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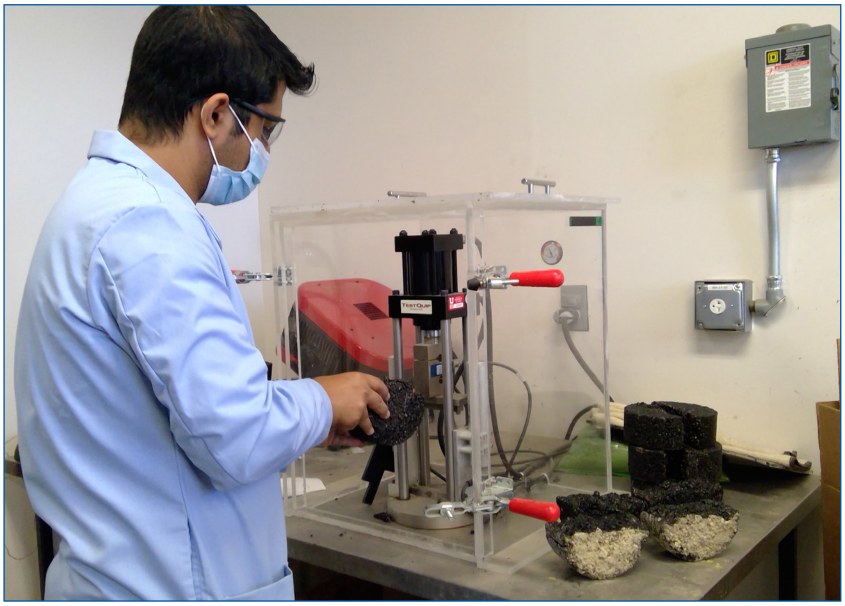
TESTING OF FIELD CORES TO DETERMINE PERFORMANCE OF ASPHALT MIXTURES



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16. Abstract

A study was conducted in which cores were taken from pavements three years after construction. The flexibility index (FI) of the cores, a parameter that relates to intermediate temperature cracking, was measured in the lab and compared to the known values of the same material obtained during constructions. The results indicate that after three years of field aging, the FI of the mixtures can decrease by as much as 50% or more. The change was affected by the temperature where the pavement was located.

A comparison was done between two tests that are designed to predict asphalt mixture performance at intermediate temperatures. It was found that both tests can predict the mixtures with the worst performance, but there was little agreement in other mixtures. Furthermore, high variability was observed on both tests evaluated.

It was concluded that the effects of aging should be considered during the mix design process when selecting a possible threshold value to prevent intermediate temperature cracking.

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asphalt mixtures, cores (specimens), cracking, field tests, materials at high or low temperatures, pavement performance

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Testing of Field Cores to Determine Performance of Asphalt Mixtures

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Disclaimer

ABSTRACT

A study was conducted in which cores were taken from pavements three years after construction. The flexibility index (FI) of the cores, a parameter that relates to intermediate temperature cracking, was measured in the lab and compared to the known values of the same material obtained during constructions. The results indicate that after three years of field aging, the FI of the mixtures can decrease by as much as 50% or more. The change was affected by the temperature where the pavement was located.

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EXECUTIVE SUMMARY

The work presented here documents a study conducted in which cores were taken from pavements three years after construction. The flexibility index (FI) of the cores, a parameter that relates to intermediate temperature cracking, was measured in the lab and compared to the known values of the same material obtained during constructions. The results indicate that after three years of field aging, the FI of the mixtures can decrease by as much as 50% or more. The change was affected by the temperature where the pavement was located.

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1. INTRODUCTION

1.1 General

Pavements are perhaps the largest and most important asset of our transportation network. A significant amount of research has been dedicated to evaluate and predict the performance of asphalt mixtures once placed on the field. The Semi-Circular Bend Flexibility Index Test (SCB-iFIT), as described in AASHTO TP126, has been recognized as an appropriate test to measure the properties of asphalt mixtures at intermediate temperatures. More recently, the IDEAL CT Tests, as described in ASTM 8225, has gained popularity due to its simplicity. However, while it has been shown that these tests can identify mixtures with high propensity for cracking, the effect of field aging is still not well understood. As part of a previous study, materials from seven different field sections were collected during construction and tested in the laboratory, resulting in initial values. This was documented in MPC Report 546. After three years of field placement, the pavement sections were surveyed, and it was determined that those mixtures with a low initial flexibility index (FI) (below 6) showed early signs of fatigue cracking. This was documented in MPC Report 611. This report is the third in the series that documents the properties of these same mixtures after being subjected to three years of aging.

