

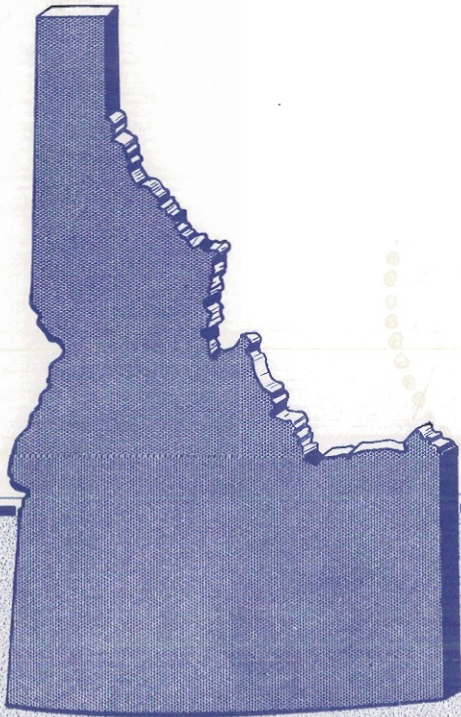
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ASPHALT PAVEMENT MIXTURE PERFORMANCE EVALUATION

ITD - RP070

JULY 1974

RESEARCH PROJECT NO. 70



STATE OF IDAHO DEPARTMENT OF HIGHWAYS

ASPHALT PAVEMENT MIXTURE PERFORMANCE
EVALUATION

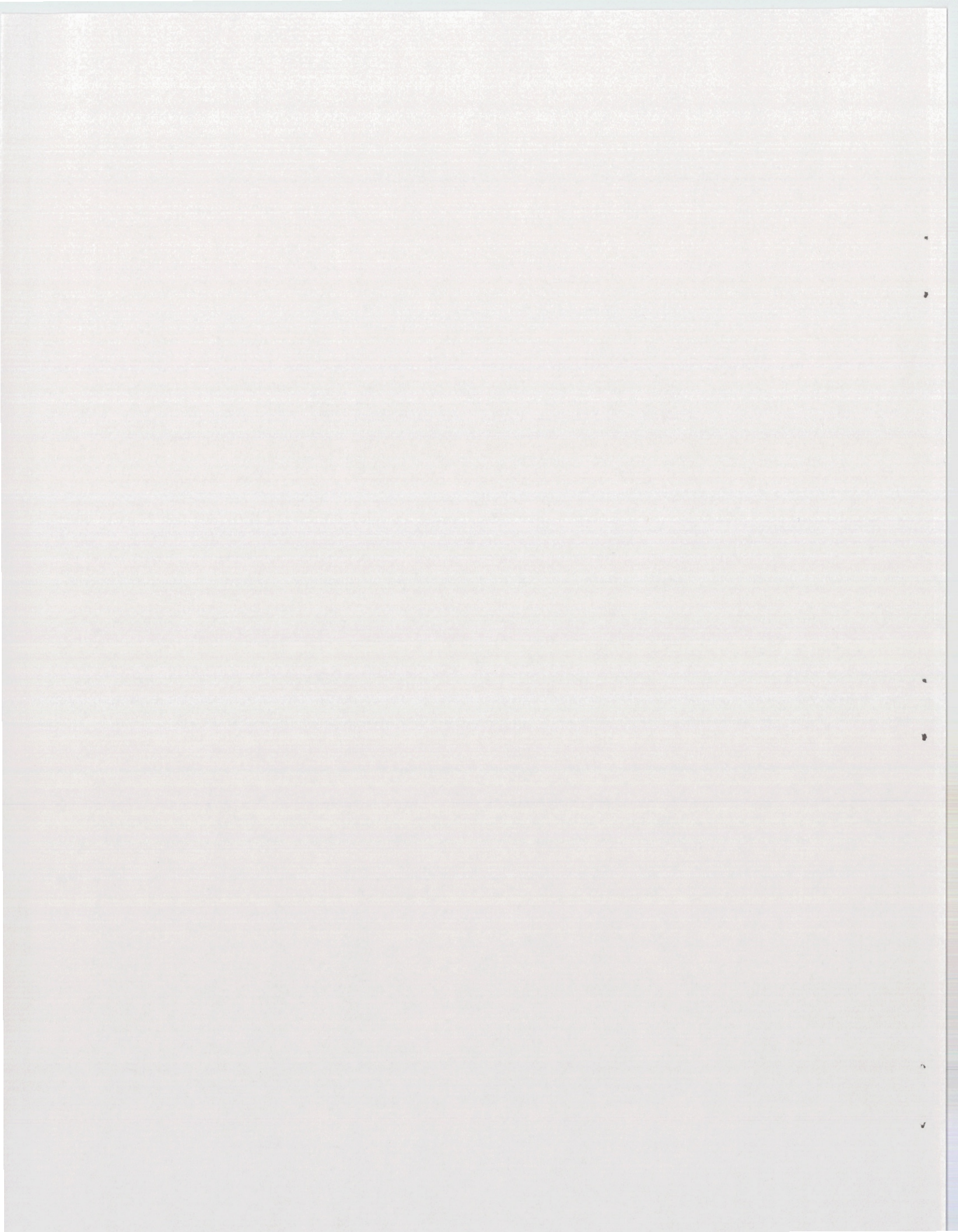
By

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ABSTRACT

The State of Idaho has many miles of interstate that are showing signs of premature pavement distress. The distress is evidenced by extensive pavement cracking. The purpose of this research project was to determine the conditions that were contributing to cracking. The study was confined to the southeastern section of the State.

Roadway cores were taken and physical properties of recovered cores were determined. Project construction history as well as current national research activities relevant to the study was reviewed.

Stripping aggregates and improper asphalt selection were considered to be the primary factors causing premature pavement cracking. Selection of asphalt based on its temperature susceptibility is recommended. Since the mechanics and cure for stripping, which simply is a bond failure between the asphalt and aggregate, is still a point of conjecture and until the time that a more definitive answer is available, continued emphasis should be placed on seal coats, permeable bases, and low pavement air voids. These are proven steps that can minimize damage to pavements from water induced stripping.

INTRODUCTION

Of prime importance in the selection of one pavement type over another (i.e. portland cement concrete opposed to asphalt concrete) is durability. When either pavement fails to fulfill its respective design life then the economic justification procedure loses its validity.

If for some reason a particular type of pavement falls short of meeting its design life, two options are available. (1) Determine why the pavement type is not achieving design durability and correct the design deficiencies, (2) Abandon the use of the type in favor of a more suitable type. The first option might increase the initial cost inordinately for a particular type precipitating the selection of Option 2. In essence this report deals with Option 1. The purpose of this research study is to determine why, in certain geographical areas within the State, flexible asphalt pavements are showing signs of premature deterioration. Evidence of deterioration can be seen in badly cracked sections of interstate highways in southeastern Idaho.

In an effort to find causes or conditions which have reduced service life of flexible pavement, Research Project #70 was initiated to study several selected projects in the areas that are performing unsuitably. Each project was cored and studied with hopes that a solution could be found which could then be applied to our design standards, ultimately extending intended design life.

In an effort to reduce variables certain research conditions were imposed. Projects were studied in pairs. The paired projects were in proximity to each other; one that showed signs of premature distress, the other apparently performing as designed. By this method of study, variables such as climatic conditions, sources, asphalt source and other variables were minimized.

Shown on the following page are six projects (3 paired projects) that were selected for study. Listed are the project number, district location, conditional assessment and descriptive location. It is important to note that conditional assessments were made visually during a field examination. Initial assessments were not supported by any physical testing, only superficial observations were made. Assessments as to true condition were revealed after testing was completed. It was discovered, after testing and examination of cores, the preliminary observations were not entirely accurate.

As testing proceeded at the Materials Laboratory, considerable time was spent studying current national research activities in pavement failures.

Research 70
Projects Under Study

<u>Project</u>	<u>District</u>	<u>Condition*</u>	<u>Location</u>
I-15W-4(13)97	1	Good	Massacre Rocks-Rockland Jct.
I-15W-4(9)88	1	Poor	Rockland Jct. - Igo Overhead
I-80N-3(34)196	2	Good	Hazleton I.C. - Kasota Rd. I.C.
I-80N-3(7)199	2	Poor	Kasota Rd. I.C. - Burley-Paul I.C.
I-15-3(11)187	6	Good	Pleasant Valley - Monida
I-15-3(21)163	6	Poor	3 Mi. So. Dubois - China Point

* Judgement made by a visual observation at the outset of Research #70.

RECOMMENDATIONS

Most experts in the field of asphalt technology agree that water is the mechanism which causes debonding or stripping of the asphalt coating from the mineral aggregate. They do not all agree on how water and other factors work together to cause this phenomenon. Although all answers associated with asphalt stripping are not known, certain steps can be taken to reduce or possibly eliminate stripping, hence extending pavement life.

Since a great portion of the pavement problems encountered in southeastern Idaho are associated with aggregate-asphalt interface debonding, the recommendations listed below are directed towards reducing the severity of this problem. Furthermore, many of these recommendations are not new and are currently being practiced with varying degrees of success.

1. Air Void Control - Pavement air voids should be strictly controlled to 3% - 7%. This is emphasized in literature dealing with stripping.
2. Aggregate Control - Compaction to a density of 3% - 7% air voids is dependent upon proper gradation for the particular source. The Laboratory must provide a gradation that meets mix design minimums and is economical to produce. Control of that gradation within tolerable limits must occur at the crusher.
3. Rolling - Rolling must be completed at as high a temperature as possible. Thin courses (0.15' and less) and unfavorable weather conditions (wind and temperature) must be avoided.
4. Anti-Strip Measures - The immersion compression anti-strip test (AASHO T 165 and AASHO T 167) is a standard lab test for determining anti-strip measures but it does not correlate well with field performance; i.e. materials sources CL-40 and CL-56 based on Lab aggregate source records are not strippers, hence, no antistrip was used. However, moderate to severe stripping was encountered on both projects that used aggregate out of these sources. The Igo section, when built with aggregate source Pw-54, did not show stripping problems in preliminary testing but this project is now severely stripped. Aggregate source Bk-142s is known to be a stripping aggregate, yet according to Robert Lottman's investigations into stripping Bk-142 did not show any visual damage.

I recommend a study be undertaken to modify our AASHO method or adopt one that will more accurately predict field performance. Dr. Lottman of the University of Idaho, outlines in detail the tensile split test in NCHRP 4-8(3). This method appears to correlate better to field performance. Consideration should be given to using this test method as a replacement for our AASHO test method.

Our immersion compression test method for detecting stripping does not correlate with field performance. Furthermore, it has been noted that anti-strip tests are often carried out with asphalt brands that are not used during construction. Asphalt to be used on the project should be known in advance so that anti-strip and mix design tests are more representative of field conditions. In essence, testing should be closely related to what will be used in the field.

5. Some aggregate bases appeared to trap water, thus promoting stripping. Gradation requirements for granular bases should be reviewed to assure ourselves that they will promote free migration of water. Macadam type bases could conceivably provide alternatives for impermeable granular bases.

Two recommendations not related to stripping are suggested. It is recommended that all asphalt cements be selected with regard to environmental temperatures as outlined in the discussion. In no case should a brand or grade change be allowed without approval of the State Materials Engineer.

It is also recommended that all resident engineers or chiefs and project engineers or chiefs be thoroughly schooled in mix design procedures and asphalt technology. In this way they will be able to recognize and properly implement lab findings.

TESTING PROGRAM

It was decided at the outset that two cores, within a few feet of each other, would be taken for each mile of roadway on each project. The additional core would be necessary to facilitate the testing program as outlined below. All testing was done at the Boise Central Materials Laboratory to the extent and nature as listed below:

CORE I

<u>Tests</u>	<u>Test Method</u>
Tensile Split (Wet)	Idaho T-11
Bulk Specific Gravity	Idaho T-86
Rice Gravity	Idaho T-86

CORE II

<u>Tests</u>	
Tensile Split (Dry)	Idaho T-10
Bulk Specific Gravity	Idaho T-86
Rice Gravity	Idaho T-86

On a random selection of several cores the following tests were run:

Test

Reflux Extraction	Idaho T-3
Gradation	Idaho T-1

Tests on Recovered Asphalt

Ductility @ 77°F & 39.2°F	AASHO T-51
Retained Penetration @ 77°F & 39.2°F	AASHO T-49
Kinematic Viscosity @ 275°F	AASHO T-201

Testing followed the procedure established in NCHRP Project 4-8(3). The wet tensile split test differs from the dry split by preconditioning in water. The wet break includes a 30-minute vacuum saturation in water, followed by a 30-minute soak outside of the vacuum. Split testing on the wet core is started after a 2-hour bath in distilled water at 73°F in lieu of 55°F used in NCHRP

4-8(3) as no means were available to cool to 55°F. The dry cores are not pre-conditioned and are tested with the cores at room temperature (73°F).

