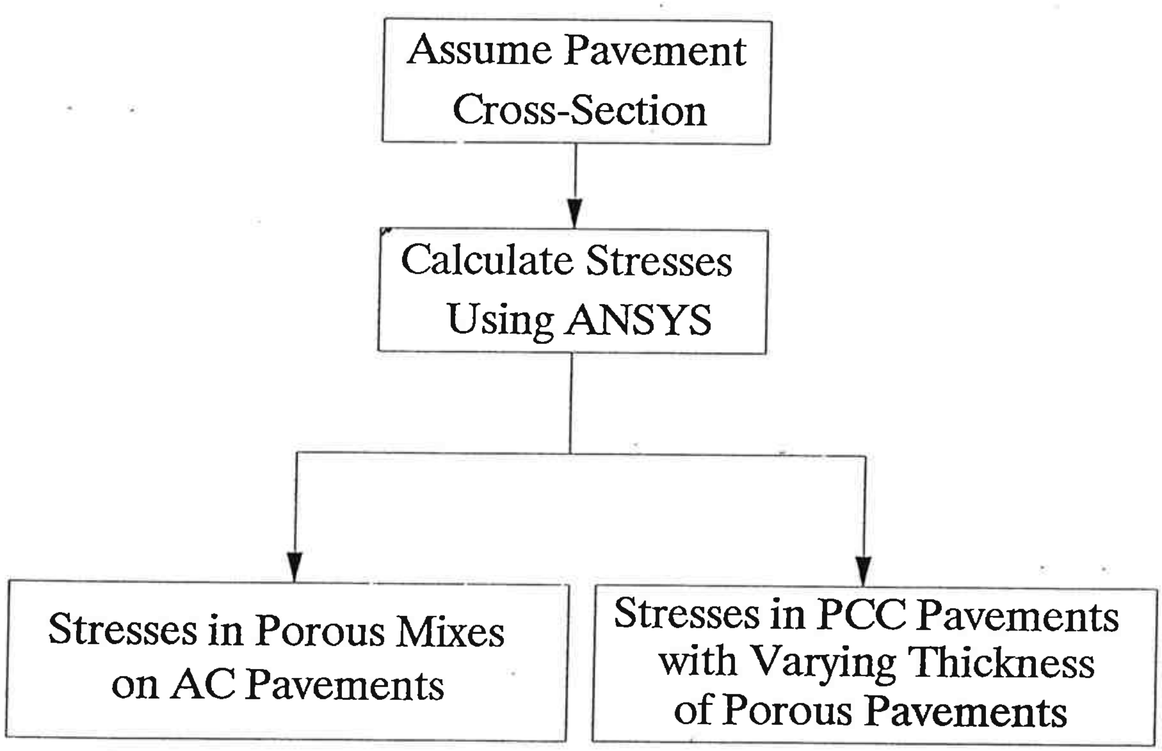


Figure F-1. Approach used

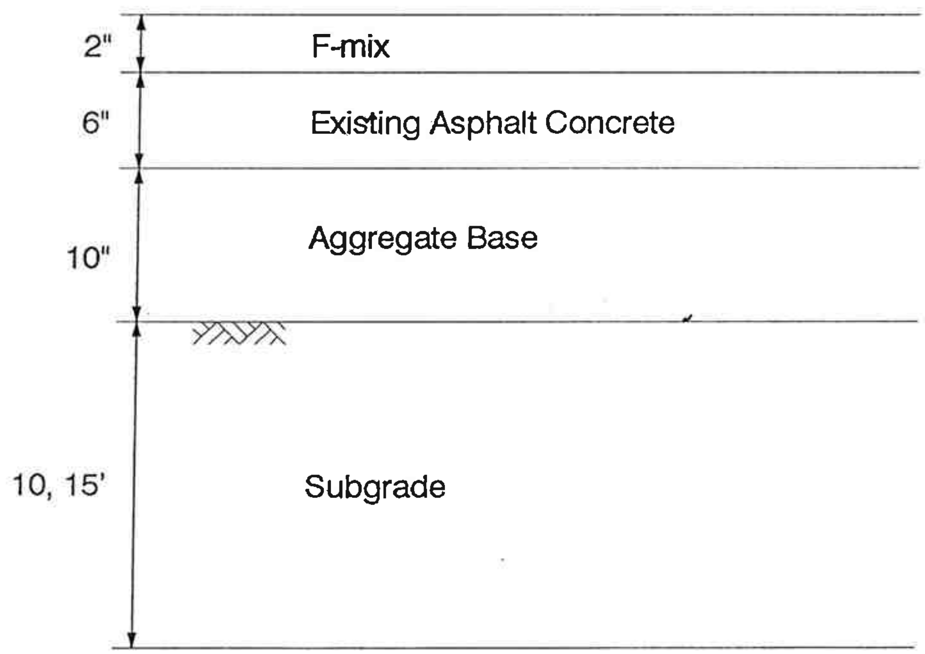
