A LABORATORY EVALUATION OF ASPHALTIC CONCRETE CONTAINING ASPHADUR

HIGHSWAY DIVISION
OFFICE OF MATERIALS
DECEMBER 1978
A LABORATORY EVALUATION OF ASPHALTIC CONCRETE CONTAINING ASPHADUR

by

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December 1978

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS
Ames, Iowa 50010
Disclaimer

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A LABORATORY EVALUATION OF ASPHALTIC CONCRETE CONTAINING ASPHADUR

SUMMARY

A laboratory evaluation of three asphaltic concrete, plant produced mixtures containing Asphadur has been made. The mixtures represent a type A asphaltic concrete and two type B asphaltic concretes.

The type A and one of the type B mixtures were used in pavements and will be evaluated later for durability and serviceability. The second type B mixture was made only for laboratory testing.

In each instance, control batches of the same mixtures but without Asphadur were made for comparison.

Type A is a high type asphaltic concrete, requires a minimum of 65% crushed particles and is generally used for higher traffic volume roads. Type B is used for intermediate or lower traffic volumes and requires a minimum of 30% crushed particles.

CONCLUSIONS

In each of the three projects, the addition of Asphadur to the asphalt mixtures increased the Marshall stability and the indirect tensile strength. These characteristics certainly would increase the resistance of the pavement to deformation due to heavy traffic loads or shoving due to accelerating or decelerating traffic.
We must also remain cognizant of the fact that the high temperature to which the mixture is subjected would also tend to give test results in the same direction as the Asphadur. If the Asphadur negates the hardening effect due to the overheating of the asphalt and does, in fact, improve the durability and temperature susceptibility of the asphalt, then Asphadur could become an important tool in certain areas of asphaltic concrete usage.

It appears, at this point, that the most meaningful and valid evaluation of the represented characteristics of Asphadur must come from performance reports, both visual and by laboratory testing, after the pavements have been in usage over periods of time.

It is recommended at this time, that for continued evaluation, that Asphadur be considered for additional projects in suitable and selected locations.

INTRODUCTION

Asphadur is the trade name of an Austrian manufactured mixture of polymers of unsaturated hydrocarbons of varying lengths used with asphaltic concrete to improve its properties. Asphadur when added to the asphalt mixture is represented as increasing resistance to deformation due to heavy traffic, increasing the durability of the pavement, increasing the resistance to wear, decreasing the temperature susceptibility of the asphalt, and influencing the structure of the asphalt so
that a favorable relationship between asphaltines and maltenes is achieved. This evaluation was directed primarily in studying the deformation problem through stability and indirect tensile strength and other related tests, i.e., asphalt content, aggregate gradations, etc. No effort was attempted to show any chemical change or shift in the composition of asphalt that might be effected by Asphadur.

Plastics can be classified broadly as thermosetting or thermoplastic. The thermosetting plastics remain solid at elevated temperatures until they reach a temperature at which they decompose. Thermoplastics have no definite melting point but become softer with an increase in temperature until they become liquid.

Asphadur is a thermoplastic and at a temperature of about 400°F. (204°C.), with sufficient shear force, can be mixed with asphalt cement or asphaltic concrete.

Figure 1 is a photomicrograph of 72X magnification showing the Asphadur particles recovered from a mix. These are the particles that were retained on a No. 325 sieve which has sieve openings of 0.045 mm. Note the irregularity of shape and the tendency toward elongation of the particles.

The most convenient method, at the present, to use Asphadur is to introduce the granulated material directly into the pugmill. The high shear force of the pugmill, the elevated temperature of the mix, and the increase in mixing time reduce the softened Asphadur into small sizes and shapes as shown in
Figure 1. Asphadur could be added directly to asphalt cement, but constant agitation would be required for dispersion and retaining the homogenous mixture.

Figure 1. Extracted Asphadur

SCOPE

An Asphadur mixture was produced from batch plants at the following paving plant sites:

1. Contractor: Iowa Road Builders Co.
   Location of plant: Ames
   Location of project: -
   Length and description of project: Three batches of Asphadur mix along with one control batch were produced for laboratory testing only.

2. Contractor: Brower Construction Co.
   Location of plant: Sioux City
Location of project: Two locations in Sioux City; (1) on Glenn Avenue between St. Aubin and Royce Streets and (2) on Floyd Street south of Dace Avenue. Length and description of project: (1) The Glenn Avenue project was a one-block section on a steep incline in a residential area with a stop sign at the bottom of the section. It represented a typical problem area where movement and shoving occurred at the stop sign. (2) The one-block section on Floyd Street was in an industrialized area that received heavy truck traffic from an off ramp of Interstate 29.

3. Contractor: Cedar Rapids Asphalt and Paving Co.

Location of plant: Cedar Rapids Location of project: At the intersection of U.S. 30 and West Post Road in Cedar Rapids. The Asphadur section was in the westbound lane only, and was from the west edge of the intersection extending to the east 500 feet. The taper on the westbound lane also used the Asphadur mix.

Six-percent Asphadur based on the weight of the asphalt being used was added to the mixes for each of the 3 projects. For the Sioux City and the Cedar Rapids projects the mixing cycle consisted of 5 seconds of drymixing, 20 seconds of wet mixing and 60 seconds of mixing after the addition of the Asphadur.

The mix temperature at delivery from the pugmill for the
Sioux City project averaged slightly over 400° F. while at Cedar Rapids it was about 385° F. The Asphadur mix produced at Ames had a temperature of 350° F. and additional mixing times of 2, 3 and 5 minutes.

The original mix designs, the three projects are based upon, are shown in Appendix A. In addition, a laboratory mix design containing Asphadur is included for the Sioux City project.

The laboratory test results of the three Asphadur mixes along with their control batches are shown in Appendix B. The indirect tensile strengths were run at 140° F.

