EVALUATION OF ASPHALT STABILIZING ADDITIVES

FINAL REPORT FOR
Iowa DOT Project HR-542

Federal Highway Administration
Project IA-88-02

MAY 1994

Project Development Division

Iowa Department of Transportation
Final Report
for
Iowa DOT Project HR-542
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Federal Highway Administration
Experimental Project No. 3 - IA-88-02

EVALUATION OF
ASPHALT STABILIZING ADDITIVES

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May 1994
Efforts are constantly being put forth by researchers, highway related industries and product suppliers to improve the life and performance of asphalt pavements. As a result of those efforts, a variety of asphalt modifiers have been developed and evaluated in experimental sections over the years. Evaluations of the polymer asphalt modifiers have been done and results were usually compared with conventional sections within each respective project. The research presented in this report is also a comparison of asphalt modifiers with each other as well as a comparison of a modifier with its respective conventional section, when they exist. Several of the modifiers showed some improvements in performance while others did not.
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**DISCLAIMER**

The contents of this report reflect the views of the author and do not necessarily reflect the official views of the Iowa Department of Transportation. This report does not constitute any standard, specification or regulation.
ACKNOWLEDGEMENTS

Appreciation is expressed to the Federal Highway Administration for their support in funding the evaluation portion of this research under Experimental Project No. 3, "Evaluation of Asphalt Stabilizing Additives."

The author wishes to also extend appreciation to the Iowa Department of Transportation Materials Department, Special Investigations and the Materials Laboratory personnel who assisted in the gathering and analysis of field samples.

INTRODUCTION

Various asphalt additives have been used at several Iowa locations over the years. Unfortunately, the analysis and comparison of performance between the sites has not always been thoroughly documented. This project was initiated to evaluate and summarize the experiences to date of approximately 15 different Iowa sites where various asphalt additives have been used. In many cases, the projects used in this research were completed before this research was initiated. Project correspondence and agreement are in Appendix A.

OBJECTIVE

The objective of the research is to compare performance results of various asphalt modifiers as used in various Iowa test sections.
PROJECT DESCRIPTION
The research project consists of a combination of various projects and test sections with asphalt additives which have been used or are under study in recent years.

Eight different types of asphalt additives were evaluated in the project. The additives were applied in a total of 15 specific Iowa sites. Four products were applied at more than one site. In some cases, a conventional section within the project was not available for comparison to the test additive. Data collected, as well as results found from each site, were unique for each application. Applications were often very different from each other. The various projects consisted of seal coats, microsurfacing treatments and sometimes one or more courses of asphalt on a highway or at a specific area near a signalized intersection. Evaluations were done mainly through visual inspections and rut depth measurements. Core densities and percent air were also obtained, where applicable. See Appendix C.

PROJECT LOCATIONS
A list of the locations of the projects and the asphalt additives used is as follows:
<table>
<thead>
<tr>
<th>SITE</th>
<th>ASPHALT MODIFIER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Jasper County, in the city of Newton</td>
<td>PAC 40 Styrene Butadiene Styrene (SBS)</td>
</tr>
<tr>
<td>2. Clinton County in the city of Clinton on US 67</td>
<td>PAC 40 Styrene Butadiene Neoprene (SBN)</td>
</tr>
<tr>
<td>3. O’Brien County in the city of Sheldon on US 18</td>
<td>PAC 40 Styrene Butadiene Rubber (SBR)</td>
</tr>
<tr>
<td>4. Pottawattamie County in the city of Council Bluffs on I-480 (1979)</td>
<td>Asphadur</td>
</tr>
<tr>
<td>5. Woodbury County in the city of Sioux City on IA 12, Gordon Drive</td>
<td>AC-13 (Styrelf-13)</td>
</tr>
<tr>
<td>6. Story County, south of Napier on county road E57</td>
<td>Chem-Crete</td>
</tr>
<tr>
<td>7. Polk County, south of Madrid on IA 415</td>
<td>Ductilad D1002</td>
</tr>
<tr>
<td>8. Polk County, north of Ankeny on US 69</td>
<td>Ralumac</td>
</tr>
<tr>
<td>9. Story County, north of Nevada on county road E29</td>
<td>UltraPave</td>
</tr>
<tr>
<td>10. Pottawattamie County in the city of Council Bluffs on I-480 (1988 resurfacing of site 4)</td>
<td>3M additive 5990 (Asphadur)</td>
</tr>
<tr>
<td>11. Webster County, south of Ft. Dodge on US 169</td>
<td>Ralumac</td>
</tr>
<tr>
<td>12. Polk County in the city of Des Moines on Fleur Drive</td>
<td>PAC 30 Styrene Butadiene Styrene (SBS)</td>
</tr>
<tr>
<td>13. Story County in the city of Ames on US 69, Duff Avenue</td>
<td>PAC 30 Styrene Butadiene Styrene (SBS)</td>
</tr>
<tr>
<td>14. O’Brien County in the city of Sheldon on IA 60</td>
<td>PAC 40 Styrene Butadiene Rubber (SBR)</td>
</tr>
<tr>
<td>15. Polk County in the city of Des Moines on Fleur Drive</td>
<td>PAC 30 Styrene Butadiene Styrene (SBS)</td>
</tr>
</tbody>
</table>
PAC 30, PAC 40, SITES 1, 2, 3, 12, 13, 14 and 15

Seven different sites were selected to evaluate polymer modified asphalt cements, PAC 30s and PAC 40s. The seven sites were selected from different areas of the state and with different average daily traffic counts. All the sites were in areas of city traffic and often at street intersections with a high number of traffic stops and starts.

Location, Date, Evaluation and Conclusion

Details for site No.:

1. Jasper County, in the city of Newton on US 6, project FN-6-4(85)--21-50. The project extends from West 15th Place north to West 3rd Street and from East 2nd Street to East 28th Street.

   The PAC 40 Styrene Butadiene Styrene (SBS) treatment is in both the 38.1 mm (1½ in.) thick binder and surface course from 30.5 m (100 ft.) east to 30.5 m (100 ft.) west of signalized intersections.

   The Average Daily Traffic (ADT) was 10,000 with 3.3% trucks. The project was constructed in September 1987.

   Evaluations for this project were near the intersection of East 23rd Street for both the test and conventional sections. Visual evaluations and rut depth measurements were recorded.
Visual evaluation showed no major amount of stripping, raveling or cracking and no significant difference when comparing the PAC 40 to the conventional section.

Rut depth average measurements in mm (in.) were:

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC 40</td>
<td>2.54 mm</td>
<td>4.1 mm</td>
</tr>
<tr>
<td></td>
<td>(0.10 in.)</td>
<td>(0.16 in.)</td>
</tr>
<tr>
<td>Conventional</td>
<td>5.08 mm</td>
<td>5.08 mm</td>
</tr>
<tr>
<td></td>
<td>(0.20 in.)</td>
<td>(0.20 in.)</td>
</tr>
</tbody>
</table>

The contract prices quoted did not show an extra cost for the polymerized (PAC 40) asphalt. The conventional and PAC 40 asphalt cement concretes were both quoted at $0.02 per kg ($11.73 per ton), so no cost comparisons is available.

In conclusion, the polymerized (PAC 40) asphalt cement concrete performed slightly better than the conventional asphalt cement concrete even when placed near a signalized intersection. The rut depth measurement showed slightly less rutting in the PAC 40 test section.

See Appendix B - 1 for Materials Data.

2. Clinton County, in the city of Clinton on US 67, project FN-67-2(42)--21-23. The project extends from 7th Avenue South, north 1.3 km (0.8 miles) to 7th Avenue North and from North 2nd Street, west to North 3rd Street.
The PAC 40 Styrene Butadiene Neoprene (SBN) modified asphalt was applied in the center 12.2 m (40 ft.) from Sta. 17+69.90 (MP 38.11) to Sta. 39+82.90 and center 9.8 m (32 ft.) on Main Street from 2nd Street to 3rd Street. The ADT was 13,400 on US 67 and 6,380 on Main Street. The project was constructed in May 1987.

Evaluations for this project were on US 67 between 2nd and 3rd Street South, between 4th and 5th Street North and on Main Street between N. 2nd Street and N. 3rd Street. Visual evaluations and rut depth measurements were recorded.

Visual evaluations showed no stripping or raveling. Some cracking was evident, but it appeared to be reflective or related to city utility lines. It appeared to be similar in the PAC 40 and conventional sections.

Rut depth averages in mm (in.) were:

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC 40</td>
<td>0.25 mm</td>
<td>2.0 mm</td>
</tr>
<tr>
<td></td>
<td>(0.01 in.)</td>
<td>(0.08 in.)</td>
</tr>
<tr>
<td>Conventional</td>
<td>1.27 mm</td>
<td>2.3 mm</td>
</tr>
<tr>
<td></td>
<td>(0.05 in.)</td>
<td>(0.09 in.)</td>
</tr>
</tbody>
</table>

The contract prices quoted were the same for the polymerized (PAC 40) asphalt cement concrete and the conventional asphalt cement concrete. The price for each was quoted at $0.03 per kg ($23.00 per ton) so no cost comparison is available.
The conclusion from evaluations at this site would be similar to site 1. Raveling and stripping were not evident. Some cracks were observed but appeared to be reflective or related to underground utilities. The rut depth measurements show that the modified asphalt (PAC 40) cement concrete had slightly less rutting with a difference which is relatively insignificant.

In this case, performance of the asphalt modifier would not justify any increase in product cost.

See Appendix B - 2 for Materials Data.

3. O'Brien County, in the city of Sheldon on US 18 from the railroad tracks east to the east city limit of the city of Sanborn at the junction of US 69. The project is FN-18-2(50)--21-71.

The section of modified asphalt (PAC 40 Styrene Butadiene Rubber (SBR)) cement extends from the intersection of US 18 and IA 60, eastward from Sta. 29+73 to Sta. 35+50.

The ADT is 5,300 with 14% trucks. The project was constructed in June 1987.
Evaluation of the modified asphalt (PAC 40) cement concrete section was of the westbound inside lane and results were compared with the conventional section. Visual evaluations showed that there was no significant stripping or raveling and that some cracking did exist, however, it was similar to the conventional section.

Rut depth measurements in mm (in.) were:

<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1991</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC 40</td>
<td>2.29 mm</td>
<td>2.29 mm</td>
<td>3.30 mm</td>
</tr>
<tr>
<td></td>
<td>(0.09 in.)</td>
<td>(0.09 in.)</td>
<td>(0.13 in.)</td>
</tr>
<tr>
<td>Conventional</td>
<td>1.27 mm</td>
<td>2.54 mm</td>
<td>2.80 mm</td>
</tr>
<tr>
<td></td>
<td>(0.05 in.)</td>
<td>(0.10 in.)</td>
<td>(0.11 in.)</td>
</tr>
</tbody>
</table>

The contract price for PAC 40 is not quoted as it was substituted in the place of Asphadur in this project.

Based on visual evaluations and on rut depth measurements, the conclusions from this test site are that the PAC 40 performed similar to the conventional asphalt cement concrete. A significant extra cost for the PAC 40 would not have been recovered through extra or exceptional performance. The conventional section performed as well as the PAC 40 section.

See Appendix B - 3 for Materials Data.
12. Polk County, in the city of Des Moines, on Fleur Drive from McKinley Avenue, north approximately 2.4 km (1.5 miles) to the railroad viaduct. The project is WO 0206-85-009 constructed in 1986.

A modified asphalt PAC 30 cement concrete was used in two 38.1 mm (1½ in.) lifts.

The ADT was 30,000 with 5% trucks.

Visual evaluations and rut depth measurements were mainly in the southbound driving lane south of the intersection with Wakonda View Drive. There was no conventional section in this project. There was no evidence of stripping or raveling. Some reflective cracking did exist.

Rut depth measurement averages in mm (in.) were:

<table>
<thead>
<tr>
<th>Year</th>
<th>1990</th>
<th>1991</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.30 mm (0.13 in.)</td>
<td>2.79 mm (0.11 in.)</td>
<td>5.59 mm (0.22 in.)</td>
</tr>
</tbody>
</table>

The contract quoted price for asphalt cement, polymerized, was $0.33 per kg ($296.06 per ton). The average price for regular asphalt cement in 1986 was $0.23 per kg ($204.00 per ton).
The polymerized asphalt cement concrete, PAC 30, put down in 1986 was still performing fairly well in 1993. The most evident and increasing problem was wheelpath rutting which measured 5.59 mm (0.22 in.) in 1993. Without a conventional section for comparison, it can only be concluded that the polymerized asphalt performed in a satisfactory manner under the heavy traffic conditions and the long period of time.

See Appendix B - 12 for Materials Data.

13. Story County, in the city of Ames on Us 69, Duff Avenue, from the Squaw Creek Bridge north to South Third Street. The test section for evaluation of the PAC 30 extends from the centerline of South 5th Street 42.98 m (141 ft.) southerly. The remainder of the project southward was the conventional section.

The PAC 30 treatment was applied in both the 38.1 mm (1½ in.) thick binder and surface courses.

The ADT was 19,000 with 3% trucks. The project was constructed in August 1988.

Evaluations for this project were between South 5th Street and the Squaw Creek Bridge. Visual evaluations and rut depth measurements were recorded for the PAC 30 section and for the conventional section.
There was no evidence of stripping or raveling in either section. Cracking was observed, but was minimal in both sections.

Rut depth average measurements in mm (in.) were:

<table>
<thead>
<tr>
<th></th>
<th>1990</th>
<th>1991</th>
<th>1994</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC 30</td>
<td>1.27 mm</td>
<td>2.03 mm</td>
<td>2.79 mm</td>
</tr>
<tr>
<td></td>
<td>(0.05 in.)</td>
<td>(0.08 in.)</td>
<td>(0.11 in.)</td>
</tr>
<tr>
<td>Conventional</td>
<td>2.29 mm</td>
<td>2.54 mm</td>
<td>3.30 mm</td>
</tr>
<tr>
<td></td>
<td>(0.09 in.)</td>
<td>(0.10 in.)</td>
<td>(0.13 in.)</td>
</tr>
</tbody>
</table>

The contract quoted price was $0.17/kg ($148.00/ton) for the conventional asphalt cement and $0.31/kg ($275.00/ton) for the polymerized (PAC 30) asphalt cement.

The conclusion from field evaluations of the polymer modified asphalt cement concrete is that it is performing in a satisfactory manner. Considering that the PAC 30 section was placed at a signalized intersection where it was exposed to the extra stresses from stopping, starting and turning traffic, it still performed better than the conventional asphalt mix. Rut depth measurements were also lower in the PAC 30 section. Considering the high volume of traffic and the location of the PAC 30 test section, it can be concluded that the PAC 30 modified asphalt cement is, under these conditions, performing better than the conventional asphalt and it's performance would support some additional expenditure on PAC 30 modifier.
See Appendix B - 13 for Materials Data.

14. O'Brien County, on IA 60 from US 18 in Sheldon north to the C&NW RR in Sibley.

A modified asphalt cement, PAC 40, was applied north of the signalized intersection with US 18. The PAC 40 was used in both the 38.1 mm (1 1/2 in.) thick binder and surface courses from Sta. 1750+15 north to Sta. 1763+07. The project number was FN-60-3(11)--21-71.

The ADT was 8,400 with 14% trucks and the project was constructed in 1987.

Visual evaluations for this test site and the adjoining conventional section identified no significant stripping or raveling in either section. Some cracks were evident but they appeared to be reflective. Rut depth measurements in mm (in.) were:

<table>
<thead>
<tr>
<th></th>
<th>1989</th>
<th>1991</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>PAC 40</td>
<td>2.54 mm (0.10 in.)</td>
<td>3.81 mm (0.15 in.)</td>
<td>1.78 mm (0.07 in.)</td>
</tr>
<tr>
<td>Conventional</td>
<td>1.27 mm (0.05 in.)</td>
<td>0.76 mm (0.03 in.)</td>
<td>0.76 mm (0.03 in.)</td>
</tr>
</tbody>
</table>

The contract quoted prices for the asphalt cement concrete mixes were:

- Conventional - $0.02 per kg ($13.75 per ton)
- Polymer modified (PAC 40) - $0.03 per kg ($23.00 per ton)
Conclusions, based upon field performance and product cost only at this site, may be misleading. The polymerized asphalt mix did cost more. From visual evaluations, it did not perform better than the conventional mix. Rut depth measurements would imply that the polymerized mix did not perform quite as well as the conventional mix. However, the polymerized mix was placed in a location of vehicle braking, accelerating or turning which clearly puts additional stresses on the pavement. The conventional mix was placed in the main line away from the signalized intersection. Under these conditions of extra stress, the polymerized asphalt, PAC 40 mix, did perform in a very acceptable manner considering its location.

See Appendix B - 14 for Materials Data.

15. Polk County, in the city of Des Moines on Fleur Drive, from McKinley Avenue south to Army Post Road. The project number is 020687003.

A polymer modified asphalt cement (PAC 30) was used in the mix for two 38.1 mm (1\frac{1}{2} in.) thick lifts constructed in 1989.

The ADT was 30,000 with 5% trucks.
Performance evaluations were mainly of the southbound lanes just south of Hackley Avenue. Visual evaluations showed no stripping or raveling. There was minimal transverse cracking which appeared to be reflective.

Rut depth measurement averages in mm (in.) were:

<table>
<thead>
<tr>
<th>Year</th>
<th>1989</th>
<th>1990</th>
<th>1991</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>2.03</td>
<td>2.03</td>
<td>4.32</td>
<td>3.56</td>
</tr>
<tr>
<td>in.</td>
<td>0.08</td>
<td>0.08</td>
<td>0.17</td>
<td>0.14</td>
</tr>
</tbody>
</table>

There was no conventional section within this project for comparison of asphalt performance and material cost.

