Research Report
UKTRP-87-31

LABORATORY ANALYSIS OF FAILED ASPHALTIC CONCRETE SURFACE -- US 23, LAWRENCE COUNTY

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Kentucky Transportation Research Program
College of Engineering
University of Kentucky

in cooperation with
Transportation Cabinet
Commonwealth of Kentucky

and

Federal Highway Administration
U. S. Department of Transportation

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October 1987
Laboratory Analysis of Failed Asphaltic Concrete Surface -- US 23, Lawrence County

L. John Fleckenstein and David L. Allen

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Prepared in cooperation with the U.S. Department of Transportation, Federal Highway Administration

Study Title: Pavement Investigation and Evaluation, US 23, Lawrence County

Laboratory analyses of a failed asphaltic concrete surface are presented. Construction procedures, mix design data, density tests, repeated load tests, asphalt extraction tests, and gradation tests are summarized.
INTRODUCTION

On March 10, 1986 the Kentucky Department of Highways requested an investigation on a premature pavement failure that had occurred on US 23 in Lawrence County (Project No. ACAPD 23-1(47)). The pavement rutted severely shortly after placement. This particular section of US 23 carries a large number of heavy coal trucks. Asphalt cores were taken by state personnel after failures started to occur in the pavement, and the failed asphalt surface was milled off. No additional data could be gathered apart from the information obtained from the field cores, and a memorandum written by state officials who had directly seen the failed conditions in the field. The conclusions of this report are based partly on engineering judgment and experience and not fully supported due to the limited data and funds that were available to conduct the study.

The objective of this study was to conduct laboratory tests on pavement cores, analyze data, and attempt to determine the reason for the premature distress.

CONSTRUCTION

The Class A asphaltic concrete surface was placed on US 23 in June 1985. The AC-20 surface course was constructed by Mountain Enterprises from Ulysses, Kentucky. Large scale rutting was first observed approximately two months after placement. The rutted surface was milled 1 1/2-inches in depth and overlaid with 1 1/2-inches of bituminous concrete, Class K, in accordance with requirements of the Special Note for that mixture.
MIX DESIGN

The mixture designs for the base and surface courses were for well graded mixtures. Results of particle-size analyses performed on April 17, 1987 on the cores obtained after the pavement exhibited rutting indicated there was little to no degradation of the aggregate (Table 1 and Figures 1 and 2). The laboratory mixture design information also is contained in Table 1 and in the Appendix. Previous studies have shown that finer bituminous mixtures such as the one used on US 23 usually have less degradation than coarser mixtures.

LABORATORY TESTS

DENSITY TESTS

Laboratory density tests performed on the cores indicated a field density of 135.1 pounds per cubic foot, which is 3.4 percent less than the target density.

REPEATED LOAD TESTS

Results of repeated load tests performed on February 12, 1987 are summarized in Figures 3 through 5. In comparing repeated load tests of US 23 specimens and those of Class I laboratory reference specimens (1, 2), the US 23 specimens had 3.7 times more permanent strain between 100 and 1,000 cycles than did the standard laboratory specimens. Between 100 and 1,000 cycles, US 23 Specimen 5 had 4.6 times more deflection than reference laboratory specimens and US 23 Specimen 6 deflected 3.7 times greater between 100 and 1,000 cycles than the laboratory reference. Repeated load tests were not performed on the base material. In comparing field cores and laboratory cores of the same mix design there seems to be a standard range in which field cores will
exhibit deflections approximately 3 to 5 times that of laboratory cores. The asphalt cores were taken after the failures started to occur. The cores were probably tested in a failed condition.

**ASPHALT EXTRACTION AND GRADATION**

The mixture design for the surface course specified an asphalt content of 7.0 percent. Asphalt extraction tests performed on December 4, 1987, indicated 7.11 and 6.50 percent asphalt (extraction tests are corrected for dust). The asphalt extraction test were done in accordance with KM 64-405-85 centrifuge method. Asphalt extraction tests performed on the base course indicated 5.8 percent asphalt.

Results of the particle-size analyses performed on the cores indicated the gradation of the surface course closely compared to the gradation of the specified mixture design (Table 1).

**CONCLUSION OF LABORATORY TESTS**

The failure of the asphaltic concrete on US 23 does not appear to have been due to variations from the design mixture. Gradation tests conducted on field cores indicated there was little or no degradation of the aggregate.

