MOUNTAIN-PLAINS CONSORTIUM

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FIELD PERFORMANCE OF ASPHALT MIXTURES BASED ON FLEXIBILITY INDEX RESULTS

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16. Abstract

This document presents the continuous effort to develop mechanical tests that can relate to the expected performance of asphalt mixtures once placed in the field. During a previous research project, asphalt mixtures of different compositions were collected from different locations across the state of Utah. Based on the tests, it was found that asphalt mixtures sampled at the plant had a flexibility index, FI, between 3.0 and 20.0. This means that some mixtures were likely to show premature fatigue cracking.

To verify if the laboratory predicted performance matched the field performance, the locations where five different mixtures were placed were surveyed and their level of distresses was documented.

It was found that out of the 5 sections surveyed, the one that had the lowest flexibility index showed premature fatigue cracking. A different section also shows significant low-temperature cracking.

Based on the results, it is concluded that the proposed mechanical testing at intermediate temperatures can be used to identify mixtures that might have poor cracking performance in the field. However, since no other section showed any distresses, it is not known if a specific minimum FI can be developed at this time.

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Field Performance of Asphalt Mixtures Based on Flexibility Index Results

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Disclaimer

ABSTRACT

This document presents the continuous effort to develop mechanical tests that can relate to the expected performance of asphalt mixtures once placed in the field. During a previous research project, asphalt mixtures of different compositions were collected from different locations across the state of Utah. Based on the tests, it was found that asphalt mixtures sampled at the plant had a flexibility index (FI) between 3.0 and 20.0. This means that some mixtures were likely to show premature fatigue cracking.

To verify if the laboratory predicted performance matched the field performance, the locations where five different mixtures were placed were surveyed and their level of distresses was documented.

It was found that out of the five sections surveyed, the one that had the lowest flexibility index showed premature fatigue cracking. A different section also shows significant low-temperature cracking.

Based on the results, it is concluded that the proposed mechanical testing at intermediate temperatures can be used to identify mixtures that might have poor cracking performance in the field. However, since no other section showed any distresses, it is not known if a specific minimum FI can be developed at this time.

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EXECUTIVE SUMMARY

The work presented in this document is part of a continuous effort to develop mechanical tests that can relate to the expected performance of asphalt mixtures once placed in the field. During a previous research project, asphalt mixtures of different compositions were collected from different locations across the state of Utah. The mixtures were brought to the lab and tested to determine their intermediate temperature performance using the Illinois Flexibility Index Test based on AASHTO TP-126. Based on the tests, it was found that asphalt mixtures sampled at the plant had a flexibility index (FI) between 3 and 20. This means that some mixtures were likely to show premature fatigue cracking.

To verify if the laboratory predicted performance matched the field performance, the locations where five different mixtures were placed were surveyed and their level of distresses was documented.

It was found that out of the five sections surveyed, the one that had the lowest flexibility index showed premature fatigue cracking. A different section also shows significant low-temperature cracking.

Based on the results obtained as part of this work and the previous laboratory work, it is concluded that the proposed mechanical testing at intermediate temperatures can be used to identify mixtures that might have poor cracking performance in the field. The tests can be used during the mix design process to prevent poor-performing mixtures from being placed in the field. However, since no other section showed any distresses, it is not known if a specific minimum FI can be developed at this time.

It is recommended that a follow-up study be conducted to test cores obtained from these pavement sections to evaluate the effect of field aging.

1. INTRODUCTION

1.1 General

The flexibility index (FI) of asphalt mixtures have been identified as a valuable parameter to evaluate the intermediate temperature performance of roads [1, 2, 3]. However, while it is known that low FI values result in high propensity for cracking, an actual threshold value has not been determined in the state of Utah. Values between 6 and 10 have been suggested for other states (Illinois, Wisconsin, etc.) but it is not known if these values are appropriate for the state of Utah [4]. This report is the second of a series of studies to address this issue.

A study was conducted where hot-mix asphalt samples were collected from seven different sites, both at the plant and at laydown. The samples were tested using the Illinois Flexibility Index Test as per AASHTO TP-126 [1]. The results in FI values ranged from a low of 3 to a high of 20. While it is known that asphalt mixtures with low FI values will have high propensity for cracking, an actual threshold value has not been determined in the state of Utah. Evaluation of paving mixes placed in Utah over the last 15 years indicates that mixes with a high propensity for cracking typically show early-age cracking as early as years two or three after being placed. Based on this information, an evaluation of the field performance of the seven mixtures collected in a previous study was conducted to validate and determine of appropriate values for the FI under the conditions in Utah. [2, 3]

1.2 Research Objectives

The objective of this research is to document the early performance of asphalt pavements in the state of Utah and correlate their performance to the FI values previously obtained in the lab. Knowing the relation between FI and field performance will allow for the development of asphalt mixtures optimized for all weather conditions.