A conclusion, based upon the evaluation of field performance of the modified asphalt cement PAC 30, is that it has performed in an acceptable manner. There are indications of wheelpath rutting problems and this is a point of concern. Considering the length of time in service and the volume of traffic, the polymerized asphalt cement, PAC 30, concrete mix has performed at least as well or better than would be expected from a conventional asphalt cement concrete mix.

See Appendix B - 15 for Materials Data.

**CONCLUSIONS**

**PAC 30, PAC 40, Sites 1, 2, 3, 12, 13, 14 and 15**

At some project sites, the polymerized asphalt cement PAC 30 and
PAC 40 concretes were applied at the stop, start and turn areas near signalized intersections. These areas of asphalt pavement are known to be highly stressed from vehicle tires. In most cases, the modified asphalt at those sites performed at least as good as the conventional asphalt even though the stresses were abnormally high. This performance indicates that the polymer modified asphalts are more durable than the conventional asphalts in the areas of normal stress.

**ASPHADUR, SITES 4 and 10**

Two different sites were selected for the experimental application of the polymer modified asphalt cement concrete containing Asphadur. They were both applied at the same location on I-480 in Pottawattamie County in different projects, in 1979 and in 1988. For details on the polymer asphalt modifier, Asphadur, see Ref. 1.

**Location, Date, Evaluation and Conclusion**

Details for site No.:

4. Pottawattamie County, in the city of Council Bluffs on I-480 over North 41st Street. The project number is I-IR-480-1(114)0--14-78.

The polymer modified asphalt cement concrete containing 6% Asphadur was applied in this project as a 50.8 mm (2 in.) thick surface course constructed in 1979.
Project estimates called for 865 tons of the modified asphalt cement concrete. The estimated cost was $0.04 per kg of mix ($35.00 per ton of mix). The 1980 ADT was 40,300 with 6% trucks.

Visual evaluations and rut depth measurements were not made in the project as it was resurfaced in 1988 soon after the start of this research project with another polymer modified asphalt cement containing Asphadur.

No conclusion will be made on the performance of Asphadur at this site due to its being resurfaced.

See Appendix B - 4 for Materials Data.

10. Pottawattamie County, in the city of Council Bluffs on I-480 from the Missouri River Bridge to I-29. The project number is IR-480-1(1117)0--12-78.

The Asphadur modified asphalt cement concrete was applied in two lifts for a total of 101.6 mm (4 in.) thickness in June 1988.

The ADT was 44,000 with 5% trucks.
Evaluations were approximately 100.58 m (330 ft.) west of the bridge over North 41st Street. There was no conventional section for comparison.

Visual evaluations showed no stripping. Some transverse cracks were visible. The surface showed many small map cracks and substantial raveling. The asphalt gave an appearance of being very hard, brittle and aged.

Rut depth average measurements in mm (in.) were:

<table>
<thead>
<tr>
<th>Year</th>
<th>1989</th>
<th>1991</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.76 mm</td>
<td>2.54 mm</td>
<td>2.03 mm</td>
</tr>
<tr>
<td></td>
<td>(0.03 in.)</td>
<td>(0.10 in.)</td>
<td>(0.08 in.)</td>
</tr>
</tbody>
</table>

Considering the high volume of traffic, rut depths were considered minimal.

The additional cost of the Asphadur for this project was only $2,572.80. The Asphadur was provided from the Iowa DOT owned stock which was valued at $0.36/kg ($0.16/lb.) for 7,293.89 kg (8.04 tons) used. The percent of Asphadur in the mix was 6%. In this case, no cost comparisons were made.

Conclusions made from this site on the use of the asphalt polymer modifier, Asphadur, would be that the asphalt mix appears to be quite resistant to wheelpath rutting. However, the appearance of early aging, brittleness and major raveling
on the surface does give cause for concern as to possibly some adverse effect such as accelerated aging from the addition of a modifier. Asphadur is not currently available. Asphadur additive was also marketed as 3M Additive 5990.

See Appendix B - 10 for Materials Data.

**AC-13, SITE 5**

**Location, Date, Evaluation, Conclusion**

A polymer modified asphalt cement AC-13 (Styrelf-13) has been developed to exhibit characteristics of very high stability in asphalt mixes. It is intended to prolong good performance of asphalt pavement life in areas of heavy traffic stopping, starting and turning maneuvers. Use of AC-13 should reduce the distortions of asphalt rutting and shoving. It should also reduce the need for maintenance cold milling or heater planing operations to maintain a smooth roadway.

The AC-13 modified asphalt research site was located in Woodbury County, on Sioux City Iowa Primary Road 12 (Gordon Drive). The project extends from near US 75 east, southeast for 4.18 km (2.6 miles). This is a limited access 4-lane facility with turning lanes at service roads and intersections. Traffic volumes range from 6,000 ADT with 10% trucks near the east end and 17,000 ADT with 5% trucks near the west end.
The AC-13 modified asphalt was applied at 5 specific sites within the project. Four sites were at signalized intersections and one site was at a 4° circular curve that was not super elevated.

Construction of the project was done in July, 1984.

For a final report on this project, see Ref. 2.

The field performance of the AC-13 asphalt concrete cement was evaluated in several ways. Cores were taken and analyzed for density and air voids at the time of construction. Each year for the 3 years which followed, cores were taken to determine the change in the absolute viscosity, penetration and ductility of the recovered AC-13. Rut depth, reflective cracking and surface raveling data was also recorded over a three-year period.

Project operations included first removal of the old asphalt cement concrete from the portland cement concrete base. Base repair work was also done. Two 38.1 mm (1½ in.) lifts of recycled asphalt concrete cement were applied throughout the project except for in the research areas. Virgin aggregate asphalt concrete cement containing AC-13 was placed in the five research areas.

Some conclusions on the performance of AC-13 from experience in this project are:
Test results from the surface lift cores show a hardening or aging of the recovered AC-13 each year and the rate accelerated during the third year to an absolute viscosity of 34,994 poise. The higher viscosity did not appear to be detrimental in the pavement performance.

AC-13 did not stop all rutting from occurring. Rutting was increasing each year but appeared to stabilize by the third year at less than 6.35 mm (1/4 in.).

The polymer modified asphalt cement was not effective in controlling transverse joint reflection cracks.

There were no signs of raveling after 3 years.

With 5 years of extended evaluations beyond the 3 years covered in the final report no significant changes had occurred. Over the total of 8 years, rutting remained less than 6.35 mm (0.25 in.) with most values being around 2.54 mm (0.10 in.). Raveling and stripping were not significant. Most cracks appeared to be reflective.

Eight years after construction the AC-13 polymer modified asphalt pavement appears to be performing well, for its age.

See Appendix B - 5 for Materials Data.

CHEM-CRETE, SITE 6

Location, Date, Evaluation and Conclusion

Chem-Crete Bitumen is an asphalt modifier specifically designed to upgrade the performance of asphalt mixes which use deficient aggregates. It is promoted as a product which increases stability, durability and fatigue response at all temperatures.

Chem-Crete was used in two asphalt mixes, one containing a poorly graded sand and the other, a Type B, Class 2 asphalt concrete mix. The mixes were blended 1:9 with an AC 10 asphalt. Both of these mixes were also used with unmodified asphalt cement. Two 38.1 mm (1 1/2 in.) lifts were placed for a total thickness of 76.2 mm (3 in.).
The location of the Chem-Crete application was on Story County road E57. The application covered 1.68 km (1.046 miles) from the Boone County line eastward. The ADT of this roadway in 1980 was 160 with 20% trucks.

The application of the Chem-Crete on county road E57 began on September 15, 1980.

Visual evaluations showed that the Chem-Crete additive did not improve asphalt performance, in fact, in this case it was detrimental to long-term performance. In comparison, the Chem-Crete sections began showing extensive cracking with many full length transverse cracks very early. Within six months, the ratio of feet of cracks in the two Chem-Crete sections compared to the conventional section was 16 to 1 and 40 to 1.

Road Rater tests were also done. In the Type B mix, strength values of the Chem-Crete were lower than the conventional sections.

For a final report on this project, see Ref. 3.

Based upon results from field tests of the use of Chem-Crete and the comparison of its transverse cracking with a conventional test section, it was concluded that Chem-Crete did not perform well. Maintenance against major cracking problems was required.
within two years in the Chem-Crete test section. Further testing or use of Chem-Crete is not recommended.

See Appendix B - 6 for Materials Data.

**DUCTILAD D1002, SITE 7**

**Location, Date, Evaluation and Conclusion**

A polymer modified asphalt was used at site number 7 in a seal coat treatment over an old asphalt surface. The polymer additive, Ductilad D1002, was added to the asphalt cement at a rate of 3% by weight.

The location of the project was in Polk County on IA 415 from near the north city limit of Polk City north 9.82 km (6.1 miles) to near the junction with IA 17. The research section containing Ductilad D1002 is in the southbound lane, starting near IA 17. The section extends 4.22 km (2.62 miles) from Station 1074+80 to Station 936+47. The adjacent opposing lane, containing a regular CRS-2 binder, was used as the conventional section.

The seal coat was applied July 13, 1987.

The evaluation of Ductilad D1002 was done by comparing the loss of aggregate chips over a 5 year period between the Ductilad section and the conventional section.
Samples of the seal coat were removed from the conventional and the test sections of the project. The weight of aggregate chips recovered was determined and the rate of loss over the years was compared. For a final report on this project, see Ref. 4.

By the comparison of weight of aggregate chips retained, it is shown that the overall amount retained was slightly higher in the Ductilad section. However, it should be noted that test results from chips varied widely from year to year and that by visual evaluations, no difference could be determined between the performance of the conventional and test sections. See Appendix B-7 for Materials Data and for Grams of Aggregate Chips Recovered.

The results show that any appreciable increase in cost for the polymerized asphalt and processing operations, estimated to be $0.06/L ($0.21/gal.) would most likely not be recovered.

RALUMAC, SITES 8 AND 11

Two different sites were selected to evaluate a latex modified asphalt microsurfacing treatment called Ralumac. Both treatments were applied as a slurry seal coat. The treatment at site 8 was applied over an old roadway after an estimated 250.83 sq. m (300 sq. yds.) of full depth ACC repairs were made. The old pavement consisted of 203.2 mm (8 in.) of PCC overlaid with 171.45 mm (6.75 in.) of ACC.
A second Ralumac latex modified asphalt microsurfacing treatment was applied at site 11 mainly to fill in wheelpath ruts, but also to provide a new microsurface and to seal the old asphalt pavement.

**Location, Date, Evaluation and Conclusion**

Details for site No. 8. A Ralumac microsurfacing treatment in Polk County on US 69 constructed in July 1982 extends from just north of 1st Street in Ankeny north 8.10 km (5.035 miles) to 1.61 km (1 mile) north of IA 87.

The project number is MP-1700-69-77. The ADT in 1982 was 8,160 with 3% trucks.

Visual evaluations, friction tests and rut depth readings were taken in the test area.

Visual evaluations confirmed that the Ralumac performed in a satisfactory manner at this site. It appeared very stable. Longitudinal marks left during construction in 1982 were still visible in the wheelpaths in 1988. Ralumac material removed with a screwdriver in 1986 was approximately 9.53 mm (3/8 in.) thick but did not appear to be flexible and resilient.
Friction test result averages were increasing slightly over the years from 1983 to 1988. The overall average value was 36.

Rut depth values taken in 1986 averaged 1.27 mm (0.05 in.).

Reflective cracks were occurring but they were being sealed.

A conclusion from this evaluation is that Ralumac can provide a good sealing and wearing surface on old asphalt roadways. Ralumac performance and success is highly dependent upon careful and correct control of product mixing and application.

In this test application, the Ralumac treatment performed very well and would be competitive to conventional slurry seals.

A limited amount of information is available on this test site as it was constructed some time before this research project was initiated.

See Appendix B - 8 for Materials Data

11. The location of the project was in Webster County on US 169 near the south edge of Ft. Dodge. The project extends north
for about 0.80 km (1/2 mile) from the county road P51. The Ralumac was applied from Station 1150+00 to Station 1180+00. There was no conventional section on this project constructed as project FN-6-4(185)--21-50 on June 16, 1988.

The evaluation of the Ralumac section was done mainly through visual evaluations and by rut depth measurements. Evidence of wheelpath rutting was seen soon after traffic was allowed on the new Ralumac surface. Within 60 days after construction, rut depth averages were already approximately 6.35 mm (0.25 in.) deep.

For a final report on this project, see Ref. 5.

During the process of applying the Ralumac, it was evident that there were difficulties in getting the proper ratios of materials in the mix. In some areas, the emulsion was very slow to break. The application of the Ralumac treatment was done by an experienced crew provided by the product supplier.

From observations made during the application of the Ralumac treatment, and from the development of ruts soon after, product mixing and application may be quite critical and somewhat difficult to control.
Due to a poorly controlled mix ratio and the resulting slow breaking of the emulsion, some of the Ralumac was eroded away by a rainfall 18 hours after application. With evidence of early rutting and continued rutting, it can be concluded that the Ralumac treatment was not successful in this test.

There were no charges for the Ralumac material and application under this demonstration project so no cost comparisons are available. If there were charges for the Ralumac additive or treatment, the result would have been, in this case, that it was not a cost effective treatment. The long-term performance of the product was not good.

See Appendix B - 11 for Materials Data.

ULTRAPAVE, SITE 9

Location, Date, Evaluation and Conclusion

UltraPave, a latex modifier added to an AC 10 asphalt cement, was used for resurfacing at site number 9. The UltraPave was used in the top 44.45 mm (1\frac{1}{4} in.) lift of a 88.9 mm (3\frac{1}{8} in.) resurfacing project. The purpose of UltraPave is to "waterproof," add flexibility, retain aggregate better and longer and extend the life of the road.

The project was located in Story County on county road E29. The UltraPave was applied in the westbound lane beginning
approximately 3.62 km (2.25 miles) east of Story County road S14. The test section west from Station 114+60 to Station 126+00. The eastbound lane of the project was a conventional Type B asphalt cement. The resurfacing project was constructed on July 19, 1983.

The long-term evaluation of UltraPave was done visually in comparing results from UltraPave in the westbound lane with results of the conventional asphalt cement in the eastbound lane.

A preliminary evaluation at the time of construction showed that the UltraPave mix was very sticky and difficult to work with. A later evaluation, February 12, 1986, showed no significant difference in cracking between the UltraPave and the conventional sections.

A long-term evaluation showed that slightly less rutting and more cracks were observed in the UltraPave section. The final evaluation results were:

May 12, 1993 - Across two 30.5 m (100 ft.) sections

<table>
<thead>
<tr>
<th></th>
<th>CRACKS (AVG.)</th>
<th>RUTS (AVG.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UltraPave</td>
<td>12 cracks/30.5 m (100 ft.)</td>
<td>3.8 mm (0.15 in.)</td>
</tr>
<tr>
<td>Conventional</td>
<td>9 cracks/30.5 m (100 ft.)</td>
<td>4.8 mm (0.19 in.)</td>
</tr>
</tbody>
</table>
The UltraPave latex additive was added into the pugmill after the asphalt and aggregate were heated to at least 148.9°C (300°F). The mix became extremely sticky. It was difficult to remove from the trucks and caused problems in passing through the paver. Severe tearing of the mat was observed behind the paver.

The UltraPave latex provided by Seal Lock of Iowa Incorporated was a product promotion and, therefore, no product costs are available.

From the experimental use of the latex polymer additive UltraPave, we can conclude that it does not give overall superior performance and that, in this case, it would not be cost effective. It was more difficult to work with during construction. Follow-up visual evaluations indicated more cracks existed in the UltraPave section but rutting was slightly less. In general, cracking was severe. The UltraPave section had 12 cracks per 30.5 m (100 ft.) while the control section had 9 cracks per 30.5 m (100 ft.). See Appendix B - 9 for Materials Data.

GENERAL CONCLUSIONS

Of all the different polymer modifiers for asphalt evaluated over the 15 different sites in this research project, it has been determined that some of the products did not perform well in spite of supplier support, or approved installation. In other
cases, other products did perform better than their conventional counter part in the same roadways.

In many cases, the products tested were applied in relatively short sections of a complete project. Under that condition, there is commonly a problem of a poorer mix or quality control in the "start up" phase of a new mix. By the time mix adjustments are brought under control, the test section is completed. The Ralumac, applied at site 11 may have failed as a result of that situation.

Evaluations have shown that the polymer modifiers PAC 40 SBS, PAC 40 SBN, PAC 40 SBR and PAC 30 SBS performed well in their special applications. Those products, combined with today’s state-of-the-art crushed aggregate gradations should provide a very durable asphalt cement concrete roadway and would be cost effective for high stress or critical areas such as at signalized intersections with heavy traffic.

Chem-Crete resulted in very poor performance. Ductilad and UltraPave were not deemed cost effective.

**GENERAL RECOMMENDATIONS**

Based upon the evaluations and results from the various polymer modified asphalts used in the 15 sites in the state of Iowa, the recommendations are as follows:
Some modified asphalts have shown to perform better in the high stress areas, such as near signalized intersections, than the conventional asphalt applied in the lower stress areas of the same roadway away from signalized intersections. Under those conditions, it would be recommended that some amount of additional investment could be justified for an asphalt modifier and it would be cost effective. The modifiers in this case are those applied as follows:

Site 1   PAC 40  Styrene Butadiene Styrene  
Site 2   PAC 40  Styrene Butadiene Neoprene  
Site 3   PAC 40  Styrene Butadiene Rubber  
Site 4   AC-13  Styrelf-13  
Site 5   PAC 30  Styrene Butadiene Styrene  
Site 6   PAC 30  Styrene Butadiene Styrene  
Site 7   PAC 40  Styrene Butadiene Rubber  
Site 8   PAC 30  Styrene Butadiene Styrene  

The performance of the remaining asphalt modifiers used in this project, did not perform as proposed, expected or in a satisfactory manner for one or more reasons. They are as follows:

Site 4   Asphadur  
Site 6   Chem-Crete  
Site 7   Ductilad D1002  
Site 8   Ralumac  
Site 9   UltraPave
Site 10  Asphadur (3M-5990)
Site 11  Ralumac

Some of these reasons could be improper product preparation or application. No recommendations are being made for further tests, evaluations or use of products used in those sites.