It is known that the properties of asphalt mixtures change when exposed to field conditions. These irreversible changes are referred to as long-term aging. In a previous study, it was recommended that cores be extracted from the pavement sections and brought to the lab for testing to compare the properties of fresh material to field-aged material. Such comparison would allow for quantifying how the material properties have changed. This report documents the results based on the FI; it also introduces the IDEAL CT as an alternative test method for intermediate temperature cracking.

1.2 Research Objectives

The objective of this research is to obtain field cores and test them in the laboratory to evaluate the changes in material properties caused by field aging. Knowledge of the change in material properties from field aging will help in developing an appropriate limit to prevent premature failure from intermediate temperature cracking. The ultimate goal of this research is to establish a cracking parameter on fresh mixes that can identify, and potentially eliminate, asphalt mixtures that might show poor performance once placed in the field.

1.3 Scope

The scope of this project consists in taking cores from five pavement sections that were used as part of a previous study and test them in the lab to compare how their FI changed with field aging. Complete details of the study can be found in MPC Project Report 564 and MPC Project Report 611. This report will compare the properties of the mix as obtained during construction and after three years of field aging.

2. PAVEMENT SECTIONS

2.1 Overview

Five pavement sections were inspected and the observed distresses were documented. Cores were taken from the locations after three years of service and brought to the lab for testing.

2.2 Locations

A map with the location of the different pavement sections is shown in Figure 2.1. As can be seen on the figure, the unique topography of the state ensures that, during the evaluation period, some sections were subjected to unique environments; thus, it is expected that all these locations result in different aging of the mixtures.

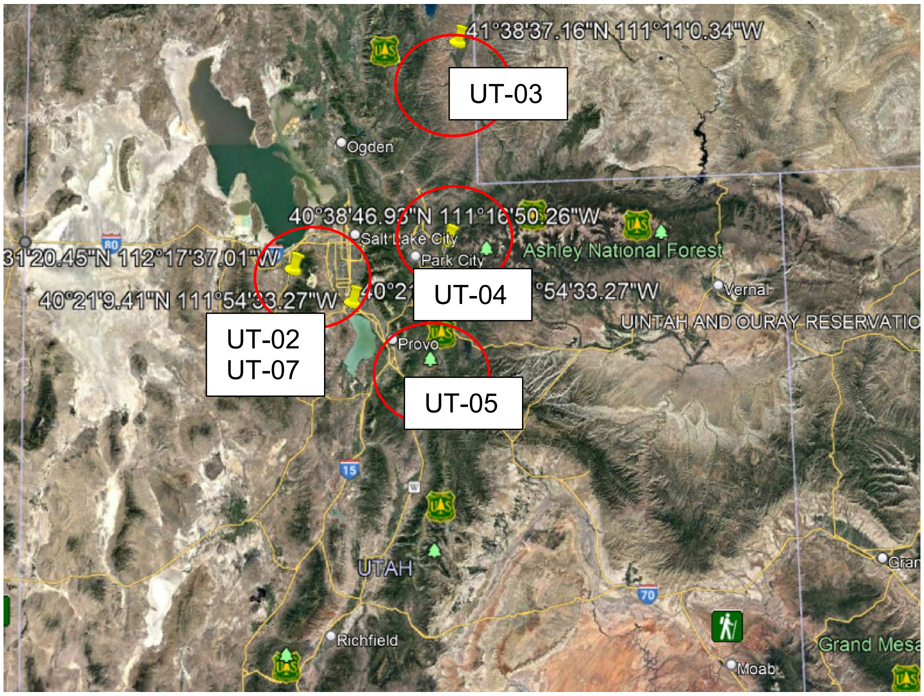


Figure 2.1 Map of Northern Utah Showing the Location of the Sections from Where Cores were Obtained

2.3 Mixture Original Properties

As was reported in previous work, the mixtures were designed using different procedures and not all were intended for highway use. This was done to ensure diversity in the results. Table 2.1 shows some relevant mixture design parameters.