RESULTS

Ames Project

Table 1 shows an increase of Marshall stability and indirect tensile strength with the addition of Asphadur, but it also indicates these properties along with the laboratory density are related to the additional mixing time. The highest stability and indirect tensile strength and the lowest density are obtained with 2 minutes of additional mixing. As the mixing time increases, the stability and tensile strength decrease while the density increases. Normally with a decrease in laboratory density the stability and tensile strength also decrease but this condition is reversed with Asphadur in this instance.
Table 1
Laboratory Test Results

<table>
<thead>
<tr>
<th>Control Batch</th>
<th>Asphadur Mix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Density (Sp. Gr.)</td>
<td>2.38</td>
</tr>
<tr>
<td>Marshall Stability - lbs.</td>
<td>1900</td>
</tr>
<tr>
<td>Ind. Tensile Strength p.s.i.</td>
<td>11.4</td>
</tr>
<tr>
<td>Additional Mixing Time</td>
<td>--</td>
</tr>
</tbody>
</table>

Sioux City Project

The mixing time on this project was an additional one minute of mixing after the introduction of the Asphadur. Table 2 shows the test results obtained for this project. The same trends are followed as were shown in the Ames Project; although, the amount of increase in stability was not as great.
Table 2
Laboratory Test Results

<table>
<thead>
<tr>
<th></th>
<th>Control Batch</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Density (Sp. Gr.)</td>
<td>2.39 2.39 2.39</td>
<td></td>
</tr>
<tr>
<td>Marshall Stability - lbs.</td>
<td>2770 2720 2783</td>
<td>2758</td>
</tr>
<tr>
<td>Ind. Tensile Strength p.s.i.</td>
<td>21.7 26.0 23.8</td>
<td>23.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Asphadur Mix</th>
<th>Avg.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab Density (Sp. Gr.)</td>
<td>2.32 2.32 2.33 2.33 2.33</td>
<td></td>
</tr>
<tr>
<td>Marshall Stability - lbs.</td>
<td>3133 3007 2890 3083 2965 3190 3035</td>
<td></td>
</tr>
<tr>
<td>Ind. Tensile Strength p.s.i.</td>
<td>34.1 30.2 29.2 35.3 32.7 32.8 32.2</td>
<td></td>
</tr>
</tbody>
</table>

Cedar Rapids Project (Linn County)

The mixing time on this project again was an additional one minute of mixing after the introduction of the Asphadur. The stability and the indirect tensile strength increased with the use of Asphadur but the laboratory density did not decrease as was the case with the other two mixes. The test results are shown in Table 3.

One area that appeared to give a problem that was evident, especially in the Sioux City Project, was the probable interference of the Asphadur in the sieve analysis. All the Asphadur mixes appeared different from the control batches in the "wash" portion of the sieve analysis procedure. A bulking effect became apparent and difficulty was experienced in washing the samples on the No. 200 sieve. The Sioux City Project gave varying and
unexpected results of the -200 material, as shown in Appendix B (pp. 25-26, 27-28, 29-30). The bulking effect evidently carried over to the dry sieving because on the control samples the No. 200 sieve averaged 8.2% passing, with little deviation between the individual samples. The Asphadur samples on the No. 200 sieve averaged 4.1% passing and had a large deviation between individual samples.
ACKNOWLEDGEMENT

Through efforts initiated by the Iowa Development Commission it was possible to introduce Asphadur into two demonstration paving projects in Iowa.

The authors would also like to thank Shicker and Co. (Austria), Iowa Road Builders Co., Brower Const. Co., Cedar Rapids Asphalt and Paving Co., The City of Sioux City, and Linn County for the cooperation and contribution that made this research possible. Appreciation is also extended to Mr. Charles Huisman, Materials Engineer of the Iowa D.O.T., for his contribution and guidance in the development and accomplishment of the project.
APPENDIX A

MIX DESIGNS
MIX, TYPE AND CLASS: TYPE B BINDER

INTENDED USE:

SIZE 3/4" SPEC. NO. 823 DATE REPORTED 6/26/78
DOONE FN-89-2(2)--21-08
COUNTY STORY PROJECT FN-89-3(1)--21-85
STORY IN-35-4(35)112--15-85

CONTRACTOR IOWA ROAD BLDG.
FROM WOODWARD EASTERLY 3.4 MI.; ON IA. 210 FROM I-35 WEST
PROJECT LOCATION 6.0 MI. TO SLATER; TYPE B BINDER SUBSTITUTED FOR A.T.B. ON
INTERCHANGE AT AMES

AGG. SOURCES 3/4" CR. GRAVEL - HALLETT PIT - STORY CO.,
3/4" PIT RUN GRAVEL - HALLETT PIT - STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% AAT8-299, 70% AAT8-300

--- JOB MIX FORMULA - COMBINED GRADATION ---

<table>
<thead>
<tr>
<th>1/4&quot;</th>
<th>1/2&quot;</th>
<th>3/4&quot;</th>
<th>1/2&quot;</th>
<th>3/8&quot;</th>
<th>NO.4</th>
<th>NO.8</th>
<th>NO.16</th>
<th>NO.30</th>
<th>NO.50</th>
<th>NO.100</th>
<th>NO.200</th>
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<tbody>
<tr>
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<td>89</td>
<td>77</td>
<td>61</td>
<td>51</td>
<td>42</td>
<td>32</td>
<td>18</td>
<td>7.6</td>
<td>5.9</td>
<td></td>
<td></td>
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</table>

TOLERANCE: 98/100

75 BLOW MARSHALL DENSITY 2.36

ASPHALT SOURCE AND APPROXIMATE VISCOSITY SUGAR CREEK - 1050 POISES

PLASTICITY INDEX N. P.