REFERENCES


5. R. Steffes, HR-2041, "Ralumac Latex Modified Asphalt,"
Final Report, Iowa Department of Transportation, Project
Appendix A
Project Correspondence and Agreement
Mr. Robert L. Humphrey
Director, Iowa Department of Transportation
800 Lincoln Way
Ames, Iowa  50010

Dear Mr. Humphrey:

Enclosed are two copies of a Work Order for evaluating and reporting on the performance of asphalt additives under Experimental Project No. 3. This Work Order is issued under our Cooperative Agreement dated March 24, 1982, and amendment No. 1 dated September 26, 1983.

Please execute both copies of the Work Order, enter the name, address and telephone number of the principal investigator under ARTICLE IV - KEY PERSONNEL of the Work Order and return one copy with original signatures to the office.

Any questions concerning this Work Order may be directed to Mr. Tommy L. Beatty at (202) 366-4667.

Sincerely yours,

Douglas A. Bernard
Chief, Demonstration Projects Division

Enclosures

cc:  FHWA, Mr. E. Dean Carlson, Region 7, Kansas City, MO, HST-07
**U.S. DEPARTMENT OF TRANSPORTATION**  
**FEDERAL HIGHWAY ADMINISTRATION**  
**DEMONSTRATION PROJECTS PROGRAM**  
**COOPERATIVE AGREEMENT WORK ORDER**

**WORK ORDER NO.:** DTFH71-88-503-IA-28  
**EFFECTIVE DATE:** SEP 16, 1988

**ISSUED BY:**  
U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION  
400 7TH ST. S.W.  
WASHINGTON, D.C. 20590

**COORDINATING AGENCY:**  
IOWA DEPARTMENT OF TRANSPORTATION  
800 LINCOLN WAY  
AMES, IOWA 50010

**EXPERIMENTAL PROJECT NO. 3, ASPHALT ADDITIVES**

**ACCOUNTING AND APPROPRIATION DATA:** 248-15-73-1C-1060-8503

**FUNDS AVAILABLE:** $9,900


**COORDINATING AGENCY:**  
IOWA DEPARTMENT OF TRANSPORTATION  
800 LINCOLN WAY  
AMES, IOWA 50010

**ISSUING OFFICE:**  
U.S. DEPARTMENT OF TRANSPORTATION  
FEDERAL HIGHWAY ADMINISTRATION  
400 7TH ST. S.W.  
WASHINGTON, D.C. 20590

**SIGNATURES:**  
BY (AUTHORIZED SIGNATURE)  
**TYPED NAME:** R. L. Humphrey  
**DATE:** October 18, 1988  
**TITLE:** Highway Division Director  
**Chief Engineer**

**TYPED NAME:** GARY L. KLINEDINST  
**DATE:** SEP 16, 1988  
**TITLE:** DIVISION ENGINEER
ARTICLE I - STATEMENT OF WORK

The Cooperating Agency shall provide for the reporting on the performance of nine asphalt additives on projects that are completed. These additives and their locations are listed in Exhibit C. The Cooperating Agency will also evaluate and report on the performance of six undetermined asphalt additives on future projects.

ARTICLE II - WORK PLAN

The work plan, attached as Exhibit A, is approved subject to the modifications shown in Exhibit B.

ARTICLE III - PERIOD OF PERFORMANCE

The final report for Phase I of the project shall be submitted no later than November 1, 1991.

ARTICLE IV - KEY PERSONNEL

The Cooperating Agency shall assign the following individual(s) as principal investigator(s):

Robert Steffes
Materials Research Assistant
Iowa Department of Transportation
800 Lincoln Way
Ames, IA 50010
511-239-1392

ARTICLE V - CONSIDERATION AND PAYMENT

The Federal Highway Administration's Demonstration Projects Division (FHWA-DPD) agrees to reimburse the Cooperating Agency up to $9,900 for allowable costs in evaluating the performance of the Asphalt Additives listed as stated in the work plan.

Following acceptance of each interim report by FHWA-DPD, the Cooperating Agency may submit vouchers for partial payment not to exceed 70 percent of the amount being provided for the work item. After acceptance of the final report by FHWA-DPD, the Cooperating Agency may submit a voucher for reimbursement of all remaining allowable cost. Each voucher must itemize the costs incurred by the Cooperating Agency.

The Demonstration Projects Division funds provided by this Work Order shall not be used by the Cooperating Agency as matching funds for federally funded programs.
INTRODUCTION

Many asphalt pavements built in the past which were considered to be properly designed and constructed began to show some early signs of distress and poor performance. The distress signs occurred in the form of rutting, shoving and cracking.

Suppliers of asphalt additives claim they have products which will improve asphalt performance, stabilize pavements and reduce rutting and cracking.

Some of these products for stabilizing asphalts have been used in various locations in Iowa. However, documentation and follow-up on these applications were not extensive and conclusions were not formulated or reported as to the success and cost effectiveness of the additives used.

This research proposes to study the performance of asphalt stabilizing additives at approximately 15 project sites and to develop a conclusion concerning the additives effectiveness based on results from field applications.

OBJECTIVE

The objective of this project is to determine the performance and cost effectiveness of asphalt stabilizing additives used to minimize rutting, shoving and cracking in asphalt pavements.

Additive applications to be evaluated would include rubber, chemical or natural products. Chemical antistrip agents and mineral fillers would not be included in the project.

A summary of results from this study of field applications of various additives could be used as a guide to help improve asphalt pavement mix designs and pavement performance on future projects.

STARTING DATE

The proposed starting date for the project will be July 1, 1988.

PROPOSED RESEARCH

The project will study approximately nine sites of previous applications of asphalt additives and an estimated six sites of future applications planned to be constructed before December 31, 1988. Phase I evaluation will cover a minimum of three years from the contract date. Phase II evaluation will continue with periodic reviews.
1. **Experimental Features**

There are currently nine locations in Iowa which are considered as candidates for evaluation of existing applications of asphalt stabilizing additives. In addition, new applications, estimated to be 6 before the end of 1988, will be considered for evaluation.

The performance evaluation will cover:

a. Detailed information on the design, construction, and performance of experimental sections and on control sections when available.

2. **Design and Preconstruction Testing Details**

Available information will be documented for both the test section(s) covering:

a. Structural design data and assumptions (ADT, percentage of trucks, etc.).

b. Subgrade, subbase, and base data

c. Materials data (asphalt grade, asphalt source, additive type, aggregate types and gradation, etc.)

d. Mix design

e. Results of materials and design testing, and

f. Special design of materials, concerns, or features

3. **Construction Procedures**

Information will be provided on:

a. Plant Operations

   1) Plant type and needed modifications

   2) Mix temperatures

b. Mix control testing results (Gradations, extractions, stabilities, VMA, VTM, etc.)

c. Laydown temperature and densities

d. Weather conditions

e. Laydown and compaction equipment used
f. Toxic emissions during construction

g. Special construction concerns or features

4. Performance Measurements

Field measurements, tests or surveys will be done by the Iowa DOT as follows:

<table>
<thead>
<tr>
<th>Test</th>
<th>Const. Yr.</th>
<th>One Yr.</th>
<th>Two Yrs.</th>
<th>Three Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Rutting</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>b. Raveling</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>c. Cracking</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>d. Stripping</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>e. Densities, void contents</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

5. Cost

An analysis will be made on a comparison of the costs (dollars per ton) of the material with the asphalt additive versus the material without the asphalt additive.

6. Performance Reporting

The first phase will be a detailed and frequent investigation that lasts a minimum of three years. The second phase will be a long-term evaluation that would involve selective investigations at periodic intervals throughout the life of the project.

a. Phase I Reporting:

1) Initial Report: This report will be prepared within 90 days of completion of an agreement to perform this evaluation or within 90 days of completion of construction of the project, as appropriate. It will contain all information as required under Items 1 through 5.

2) Interim Reports: Information obtained from Item 4, will be reported annually, presented in a form easily understood, and summarized. If appropriate, it will include any discussions useful in assessment of the asphalt additives.

3) Final Report: This will include a comprehensive summary of all data collected, an overall evaluation of the cost-effectiveness of the asphalt additive and con-
clissions and recommendation based on the information collected.

b. Phase II Reporting:

1) Periodic Progress Reports: After completing Phase I of the evaluation, monitoring of the project will continue through six years. Data on information included under Item 4 will be reported every 2 years or as appropriate.

2) These periodic progress reports will be similar to the interim reports described above.

7. Estimated Evaluation Cost

Project costs are estimated to be $9900.00 to cover performance evaluation and report writing (see Appendix A).

8. Principal Investigator

The Principal Investigator for the project will be:

Robert Steffes
Materials Research Assistant
Iowa Department of Transportation
Phone: 515-239-1392
## Appendix A

Estimated Evaluation Cost, Dollars (for 15 sites)

<table>
<thead>
<tr>
<th>TEST</th>
<th>'88</th>
<th>'89</th>
<th>'90</th>
<th>'91</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CONST</td>
<td>ONE</td>
<td>TWO</td>
<td>THREE</td>
</tr>
<tr>
<td>Rutting</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Raveling</td>
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<td>475</td>
<td>475</td>
<td>475</td>
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<tr>
<td>Cracking</td>
<td>2000</td>
<td>400</td>
<td>400</td>
<td>400</td>
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<tr>
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<td>800</td>
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<tr>
<td>Densities</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sub Total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Rpt</td>
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<td></td>
</tr>
<tr>
<td>Interim Rpt</td>
<td>1875</td>
<td></td>
</tr>
<tr>
<td>Final Rpt</td>
<td>1875</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1875</td>
<td></td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>$9900.00</td>
</tr>
</tbody>
</table>

---
Work Plan Modification

The work plan is modified as follows:

A draft final report will be submitted to the FHWA for review and comment following completion of Phase I of the study. The FHWA review is to be completed and comments furnished to the Cooperating Agency within 60 days. A reproducible copy of the final report shall be furnished to the FHWA within 60 days of the return of the draft to the Cooperating Agency.

The six additives and their locations will be identified prior to construction.
HR-542 - Evaluation of Asphalt Stabilizing Additives

<table>
<thead>
<tr>
<th>Asphalt Stabilizing Additive</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.</strong> PAC 40 Hot mix Styrene Butadiene Styrene (SBS) Asphaltic cement concrete</td>
<td>Jasper Co. Newton, W. 15th St. E. to E. City Limit</td>
</tr>
<tr>
<td><strong>2.</strong> PAC 40 Hot Mix Neoprene (SBN) Asphaltic cement concrete</td>
<td>Clinton Co. Clinton, 7th Ave. So./No. to W. Jct. of IA 136</td>
</tr>
<tr>
<td><strong>3.</strong> PAC 40 Hot Mix Styrene Butadiene Rubber (SBR) Asphaltic cement concrete</td>
<td>O'Brien Co. Sheldon, Hwy. 18/60 Intersection, E. and N.</td>
</tr>
<tr>
<td><strong>4.</strong> Asphadur Hot Mix Asphaltic cement concrete</td>
<td>Pottawattamie Co. Council Bluffs, I-480 EB from Mo. R. Br. to N. 41st St.</td>
</tr>
<tr>
<td><strong>5.</strong> Asphadur Hot Mix Asphaltic cement concrete</td>
<td>Woodbury Co. Sioux City, Intersections IA 12 So. Fairmont, So. Martha, Stone and So. Palmetto St.</td>
</tr>
<tr>
<td><strong>6.</strong> Chemcrete Hot Mix Manganese modified Asphaltic cement concrete</td>
<td>Story Co. So. of Napier on E-57, near R-38, 1 mi.</td>
</tr>
<tr>
<td><strong>7.</strong> Ductilad Cold Mix Polymer modified emulsion Chip seal</td>
<td>Polk Co. So. of Madrid on Hwy. 415, near Hwy. 17, EBL, 2.6 mi.</td>
</tr>
<tr>
<td><strong>8.</strong> Ralumac Cold Mix Latex modified emulsion Slurry</td>
<td>Polk Co. Hwy. 69, from Ankeny N, 5 miles</td>
</tr>
<tr>
<td><strong>9.</strong> Ultra Pave Hot Mix Latex modified Asphaltic cement concrete</td>
<td>Story Co. on E-29, WBL, from 2.25 mi. E. of S-14 (Sta. 114+60 to 126+00) 1/4 mi.</td>
</tr>
</tbody>
</table>
Thank you for your assistance on this evaluation of asphalt additives.

The experimental project DTFH71-88-503-IA-28, Asphalt Additives, work plan calls for the evaluation of 15 sites. Nine sites were designated from previously completed projects and are already listed in the project work plan, Exhibit C. The remaining 6 sites were to be selected later from projects completed by December 31, 1988. Due to a lack of 6 suitable projects by that date, we made five selections and one more in the spring of 1989. You will find the list of 6 additional projects for the Asphalt Stabilizing Additives study attached.

by B. C. Brown
Materials Engineer

RLH:BCB/VJM/kmd
cc: J. Bergren
    V. Marks
<table>
<thead>
<tr>
<th>No.</th>
<th>Asphalt Stabilizing Additive</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.</td>
<td>Asphadur Hot Mix Asphalitic Cement Concrete</td>
<td>Pottawattamie County Council Bluffs, I-480, EB Mo. R Br to I-29 1988</td>
</tr>
<tr>
<td>11.</td>
<td>Ralumac Cold Mix Latex modified emulsion</td>
<td>Webster Co. So. of Ft. Dodge on Hwy. 169 MP 155 1988</td>
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<tr>
<td>12.</td>
<td>Pac 30 (Elf) Hot Mix Asphalitic Cement Concrete</td>
<td>Polk County Des Moines, Army Post Road/SE 5th Street 1988</td>
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<tr>
<td>13.</td>
<td>Asphadur Hot Mix Asphalitic Cement Concrete</td>
<td>Story County Hwy. 69, Ames 1988</td>
</tr>
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<td>14.</td>
<td>Pac 40 Hot Mix Asphalitic Cement Concrete</td>
<td>O'Brien County IA 60, From US 18 to Sibley 1987</td>
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<tr>
<td>15.</td>
<td>Pac 30 Hot Mix Asphalitic Cement Concrete</td>
<td>Polk County Des Moines, Fleur Dr., McKinley Ave. to Army Post Road 1989</td>
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</tbody>
</table>
Appendix B
Materials Data
B-1
1) Conventional
2) Conventional
3) PAC-40

Surface
Binder
MIX, TYPE AND CLASS: TYPE A RECYCLED

INTENDED USE: SURFACE

SIZE 1/2

COUNTY JASPER

PROJECT FN-6-4(85)-21-50

CONTRACTOR DES MOINES ASPHALT

PROJ. LOCATION FROM W. 15TH PLACE TO E. 20TH ST. N. IN NEWTON

AGG. SOURCES MILLED @ 5.5%-PROJECT; CR. LST & CHIPS- KASER, SULLY QRY, JASPER CO; SAND- VAN DUSSELDOORP, COLFAX, JASPER CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 30% ABC7-310; 15% AAT7-111; 27.5% AAT7-1

JOB MIX FORMULA - COMBINED GRADATION

TOLERANCE: 98/100 7 7 7 5 4 2

% ASPHALT ADDED 3.10 4.10

ASPHALT SOURCE AND APPROXIMATE VISCOSITY KOCH - 965 POISES

PLASTICITY INDEX

% ASPH. IN MIX 4.75 5.75

NUMBER OF MARSHALL BLOWS 50 50

MARSHALL STABILITY - LBS. 2477 2363

FLOW - 0.01 IN. 7 8

SP.GR. BY DISPLACEMENT(LAB DENS.) 2.315 2.348

BULK SP. GR. COMB. DRY AGG. 2.640 2.640

SP. GR. ASPH. @ 77 F. 1.032 1.032

CALC. SOLID SP.GR. 2.568 2.471

% VOID IN THE MINERAL AGGREGATE 16.28 16.17

% V.I.A. FILLED WITH ASPHALT 93.22 97.95

CALCULATED ASPH.FILM THICKNESS(MICRONS) 7.47 9.50

FILLER/BITUMEN RATIO 0.98

A CONTENT OF 5.4% ASPHALT IS RECOMMENDED TO START THE JOB.

THIS IS AN ADD. 3.75% AC 10. *ALSO CONTROLLED BY FILLER/BIT. RATIO.