Table 2.1 Mixture Design Properties

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

1. Marshal design based on APWA specifications, Superpave design based on UDOT 2741
2. NMAS, nominal maximum aggregate size

The materials were collected at two locations: at the plant and at laydown. They were brought to the laboratory where the mixtures were compacted into cylindrical samples following the procedures described in AASHTO T312: Standard Method of Test for Preparing and Determining the Density of Asphalt Mixtures by Means of the Superpave Gyratory Compactor. Once compacted, the air voids of each sample were determined following the procedures described in AASHTO T269: Percent Air Voids in Compacted Dense and Open Asphalt Mixtures. The number of gyrations to reach compaction and the air voids for each sample were recorded. Samples whose air voids fell outside the specified range of 7% ± 0.5% were still tested.

Testing consisted of measuring the FI of the mix following the procedures described in AASHTO TP-126: Standard Method of Test for Determining the Fracture Potential of Asphalt Mixtures Using the Illinois Flexibility Index Test (I-FIT). The results are shown in Table 2.2.

Table 2.2 Relevant FI Results of Lab Compacted Mixtures

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

1. Based on 8 samples.

3. RESULTS

3.1 General

After three years of field aging, cores were taken in five pavement sections. The cores were brought to the University of Utah laboratory where they were cut as required and tested using the SCB-IFIT test (AASHTO TP 126). Given that the specimens were obtained from field cores, no air voids were determined.

3.2 Test Results

The FI of the cores, as tested in the lab, is summarized in Table 3.1. As can be seen in the results, the coefficient of variation (standard deviation as a percent of the mean) is very high for some sections. Given the high variability, it was decided to try a trimmed mean approach. In most cases, this resulted in decreased variability without a significant change in the mean.

Table 3.1 Flexibility Index Results of Field Cores

		FI-4[1]	**FI-3**[2]
UT-02	**Average**	**1.49**	**1.03**
	Coeff of Var (%)	64	28
UT-03	**Average**	**8.32**	**7.84**
	Coeff of Var (%)	15	12
UT-04	**Average**	**6.63**	**6.22**
	Coeff of Var (%)	17	16
UT-05	**Average**	**3.71**	**2.84**
	Coeff of Var (%)	48	20
UT-07	**Average**	**--**	**3.65**
	Coeff of Var (%)	--	23

1. Based on 4 samples obtained from 2 cores
2. Based on 3 samples after eliminating the highest value

3.3 Comparison of FI at Different Aging Conditions

Table 2.1 shows the FI obtained during construction and Table 3.1 shows the FI after three years of field service. These values are compared in Figure 3.1. The figure is based on the complete set of data from the cores (i.e., FI-4). The figure shows that sections UT-02 and UT-05 both have the lowest FI values; these two sections were expected to show poor cracking performance based on FI values lower than 5. Such expectation was confirmed based on field observations as documented in MPC Report 611.

In all sections, the effect of aging is obvious since the FI values from three-year old cores are lower than the results obtained during laydown.