% ASPH. IN MIX 4.50 5.50 6.50

NUMBER OF MARSHALL BLOWS 50 50

MARSHALL STABILITY - LBS. 2133 2672 1613

FLOW - 0.01 IN. 6 7 9

SP. GR. BY DISPLACEMENT (LAB DENS.) 2.30 2.32 2.34

BULK SP. GR. COMB. DRY AGG. 2.683 2.683 2.683

SP. GR. ASPH. @ 77 F. 1.031 1.031 1.031

CALC. SOLID SP. GR. 2.52 2.48 2.45

% Voids - Calc. 8.8 6.6 4.4

% R.E. SP. GR. 2.50 2.47 2.43

% Voids - RICE 7.9 6.1 3.8

% WATER ABSORPTION - AGGREGATE 0.67 0.67 0.67

% Voids in the MINERAL AGGREGATE 18.1 18.3 18.4

% V.M.A. FILLED WITH ASPHALT 51.4 63.8 76.1

CALCULATED ASPH. FILM THICKNESS (MICRONS) 6.6 8.2 9.9

A CONTENT OF 6.00% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

ASPH. MIX DESIGN
PROJECTS LISTED ABOVE
D. ANDERSON
D. SMITH
R. SHELQUIST
D. JORDISON
L. ZEARLEY
IOWA ROAD BLDG.
C. JONES
D. HINES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER
MIX, TYPE AND CLASS: 1/2" TYPE B SURFACE
LAB NO. ABD8-210

INTENDED USE:

SIZE 1/2" SPEC. NO. DATE REPORTED 10-19-78

COUNTY WOODBURY PROJECT DEPT. INFO.

CONTRACTOR: BROWER CONST.

PROJ. LOCATION: TWO SECTIONS OF CITY STREETS IN SIOUX CITY-STEEL GRADE-INTERSEC.

AGG. SOURCES: 3/8" CR. LST.-GILMORE CITY-POCAHONTAS CO.; 5/8" QUARTIZITE CHIPS
DELL RPAIDS-S. DAK.; CONCRETE SAND-HAWARDEN-SIOUX CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% AAT8-559; 30% AAT8-550; 40% AAT8-551

JOB MIX FORMULA - COMBINED GRADATION

<table>
<thead>
<tr>
<th>SIZE</th>
<th>NO.4</th>
<th>NO.8</th>
<th>NO.16</th>
<th>NO.30</th>
<th>NO.50</th>
<th>NO.100</th>
<th>NO.200</th>
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<td>99</td>
<td>82</td>
<td>66</td>
<td>55</td>
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<td>3/8&quot;</td>
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<td>15</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

TOLERANCE: ASPHALT ADDED TO THE MIX IN THE AMOUNT OF 6.0% BY WT. OF ASPHALT
75 BLOW MARSHALL DENSITY 2.38

ASPHALT SOURCE AND APPROXIMATE VISCOSITY SUGAR CREEK - 1000 POISES

PLASTICITY INDEX N.P.

% ASPH. IN MIX 4.50 5.50 6.50

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 2835 2683 2173

FLOW - 0.01 IN. 9 9 14

SF. GR. BY DISPLACEMENT(LAB DENS.) 2.32 2.36 2.36

BULK SP. GR. COMB. DRY AGG. 2.657 2.657 2.657

SP. GR. ASPH. @ 77 F. 1.033 1.033 1.033

CALC. SOLID SP. GR. 2.48 2.45 2.42

% Voids - Calc. 6.7 3.7 1.9

RICE SP. GR. 2.48 2.45 2.40

% Voids - Rice 6.6 3.6 1.9

% Water Absorption - Aggregate 0.20 0.20 0.20

% Voids in the Mineral Aggregate 16.6 16.1 16.6

% V.M.A. Filled with Asphalt 59.5 76.9 88.6

CALCULATED ASPH. FILM THICKNESS(MICRONS) 7.1 8.8 10.5

ASPHALT WAS NOT CONSIDERED IN THE CALCULATIONS FOR THE TEST RESULTS. SEE ABD8-171 (WOODBURY FN-141) FOR COMPARISON

SIGNED: BERNARD C. BROWN TESTING ENGINEER
MIX, TYPE AND CLASS: TYPE B SURFACE

INTENDED USE:

SIZE 1/2"

COUNTY WOODBURY

PROJECT FN-141-1(10)--21-97

CONTRACTOR BROWER

PROJ. LOCATION FROM 3 MILES EAST OF HORWICK EAST 0.8 MI.

AGG. SOURCES 3/8" CR. LST.-GILMORE CITY - POCAHONTAS CO., 5/8" QUARTZITE

CHIPS - DELL RAPIDS, S. DAK., CONC. SAND-HAWARDEN - SIOUX CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% AAT8-559; 30% AAT8-550; 40% AAT8-551

JOB MIX FORMULA - COMBINED GRADATION

TOLERANCE: 98/100 7 7 6 5 3

75 BLOW MARSHALL DENSITY 2.38

ASPHALT SOURCE AND APPROXIMATE VISCOSITY SUGAR CREEK - 968 POISES

PLASTICITY INDEX N.P.

% ASPH. IN MIX 4.50 5.50 6.50

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 2207 2237 1822

FLOW - 0.01 IN. 7 8 11

SP. GR. BY DISPLACEMENT(LAB DENS.) 2.32 2.36 2.37

BULK SP. GR. COMB. DRY AGG. 2.657 2.657 2.657

SP. GR. ASPH. @ 77 F. 1.033 1.033 1.033

CALC. SOLID SP.GR. 2.48 2.45 2.42

% VOIDS - CALC. 6.7 3.7 1.9

% JE SP. GR. 2.48 2.44 2.41

% WATER ABSORPTION - AGGREGATE 0.20 0.20 0.20

% VOIDS IN THE MINERAL AGGREGATE 16.6 16.1 16.6

% V.M.A. FILLED WITH ASPHALT 59.5 76.9 88.6

CALCULATED ASPH.FILM THICKNESS(MICRONS) 7.1 8.8 10.5

A CONTENT OF 5.25% ASPHALT IS RECOMMENDED TO START THE JOB.