1.3 Scope

The scope of this project consists of visual inspection of the pavement sections for which material was evaluated in a previous study. Complete details of that study can be found in MPC 22-465. The early condition of the pavement will be related to the FI values previously obtained.

2. MATERIALS

2.1 Overview

A study (MPC Report 546) was conducted where hot-mix asphalt materials were collected from seven different plants and at two locations: at the plant (minimum aging) and at laydown (short-term aging). The asphalt mixtures were brought to the lab where samples were compacted and tested at 25ºC using the semi-circular bend, SCB-IFIT, configuration, resulting in FI values.

2.2 Material Properties

Asphalt mixtures were collected from seven different facilities and at two locations: at the plant and at the field (laydown). At the plant, material was sampled from the conveyor slat as it came from the mixer, thus representing some aging during mixing (loss of volatiles). At laydown, the material was collected from the windrow dump representing the condition referred to as short-term aging. For all cases, the material was placed in five-gallon metal buckets and sealed while still hot. The material was then transported to a central location where it was distributed to three different labs where it was tested for its mechanical properties.

Table 2.1 shows the material properties of the original mixtures tested. Sections in grey were part of the original report but are not included on this report due to lack of access to the sections.

Table 2.1 Material Properties

Mix ID	Design Method	Aggregate NMAS	RAP Content	Total Binder by Mass	Virgin Binder by Mass/ Vol	Virgin Binder	Intended Climate
UT-01	50-Blow Marshall[1]	12.5 mm	30%	5.4%	3.8%/ 9.0%	PG 64-22	Hot
UT-02	75-Blow Marshall[1]	19 mm	30%	4.9%	3.4%/ 9.6%	PG 58-34	Medium
UT-03	75-NDES Superpave[2]	12.5 mm	25%	5.3%	4.0%/ 9.6%	PG 64-34	Cold
UT-04	75-NDES Superpave[2]	12.5 mm	15%	5.3%	4.6%/ 10.9%	PG 64-34	Medium
UT-05	50-Blow Marshall[1]	12.5 mm	30%	6.3%	4.4%/ 10.1%	PG 58-28	Cold
UT-06	75-NDES Superpave[2]	12.5 mm	25%	4.8%	3.7%/ 11.2%	PG 58-28	Cold
UT-07	75 NDES Superpave[2]	12.5 mm	10%	5.3%	4.9%/ 11.1%	PG 64-28	Medium

[1]Based on APWA Specifications

[2]Based on UDOT 2741 Specification

All information provided by the supplier and not verified by the research team

Greyed lines are mixtures not part of the current work

2.3 Testing Results

Table 2.2 shows the FI results. All data were collected at the University of Utah and only results relevant to the current study are presented.

Table 2.2 Relevant FI Results

		Plant	Field[2]
UT-02	**Average[1]**	**4.9**	**3.4**
	C of Var	29%	24%
UT-03	**Average[1]**	**8.3**	**8.7**
	C of Var	20%	27%
UT-04	**Average[1]**	**11.8**	**8.7**
	C of Var	38%	27%
UT-05	**Average[1]**	**5.8**	**7.0**
	C of Var	39%	40%
UT-07	**Average[1]**	**11.6**	**12.9**
	C of Var	28%	29%

[1]Based in 8 samples tested except for UT-03
[2]Field refers to laydown

2.4 Summary

Background on the original study and a summary of relevant results are given in this section. More information can be found in MPC 22-465.

3. FIELD OBSERVATIONS

3.1 Overview

Evaluation of paving mixes placed in Utah over the last 15 years indicates that mixtures with a high propensity for cracking will typically show early-age cracking as early as year two or three. Therefore, it was decided to return to the locations where the mixtures were placed after two years of service to document their performance. Unfortunately, only five out of the original seven sections were available.

This section summarizes these observations and compares the performance predictions with the observed distresses.

3.2 Performance

For each section, the following performance was observed.

3.2.1 Section UT-02

This section is located in Tooele City, Skyline Drive, approximately 100 feet west of 200 East on the westbound travel lane (40°31'20.45"N 112°17'37.01"W). The pavement is not holding well; it shows sign of raveling and there is noticeable cracking observed in the section. This is shown in Figure 3.1.