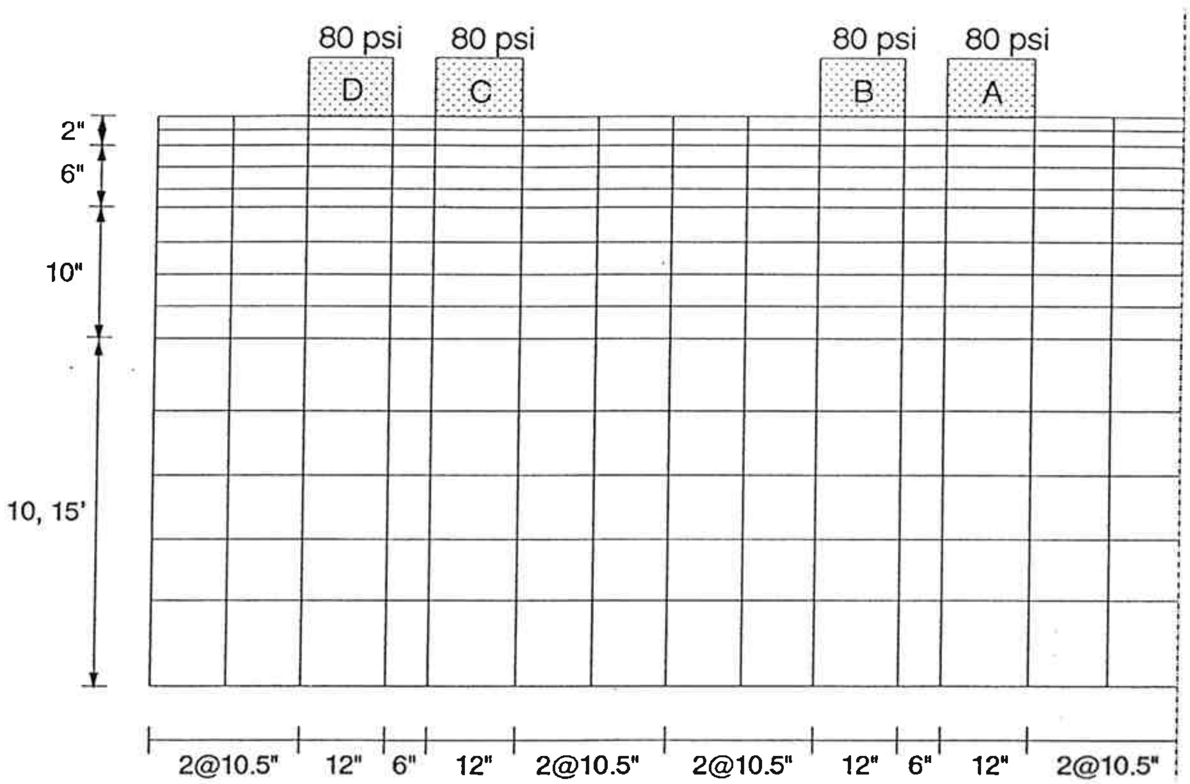
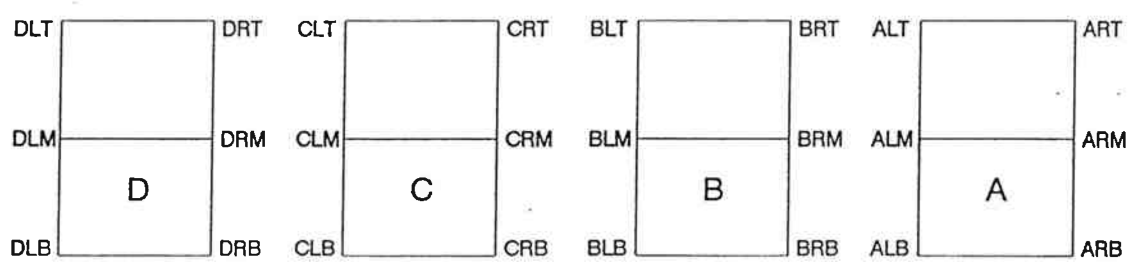