SIGNED: BERNARD C. BROWN
TESTING ENGINEER
MIX, TYPE AND CLASS: TYPE A SURFACE  
LAB NO. ARD6-107

INTENDED USE:

SIZE 1/2"  
SPEC. NO. 773.  DATE REPORTED 7/2/76  
COUNTY LINN  
PROJECT RF-970-2(2)-35-57

CONTRACTOR: CEDAR RAPIDS ASPHALT

PROJ. LOCATION: ON US 30 FROM BENTON CO. LINE EAST 4.0 MI.

AGG. SOURCES: 1/2" CR. LST. - S. CEDAR RAPIDS QR. - LINN CO.,  
SAND - BAIRD PIT - LINN CO.

JOB MIX FORMULA: AGGREGATE PROPORTIONS: 65% AAT6-307, 35% AAT6-308

<table>
<thead>
<tr>
<th>JOI MIX FORMULA - COMBINED GRADATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2&quot; 1&quot; 3/4&quot; 1/2&quot; 3/8&quot; NO.4 NO.8 NO.16 NO.30 NO.50 NO.100 NO.200</td>
</tr>
<tr>
<td>100 95 75 55 40 26 13  9.5  8.5</td>
</tr>
</tbody>
</table>

TOLERANCE: + OR - 98/100  
75 BLOW MARSHALL DENSITY 2.37

ASPHALT SOURCE AND APPROXIMATE VISCOSITY: SINCLAIR - 930 POISES (AC-10)

PLASTICITY INDEX
% ASPH. IN MIX  5.0  6.0  7.0

NUMBER OF MARSHALL BLOWS  50  50  50

MARRSHALL STABILITY - LBS.  2692  2617  2092

FLOW - 0.01 IN.  7  8  9

SP. GR. BY DISPLACEMENT (LAB DENS.)  2.31  2.36  2.36

BULK SP. GR. COMB. DRY AGG.  2.717  2.717  2.717

SP. GP. ASPH. @ 77 F.  1.031  1.031  1.031

CALC. SOLID SP. GR.  2.52  2.49  2.45

% VOIDS - CALC.  8.6  5.2  3.8

ICE SP. GR.  2.49  2.45  2.41

% VOIDS - RICE  7.3  3.7  2.2

% WATER ABSORPTION - AGGREGATE  0.57  0.57  0.57

% VOIDS IN THE MINERAL AGGREGATE  19.2  18.4  19.2

% V.M.A. FILLED WITH ASPHALT  55.1  71.5  80.2

CALCULATED ASPH. FILM THICKNESS (MICRONS)  6.8  8.3  9.8

A CONTENT OF 5.50% OF ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:

ASPH. MIX DESIGN  
RF-970-2(2)-35-57, LINN  
VAN SNYDER  
D. DAVICK  
B. ORTGIES  
C. HUISMAN  
L. ZEARLEY  
C. R. ASPHALT  
C. JONES  
D. HINES

SIGNED: BERNARD C. BROWN  
TESTING ENGINEER.
APPENDIX B

TEST RESULTS
Asphaltic Concrete (Asphadur) Laboratory No. ABC8-383

Intended Use Laboratory Evaluation

Project No. Department Information County

Contractor

Producer Iowa Road Builders

Plant North of Ames

Unit of Material Sample #1 regular mix sample

Sampled by Producer Sender's No.

Date Sampled 9-8-78 Date Rec'd 9-11-78 Date Reported 10-5-78

SIEVE ANALYSIS — PER CENT PASSING

<table>
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<tr>
<th>1½&quot;</th>
<th>1&quot;</th>
<th>3/4&quot;</th>
<th>1/2&quot;</th>
<th>3/8&quot;</th>
<th>No. 4</th>
<th>No. 8</th>
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<td>81</td>
<td>64</td>
<td>53</td>
<td>44</td>
<td>35</td>
<td>20</td>
<td>9.2</td>
<td>6.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% Aggregate—By Extraction 93.6 %
% Bitumen—By Extraction 6.4 %

% Peg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.
% Peg. No. 8 after 25 Cycles F&T, Water Solution
% of Wear, Los Angeles Abrasion, Grading

Liquid Limit
Plastic Limit
Plasticity Index

COMPACATION & STABILITY TESTS

Laboratory Density (Specific Gravity) 2.38
Marshall Stability (lbs.) 1900
Marshall Flow (ins.) 10
Hveem Side Pressure (PSI) 2441
Rice Sp. Gr. 2.441
Indirect tensile strength p.s.i. 11.4

DISPOSITION:

By Testing Engineer
- 18 -

IOWA DEPARTMENT OF TRANSPORTATION
Highway Division
Office of Materials

TEST REPORT — BITUMINOUS MATERIALS

Material: Asphaltic Concrete (Asphadur) Laboratory No. ABC8-384

Intended Use: Laboratory Evaluation

Project No.: Department Information County

Contractor

Producer: Iowa Road Builders

Plant: North of Ames

Unit of Material: 2 contained asphaltur mixed @ 350° F.

mixed for 2 minutes

Sampled by: Producer

Sender's No.

Date Sampled 9-8-78 Date Rec'd 9-11-78 Date Reported 10-5-78

SIEVE ANALYSIS — PER CENT PASSING


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<th>1%</th>
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<td>37</td>
<td>20</td>
<td>8.9</td>
<td>6.6</td>
<td></td>
</tr>
</tbody>
</table>

% Aggregate—By Extraction 95.0 %
% Bitumen—By Extraction 5.0 %

% Ptg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.
% Ptg. No. 8 after 25 Cycles F&T, Water Solution
% of Wear, Los Angeles Abrasion, Grading

Liquid Limit
Plastic Limit
Plasticity Index

COMPAC TION & STABILITY TESTS

Laboratory Density (Specific Gravity) 2.33
Marshall Stability (lbs.) 3020
Marshall Flow (ins.) 8
Hveem Side Pressure (PSI)
Rice Sp. Gr. 2.463
Indirect tensile strength p.s.i. 24.4