NRC. CAL: TEMP= 485; WT= 7200; SLOPE= 5.34; I'CEPT= (-6.30)

COPIES:

ASPHALT MIX DESIGN

FN-6-4(85)-21-50, JASPER:

R. KUMM
J. PETERS
R. MONROE
J. SMYTHE
D. HEINS
DES MOINES ASPHALT
W. OPPEDAL

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER
MIX, TYPE AND CLASS: TYPE A RECYCLED  
LAB NO.  ABD7-201

INTENDED USE: BINDER

SIZE  3/4"  SPEC. NO.  1043  DATE REPORTED  9/15/87

COUNTY  JASPER  PROJECT  FM-6-4(85)--21-50

CONTRACTOR  DES MOINES ASPHALT

PROJ. LOCATION  FROM W. 15TH PLACE TO E. 28TH ST. N IN NEWTON

AGG. SOURCES  MILLED @ 5.51% PROJECT; CR. LST. & CHIPS - KASER, SULLY WRY,  
JASPER CO.; SAND - VAN DUSSELDORP, COLFAK, JASPER CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS:  30% ABC7-310; 17.5% AAT7-1080;  
25% AAT7-1081; 27.5% AAT7-1082

JOB MIX FORMULA - COMBINED GRADATION

<table>
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<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>
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<td>23</td>
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<td>11</td>
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<td>5.5</td>
<td>5.5</td>
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</table>

TOLERANCE: 95/100

% ASPHALT ADDED: 3.10

% ASPHALT IN MIX: 4.75

% MARSHALL BLOWS: 50

MARSHALL STABILITY - LBS.: 2408

FLOW - 0.61 IN.: 10

SP. GR. BY DISPLACEMENT (LAB DENS.): 2.332

BULK SP. GR. CORB. DRY AGG.: 2.648

SP. GR. ASPH. @ 77 F.: 1.032

CALC. SOLID SP. GR.: 2.511

% VOIDS - CALC.: 7.12

% VOIDS - RICE: 2.463

% RICE: 2.419

% WATER ABSORPTION - AGGREGATE: 1.61

% VOIDS IN THE MINERAL AGGREGATE: 15.79

% V.M.A. FILLED WITH ASPHALT: 72.48

CALCULATED ASPH. FILM THICKNESS (MICRONS): 7.43

FILLER/BITUMEN RATIO: 1.08

A CONTENT OF 5.1% ASPHALT IS RECOMMENDED TO START THE JOB.

THIS IS AN ADD. 3.45 AC 10. ALSO CONTROLLED BY FILLER/BITUMEN RATIO.

NRC: CAL.: TEMP = 200; WT = 7200; SLOPE = 4.60; INTERCEPT = (-4.75)

COPIES:

ASPHALT MIX DESIGN
FM-6-4(85)--21-50, JASPER
R. MUHLM
J. PETERS
R. MONROE
J. SMYTHE
D. HEINS
DES MOINES ASPHALT
W. OPPEDAL

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER
INTENDED USE
COUNTY JASPER
DESIGN
PRODUCER BITUCOTE
SOURCE DES MOINES

UNIT OF MATERIAL
SAMPLED BY G. SCHIPPERS

DATE SAMPLED 9-29-87 RECD 10-1-87 REPORTED 10-5-87

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<th>LAB NO.</th>
<th>PROJ NO.</th>
<th>CONTRACT NO.</th>
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<td>1DBA7-908 &amp; 909</td>
<td>FN-6-4(85)-2150</td>
<td>27515</td>
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MATERIAL PAC-40
CONTRACTOR DES MOINES ASPHALT

ABSOLUTE VISCOSITY AT 140 F., 30 CM. HG. VACUUM = 2620 POISES
ABSOLUTE VISCOSITY AT 140 F., 30 CM. HG. VACUUM = 2540 POISES

DISPOSITION: DOES NOT COMPLY

SIGNED: DISTRICT 1 MATERIALS
<table>
<thead>
<tr>
<th>B-2</th>
<th>1) PAC-40</th>
<th>Binder/Surface</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2) Conventional</td>
<td>Binder/Surface</td>
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**MIX, TYPE AND CLASS:** TYPE A  
**LAB NO.: ABD7-23**

**INTENDED USE:** Binder/Surface

**SIZE:** 1/2"  
**SPEC. NO.:** 1030  
**DATE REPORTED:** SS-1034  
**COUNTY:** CLINTON  
**PROJECT:** FN-67-2(42)-21-23  
**CONTRACTOR:** DETERMANN

**PROJ. LOCATION:** IN CLINTON FROM 7TH AVE. S. TO 7TH AVE. N. & N. 2ND TO N. 3RD ST

**AGG. SOURCES:** 1/2" CR. LST. & 3/8" CHIPS-AGGRECON, SHAFTON, CLINTON CO.; SAND - AGGRECON, DOYLE, CLINTON CO.

**JOB MIX FORMULA:** 52.5% RAA7-65; 020% TAA7-66; 27.5% ATT7-67

**JOB MIX FORMULA - COMBINED GRADATION**

<table>
<thead>
<tr>
<th>1-1/2&quot;</th>
<th>1&quot; 3/4&quot;</th>
<th>1/2&quot; 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>
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<td>20</td>
<td>10</td>
<td>6.1</td>
<td>4.8</td>
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**TOLERANCE:**

| 92/100 | 7   | 7   | 5   | 4   | 2*   |

**ASPHALT SOURCE AND APPROXIMATE VISCOSITY**

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<th>KOCH - PAC 40 - 3990 POISES</th>
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**PLASTICITY INDEX**

<table>
<thead>
<tr>
<th>% ASPH. IN MIX</th>
<th>75</th>
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</thead>
</table>

**NUMBER OF MARSHALL BLOWS**

| 75    |

**MARSHALL STABILITY - LBS.**

| 2893  | 2608  |

**FLOW - 0.01 IN.**

| 9     | 11    |

**SP. GR. BY DISPLACEMENT (LAB DENS.)**

| 2.330 | 2.359 |

**BULK SP. GR. COMB. DRY AGG.**

| 2.621 | 2.621 |

**SP. GR. ASPH. @ 77 F.**

| 1.024 | 1.024 |

**CALC. SOLID SP.GR.**

| 2.477 | 2.440 |

**% VOIDS - CALC.**

| 5.94  | 3.34  |

**RICE SP. GR.**

| 2.432 | 2.403 |

**% VOIDS - RICE**

| 4.19  | 1.83  |

**% WATER ABSORPTION - AGGREGATE**

| 2.29  | 2.29  |

**% VOIDS IN THE MINERAL AGGREGATE**

| 15.99 | 15.85 |

**% V.M.A. FILLED WITH ASPHALT**

| 62.86 | 78.93 |

**CALCULATED ASPH. FILM THICKNESS (MICRONS)**

| 9.15  | 11.38 |

**FILLER/BITUMEN RATIO**

| 0.86 |

A content of 5.6% asphalt is recommended to start the job.  
* Also controlled by filler/bitumen ratio.

**NOC. CAL. TEMP.:** 210; WT. = 7300; SLOPE = 3.86; INTER = (-3.31)

**COPIES:**

ASPHALT MIX DESIGN  
PR-67-2(42)-21-23, CLINTON  
R. MERRITT  
B. KUEHL  
R. MONROE  
J. SKYTHE  
D. HEINS  
DETERMANN  
W. OPPEDAL

**SIGNED:** ORRIS J. LANE, JR.  
TESTING ENGINEER
MIX, TYPE AND CLASS: TYPE A

INTENDED USE: BINDER/SURFACE

SIZE 1/2"

COUNTY CLINTON

CONTRACTOR DETERMANN

PROJ. LOCATION IN CLINTON FROM 7TH AVE S. TO 7TH AVE. N & N. 2ND ST. TO N 3RD.

AGG. SOURCES
1/2" CR. LST. & 3/8" CHIPS-AGGRECON, SHAFTON, CLINTON CO.;
SAND-AGGRECON, DOYLE, CLINTON CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 52.5% AAT7-65; 20% AAT7-66; 27.5% AAT7-67

1-1/2" 1” 3/4” 1/2” 3/8” NO.4 NO.8 NO.16 NO.30 NO.50 NO.100 NO.200
100 98 90 63 41 31 20 10 6.1 4.8

TOLERANCE: 98/100 7 7 5 4 2

ASPHALT SOURCE AND APPROXIMATE VISCOSITY

Koch - 2220 POISES

PLASTICITY INDEX
% ASPH. IN MIX 4.5 5.5 6.5
NUMBER OF MARSHALL BLOWS 75 75 75
MARBALL STABILITY - LBS. 3373 3158 3140
FLOw - 0.01 IN. 8 9 9
SP.GR. BY DISPLACEMENT(LAB DENS.) 2.313 2.331 2.354
BULK SP. GR. COMB. DRY AGG. 2.621 2.621 2.621
SP. GR. ASPH. @ 77 F. 1.035 1.035 1.035
CALC. SOLID SP.GR. 2.517 2.480 2.444
% VOIDS - CALC. 8.11 6.01 3.68
RICE SP. GR. 2.491 2.447 2.424
% VOIDS - RICE 7.15 4.74 2.89
% WATER ABSORPTION - AGGREGATE 2.29 2.29 2.29
% VOIDS IN THE MINERAL AGGREGATE 15.72 15.96 16.02
% V.M.A. FILLED WITH ASPHALT 48.42 62.36 77.06
CALCULATED ASPH.FILM THICKNESS(MICRONS) 6.98 9.15 11.38
FILLER/BITUMEN RATIO 0.83

A CONTENT OF 5.0% ASPHALT IS RECOMMENDED TO START THE JOB.

NUR. CAL. TEMP = 215; WT. = 7300; SLOPE = 4.22; INTER = -4.06

COPIES:
- ASPHALT MIX DESIGN
- FN-67-2(42)--21-23, CLINTON
- R. MERRITT
- B. KUEHL
- R. MONROE
- J. SMYTHE
- D. HEINS
- DETERMANN
- W. OPPEDAL

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER
<table>
<thead>
<tr>
<th>B-3</th>
<th>1) Conventional</th>
<th>Base/Binder</th>
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<tbody>
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<td>2) Conventional</td>
<td>Surface</td>
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<td></td>
<td>3) PAC-40</td>
<td>Some as site 14</td>
</tr>
<tr>
<td></td>
<td>4) PAC-40</td>
<td>Surface</td>
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</table>
MIX, TYPE AND CLASS: TYPE B CLASS I (RECYCLED) AB NO. ABD7-34

INTENDED USE: BASE, BINDER

SIZE 3/4' SPEC. NO. 1024 DATE REPORTED 5/14/87

COUNTY O'BRIEN PROJECT FN-18-2(50)--21-71

CONTRACTOR ROHLIN

PROJ. LOCATION FROM RR IN SHELDON THROUGH SANBORN MILLED Ø 5.2% -- PROJECT;

AGG. SOURCES CR. GRAVEL & WASHED GRAVEL -- JOE'S READY MIX, O'BRIEN CO.;
PIT RUN GRAVEL -- ROHLIN, 28-98-42 OSCEOLA CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 20% ABC7-34; 17% AAT7-177; 38% AAT7-179; 25% AAT7-179

JOB MIX FORMULA - COMBINED GRADATION

<table>
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<tr>
<th>Size</th>
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<th>1'</th>
<th>3/4'</th>
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TOLERANCE: 98/100

% ASPHALT ADDED 3.96 4.96 5.96

ASPHALT SOURCE AND APPROXIMATE VISCOSITY KOCH = 471 POISES

PLASTICITY INDEX NOT TESTED

% ASPH. IN MIX 5.0 6.0 7.0

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 1762 1783 1723

FLOW - 0.01 IN. 7 8 10

SP. GR. BY DISPLACEMENT (LAB DENSI.) 2.281 2.325 2.339

BULK SP. GR. CORR. DRY AGG. 2.631 2.631 2.631

SP. GR. ASPH. @ 77 F 1.019 1.019 1.019

CALC. SOLID SP. GR. 2.478 2.441 2.406

% VOIDS - CALC. 7.96 4.77 2.77

RICE SP. GR. 2.475 2.434 2.409

% VOIDS - RICE 7.84 4.48 2.91

% WATER ABSORPTION - AGGREGATE 1.42 1.42 1.42

% VOIDS IN THE MINERAL AGGREGATE 17.64 16.93 17.32

% V.M.A. FILLED WITH ASPHALT 54.90 71.86 84.01

CALCULATED ASPH. FILM THICKNESS (MICRONS) 8.04 10.04 12.05

FILLER/BITUMEN RATIO 0.81

A CONTENT OF 6.2% ASPHALT IS RECOMMENDED TO START THE JOB.

THIS IS AN ADDITIONAL 5.16% ASPHALT.

MUC. CAL. TEMP = 220; WT. = 7300; SLOPE = 4.75; INTER. = (-5.14)


SIGNED: ORRIS J. LANE, JR.

TESTING ENGINEER
MIX, TYPE AND CLASS: TYPE A (RECYCLED)  

INTENDED USE: SURFACE

SIZE 1/2" 

COUNTY O'BRIEN

CONTRACTOR ROHLIN

PROJECT LOCATION FROM RR IN SHELDON THROUGH SANBORN

AGG. SOURCES MILLED @ 5.2% PROJECT; 1/2" CHIPS & 1/4" CR. LST. - MIDWEST LST., GILMORE CITY, POCAHONTAS CO.; SAND-HALLETTS, 2B-98-42, OSCEOLA CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 22% ABCT-34; 26% AAT7-235; 20% AAT7-236; 32% AAT7-237

JOB MIX FORMULA - COMBINED GRADATION

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<th>3/4&quot;</th>
<th>1/2&quot;</th>
<th>3/8&quot;</th>
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TOLERANCE: 98/100 7 7 5 3.86 4.86 5.86

2% ASPHALT ADDED

% ASPHALT IN MIX 5.0 6.0 7.0

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 2425 2517 1808

FLOW - 0.01 IN. 7 9 13

SP. GR. BY DISPLACEMENT (LAB DENS.) 2.319 2.358 2.352

BULK SP. GR. COMB. DRY AGG. 2.608 2.608 2.608

SP. GR. ASPH. @ 77 F. 1.019 1.019 1.019

CALC. SOLID SP.GR. 2.462 2.426 2.391

% VOIDS - CALC. 5.80 2.79 1.61

RICE SP. GR. 2.467 2.431 2.399

% WATER ABSORPTION - AGGREGATE 1.53 1.53 1.53

% VOIDS IN THE MINERAL AGGREGATE 15.53 15.01 16.31

% V.M.A. FILLED WITH ASPHALT 62.63 81.41 89.99

CALCULATED ASPH.FILM THICKNESS (MICRONS) 7.02 8.77 10.56

FILLER/BITUMEN RATIO 0.98

A CONTENT OF 5.6% ASPHALT IS RECOMMENDED TO START THE JOB. THIS IS AN ADD. 4.46%; *ALSO CONTROLLED BY FILLER/BITUMEN RATIO.

NUC. CAL.: TEMP = 220; WT = 7300; SLOPE = 4.32; INTER = (-3.95)

SIGNED: ORRIS J. LANE, JR.  
TESTING ENGINEER
Iowa Department of Transportation

CHANGE OR EXTRA WORK ORDER

No. 1

Contract No. 25956

County O'Brien

Group 1

Project FN-18-2(50)-21-71

Kind of Work A.C.C. Resurfacing

Date Prepared June 11, 1987

To Rohlin Construction Co., Inc., Estherville

Contractor

You are hereby ordered to make the following changes from the plans or do the following extra work on your contract dated 7/17/86.

A - Description of change to be made or extra work to be done:

Delete Item #5 - Asphalt cement concrete, asphadur modified, recycled—810 tons

Add Item 8002 - Asphalt cement concrete, Type A surface, polymerized (PAC-40), 1/2 inch mixture, recycled

B - Reason for ordering change or extra work:

Contractor has requested permission to combine work required at the intersection of US #18 and IA #60 on this project and near the intersection on project FN-60-3(11)-21-71, to eliminate duplication of traffic control and inconvenience to the traveling public on IA #60. This requires using the same polymerization material and the same aggregate gradations on both projects. Item #5 will be deleted to eliminate reference to asphadur. Item 8002 will be added to make polymerization material and gradation requirements the same on both projects.

(Continued on reverse side)

Approved T. E. DeWitte (Const.) Wm. R. Bennett (Const.)

Approved contingent upon funds being available under the existing project agreement or upon additional Federal-aid funds being made available by a modified project agreement.

Approved

T. E. DeWitte (Const.) Wm. R. Bennett (Const.)

ROHLIN CONSTRUCTION CO., INC.

By Keith W. Godfrey 6-15-87

Keith W. Godfrey 6-15-87

Construction Engineer

(Continued on reverse side)

MIX, TYPE AND CLASS: TYPE A

INTENDED USE: SURFACE

SIZE 3/4

SPEC. NO. 1634  DATE REPORTED 9-16-87

COUNTY O'BRIEN  PROJECT FN-60-3(11)-21-71

CONTRACTOR ROHLIN

PROJ. LOCATION FROM U.S. 18 TO RR IN JIBLEY

AGG. SOURCES CR. GRAVEL & GRAVEL- ROHLIN, 32-99-37, DICKINSON CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AAT7-1120; 35% AAT7-1121

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<td>6.7</td>
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</table>

TOLERANCE: 98/100  7  7  7  5  4  2%

ASPHALT SOURCE AND APPROXIMATE VISCOSITY JEBRO - 3350 POISES

PLASTICITY INDEX

% ASPH. IN MIX  4.75  5.75  6.75

NUMBER OF MARSHALL BLows  50  50  50

MARSHALL STABILITY - LBS.  3252  2952  2583

FLOW - 0.01 IN.  12  18  20

SP. GR. BY DISPLACEMENT(LAB DENS.)  2.369  2.403  2.395

BULK SP. GR. COMB. DRY AGG.  2.674  2.674  2.674

SP. GR. ASPH. @ 77 F.  1.634  1.034  1.034

CALC. SOLID SP.GR.  2.516  2.489  2.444

% VOIDS - CALC.  5.91  3.12  2.01

RICE SP. GR.  2.569  2.449  2.415

% VOIDS - RICE  5.72  1.88  0.83

% WATER ABSORPTION - AGGREGATE  1.09  1.08  1.08

% VOIDS IN THE MINERAL AGGREGATE  15.0  15.3  16.48

% V.M.A. FILLED WITH ASPHALT  82.13  79.60  87.80

CALCULATED ASPH. FILM THICKNESS(MICRONS)  8.67  10.84  13.06

FILLER/BITUMEN RATIO  1.08

A CONTENT OF 5.0% ASPHALT IS RECOMMENDED TO START THE JOB.