Figure F-2. Cross section used for calculating stresses in porous mixes



a) Grid used



b) Nodal locations under load

Figure F-3. Finite element grid for porous mix over dense mix

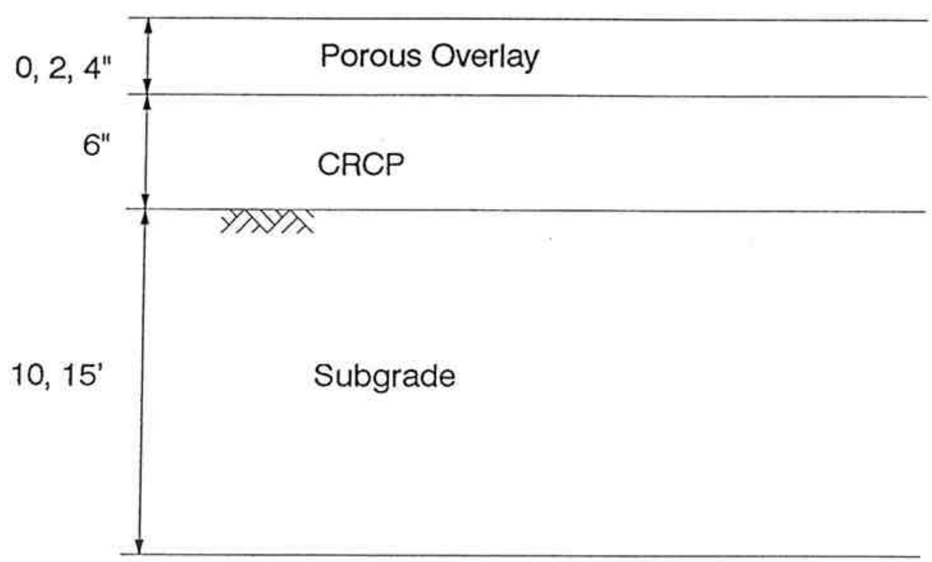
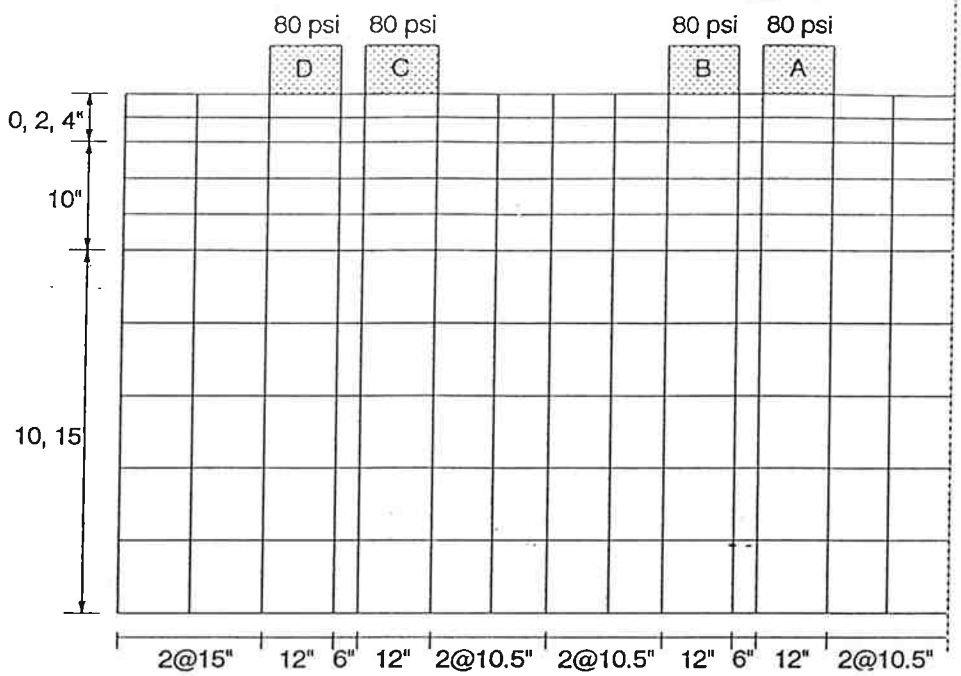