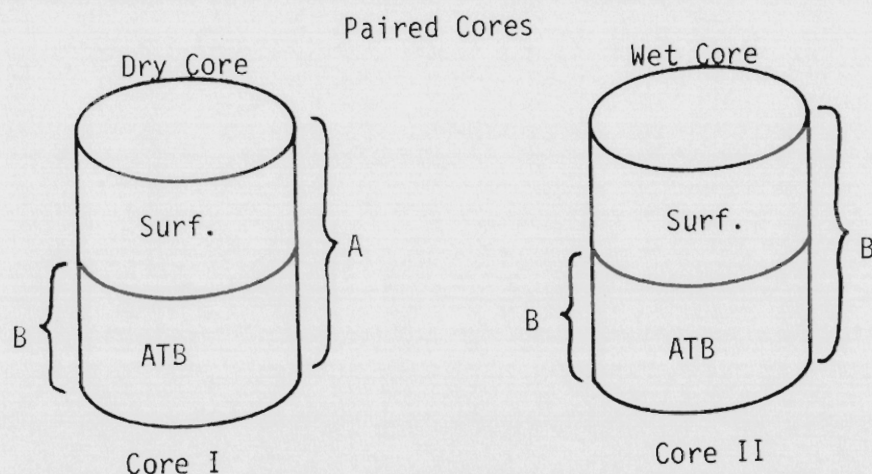


Figure 1

Figure 1 shows how the cores were numbered. At every milepost two cores were taken within a few feet longitudinally of each other, one received an "A" postscript (i.e. 601A) the other "B" (i.e. 601B). If the project had an asphalt treated base and was of sufficient depth for testing it was cut away and testing was conducted separately on the ATB portion of the core. To distinguish between ATB and surfacing for a given core a second postscript was assigned to the ATB portion of the core (i.e. 601AB for the ATB portion of core A, 601BB for the ATB portion of core B).

Bulk and Rice specific gravities were run on all cores. A few select cores underwent Abson Recovery Tests. This includes a reflux extraction to recover the asphalt. The residue was distilled and the recovered asphalt received ductility and retained penetration tests at high and low temperatures. In addition to these two tests Kinematic Viscosity @ 275°F was determined.

Before the testing program was set up, certain goals were set and the testing program was tailored to achieve those goals. Tensile strength of an asphalt concrete pavement is a very important property as related to durability, hence, selection of the tensile split test to indicate this quality.

The active forces on a pavement may be external or internal. The external force is obviously traffic. Internal forces may be created by liquid pressures or thermal stress induced by changes in temperatures. It is common knowledge that tensile failure is the major mode of failure in an asphalt concrete pavement. Most pavement cracking is the result of tensile failure. Oxidation and stripping of asphalt are factors in pavement deterioration and are indicated by tensile strength loss.

Another advantage of the tensile split test is to quantitatively evaluate potential stripping aggregates. The wet core is subject to more severe conditions and if the aggregate in a mix is potentially hydrophylic the wet cylinder will have lower tensile strengths. The tensile split measures the loss of adhesion due to the severe preconditioning during the wet procedure.

The bulk specific gravity and rice gravity are used in calculating roadway densities and maximum theoretical density, respectively. The ratio of bulk specific gravity to rice gravity is a means of computing air voids.

The reflux extraction is necessary in order to establish the asphalt content of the asphaltic concrete and to recover asphalt for testing of the residue material. Gradation can be compared to that of the suggested mix design to insure that the gradation complies reasonably with the one recommended.

The recovered asphalt was tested for ductility, retained penetration, and kinematic viscosity.

Ductility is an important characteristic of asphalt cements. Ductile asphalts are more pliable and more temperature susceptible at low temperatures.

Penetration is an index to asphalt hardness or consistency - the softer the asphalt or less viscous the greater will be the penetration.

Viscosity tests are used to determine the flow characteristics of asphalts in a temperature range.

Tables I, II, and III summarize the test results for all projects studied. Additional information on all projects is to be found in the Appendices, including project history, core logs, and individual results.

Tests	PAIR I		PAIR II		PAIR III	
	Igo Overhead to Rockland Jct. I.C. 10 yrs.	Massacre Rocks to Rockland Jct. I.C. 12 yrs.	Dubois to China Point 9 yrs.	Pleasant Valley to Monida *7 yrs./14 yrs.	Kasota Rd. I.C. to Hazelton I.C. 6 yrs.	Burley I.C. to Kasota Rd. I.C. 7 yrs.
	Surfacing	Surfacing	Surfacing	Surfacing	Surfacing	Surfacing
Avg. Tensile Strength						
Dry (psi)	39.8 (27)	64.9 (12)	47.4 (12)	27.5 (22)	84.7 (11)	82.8 (11)
Air Voids (%)	4.5 (47)	6.5 (21)	4.9 (16)	8.2 (17)	4.8 (42)	5.3 (26)
Wet (psi)	39.4 (47)	75.8 (18)	61.9 (13)	37.3 (14)	93.4 (12)	94.2 (11)
Air Voids (%)	4.8 (43)	6.7 (18)	4.9 (20)	8.2 (16)	4.5 (24)	5.9 (20)
Number of Samples						
Dry/Wet	18/18	15/15	21/20	10/10	13/10	14/13
Index of Retained Strength						
Wet % Dry	.99	1.17	1.31	1.36	1.10	1.14
Asphalt						
% Const. Records	-	4.7	5.1	5.2	6.0	5.6
					3.8	4.5

Values in parenthesis are coefficients of variation.
*Of the project length 3 miles (Monida-3 Miles South) was constructed in 1959

TABLE I

Project	Location	Grade	Penetration at 77°F	*Asphalt Properties Viscosity at 275°	Ductility at 77°
I-15-3(11)187 Pleasant Valley-Monida	Surfacing	85-100	91.5	252	110
I-15-3(21)163 Dubois-China Point	Surfacing & ATB	85-100 120-150	90 129	242 190	140+ 140+
I-15W-4(9)88 Igo Overhead-Rock. Jct.	Surfacing	120-150	143	152	123
I-15W-4(13)97 Massacre Rocks-Rock. Jct.	Surfacing Surfacing	120-150 85-100	125 91	138 156	110+ 131
I-80N-3(7)199"A" Burley-Kasota	Surfacing & ATB	60-70	66	252	110
I-80N-3(34)196"A" Kasota-Hazelton	Surfacing & ATB	60-70	67	288	125
I-15-3(2)194 3 Mi. So. to Monida	Surfacing Surfacing	200-300 85-100	- 95	- -	- -

*Average values taken from quality control construction records.

TABLE II

SUMMARY OF VISUAL STRIPPING EVALUATIONS FOR ALL PROJECTS

Project	Age	No. of Samples	% Coating				50-75		< 50	
			100 +4* -4**	90-100 +4 -4	15-90 +4 -4	50-75 +4 -4	< 50 +4 -4	< 50 +4 -4	< 50 +4 -4	< 50 +4 -4
Monida - Pleasant Valley	7 & 14	22	0	-	14	-	6	-	0	-
Dubois - North	9	162	9	24	43	34	17	17	9	4
Igo Overhead-Rockland Jct.	10	36	2	3	9	7	3	5	2	1
Massacre Rocks- Rockland Jct.	12	60	14	24	13	4	1	2	1	6
Burley I.C.-Kasota Rc. I.C.	7	54	0	-	52	-	2	-	0	-
Hazelton I.C.-Kasota Rd. I.C.	6	48	0	-	41	-	7	-	0	-

*Material retained on No. 4 mesh and above

**Material passing No. 4 screen

TABLE III

Igo Overhead-Rockland Jct. I.C. and
Rockland Jct. I.C. to Massacre Rocks

Discussion of Test Results

The section of Interstate from Igo Overhead to Rockland Jct. I.C. (American Falls Bypass) shows more distress in terms of pavement cracking than any of the other projects studied. Shown below is a picture which typifies the type and amount of cracking encountered along this section.



Cracking was most severe in the travel lane and portions of the mat were being displaced due to traffic action. Examination of test results (Tables I and II) show low average tensile strength for the Bypass Section. The tensile strength for Massacre Rocks Section are acceptable for the pavement age. Average air voids on both projects are within reasonable limits and the 4.6% air void average is quite acceptable for the American Falls Bypass Section.

Abson recovery results are normal with the Bypass Section showing excellent average retained pens and ductilities. The low average air void content is probably an important factor in retarding the aging process of the recovered asphalt. The Massacre Rocks section shows rather poor average ductilities with normal penetrations and viscosities.

Aging (increase in viscosity, loss of pen, and ductility) occurs very rapidly the first few years, then approaches a steady state condition at which

further losses (gains in regard to viscosity) occur very slowly. In fact, a loss of about 50% in penetration for an asphalt is not unusual after the mixing and laydown operation are completed.

Plantmix aggregate gradations taken from construction records were compared with those obtained from abson recovery tests. No aggregate degradation was apparent. This comparison was made on all projects and the results were similar.

Conclusions

The Massacre Rocks Section is performing well with little evidence of stripping. Figure 2, on the following page, shows the typical cores taken from this section. Cores were sound with almost no evidence of stripping. Aggregate source PW-31 from which this section was built, historically speaking, is not a stripper. The Igo-Rockland Interstate Section is badly stripped and the aggregate source PW-54 has shown a need for anti-strip additives in all recent Hveem mix designs.

Project data indicates that no anti-strip additives were used in the mix. It would appear based on project history, recovered cores, test data and field observation that the extensive cracking is directly related to severe stripping problems.

During the field coring operations two important observations were made:

(1) Roadway cores were stripped from the bottom up. Figure 3 shows recovered cores taken from the Igo-Rockland Section. Although not as apparent on the "A" cores, the "B" cores show evidence of stripping. Some cores were so badly stripped that they disintegrated during the drilling operation.

(2) Untreated base material was holding water and not allowing free migration downward. Figure 4 was taken some 10-15 minutes after the water was introduced into the core hole. Holding or ponding of water occurred at almost all drill holes where stripping was observed. There was not apparent drawdown even after one-half hour. The core hole depth was approximately 0.4' deep with the unprimed base exposed. Drainage should have occurred in the base but did not. It was evident that this base was not free draining as intended.

Several situations may be occurring independently or in combination. When certain soils or aggregates demonstrate low permeability they nearly always will have high capillarity. This might be possible, however, no testing was conducted on base material. Any water that can enter the pavements through cracks or surface imperfections will not be readily drawn away from the pavement-base interface, thus creating the environment for stripping activity at this interface. As stated earlier this stripping was progressively worse from top to bottom of each core observed. In summary, three distinct areas have contributed to rapid deterioration in this pavement.

(1) Failure to apply anti-strip measures, i.e. rejection of the source or use of the same source with additives.