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

COPIES:

ASPHALT MIX DESIGN
FN 60-3(11)-21-71; O'BRIEN
C. LEONARD
W. BENNETT
R. MONROE
J. SMYTHE
D. HEINS
ROHLIN
W. OPPEDAL
B-4  1) Asphadur  

Surface
MIX, TYPE AND CLASS: TYPE A SURFACE  
LAB NO. ABD9-191

INTENDED USE: ASPHALDUR - 6% BY WT. OF ASPHALT

SIZE 1/2"  
SPEC. NO.  
DATE REPORTED 10/23/79

COUNTY POTTAWATTAMIE  
PROJECT I-IR-480-1(114)0--44-78

CONTRACTOR DELTA

PROJ. LOCATION IN COUNCIL BLUFFS OVER 41ST STREET

AGG. SOURCES 1/2" CR. GRAVEL - AVOCA PIT - POTTAW. CO.; SAND - VALLEY, NEBR.;  
1/2" COVER AGG. - AVOCA PIT - POTTAW. CO.,

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AAT9-713, 30% AAT9-715, 5% AAT9-714

<table>
<thead>
<tr>
<th>JOY MIX FORMULA - COMBINED GRADATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

TOLERANCE:
75 BLOW MARSHALL DENSITY 2.38

ASPHALT SOURCE AND APPROXIMATE VISCOSITY PHILLIPS - 2020 POISES

PLASTICITY INDEX
% ASPH. IN MIX 4.9 5.0 6.0

NUMBER OF MARSHALL BLOWS 50 50

MARSHALL STABILITY - LBS. 3372 3262 3020

FLOW - 0.01 IN. 8 9 12

SP.GR. BY DISPLACEMENT (LAB DENS.) 2.31 2.36 2.38

BULK SP. GR. COMB. DRY AGG. 2.702 2.702 2.702

SP. GR. ASPH. @ 77 F. 1.017 1.017 1.017

CALC. SOLID SP.GR. 2.55 2.51 2.47

% VOILS - CALC. 9.3 5.9 3.6

RICE SP. GR. 2.50 2.45 2.41

% VOILS - RICE 7.4 3.7 1.4

% WATER ABSORPTION - AGGREGATE 0.44 0.44 0.44

% VOILS IN THE MINERAL AGGREGATE 17.9 17.9 17.2

% V.M.A. FILLED WITH ASPHALT 48.0 65.3 78.8

CALCULATED ASPH. FILM THICKNESS (MICRONS) 6.2 8.0 9.7

THIS MIXTURE CONTAINS ASPHALDUR IN THE AMOUNT OF 6.0% BY WT. OF ASPHALT (SEE ABD9-190). MIXED AT 400 F. - 4 MIN.; MOLDED AT 300 F.

COPIES:
ASPHALT MIX DESIGN  
I-IR-480-1(114)0--44-78, POTTAW.
V. R. SNYDER
R. SHELQUIST
D. JORDINSON
L. ZEARLEY
DELTA
C. JONES
D. HINES

SIGNED: BERNARD C. BROWN
B-5 1) AC-13 Surface/Binder
**MIX. TYPE AND CLASS:** TYPE A SURFACE - BINDER LAB NO. ABD4-93

**INTENDED USE:**

- **SIZE 1/2"**
- **SPEC. NO. 941, 951 DATE REPORTED 3/3/84 942**
- **COUNTY WOODBURY PROJECT FR-12-1(G)--2G-97**
- **CONTRACTOR BROWER**

**PROJECT LOCATION** FROM SOUTH LINN STREET TO E.C.L. IN SIOUX CITY

**AGG. SOURCES** 5/8"x4. 3/8"x8 QTZ. - L. G. EVERIST, MINNEHAHA, S. DAK.
- **SAND** - L. G. EVERIST, 15-95-48 - SIOUX CO.

**JOB MIX FORMULA** AGGREGATE PROPORTIONS: 15% AAT4-408: 15% AAT4-352: 30% AAT4-351:
- 10% AAT4-372: 30% AAT4-353

**JOB MIX FORMULA** - COMBINED GRADATION

<table>
<thead>
<tr>
<th>Size</th>
<th>1-1/2&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>
<th>NO.16</th>
<th>NO.30</th>
<th>NO.50</th>
<th>NO.100</th>
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<td>100</td>
<td>90</td>
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<td>60</td>
<td>57</td>
<td>46</td>
<td>32</td>
<td>17</td>
<td>9.0</td>
<td>5.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOLERANCE:** 98/100 7 7 5 2%

**ASPHALT SOURCE AND APPROXIMATE VISCOSITY** BITUCOTE-3240 POISES (STYRELF 13)

**PLASTICITY INDEX**

<table>
<thead>
<tr>
<th>Index</th>
<th>4.50</th>
<th>5.50</th>
<th>6.50</th>
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<tbody>
<tr>
<td>MARSHALL STABILITY - LABS.</td>
<td>75</td>
<td>75</td>
<td>75</td>
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<tr>
<td>FLOW - 0.01 IN.</td>
<td>3.443</td>
<td>3.227</td>
<td>3.130</td>
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<tr>
<td>SP. GR. BY DISPLACEMENT(LAB DENS.)</td>
<td>2.32</td>
<td>2.34</td>
<td>2.36</td>
</tr>
<tr>
<td>BULK SP. GR. COMB. DRY AGG.</td>
<td>2.651</td>
<td>2.651</td>
<td>2.651</td>
</tr>
<tr>
<td>SP. GR. ASPH. @ 77 F.</td>
<td>1.028</td>
<td>1.028</td>
<td>1.028</td>
</tr>
<tr>
<td>CALC. SOLID SP. GR.</td>
<td>2.486</td>
<td>2.449</td>
<td>2.414</td>
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<tr>
<td>V. OIIDS - CALC.</td>
<td>5.67</td>
<td>4.46</td>
<td>2.24</td>
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<tr>
<td>ICE SP. GR.</td>
<td>2.476</td>
<td>2.441</td>
<td>2.398</td>
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<tr>
<td>% OIIDS - RICE</td>
<td>4.30</td>
<td>4.14</td>
<td>1.58</td>
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<tr>
<td>% WATER ABSORPTION - AGGREGATE</td>
<td>6.37</td>
<td>6.37</td>
<td>6.37</td>
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<tr>
<td>% VOLUME FILLED WITH ASPHALT</td>
<td>16.42</td>
<td>16.59</td>
<td>16.67</td>
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<tr>
<td>CALCULATED ASPHALT FILM THICKNESS(MICRONS)</td>
<td>6.68</td>
<td>8.32</td>
<td>9.99</td>
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<tr>
<td>FILLER/BITUMEN RATIO</td>
<td>1.05</td>
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</table>

A CONTENT OF 5.15% ASPHALT IS RECOMMENDED TO START THE JOB.

* ALSO Controlled by FILLER/BITUMEN RATIO.

**COPIES:**
- ASPH. MIX DESIGN
- FR-12-1(G)--2G-97. WOODBURY
- J. BUKP
- R. BOLTON
- R. SHELGUST
- D. JORDISON
- D. HEINS
- BROWER
- W. OPPEDAL

**SIGNED:** GERHARD C. BROWN

TESTING ENGINEER
B-6

1) Type B Class 2 - Chem-Crete
2) Type B Class 2
3) Special Sand - Chem-Crete
4) Special Sand
5) Asphalt Chem-Crete
MIX, TYPE AND CLASS: TYPE B CLASS 2 (CHEM-CRETE) NO. ABD0-141

INTENDED USE:

SIZE 3/4 SPEC. NO. 852-857 DATE REPORTED 8-28-80
COUNTY STORY PROJECT L-WA-180--73-85

CONTRACTOR IA. RD. BUILDERS

PROJECT LOCATION ON E57 ON N. LINE SEC. 31-83-24

AGG. SOURCES 3/4" GRAVEL-PETEson PIT - STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 100% AAT0-472

<table>
<thead>
<tr>
<th>1-1/2&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>
<th>NO.16</th>
<th>NO.30</th>
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<tr>
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<td>91</td>
<td>83</td>
<td>68</td>
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<td>30</td>
<td>16</td>
<td>8.7</td>
<td>6.7</td>
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</table>

TOLERANCE: 98/100

75 BLOW MARSHALL DENSITY 2.35

ASPHALT SOURCE AND APPROXIMATE VISCOSITY SUGAR CREEK & CHEM-CRETE - 605 POISES

PLASTICITY INDEX N.P.

% ASPH. IN MIX 5.0

NUMBER OF MARSHALL BLOWS 50

MARSHALL STABILITY - LBS. 2175

FLOW - 0.01 IN. 8

SPGR. BY DISPLACEMENT (LAB DENS.) 2.29

BULK SP. GR. COMB. DRY AGG. 2.670

SP. GR. ASPH. @ 77 F. 1.028

CALC. SOLID SP. GR. 2.49

% VOIDS - CALC. 8.2

% CE SP. GR. 2.47

% VOIDS - RICE 7.2

% WATER ABSORPTION - AGGREGATE 0.73

% VOIDS IN THE MINERAL AGGREGATE 18.5

% V.M.A. FILLED WITH ASPHALT 56.0

CALCULATED ASPH. FILM THICKNESS (MICRONS) 7.0

FILLER/BITUMEN RATIO 1.1

A CONTENT OF 6.25% ASPHALT - CHEM-CRETE IS RECOMMENDED TO START THE JOB.

COPIES:

L-WA-180--73-85, STORY

SIGNED: BERNARD C. BROWN
TESTING ENGINEER
**MIX, TYPE AND CLASS:** TYPE B CLASS 2  
**LAB NO.: ABD0-140**

**INTENDED USE:**

<table>
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<tr>
<th>SIZE</th>
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<th>DATE REPORTED</th>
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<tbody>
<tr>
<td>3/4&quot;</td>
<td>852-857</td>
<td>8/28/80</td>
</tr>
</tbody>
</table>

**COUNTY**  
BOONE

**STORY**  
STORY

**CONTRACTOR:** IOWA ROAD BUILDERS

**PROJ. LOCATION**

**AGG. SOURCES:** 3/4" GRAVEL - PETERSON PIT - STORY CO.

**JOB MIX FORMULA AGGREGATE PROPORTIONS:** 100% AAT0-472

<table>
<thead>
<tr>
<th>JOB MIX FORMULA - COMBINED GRADATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-1/2&quot;</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>100</td>
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**TOLERANCE:** 98/100

<table>
<thead>
<tr>
<th>75 BLOW MARSHALL DENSITY</th>
<th>2.36</th>
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**ASPHALT SOURCE AND APPROXIMATE VISCOITY**

| SUGAR CREEK | 914 POISES |

**PLASTICITY INDEX**

<table>
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<tr>
<th>N. P.</th>
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</thead>
<tbody>
<tr>
<td>5.0</td>
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</tbody>
</table>

**NUMBER OF MARSHALL BLOWS**

| 50 |
| 50 |

**MARSHALL STABILITY - LBS.**

| 1758 |
| 1737 |
| 1559 |

**FLOW - 0.01 IN.**

| 7 |
| 8 |
| 10 |

**SP. GR. BY DISPLACEMENT (LAB DENS.)**

| 2.29 |
| 2.34 |
| 2.35 |

**BULK SP. GR. COMB. DRY AGG.**

| 2.670 |
| 2.670 |
| 2.670 |

**SP. GR. ASPH. @ 77 F.**

| 1.029 |
| 1.029 |
| 1.629 |

**CALC. SOLID SP. GR.**

| 2.49 |
| 2.46 |
| 2.42 |

**" VOIDS - CALC.**

| 8.2 |
| 4.8 |
| 2.9 |

**ICE SP. GR.**

| 2.48 |
| 2.43 |
| 2.40 |

**% VOIDS - RICE**

| 7.8 |
| 3.9 |
| 2.6 |

**% WATER ABSORPTION - AGGREGATE**

| 0.73 |
| 0.73 |
| 0.73 |

**% VOIDS IN THE MINERAL AGGREGATE**

| 18.5 |
| 17.6 |
| 18.2 |

**% V.M.A. FILLED WITH ASPHALT**

| 55.9 |
| 73.0 |
| 83.8 |

**CALCULATED ASPHALT FILM THICKNESS (MICRONS)**

| 7.0 |
| 8.6 |
| 10.2 |

**FILLER/BITUMEN RATIO**

| 1.1 |

A CONTENT OF 6.25% ASPHALT IS RECOMMENDED TO START THE JOB.

**COPIES:**

- ASPH. MIX DESIGN
- PROJECTS LISTED ABOVE
- R. HUMPHREY
- D. JESPERSEN
- C. SCHNOR
- D. JORDISON
- R. SHELQUIST
- L. ZEARLEY
- IOWA ROAD BUILDERS
- C. JONES

**SIGNED:** BERNARD C. BROWN  
TESTING ENGINEER
MIX, TYPE AND CLASS: SPECIAL SAND-CHEMCRETE LAB NO. AB00-144

INTENDED USE:

SIZE SPEC. NO. 852-857 DATE REPORTED 9/2/80

COUNTY STORY PROJECT L-WA-180-73-85

CONTRACTOR IOWA ROAD BUILDERS
ON ES7 ON THE N. LINE SEC. 31-83-24, 1 MI., FROM W 1/4 COR.
PROJ. LOCATION 20-84-24 SOUTH 2.4 MI. TO C.&N.W. RAILROAD

AGG. SOURCES SAND - WILLIAMS PIT - STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 100% AAT0-469

<table>
<thead>
<tr>
<th>SIZE</th>
<th>COUNTY STORY</th>
<th>SPEC. NO.</th>
<th>DATE REPORTED</th>
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<tbody>
<tr>
<td>1-1/2&quot;</td>
<td>L-WA-180-73-85</td>
<td>852-857</td>
<td>9/2/80</td>
</tr>
</tbody>
</table>

TOLERANCE:
75 BLOW MARSHALL DENSITY 2.26

ASPHALT SOURCE AND APPROXIMATE VISCOSITY SUGAR CREEK & CHEMCRETE-605 POISES

PLASTICITY INDEX 6.0

% ASPH. IN MIX 7.0 8.0

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 1260 1705 1642

FLOW - 0.01 IN. 8 8 9

SP. GR. BY DISPLACEMENT(LAB DENS.) 2.23 2.25 2.27

BULK SP. GR. COMB. DRY AGG. 2.658 2.658 2.658

SP. GR. ASPH. @ 77 F. 1.028 1.028 1.028

CALC. SOLID SP. GR. 2.45 2.41 2.38

% Voids - Calc. 8.9 6.7 4.5

RILL SP. DR. 2.43 2.40 2.36

% Voids - Rill 9.1 6.1 4.0

% WATER ABSORPTION - AGGREGATE 0.74 0.74 0.74

% Voids IN THE MINERAL AGGREGATE 21.1 21.3 21.4

% V.M.A. FILLED WITH ASPHALT 50.0 68.5 78.9

CALCULATED ASPH.FILM THICKNESS(MICRONS) 9.1 10.9 12.6

FILLER/BITUMEN RATIO 9.6

A CONTENT OF 7.0% ASPHALT - CHEMCRETE IS RECOMMENDED TO START THE JOB

COPIES:
ASPH. MIX DESIGN
PROJECTS LISTED ABOVE
R. HUMPHREY
D. JESPERSSEN
D. JORDISON
R. SHELUQUIT
L. ZEARLEY
IOWA ROAD BUILDERS
V. MARKS
C. JONES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER
MIX, TYPE AND CLASS: SPECIAL SAND

INTENDED USE: SPEC. NO. 852-857-861E REPORTED 9-2-80

COUNTY STORY PROJECT L-WA-180--73-85

CONTRACTOR IA. ROAD BUILDERS, L-F-180--73-85

PROJ. LOCATION ON E57 ON N. LINE SEC. 31-83-24, 1 MI. FROM W 1/4 COR. 26-84-24
SOUTH 2.4 MI. TO C & NW RAILROAD.

AGG. SOURCES SAND-WILLIAMS PIT - STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 100% AAA90-469

<table>
<thead>
<tr>
<th>JOB MIX FORMULA - COMBINED GRADATION</th>
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<tbody>
<tr>
<td>1-1/2&quot;</td>
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</table>

TOLERANCE:
75 BLOW MARSHALL DENSITY 2.28

ASPHALT SOURCE AND APPROXIMATE VISCOSITY SUGAR CREEK - 914 POISES

PLASTICITY INDEX N.P.

% ASPH. IN MIX 6.0 7.0 8.0

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 699 952 717

FLOW - 0.01 IN. 6 7 9

SP. GR. BY DISPLACEMENT(LAB DENS.) 2.22 2.27 2.28

BULK SP. GR. COMB. DRY AGG. 2.658 2.658 2.658

SP. GR. ASPH. @ 77 F. 1.029 1.029 1.029

CALC. SOLID SP.GR. 2.45 2.41 2.38

% IDS - CALC. 9.3 5.9 4.4

RILL SP. GR. 2.43 2.40 2.36

% VOIDS - RICE 8.6 5.3 3.4

% WATER ABSORPTION - AGGREGATE 0.74 0.74 0.74

% Voids in the Mineral Aggregate 21.5 20.6 21.1

% V.M.A. FILLED WITH ASPHALT 56.7 71.4 86.5

CALCULATED ASPH.FILM THICKNESS(MICRONS) 9.1 10.8 12.6

FILLER/BITUMEN RATIO 0.6

A CONTENT OF 7.0% ASPHALT IS RECOMMENDED TO START THE JOB.

COPIES:
ASPH. MIX DESIGN
PROJECTS LISTED ABOVE
JESPERSON
R. HUMPHREY
R. SHELQUIST
L. ZEARLEY
IA. ROAD BUILDERS
MARKS
C. JONES

SIGNED: BERNARD C. BROWN
TESTING ENGINEER
MATERIAL: ASPHALT CHEM-CRETE  
LAB NO.: 80-197

INTENDED USE: SPECIAL SAND MIXTURE & TYPE B CLASS 2 ACC

COUNTY: STORY

DESIGN: L-WA-180--73-85

PROJECT NO.: L-F-180--73-85

PRODUCER: CHEM-CRETE CORP.