Figure 3.1 Section UT-02 showing fatigue cracking and raveling

3.2.2 Section UT-03

This section is located in Randolph, approximately 1.5 miles south of Church Street on the southbound travel lane (41°38'37.16"N 111°11'0.34"W). Randolph is at an elevation greater than 6,200 feet, and it is worth mentioning that Rich County, where this is located, has often set low temperature records for the state of Utah. Therefore, it is not surprising that Figure 3.2 shows severe thermal and reflective cracking.

Figure 3.2 Section UT-03 showing thermal and reflective cracking

3.2.3 Section UT-04

This section is part of SR 32 in Kamas. It is in the 200 North eastbound lane, in line with the east sidewalk (40°38'46.93"N 111°16'50.26"W). The section shows some longitudinal joint opening but no other distress. This is shown in Figure 3.3.

Figure 3.3 Section UT-04 Showing some joint opening

3.3.4 Section UT-05

This section is located in a subdivision in Provo at 3550 N 180 E. The material was used as a patch and was sampled from a 17-hour-old stockpile for custom sales. The small size of the patch makes any performance evaluation meaningless. Figure 3.4 is a picture of the section.

Figure 3.4 Section UT-05 used as a patch material

3.3.5 Section UT-07

This section is located on Heartstone Lane in Saratoga Springs, between Valkyries and School House (40°21'9.41"N 111°54'33.27"W). As shown in Figure 3.5, the road is part of a residential area and shows no visible distresses.

Figure 3.5 Section UT-07 showing no visible distresses

3.4 Summary

The observations described in this chapter indicate that section UT-02 has not performed well as far as fatigue cracking distresses. This section had the most distresses after only two to three years of service. Section UT-03 showed significant thermal cracking. Section UT-05 shows some joint opening, which is considered a construction issue and not a materials issue. No distresses were seen in sections UT-04 or UT-07.

4. RELATION BETWEEN FI AND OBSERVED DISTRESSES

4.1 General

Asphalt mixtures from five different locations were collected during the construction process and tested to determine their flexibility index (FI). Sections with low FI values are expected to perform poorly once placed in the field. After two years, the sections were surveyed and any distresses were noted.

4.2 Flexibility Index Results

As previously discussed, FI values between 6 and 10 have been suggested as limits or thresholds in terms of performance, but no value has been specifically selected for Utah. The results shown in Table 2.2 indicate that section UT-02 is the only section with an FI value below 6 based on material sampled at both locations. Therefore, it is likely to be the worst performer of the group. As shown in the previous section, this was indeed the case, as this was the only section that showed signs of fatigue cracking.

While one section is not enough to validate the tests, the results are, at least, encouraging regarding the ability of the FI to eliminate poor performing asphalt mixtures.

4.3 Development of Threshold Value

The data obtained as part of this work show that the FI obtained at 25ºC can identify mixtures with potential for premature failure. This means that the test can be used to detect potentially problematic mixtures. The one section that showed distress had an FI below 6, which is the minimum value shown in the literature. However, not enough sections have been tested to make a definite recommendation. More testing is required before a set value can be determined.

It is also recognized that the FI might represent a pass/fail value only. There is not enough information from this work to determine the validity of the tests to predict performance beyond this pass/fail determination. Mixtures that had cracking indices greater than 6 showed no distresses; however, no inference is made beyond that statement. In other words, there is no evidence that a material with a very high flexibility index would result in better performance than a material with an acceptable index (i.e., a value higher than the threshold). Information on a large number of pavement sections over a longer period of time would be needed to make such a determination.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Results

Five pavement sections were surveyed for early distresses. The properties of the asphalt mixtures used to make these sections were previously measured so that comparisons between predictions and performance could be made. Out of the five sections, one showed sign of fatigue cracking. The FI of that section was the only one that was below 6.

5.2 Conclusions

Based on the results obtained as part of this project, it is concluded that the proposed mechanical testing at intermediate temperatures can be used to identify mixtures that might have poor cracking performance in the field. The tests can be used during the mix design process to prevent poor-performing mixtures from being placed in the field.

5.3 Limitations and Recommendations

While the results presented in this report are encouraging, they are based on the limited pavement sections evaluated. A larger database should be created before a final threshold value can be determined.

Furthermore, it is recognized that the properties of the materials, as tested during mixing and laydown, might be different than the properties of the materials after a few years of being in the field due to oxidative aging. It is recommended that cores be taken from the sections evaluated and brought to the laboratory for further testing.

6. REFERENCES

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