Field cores had resilient modulus values which correlate with standard laboratory samples of a similar mixtures for repeated load tests.

Asphalt extraction tests performed on the field cores indicated little variation from the design mixture.

Laboratory density tests performed on the field cores indicated the field density closely correlated with that of the target density.
DISCUSSION

A memorandum written at the time of failure indicate several contributing factors may have caused the asphaltic pavement to fail.

1.) The major cause of failure appears to be related to heavy loads that were placed on the asphalt in the area of failure.

a.) A majority of the loaded coal truck traffic was entering onto US 23 from Ky. 645. That traffic was then heading north where the major failure occurred.

b.) The area of failure occurred in front of a restaurant at the bottom of a descending vertical and horizontal curve. The restaurant was frequently visited by truck drivers. The rutting was accelerated in this area due to the acceleration and deceleration of the trucks entering and leaving the restaurant (This type rutting is similar to the rutting which occurs at stop lights, although there is not a standing dead load present).

c.) The heavily loaded trucks traveling in that area could have overly compacted the asphalt.

REFERENCES

TABLE 1. PARTICLE-SIZE ANALYSIS

US 23, LAWRENCE COUNTY

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>BASE COURSE</th>
<th>SURFACE COURSE</th>
<th>DESIGN MIX</th>
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<tr>
<td></td>
<td>PERCENT</td>
<td>PERCENT</td>
<td>PERCENT</td>
</tr>
<tr>
<td>PASSING</td>
<td>PASSING</td>
<td>PASSING</td>
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</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>1 in.</td>
<td>100.0</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>3/4 in.</td>
<td>93.6</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>1/2 in.</td>
<td>67.1</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>3/8 in.</td>
<td>55.4</td>
<td>95.1</td>
<td>95.0</td>
</tr>
<tr>
<td>#4</td>
<td>39.5</td>
<td>66.2</td>
<td>70.0</td>
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<td>27.8</td>
<td>49.3</td>
<td>50.0</td>
</tr>
<tr>
<td>#16</td>
<td>19.8</td>
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</tr>
<tr>
<td>#30</td>
<td>14.1</td>
<td>-----</td>
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<td>8.3</td>
<td>12.1</td>
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<tr>
<td>#200</td>
<td>2.2</td>
<td>4.4</td>
<td>3.5</td>
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</table>
Figure 2. Sieve Sizes

Field Core

Minimum

Maximum

% Passing, by Weight

Diameter in mm

US 23 Lawrence Base
FIGURE 3.
RESULTS OF REPEATED LOAD TESTS (SAMPLE NO. 3)

NUMBER OF DEVIATOR STRESS REPETITIONS

PERMANENT STRAIN

1E-1  1E-2  1E-3  1E-4  1E-5

1E+0  1E+1  1E+2  1E+3  1E+4  1E+5

△ U.S. 23 LAWRENCE COUNTY
● LABORATORY STANDARDS
FIGURE 4.
RESULTS OF REPEATED LOAD TESTS (SAMPLE NO. 5)

U.S. 23 LAWRENCE COUNTY LABORATORY STANDARDS

PERMANENT STRAIN

NUMBER OF DEVIATOR STRESS REPETITIONS
FIGURE 5.
RESULTS OF REPEATED LOAD TESTS (SAMPLE NO. 6)

- U.S. 23 LAWRENCE COUNTY
- LABORATORY STANDARDS

NUMBER OF DEVIATOR STRESS REPETITIONS

PERMANENT STRAIN

1E-1

1E-2

1E-3

1E-4

1E-5

1E+0  1E+1  1E+2  1E+3  1E+4  1E+5
APPENDIX A

JOB-MIX INFORMATION SHEETS
## CONTRACTORS JOB-MIX FORMULA & ASPHALT PLANT (BATCH) MIX DESIGN

**3-3-84**

### CONTRACTOR & PLANT DATA

- **County**: Lawrence
- **Name**: B. Pelfrey
- **Crew**: Mt. Ent.
- **Sample Sequence No.**: 00000000, 07-81-64
- **Description**: C.I.A. Surface

### Job-Mix

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Job-Mix</th>
<th>Extractions Mix Gradations</th>
<th>Rev JMF</th>
<th>JMF/Specs</th>
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</tr>
<tr>
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</tr>
<tr>
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</tr>
<tr>
<td>1</td>
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</tr>
</tbody>
</table>