DISPOSITION: By Testing Engineer...
Asphaltic Concrete (Asphadur) Laboratory No. ABC8-385

Intended Use: Laboratory Evaluation

Project No.: Department Information

Contractor

Producer: Iowa Road Builders

Plant: North of Ames

Unit of Material: 3 contained asphadur mixed @ 350° F.
mixed for 3 minutes

Sampled by: Producer

Date Sampled: 9-8-78

Date Rec’d: 9-11-78

Date Reported: 10-5-78

SIEVE ANALYSIS — PER CENT PASSING

<table>
<thead>
<tr>
<th>Sieve Size</th>
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<th>1”</th>
<th>3/4”</th>
<th>1/2”</th>
<th>3/8”</th>
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<th>No. 50</th>
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% Aggregate—By Extraction: 94.1%

% Bitumen—By Extraction: 5.9%

% Peg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.

% Peg. No. 8 after 25 Cycles F&T, Water Solution

% of Wear, Los Angeles Abrasion, Grading

Liquid Limit

Plastic Limit

Plasticity Index

COMPACATION & STABILITY TESTS

Laboratory Density (Specific Gravity): 2.38

Marshall Stability (lbs.): 2567

Marshall Flow (ins.): 12

Hveem Side Pressure (PSI)

Rice Sp. Gr.: 2.422

Indirect tensile strength p.s.i.: 18.3

DISPOSITION: By Testing Engineer
IOWA DEPARTMENT OF TRANSPORTATION
Highway Division
Office of Materials

TEST REPORT — BITUMINOUS MATERIALS

Material: Asphalitic Concrete (Asphadur)  Laboratory No. ABC8-386

Intended Use: Laboratory Evaluation

Project No.: Department Information  County

Contractor: Iowa Road Builders

Producer: Iowa Road Builders

Plant: North of Ames

Unit of Material: 4 contained asphadur mixed @ 350° F.
mixed for 5 minutes

Sampled by: Producer  Sender’s No.

Date Sampled: 9-8-78  Date Rec’d: 9-11-78  Date Reported: 10-5-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction: 94.0%

% Bitumen—By Extraction: 6.0%

% Psg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.

% Psg. No. 8 after 25 Cycles F&T, Water Solution

% of Wear, Los Angeles Abrasion, Grading

Liquid Limit

Plastic Limit

Plasticity Index

COMPACTION & STABILITY TESTS

Laboratory Density (Specific Gravity): 2.39

Marshall Stability (lbs.): 2175

Marshall Flow (ins.): 14

Hveem Side Pressure (Pai)

Rice Sp. Gr.: 2.424

Indirect tensile strength: 14.2

DISPOSITION:

By [Signature]

C. [Signature]
TEST REPORT — BITUMINOUS MATERIALS

Material: Asphalitic Concrete @ 5.5%  Laboratory No. ABC8-723

Intended Use:

Project No.:  U-7 (Dept. Info.)  County: Linn

Contractor:  

Producer:  

Plant:  

Unit of Material: Sample Without Asphalt for Central Laboratory for experimental testing and analysis

Sampled by:  Sender's No. 1

Date Sampled:  Date Reo'd 11-14-78  Date Reported 11-15-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction  94.3%
% Bitumen—By Extraction  5.7%

% Peg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.
% Peg. No. 8 after 25 Cycles F&T, Water Solution
% of Wear, Los Angeles Abrasion, Grading

Liquid Limit
Plastic Limit
Plasticity Index

COMPACITION & STABILITY TESTS

Laboratory Density (Specific Gravity)  2.41
Marshall Stability (lbs.)  3603
Marshall Flow (ins.)  9
Hveem Side Pressure (PSI)  
Rice Sp. Gr.  2.485
Indirect tensile strength psi  24.3
Recovered Asphalt
Penetration @ 77F. 100 gms. 5 Sec.  64
Abs. Vis. @ 140F. 300 MM. Hg  1660

DISPOSITION:  By Testing Engineer
MATERIAL PLANT MIX (ASPHADUR RESEARCH)  LAB NO  ABC8-708
INTENDED USE ASPH. CONC. PAVING  PROJECT NO CITY OF SIOUX CITY STS.
CONTRACTOR BROUER CONSTR. CO.  COUNTY WOODBURY
PRODUCER CONTRACT NO
PLANT
UNIT OF MATERIAL SAMPLED FROM TRUCK @ PLANTSITE (CONTAINS NO ASPHADUR)
SENDERS NO 3ELB-21928
SAMPLED BY E. LANOUREUX
DATE SAMPLED 10/25/78  DATE RECD 11/1/78  DATE REPORTED 11/9/78

SIEVE ANALYSIS PERCENT PASSING

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DRY WT.  1451.000
SUM OF RETAINED WTS.  1453.500

% AGGREGATE BY EXTRACTION  94.800
% BITUMEN BY EXTRACTION  5.200
SPECIFIC GRAVITY  2.390
MARSHALL STABILITY  2770.000
MARSHALL FLOW 0.01 IN.  10.000

INDIRECT TENSILE STRENGTH, P.S.I.  21.7
RICE SP. GR.  2.467
RECOVERED ASPHALT
PENETRATION @ 77 F. 100 GMS. 5 SEC.  32
ABS. VIS. @ 140 F. 500 MM HG. POISES  3926

COPIES TO:

ASPH. CONC.
J. BUNF
R. SHEQUIST
L. ZEARLEY

BY  BERNARD C. BROWN
TESTING ENGINEER
- 23 -

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
AMES LABORATORY
TEST REPORT - BITUMINOUS MATERIALS

MATERIAL PLANT ALX (ASPHALT RESEARCH) LAB NO ABCB-709
INTENDED USE ASPH. CONC. PAVING COUNTY WOODBURY
PROJECT NO CITY OF SIoux CITY STS. CONTRACT NO
CONTRACTOR BROWER CONSTR. CO.
PRODUCER
UNIT OF MATERIAL SAMPLED FROM TRUCK & PLANT SITE. (CONTAINS NO ASPHALT)
SAMPLED BY E. LAHOREUX
SAMPLED ON 10/25/78 DATE RECD 11/4/78 DATE REPORTED 11/9/78