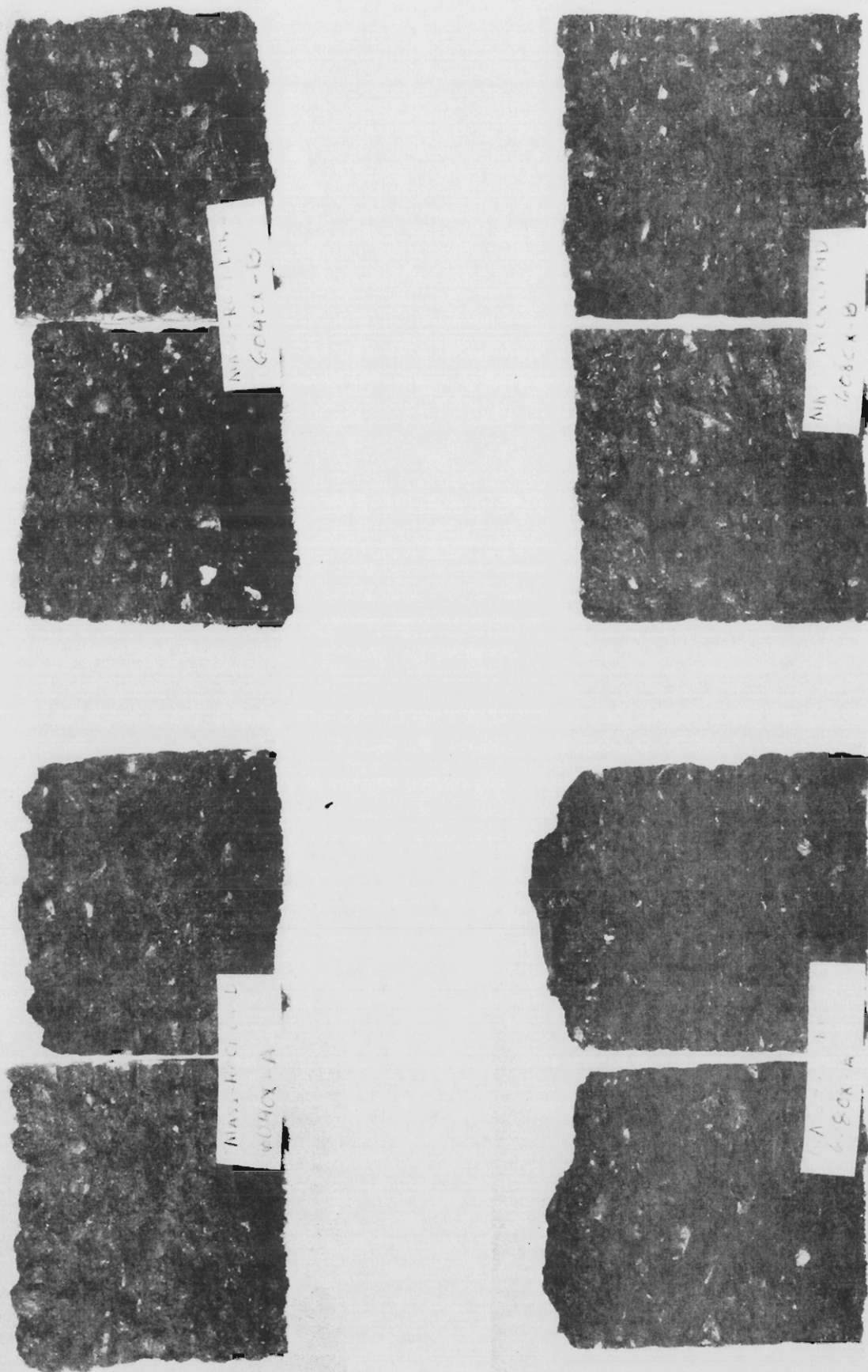
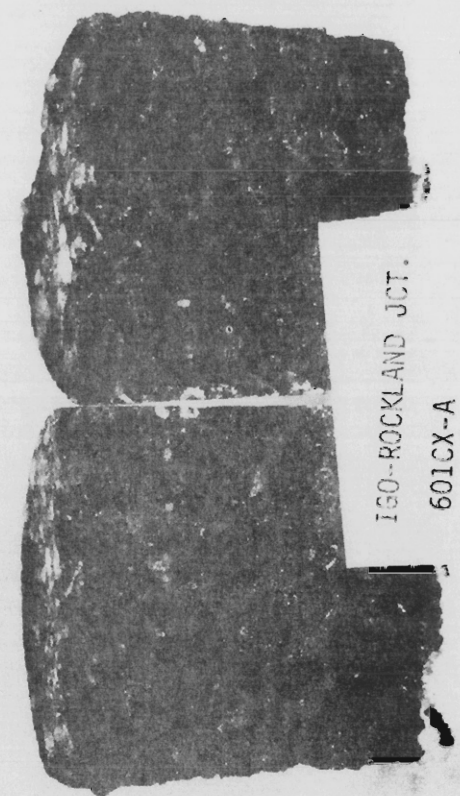
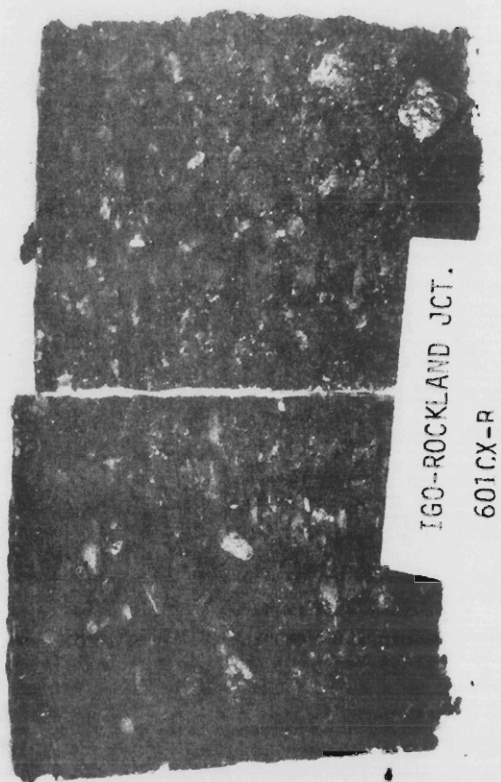


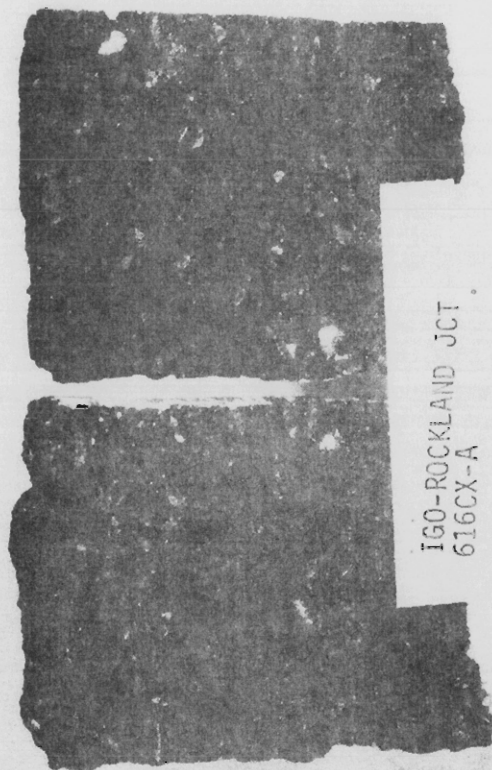
Figure 2 - Typical Cores Taken from Massacre Rocks Section of Interstate.



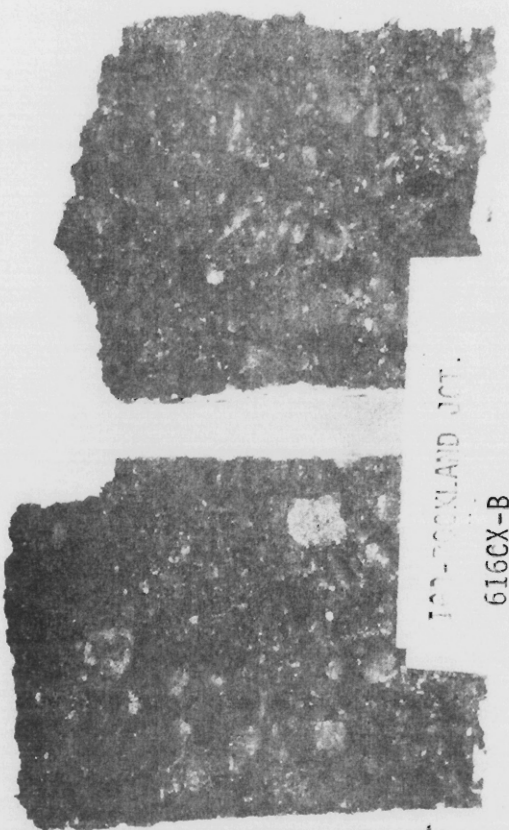
IGO-ROCKLAND JCT.
601CX-A



IGO-ROCKLAND JCT.
601CX-R



IGO-ROCKLAND JCT.
616CX-A



IGO-ROCKLAND JCT.
616CX-B

Figure 3 - Recovered cores from Igo-Rockland Section of Interstate.

(2) Poor permeability of the base material. The extensive cracking is merely symptomatic of loss of strength in pavement course due to progressive stripping.

(3) During moist and freezing periods of the year, freeze-thaw action of a saturated base can result in additional cracking. Once the mat opens up with the first cracks the problem is continually aggravated by the influx of moisture into the pavement and base course. Low air voids and permeable bases will go far in alleviating stripping problems as shown by Dr. R. P. Lottman in Idaho Research Project No. 47 - The Moisture Mechanism that Causes Stripping in Asphaltic Pavement Mixtures.



Figure 4 - American Falls Bypass

Dubois - China Point
and
Pleasant Valley - Monida

Discussion of Test Results

The Dubois Section was built 9 years ago, while Pleasant Valley to Monida was built in two sections - Pleasant Valley to 3 Miles South and 3 Miles South to Monida, 7 and 13 years ago respectively.

On the basis of test results and contrary to expectation the Dubois project shows higher average tensile strengths and lower average air voids. The Monida project tensile split tests ran lower (26.9 psi) than any other project studied.

Average air voids for the Dubois project are 5%; for Monida are 8.2%. Tests on recovered asphalt indicate a greater loss of low temperature ductility for Monida. Monida also showed the highest kinematic viscosity at 911 centistokes. Low and high temperature penetration were comparable and normal for projects of this age.

Contrary to expectations wet tensile strengths were greater than dry making indexes of retained strength greater than one. Correlation tests were run at the University of Idaho by Dr. Robert Lottman and similar results were encountered. This situation has occurred during routine mix design at the Central Materials Laboratory on immersion compression cylinders.

Only theories exist as to possible reasons for wet strengths exceeding dry strengths. In fact, on almost all projects studied, under Research 70, wet strengths exceed dry strengths.

Conclusions

After 7 years the average air voids found on the Monida project remained unusually high at 8.2%. Normally air voids will drop about 1% to 2% each year during the first 1 or 2 years. This is brought about by additional traffic compaction. When this project was built average air voids must have been nearly 10%. When plantmix is placed with such high air voids, mat life is unquestionably reduced by rapid oxidation of the asphalt.

A check of the aggregate source records for C1-40 and C1-56, used respectively on Monida and Dubois, shows that neither demonstrated stripping tendencies using the immersion compression test-Idaho T-35. Table III is a visual stripping evaluation made after cores were broken open following the tensile split test. The +4 column indicates percent coating of aggregate contained on the No. 4 screen and above. The -4 column represents percent coating of aggregate falling below the No. 4 screen.

Although C1-40 and C1-56, based on aggregate source records, were not supposed to be stripping aggregates, stripping was quite evident on both projects. Figure 5 shows pictures of roadway cores taken from the Dubois project portraying some of the cores that were stripped.

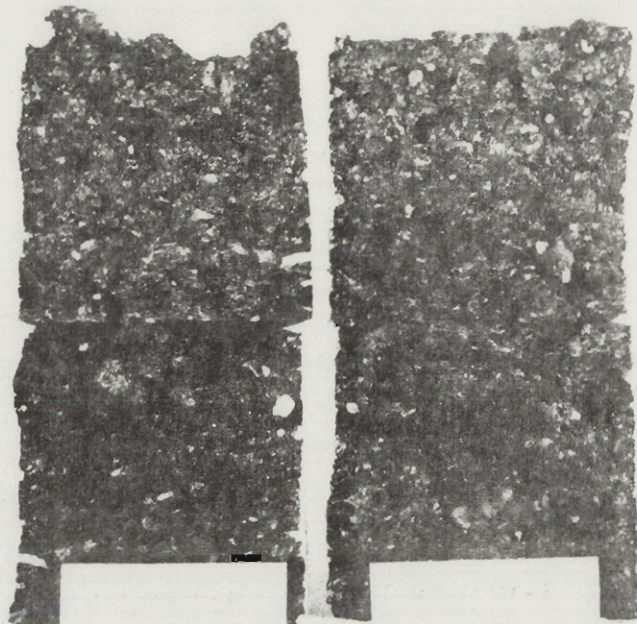


Figure 5 - Cores taken from Dubois Section of Interstate.

Burley I.C. - Kasota Rd. I.C. and
Kasota Rd. I.C. - Hazelton I.C.

Discussion of Test Results

Project history data compiled in the Appendix of this report show remarkable similarities between these two projects: same contractor; aggregate source and type; asphalt supplier and grade; total depth and individual lift depths equal; and average daily traffic. The only obvious differences are 1% hydrated lime was used as a filler in the surfacing of the Hazelton Section. This section was also built 1 year later in 1967. A look at Tables I and II show similar happenings.