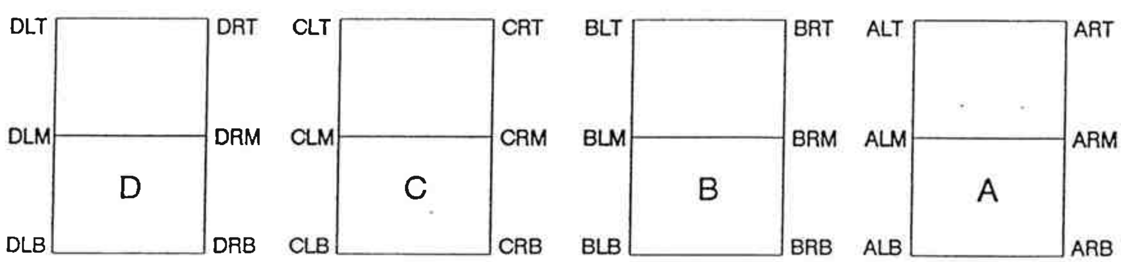
Figure F-4. Cross section used to calculate stresses in PCC pavement

tire pressure of 80 psi was employed for the analysis. The critical stress was the maximum flexural stress at the bottom of the PCC.

Figure F-5a describes how the elements were set up to handle this particular problem. As the critical stress at the bottom of the PCC was desired, the elements abutting this layer were used. The maximum critical stress would then be along the bottom of the elements shown in Figure F-5b.



a) Grid used



b) Nodal locations under load

Figure F-5. Finite element grid for calculating stresses in PCC pavement

3.0 RESULTS

3.1 Stresses in Porous Mixes

As discussed earlier, the horizontal stresses in the porous mix were calculated just outside the wheel loads and are summarized below.

3.1.1 Under Wheel Loads A and B

As indicated in Figures F-6 and F-7, stresses were maximum at the surface of the F-mix overlay and decreased with depth. The maximum stresses for inner sides (left side of wheel load A and right side of wheel load B) were greater than those for outer sides. The maximum stresses for outer sides ranged from 100 to 230 psi and from 130 to 330 psi for inner sides for both 2 in and 4 in F-mixes.

No significant differences in horizontal stresses were found with varying thickness of F-mix overlay were found. The stresses also tended to increase as the subgrade modulus decreased. The horizontal stresses were not significantly affected by the thickness of subgrade. Stresses for thicker subgrade were slightly lower than those for thinner subgrade.

3.1.2 Under Wheel Loads C and D

As shown in Figure F-8, the maximum stresses were at the surface of the porous mix overlay and decreased with depth. Maximum stresses for inner sides (left side of wheel load C and right side of wheel load D) were greater than those for outer sides.

The maximum confining stresses under wheel loads C and D were lower than those under wheel loads A and B. It is considered that these are due to the effect of fixed boundary along the left edge. As shown in Figure F-9, wheel loads C and D are closer to the fixed boundary.