SIEVE ANALYSIS PERCENT PASSING

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<th>% PSG</th>
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NET WT. 1442.000
SUM OF RETAINED WTS. 1443.000

% OXIDATE BY EXTRACTION 94.000
% INTOXICATED BY EXTRACTION 5.100
SPECIFIC GRAVITY 2.390
MARSHALL STABILITY 2720.000
MARSHALL FLOW 0.01 IN. 9.000

INDIRECT TENSILE STRENGTH-P.S.I. 26.0
RECOVERED ASPHALT
PERMEATION 0.77 F. 100 GMS. 5 SEC. 30
ABS. WTS. @ 140 F. 300 MGS. 4260

COPIES TO:
ASPH. CONC.
J. DUNP
K. SHELDQUIST
L. ZEARLEY
- 24 -

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
AMES LABORATORY
TEST REPORT - BITUMINOUS MATERIALS

MATERIAL PLANT MIX (ASPHALTUR RESEARCH)
INTENDED USE ASPH. CONC. PAVING
PROJECT NO CITY OF STOXS CITY STS.
CONTRACTOR BROWSER CONSTR. CO.
PRODUCER
PLANT
UNIT OF MATERIAL SAMPLED FROM TRUCK @ PLANT SITE. (CONTAINS NO ASPHALTUR)
SENDERS NO 3ELB-21926
SAMPLED BY E. LAMOUREUX
DATE SAMPLED 10/29/76 DATE REC'D 11/1/76 DATE REPORTED 11/7/76

SIEVE ANALYSIS PERCENT PASSING

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GRT WT. 1441.000
SUM OF RETAINED WTS. 1441.500

% AGGREGATE BY EXTRACTION 94.800
% BITUMEN BY EXTRACTION 5.200
SPECIFIC GRAVITY 2.390
MARSHALL STABILITY 2783.000
MARSHALL FLOW 0.01 IN. 7.000

INDIRECT TENSILE STRENGTH, P.S.I. 23.4
Strength Retention
Marshall Stability (original) 2623
Marshall Stability (after soak) 2627
% strength retention 100

COPIES TO:

ASPH. CONC.
J. BUMP
R. SHELQUIST
T. ZEARLEY
<table>
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<th>SIZE (IN.)</th>
<th>RET. %</th>
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MATERIAL: ASPHALT MIX-TYPE B SURFACE 1/2"  
INTENDED USE: TO BE USED ON CITY STREETS  
PROJECT NO: DEPT. INFO.  
CONTRACTOR: BROWER CONST. CO.  
PRODUCER: BROWER CONST. CO.  
PLANT: SIoux City, IA  
UNIT OF MATERIAL: ONE BLOCK SECTION OF STREET (CONTAINS 0.32% ASPHADUR)  
SENDERS NO: 3-RAB-37  
SAMPLED BY: ALAN AND TUTTLE  
DATE SAMPLED: 10-24-78  
DATE REC'D: 11-1-78  
DATE REPORTED: 11-7-78

###sieve analysis

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DRY WT.: 1482.000  
SUM OF RETAINED WTS.: 1481.500

% aggregate by extraction: 95.000  
% bitumen by extraction: 5.000  
SPECIFIC GRAVITY: 2.320  
MARSHALL STABILITY: 3007.000  
MARSHALL FLOW 0.01 IN.: 9.000  

INDIRECT TENSILE STRENGTH PSI: 30.2  
RICE SP. GR.: 2.458  
RECOVERED ASPHALT Penetration @ 77 F.: 199 Ohs 5 SEC: 26  
ABS. VIS. @ 140 F.: 300 MM. HG. (POISES): 9329

COPIES TO:  
ASPHALTIC CONCRETE  
J. BUMP  
L. ZEARLEY  
R. SHELQUIST
- 27 -

IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
AMES LABORATORY
TEST REPORT - BITUMINOUS MATERIALS

MATERIAL ASPHALT KILN - TYPE B SURFACE 1/2"
INTENDED USE TO BE USED ON CITY STREETS
PROJECT NO DEPT. INFO.
CONTRACTOR BROKER CONSTR. CO.
PRODUCER BROKER CONSTR. CO.
PLANT SIOUX CITY, IOWA
UNIT OF MATERIAL ONE LOCK SECTION OF STREET
SENDERS NO 3-RAB-37
SAMPLED BY ALLAN AND TUTTLE
DATE SAMPLED 10/24/78 DATE RECD 11/1/78 DATE REPORTED 11/9/78

SIEVE ANALYSIS PERCENT PASSING

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DRY WT. 1439.000
SUM OF RETAINED WTS. 1437.500

% AGGREGATE BY EXTRACTION 94.900
% BITUMEN BY EXTRACTION 5.100
SPECIFIC GRAVITY 2.330
MARSHALL STABILITY 2890.000
MARSHALL FLOW 0.01 IN 9.000
CITY

INDIRECT TENSILE STRENGTH, P.SI. 29.2
RECOVERED ASPHALT
PENETRATION @ 77 F, 100 GMS. 5 SEC. 28
ABS. VISC. @ 140 F, 500 MH HOG. POISES 8450

COPIES TO:
ASPH. CONC.
J. BUMP
E. SHELQUIST
E. ZEARLEY
IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
AMES LABORATORY
TEST REPORT - BITUMINOUS MATERIALS