### Cold Feed Data

- **% Natural Sand**: 4.5%

### Bitumen (By Design)

- **% Additive**: 7.0%

### Action Tests & Plant Data

- **Lbs Asph/Batch (Lbs.)**: __________
- **Lbs Gals of Asph/Batch (Fluidometer)**: __________
- **Asph/Batch**: __________
- **Total Batch Wt**: __________

### Mix Approval Data

- **Date**: __________
- **As Proposed**: __________
- **With Changes**: __________
- **Disapproved (See Remarks)**: __________

### Plant Inspector

- **Date**: __________
- **MTLS Rep.**: __________
MARSHALL TEST

<table>
<thead>
<tr>
<th>Project Code</th>
<th>Project Number</th>
<th>Quantity Assigned</th>
<th>Project Number</th>
<th>Quantity Assigned</th>
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</thead>
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<tr>
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<td>06 4 C</td>
<td>C0000000</td>
<td>C0000000 0</td>
<td>07-10-84</td>
</tr>
</tbody>
</table>

Date/ERC: 07-13-84, Date COM. 08-21-84

Type of Inspection: Plant Inspection

Product No. 71.4, Description: SLS, Surface

Producer No./Supp. No.: 111S

Date Sampled: 07-13-84, Sample Sequence No.: 0001143

Date 1: 07-01-84

Date 2: 07-13-84

Sampled From: Plant Inspector

Responsible Loc: Materials Lab

Ind Test: Distribution

Design Results for:

- Stability Lbs: 2350
- Flow Ins. %: 0.08
- Max. Spec. Gr. %: 3.675
- Asph. Content %: 7.3

Total Weight PCF: 254.4

Remarks:

The above compactive effort is to be done in accordance with the design. Significant revisions will require a new mix design. The design asphalt content of 7.0% will only be in effect until Sept. 15, 1984. Any material placed between Sept. 15, 1984 and Oct. 1, 1984 will have an asphalt content of 7.2%. Any material placed between Oct. 1, 1984 and May 1, 1985 will have an asphalt content of 7.5%

Mountain Enterprises

Richard Ray

A. P. Peele

Files.
Laboratory Mix Design Report for a Bituminous Mixture

Federal Proj. No. ACAPD 23-1(47)

<table>
<thead>
<tr>
<th>County</th>
<th>Lawrence</th>
<th>State Proj. No.</th>
<th>FAP 064 0023 000-017 069 C</th>
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<tbody>
<tr>
<td>Date Received</td>
<td>7-23-84</td>
<td>Date Reported</td>
<td>8-22-84</td>
</tr>
<tr>
<td>Identification</td>
<td>Class &quot;A&quot; Surface</td>
<td>Submitted By</td>
<td>B. Pelfrey</td>
</tr>
<tr>
<td>Paving Contractor and Location</td>
<td>Mountain Enterprises @ Ulysses</td>
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</tr>
</tbody>
</table>

**DESIGN DATA AND RESULTS**

<table>
<thead>
<tr>
<th>Aggregate (Type &amp; Size)</th>
<th>Source &amp; Location</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slag - 8's</td>
<td>(1) Hackett Slag</td>
<td>35</td>
</tr>
<tr>
<td>Natural Sand</td>
<td>(133) Maysville Dredging</td>
<td>30</td>
</tr>
<tr>
<td>Limestone Sand</td>
<td>(123) Elkhorn Stone</td>
<td>35</td>
</tr>
</tbody>
</table>

Bitumen (Type & Grade) AC-20 Source Ashland/Ashland

Recommended Mixing Temperature: 199°F

*This temperature indicated from kinematic viscosity of bitumen for normal conditions.

Compaction: 75 Blows, for Heavy Traffic Intensity

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Stockpile Aggregate Gradations</th>
<th>Design Mix Gradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
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<td>50</td>
</tr>
<tr>
<td>200</td>
<td></td>
<td>50</td>
</tr>
</tbody>
</table>

Recommended Design Bitumen Content, Percent: 7.0
Note: The design bitumen content is recommended for the design mix gradation shown. Deviations from the materials furnished the laboratory or in the actual job gradation may require an adjustment in the design bitumen content; however, every effort should be made to produce a mix according to the design. Unit weight, pcf, results shall be used for density calculations.

Remarks: S.E. = 75.