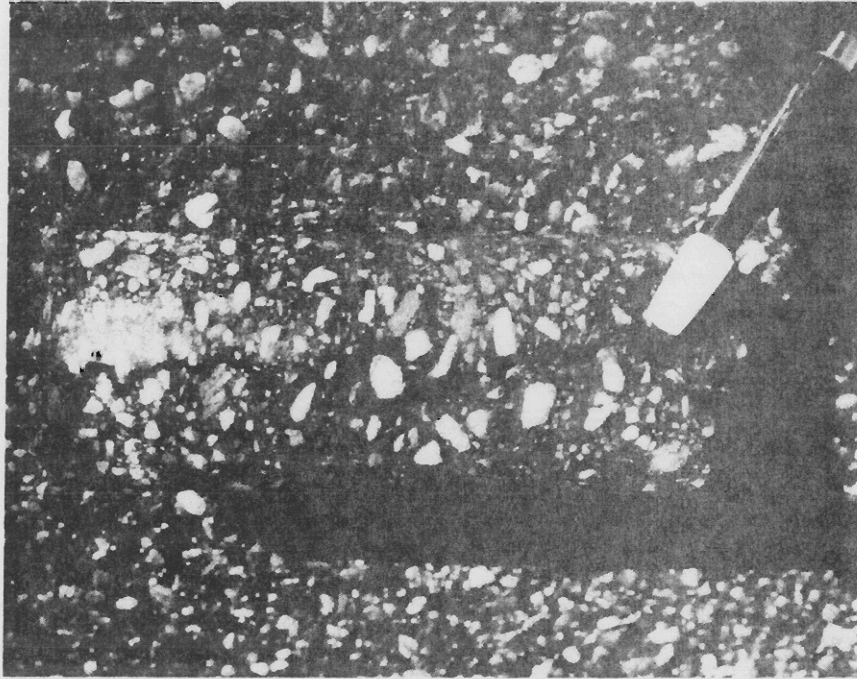
Individual cores were separated at the ATB-surfacing interface and testing was conducted on each segment. Tensile split tests on the surfacing are excellent and comparable for both projects. Air voids for the surfacing are excellent, both averaging near 5%. The ATB tensile splits show an expected normal decline in strength with the dry tensile strength of the Hazelton job about 8 psi below the Burley section. The average percent asphalt extracted for the ATB on this section is lower, no doubt contributing to lower tensile strengths.

Air voids of the ATB are high in both sections. The ATB on these sections was placed in a single 0.4' lift. This type of thick lift construction retains its temperature for longer periods of time when compared with thinner 0.1' to 0.2' lifts. In light of this it seems doubtful then that the mat chilled before rolling was completed. Aggregate gradation problems or insufficient compactive effort may have contributed to high air voids in the ATB.

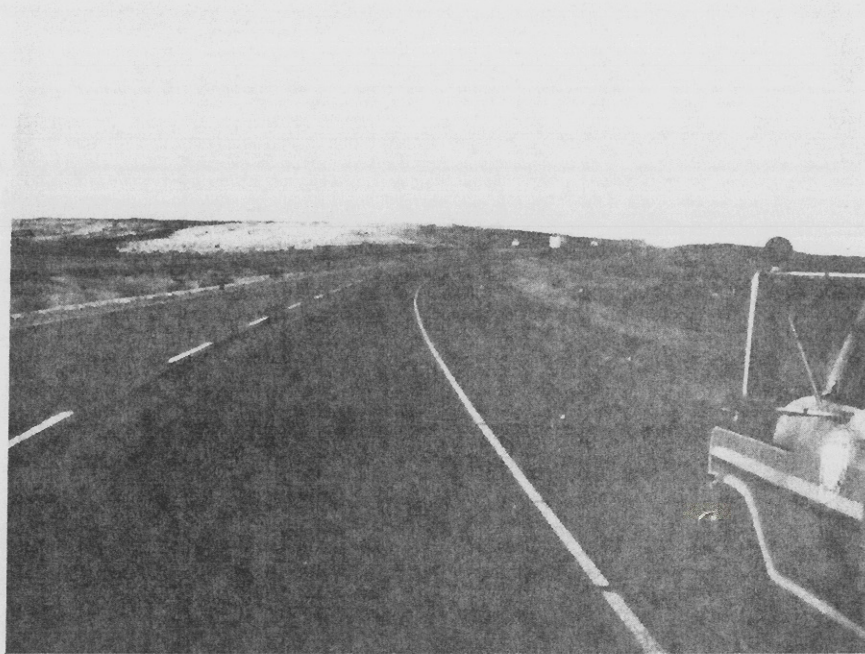
Average penetrations are identical and the asphalt aging process is stabilizing. Ductilities and viscosities for both projects appear to be low and high respectively as compared to other projects. However, it is significant that the original asphalt was a low viscosity-low penetration (60-70) asphalt cement and with the aging process proportionately lower retained ductility and higher viscosity values have occurred. Cs-142, the aggregate source used on both projects, is a source that lacks natural fines and sufficient oversize material to make the needed fines; therefore, it is difficult to make up a suitable mix design without rejecting or importing fines. By examining pit file information it cannot be concluded that Cs-142 is or is not a stripping aggregate. The roadway cores show little evidence of stripping.

The Burley Section appeared to be in the poorest condition based on a preliminary visual examination. A closer look during the field coring program showed little physical difference between either project.

Figure 6 graphically portrays the problem encountered on both sections. Full width-full depth transverse cracks are occurring at 50'-150' intervals.



Core taken on transverse crack (cracked entire depth).



Full width transverse cracking occurring 50' to 150' intervals.

Conclusions

Based on test results, it is difficult to find conclusive evidence as to what condition or conditions caused the extensive, transverse cracking. Library research has uncovered an article which provides the most probable explanation.

The article entitled "Low Temperature Pavement Cracking in Canada-The Problem and Its Treatment" was written by many leading Canadian experts in the field of asphalt technology. The article notes that as temperatures become successively lower, two things happen to the paving surface.

- (1) The pavements try to contract but frictional restraint of underlying layers tend to restrict movement, creating induced stress that may exceed tensile strengths resulting in pavement fracture or cracks.
- (2) With cold temperatures, some asphalts become much stiffer and are more likely to crack than others.

Transverse cracking as opposed to longitudinal is prevalent since pavement stresses are greater in the longitudinal direction.

Table IV contains weather information recorded at the Burley Airport which is within a few miles of each project. Temperatures in this local area drop to below zero and minimum temperatures last late into the spring and early in the fall. The purpose of this table is to show temperatures are severe enough to consider low temperature pavement cracking as suspect.

Year	Lowest Temp	Last Spring		Minimum		First Fall		Minimum	
		16° or Below Date Temp	32° or Below Date Temp	16° or Below Date Temp	32° or Below Date Temp	16° or Below Date Temp	32° or Below Date Temp	16° or Below Date Temp	32° or Below Date Temp
1967	- 7	4-1 16	5-14 26	11-6 16	9-13 30				
1968	- 6	3-31 15	5-16 27	11-14 15	10-3 25				
1969	2	3-14 14	4-30 26	11-23 12	10-3 32				
1970	- 1	3-25 14	5-15 32	10-28 16	9-14 30				
1971	- 8	3-18 9	4-18 32	10-39 9	9-18 32				
1972	-23	3-27 15	5-9 28	10-30 14	9-12 32				

Table IV - Temperature Extremes and Freeze Data
(Burley FAA Airport)

Figure 7 is a bar graph taken from the aforementioned report from Canada on low temperature cracking. This chart graphically summerizes the two most important variables outlined in this report.

Note in the upper chart how the number of transverse cracks per mile decline with an increase in viscosity for a nearly constant pen grade asphalt. Referring to the other bar graph, as the pen increases the number of transverse cracks per mile decrease. The penetration and ductility numbers are original test values before mixing or laydown operations. Stated conversely a decrease in penetration number results in more transverse cracks and similarly a decrease in viscosity for a given penetration grade of asphalt also results in an increase in transverse cracking.

Referring once again to Table II, it is apparent that a low pen grade asphalt was used (60-70) on both projects. This is undesirable as outlined above. The original kinematic viscosity of the 60-70 pen grade asphalt was 288 and 252 for Hazelton and Burley, respectively. These viscosities fall within the lower viscosity limits of this particular pen grade asphalt which again causes increased transverse cracking.

It is the author's opinion that the three conditions previously discussed, i.e. low viscosity, low penetration, and cold temperatures have been the primary cause of transverse cracking encountered in this area.

A search of other projects statewide was made to determine if any projects used the same pen grade asphalt full depth (i.e. surfacing and base). Only two projects were found and they used 60-70 pen grade asphalt in surface only, with higher penetration grades used in the ATB.

Summarizing the Canadian work, Norman McLeod suggests, "That the selection of original asphalt cement should be primarily guided by *penetration index and the minimum pavement temperature." He further emphasizes, "That if higher temperature stability requirements are not met, a less desirable asphalt cement would have to be chosen and some cracking tolerated."

McLeod has prepared a design aid (Figure 8) which can be used for selecting the proper pen grade asphalt, knowing viscosity and original pens. For example, let's determine the minimum pen grade asphalt that could be used in the Burley area. Surface pavement temperatures might be expected, based on historical temperature data, to drop to 0°F. Entering the chart, for PI's between 0 and -1.5, selection is limited to 85-100 penetration grades and above. Pen grades with PI between .86 and 1.5 would require pens of 150-200.

Based then on these efforts in Canada, to control transverse pavement cracking, selection of the 60-70 pen asphalt for the Burley section was not wise.

**The penetration index, developed by Pfeiffer and Van Doormaal, is a method for measuring the temperature susceptibility of asphalt cements based on softening point and penetration at 77°F.*

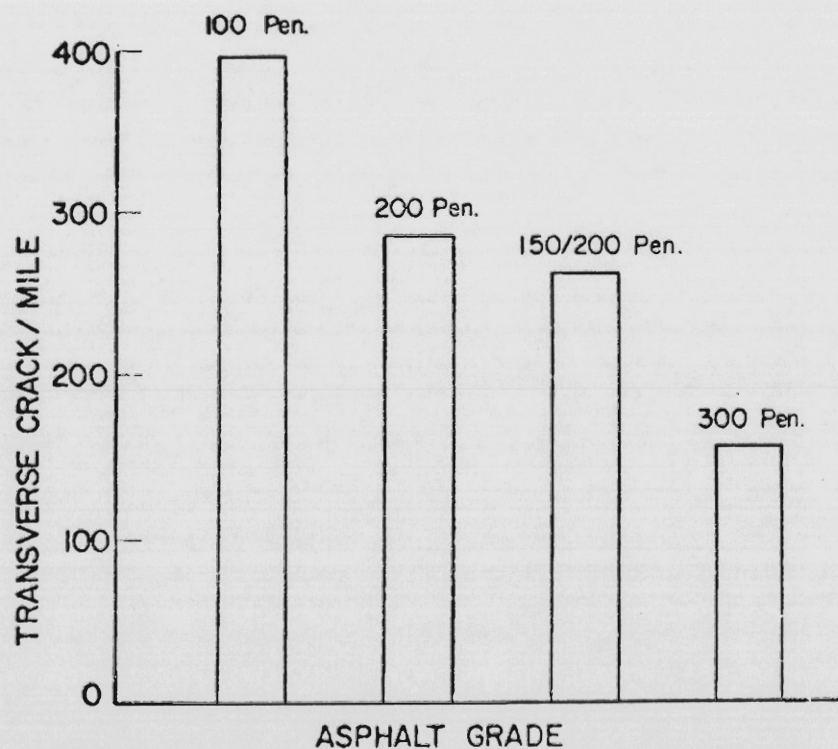
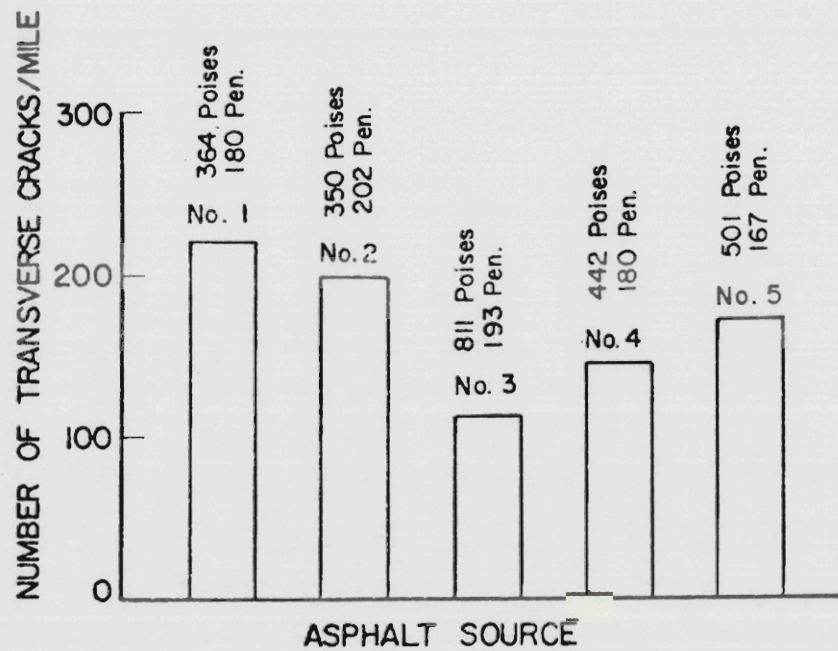


Figure 9 Summary of cracking versus asphalt source and asphalt grade from Saskatchewan experiment

Figure 7 - "Low Temperature Pavement Cracking in Canada-The Problem and Its Treatment" by N. W. McLeod, et. al.

