Evaluation of TechniSoil G5® Stabilizer with 100% Recycled Asphalt Pavement (RAP)

Introduction

This pamphlet summarizes the test results for the laboratory evaluation that was conducted at the University of Nevada, Reno to assess the mechanical and mechanistic performance of a TechniSoil G5® stabilizer with 100% recycled asphalt pavement (RAP) material. The TechniSoil G5® stabilizer is a patent pending, new class of super polymers. It is a bio base stabilizing polymer that reacts with soil/base/RAP components, forming a water insoluble polymer network.

In this study, the TechniSoil G5® was added to the RAP material at a rate of 5% by weight of RAP. The mixture was placed and compacted in a large slab in a controlled environment.

Mechanical Properties

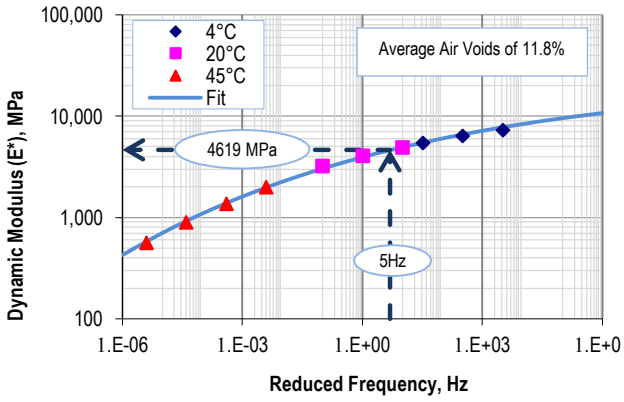
Core samples were taken from the compacted slab of 100% RAP with TechniSoil G5® material and evaluated for **dynamic Modulus, rutting resistance, and thermal cracking resistance**. Beam specimens were also cut out of the compacted slab and evaluated for **fatigue cracking Resistance.**

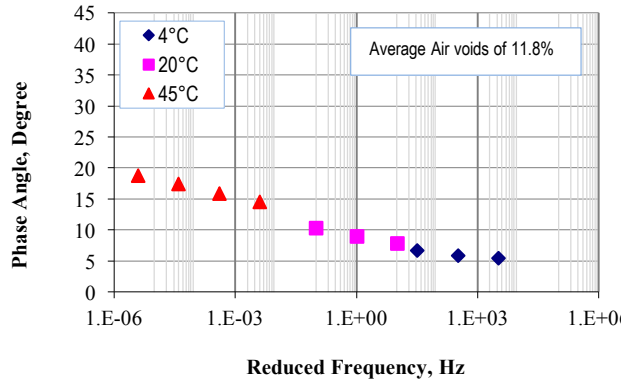
Dynamic Modulus

The dynamic modulus (E*) is a fundamental engineering property which provides an indication of the overall quality of a mixture. The E* for the 100% RAP with TechniSoil G5® mixture was measured in accordance with the AASHTO TP79 and the master curve was developed according to the AASHTO PP61. The test was conducted at three different temperatures (4, 20, and 40°C) and multiple frequencies (0.01, 0.1, 1, and 10Hz). The master curve was developed at a reference temperature of 20°C using the time-temperature superposition principle.

The dynamic modulus test results indicated a good stability for the 100% RAP with TechniSoil G5® mixture under traffic loading. The observed low phase angle also indicated good elastic properties