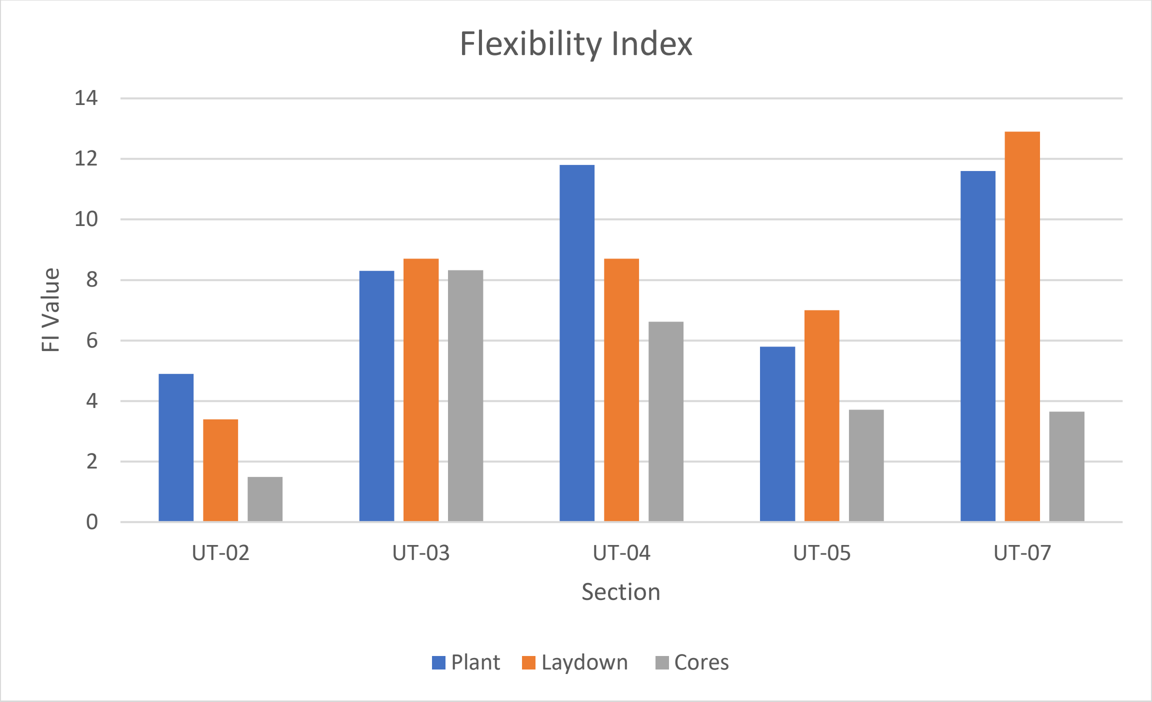


Figure 3.1 Comparison of FI Values at Different Ages

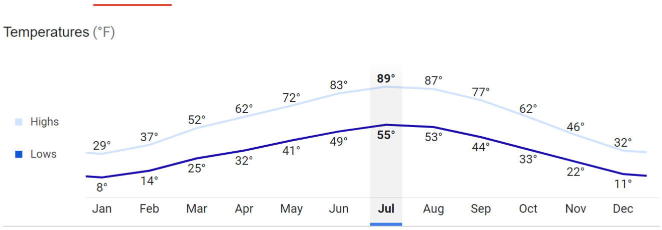
3.4 Discussion

Figure 3.1 shows that for sections UT-02 and UT-04, there is a noticeable effect of short-term aging (difference between plant and laydown condition). However, such a trend is not consistent across all sections since other sections show an increase in FI value. It is believed that some of that lack of consistency is due to the high variability observed in the tests. Mixtures from sections UT-05 and UT-07 had coefficients of variation of almost 30% and 40%, respectively. This high variability makes it difficult to evaluate the differences in results.

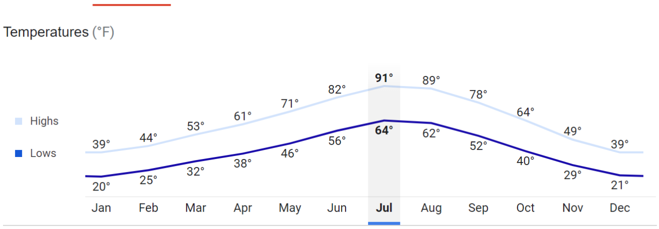
Regardless of the aging conditions, Section UT-02 is predicted to have the worst performance. It should be noted that this mixture along with UT-05 were designed following Marshall procedures and, thus, are not meant for highway use. Section UT-03 is the most consistent (i.e., no aging effects) with negligible changes in FI values across different aging periods and consistent values above 8. No intermediate temperature cracking is expected from this section.