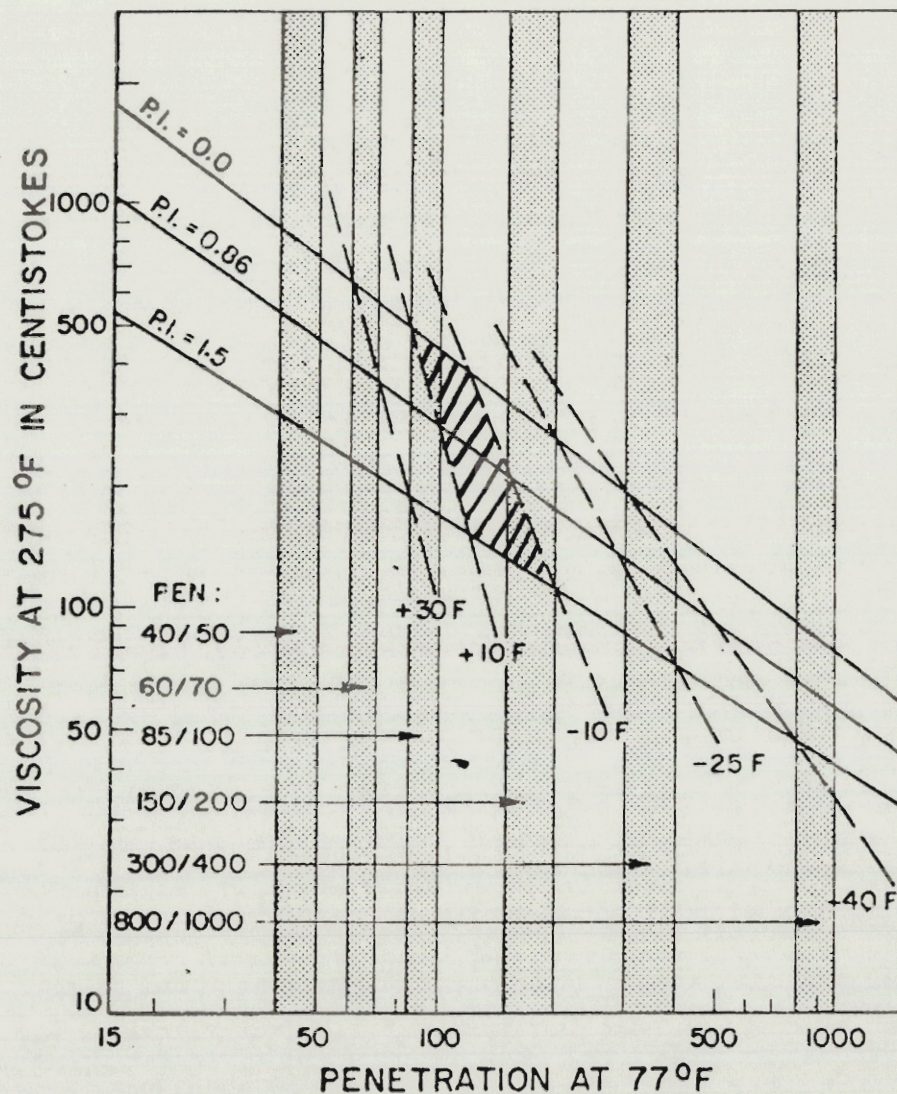


Figure 15 Correlation between viscosity at 275°F and penetration at 77°F

Figure 8 - "Low Temperature Pavement Cracking in Canada
The Problem and Its Treatment" by
N.W. McLeod, et.al.

A P P E N D I X

KEY TO LOG OF ROADWAY CORES

Trans. - Transverse

Long. - Longitudinal

O.W.P. - Outer Wheel Path

I.W.P. - Inner Wheel Path

B.W.P. - Between Wheel Path

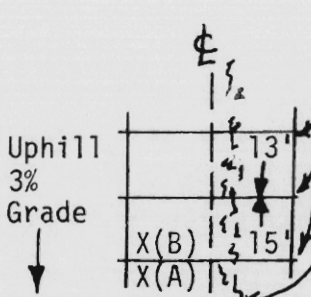
P. O. - Passing Lane

T. L. - Travel Lane

I.C. - Interchange

Two cores are represented by each sample number; the postscript "A" or "B" differentiates between paired cores taken at the same location.

LOG OF ROADWAY CORES
Pleasant Valley-Monida

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
601 CX-A & B	196.6	SBL 1/2 Mi. from State Line	BWP	30' from full width trans. crack
602 CX-A & B	196.0	NBL	OWP	
603 CX-A & B	195.0	SBL	IWP	30' down slope from full width trans. crack - numerous full width trans. cracks from State Line - occasional alligators
604 CX-A & B	194.0	NBL	OWP	No local cracking.
605 CX-A & B	193.0	SBL	OWP	Full width trans. cracks 300'
606 CX-A & B	192.0	NBL	IWP	No local cracking
607 CX-A & B	191.0	SBL 400' N. of Humphries I.C.	BWP	2' down slope from full width trans. cracks
608 CX-A & B	190.0	NBL	OWP	(30' fill) No cracking
609 CX-A & B	189.3	SBL	IWP	Very little cracking last 3 mi. 192.0 MP - 189.0 MP. "A" core drilled 2' from full width trans. crack
610 CX-A & B	188.3	NBL	BWP	No local cracking

LOG OF ROADWAY CORES
Dubois - China Point

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
601 CX-A & B	164.8	SBL	OWP	Drilled 1' from long. cracks 4'-5' long in W.P.
602 CX-A & B	165.0	NBL	OWP	Long. joint cracking
603 CX-A & B	165.4	SBL	OWP	Multiple short long. W.P. cracks, cracking in OWP, core taken 2' from cracks
604 CX-A & B	165.8	SBL	OWP	Extensive long. and trans. cracking
605 CX-A & B	166.0	SBL	IWP	No local cracking
606 CX-A & B	166.45	SBL	OWP	Fill 2', no local cracking. Cores taken 300' south of 607 CX-A (stripped core)
607 CX-A & B	166.5	SBL	OWP	Small amount of short long. cracks- EXTREME STRIPPING*
608 CX-A	167.1	NBL	OWP	Taken 2" from long. crack
B				Drilled on crack
609 CX-A & B	168.0	NBL	OWP-PL	100' South of Dubois I.C.(no cracking)
610 CX-A & B	169.0	NBL	OWP	No cracking
611 CX-A	170.0	SBL	OWP	Cored 3" away from localized alligator cracking
B				Predominantly long. cracks
C				Drilled on crack

*unable to recover complete core, core taken 2' from cracks - 4' cut - poor drainage - drilling water stands in hole.

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
612 CX-A	171.0	NBL	IWP	Near short (3"-4" long) Long. crack
B				1/2" from crack
C				2' from crack
613 CX-A & B	172.0	SBL	OWP	No cracking
614 CX-A & B	173.4	NBL	IWP	BWP cracking-"A" core taken 1' from crack
615 CX-A & B	174.0	SBL	IWP	No cracks
616 CX-A & B	175.0	NBL	OWP	No cracks
617 CX-A & B	176.0	SBL	BWP	6' from full width Trans. crack. Some Long. seam cracking
618 CX-A & B	177.0	NBL	OWP	6' from small Long. crack (10'in length)
619 CX-A & B	178.0	SBL	IWP	4' from ϕ seam crack continuous both directions - no other cracks - cored on 3% grade.
620 CX-A & B	179.0	NBL	OWP	Minor shoulder cracking - cored on 4% grade
621 CX-A & B	179.7	SBL	BWP	Cracking BWP, end of job (China Pt.) 100' south of grade structure - joint cracking Long.

LOG OF ROADWAY CORES
Igo Overhead to Rockland Jct. I.C.

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
601 CX-A & B	279.5	WBL	OWP-TL	
602 CX-A & B	278.0	WBL	BWP-TL	
603 CX-A & B	277.0	WBL	OWP-TL	Long. crack BWP, IWP
604 CX-A & B	276.5	WBL	IWP-TL	
605 CX-A & B	275.0	WBL	IWP-PL	
606 CX-A & B	274.0	WBL	BWP-TL	Extreme Long. & Trans. cracking Core "A" drilled on small crack
607 CX-A & B	273.5	WBL	OWP-TL	1/2 core recovered-remainder stripped
608 CX-A & B	273.5	WBL	OWP-PL	Across road from sample 607 CX
609 CX-A & B	273.0	WBL	BWP-TL	Mult. Long. cracking
610 CX-A & B	272.0	WBL	BWP-TL	"A" Core stripped "B" Core stripped (drilled on crack)
611 CX-A & B	270.8	WBL	IWP-TL	
612 CX-A & B	271.0	EBL	OWP-TL	
613 CX-A & B	272.5	EBL	IWP-TL	
614 CX-A & B	274.0	EBL	BWP-TL	
615 CX-A & B	275.5	EBL	OWP-PL	
616 CX-A & B	277.0	EBL	OWP-TL	
617 CX-A & B	278.5	EBL	BWP-TL	
618 CX-A & B	280.0	EBL	OWP-TL	

LOG OF ROADWAY CORES
Massacre Rocks to Rockland Jct. I.C.

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
601 CX-A & B	270.0	WBL	OWP	
602 CX-A & B	268.5	WBL	BWP	
603 CX-A & B	267.0	WBL	IWP	
604 CX-A & B	265.5	WBL	IWP	
605 CX-A & B	264.0	WBL	OWP	
606 CX-A & B	263.0	WBL	BWP	
607 CX-A & B	262.5	WBL	BWP	End of project-shows some extensive cracking
608 CX-A & B	262.5	EBL	OWP	Full width crack 10' from core (Trans.)
609 CX-A & B	263.5	EBL	IWP	
610 CX-A & B	264.5	EBL	BWP	
611 CX-A & B	266.0	EBL	OWP	1' from full width trans. crack (stripped)
612 CX-A & B	267.5	EBL	IWP	
613 CX-A & B	268.0	EBL	BWP	
614 CX-A & B	269.0	EBL	OWP	10' from full width trans. crack
615 CX-A & B	269.5	EBL	IWP	

LOG OF ROADWAY CORES
Burley I.C. to Kasota Rd. I.C.

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
601 CX-A & B	218.0	WBL	OWP	
602 CX-A & B	217.0	WBL	IWP-TL	850' West Rd. Overhead
603 CX-A & B	216.0	WBL	OWP-PL	
604 CX-A & B	215.0	WBL	BWP-TL	6" from F.W. Trans. crack
605 CX-A & B	214.0	WBL	BWP-TL	3' from F.W. Trans. crack
606 CX-A & B	213.0	WBL	IWP-TL	2' from Long. Seam crack
607 CX-A & B	212.0	WBL	IWP-PL	Trans. cracking - 50'- 75' apart
608 CX-A & B	211.4	EBL	BWP-TL	300' E. of Kasota Rd. I.C.
C				Drilled on F.W. Trans. crack
609 CX-A & B	213.0	EBL	OWP-PL	
610 CX-A & B	214.0	EBL	OWP-TL	
611 CX-A & B	215.0	EBL	OWP-PL	
612 CX-A & B	216.0	EBL	OWP-TL	
613 CX-A & B	217.0	EBL	BWP-TL	

LOG OF ROADWAY CORES
Kasota Rd. I.C. to Hazelton I.C.