Dynamic Modulus and Phase Angle Values Indicating a Good Stable Mixture





Compacting G5 with 100% RAP

Coring G5 with 100% RAP

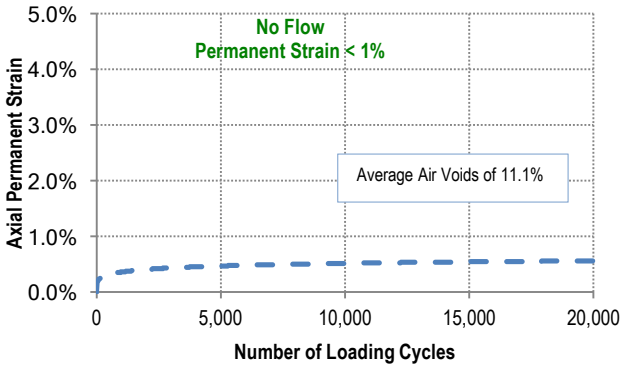
Core for G5 with 100% RAP

Resistance to Rutting

The rutting resistance of the 100% RAP with TechniSoil G5® mixture was evaluated in accordance with the AASHTO TP79. A 100 mm diameter cylindrical specimen was subjected to a repeated haversine axial compressive pulse load of 0.1 s and rest period of 0.9s. The resulting axial permanent deformation is measured as a function of the load cycles. The permanent strain with number of cycles was fit to the Franken model and the flow number (FN), the point at which the specimen exhibits tertiary flow, was computed. The FN criteria based on the expected traffic level during the design period are provided in table below (AASHTO TP79).

The FN test results indicated an excellent resistance for the 100% RAP with TechniSoil G5® mixture under all traffic levels.

Excellent Resistance to Rutting



AASHTO TP79 – FN Requirements					Results
Traffic Level (Million ESALs)	**< 3**	**3 to < 10**	**10 to < 30**	**≥ 30**	**100% RAP with TechniSoil G5®**
Minimum Flow Number (Cycles)[1]	Testing Not Needed	53	190	740	No Flow after 20,000 Cycles

[1] FN test conditions: (1) unconfined; (2) 600 kPa (87 psi) deviator stress; (3) and at 7-day maximum pavement temperature 20 mm below the pavement surface, at 50% reliability.

Fatigue Resistance

The fatigue resistance of the mixture was determined in accordance with the AASHTO T321. A rectangular beam (50x63x380mm) was subjected to a 4-point repeated flexural bending in strain controlled mode until failure. The failure at a given strain level is defined as the point of 50% reduction in initial stiffness. The fatigue test was conducted at the temperature of 21.1°C, loading frequency of 10Hz, and different strain levels. The test Specimens were *long-term aged* for 5 days at 85°C in a forced-draft oven in accordance with AASHTO R30.

The flexural beam test results indicated a very good fatigue relationship for the 100% RAP with TechniSoil G5® mixture.

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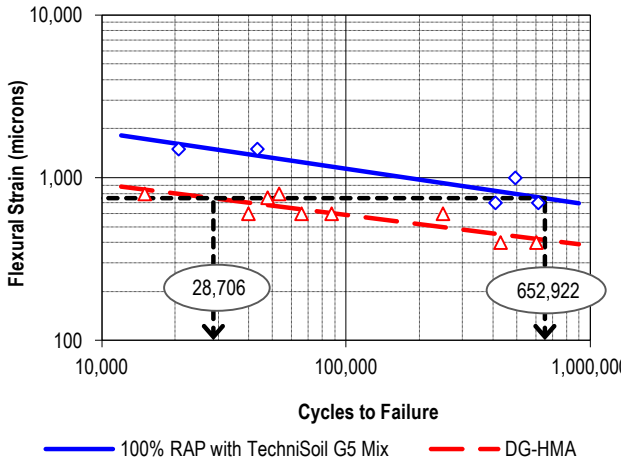
Excellent Resistance to Fatigue Cracking at 21.1°C



Property	100% RAP+G5 Mix	DG-HMA
Average air voids	11.2%	6.7%
Average flexural stiffness	5,812 MPa (843 ksi)	1,186 MPa (172 ksi)
K_1	4.524E-09	8.293E-13
K_2	4.531	5.293

Thermal Cracking Resistance

The Uniaxial Thermal Stress and Strain Test (UTSST) was used to determine the thermal cracking resistance of the mixture. The test measures the thermal stress build-up in a restrained cylindrical specimen (57x140mm) and thermal strain in an un-restrained cylindrical specimen (57x270mm) when subjected to a cooling rate of 10°C/hour. The temperature at which the specimen cracks is referred to as the fracture temperature and the stress at which the fracture occurs is referred to as fracture stress. The fracture temperature and fracture stress represent the anticipated field condition under which the pavement will most likely experience thermal cracking. These two properties were measured from the restrained specimen and the linear coefficient of thermal contraction was obtained from the un-restrained specimen. The test Specimens were *long-term aged* for 5 days at 85°C (185°F) in a forced-draft oven in accordance with AASHTO R30.