3.4.1 Field Aging

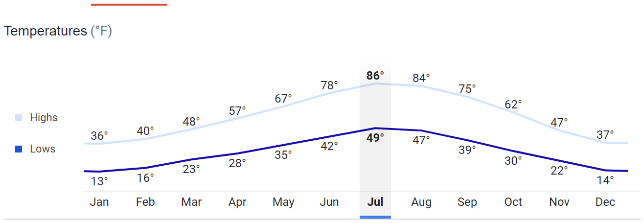
Four out of the five sections evaluated show a clear decrease in the FI as a result of field aging. While many factors are known to contribute to the aging, it is known that temperature has an effect. Figure 3.2 shows the average monthly temperature for cities in the vicinity where the cores were taken. As can be seen, Provo and Tooele have higher temperatures than Kamas and Vernal. This means that, based on temperature alone, more field aging would be expected in sections UT-02, UT-05, and UT-07 than in sections UT-03 and UT-04.



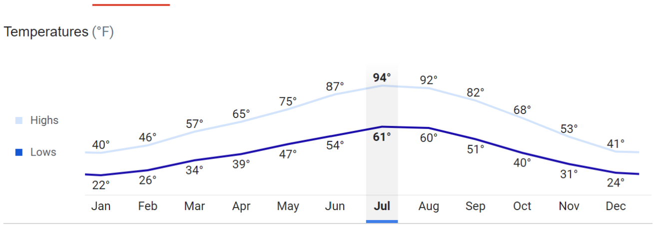
(a) Vernal, Utah (Section UT-03)



(b) Tooele, Utah. (Sections UT-02 and UT-07)



(c) Kamas, UT (Section UT-04)



(d) Provo, UT (Section UT05)

Figure 3.2 Monthly Temperature Averages for Different Locations in Utah

As expected, Table 3.2 shows those sections that were located in an area with higher temperatures resulted in the most aging (Sections UT-02, UT-05, UT-07). However, it must be noted that temperature is just one of many factors that drives the complex thermodynamic changes that determine how a material will age. Other factors such as mixture parameters, RAP content, and binder volume are known to play a role in the process. Furthermore, construction factors, such as in field-density, also affect aging.

From a mixture design process, the data show that the FI of a mix can decrease by 50% or more due to aging. The magnitude of this change should be considered when determining a minimum acceptable FI value during mix design.

Table 3.2 Changes in Flexibility Index Caused by Field Aging

	Change in FI Laydown – Cores	**Change as percent**
UT-02	1.9	56
UT-03	0.4	5
UT-04	2.1	24
UT-05	3.3	47
UT-07	9.3	72

3.5 IDEAL CT Data

One of the concerns regarding the adoption of the FI as a parameter to evaluate intermediate-temperature cracking is the sample preparation required. For laboratory prepared samples, the IDEAL CT test requires no sample cutting, which makes the test more desirable to some labs. Of course, cutting is required to isolate the relevant layers in a cored sample.

Some of the cores obtained from each section were tested using the IDEAL CT tests. The results are shown in Table 3.3.

Table 3.3 CT Index Results for Field Cores

		CT Index
UT-02	**Average**[1] Coeff of Var (%)	**31.8** **40**
UT-03	**Average** Coeff of Var (%)	**191.8** **49**
UT-04	**Average** Coeff of Var (%)	**66.9** **11**
UT-05	**Average** Coeff of Var (%)	**106.2** **6**
UT-07	**Average** Coeff of Var (%)	**125.0** **41**

1. Based on 4 samples.

3.5.1 Comparisons

In the same way as the other test, the CT index predicts that section UT-02 will have the worst performance of the group while section UT-03 is predicted to have the best performance of the group. However, no agreement exists regarding the other sections. This is shown in Figure 3.3.

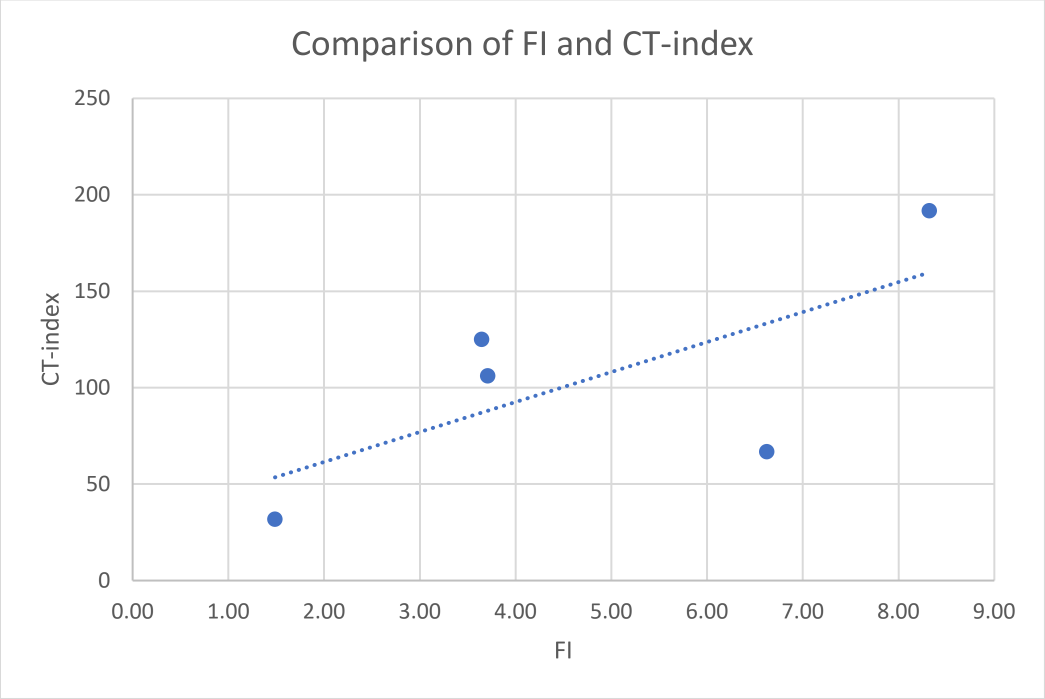


Figure 3.3 Comparison between FI and CT Index

As Figure 3.3 shows, there is no agreement between the predictions outside the high and the low value. While agreement regarding the expected poor performer is desirable, the lack of consistency creates a problem when a threshold, or minimum value, is selected. For example, based on the CT Index, Section UT-04 should probably be rejected by having the second lowest value; however, based on the FI, this section is considered the second-best performer. Similarly, based on FI, Section UT-07 should probably be rejected; yet, based on the CT Index, this section is the second-best performer. In other words, even though both tests are meant to predict potential poor performing mixtures at intermediate temperatures, there is no agreement regarding which mixtures to accept and which mixtures to reject. This issue should be resolved before any test or threshold parameter is selected.

4. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 Summary of Results

The objectives of this research were to evaluate the predicted performance of pavement sections constructed from mixtures previously evaluated and then determine the effect of field aging based on cores obtained from these pavement sections. The purpose of such testing was to determine if a single value from mechanical testing such as the FI or the CT Index relates to field performance in terms of pavement cracking at intermediate temperatures.

The following results were found:

- Cores taken from the road after three years have lower FI, in some cases by more than 50% of the original value, when compared with the results from samples obtained during construction.
- Temperature was shown to be one of the many factors that affect field aging.
- A comparison between the FI and the CT index indicate that both tests can predict the extreme performing mixtures, but no agreement was found regarding the other sections. Furthermore, the variability in the results is consistently high for both tests.

4.2 Conclusions

The data obtained as part of this work show that either the FI or the CT index could identify poor performing mixtures and that the poor performance was verified in the field. However, there was no agreement between the test regarding the other mixtures, which could make developing a threshold difficult.

The results show that the amount of aging an asphalt mixture undergoes after three years of being in the field is affected by the temperature and resulting in a FI that is 50% (or more) lower than the original value. Such a decrease in FI must be considered when evaluating mixtures during design.

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

4.3 Recommendations

The findings of this research are limited to the specific pavement sections evaluated under the specific testing conditions. A larger database can provide more precise information regarding the relation between mechanical testing and pavement performance.

A study of the variability of the tests is recommended. The within-lab and between-lab variability should be quantified. The decrease in flexibility due to aging should be considered when evaluating mixtures during the design process.

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