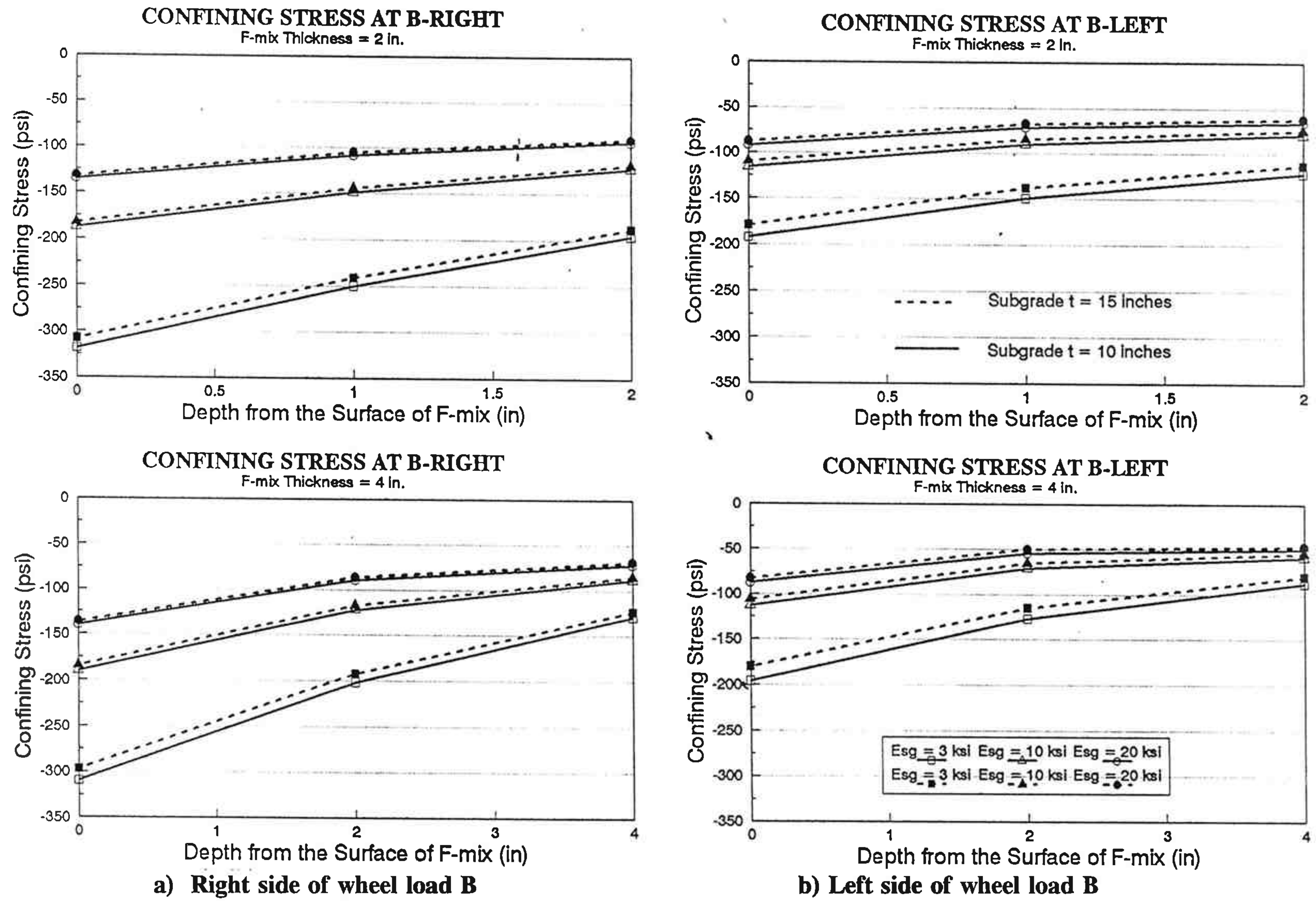
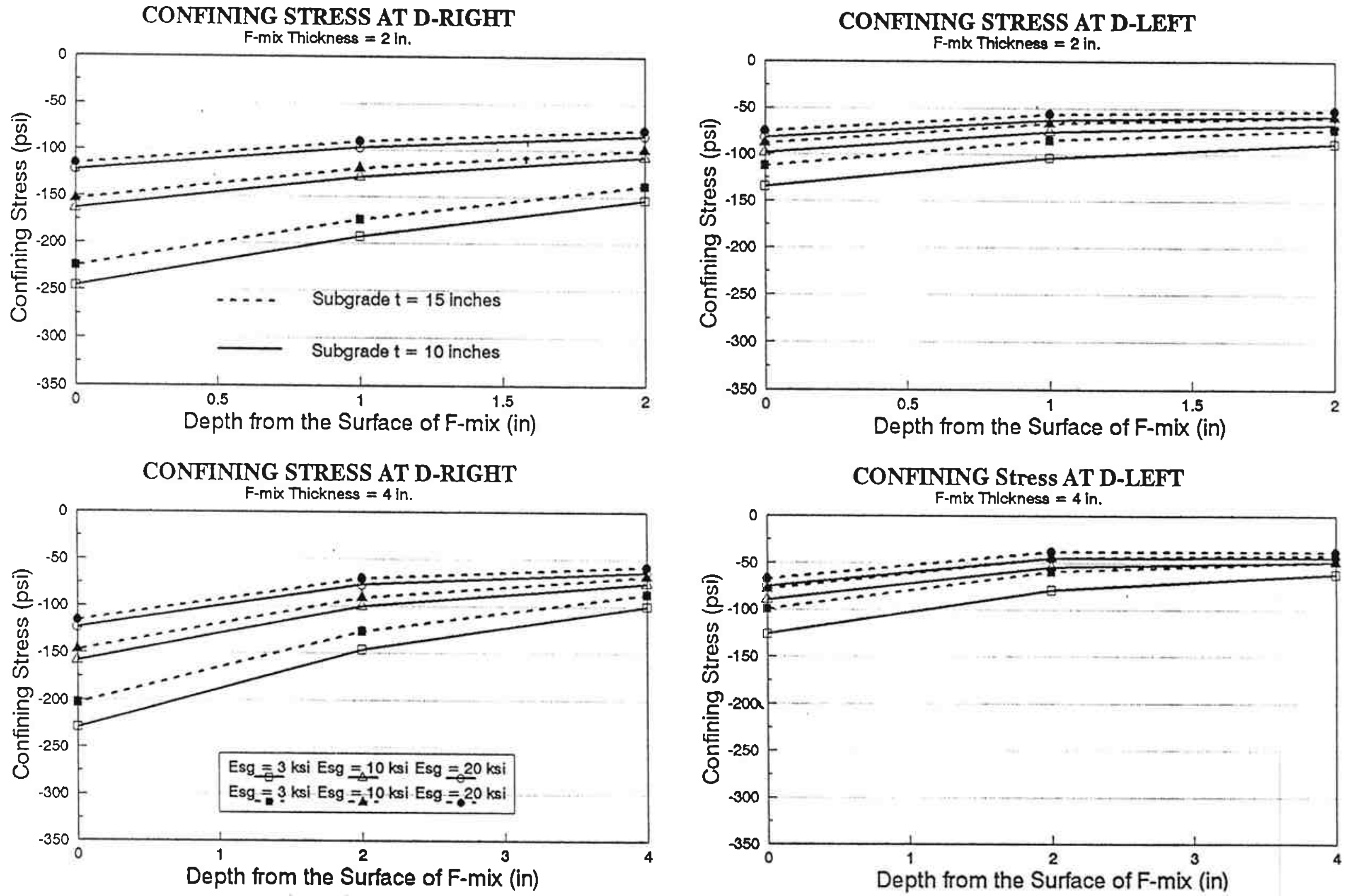