MATERIAL ASPHALT MIX-TYPE B SURFACE 1/2"
INTENDED USE TO BE USED ON CITY STREETS
PROJECT NO DEPT INFO
CONTRACTOR BROWER CONST. CO.
PRODUCER BROWER CONST. CO.
PLANT SIOUX CITY, IA
UNIT OF MATERIAL ONE BLOCK SECTION OF STREET (CONTAINS 0.32% ASPHADUR)
SENDERS NO 3-RA8-37
SAMPLED BY ALLAN AND TUTTLE
DATE SAMPLED 10-24-78 DATE RECD 11-1-78 DATE REPORTED 11-9-78

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DRI WT. 1447.000
SUM OF RETAINED WTS. 1445.500

| % AGGREGATE BY EXTRACTION | 94.600 |
| % BITUMEN BY EXTRACTION  | 5.400  |
| SPECIFIC GRAVITY         | 2.330  |
| MARSHALL STABILITY       | 3083.000|
| MARSHALL FLOW 0.01 IN.   | 9.000  |

INDIRECT TENSILE STRENGTH PSI 35.3
Strength Retention
Marshall Stability (original) 3122
Marshall Stability (after soak) 2692
% strength retention 86.2

COPIES TO:

ASPHALTIC CONCRETE
J. BUMP
R. SHELQUIST
T. ZEARLEY
TOWN DEPARTMENT OF TRANSPORTATION  
OFFICE OF MATERIALS  
AMES LABORATORY  
TEST REPORT - BITUMINOUS MATERIALS

MATERIAL: ASPHALT MIX - TYPE B SURFACE 1/2"  
LAB NO: ABC8-715  
INTENDED USE: TO BE USED ON CITY STREETS - SIOUX CITY  
PROJECT NO: DEPT. INFO.  
CONTRACTOR: BROWER CONSTR. CO.  
PRODUCER: BROWER CONSTR. CO.  
PLANT: SIOUX CITY, IOWA  
UNIT OF MATERIAL: ONE BLOCK SECTION OF STREET (CONTAINS 0.32% ASPHADUR)  
SEEDS NO: 3-RAB-37  
SAMPLED BY: ALLAN & TUTTLE  
DATE SAMPLED: 10/24/78  
DATE RECEIVED: 11/1/78  
DATE REPORTED: 11/9/78

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DRIE WT. 1455.000
SUM OF RETAINED WTS. 1454.000

% AGGREGATE BY EXTRACTION 95.000  
% BITUMEN BY EXTRACTION 5.000  
SPECIFIC GRAVITY 2.330  
MARSHALL STABILITY 2965.000  
MARSHALL FLOW 0.04 IN. 9.000

INDIRECT TENSILE STRENGTH - P.S.I. 31.7  
RICE SP. 50. 2.457

RECOVERED ASPHALT  
FEMETRATION @ 77 F. 100 GMS. 5 SEC. 27  
ABS. VIS. @ 140 F. 309 MM HG. POISES 6470

COPIES TO:

ASPH. CONC.  
J. DUNP  
R. SHELLOUIST  
- J. SHELLEY

BY: BERNARD C. BROWN  
TESTING ENGINEER
MATERIAL: ASPHALT MIX-TYPE B SURFACE 1/2"
INTENDED USE: TO BE USED ON CITY STREETS
PROJECT NO.: DEPT. INFO.
CONTRACTOR: BROWER CONST. CO.
PRODUCER: BROWER CONST. CO.
PLANT: SIOUX CITY, IA
UNIT OF MATERIAL: ONE BLOCK SECTION OF STREET
(SHETER NO.: 3-RA8-37)
SAMPLED BY: ALLAN AND TUTTLE
DATE SAMPLED: 10-24-78
DATE RECD: 11-1-78
DATE REPORTED: 11-9-78

SIEVE ANALYSIS PERCENT PASSING

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DRY WT.  1457.000
SUM OF RETAINED WTS.  1454.500

% AGGREGATE BY EXTRACTION  75.100
% BITUMEN BY EXTRACTION    1.900
SPECIFIC GRAVITY           2.330
MARSHALL STABILITY         3190.000
MARSHALL FLOW 0.01 IN.     8.000

INDIRECT TENSILE STRENGTH  PSI    32.8

COPIES TO:
- ASPHALTIC CONCRETE
  J. BUMP
  R. SHELOQUIST
  ZEARLEY

BY BERNARD C. BROWN
TESTING ENGINEER
TEST REPORT — BITUMINOUS MATERIALS

Material: Asphalitic Concrete @ 5.5%  Laboratory No. ABC8-724

Intended Use:

Project No.: U-7 Department Information  County: Linn

Contractor:

Producer:

Plant:

Unit of Material: Sample without asphalt for central lab. for experimental testing and analysis.

Sampled by:  
Sender's No.: 2

Date Sampled:  
Date Rec'd: 11-6-78  Date Reported: 11-14-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction: 94.4%
% Bitumen—By Extraction: 5.6%

% Pavg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.:  
% Pavg. No. 8 after 25 Cycles F&T, Water Solution:  
% of Wear, Los Angeles Abrasion, Grading:

Liquid Limit:  
Plastic Limit:  
Plasticity Index:  

COMPACTION & STABILITY TESTS

Laboratory Density (Specific Gravity): 2.34
Marshall Stability (lbs.): 2817
Marshall Flow (in.): 8
Hveem Side Pressure (PSI):  

Indirect tensile strength: 20.2 p.s.i.

DISPOSITION:

By: Testing Engineer
IOWA DEPARTMENT OF TRANSPORTATION
Highway Division
Office of Materials

TEST REPORT — BITUMINOUS MATERIALS

Material: Asphalitic Concrete @ 5.5%  Laboratory No.: ABC8-725

Intended Use: 

Project No.: U-7 Department Information  County: Linn

Contractor: 

Producer: 

Plant: 

Unit of Material: Sample with asphadur for central lab for experimental testing and analysis.