<u>Sample Number</u>	<u>Mile Post</u>	<u>Lane</u>	<u>Location</u>	<u>Remarks</u>
601 CX-A & B	210.5	WBL	OWP-TL	
602 CX-A & B	210.0	WBL	BWP-TL	Trans. crack 50-100' apart
603 CX-A & B	209.0	WBL	IWP-TL	
604 CX-A	208.0	WBL	OWP-PL	
B				10' from trans. crack
C				Drilled on F.W. trans crack
605 CX-A & B	207.0	WBL	OWP-TL	Drilled 6' down slope from full width trans. crack
606 CX-A & B	206.0	WBL	BWP-TL	Trans cracks 50-100' center to center
607 CX-A & B	205.0	WBL	IWP-TL	300' east of Northside Canal-1' and 2' from long. & trans. crack respectively
608 CX-A & B	205.0	EBL	OWP-TL	Trans. cracking 50-100' spacing
609 CX-A & B	206.0	EBL	BWP-TL	
610 CX-A & B	207.0	EBL	IWP-TL	
611 CX-A & B	208.0	EBL	OWP-PL	
612 CX-A & B	209.0	EBL	OWP-TL	
613 CX-A & B	210.0	EBL	BWP-TL	
614 CX-A & B	211.2	EBL	IWP-TL	300' W. of Kasota Rd. I.C.

Test Results-Monida-Pleasant Valley

Sample Number	Location	Tensile Split (psi)		Surfacing Density Air Voids Stripping (% coating)		Tensile Split (psi)		Asphalt Treated Base Density Air Voids Stripping (% coating)	
		Dry	Wet	+	-	Dry	Wet	+	-
601-A	MP-196.6	32.7	-	137.4	9.8	90-100	-	-	-
601-B	SBL-BWP	-	35.9	136.8	10.1	90-100	-	-	-
602-A	MP-196.0	40.0	-	137.8	9.6	90-100	-	-	-
602-B	NBL-OWP	-	44.0	138.5	8.7	50-75	-	-	-
603-A	MP-195.0	30.1	-	137.2	10.0	90-100	-	-	-
603-B	SBL-IWP	-	40.0	137.2	9.4	75-90	-	-	-
604-A	MP-194.0	24.3	-	140.0	7.0	90-100	-	-	-
604-B	NBL-OWP	-	44.4	140.4	6.6	75-90	-	-	-
605-A	MP-193.0	27.1	-	139.6	7.4	90-100	-	-	-
605-B	SBL-OWP	-	32.4	139.8	7.0	50-75	-	-	-
606-A	MP-192.0	26.2	-	140.9	6.0	90-100	-	-	-
606-B	NBL-IWP	-	36.7	140.3	6.5	75-90	-	-	-
607-A	MP-191.0	17.3	-	136.7	9.1	90-100	-	-	-
607-B	SBL-BWP	-	27.2	137.1	9.1	75-90	-	-	-
608-A	MP-190.0	25.1	-	138.0	8.4	90-100	-	-	-
608-B	NBL-OWP	-	38.7	137.4	9.1	90-100	-	-	-
609-A	MP-189.3	23.1	-	139.9	7.2	90-100	-	-	-
609-B	SBL-IWP	-	35.5	139.6	7.2	75-90	-	-	-
609-AB		-	-	-	-	-	21.4	-	137.5
609-BB							-	33.1	137.5
610-A	MP-188.3	29.0	-	139.8	7.4	90-100	-	-	90-100
610-B	NBL-BWP	-	38.5	139.1	7.9	90-100	-	-	75-90
Average		27.5	37.3	138.7	Dry=8.2	Wet=8.2			
Std.Dev.		6.1	5.1	1.4	1.4	1.3			
Coeff. of Var. %		22%	14%	1%	17	16			

Test Results-Dubois-China Point

Sample Number	Location	Tensile Split (psi)		Surfacing Density Air Voids (%)		Stripping (%)		Tensile Split (psi)		Asphalt Density (lbs/ft ³)	Air Voids Stripping (%)	
		Dry	Wet	(lbs/ft ³)	%	+4	-4	Dry	Wet		+4	-4
601-A	MP-164.8	49.2	-	143.6	4.5	90-100	90-100	-	-	-	-	-
601-B	SBL-OWP	-	62.8	142.9	6.1	100	100	-	-	-	-	-
601-AB								32.0	43.0	144.6	90-100	90-100
601-BB								-	-	143.7	75-90	75-90
602-A	MP-165.0	54.8	-	143.2	5.0	90-100	100	40.5	-	143.3	100	100
602-B	NBL-OWP	-	71.4	144.0	4.5	50-75	75-90	-	54.1	143.5	90-100	75-90
602-AB								-	-	-	-	-
602-BB								-	-	-	-	-
603-A	MP-165.4	42.0	-	145.0	3.8	90-100	100	27.2	-	143.8	90-100	90-100
603-B	SBL-OWP	-	70.5	144.6	4.1	90-100	100	-	45.2	143.7	75-90	90-100
603-AB								-	-	-	-	-
603-BB								-	-	-	-	-
604-A	MP-165.8	54.1	-	142.3	5.8	90-100	100	32.1	-	144.6	50-75	50-75
604-B	SBL-OWP	-	47.1	143.1	5.4	< 50	50-75	-	23.0	144.8	< 50	< 50
604-AB								-	-	-	-	-
604-BB								-	-	-	-	-
605-A	MP-166.0	45.9	-	145.8	3.1	90-100	100	37.9	-	144.0	90-100	90-100
605-B	SBL-IWP	-	68.4	147.4	2.1	90-100	100	-	49.5	144.2	50-75	75-90
605-AB								-	-	-	-	-
605-BB								-	-	-	-	-
606-A	MP-166.45	44.2	-	145.1	4.0	90-100	90-100	34.0	-	145.4	90-100	90-100
606-B	SBL-OWP	-	61.4	144.5	4.3	75-90	90-100	-	46.8	145.2	75-90	75-90
606-AB								-	-	-	-	-
606-BB								-	-	-	-	-
607-A	MP-166.50	57.0	-	144.1	4.5	< 50	< 50	-	-	-	-	-
	SBL-OWP											

Test Results-Dubois-China Point

Sample Number	Location	Tensile Split (psi)		Surfacing			Asphalt Treated Base		
		Dry	Wet	Density (lbs/ft ³)	Air Voids %	Stripping(% Coating)	Density (lbs/ft ³)	Air Voids %	Stripping(% Coating)
608-A	MP-167.1	50.1	-	143.1	4.7	90-100	140.9	7.3	75-90
608-B	NBL-OWP	-	55.9	141.9	5.8	50-75	139.2	8.5	50-75
608-AB									
608-BB									
609-A	MP-168.0	44.1	-	141.7	5.6	90-100	141.7	6.2	90-100
609-B	NBL-OWP-PL	-	61.8	142.2	4.8	90-100	143.0	5.8	75-90
609-AB									
609-BB									
610-A	MP-169.0	51.0	-	144.5	4.1	90-100	143.8	5.9	90-100
610-B	NBL-OWP	-	78.8	144.9	3.7	100	143.9	6.2	90-100
610-AB									
610-BB									
611-A	MP-170.0	53.1	-	143.5	4.8	100	145.4	4.6	75-90
611-B	SBL-OWP	-	57.1	143.7	4.6	90-100	145.1	4.2	50-75
611-C		-	-	140.5	8.4	-	146.2	4.4	-
611-AB									
611-BB									
611-CB									
612-A	MP-171.0	47.1	-	144.0	4.6	100	143.9	5.5	90-100
612-B	NBL-IWP	-	-	142.0	6.4	-	142.0	-	-
612-AB									
612-BB									
612-C		-	66.8	144.5	4.4	90-100	143.4	6.2	75-90
612-CB									
613-A	MP-172.0	46.8	-	141.7	6.0	100	138.9	9.2	90-100
613-B	SBL-OWP	-	56.5	141.9	6.2	90-100	137.6	10.0	90-100
613-AB									
613-BB									

Test Results-Dubois-China Point

Sample Number	Location	Tensile Split (psi)		Surfacing Density Air Voids Stripping(% Coating)		Tensile Split(psi)		Asphalt Treated Base		
		Dry	Wet	Density (lbs/ft ³)	%	Dry	Wet	Density (lbs/ft ³)	Air Voids %	Stripping(% Coating)
614-A	MP-173.4	48.6	-	142.6	5.9	15.0	-	138.6	9.9	90-100
614-B	NBL-IWP	-	58.8	143.2	5.3	-	35.0	140.3	8.1	75-90
614-AB										100
614-BB										75-90
615-A	MP-174.0	44.0	-	142.2	6.0	33.2	-	142.2	6.8	90-100
615-B	SBL-IWP	-	64.6	142.2	5.9	-	49.1	142.5	7.6	75-90
615-AB										90-100
615-BB										75-90
616-A	MP-175.0	43.1	-	143.2	5.4	20.8	-	138.1	9.7	90-100
616-B	NBL-OWP	-	67.6	143.1	5.3	-	31.4	137.8	10.4	90-100
616-AB										100
616-BB										90-100
617-A	MP-176.0	46.3	-	143.7	4.5	20.5	-	140.4	8.0	90-100
617-B	SBL-BWP	-	57.9	143.8	4.4	-	32.7	140.6	7.9	75-90
617-AB										100
617-BB										75-90
618-A	MP-177.0	55.4	-	142.5	5.4	23.9	-	138.5	9.1	90-100
618-B	NBL-OWP	-	68.1	142.6	5.1	-	34.2	138.3	9.4	75-90
618-AB										90-100
618-BB										75-90
619-A	MP-178.0	46.9	-	144.1	5.3	24.8	-	140.7	7.3	90-100
619-B	SBL-IWP	-	60.9	143.9	5.4	-	33.7	139.9	8.6	75-90
619-AB										90-100
619-BB										90-100
620-A	MP-179.0	38.0	-	143.8	4.7	24.8	-	140.6	7.9	90-100
620-B	NBL-OWP	-	57.4	142.8	5.5	-	37.5	140.7	7.8	75-90
620-AB										90-100
620-BB										90-100

Test Results-Dubois-China Point

Sample Number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ³)		Air Voids Stripping(% Coating)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ³)		Air Voids Stripping(% Coating)	
		Dry	Wet			%		Dry	Wet	%		%	
621-A	MP-179.7	32.8	-	144.2	4.8	90-100	100						
621-B	SBL-BWP	-	45.4	144.7	4.4	50-75	50-75	16.3	-	140.0	8.7	90-100	100
621-AB								-	24.3	140.9	8.5	75-90	75-90
621-BB													
Average		47.4	61.9	Dry=4.9		Wet=4.9		29.1	40.1	Dry= 6.9		Wet=7.1	
Std. Dev.		5.9	8.01	.8		1.0		8.1	10.2	1.7		1.8	
Coeff. of Var. %		12	13	16		20		28%	25%	25%		25%	

Test Results-Igo Overhead-Rockland Jct. I.C.

Sample Number	Location	Tensile Split (psi)		Surfacing Density Air Voids (%)		Stripping (%)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ³)	Air Voids (%)	Stripping (%)
		Dry	Wet	Dry	Wet	+4	-4	Dry	Wet			
601-A	MP-279.5	31.4	-	149.3	1.7	75-90	90-100	-	-	-	-	-
601-B	WBL-OWP-TL	-	22.7	149.9	1.8	-	-	-	-	-	-	-
602-A	MP-278.0	26.9	-	148.8	2.2	90-100	100	-	-	-	-	-
602-B	WBL-BWP-TL	-	20.2	148.4	2.7	-	-	-	-	-	-	-
603-A	MP-277.0	28.6	-	418.9	2.4	100	100	-	-	-	-	-
603-B	WBL-OWP-TL	-	30.4	148.8	2.2	-	-	-	-	-	-	-
604-A	MP-276.5	37.6	-	147.8	2.9	50-75	75-90	-	-	-	-	-
604-B	WBL-IWP-TL	-	56.7	146.8	3.2	-	-	-	-	-	-	-
605-A	MP-275.0	43.4	-	142.0	6.5	100	90-100	-	-	-	-	-
605-B	WBL-IWP-PL	-	58.1	141.9	7.1	-	-	-	-	-	-	-
606-A	MP-274.0	20.7	-	144.0	5.1	< 50	< 50	-	-	-	-	-
606-B	WBL-BWP-TL	-	27.3	143.5	5.8	-	-	-	-	-	-	-
607-A	MP-273.5	33.6	-	147.1	2.6	< 50	< 50	-	-	-	-	-
607-B	WBL-OWP-TL	-	18.8	148.5	2.6	-	-	-	-	-	-	-
608-A	MP-273.5	43.6	-	142.5	6.2	90-100	100	-	-	-	-	-
608-B	WBL-OWP-PL	-	51.7	142.1	6.4	-	-	-	-	-	-	-
609-A	MP-273.0	34.6	-	146.0	3.6	75-90	75-90	-	-	-	-	-
609-B	WBL-BWP-TL	-	17.5	144.7	4.3	-	-	-	-	-	-	-
610-A	MP-272.0	33.5	-	147.9	2.9	50-75	50-75	-	-	-	-	-
610-B	WBL-BWP-TL	-	-	146.1	4.1	-	-	-	-	-	-	-
611-A	MP-270.8	56.3	-	143.1	6.5	90-100	90-100	-	-	-	-	-
611-B	WBL-IWP-TL	-	73.7	143.0	6.7	-	-	-	-	-	-	-

Test Results-Igo Overhead-Rockland Jct. I.C.