Figure F-7 Stresses under wheel load B in porous mix



a) **Right side of wheel load D**

b) **Left side of wheel load D**

Figure F-9 Stresses under wheel load D in porous mix

The effect of changing the thickness of subgrade was not significant for the confining stresses in the porous mixes. The confining stresses in thicker porous mixes were slightly lower.

3.2 Stresses in PCC Pavement

Figures F-10 and F-11 summarize the results of calculations for porous mixes over portland cement concrete. The results indicate the following:

1) Stresses in the PCC are not greatly reduced by the porous mix overlay.

2) Subgrade stiffness greatly reduces the critical stress in the PCC.

Figure F-10 exhibits relationships between the maximum tensile stresses at the bottom of PCC and the subgrade modulus for varying the thickness of porous mix overlay. The effect of increasing thickness of porous mix overlay on reducing tensile stresses at the bottom of PCC was not significant. The maximum tensile stresses at the bottom of PCC decreased slightly with increasing thickness of porous mix overlay.

The tensile stresses at the bottom of PCC were greatly reduced by increasing the subgrade modulus. The tensile stresses were reduced by half by increasing the subgrade modulus from 3,000 to 30,000 psi.

The effect of increasing the thickness of subgrade was significant for a lower subgrade modulus. The reduction in tensile stresses was about 100 psi for the subgrade modulus of 3,000 psi, but the amount of reduction was minor for the subgrade modulus of 30,000 psi.