Sampled by: 

Sender's No.: 3

Date Sampled: 

Date Rec'd: 11-6-78  Date Reported: 11-14-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction: 94.7%
% Bitumen—By Extraction: 5.3%

% Psg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.: 
% Psg. No. 8 after 25 Cycles F&T, Water Solution: 
% of Wear, Los Angeles Abrasion, Grading: 

Liquid Limit: 
Plastic Limit: 
Plasticity Index: 2.34

COMPACATION & STABILITY TESTS

Laboratory Density (Specific Gravity): 2.34
Marshall Stability (lbs.): 3045
Marshall Flow (ins.): 8
Hveem Side Pressure (PSI): Indirect tensile strength p.s.i. 30.8

Retained stability percent 90.5

DISPOSITION: 

By: Testing Engineer
TEST REPORT — BITUMINOUS MATERIALS

Material: Asphaltic Concrete @ 5.5%  Laboratory No. ABC8-726

Intended Use:

Project No. U-7 (Dept. Info.)  County: Linn

Contractor
Producer
Plant

Unit of Material: Sample with Asphadur for Central Lab for experimental testing and analysis.

Sampled by:  Sender's No. 4
Date Sampled:  Date Rec'd: 11-6-78  Date Reported: 11-14-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction 94.7%
% Bitumen—By Extraction 5.3%

% Peg. No. 8 after 16 Cycles F&T, Water-Alco. Sol.
% Peg. No. 8 after 25 Cycles F&T, Water Solution
% of Wear, Los Angeles Abrasion, Grading

Liquid Limit
Plastic Limit
Plasticity Index

Rice Sp. Gr. 2.480
Indirect tensile strength 30.0

COMPACION & STABILITY TESTS

Laboratory Density (Specific Gravity) 2.33
Marshall Stability (lbs.) 2948
Marshall Flow (ins.) 8

Hveem Side Pressure (PSI)
RECOVERED ASPHALT
Penetration @ 77°F. 100 gms. 5 sec. 33
Abs. Vis. @ 140°F. 300 mm. hg. (Poises) 7900

DISPOSITION: By Testing Engineer
TEST REPORT — BITUMINOUS MATERIALS

Material: Asphallic Concrete @ 5.5 %  
Intended Use: 
Project No.: U-7  
Department: Information  
County: Linn  
Contractor: 
Producer: 
Plant: 
Unit of Material: Sample with Asphadur for Central Lab for experimental 
Testing and analysis. 
Sampled by: 
Sender's No.: 5  
Date Sampled: 
Date Rec'd: 11-6-78  
Date Reported: 11-14-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction = 94.6 %  
% Bitumen—By Extraction = 5.4 %  
% Peg. No. 8 after 16 Cycles F&T, Water-Alco. Sol. 
% Peg. No. 8 after 25 Cycles F&T, Water Solution 
% of Wear, Los Angeles Abrasion, Grading 
Liquid Limit 
Plastic Limit 
Plasticity Index

COMPACmON & STABILITY TESTS

Laboratory Density (Specific Gravity) = 2.34  
Marshall Stability (lbs.) = 2843  
Marshall Flow (ins.) = 7  
Hveem Side Pressure (PSI) 
Indirect tensile strength p.s.i. = 28.3

DISPOSITION: 
By: Testing Engineer
# TEST REPORT — BITUMINOUS MATERIALS

**Material**: Asphalitic Concrete @ 5.5 %

**Laboratory No.**: ABC8-728

**Project No.**: U-7

**Department**: Information

**County**: Linn

**Contractor**: 

**Producer**: 

**Plant**: 

**Unit of Material**: Sample with asphalud for Central Lab for experimental testing and analysis.

---

**Sampled by**: 

**Date Sampled**: 

**Date Rec'd**: 11-6-78

**Date Reported**: 11-14-78

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## SIEVE ANALYSIS — PER CENT PASSING

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- **% Aggregate—By Extraction**: 94.8 %
- **% Bitumen—By Extraction**: 5.2 %

**% Pge. No. 8 after 16 Cycles F&T, Water-Alco. Sol.**: 

**% Pge. No. 8 after 25 Cycles F&T, Water Solution**: 

**% of Wear, Los Angeles Abrasion, Grading**: 

**Liquid Limit**: 

**Plastic Limit**: 

**Plasticity Index**: 

**Rice Sp. Gr.**: 2.478

**Indirect tensile strength p.s.i.**: 33.1

---

## COMPACTION & STABILITY TESTS

- **Laboratory Density (Specific Gravity)**: 2.34
- **Marshall Stability (lbs.)**: 3170
- **Marshall Flow (Ins.)**: 8
- **Hveem Side Pressure (PSI)**: 

**RECOVERED ASPHALT**

- **Penetration @ 77°F. 100 gms 5 Sec.**: 35
- **Abs. Vis. @ 140°F. 300 mm. hq. (Poises)**: 5570

---

**DISPOSITION:**

**By**: Testing Engineer
TEST REPORT — BITUMINOUS MATERIALS

Material: Asphaltic Concrete @ 5.5%  Laboratory No.: ABC-729

Intended Use:

Project No.: U-7 (Department Information)  County: Linn

Contractor:
Producer:

Plant:

Unit of Material: Sample with Asphalur for Central Lab. for experimental testing and analysis

Sampled by:  Sender's No.: 

Date Sampled: Date Rec'd: 11-6-78  Date Reported: 11-14-78

SIEVE ANALYSIS — PER CENT PASSING

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% Aggregate—By Extraction: 94.7%
% Bitumen—By Extraction: 5.3%

% Pge. No. 8 after 16 Cycles F&T, Water-Alco. Sol.
% Pge. No. 8 after 25 Cycles F&T, Water Solution
% of Wear, Los Angeles Abrasion, Grading

Liquid Limit
Plastic Limit
Plasticity Index

COMPAC TION & STABILITY TESTS

Laboratory Density (Specific Gravity): 2.33
Marshall Stability (lbs.): 3408
Marshall Flow (ins.): 8
Hveem Side Pressure (PSI)

Indirect tensile strength psi: 32.6

DISPOSITION:

By: Testing Engineer