Sample Number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ³)		Air Voids Stripping(% Coating)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ³)		Air Voids Stripping(% Coating)	
		Dry	Wet	Dry	Wet	+4	-4	Dry	Wet	(lbs/ft ³)	%	+4	-4
612-A	MP-271.0	49.5	-	146.8	-	90-100	90-100	-	-	146.8	3.9	-	-
612-B	EBL-OWP-TL	-	46.1	147.2	-	-	-	-	-	147.2	3.5	-	-
613-A	MP-272.5	64.2	-	143.3	-	90-100	75-90	-	-	143.3	5.8	-	-
613-B	EBL-IWP-TL	-	71.2	143.5	-	-	-	-	-	143.5	6.3	-	-
614-A	MP-274.0	45.8	-	140.9	-	90-100	75-90	-	-	140.9	7.8	-	-
614-B	EBL-BWP-TL	-	42.4	140.8	-	-	-	-	-	140.8	7.9	-	-
615-A	MP-275.5	44.6	-	139.5	-	90-100	90-100	-	-	139.5	9.0	-	-
615-B	EBL-OWP-TL	-	52.1	140.0	-	-	-	-	-	140.0	8.7	-	-
616-A	MP-277.0	35.7	-	146.3	-	90-100	90-100	-	-	146.3	3.8	-	-
616-B	EBL-OWP-TL	-	21.6	145.8	-	-	-	-	-	145.8	4.5	-	-
617-A	MP-278.5	37.8	-	145.2	-	90-100	90-100	-	-	145.2	5.0	-	-
617-B	EBL-BWP-TL	-	35.9	145.6	-	-	-	-	-	145.6	5.0	-	-
618-A	MP-280.0	48.5	-	147.4	-	75-90	75-90	-	-	147.4	2.8	-	-
618-B	EBL-OWP-TL	-	23.8	147.3	-	-	-	-	-	147.3	3.6	-	-
Average		39.8	39.4	Dry=4.5		Wet=4.8							
Std. Dev.		10.9	18.6	2.1		2.0							
Coeff. of Var.		27%	47%	47%		43%							

Test Results-Massacre Rocks-Rockland Jct. I.C.

Sample number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ³)		Air Voids %		Stripping(% Coating)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ³)		Air Voids Stripping(% Coating)	
		Dry	Wet	Dry	Wet	Dry	Wet	+4	-4	Dry	Wet	Dry	Wet	+4	-4
601-A	MP-270.0	69.0	-	141.4	141.3	6.5	6.4	90-100	100						
601-B	WBL-OWP	-	69.3	141.3	141.3	6.4	6.4	90-100	100						
602-A	MP-268.5	55.6	-	139.3	138.8	8.1	8.1	100	100						
602-B	WBL-BWP	-	72.0	138.8	138.8	8.1	8.1	100	100						
603-A	MP-267.0	75.0	-	141.1	140.3	6.5	7.3	100	100						
603-B	WBL-IWP	-	82.6	140.3	140.3	7.3	7.3	90-100	100						
604-A	MP-265.5	70.3	-	140.5	140.3	7.7	7.2	100	100						
604-B	WBL-IWP	-	75.3	140.3	140.3	7.2	7.2	100	100						
605-A	MP-264.0	69.5	-	140.2	139.3	6.8	7.4	100	100						
605-B	WBL-OWP	-	67.4	139.3	139.3	7.4	7.4	90-100	100						
606-A	MP-263.0	59.6	-	140.6	141.6	6.9	5.7	100	100						
606-B	WBL-BWP	-	82.9	141.6	141.6	5.7	5.7	100	100						
607-A	MP-262.5	70.0	-	138.8	139.0	7.6	7.1	90-100	90-100						
607-B	WBL-BWP	-	70.1	139.0	139.0	7.1	7.1	90-100	90-100						
608-A	MP-262.5	59.7	-	141.3	141.1	5.7	6.3	75-90	90-100						
608-B	EBL-OWP	-	89.0	141.1	141.1	6.3	6.3	90-100	90-100						
609-A	MP-263.5	69.3	-	140.0	138.3	6.9	7.4	100	100						
609-B	EBL-IWP	-	94.0	138.3	138.3	7.4	7.4	100	100						
610-A	MP-264.5	74.6	-	138.8	138.6	8.1	8.1	100	100						
610-B	EBL-BWP	-	92.2	138.6	138.6	8.1	8.1	90-100	100						
611-A	MP-266.0	47.7	-	142.7	143.9	3.6	4.1	< 50	75-90						
611-B	EBL-OWP	-	48.8	143.9	143.9	4.1	4.1	50-75	75-90						

Test Results-Massacre Rocks-Rockland Jct. I.C.

Sample Number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ³)		Air Voids %		Stripping(% Coating)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ³)		Air Voids %		Stripping(% Coating)	
		Dry	Wet	Dry	Wet	Dry	Wet	-4	+4	Dry	Wet	Dry	Wet	-4	+4	-4	+4
612-A	MP-267.5	71.6	-	140.7	-	6.4	-	100	-	100	-	100	-	100	-	-	-
612-B	EBL-IWP	-	49.4	141.3	-	6.6	-	90-100	-	100	-	100	-	90-100	-	-	-
613-A	MP-268.0	58.9	-	139.2	-	7.7	-	100	-	100	-	100	-	100	-	-	-
613-B	EBL-BWP	-	70.0	138.8	-	7.7	-	90-100	-	100	-	100	-	90-100	-	-	-
614-A	MP-269.0	58.0	-	142.7	-	5.1	-	100	-	100	-	100	-	100	-	-	-
614-B	EBL-OWP	-	87.8	141.6	-	6.2	-	90-100	-	100	-	100	-	90-100	-	-	-
615-A	MP-269.5	64.5	-	143.8	-	4.1	-	90-100	-	100	-	100	-	90-100	-	-	-
615-B	EBL-IWP	-	86.7	143.7	-	4.4	-	90-100	-	100	-	100	-	90-100	-	-	-
Average		64.9	75.8	Dry=6.5		Wet=6.7											
Std. Dev.		7.9	14.0	1.4		1.2											
Coeff. of Var.		12%	18%	21%		18%											

Test Results-Burley I.C.-Kasota Rd. I.C.

Sample number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft³)	Air Voids		Stripping(% Coating)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft³)		Air Voids		Stripping(% Coating)	
		Dry	Wet		%	+4	-4	Dry	Wet	%	+4	-4				
601-A	MP-218.0	93.1	-	136.9	4.4	90-100	-	-	-	-	-	-	-	-	-	-
601-B	WBL-OWP-TL	-	94.4	137.0	4.4	90-100	-	-	-	-	-	-	-	-	-	-
601-AB									51.7	-	131.6	9.3	90-100	-	-	-
601-BB									-	51.8	131.4	9.9	90-100	-	-	-
602-A	MP-217.0	87.3	-	136.5	4.5	90-100	-	-	Speciman separated unevenly							
602-B	WBL-IWP-TL	-	90.7	136.2	5.3	90-100	-	-	Speciman separated unevenly							
602-AB																
602-BB																
603-A	MP-216.0	70.6	-	133.9	5.9	90-100	-	-	-	-	-	-	-	-	-	-
603-B	WBL-OWP-PL	-	80.2	133.6	6.7	90-100	-	-	49.0	-	132.9	8.2	90-100	-	-	-
603-AB									-	42.4	133.0	8.5	90-100	-	-	-
603-BB																
604-A	MP-215.0	94.9	-	137.2	3.8	90-100	-	-	-	-	-	-	-	-	-	-
604-B	WBL-BWP-TL	-	102.5	137.2	4.2	90-100	-	-	40.4	-	129.4	10.6	90-100	-	-	-
604-AB									-	46.9	132.4	9.3	90-100	-	-	-
604-BB																
605-A	MP-214.0	75.8	-	135.1	5.5	90-100	-	-	-	-	-	-	-	-	-	-
605-B	WBL-BWP-TL	-	93.3	134.4	5.9	90-100	-	-	51.3	-	130.9	9.8	90-100	-	-	-
605-AB									-	53.8	130.4	11.1	90-100	-	-	-
605-BB																
606-A	MP-213.0	95.4	-	137.5	3.7	90-100	-	-	-	-	-	-	-	-	-	-
606-B	WBL-IWP-TL	-	114.7	137.2	-	90-100	-	-	42.3	-	131.7	9.4	90-100	-	-	-
606-AB									-	49.2	131.5	-	90-100	-	-	-
606-BB																
607-A	MP-212.0	69.9	-	132.2	7.7	90-100	-	-	-	-	-	-	-	-	-	-
607-B	WBL-IWP-PL	-	90.6	132.0	7.4	90-100	-	-	42.8	-	129.7	10.7	90-100	-	-	-
607-AB									-	53.4	129.2	10.7	90-100	-	-	-
607-BB																

Test Results-Burley I.C.-Kasota Rd. I.C.

Sample Number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ³)		Air Voids		Stripping(% Coating)		Tensile Split (psi)		Asphalt Density (lbs/ft ³)		Air Voids		Stripping(% Coating)	
		Dry	Wet					+4	-4	Dry	Wet					+4	-4
608-A	MP-211.4	66.9	-	132.2	7.5	90-100	-	-	-	-	-	-	-	-	-	-	-
608-B	EBL-BWP-TL	-	78.8	132.2	7.3	90-100	-	-	-	54.7	-	132.8	8.7	90-100	-	-	-
608-AB										-	61.6	133.3	8.4	90-100	-	-	-
608-BB																	
609-A	MP-213.0	78.2	-	132.5	7.5	90-100	-	-	-	-	-	133.0	8.6	90-100	-	-	-
609-B	EBL-OWP-PL	-	85.5	132.0	7.7	90-100	-	-	-	55.3	-	133.1	8.6	90-100	-	-	-
609-BB																	
610-A	MP0214.0	86.1	-	135.8	4.8	90-100	-	-	-	-	-	133.2	7.9	90-100	-	-	-
610-B	EBL-OWP-TL	-	89.0	135.0	6.1	75-90	-	-	-	52.0	-	133.8	8.1	75-90	-	-	-
610-BB																	
611-A	MP-215.0	83.6	-	134.5	5.4	90-100	-	-	-	-	-	132.5	8.0	90-100	-	-	-
611-B	EBL-OWP-PL	-	102.7	134.4	5.6	90-100	-	-	-	50.9	-	132.3	8.4	90-100	-	-	-
611-BB																	
612-A	MP-216.0	82.5	-	136.3	4.2	90-100	-	-	-	-	-	132.3	9.0	90-100	-	-	-
612-B	EBL-OWP-TL	-	93.5	135.8	4.8	90-100	-	-	-	50.1	-	131.8	9.1	90-100	-	-	-
612-AB																	
612-BB																	
613-A	MP-217.0	84.4	-	135.3	5.3	90-100	-	-	-	-	-	128.5	11.9	90-100	-	-	-
613-B	EBL-BWP-TL	-	94.7	134.5	6.3	90-100	-	-	-	40.9	-	128.9	11.8	90-100	-	-	-
613-BB																	
614-A	MP-218.0	90.0	-	136.9	4.3	90-100	-	-	-	-	-	131.1	9.6	90-100	-	-	-
614-B	EBL-IMP-TL	-	109.4	136.7	4.5	90-100	-	-	-	36.1	-	131.1	9.3	90-100	-	-	-
614-BB																	
Average		82.8	94.2	Dry=5.3	Wet=5.9					47.5	51.6	Dry=9.4	Wet=9.4				
Std. Dev.		9.3	10.2	1.4	1.2					6.2	7.2	1.2	1.2				
Coeff. of Var.		11%	11%	26%	20%					13%	14%	13%	13%				