SOURCE: BEAUMONT, TEXAS

CONTRACTOR: IOWA ROAD BUILDERS

UNIT OF MATERIAL: ONE TANKER. 38,440 LBS.

SAMPLED BY: BOB HOBSON

SAMPLED: 9/10/80  
RECEIVED: 9/11/80  
REPORTED: 9/16/80

SPECIFIC GRAVITY AT 60°F/60°F: 0.994

SOFT POINT: METHOD (R & B)

PENETRATION AT 77°F: 100 GMS. 5 SEC.

FLASH POINT:

SOLUBLE IN TRICHLOROETHYLENE: 97.49%

DUCTILITY AT 77°F:

SPOT TEST:

KINEMATIC VISCOSITY @ 140°F., CENTISTOKES: 3056

THIN FILM LOSS ON HEATING 5 HRS AT 325°F: 1.76%

% ORIGINAL PENETRATION (THIN FILM RES.):

PENETRATION OF RES. AT 77°F: 100 GMS. 5 SEC.

DUCTILITY AT 77°F (THIN FILM RES.): 37 CMS.

ABSOLUTE VISCOSITY ORIGINAL @ 140°F: 30 CM HG

31 POISES

ABSOLUTE VISCOSITY THIN FILM RES. @ 140°F: 30 CM HG

532 POISES

KIN. VISCOSITY ORIGINAL @ 275°F:

COPIES:

ASHPALT
R. HUMPHREY
PROJECTS LISTED ABOVE

DISPOSITION:

SIGNED: BERNARD C. BROWN
TESTING ENGINEER
B-7  1-4) Ductilad D1002
      5) Grams of Aggregate Chips Recovered
DUCTILAD™ D1002 is a liquid polymeric additive formulated to enhance the life and durability of asphalt cements and asphalt paving mixtures. DUCTILAD D1002 is particularly valuable when added to asphalt binders used in chip-seals or other surface treatments. DUCTILAD D1002 improves the initial “stickiness” of the asphalt cement and provides the binder with better long-term aged properties.

Primary factors affecting the durability and service life of a chip-seal or surface treatment are the amount of hardening of the asphalt binder during construction and the rate of age-hardening that the binder later displays during its service life. Throughout the United States, chip-seals have suffered premature failures due to the rapid oxidative aging of the asphalt binder and the attendant lack of chip adhesion.

Many physical characteristics of a surface seal, such as asphalt film thickness, aggregate properties, and environmental factors, affect the rate at which the asphalt cement will age and harden during the seal’s service life. Consequently, an accelerated laboratory test to accurately predict the actual in-service aging and hardening is not available. However, a binder’s tendency to age may be evaluated through some common laboratory tests.

Thin film oven tests of asphalt cements are widely used to measure changes in properties when asphalts are exposed, as thin films, to air at high temperatures. The relative changes in the asphalt cements’ properties are used to judge expected field performance. The effectiveness of DUCTILAD D1002 can be evaluated in these thin film oven tests. The ASTM D1754 procedure exposes a static film of asphalt cement to heat and air while the ASTM D2872 procedure exposes a moving or rolling film. The California Department of Transportation has developed a modified rolling thin film oven test to simulate the severe aging that an asphalt binder faces in the California deserts.

DUCTILAD D1002 when added at 1-4% by weight to asphalt cement dramatically changes the character of the asphalt cement. Additionally, DUCTILAD D1002 allows the asphalt binder to better maintain its initial characteristics after aging. On the facing page, the results from several thin film oven tests are shown. The results offer strong evidence that DUCTILAD D1002 reduces the aging of asphalt cements when exposed to severe conditions. The lowered viscosity increase and improved retained ductility means that the asphalt binder still has much of its original life and “stickiness” left, and this translates to longer chip-seal life.

DUCTILAD D1002 is designed for use in all surface seals and will not affect the design or placement of these seals. More detailed information about DUCTILAD D1002 is available upon request.
A. Thin Film Oven Tests (ASTM D1754)

DUCTILAD D1002 treated asphalt binders display improved aged characteristics.

DUCTILAD D1002 retains more of the AC's original viscosity and ductility under laboratory aging tests.

B. California Tilt Oven Asphalt Durability Test

Under simulated desert conditions, DUCTILAD D1002's improvements are dramatic.
Ductilad™ D1002
Asphalt Additive

Description:
Ductilad D1002 asphalt additive is an easy to handle, liquid containing polymer for use in chip-seals and other surface seals. Ductilad D1002 improves the tackiness of the asphalt binder while improving the aged properties of the binder.

Typical Properties:

Form: Liquid
Appearance: Clear, Amber
Viscosity (104°F): 6,000 cSt
(212°F): 750 cSt
LBS/GAL: 7.56
Flash Point (C.O.C.): 310°F
Pour Point: 23°F

Availability:
Bulk (tank car or tank truck).
55 gallon non-returnable drums.
FOB Painesville, Ohio; Deer Park, Texas

Contact:
LBD Asphalt Products Company
99400 Lakeland Blvd.
Wickliffe, Ohio 44092
Phone: (216) 261-9681
Grams of Aggregate Chips Removed

Year


Grams (Thousands)

17 16.5 16 15.5 15 14.5 14 13.5 13

Control
Ductilad D1002
B-8 1) Ralumac
MIX, TYPE AND CLASS: RALUMAC

INTENDED USE:

SIZE 3/8'

COUNTY POLK & BOONE

CONTRACTOR N.B. WEST

PROJ. LOCATION U.S. 69 FROM JUST N. OF 1ST STREET IN ANKENY N. 5.0 MILES ON IOWA 17 FROM JUST N. OF U.S. 30 NORTH & EAST, APPROX. 3 MILES

AGG. SOURCES 3/8' CR. LST. - AMES MINE - STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 100% AAT2-401

<table>
<thead>
<tr>
<th>1-1/2&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>
<th>No.16</th>
<th>No.30</th>
<th>No.50</th>
<th>No.100</th>
<th>No.200</th>
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</thead>
<tbody>
<tr>
<td>100</td>
<td>80</td>
<td>56</td>
<td>42</td>
<td>34</td>
<td>24</td>
<td>17</td>
<td>12</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

TOLERANCE:

PARTS RALUMAC ADDED: 10

ASPHALT SOURCE AND APPROXIMATE VISCOSITY:

RALUMAC

PITSTICITY INDEX:

ASPH. IN MIX: 6.0 7.1 8.2

NUMBER OF MARSHALL BLOWS:

50 50 50

MARSHALL STABILITY - LBS.

3700 3722 2667

FLOW - 0.01 IN.

13 16 25

SP. GR. BY DISPLACEMENT (LAB DENs.):

2.33 2.34 2.36

BULK SP. GR. COMB. DRY AGG.

2.617 2.617 2.617

SP. GR. ASPH. @ 77 F.

1.026 1.026 1.026

CALC. SOLID SP. GR.

2.43 2.39 2.35

% VOIDS - CALC.

4.1 2.1 -0.3

RICE SP. GR.

% VOIDS - RICE

1.31 1.31 1.31

% WATER ABSORPTION - AGGREGATE

16.3 16.9 17.2

% VOIDS IN THE MINERAL AGGREGATE

74.9 87.4 101.5

% V.M.A. FILLED WITH ASPHALT

CALCULATED ASPH. FILM THICKNESS (MICRONS)

5.5 6.7 7.9

A CONTENT OF 11 PARTS TOTAL EMULSION AND 9 PARTS TOTAL WATER IS RECOMMENDED TO START THE JOB. THE MIXTURE ALSO CONTAINS 2 PARTS TYPE 1 CEMENT AND 2 PARTS ADDITIVE P.

COPIES:

ASPH. MIX DESIGN
R. HUMPHREY
B. DUNSHEE
R. SHELQUIST
L. ZEARLEY
T. CACKLER
N.B. WEST
KEN GILL
DIST. 1 LAB
F. BLAIR

SIGNED: BERNARD C. BROWN
DISTRICT 1 MATERIALS
B-9 1) UltraPave
MIX, TYPE AND CLASS: TYPE B CLASS 2  LAB NO. ADD3-07

INTENDED USE:

SIZE 3/4"  SPEC. NO. 915  DATE REPORTED 7-6-83

COUNTY STORY  PROJECT SN-4793(3) -- 51-85

CONTRACTOR MANATTS

PROJ. LOCATION ON E. 29 FROM S14 3 MI. N OF NEVADA EAST 3.0 MILES


JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AAT3-370; 15% AAT3-379; 20% AAT3-380

JOB MIX FORMULA - COMBINED GRADATION

<table>
<thead>
<tr>
<th>1-1/2&quot;</th>
<th>1&quot;</th>
<th>3/4&quot;</th>
<th>1/2&quot;</th>
<th>3/8&quot;</th>
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<th>N0.8</th>
<th>NO.16</th>
<th>NO.30</th>
<th>NO.50</th>
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<tbody>
<tr>
<td>100</td>
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<td>79</td>
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<td>42</td>
<td>34</td>
<td>17</td>
<td>7.1</td>
<td>4.42</td>
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</tbody>
</table>

TOLERANCE: 98/100 7  7  6  5  3*

75 BLOW MARSHALL DENSITY 2,35

ASPHALT SOURCE AND APPROXIMATE VISCOSITY KOCH - 974 POISES

PLASTICITY INDEX N.P.

% ASPH. IN MIX 5.5 6.5 7.5

NUMBER OF MARSHALL BLOWS 50 50 50

MARSHALL STABILITY - LBS. 1387 1137 870

FLOW - 0.01 IN. 7 9 15

SP. GR. BY DISPLACEMENT (LAB DEN.) 2.32 2.33 2.34

BULK SP. GR. COH. DRY ABB. 2.655 2.655 2.655

SP. GR. ASPH. @ 77 F. 1.029 1.029 1.029

CALC. SOLID SP. GR. 2.48 2.44 2.40

% VOIDS - CALC. 6.3 4.5 2.7

RICE SP. GR. 2.45 2.41 2.38

% VOIDS - RICE 5.2 3.4 1.7

% WATER ABSORPTION - AGGREGATE 1.10 1.10 1.10

% Voids in the mineral aggregate 17.4 18.9 18.5

% V.M.A. FILLED WITH ASPHALT 64.0 72.1 85.6

CALCULATED ASPH. FILM THICKNESS (MICRONS) 8.5 10.4 12.2

FILLER/BITUMEN RATIO 0.7

A CONTENT OF 6.50% ASPHALT IS RECOMMENDED TO START THE JOB.

* ALSO CONTROLLED BY FILLER/BITUMEN RATIO.

COPIES:

ASPH. MIX DESIGN
PROJECT SN-4793(3) -- 51-85, STORY
R. HUMPHREY
J. JORESHON
D. JORDISON
R. SHELQUIST
L. ZEARLEY
MANATTS
W. OPPEDAL

SIGNED: BERNARD C. BROWN

TEST TUR FRAZIER
B-10  
1) Asphadur  
2) Asphadur

Binder  
Surface
MIX, TYPE AND CLASS: TYPE A ASPHALT CEMENT 

INTENDED USE: BINDER 

SIZE 3/4 

COUNTY POTAWATTAMIE 

CONTRACTOR OMNI ENGR. 

PROJ. LOCATION NO. RIVER TO I-29 

AGG. SOURCES CR. LST. & SAND - SCHILDBERG, CRESCENT, POTAWATTAMIE CO. 

JOB MIX FORMULA AGGREGATE PROPORTIONS: 85% AATB-25; 15% AATB-26 

<table>
<thead>
<tr>
<th>MPH</th>
<th>1/2'</th>
<th>3/4'</th>
<th>1'</th>
<th>3/8'</th>
<th>1/2'</th>
<th>3/8'</th>
<th>1/2'</th>
<th>2'</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>99</td>
<td>81</td>
<td>61</td>
<td>36</td>
<td>24</td>
<td>20</td>
<td>16</td>
<td>7.5</td>
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</table>

TOLERANCE: 98/100 7 7 7 5 4 2

ASPHALT ADDED 

PRODUCT VISCOSITY KOCH 2350 POISES 

PLASTICITY INDEX 

% ASPH. IN MIX 4.25 5.25 6.25 

NUMBER OF MARSHALL BLOWS 13 14 16 

MARSHALL STABILITY - LBS. 2,338 2,359 2,360 

SP.GR. BY DISPLACEMENT(LAB DENS.) 2.633 2.633 2.633 

BULK SP. GR. COMB. DRY AGG. 1.503 1.036 1.036 

SP. GR. ASPH. @ 77 F. 2.503 2.466 2.431 

CALC. SOLID SP.GR. 6.59 4.35 2.92 

RICE SP. GR. 2.459 2.426 2.411 

% Voids - Calc. 4.92 2.76 2.12 

% WATER ABSORPTION - AGGREGATE 1.11 1.11 1.11 

% Voids in the mineral aggregate 14.98 15.11 15.97 

% V. M. A. FILLED WITH ASPHALT 54.03 71.19 81.73 

CALCULATED ASPH. FILM THICKNESS(MICRONS) 8.25 10.48 12.71 

FILLER/BITUMEN RATIO 1.17 

A CONTENT OF 4.62% ASPHALT IS RECOMMENDED TO START THE JOB. 

*ALSO CONTROLLED BY FILLER/BITUMEN RATIO. NUC. CAL.: INVALID 

SIGNED: ORRIS L. LANE, JR. 

TESTING ENGINEER 

81
MIX, TYPE AND CLASS: TYPE A ASPHALUR LAB NO. ABD8-9

INTENDED USE: SURFACE

SIZE 3/4" SPEC. NO. 1048 DATE REPORTED 4/5/88

COUNTY POTWAWATTAMIE PROJECT IR-480-1(117)A--12-78

CONTRACTOR OMNI ENGR.

PROJ. LOCATION NO. RIVER TO I-29

AGG. SOURCES QUARTZITE CONC. MATLS., SIOUX FALLS S.D.; CR. LST. -SCHILDBERG, CRESCENT, POTWAWATTAMIE CO.; SAND - MARTIN MARIE, GRETNA NE

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AATB-27; 20% AATB-28; 15% AATB-29

<table>
<thead>
<tr>
<th>1-1/2&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>
<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>
<td>100</td>
<td>95</td>
<td>69</td>
<td>48</td>
<td>37</td>
<td>31</td>
<td>23</td>
<td>15</td>
<td>9.1</td>
<td>6.3</td>
<td>4.9</td>
<td></td>
</tr>
</tbody>
</table>

TOLERANCE: 95/100 7 7 7 5 4 2%

HYDRATED LIME & ASPHALUR - ADDED

ASPHALUR SOURCE AND APPROXIMATE VISCOSE KOCH - 2350 POISES

PLASTICITY INDEX

% ASPH. IN MIX 4.0 5.0

NUMBER OF MARSHALL BLOWS 75 75

MARSHALL STABILITY - LBS. 3515 3497

FLOW - 0.01 IN. 11 19

SP.GR. BY DISPLACEMENT(LAB DENS.) 2.356 2.379

BULK SP. GR. COMB. DRY AGG. 2.634 2.634

1.923 1.636

1.636

CALC. SOLID SP. GR. 2.492 2.456

RICE SP. GR. 2.472 2.440

% RICE - RICE 4.69 2.50

% WATER ABSORPTION - AGGREGATE 0.46 0.40

% voids in the mineral aggregate 14.13 14.20

X.V.M.A. FILLED WITH ASPHALUR 61.28 77.80

CALCULATED ASPH.FILM THICKNESS(MICRONS) 8.33 10.52

FILLER/BITUMEN RATIO 1.14

A CONTENT OF 4.3% ASPHALUR IS RECOMMENDED TO START THE JOB.

* ALSO CONTROLLED BY FILLER/BITUMEN RATIO. NUC. CAL: NONE,

MATERIAL.

COPY: ASPHALT MIX DESIGN

IR-480-1(117)A--12-78, POTWAWATTAMIE

G. MILLER W. COOK
R. MONROE J. SMYTHE
D. HEINS OMNI ENGRS.
W. DIPPEL

SIGNED: ORRIS J. LANES, JR.
TESTING ENGINEER
<table>
<thead>
<tr>
<th>B-11</th>
<th>1) Ralumac</th>
<th>Design</th>
</tr>
</thead>
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<tr>
<td></td>
<td>2) Ralumac</td>
<td>Performance</td>
</tr>
<tr>
<td></td>
<td>3) Ralumac</td>
<td>Rut Filling</td>
</tr>
</tbody>
</table>
KOCH MATERIALS COMPANY  
Chicago, Il.