Figure F-11 exhibits relationships between the maximum compressive stresses at the top of subgrade and the strength of the subgrade, for varying thickness of porous mix overlay. These following relationships were found:

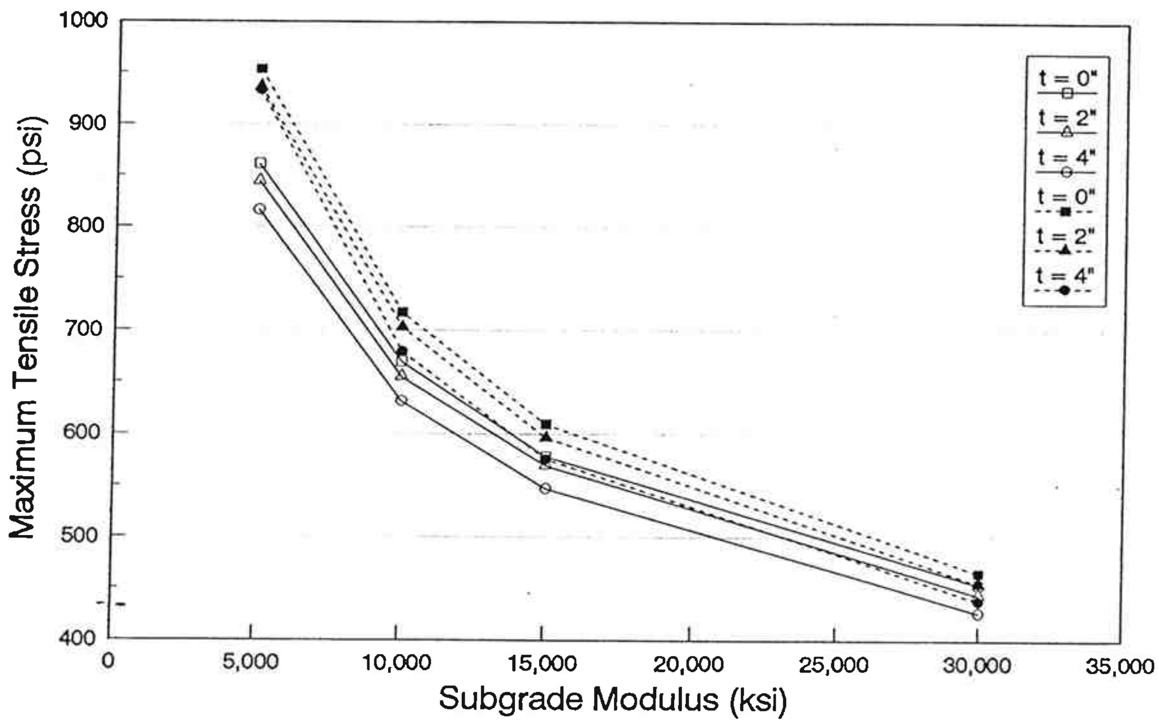


Figure F-10 Maximum tensile stresses under PCC vs. subgrade modulus

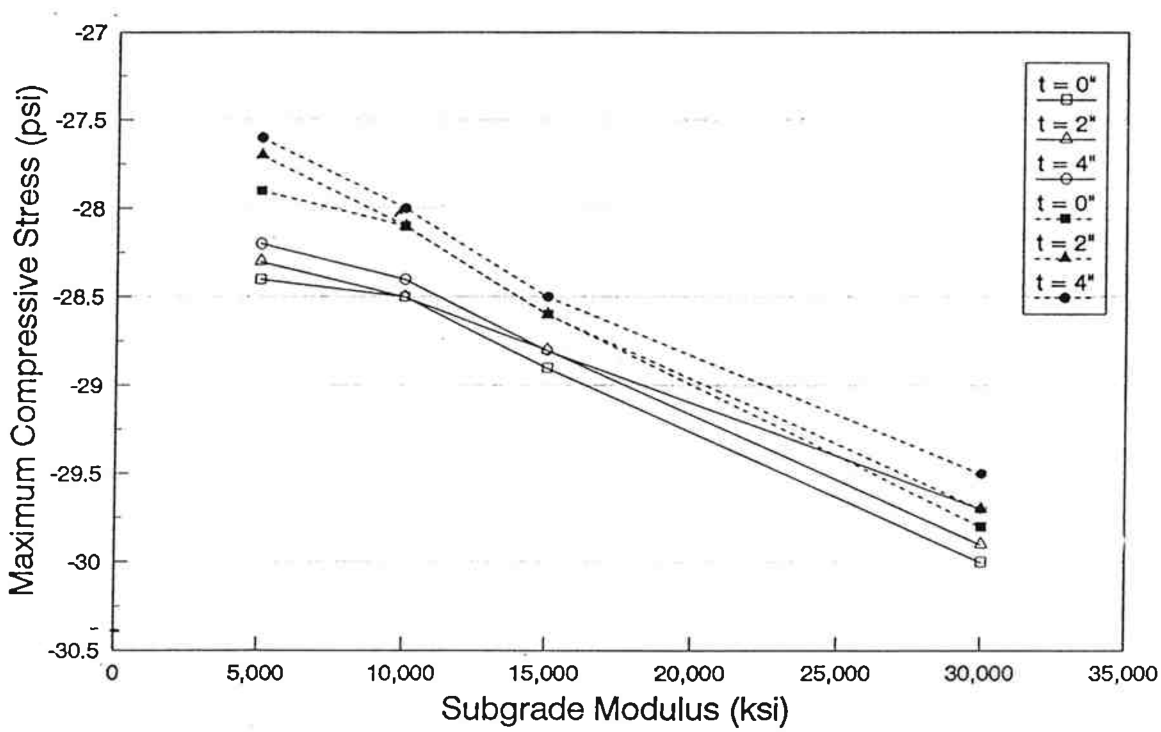


Figure F-11 Maximum compressive stresses at the top of subgrade vs. subgrade modulus

1) Increasing the thickness of porous mix overlay did not greatly reduce the compressive stresses at the top of subgrade.

2) Increasing the subgrade modulus tends to reduce compressive stresses at the top of subgrade but the amount of reduction was not considered significant.

3) The effect of increasing the thickness of subgrade on reducing compressive stresses was minor.

3.3 Discussion of Results

The data acquired from the study of the confining stress of open-graded mixes show that a confining stress between 100 to 300 psi can be found. This information can be used for the testing of open-graded mixes in many aspects. The fact that the subgrade has an effect on the stresses in the stresses on open-graded layer suggests that open-graded mixes can differ with respect to layers other than the normal dense graded AC subbase layer.

The information gleaned from the study into the compressive stress changes from open-graded mix overlays on PCC pavements only proves a long standing suspicion. It has been believed for some time that the addition of a porous AC layer does not contribute any significant stress reduction in the overlaid layers. The fact that no significant reduction was discovered does not mean that porous pavements are not useful, just that they do not assist in alleviating the stresses in the overlaid pavements.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The following conclusions appear warranted:

1) The confining stresses in the porous mix over the B-mix were affected by the subgrade modulus. The confining stresses increased as the subgrade modulus decreased.

2) The confining stresses in the porous mix over the asphalt cement concrete pavement were not significantly influenced by the thickness of subgrade.

3) The confining stresses in the porous mix were greater for inner sides between two wheel loads.

4) The critical tensile stresses were greatly reduced by increasing the subgrade modulus.

5) The critical tensile stresses at the bottom of PCC was not significantly influenced by the thickness of porous mix overlay.

6) The critical compressive stresses at the top of subgrade were not significantly reduced by increasing the thickness of porous mix overlay or increasing the subgrade modulus.

4.2 Recommendations

The following recommendations are a result of this study:

1) The confining stress in tests like the sharp shear tester for open-graded pavements should be in the range of 100 to 300 psi depending on the severity of the sublayer changes for any specific project.

2) F-mixes, while not a stress relieving layer, have not been proven by this paper to be an invalid overly type for PCC pavements.

5.0 REFERENCES

1. Swanson Analysis Systems, Inc., "ANSYS User's Manual for Revision 5.0," Volume I Procedures, DN-R300:50-1, December 23, 1992.

2. Swanson Analysis Systems, Inc., "ANSYS User's Manual for Revision 5.0," Volume III Elements, DN-R300:50-3, December 23, 1992.

3. Swanson Analysis Systems, Inc., "ANSYS User's Manual for Revision 5.0," Volume IV Theories, DN-R300:5.0-4, December 23, 1992.

4. Swanson Analysis Systems, Inc., "ANSYS Revision 5.0 Tutorials," Volume II, DN-TO42:5.0, December 23, 1992.