Test Results-Eden-Hazelton I.C.-Kasota Rd. I.C. (Greenwood)

Sample Number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ³)		Air Voids (%)		Stripping (%)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ³)		Air Voids (%)		Stripping (%)		Coating
		Dry	Wet	Dry	Wet	-4	+4	-4	+4	Dry	Wet	-4	+4	-4	+4	-4	+4	
601-A	MP-210.5	85.9	-	137.9	4.0	90-100	-	-	-	-	-	-	-	-	-	-	-	-
601-B	WBL-OWP-TL	-	89.5	137.3	4.0	90-100	-	-	-	46.5	-	132.6	9.5	9.1	-	90-100	-	-
601-AB										-	36.0	133.1	-	-	-	-	-	-
601-BB										-								-
602-A	MP-210.0	88.1	-	137.2	-	90-100	-	-	-	-	-	-	-	-	-	-	-	-
602-B	WBL-BWP-TL	-	*109/82	136.0	-	-	-	-	-	37.0	*48/55	130.5	-	-	-	90-100	-	-
602-AB										-		134.8	-	-	-	-	-	-
602-BB										-								-
603-A	MP-209.0	60.3	-	136.2	4.6	90-100	-	-	-	45.6	-	132.8	6.9	-	-	90-100	-	-
603-B	WBL-IWP-TL	*107/89	-	135.7	-	-	-	-	-	*56/53	-	133.0	-	-	-	-	-	-
603-AB										-								-
603-BB										-								-
604-A	MP-208.0	90.1	-	136.0	3.1	90-100	-	-	-	-	-	-	-	-	-	-	-	-
604-B	WBL-OWP-PL	*92/76	-	136.0	-	90-100	-	-	-	44.1	-	131.7	9.2	-	-	90-100	-	-
604-AB										*50/54	-	132.1	-	-	-	-	-	-
604-BB										-								-
605-A	MP-207.0	86.1	-	136.8	4.1	90-100	-	-	-	25.1	-	129.7	11.0	-	-	90-100	-	-
605-B	WBL-OWP-TL	-	91.7	136.0	4.1	90-100	-	-	-	-	28.8	130.5	10.3	-	-	90-100	-	-
605-AB										-								-
605-BB										-								-
606-A	MP-206.0	87.8	-	136.7	3.9	90-100	-	-	-	-	-	-	-	-	-	-	-	-
606-B	WBL-BWP-TL	-	96.4	136.5	4.0	90-100	-	-	-	30.8	-	131.3	9.8	-	-	90-100	-	-
606-AB										-	31.7	130.5	10.2	-	-	75-90	-	-
606-BB										-								-
607-A	MP-205.0	78.8	-	135.8	4.8	75-90	-	-	-	48.9	-	134.9	6.5	-	-	75-90	-	-
607-B	WBL-IWP-TL	-	84.7	137.0	3.6	90-100	-	-	-	-	39.1	130.0	10.1	-	-	90-100	-	-
607-AB										-								-
607-BB										-								-

*Correlation test run at Moscow Lab by Dr. Lottman

Test Results-Eden-Hazelton I.C.-Kasota Rd. I.C. (Greenwood)

Sample Number	Location	Tensile Split (psi)		Surfacing Density (lbs/ft ²)		Air Voids %		Stripping (% Coating)		Tensile Split (psi)		Asphalt Treated Base Density (lbs/ft ²)		Air Voids %		Stripping (% Coating)	
		Dry	Wet	Dry	Wet	Dry	Wet	+4	-4	Dry	Wet	Dry	Wet	Dry	Wet	+4	-4
608-A	MP-205.0	79.4	-	136.8	-	4.3	-	75-90	-	-	-	-	-	-	-	-	-
608-B	EBL-OMP-TL	-	97.2	136.0	-	5.0	-	90-100	-	40.8	-	131.4	-	9.8	-	90-100	-
608-AB										-	41.5	131.0	-	11.2	-	90-100	-
608-BB										-	-	-	-	-	-	-	-
609-A	MP-206.0	83.1	-	128.1	-	11.2	-	90-100	-	33.9	-	130.2	-	10.5	-	90-100	-
609-B	EBL-BWP-TL	-	84.1	135.5	-	6.2	-	90-100	-	-	33.3	129.0	-	11.3	-	90-100	-
609-AB										-	-	-	-	-	-	-	-
609-BB										-	-	-	-	-	-	-	-
610-A	MP-207.0	96.3	-	139.0	-	2.9	-	90-100	-	28.0	-	131.8	-	9.1	-	90-100	-
610-B	EBL-IWP-TL	-	114.7	139.1	-	2.5	-	90-100	-	-	24.8	130.2	-	10.4	-	90-100	-
610-AB										-	-	-	-	-	-	-	-
610-BB										-	-	-	-	-	-	-	-
611-A	MP-208.0	82.7	-	135.5	-	4.4	-	90-100	-	43.8	-	130.4	-	10.9	-	90-100	-
611-B	EBL-OMP-PL	-	81/83	134.7	-	-	-	-	-	-	38/27	130.3	-	-	-	-	-
611-AB										-	-	-	-	-	-	-	-
611-BB										-	-	-	-	-	-	-	-
612-A	MP-209.0	79.3	-	135.7	-	5.4	-	90-100	-	31.5	-	132.1	-	9.3	-	90-100	-
612-B	EBL-OMP-TL	-	86.5	135.8	-	5.3	-	90-100	-	-	30.8	131.4	-	9.3	-	90-100	-
612-AB										-	-	-	-	-	-	-	-
612-BB										-	-	-	-	-	-	-	-
613-A	MP-210.0	77.3	-	136.3	-	5.0	-	75-90	-	30.0	-	132.8	-	9.0	-	75-90	-
613-B	EBL-BWP-TL	-	95.5	135.8	-	5.7	-	90-100	-	-	47.6	132.3	-	9.6	-	90-100	-
613-AB										-	-	-	-	-	-	-	-
613-BB										-	-	-	-	-	-	-	-
614-A	MP-211.2	84.1	-	136.6	-	5.3	-	75-90	-	35.2	-	130.3	-	10.7	-	90-100	-
614-B	EBL-IWP-TL	-	112.9	136.5	-	4.5	-	90-100	-	-	40.4	130.0	-	10.0	-	90-100	-
614-AB										-	-	-	-	-	-	-	-
614-BB										-	-	-	-	-	-	-	-
Average		84.7	93.4	Dry=4.8	Wet=4.5					40.8	37.3	Dry=9.4	Wet=10.1				
Std. Dev.		9.6	11.5	2.0	1.1					9.7	8.7	1.4	.7				
Coeff. of Var.		11%	12%	42%	24%					24%	23%	15%	7%				

PROJECT HISTORY DATA

PAGE

YEAR - NO.	DISTRICT	ROUTE	PROJECT	MILE POST TO MILE POST	TOTAL ADT (1970)	COMMERCIAL ADT (1970)	CONSTRUCTION DATE	PAVEMENT COURSE	COURSE THICKNESS	ASPHALT SOURCE	AMOUNT ASPH. USED	GRADE OF ASPHALT OR CEMENT	AGGREGATE SOURCE	AGGREGATE GRADATION	FILLER	ADDITIONAL	PERCENT ADDITIVE	AGGREGATE TYPE	REMARKS
66-8	2	I-80N	I-80N-3(34)196"AM	1205-211	6400	350	6/67-7/67	1	0.20	AM	6.2	60-70	CS-142	1/2	1.0%			CG	C1 "D"
			(Kasota Rd. I.C. to Hazelton I.C.)				9/66-6/67	2	0.20	AM	5.5	60-70	CS-142	3/4	1.0%			CG	C1 "B"
							9/66-5/67	3	0.40	AM	4.2	60-70	CS-142	3/4				CG	ATB
							5/66-6/66	4	0.20				CS-142	3/4				CG	Ty. "A" Base
66-9	2	I-80N	I-80N-3(7)193"AM	211-219	6400	850	7/66-8/66	1	0.20	AM	5.7	60-70	CS-142	1/2				CG	C1 "D"
			(Burley I.C. - Kasota Rd. I.C.)				7/66-8/66	2	0.20	AM	5.6	60-70	CS-142	3/4				CG	C1 "B"
							6/66-8/66	3	0.40	AM	4.3	60-70	CS-142	3/4				CG	ATB
							6/66-8/66	4	0.60				CS-142	3/4				CG	Ty. "A" Base

AM-American Oil
HM-Humble Oil

Individual Abson Recovery Test Results All Projects

Project	Sample	Penetration @77°F	Penetration @39.2°F	Ductility @77°F	Ductility @39.2°F	Viscosity @275°F
I-15-3(2)194 & I-15-3(11)187 Monida-Pleasant Valley	601-A=194	28	26	5.0	-	1300
	601-B=194	28	23	-	.5	1265
	606-A=187	44	24	-	.5	540
	606-B=187	44	24	85.0	-	539
I-15-3(21)163 Dubois - China Point	604-A & B	35	17	34	2	626
	604-AB & BB	43	22	40	3.5	504
	616-A & B	40	22	18	3.5	654
	616-AB & BB	45	23	32	4	535
I-16-15W-4(9)88 Igo - Rockland	603-A & B	61	25	87	1	303
	607-A & B	46	20	69	3.5	381
I-15W-4(13)97 Massacre Rocks-Rockland	604-A	26	14	5	1	815
	608-A	37	18	7	1	482
I-80N-3(7)199"A" Burley I.C. to Kasota Road I.C.	603-A	30	17	-	1	696
	603-B	30	17	26	-	698
	603-AB	34	18	-	-	831
	603-BB	35	18	5	-	981
	610-A	32	16	-	1	715
	610-B	33	18	12	-	757
	610-AB	33	18	11	-	824
	610-BB	33	18	-	1	773
I-80N-3(34)196"A" Hazelton I.C. to Kasota Road I.C.	606-A	32	19	-	1	837
	606-B	35	20	12	-	761
	606-AB	38	19	40	-	572
	606-BB	38	21	-	3	551
	612-A	32	18	18	-	712
	612-B	30	18	-	1	728
	612-AB	44	22	26	-	568
	612-BB	42	21	-	3	580

Note: ATB=combined two (surfacing) cores to gain sufficient material for testing
AB & BB= combined two asphalt treated base cores to gain sufficient material for testing

TEMPERATURE EXTREMES AND FREEZE DATA

BURLEY FAA AIRPORT YEAR	Highest Date	Lowest Date	Last spring minimum of										First fall minimum of										Number of days between dates						
			16° or below	20° or below	24° or below	28° or below	32° or below	Date	Temp.	Date	Temp.	Date	Temp.	28° or below	24° or below	20° or below	Date	Temp.	Date	Temp.	16° or below	20° or below	24° or below	28° or below	32° or below				
			Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.	Date	Temp.			
1967	97 7-13	-7 12-13	4-1	16	5-1	19	5-4	24	5-14	26	9-13	30	10-15	24	10-15	24	10-15	24	10-15	24	10-15	24	10-15	24	10-15	24			
1968	98 7-28	-6 12-22	3-31	15	4-22	19	4-23	22	5-16	27	5-16	27	10-3	25	10-3	25	10-3	25	10-3	25	10-3	25	10-3	25	10-3	25			
1969	98 7-27	2 1-23	3-14	14	3-20	20	3-25	24	4-30	26	4-30	26	10-3	32	10-4	25	10-11	24	10-15	18	11-23	12	25	4	20	200	157	156	
1970	98 8-7	-1 1-7	3-25	14	4-21	17	4-24	21	5-11	28	5-15	32	9-14	30	9-16	27	9-25	23	10-15	17	10-28	16	217	177	154	128	122		
1971	97 8-13	-8 1-5	3-18	9	4-1	18	4-10	14	4-16	28	4-18	32	9-18	32	9-27	28	10-28	20	10-28	20	10-29	9	225	210	201	164	153		
1972	96 8-11	-23 12-11	3-27	15	3-27	15	5-1	23	5-9	28	5-9	28	9-12	32	9-29	27	10-27	23	10-27	23	10-29	20	10-30	14	217	216	179	143	126

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