Performance Analysis Report
for City of Mesa / EVAC Mix Designs

August 10, 2020

Prepared for:
Matthew Manthey
City of Mesa
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Prepared By

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August 10, 2020 Integer Consulting Project #: 20-0112-20-0115

Matt Manthey
City of Mesa
Pavement management Supervisor
Mesa, Arizona

Subject: Limited Pavement Performance Analysis for EVAC Mix designs: AZ3412PMV, AZ3412PMV-25, AZ3412TR and AZ3412TR-25.

Dear Mr. Manthey

The attached report summarizes the findings and recommendations of the limited pavement analysis conducted by Integer Consulting, LLC for the above referenced project. This report includes project background, scope of work, summary of mix designs, laboratory testing, and findings.

We appreciate the opportunity to provide our services for this project. Should you have any questions concerning this report, or if we may be of any further assistance, please contact the undersigned.

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Expires: 12/31/2020

1.0 Introduction

1.1 Project Description

City of Mesa, Arizona tasked Integer Consulting LLC to conduct a limited performance analysis for asphalt concrete (AC) mixtures established per EVAC designs: AZ3412PMV25, AZ3412PMV, AZ3412TR25, and AZ3412TR. The four mix designs were established by Integer and are summarized in the Section 2.0 of this report. This analysis focused on the cracking and rutting resistance properties of the four AC mixtures. The cracking resistance was determined using the Illinois Flexibility Index Test, referred to as “I-FIT”. The Hamburg wheel track test was used to evaluate the rutting resistance. The four AC mixtures were evaluated at optimum binder content (OBC), OBC-0.70% for cracking resistance, and OBC±0.7% for rutting resistance to account for the mixtures performance at the current limits for remove and replace requirements per MAG and EVAC.

1.2 Scope of Work

The limited analysis included the following activities:

- Review of mix designs
- Cracking resistance of AC mixes
- Rutting resistance of AC mixes
- Findings and recommendations

2.0 Review of Mix Designs

All of the evaluated AC mixtures were produced in the laboratory following the respective mix designs. The mix designs for the four AC mixtures evaluated in this study are summarized below:

<u>Mix ID: AZ3412PMV25</u>

- Mix Type: 1/2”- Gyratory with Ndesign: 100 gyrations
- Performance grade of the asphalt binder: PG76-22TR+
- Amount and source of RAP: 25%, Hanson Higley Plant 34
- Type of admix: Type Π Cement at 1%
- Optimum binder content: 6% by total weight of mix (twm)
- Percent air voids at optimum binder content: 3.9%
- Dry tensile strength at optimum binder content of 6%, 77^{o}F: 269 psi
- The bulk (dry) specific gravity of the aggregate: 2.627
- At the time of laboratory evaluation, the mix design met all the EVAC specifications

<u>Mix ID: AZ3412PMV</u>

- Mix Type: 1/2”- Gyratory mix with Ndesign: 100 gyrations
- Performance grade of the asphalt binder: PG76-22TR+
- Amount and source of RAP: None
- Type of admix: Type Π Cement at 1%
- Optimum binder content: 6.2% by total weight of mix (twm)
- Percent air voids at optimum binder content: 3.8%

- Dry tensile strength at optimum binder content of 6.2%, 77°F: 179 psi
- The bulk (dry) specific gravity of the aggregate: 2.619
- At the time of laboratory evaluation, the mix design met all the EVAC specifications

Mix ID: AZ3412TR25

- Mix Type: 1/2"- Gyratory mix with Ndesign: 100 gyrations
- Performance grade of the asphalt binder: PG70-16TR
- Amount and source of RAP: 25%, Hanson Higley Plant 34
- Type of admix: Type Π Cement at 1%
- Optimum binder content: 5.8% by total weight of mix (twm)
- Percent air voids at optimum binder content: 3.3%
- Dry tensile strength at optimum binder content of 5.8%, 77°F: 268 psi
- The bulk (dry) specific gravity of the aggregate: 2.626
- At the time of laboratory evaluation, the mix design met all the EVAC specifications

Mix ID: AZ3412TR

- Mix Type: ½''- Gyratory mix with Ndesign: 100 gyrations
- Performance grade of the asphalt binder: PG70-16TR
- Amount and source of RAP: None
- Type of admix: Type Π Cement at 1%
- Optimum binder content: 5.5% by total weight of mix (twm)
- Percent air voids at optimum binder content: 3.1%
- Dry tensile strength at optimum binder content of 5.5%, 77°F: 177 psi
- The bulk (dry) specific gravity of the aggregate: 2.617
- At the time of laboratory evaluation, the mix design met all the EVAC specifications

3.0 Cracking Resistance

Figure 1 shows the stresses generated in two AC pavement structures; left – new construction and right – AC overlay. Both pavements are subjected to shear stresses within the top 2.0 inches of the AC layer/overlay, vertical stresses throughout the various layers, and bending stresses at the bottom of the AC layer/overlay. The main difference between the two structures are the additional stresses in the forms of tension and vertical shear at the interface between the tip of the crack in the old AC layer and the AC overlay. Both the new construction and AC overlay structures are expected to experience rutting due to shear and vertical stresses and fatigue due to bending stresses. In addition, the AC overlay structure is expected to experience reflective cracking due to the existence of the tension and vertical shear stresses at the tip of the crack in the old AC layer.

Reflective cracking starts at the interface between the AC overlay and the tip of the crack in the old AC layer. Fatigue cracking is the mechanism of crack initiation at the bottom of the AC layer due to bending under repeated traffic loads. Both reflective and fatigue cracking of AC mixtures are critical at intermediate pavement temperatures and at a binder content lower than the OBC. The main difference between reflective and fatigue cracking is in the time of occurrence;

reflective cracking occurs after short-term aging (i.e., during the first 5 years of pavement life) while fatigue cracking occurs after long-term aging (i.e., after 5 years from construction). The reason for the early occurrence of reflective cracking is the high stress intensity at the tip of the crack in the old AC layer. On the other hand, the main cause of fatigue cracking is the oxidative aging of the asphalt binder/mixture, which occurs after long-term aging. This study evaluated the cracking resistance of the four AC mixtures at both the short-term and long-term aging stages in order to assess the resistance of the mixtures to both reflective and fatigue cracking, respectively.

Rutting of the AC pavement is the summation of permanent deformation from the various layers. Rutting within the AC layer/overlay are caused by the combination of the shear stresses and vertical stresses. Rutting is critical at high pavement temperatures and binder content higher than the OBC. Rutting occurs during the early part of pavement life (i.e., during the first 5 years) which is driven by the fact that the asphalt binder/mixture is still soft and flexible. This study evaluated the rutting resistance of the four AC mixtures at the short-term aging stage.

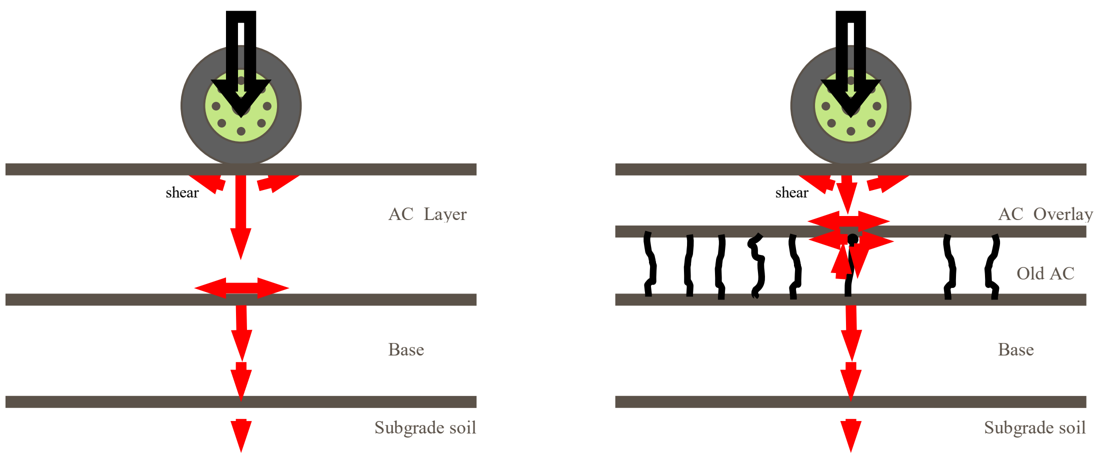

Figure 1: Left – New AC construction and Right – AC overlay construction.

3.1 Testing Method

The cracking resistance of the four mixtures were evaluated according to AASHTO TP 124-18; “Standard Method of Test for Determining the Fracture Potential of Asphalt Mixtures Using the Flexibility Index Test”. This test is referred to as the “I-FIT”. The test applies diametral loading through a constant rate of displacement of 1.97 in/min (50 mm/min) on a semi-circular disk supported on two steel rollers. Figure 2 shows a sample ready to be tested.

Test specimens are compacted using a Superpave Gyratory Compactor (SGC) to a height of 115±1mm targeting 7±1% air voids. A 50±1mm disk is cut from the middle of each SGC specimen. The disk is then cut into two identical halves with smooth parallel surfaces. The final step is to create a 15±1mm vertical notch along its symmetric axis to force the failure location through the middle of the sample. The test was conducted at 77ºF (25ºC), which represents the critical intermediate temperature for AC pavements in the City of Mesa area.

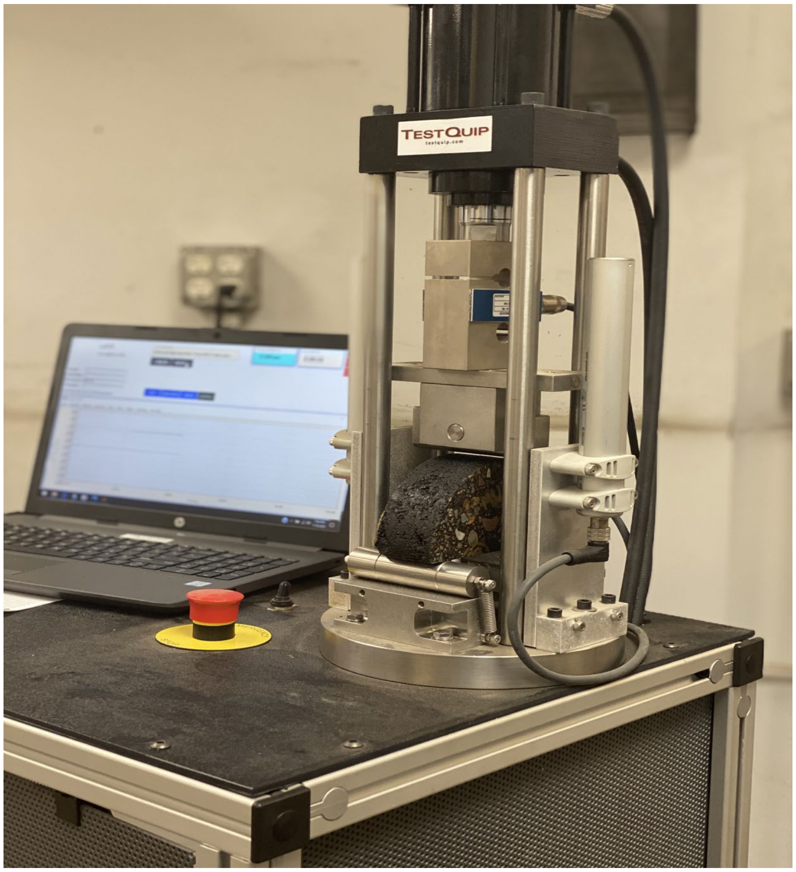

Figure 2. I-FIT sample ready to be tested.

The fracture energy, (G_f), is one of the preliminary outputs of the I-FIT which represents the energy dissipated by the propagation of the crack. This parameter is related to both; the strength of the tested material related to the peak load and to the ductility of the material related to the maximum displacement. The G_f is calculated as the area under the load-displacement curve (dashed area) divided by the cracked area, as illustrated in Figure 3. The ligament area is the product of the crack length and the thickness of the specimen prior to testing.

To assess the cracking resistance of the mixtures, the fracture index (FI) is determined based on the fracture energy (G_f) and the post-peak load versus displacement curve slope (m) of a mixture as shown in Figure 3. The FI is calculated using Equation 1:

$$FI = \left(\frac{G_f}{|m|} A\right) \qquad (1)$$

where,
FI: flexibility index
G_f: fracture energy (J/m^2)
m: post-peak slope (kN/mm)
A: scaling coefficient assumed 0.01

The FI of an AC mix represents an empirical index which is used to detect variations in the overall resistance of the asphalt mixture to crack propagation. The higher the FI value, the higher the resistance to cracking.

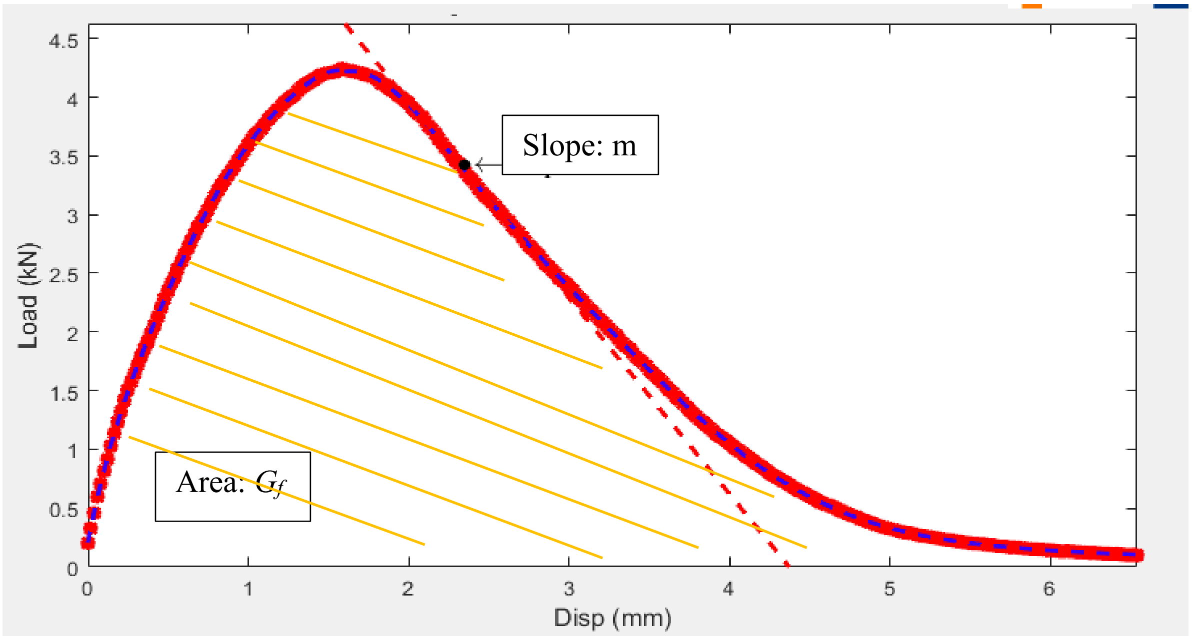

Figure 3: Example of I-FIT load-displacement curve.

3.2 Cracking Resistance at the Short-term Stage

As discussed earlier, the properties of the mixtures at the short-term aging stage give indication on their resistance to reflective cracking. The short-term aging of the four AC mixtures was accomplished through conditioning of the loose mix in the oven for two hours at the compaction temperature. Table 1 summarizes the cracking resistance, in terms of FI property, of the four AC mixtures at the short-term aged measured in the I-FIT at the OBC and OBC-0.70%. It should be noted that the mixtures to cracking was not measured at OBC+0.70 since the cracking resistance improves with increased binder content. Three replicate samples were tested for each AC mixture. A review of the crack resistance of the four evaluated short-term aged AC mixtures presented in Table 1, leads to the following observations:

- Mixtures with PG76-22TR+ binders; the highest FI value of 25.8 was achieved by the AZ3412PMV mix at the OBC. Reducing the binder content by 0.70% resulted in a decrease in the FI value to 16.0. The AZ3412PMV25 at OBC showed relatively lower FI value of 15.0 indicating the negative impact of the 25% RAP. Such results were expected since the use of RAP will result in a stiffer and more brittle mix, leading to a lower FI. Reducing the binder content by 0.70% resulted in a decrease in the FI value to 6.4. For mixes with and without RAP, reducing the OBC by 0.70% led to a significant decrease in the FI value, indicating a reduced resistance to cracking when compared with mixes at their respective OBC.
- Mixtures with PG70-16TR binders; the highest FI value of 11.4 was achieved by the AZ3412TR mix at OBC. The FI value decreased to a value of 8.1 when the OBC is lowered by 0.70%. The AZ3421TR25 mix, having 25% RAP, resulted in relatively lower FI value of 9.2 showing the negative impact of the addition of the recycled material. Reducing the binder content by 0.70% resulted in a decrease in the FI value, indicating a reduced resistance to cracking when compared with mixes at their respective OBC.

Table 1. I-FIT Test Results for Short-Term Aged AC Mixtures.

Sample ID	Binder content (%)	Fracture Energy (J/m2)	Slope, m	Flexibility Index FI	Average FI
	AZ3412PMV @OBC				
PMV-1	6.0	4322	-1.7	25.9	25.8
PMV-2	6.0	4331	-1.7	25.9	
PMV-3	6.0	4276	-1.7	25.6	
	AZ3412PMV @OBC-0.7%				
LPMV-1	5.3	2891	-1.6	17.9	16.0
LPMV-2	5.3	3024	-2.1	14.6	
LPMV-3	5.3	3259	-2.1	15.5	
	AZ3412PMV25 @OBC				
PMV25-1	6.2	2939	-2.1	13.8	15.0
PMV25-2	6.2	3148	-2.3	13.8	
PMV25-3	6.2	3123	-1.8	17.5	
	AZ3412PMV25 @OBC-0.7%				
LPMV25-1	5.5	2515	-3.5	7.1	6.4
LPMV25-2	5.5	2444	-2.9	8.4	
LPMV25-3	5.5	2088	-5.8	3.6	
	AZ3412TR @OBC				
TR-1	5.8	2675	-3.5	7.7	11.4
TR-2	5.8	2487	-2.5	9.9	
TR-3	5.8	3524	-2.1	16.6	
	AZ3412TR @OBC-0.7%				
LTR-1	5.1	2777	-3.2	8.8	8.1
LTR-2	5.1	2915	-4.8	6.1	
LTR-3	5.1	3018	-3.2	9.5	
	AZ3412TR25 @OBC				
TR25-1	5.5	2940	-3.1	9.6	9.2
TR25-2	5.5	2487	-2.5	9.9	
TR25-3	5.5	3073	-3.9	7.9	
	AZ3412TR25 @OBC-0.7%				
LTR25-1	4.8	2854	-4.0	7.1	7.5
LTR25-2	4.8	2817	-4.0	7.1	
LTR25-2	4.8	2801	-3.4	8.2	

3.3 Cracking Resistance at the Long-term Stage

As discussed earlier, the properties of the mixtures at the long-term aging stage give indication on their resistance to fatigue cracking. The long-term aging of the four AC mixtures was accomplished following AASHTO R30 where the compacted samples were placed in a forced draft oven at 185ºF (85ºC) for 5-days. Table 2 summarizes the cracking resistance of the four long-term aged AC mixtures measured in the I-FIT at the OBC and OBC-0.70%. Three replicate samples were tested for each AC mixture. No precision statement has been developed for this test method yet.

Table 2. I-FIT Test Results for Long-Term Aged Mixtures.

Sample ID	Binder content (%)	Fracture Energy (J/m2)	Slope, m	Flexibility Index FI	Average FI
	AZ3412PMV @OBC				
PMV-1	6.0	3453	-2.5	13.9	13.7
PMV-2	6.0	2734	-2.3	12.1	
PMV-3	6.0	3701	-2.4	15.2	
	AZ3412PMV @OBC-0.7%				
LPMV-1	5.3	2703	-3.9	6.9	7.3
LPMV-2	5.3	3101	-4.8	6.5	
LPMV-3	5.3	3322	-4.0	8.4	
	AZ3412PMV25 @OBC				
PMV25-1	6.2	2281	-4.1	5.5	5.8
PMV25-2	6.2	2437	-3.8	6.5	
PMV25-3	6.2	2684	-5.0	5.3	
	AZ3412PMV25 @OBC-0.7%				
LPMV25-1	5.5	2483	-5.4	4.6	2.9
LPMV25-2	5.5	2377	-7.6	3.1	
LPMV25-3	5.5	1372	-	1.0	
	AZ3412TR @OBC				
TR-1	5.8	1373	-	1.0	2.5
TR-2	5.8	2224	-7.5	3.0	
TR-3	5.8	2412	-6.7	3.6	
	AZ3412TR @OBC-0.7%				
LTR-1	5.1	2120	-17.1	1.2	1.3
LTR-2	5.1	1374	-	1.0	
LTR-3	5.1	1839	-11.2	1.6	
	AZ3412TR25 @OBC				
TR25-1	5.5	2880	-6.0	4.8	4.2
TR25-2	5.5	2745	-7.7	3.6	
TR25-3	5.5	-	-	-	
	AZ3412TR25 @OBC-0.7%				
LTR25-1	4.8	2416	-9.7	2.5	2.4
LTR25-2	4.8	2285	-8.8	2.6	
LTR25-2	4.8	2087	-9.5	2.2	

A review of the crack resistance of the four evaluated AC mixtures at the long-term aged stage presented in Table 2, leads to the following observations:

- Mixtures with PG76-22TR+ binders; the highest FI value of 13.7 was achieved by the AZ3412PMV mix at OBC. Reducing the binder content by 0.70% led to a FI value of

7.3. Lower values were exhibited by AZ3412PMV25 at OBC and OBC -0.70% with FI values of 5.8 and 2.9, respectively, indicating the negative impact of RAP on the cracking resistance.

- Mixtures with PG70-16TR binders; the highest FI value of 4.2 was achieved by the AZ3412TR25 (i.e., 25% RAP) at OBC, which is 1.7 higher than the FI value for the same mix without RAP with a FI value of 2.5. Reducing the binder content by 0.70% for the mixture with RAP led to a FI value of 2.4. The AZ3412TR at OBC showed a higher FI value of 2.5 when compared to the same mix at OBC-0.70% with a FI value of 1.30. It should be noted that the differences up to 1.7 in the FI values may not be statistically significant considering the expected variations in the I-FIT. The current AASHTO standard does not include a Precision Statement.

3.4 Summary of Cracking Resistance

Figures 4 and 5 compare the FI values for the AC mixtures with PG76-22TR+ binders and PG70-16TR binders, respectively. The height of the bars represents the average FI value of the three replicates and the whiskers over the bars represent the 95% confidence intervals. Overlap between the 95% confidence intervals of any data sets indicates statistically similar FI values.

The Illinois DOT has established a minimum FI values of 8.0 and 5.0 as thresholds for identifying AC mixtures with good resistance to cracking at the short-term aging and long-term aging stages, respectively. Among all the mixes evaluated in this study, only the AZ3412PMV25 and AZ3412TR25 at OBC -0.70% failed to meet the minimum threshold at the short-term aging stage. Both of these mixes include 25% of RAP and lower percent of binder (i.e., OBC -0.70%). Aging causes binder stiffening and results in higher potential of cracking in asphalt mixtures, leading to low cracking resistance. The results show significantly lower FI values for mixes using PG76-22TR+ and PG70-16TR after long-term aging.

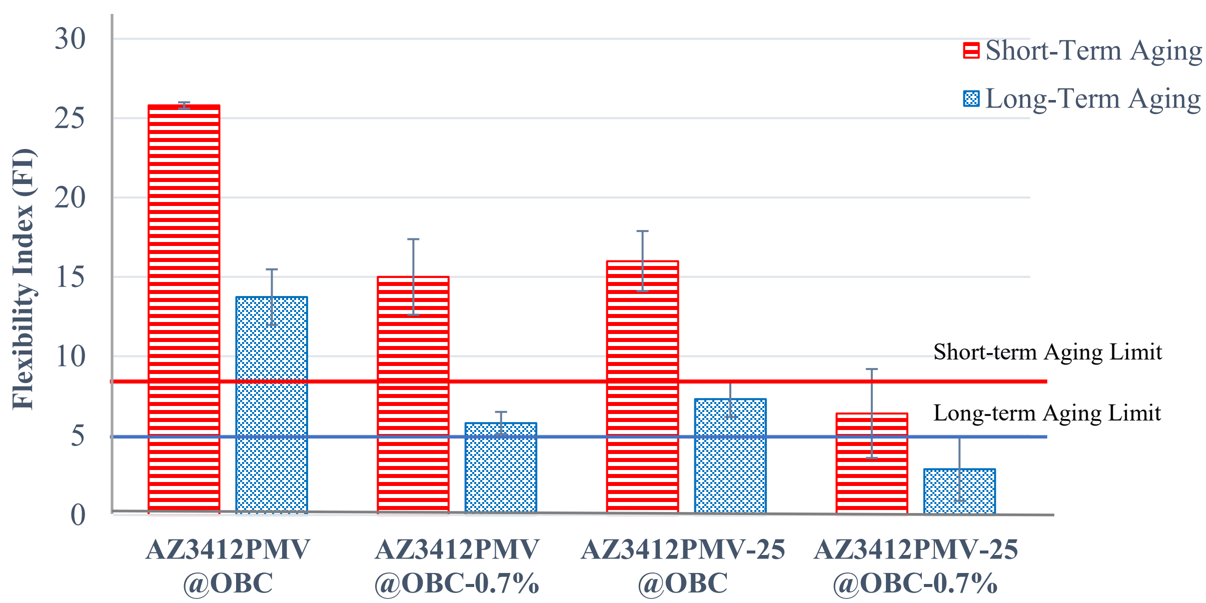

Figure 4. Comparison of FI values for short-term and long-term aged AC mixtures with PG76-22TR+ binders.

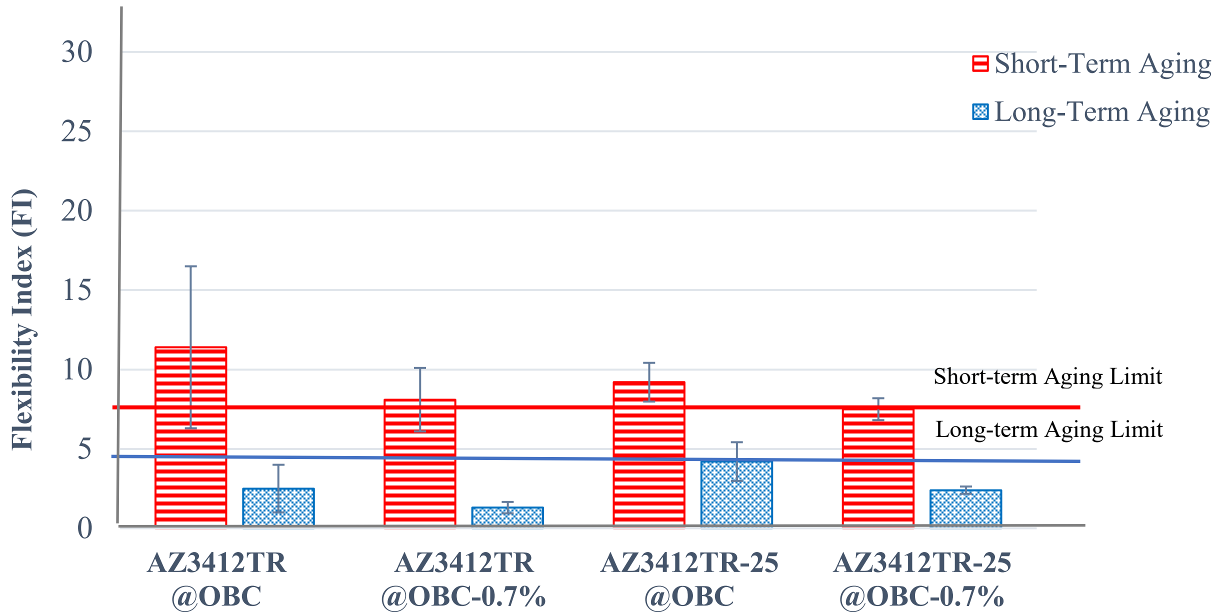

Figure 5. Comparison of FI values for short-term and long-term aged AC mixtures with PG70-16TR binders.

4.0 Rutting Resistance

As discussed earlier, rutting of AC mixtures is most critical during the early stage of pavement life, at elevated temperatures, and at a binder content higher than the OBC. However, this study evaluated the rutting resistance of the four AC mixtures at binders lower and higher than the OBC in order to account for the influence of RAP, which may improve the rutting resistance of the AC mix.

4.1 Testing Method

The rutting resistance of the AC mixtures were evaluated according to Texas Department of Transportation Tex-242-F; "Hamburg Wheel-Tracking Test". The Hamburg Wheel Tracking (HWT) test evaluates the rutting resistance of the AC mix in terms of permanent deformation as a function of loaded wheel cycles while the sample is submerged in water. Figure 6 shows the setup of the HWT test.

Specimens are compacted in the SGC targeting air voids of 7.0±1.0%. The compacted specimens are cut at the edges to ensure minimal gap width, no greater than 7.5mm, when joined together in the molds as shown in Figure 6. The mixtures were only subjected to short-term aging since rutting resistance is critical during the early part of pavement life. The testing temperature of the HWT test was 122°F (50°C). A total of four specimens are tested under the HWT's left and right wheels as shown in Figure 6. Three points are monitored under each wheel: center of each specimen and the contact of the two specimens. The rut depth under each wheel is reported as the highest of the three monitored points. The average of the rut depth under the two wheels is reported as the final rut depth at any given number of load cycles. No Precision Statement has been developed for this test method.

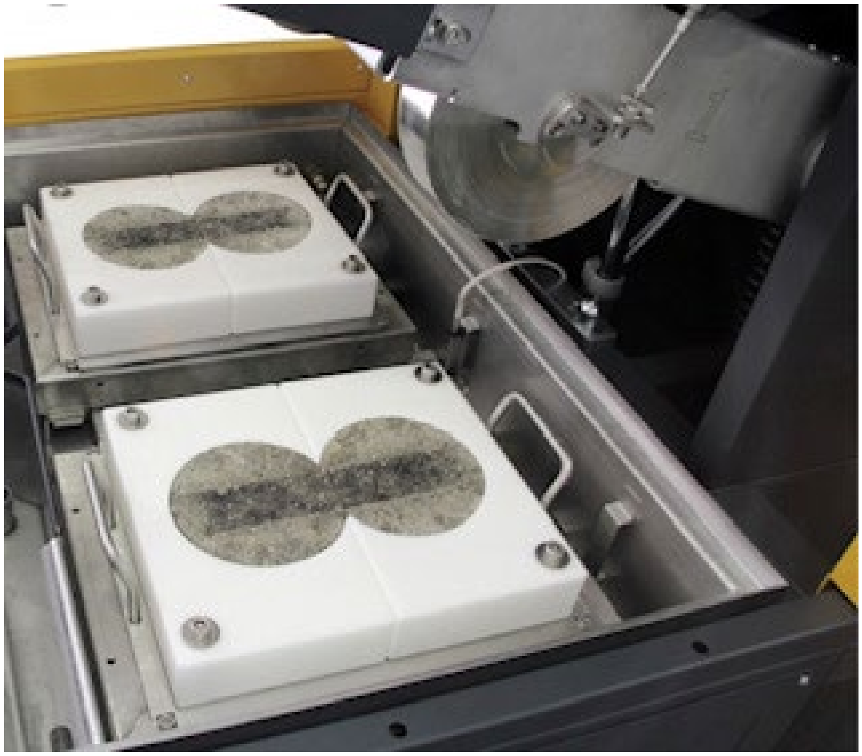

Figure 6. Samples tested using HWT.

4.2 HWT Rut Depth

The HWT machine applies 20,000-wheel passes while constantly measuring the rut depth. The test ends once the specified number of cycles is reached or if the measured rut depth reaches a value higher than 40mm. Tables 3 through 6 summarize the HWT test results.

Table 3. HWT Test Results for AZ3421PMV.

	OBC-0.7%: 5.3%	OBC: 6.0%	OBC+0.7%: 6.7%
Air Voids (%)	8.4	7.3	6.8
AZ3412PMV	@5,000 Cycles		
Rut Depth (mm)	2.6	2.3	1.9
	@10,000 Cycles		
	3.1	2.7	2.2
	@15,000 Cycles		
	3.6	3.2	2.4
	@20,000 Cycles		
	3.9	3.7	2.5

Table 4. HWT Test Results for AZ3421PMV25.

	OBC-0.7%: 5.5%	OBC: 6.2%	OBC+0.7%: 6.9%
Air Voids (%)	7.7	7.3	7.0
AZ3412PMV-25	@5,000 Cycles		
Rut Depth (mm)	1.6	1.7	1.8
	@10,000 Cycles		
	1.9	2.1	2.1
	@15,000 Cycles		
	2.0	2.3	2.3
	@20,000 Cycles		
	2.1	2.5	2.5

Table 5. HWT Test Results for AZ3421TR.

	OBC-0.7%: 5.1%	OBC: 5.8%	OBC+0.7%: 6.5%
Air Voids (%)	8.6	7.7	6.8
AZ3412TR	@5,000 Cycles		
Rut Depth (mm)	2.9	2.5	2.1
	@10,000 Cycles		
	3.6	3.1	2.5
	@15,000 Cycles		
	4.1	3.5	2.7
	@20,000 Cycles		
	4.5	3.8	2.9

Table 6. HWT Test Results for AZ3412TR25.

	OBC-0.7%: 4.8%	OBC: 5.5%	OBC+0.7%: 6.2%
Air Voids (%)	8.2	8.2	6.9
AZ3412TR-25	@5,000 Cycles		
Rut Depth (mm)	3.2	2.3	2.3
	@10,000 Cycles		
	3.8	2.7	2.7
	@15,000 Cycles		
	4.4	3.1	3.0
	@20,000 Cycles		
	5.0	3.4	3.2

A review of the rutting resistance of the four evaluated AC mixtures presented in Tables 3 through 6, leads to the following observations:

- Mixtures with PG76-22TR+ binders; low rut depth values were recorded for both AZ3412PMV and AZ3412PMV25 mixtures. The AZ3421PMV mix showed a rut depth value of 3.9mm at OBC-0.70% higher than the 2.5mm rut depth at OBC+0.70% after 20,000 cycles. This is opposite to the expected trend, which can be attributed to the difference in the air voids; 8.4% at OBC-0.70% compared to 6.8% at OBC+0.70%. AZ3412PMV25 showed relatively consistent rut depth at OBC and OBC±0.70% after 20,000 cycles. However, the AZ3412PMV25 showed higher resistance to rutting because of the addition of RAP.
- Mixtures with PG70-16TR binder; low rut depth values were measured for both AZ3412TR and AZ3412TR25 mixtures. Again, the impact of binder content on the measured rut depth was opposite to the expected trend. This contradiction can be explained by the variations in air voids of the tested specimen.

4.3 Summary of Rutting Resistance

Figure 7 compares the rut depth values for the AC mixtures with PG76-22TR+ and PG70-16TR binders. The height of the bar represents the average rut depth value recorded for each AC mix after 20,000 cycles.

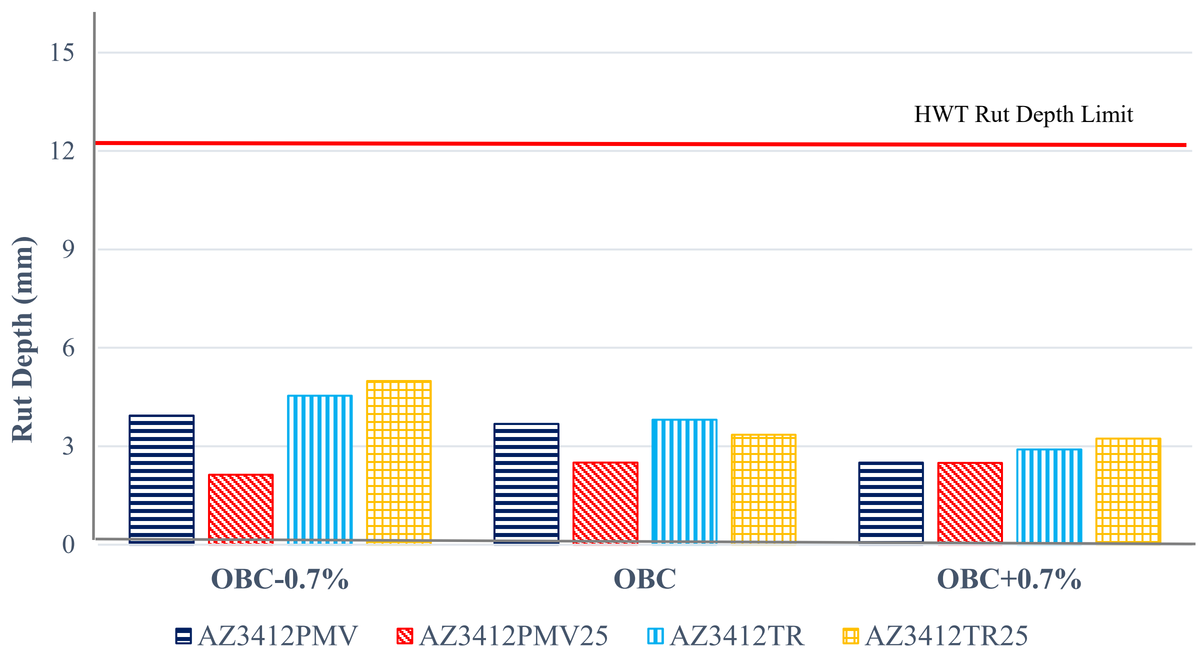

Figure 7. HWT test results at 20,000 cycles.

The Texas Department of Transportation has set a maximum rut depth of 12.5mm after 20,000 cycles as a threshold for identifying AC mixtures with good resistance to rutting. Overall, all the mixtures display very low susceptibility to rutting (below 12.5mm) after 20,000 cycles. The AZ3412PMV25 and AZ3412TR25 showed lower rut depth, indicating the positive impact of RAP on the rutting resistance of AC mixtures. In general, the AC mixtures with lower binder contents are showing lower rutting resistance. This discrepancy can be contributed to the fact that the measured rut depths of the various mixtures are significantly lower than the limit of 12.5 mm after 20,000 cycles, which makes the observed differences within the repeatability of the HWT test.

5.0 Findings and Recommendations

This investigation evaluated the cracking and rutting resistance of AC mixtures designed per EVAC specifications and containing tire rubber and polymer modifiers. In order to capture the true influence of the modifiers, mixtures were evaluated with and without RAP and at asphalt binder contents that span the entire range of acceptable mixtures under the EVAC specifications. The laboratory evaluations presented in the report lead to the following findings and recommendations:

- Both the tire rubber (TR) and tire rubber plus polymer (PMV) modified AC mixtures exhibit excellent resistance to rutting, which has been maintained over the entire range of low and high binder contents and whether or not RAP is used in the mixture.
- Figures 8 and 9 compare the cracking resistance of the evaluated mixtures. A review of the data presented in Figures 8 and 9 leads to the following findings:
    - The cracking index (FI) of the short-term aged mixtures presented in Figure 8 represent their resistance to reflective cracking. This data show the significant detrimental impact of both reducing binder content and the addition of RAP on the reflective cracking resistance of the AC mixtures. The tire rubber plus polymer modified mixture (i.e., PMV) delivers superior resistance to reflective cracking and holds more effectively at a reduced binder content than the tire rubber modified mixture (i.e., TR). However, it should be noted that the combination RAP and reduced binder content delivers the most damaging impact on the resistance of the AC mixture to reflective cracking.
    - The cracking index (FI) of the long-term mixtures presented in Figure 9 represent their resistance to fatigue cracking. This data show the significant detrimental impact of both reducing binder content and the addition of RAP on the fatigue cracking resistance of the AC mixtures. The tire rubber plus polymer modified mixture (i.e., PMV) delivers superior resistance to fatigue cracking and holds more effectively at a reduced binder content than the tire rubber modified mixture (i.e., TR). However, it should be noted that the combination RAP and reduced binder content delivers the most damaging impact on the resistance of the AC mixture to fatigue cracking.
- The analysis of the data generated from this laboratory evaluation showed the superior quality of the AC mixture modified with tire rubber and polymer (i.e., PMV) in terms of resistance to both reflective and fatigue cracking. In addition to its excellent resistance to the two modes of cracking, the PMV mixture also maintains excellent resistance to rutting. The excellent resistance of the PMV mix to the two modes of cracking coupled with its excellent resistance to rutting makes it a preferred choice for both new and overlay construction. However, it should be well noted that, even-though the PMV mix is very robust, the combination of RAP and low binder content could be very damaging to its performance and this combination should be highly avoided in the field.

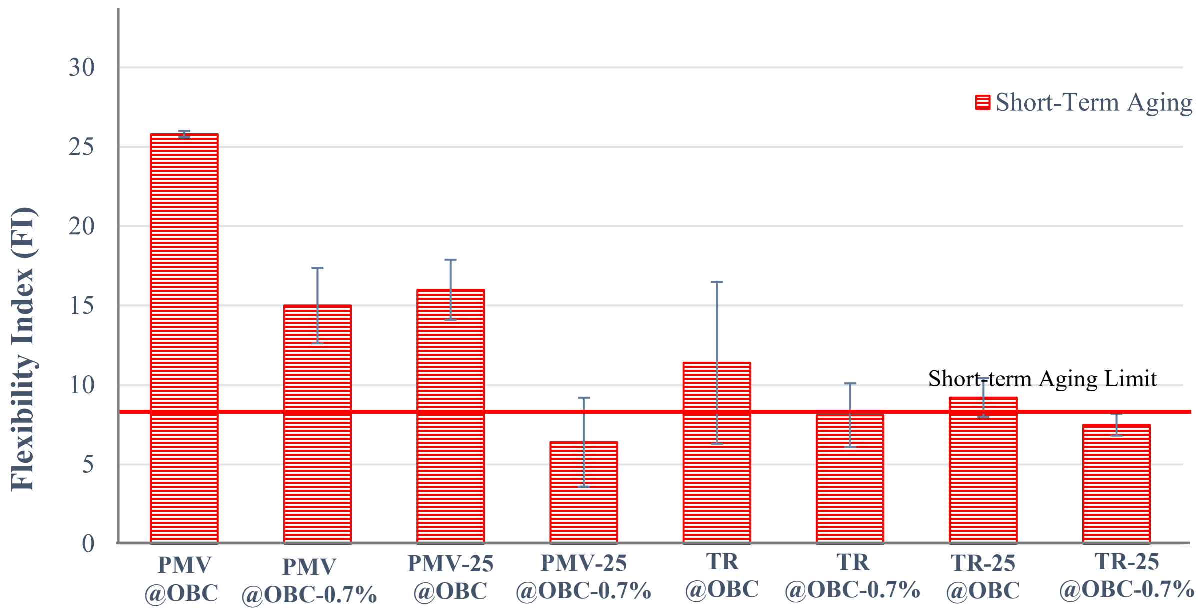

Figure 8. FI values for short-term aged AC mixtures with PG76-22TR+ and PG70-16TR binders.

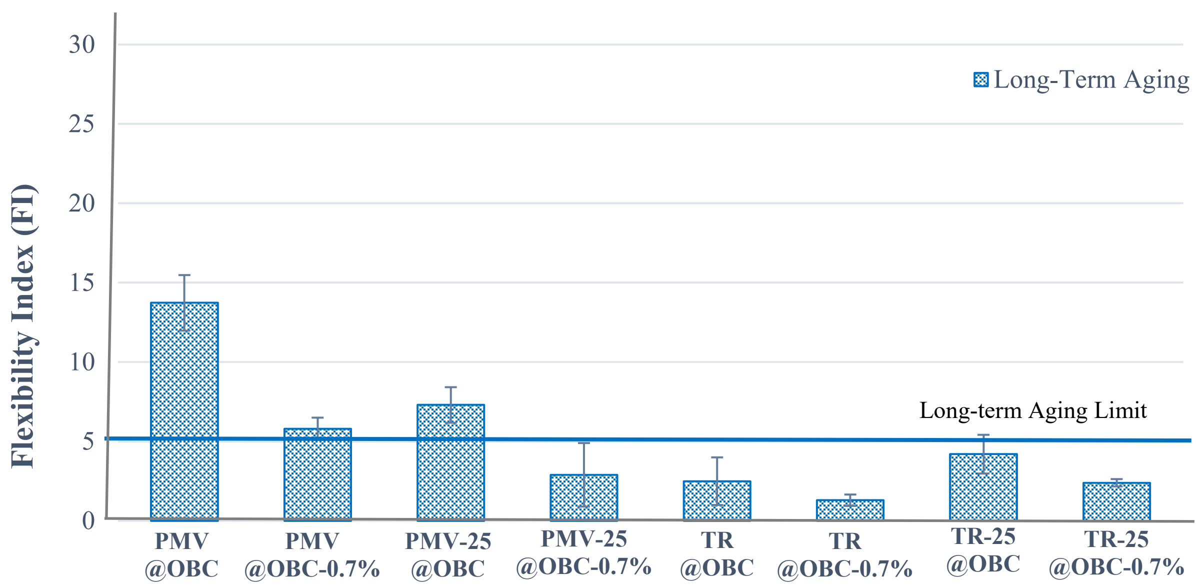

Figure 9. FI values for long-term aged AC mixtures with PG76-22TR+ and PG70-16TR binders.