DATE: 06-08-88  
SALESMAN: Bill Miteff

CUSTOMER: Scott Const.  
FILE #: RAL-8804

SOURCE: Franklin, Wi. Agg. #1

### RALUMAC MICROSURFACING DESIGN

#### GRADATION:

<table>
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<tr>
<th>Sieve Size</th>
<th>Percent Retained</th>
<th>Percent Passing</th>
<th>Ralumac Type I Spec.</th>
<th>Ralumac Type II Spec.</th>
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<td>#4</td>
<td>7.0</td>
<td>93.0</td>
<td>90 - 100</td>
<td>70 - 90</td>
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<tr>
<td>8</td>
<td>26.8</td>
<td>66.2</td>
<td>65 - 90</td>
<td>45 - 65</td>
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<tr>
<td>16</td>
<td>23.5</td>
<td>42.7</td>
<td>40 - 65</td>
<td>30 - 50</td>
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<tr>
<td>30</td>
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<td>50</td>
<td>9.9</td>
<td>19.0</td>
<td>15 - 30</td>
<td>12 - 25</td>
</tr>
<tr>
<td>100</td>
<td>6.6</td>
<td>12.4</td>
<td>10 - 21</td>
<td>7 - 18</td>
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<tr>
<td>200</td>
<td>4.5</td>
<td>7.9</td>
<td>5 - 13</td>
<td>4 - 12</td>
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#### MARSHALL SPECIMEN:

<table>
<thead>
<tr>
<th>Residual Asphalt Content</th>
<th>Stability at 140 F lbs.</th>
<th>Flow .01 inch</th>
<th>VMA</th>
<th>VTM</th>
<th>Density lbs/cf</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.0</td>
<td>3055</td>
<td>9</td>
<td>19.7</td>
<td>7.0</td>
<td>142.8</td>
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<tr>
<td>6.5</td>
<td>3067</td>
<td>13</td>
<td>19.6</td>
<td>5.8</td>
<td>143.7</td>
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<tr>
<td>7.0</td>
<td>3702</td>
<td>15</td>
<td>17.7</td>
<td>2.4</td>
<td>147.9</td>
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<tr>
<td>7.5</td>
<td>3336</td>
<td>14</td>
<td>17.9</td>
<td>1.6</td>
<td>148.2</td>
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</table>

#### COHESION TESTS:

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<tr>
<th>% PC</th>
<th>% Water</th>
<th>% Add</th>
<th>% Emul</th>
<th>Max. Mix Time</th>
<th>Set Time</th>
<th>Cohesion at (min.)</th>
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</thead>
<tbody>
<tr>
<td>1/4</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>120&quot;</td>
<td>7'</td>
<td>17</td>
</tr>
<tr>
<td>1/2</td>
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<td>2</td>
<td>10</td>
<td>90&quot;</td>
<td>6'</td>
<td>19</td>
</tr>
<tr>
<td>3/4</td>
<td>5</td>
<td>2</td>
<td>10</td>
<td>80&quot;</td>
<td>6'</td>
<td>16</td>
</tr>
<tr>
<td>1/2</td>
<td>4</td>
<td>3</td>
<td>10</td>
<td>110&quot;</td>
<td>6'</td>
<td>17</td>
</tr>
</tbody>
</table>
Performence Properties vs. Residual Asphalt Content

1. Stability - 140 F (lbs)
2. Density (lbs/ cf)
3. Flow .01 inch
4. % Voids - Total Mix
5. % Total Voids filled with Asphalt
6. % VMA
Rut Filling with Micro-Surfacing

<table>
<thead>
<tr>
<th>Rut Depth</th>
<th>.25&quot;</th>
<th>.50&quot;</th>
<th>.75&quot;</th>
<th>1.0&quot;</th>
<th>1.25&quot;</th>
<th>1.50&quot;</th>
</tr>
</thead>
</table>

The 48" and the 72" wide rut boxes are most commonly used. When the rut boxes are in use, any rut demanding more than 50 lbs./sq. yd. is pulled in two or more passes.

Micro-Surfacing

Pounds per square yard-straight surfacing

<table>
<thead>
<tr>
<th>36&quot;</th>
<th>12</th>
<th>25</th>
<th>37</th>
<th>49</th>
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</thead>
<tbody>
<tr>
<td>by</td>
<td>1/8&quot;</td>
<td>1/4&quot;</td>
<td>3/8&quot;</td>
<td>1/2&quot;</td>
</tr>
</tbody>
</table>
B-12 1) PAC 30  
Binder/Surface
MIX TYPE AND CLASS: TYPE A  
INTENDED USE: BINDER & SURFACE  

SIZE 1/2"  SPEC. NO. 1010  DATE REPORTED 6/23/86  
COUNTY POLK  PROJECT W.O. 0206-85-009  
CONTRACTOR D. M. ASPHALT  

PROJ. LOCATION IN DES MOINES ON FLEUR DR. FROM MCKINLEY TO R.R. VIADUCT  

AGG. SOURCES QUARTZIT - WEAVER, SAUK CO., WI.; LST. CHIPS - MARTIN MARIETTA, AMES MINE, STORY CO.; SAND - HALLIETT, E. O. M., POLK CO.  

JOB MIX FORMULA AGGREGATE PROPORTIONS: 55% AAT6-272; 12.5% AAT6-273; 32.5% AAT6-275  

<table>
<thead>
<tr>
<th>JOB MIX FORMULA - COMBINED GRADATION</th>
<th>1/2&quot;</th>
<th>1&quot;</th>
<th>3/4&quot;</th>
<th>1&quot;/2&quot;</th>
<th>3/8&quot;</th>
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<td>100</td>
<td>95</td>
<td>68</td>
<td>52</td>
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<td>14</td>
<td>6.9</td>
<td>5.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|
| O L E R A N C E:                       | 98/100 | 7 | 7 | 5 | 4 | 2 |

SPHALT SOURCE AND APPROXIMATE VISCOSITY  

BITUCOTE POLYMERIZED-2450 POISES  

<table>
<thead>
<tr>
<th>LASTICITY INDEX</th>
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<th>6.5</th>
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</thead>
<tbody>
<tr>
<td>ASPH. IN MIX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JMBER OF MARSHALL BLOWS</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>MARSHALL STABILITY - LBS.</td>
<td>2213</td>
<td>2027</td>
</tr>
<tr>
<td>OW - 0.01 IN.</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>JGR. BY DISPLACEMENT (LAB DENS.)</td>
<td>2.321</td>
<td>2.347</td>
</tr>
<tr>
<td>ILK SP. GR. COMB. DRY AGG.</td>
<td>2.646</td>
<td>2.646</td>
</tr>
<tr>
<td>J. GR. ASPH. @ 77 F.</td>
<td>1.025</td>
<td>1.025</td>
</tr>
<tr>
<td>LC. SOLID SP.GR.</td>
<td>2.449</td>
<td>2.414</td>
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<tr>
<td>VOIDS - CALC.</td>
<td>5.23</td>
<td>2.76</td>
</tr>
<tr>
<td>CE SP. GR.</td>
<td>2.443</td>
<td>2.414</td>
</tr>
<tr>
<td>VOIDS - RICE</td>
<td>4.99</td>
<td>2.78</td>
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<tr>
<td>WATER ABSORPTION - AGGREGATE</td>
<td>0.54</td>
<td>0.54</td>
</tr>
<tr>
<td>VOIDS IN THE MINERAL AGGREGATE</td>
<td>17.11</td>
<td>17.07</td>
</tr>
<tr>
<td>V.M.A. FILLED WITH ASPHALT</td>
<td>69.42</td>
<td>83.83</td>
</tr>
<tr>
<td>CULATED ASPH.FILM THICKNESS (MICRONS)</td>
<td>9.42</td>
<td>11.34</td>
</tr>
<tr>
<td>LER/BITUMEN RATIO</td>
<td>0.85</td>
<td></td>
</tr>
</tbody>
</table>

CONTENT OF 5.9% ASPHALT IS RECOMMENDED TO START THE JOB.  

ASPHALT DID NOT COMPLY WITH ALL P.A.C. 30 CRITERIA.  

SIGNED: MAX I. SMEELLER

G. Nauka (6-26-86)
B-13 1) PAC 30  
2) PAC 30  

Surface
Binder
MIX, TYPE AND CLASS: TYPE A

INTENDED USE: SURFACE

SIZE: 1/2

LAB NO. ABDB-147

COUNTY: STORY

PROJECT: FN-69-5(36)--21-85

CONTRACTOR: MANATTS

PROJ. LOCATION: IN AMES ON DUFF SQUAW DR. TO SO. 4TH & ON GRAND AVE.

AGG. SOURCES:
- CR. GRAVEL-HALLETT, BOONE, BOONE CO;
- CR. LST- MARTIN MARIETTA;
- AMES MINE, STORY CO;
- SAND-HALLETT, CHRISTENSEN PIT, STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS:
- 40% AAT8-646
- 35% AAT8-647
- 25% AAT8-648

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

1-1/2' 1' 3/4' 1/2' 3/8' N0.4 N0.8 N0.16 N0.30 N0.50 N0.100 N0.200
100 60 56 40 31 20 11 6.0 4.5

TOLERANCE: 92/100

ASPHALT SOURCE AND APPROXIMATE VISCOSITY:

<table>
<thead>
<tr>
<th>KOCH</th>
<th>2106 POISES</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.0</td>
<td>5.0</td>
</tr>
</tbody>
</table>

PLASTICITY INDEX:

- % ASPH. IN MIX: 75
- NUMBER OF MARSHALL BLOWS: 3707
- MARSHALL STABILITY - LBS.: 3430
- FLOW - 0.01 IN.: 9
- SP.GR. BY DISPLACEMENT(LAB DENS.): 2.369
- BULK SP. GR. COMB. DRY AGG.: 2.695
- SP. GR. ASPH. @ 77 F.: 0.9963
- CALC. SOLID SP.GR.: 2.561
- % voids - calc.: 7.48
- RICE SP. GR.: 2.531
- % voids - RICE: 6.40
- % WATER ABSORPTION - AGGREGATE: 1.21
- % voids in the mineral aggregate: 15.61
- % V.M.A. FILLED WITH ASPHALT: 52.07
- CALCULATED ASPH. FILM THICKNESS(MICRONS): 6.91
- FILLER/BITUMEN RATIO: 0.94

A CONTENT OF 4.8% ASPHALT IS RECOMMENDED TO START THE JOB.

*ALSO CONTROLLED BY FILLER/BITUMEN RATIO.

NUC. CAL: TEMP= 210; WT= 7200; SLOPE= 4.44; 1' CEFT= (-5.15)

COPY: ASPHALT MIX DESIGN
- R. NUMM
- T. JACOBSON
- R. MONROE
- J. SHYTHE
- D. HEINS
- MANATTS
- W. OPPEDAL

FN-69-5(36)--21-85, STORY

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER
MIX, TYPE AND CLASS: TYPE A  
LAB NO. AB08-136

INTENDED USE: BINDER

SIZE 3/4"  
SPE. NO. 1048  
DATE REPORTED 7/19/88

COUNTY STORY  
PROJECT FN-69-5(36)--21-85

CONTRACTOR MANATTS

PROJ. LOCATION ON S. DUFF AVE. AND ON NORTH GRAND IN AMES

AGG. SOURCES CR. LST. & CHIPS - MARTIN MARIETTA, AMES MINE, STORY CO.;  
SAND - HALLETTS, CHRISTENSEN PIT, STORY CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AATB-566; 16% AATB-547; 25% AATB-566

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

1-1/2"  1"  3/4"  1/2"  3/8"  NO.4  NO.8  NO.16  NO.30  NO.50  NO.100  NO.200
100  99  86  70  48  27  18  9.0  5.2  4.4

TOLERANCE: 98/100 7 7 7 .5

ASPHALT SOURCE AND APPROXIMATE VISCOSITY KOCH - 2106 POISES

PLASTICITY INDEX

% ASPH. IN MIX 3.75 4.75 5.75
NUMBER OF MARSHALL BLOWS 75 75 75
MARSHALL STABILITY - LBS. 2790 3037 2683
FLOW - 0.61 IN. 8 7 7
SP. GR. BY DISPLACEMENT (LAB DENS.) 2.344 2.389 2.397
BULK SP. GR. COMB. DRY AGG. 2.693 2.693 2.693
SP. GR. ASPH. @ 77 F. 1.020 1.020 1.020
CALC. SOLID SP. GR. 2.594 2.553 2.514
% VOIDS - CALC. 9.65 6.44 4.65
RICE SP. GR. 2.526 2.487 2.461
% VOIDS - RICE 6.76 3.94 2.60
% WATER ABSORPTION - AGGREGATE 1.85 1.85 1.85
% VOIDS IN THE MINERAL AGGREGATE 16.22 15.59 16.11
% V.H.A. FILLED WITH ASPHALT 40.81 58.45 71.16
CALCULATED ASPH. FILM THICKNESS (MICRONS) 6.3 8 6 10.85

FILLER/BITUMEN RATIO 0.94

A CONTENT OF 4.7% ASPHALT IS RECOMMENDED TO START THE JOB.  
# ALSO CONTROLLED BY FILLER/BITUMEN RATIO.

NOC. CAL. INVALID

COPIES:  
ASPH. MIX DESIGN  
FN 69-5(36)--21-85, STORY  
R. MUMM  
T. JACOBSON  
R. MONROE  
J. SMYTHE  
D. HEINS  
MANATTS  
W. OPPEDAL

SIGNED: ORRIS J. LANE, JR.  
TESTING ENGINEER
<table>
<thead>
<tr>
<th>B-14</th>
<th>1) Conventional</th>
<th>Binder</th>
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<tbody>
<tr>
<td></td>
<td>2) PAC 40</td>
<td>Surface</td>
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MIX, TYPE AND CLASS: TYPE A RECYCLED  

INTENDED USE: BINDER  

SIZE 3/4"  

COUNTY OSCEOLA  

LOCATION AMES  

LAB NO. ABD7-72  

DATE REPORTED 6/17/87  

SPEC. NO. 1030  

PROJECT FN-60-3(11)--21-71  

CONTRACTOR ROHLIN  

PROJ. LOCATION FROM U.S. 18 IN SHELTON TO C&NW RR IN SIBLEY  

MILLED @ 6.20% - PROJECT; 1/4" CR. LST. & 3/4" CHIPS - MIDWEST  

AGG. SOURCES LIMESTONE, GILMORE CITY, POCAHONTAS CO.; PIT RUN GRAVEL - HALLETTS, 28-98-42, OSCEOLA CO.  

JOB MIX FORMULA AGGREGATE PROPORTIONS: 35% ABC7-114; 26% AAT7-429; 25% AAT7-428  

JOB MIX FORMULA - COMBINED GRADATION  

TOLERANCE: 98/100  

% ASPHALT ADDED 2.33  

ASPHALT SOURCE AND APPROXIMATE VISCOSITY AMOCO - 299 POISES  

PLASTICITY INDEX  

% ASPH. IN MIX 4.5  

NUMBER OF MARSHALL BLOWS 50  

MARSHALL STABILITY - LBS. 3367  

FLOW - 0.01 IN. 10  

SP. GR. BY DISPLACEMENT (LAB DENS.) 2.344  

BULK SP. GR. CONB. DRY AGG. 2.649  

SP. GR. ASPH. @ 77 F. 1.020  

CALC. SOLID SP. GR. 2.502  

% VOIDS - CALC. 6.33  

RICE SP. GR. 2.479  

% VOIDS - RICE 5.45  

% WATER ABSORPTION - AGGREGATE 1.07  

% VOIDS IN THE MINERAL AGGREGATE 15.50  

% V.M.A. FILLED WITH ASPHALT 59.16  

CALCULATED ASPH. FILM THICKNESS (MICRONS) 7.38  

FILLER/BITUMEN RATIO 1.04  

A CONTENT OF 5.2% ASPHALT IS RECOMMENDED TO START THE JOB.  

THIS IS AN ADD. 3.03% AC 2.5; ALSO CONTROLLED BY FILLER/BITUMEN RATIO  

C. LEONARD  

W. BENNETT  

R. MONROE  

J. SMYTHE  

D. HEINS  

ROHLIN  

W. OPPEDAL  

SIGNED: Orris J. Lane, Jr.  

TESTING ENGINEER
MIX: TYPE AND CLASS: TYPE A  
LAB NO. ABD7-294

INTENDED USE: SURFACE

SIZE 3/4  
SPEC. NO. 1636  
DATE REPORTED 9-16-87

COUNTY O’BRIEN  
PROJECT FN-6C-3(11) -- 21-71

CONTRACTOR: ROHLIN

PROJ. LOCATION: FROM U.S. 18 TO RR IN SIBLEY

AGG. SOURCES: CR. GRAVEL & GRAVEL- ROHLIN, 32-98-37, DICKINSON CO.

JOB MIX FORMULA AGGREGATE PROPORTIONS: 65% AAT7-1120; 35% AAT7-1121

JOB MIX FORMULA - COMBINED GRADATION

<table>
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<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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<tbody>
<tr>
<td>1-1/2&quot;</td>
<td>100</td>
<td>99</td>
<td>76</td>
<td>62</td>
<td>46</td>
<td>34</td>
<td>27</td>
</tr>
<tr>
<td>1&quot;</td>
<td>17</td>
<td>19</td>
<td>10</td>
<td>6.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>2%</td>
<td></td>
<td></td>
<td></td>
</tr>
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</table>

TOLERANCE: 98/100 7 7 7 5 4 2%

ASPHALT SOURCE AND APPROXIMATE VISCOSITY

<table>
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<tr>
<th>ASPH. IN MIX</th>
<th>JBERO</th>
<th>3350 POISES</th>
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<tbody>
<tr>
<td>3.75</td>
<td>5.75</td>
<td>6.75</td>
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FLUIDITY INDEX

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<tr>
<th>NUMBER OF MARSHALL BLOWS</th>
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<tr>
<td>MARSHALL STABILITY - LBS.</td>
<td>2952</td>
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<td>FLOW - 0.01 IN.</td>
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SP. GR. BY DISPLACEMENT (LAB DENS.)

<table>
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<tr>
<th>SP. GR. BY DISPLACEMENT (LAB DENS.)</th>
<th>2.369</th>
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<tr>
<td>BULK SP. GR. COMB. DRY AGG.</td>
<td>2.674</td>
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<tr>
<td>SP. GR. ASPH. @ 77 F.</td>
<td>1.034</td>
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<tr>
<td>CALC. SOLID SP. GR.</td>
<td>2.516</td>
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<tr>
<td>% VOIDS - CALC.</td>
<td>3.91</td>
</tr>
<tr>
<td>RICE SP. GR.</td>
<td>2.500</td>
</tr>
<tr>
<td>% VOIDS - RICE</td>
<td>5.22</td>
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<tr>
<td>% WATER ABSORPTION - AGGREGATE</td>
<td>1.00</td>
</tr>
<tr>
<td>% VOID IN. THE MINERAL AGGREGATE</td>
<td>15.30</td>
</tr>
<tr>
<td>% V.M.A. FILLED WITH ASPHALT</td>
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<tr>
<td>CALCULATED ASPH. FILM THICKNESS/HIORS</td>
<td>9.67</td>
</tr>
<tr>
<td>FILLER/ELEMENT RATIO</td>
<td>1.00</td>
</tr>
</tbody>
</table>

A CONTENT OF 5.0% ASPHALT IS RECOMMENDED TO START THE JOB.