The UTSST indicated the ability of the 100% RAP with TechniSoil G5® mixture to withstand low fracture temperature while maintaining a relatively high fracture stress.

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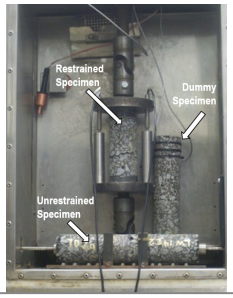
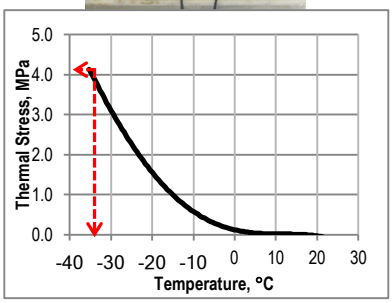
Excellent Resistance to Thermal Cracking





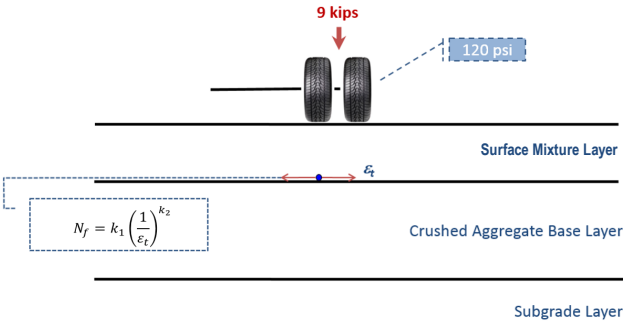
Property	Value
Fracture	
Fracture Temperature	-34.1°C
Fracture Stress	4,227 kPa (613 psi)
Linear Coefficient of Thermal Contraction (CTC)	
CTC_{liquid}	2.42×10^{-5} /°C

Simple Mechanistic-Empirical (M-E) Analysis

Mechanistic analysis covers the determination of the responses of the flexible pavement structure to the loads imparted by heavy vehicles and their impact on pavement life. In this analysis, two thin pavement sections were considered as shown in the figure below. The maximum tensile strain at the bottom of the surface layer underneath the tire was computed using the 3D-Move Analysis software which considers the viscoelastic properties of the surface layer. The number of repetitions to fatigue failure of the pavement at two different vehicle speeds (72 and 16 kph) was computed using the laboratory derived fatigue performance model and the tensile strains obtained from the 3D-move analysis. The fatigue life ratio was obtained by dividing the number of repetitions to failure of the pavement with the 100% RAP with TechniSoil G5® mixture to that of a typical dense-graded (DG) HMA mixture.

The M-E analysis showed significant improvements in the fatigue life of thin pavements with the use of 100% RAP with TechniSoil G5®.

Significantly Improved Fatigue Performance of Thin Pavements



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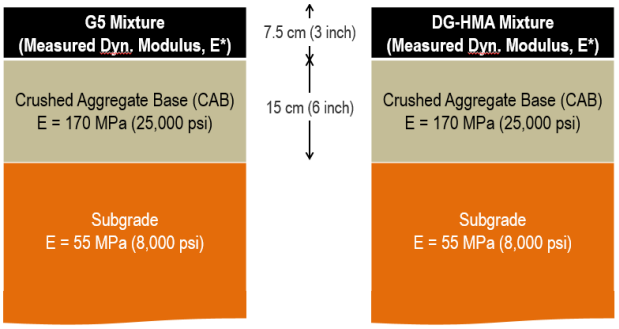

Vehicle Speed	Surface Mixture	Fatigue Analysis at 21°C (70°F)		
		Tensile strain, ε_t, (microns)	Number of repetitions to failure, N_f (millions)	Fatigue life ratio
72 kph (45 mph)	100% RAP with TechniSoil G5®	341	23.2	8.0
	DG-HMA	313	2.9	
16 kph (10 mph)	100% RAP with TechniSoil G5®	363	17.6	14.7
	DG-HMA	373	1.2	

Conclusions

An extensive laboratory evaluation of the mechanical and mechanistic performance of TechniSoil G5® stabilizer with 100% recycled asphalt pavement (RAP) material was conducted in this study. The data showed that a 100% RAP with TechniSoil G5® mixture can have excellent resistance to all critical distresses and is expected to perform very well in the field.