ALSO CONTROLLED BY FILLER/ELEMENT RATIO.

MIX. CAL.: DONE

COPIES:

ASPHALT MIX DESIGN

SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER
B-15  1) PAC 30  Surface
MATERIAL ........: TYPE A MODIFIED
INTENDED USE .......: SURFACE
PROJECT NO .......: K.O. 0206-87-003
COUNTY ...........: POLK
SPEC NO ...........: 1070.00
SAMPLED BY .......:
DATE SAMPLED: 
DATE RECEIVED: 
PROJ. LOCATION: ON FLEUR DRIVE IN DES MOINES
AGG SOURCES: CR. LST- MARTIN MARIETTA, AMES MINE, STORY CO.;
QUARTZITE- MARTIN MARIETTA, ROCK SPRINGS, WI;
SAND- HALLETT, EDM, POLK CO.

JOB MIX FORMULA-COMB. GRADATION

1 1/2" 1" 3/4" 1/2" 3/8" NO.4 NO.8 NO.16 NO.30 NO.50 NO.100 NO.200
100.0 92.0 75.0 58.0 44.0 35.0 24.0 10.0 5.4 4.6

TOLERANCE /100 :
98 7 7 5 4 2

MATERIAL MIX A85006 AW1004 A77522
% AGGR. PROP. 50.00 15.00 35.00 0.00 0.00

% ASPHALT IN MIX 4.75 5.75 0.00 0.00
NUMBER OF MARSHALL BLOWS 75 75 0 0
MARSHALL STABILITY - LBS. 2870 2583 0 0
FLOW - 0.01 IN. 9 11 0 0
SP GR BY DISPLACEMENT (LAB DENS) 2.372 2.385 0.000 0.000
BULK SP. GR. COMB. DRY AGG. 2.667 2.667 0.000 0.000
SP. GR. ASPH. @ 77 F. 1.024 1.024 0.000 0.000
CALC. SOLID SP. GR. 2.508 2.471 0.000 0.000
% VOIDS - CALC. 5.44 3.48 0.00 0.00
RICE SP.GR. 2.473 2.436 0.000 0.000
% VOIDS - RICE 4.08 2.09 0.00 0.00
% WATER ABSORPTION - AGGREGATE 1.05 1.05 0.00 0.00
% VOIDS IN MINERAL AGGREGATE 15.29 15.72 0.00 0.00
% V.M.A. FILLED WITH ASPHALT 64.40 77.88 0.00 0.00
CALC. ASPH. FILM THICK. MICRONS 8.39 10.37 0.00 0.00
FILLER/BITUMEN RATIO 0.00 0.97 0.00 0.00

A CONTENT OF 4.75% ASPHALT IS RECOMMENDED TO START THE JOB.
TOLERANCE ON #200 ALSO CONTROLLED BY FILLER/BITUMEN RATIO.

COPIES TO:
CENTRAL LAB
R. MONROE
D. HEINS
DES MOINES ASPHALT
W. OPPEDAL
CITY OF DES MOINES
DIST. 1

SIGNED: ORRIS J. LANE, JR.
Appendix C
Core Density and Percent Air
### Asphalt Concrete Cores Test Report

**Location:** Ames  
**Lab No.:** ABE1-0018

**Material:** Asphalt Cores Site #1  
**Project No.:** HR-542  
**County:** Jasper  
**Unit of Material:** Conventional Cores #51, 52, 53, 54 EB Driving Lane, Cores 51 & 52 1/4 PT, 53 & 54 OWT 51A, 52A, 53A, 54A are the Binder Cores

**Sampled by:** C. Anderson  
**Sender No.:** ACA1-12  
**Date Sampled:** 11/06/91  
**Date Received:** 02/13/91  
**Date Reported:** 03/21/91

<table>
<thead>
<tr>
<th>Core</th>
<th>Surface Density</th>
<th>% Air (HPM)</th>
<th>Binder Density</th>
<th>% Air (HPM)</th>
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<tbody>
<tr>
<td>51</td>
<td>2.341</td>
<td>4.6</td>
<td>2.318</td>
<td>6.8</td>
</tr>
<tr>
<td>52</td>
<td>2.367</td>
<td>3.4</td>
<td>2.328</td>
<td>5.4</td>
</tr>
<tr>
<td>53</td>
<td>2.367</td>
<td>3.6</td>
<td>2.360</td>
<td>3.6</td>
</tr>
<tr>
<td>54</td>
<td>2.370</td>
<td>3.1</td>
<td>2.344</td>
<td>5.8</td>
</tr>
<tr>
<td>51A</td>
<td></td>
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<td>2.318</td>
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<tr>
<td>52A</td>
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<td></td>
<td>2.328</td>
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<tr>
<td>53A</td>
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<td></td>
<td>2.360</td>
<td></td>
</tr>
<tr>
<td>54A</td>
<td></td>
<td></td>
<td>2.344</td>
<td></td>
</tr>
</tbody>
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---

**Material:** Asphalt Cores Site #1  
**Project No.:** HR-542  
**County:** Jasper  
**Unit of Material:** PAC 40 SBS Cores 55, 56, 57, 58 EB Driving Lane, Cores 55, 56 OWT; 57, 58 1/4 PT. 55A, 56A, 57A, 58A are the Binder Cores

**Sampled by:** Anderson  
**Date Sampled:** 11-6-90  
**Date Received:** 2-13-91  
**Date Reported:** 2-21-91

<table>
<thead>
<tr>
<th>Core</th>
<th>Surface Density</th>
<th>% Air (HPM)</th>
<th>Binder Density</th>
<th>% Air (HPM)</th>
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</thead>
<tbody>
<tr>
<td>55</td>
<td>2.373</td>
<td>3.7</td>
<td>2.306</td>
<td>8.4</td>
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<tr>
<td>56</td>
<td>2.385</td>
<td>3.2</td>
<td>2.392</td>
<td>3.4</td>
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<tr>
<td>57</td>
<td>2.370</td>
<td>4.3</td>
<td>2.366</td>
<td>3.3</td>
</tr>
<tr>
<td>58</td>
<td>2.334</td>
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<td></td>
</tr>
<tr>
<td>55A</td>
<td></td>
<td></td>
<td>2.306</td>
<td></td>
</tr>
<tr>
<td>56A</td>
<td></td>
<td></td>
<td>2.392</td>
<td></td>
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<tr>
<td>57A</td>
<td></td>
<td></td>
<td>2.366</td>
<td></td>
</tr>
<tr>
<td>58A</td>
<td></td>
<td></td>
<td>2.355</td>
<td></td>
</tr>
</tbody>
</table>

---

**Copies To:**  
**Central Lab**  
**C. Anderson**

**Disposition:**

**Signed:** Orris J. Lane, Jr.  
**Testing Engineer**
### IOWA DEPARTMENT OF TRANSPORTATION

**OFFICE OF MATERIALS**

**TEST REPORT - ASPHALT CONCRETE CORES**

**LAB LOCATION - AMES**

**LAB NO.: ABE1-0015**

**MATERIAL:** ASPHALT CORES Site #2  
**PROJECT NO.:** HR-542  
**COUNTY:** CLINTON

**UNIT OF MATERIAL:** Conventional Cores 35, 36, 37, 38  
Cores 35 & 36 1/4 PT., 37 & 38 OWP  
35A, 36A, 37A, 38A, ARE THE BINDER CORES

**SAMPLED BY:** STEFFES  
**SENDER NO.:**

**DATE SAMPLED:** 11/15/89  
**DATE RECEIVED:** 02/13/91  
**DATE REPORTED:** 03/21/91

<table>
<thead>
<tr>
<th>Core</th>
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<th>Density</th>
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<td>35</td>
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<td>36</td>
<td>SURFACE</td>
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<tr>
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<td>38</td>
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<tr>
<td>35A</td>
<td>BINDER</td>
<td>2.281</td>
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</tr>
<tr>
<td>36A</td>
<td>BINDER</td>
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<td>37A</td>
<td>BINDER</td>
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<tr>
<td>38A</td>
<td>BINDER</td>
<td>2.336</td>
<td>5.6</td>
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</table>

Material: Asphalt Cores Site #2  
**PROJECT NO.:** HR-542  
**COUNTY:** Clinton

**UNIT OF MATERIAL:** PAC 40 SBN Cores #31, 32, 33, 34, 39, 40, 41, 42  
Cores 31, 32, 39, 40 1/4 PT. 33, 34, 41, 42 OWP  
31A, 32A, 33A, 34A, 39A, 40A, 41A, 42A are binder cores

**SAMPLED BY:** Steffes  
**SENDER NO.:** ACA1-08

**DATE SAMPLED:** 1-15-89  
**DATE RECEIVED:** 02-13-91  
**DATE REPORTED:** 03-21-91

<table>
<thead>
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<th>Core</th>
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<th>% Air (HPM)</th>
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<tbody>
<tr>
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<td>34A</td>
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<td>42A</td>
<td>2.313</td>
<td>5.5</td>
</tr>
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---

**DISPOSITION:**

SIGNED: ORRIS J. LANE, JR.  
TESTING ENGINEER

---

**COPIES TO:**  
CENTRAL LAB  
C. ANDERSON
### TEST REPORT - ASPHALT CONCRETE CORES

**LAB LOCATION - Ames**

**LAB NO.** ABEl-0009

**MATERIAL** ASPHALT CORES Site #3

**PROJECT NO.** HR-542

**COUNTY.** O'Brien

**UNIT OF MATERIAL:** Conventional Cores #9, 10, 11, 12 WBL - Inside
9 & 10 1/4 PT. 11 & 12 OWP
9A, 10A, 11A, 12A are the binder cores

**SAMPLED BY** R. STEFFES

**SENDER NO.** ACA1-03

**DATE SAMPLED:** 09/25/89

**DATE RECEIVED:** 02/13/91

**DATE REPORTED:** 03/21/91

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<th>SURFACE</th>
<th>DENSITIES</th>
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<td>2.345</td>
<td>5.3</td>
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<tr>
<td>10</td>
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<td>2.365</td>
<td>5.0</td>
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<td>11</td>
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<td>12</td>
<td>Binder</td>
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<tr>
<td>9A</td>
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<td>2.285</td>
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<td>12A</td>
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<td>2.292</td>
<td>6.2</td>
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**MATERIAL** Asphalt Cores Site #3  
**Lab No.:** ABEl-0010

**Project no:** HR-542

**County:** O'Brien

**Unit of Material:** PAC 40 SBR Cores #13, 14, 15, 16 WBL - Inside
Cores 13 & 14 1/4 PT. 15 & 16 OWP 13A, 14A, 15A, 16A are the binder cores

**Sampled by:** Steffes

**Sender No.:** ACA1-04

**Date sampled:** 09-25-89

**Date Received:** 02-13-91

**Date Reported:** 03-21-91

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<tr>
<td>16A</td>
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<td>4.5</td>
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**SIGNED:** ORRIS J. LANE, JR.

**TESTING ENGINEER**

---

**COPIES TO:**

CENTRAL LAB

C. ANDERSON

**DISPOSITION:**
**IOWA DEPARTMENT OF TRANSPORTATION**  
**OFFICE OF MATERIALS**  
**TEST REPORT - ASPHALT CONCRETE CORES**  
**LAB LOCATION - AMES**

LAB NO.: AB1-0013

MATERIAL: ASPHALT CORES Sites #4 & #10  
PROJECT NO.: HR-542  
COUNTY: POTAWATTAMIE  
UNIT OF MATERIAL: ASPHALDUR CORES 25, 26, 27, 28, 29, 30 EBL; CORES 25, 26  
27, 1/4 PT.; 28, 29, 30 OWP; TOP LAYER 1988  

SAMPLED BY: STEFFES  
SENDER NO.: ACA1-07  
DATE SAMPLED: 09/27/89  
DATE RECEIVED: 02/13/91  
DATE REPORTED: 03/21/91

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SIGNED: ORRIS J. LANE, JR.  
TESTING ENGINEER

COPIES TO:  
CENTRAL LAB

C. ANDERSON

DISPOSITION:
# Material: Asphalt Cores Site #5

**Lab No:** ABE1-0012  
**Project No:** HR-542  
**County:** Woodbury  
**Unit of Material:** Conventional Cores 21, 22, 23, 24 WBL - Outside  
Cores #21 & 22 OWP; 23 & 24 1/4 PT.  
21A, 22A, 23A, 24A are the binder cores  
**Sampled by:** R. Steffes  
**Sender No:** ACA1-06  
**Date Sampled:** 09/26/89  
**Date Received:** 02/13/91  
**Date Reported:** 03/21/91

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# Material: Asphalt Cores Site #5

**Lab No:** ABE1-0011  
**Project No:** HR-542  
**County:** Woodbury  
**Unit of Material:** AC-13 Cores 17, 18, 19, 20 WBL - Outside  
Cores 17 & 18 1/4 PT., 19 & 20 OWP  
17A, 18A, 19A, 20A are the binder cores  
**Sampled by:** Steffes  
**Sender No:** ACA1-05  
**Date Sampled:** 09-26-89  
**Date Received:** 02-13-91  
**Date Reported:** 03-21-91

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<tr>
<td>19</td>
<td>2.287</td>
<td>5.9</td>
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<tr>
<td>20</td>
<td>2.311</td>
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<td>20A</td>
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**Copies To:**  
**Central Lab**  
**C.- Anderson**

**Disposition:**  
**Signed:** Orris J. Lane, Jr.  
**Testing Engineer**
### Asphalt Concrete Cores Site #11

**Lab No.**: ABE1-0023

**Sampled By**: STEFFES  
**Sender No.**: ACA1-16

**Date Sampled**: 06/17/88  
**Date Received**: 02/13/91  
**Date Reported**: 03/21/91

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<td>70</td>
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### Asphalt Cores Site #12

**Lab No.**: ABE1-0020

**Sampled By**: Anderson  
**Sender No.**: ACA1-14

**Date Sampled**: 02/13-91  
**Date Received**: 02-13-91  
**Date Reported**: 03-21-91

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<td>62</td>
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<td>62A</td>
<td>Binder</td>
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<td>4.4</td>
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**Copies To**: CENTRAL LAB  
**C. Anderson**

**Disposition**: SIGNED: ORRIS J. LANE, JR.  
TESTING ENGINEER
IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT CONCRETE CORES
LAB LOCATION - AMES

LAB NO.: ABE1-0017

MATERIAL: ASPHALT CORES Site #13
PROJECT NO.: HR-542
COUNTY: Story

UNIT OF MATERIAL: Conventional Cores 47, 48, 49, 50 NB Driving Lane
Cores 47 & 48 OWT Cores 49 & 50 1/4 PT.
47A, 48A, 49A, 50A, ARE THE BINDER CORES

SAMPLED BY: C. ANDERSON
SENDING NO.: ACA1-11

DATE SAMPLED: 11/08/90
DATE RECEIVED: 02/13/91
DATE REPORTED: 03/21/91

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<td>48</td>
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<td>49</td>
<td>Surface</td>
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<td>Surface</td>
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Material: Asphalt Cores Site #13
Project No: HR-542
County: Story

Unit of Material: PAC-30 SBS Cores 43, 44, 45, 46 Driving Lane
Cores 43, 44 OWT; Cores 45, 46 1/4 Point; 43A, 44A, 45A, 46A are the Binder Cores

Sampled by: ANDERSON
Send No.: ACA1-10
Date Sampled: 11-08-90
Date Received: 02-13-91
Date Reported: 03-21-91

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SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER
## Test Report - Asphalt Concrete Cores

### Lab Location: Ames

**Material:** Asphalt Cores Site #14  
**Project No.:** HR-542  
**County:** O'Brien  
**Unit of Material:** Conventional Cores #1, 2, 3, 4 SBL; 1 & 2 OWP; 3 & 4 1/4 PT.  

1A, 2A, 3A, 4A are the binder cores

**Sampled by:** R. Steffes  
**Sender No.:** ACA1-01  
**Date Sampled:** 09/25/89  
**Date Received:** 02/13/91  
**Date Reported:** 03/21/91

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Material: Asphalt Cores Site #14  
Lab No: AB1-0008  
Project No: HR-542  
County: O'Brien  
Unit of Material: PAC 40 SBR Cores #5, 6, 7, 8 SBL  
5 & 6 OWP 7 & 8 1/4 PT.; 5A, 6A, 7A, 8A are the binder cores

**Sampled by:** Steffes  
**Sender No.:** ACA1-02  
**Date Sampled:** 09-25-89  
**Date Received:** 02-13-91  
**Date Reported:** 03-21-91

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IOWA DEPARTMENT OF TRANSPORTATION
OFFICE OF MATERIALS
TEST REPORT - ASPHALT CONCRETE CORES
LAB LOCATION - AMES

LAB NO.: ABE1-0021

MATERIAL: ASPHALT CORES Site #15
PROJECT NO.: HR-542
COUNTY: POLK

UNIT OF MATERIAL: PAC 30 SBS Cores 63, 64, 65, 66 SB Driving Lane
Cores 63 & 64 1/4 PT.; 65 & 66 OWT
63A, 64A, 65A, 66A ARE THE BINDER CORES

SAMPLED BY: ANDERSON
SENDER NO.: ACA1-15
DATE SAMPLED: DATE RECEIVED: 02/13/91 DATE REPORTED: 02/21/91

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SIGNED: ORRIS J. LANE, JR.
TESTING ENGINEER

COPIES TO: CENTRAL LAB

DISPOSITION: