Gencor Industries Inc.

Gencor Ultrafoam GX2™

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WMA technology provider –
Gencor Industries
5201 North Orange Blossom Trail
Orlando, FL 32779
407-790-2600
Dennis Hunt
Senior Vice President
dhunt@gencor.com

Gencor Ultrafoam GX2™ System

Gencor has devised a simple, robust and reliable method to inject steam into the foaming process, using only the energy of the pump or head supplying the AC and water. The Ultrafoam GX2™ can achieve consistent foaming at varying production rates without the use of a powered mixing device. As a result, the AC and water can be introduced at widely different flow rates and temperatures.

The Ultrafoam GX2™'s patented design provides variable orifices for both AC and water, and a means to keep the two flows in intimate contact so that the available mixing energy is used efficiently.

When making foamed asphalt, a small percentage (1.25% to 2% by weight of total AC) of water is injected into the center of the AC flow. The Ultrafoam GX2™ design has a centrally located spring loaded water valve that will open when the pressure of the water is impressed behind the valve. External to the centrally located nozzle is a uniquely designed diaphragm plate which provides a means to introduce and direct the flow of AC to the process. This unique diaphragm allows the AC to flow through at varying rates while keeping a constant fluid pressure. As the flow of the AC is increased, the fingers of the diaphragm will deflect, allowing for increased flow area. Equally important is that the flow stream of the AC is directed toward the center nozzle such that the AC flow converges to the center of the injection point of the water.

Due to this unique patented design, the Ultrafoam GX2™ maintains the perfect ratio of AC and water at all production rates; thus creating smaller, more stable bubbles for the most consistent asphalt foaming in the industry.

Details on requited plant modifications to accommodate the technology –

The Ultrafoam GX2™™ system includes the special Gencor foaming generator which can be easily bolted to a 3" or 4" existing asphalt injection line going to the drum mixer. The Ultrafoam GX2™™ is hot oil jacketed for proper heat retention and includes (2) hot oil jumpers. A variable speed drive (VFD) and positive displacement water pump are mounted on a unitized skid which includes an inlet strainer, gauge, pressure switch, pressure relief valve, water flow meter. Operator controls consist of a start/stop button and auto/manual switch housed in a separate mountable NEMA enclosure.

The Ultrafoam GX2™™ system can be installed on drum mix and batch plants. The plant must have a source of water.

Product History

Foaming Asphalt Cement (AC) aids in distribution of the AC across the aggregate surfaces to obtain maximum coating and temporarily lowers the AC viscosity. The foaming reaction and/or prolong the reduction of viscosity, but this is not necessarily new technology. Patents dating back into the 1920s disclose drum mixers that spray soap solutions on the aggregates prior to AC coating. These patents disclose aggregate temperatures of about 250 degrees Fahrenheit in the mixer section – very much in line with today's targets.

In 1965, K.E. McConnaughay filed for a drum mixing process known as the "turbulent mass mixer," which came into commercial use in the early 1970s. This patent described a counter-flow drum mixer where the process introduced water, additives, and asphalt simultaneously that created a thoroughly coated mix at low temperatures. The patent described in detail the reaction as "turbulent mass" and "cloud", what we now more commonly call "foamed." This process was first commercialized in 1970, and by the end of 1971 had produced over 170,000 tons.

In 1974, R. Kenyon Construction had several of these systems that produced "warm mix" rather than hot mix. Mixing temperatures were normally in the range of 150 to 170 degrees Fahrenheit for base and binder courses and surface course temperatures were between 190 to 230 degrees Fahrenheit. The additives that were used are similar to those being marketed today to improve adhesion. At that time, there was a considerable advantage in mixing at lower temperatures and still being able to produce quality mixes while meeting all the requirements and specifications of the highway department. Fuel savings were reported as a distinct advantage even in the days of low fuel costs. Millions of tons and hundreds of miles of Iowa roads were produced with turbulent mass mixers, yielding very positive results. Other reported advantages were less rolling and compaction and improved smoothness. In fact, one particular Iowa Contractor with a "turbulent mass" mixing plant won an award for smooth pavement.

In 1973, the Boeing Construction Equipment Company introduced drum mixers based on technology patented by H.N. Shearer that used a similar low temperature process but in a parallel flow drum. Boeing quickly dominated the market with this improved technology, selling more plants than all other manufacturers. The early asphalt injection caused a foaming reaction between the hot asphalt oil and the water vapor released in the drum boiling zone, yielding superior aggregate coating at all mix temperatures. The low mix temperatures and early asphalt injection also yielded complete aggregate coating and proper residual moisture for superior compaction.

Gencor Industries Inc., the successor to Boeing, purchased BCE in the 1980s. Gencor developed the Ultrafoam GX system in 2008.

Field Test Results –

Project 1: Dixie Highway, Chicago Heights, IL. September 2008

Introduction

This WMA project is located on Dixie Highway in Chicago Heights, IL. The road has four-lanes. The Wma section is runs north of E. Joe Orr Rd to Ashland Ave. on both side of the road (.5 miles). The HMA control section runs south of E. Joe Orr Rd to W. 10th Street (.5 miles). Average traffic details for the test section are provided in Table 1. The project was paved on September 9 and 10, 2008.

Table 1: Traffic Details for Dixie Highway

Total AADT[1]	Single Unit Truck	Multi Unit Truck	Heavy Commercial Vehicle%	Single Unit Truck%	Multi Unit Truck%	Construction Rating of the Road
11,700	150	50	2.56	1.92	.064	7.8

[1] Annual average daily traffic

Mix Design and Mix Production

The mix design was undertaken by Chicago Testing Laboratory. Mix was produced at the Gallagher Asphalt Plant in Thornton, IL. WMA was produced by foaming asphalt through Gencor Ultrafoam process. Mix design details are summarized in Table 2. Mix production details are listed in Table 3 and 4.

Table 2: Mix Design Details for Dixie Highway

Parameter		JMF	Actual Control	Actual WMA
Pavement type N70 Surface with 20% RAP				
Grading: 12.5mm		100	100	100
9.5		98	97	97
4.75		59	56	56
2.36		38	37	35
1.18		25	26	23
0.6		18	18	15
0.3		12	13	11
0.15		9	9	7
0.075		6.1	6.6	5.3
Asphalt binder grade	PG 64-22			
Tons produced			730	1150
WMA Technology application rate (% by weight of AC)		-	-	1.25
Production temperature (°F)		320/260	313	259
Moisture content before production		N/A	N/A	N/A
Moisture content after production		-	N/A	0.0

Table 3: Lab results for Dixie Highway

	Dixie Highway Project - Lab results				
	9/9/2008		9/10/2008		
	HMA	**WMA**	**WMA**	**WMA**	**Virgin AC**
Tons	730	500	650		
Gmm	2.504	2.517	2.504	2.503	
Gmb	2.469	2.458	2.407	2.419	
Nmax Gmb			2.45		
Va (Ndes)	1.4	2.4	3.9	3.4	
Va (Nmax)			2.2		
AC	5.9	6.1	5.9	6.1	
-#200	6.6	7.7	5.3	5.3	
6 Sability	>5000		>5000		
6" Flow	>35		>35		
50 Blow Stability (lbs)			1600		
50 Blow Flow			14.3		
75 Blow Stability (lbs)			1804		
75 Blow Flow			15.5		
Penetration	40		38		63
Penetration Change	36.51%		39.68%		
Viscosity	8790		7740		2262
Viscosity Ratio	3.89		3.42		
TSR	0.81		0.93		
Gyrations to 7%	19			38	
TSR Unc. Strength" (lbs)	3421		3169		
TSR "Cond. Strength" (lbs)	2753		2941		
Tensile Strngth (PSI) Unc	97		89.9		
Tensile Strngth (PSI) Cond	78.1		83.4		
Reheat Gmm				2.508	
Reheat 240F Gmb				2.397	
Reheat 290F Gmb				2.42	
Silo Moisture (1,2,4,6 hrs)	0.00%	0.00%	0.00%		
Discharge Moisture	0.00%	0.00%	0.00%		

Table 4: Illinois DOT Core Results

Dixie Hwy Core Results		GMM	GMB	Density	TS Cond	TS Uncon	TSR Ratio
Warm Mix							
Core Number	20	2.523	2.328	92.3		82.5	
	21		2.37	93.9	76.1		
	22		2.359	93.5	85.9		
	23		2.408	95.4		153.3	
	24		2.322	92.0	95.2		
	25		2.306	91.4		119.1	
Average		2.523	2.349	93.1	85.7	118.3	0.72
Hot Mix							
Core Number	31		2.522	93.1	57.9		
	32	2.522	2.373	94.1		120.6	
	33		2.382	94.4		62.9	
	34		2.342	92.9		74.8	
	35		2.328	92.3	62.9		
	36		2.424	96.1	74.8		
Average		2.522	2.366	93.8	65.2	86.1	0.76

Construction

The Control section was constructed on 09/09/2008. The WMA sections were constructed on 09/09/2008 and 09/10/2008 respectively by Gallagher Asphalt. Weather conditions during construction of both sections were cool and sunny. Temperatures ranged between 66°F and 71°F. Standard paving procedures were followed, which involved the application of a tack coat, material were dumped directly into the paver (Blaw-Knox), and then compacted (2 Hypac rollers). Haul distance from the plant to the site was 5 miles. Haul time was between 15 minutes and 20 minutes.

Performance

November 2009

Pavement checked for rutting at intersections, none found. The WMA pavement is in good condition.

November 2009

November 2010

The Control and WMA sections are performing very similar after two years in service (see table 5). There is some raveling on the longitudinal joint of both sections. There are also a few transverse cracks in both sections these appear to be reflective cracks (Figure 6 and 7).

Table 5: Summary of Monitoring Observations for Dixie Highway

Parameter	Control			WMA	
	May 10				May 10
Overall performance	Good				Good
Texture	Good				Good
Void clogging	No				No
Mechanical damage	N0				N0
Other damage	No				No
Bleeding/flushing	No				No
Surface cracks	Yes				Yes
Binder condition	Good				Good
Aggregate loss	Some				Some
Cracks - block	No				No
Cracks - longitudinal	No				No
Cracks - transverse	Yes				Yes
Cracks - alligator	No				No
Pumping	No				No
Rutting	No				No
Raveling/stone loss	Some				Some
Undulation/settlement	No				No
Edgebreak	No				No
Potholes	No				No
Delamination	No				No
Patching	No				No
Other repairs	No				No
Riding quality	Good				Good
Skid resistance	Good				Good
Surface drainage	Good				Good
Side drainage	Good				Good

Figure 1: Control 9/2008: General view

Figure 2: Control 11/2010: General view

Figure 3: WMA 09/2008: General view

Figure 4: WMA 11/2010: General view

Figure 5: Control 11/2010: Joint

Figure 6: Control 11/2010: Transverse Crack

Figure 7: WMA 11/2010: Reflective crack

Figure 8: WMA 11/2010: Close up of pavement

Figure 9: WMA 11/2008: General view

Figure 10: WMA 11/2010: General view

Project 2: Centre County, Pennsylvania. May and June 2009

Introduction

This WMA project is located in Centre County, PA. The project (ECMS 82737 WMA Pilot Project) consisted of an HMA control section and Gencor Ultrafoam GX, Advera, Sasobit and LEA WMA process. This report will only focus on the HMA control section and the Gencor Ultrafoam GX section, located on State Route 2012 between Spring Mills and Millheim, PA. The road is used by Automobiles, pickups trucks, school buses, farm equipment, and the occasional semi-truck comprise the makeup of traffic along with numerous Amish horse drawn buggies.   The road has two lanes, with average width of twenty feet. The WMA and HMA sections are both approximately one mile in length. The HMA and WMA sections cover both lanes. The HMA and Gencor WMA sections are separated by the LEA WMA section (see figures 10, 11 and 12) Average traffic details for the test section are provided in Table 1. The HMA section was placed on May 29, 2009 and the WMA section was placed on June 8, 2009.

Table 1: Traffic Details for Centre County

Total AADT[1]	Single Unit Truck	Multi Unit Truck	Heavy Commercial Vehicle%	Single Unit Truck%	Multi Unit Truck%	Construction Rating of the Road
1621	N/A	N/A	N/A	N/A	N/A	N/A
[1] Average daily traffic						

Mix Design and Mix Production

The mix design was undertaken by Glenn O. Hawbaker's laboratory. Mix was produced at the Glenn O. Hawbaker's Pleasant Gap plant located in Pleasant Gap, PA. WMA was produced by foaming asphalt through Gencor Ultrafoam GX process. Mix design details are summarized in table 2. Mix production details are summarized in Table 3. Testing of the mix was done by the FHWA (The Mobile Asphalt Testing Laboratory, lab on sight for this entire project), PDOT, and Glenn O. Hawbaker. See also FHWA report attached to this report.

Table 2: Mix Design Details

Parameter				
		JMF	Actual Control	Actual WMA
Mix – 9.5mm SRL-M 0.3< 3 ESAL PG64-22				
Grading: 12.5mm		100	100	100
9.5		98	97	97
4.75		72	70	70
2.36		46	43	43
1.18		26	25	26
0.6		17	15	16
0.3		11	10	11
0.15		8	7	8
0.075		5.0	5.86	6.15
Asphalt binder grade	PG 64-22			
Tons produced			870	1014
WMA Technology application rate (% by weight of AC)		-	-	1.25
Production temperature (°F)		300/250	298.4	250.9
Moisture content before production (%)		N/A	2.35	2.18
Moisture content after production (%)		-	0.15	0.29

Table 3: Lab results for ECMS 82737 WMA Pilot Project

	5/29/2009	6/8/2008
	HMA	**WMA**
Tons	870	1014
Gmm w/db	2.476	2.476
Gmm wo/db	2.477	2.475
Gmb	2.357	2.386
Va	4.78	3.5
VMA	17.14	15.98
VFA	72.2	78.18
f/Pbe	1.13	1.25
%Gmm Nini	83.9	85.2
% Gmm Ndesign	94.7	96.2
AC	6.0	5.9
Cores (% compaction)	94.4	93.6
	92.3	94.0
	93.6	94.2
	93.5	93.2
Average % compaction	93.5	93.8

Construction

The Control section was constructed on 05/28/2009. The WMA section was constructed on 06/8/2009 respectively by Glenn O. Hawbaker Inc. Weather conditions during construction of the HMA section were cool and overcast. Temperatures ranged between 61°F and 67°F. The weather conditions during construction of the WMA section were warm and clear. Temperatures ranged between 67°F and 79°F. Standard paving procedures were followed, which involved the application of a tack coat, material was dumped directly into the paver (Cat), and then compacted with three rollers. Haul distance from the plant to the site was approximately 35 miles. Haul times ranged from forty-three minutes to two hours one way for the HMA section, and for the WMA section ranged fifty-five minutes to one hour and twenty minutes. Average for the HMA was one hour thirty-five minutes and the WMA average was one hour and eight minutes.

Performance

May 2011

The Control and WMA sections are performing very similar after two years in service (see table 4).

Table 4: Summary of Monitoring Observations

Parameter	Control				WMA
	May 10				May 10
Overall performance	Good				Good
Texture	Good				Good
Void clogging	No				No
Mechanical damage	No				No
Other damage	No				No
Bleeding/flushing	No				No
Surface cracks	Minimal				Minimal
Binder condition	Good				Good
Aggregate loss	Little				Little
Cracks - block	No				No
Cracks - longitudinal	Very Few				Very Few
Cracks - transverse	Some				Very Few
Cracks - alligator	No				No
Pumping	No				No
Rutting	No				No
Raveling/stone loss	None				None
Undulation/settlement	No				No
Edgebreak	Little				Little
Potholes	None				None
Delamination	No				No
Patching	No				No
Other repairs	No				No
Riding quality	Good				Good
Skid resistance	Good				Good
Surface drainage	Good				Good
Side drainage	Good				Good

Figure 1: WMA June 2009

Figure 2: WMA May 3, 2011

Figure 3: WMA Placed June 2009

Figure 4: WMA May 3, 2011

Figure 5: WMA Placed June 2009

Figure 6: WMA May 3, 2011

Figure 7: WMA May 3, 2011: Close up of pavement

HMA Section May 3, 2011 (No photos taken during initial placement)

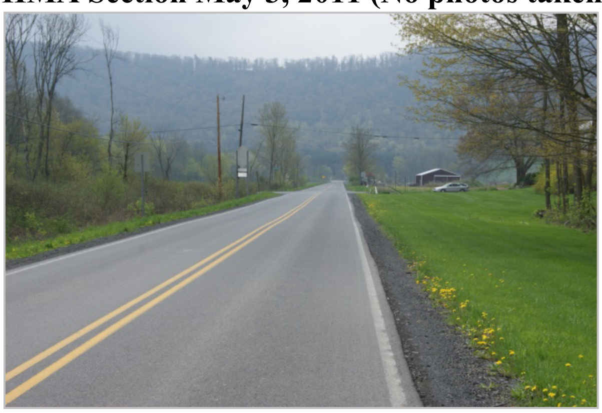

Figure 8: HMA May 3, 2011

Figure 9: HMA May 3, 2011

Figure 10: Control section ends

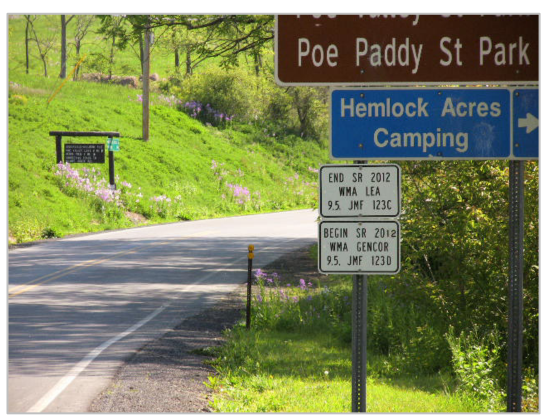

Figure 11: Gencor section begins

Figure 12: Gencor section ends

Project 2: California State Route 1 near Mendocino, Ca. June 2010

Introduction

This experiment is located on California Highway 1 between Albion and Mendocino in California and consisted of a one-inch open-graded friction course using a PG 58-34 polymer-modified binder. The road has two lanes with shoulders. Sharp bends and steep grades are prevalent. The experiment was located near the ocean about 2.5 hours haul from the Granite hot-mix plant in Ukiah, CA. This location normally experiences cool temperatures and the purpose of this experiment is to investigate the use of warm-mix technologies to see if they would help placement and compaction of the mix after the long haul. The Gencor Ultrafoam mix was placed on June 30 and July 01, 2010. A short hot-mix control, placed on June 24, 2010, was included in the study. The road carries approximately 11,000 vehicles per day, about 8 percent of which is trucks.

Table 1: Traffic Details for Highway 1

Total AADT[1]	Single Unit Truck	Multi Unit Truck	Heavy Commercial Vehicle%	Single Unit Truck%	Multi Unit Truck%	Construction Rating of the Road
11,000						

[1] Annual average daily traffic

Mix Design and Mix Production

The mix was a 1 inch overlay and was designed by Granite Construction according to CTM 304 (HVEEM) and CTM 368 (Open Graded) Method. The mix was produced at Granite Construction Company's hot-mix plant located in Ukiah, CA, using a Gencor plant fitted with the Gencor Ultrafoam system. Mix design and mix production details are summarized in Table 5.1.

Construction

The experimental sections were constructed by Granite Construction. Weather conditions were sunny and clear. The ambient temperature at the start of paving was 52°F and 67°F at the end. Tack coat was applied at a rate of approximately 0.08 gal/yd^2. The following paving equipment was used:

- Paver: CAT AP1055B
- Material Transfer Vehicle: Roadtec SB2500B
- Breakdown Roller: CAT CB564D (Dedicated Roller for each operation) 2 passes in Static mode.
- Secondary Roller: CAT CB564D-2 passes in static mode.

Table 5.1: Mix Design Details for Control and Gencor Ultrafoam on CA-1

Parameter		Wearing Course			
		Spec	Target	Actual Control	Actual Gencor
Pavement type		12.5 mm (0.5 in.) Max OGFC			
Grading:	3/4"	100	100	100	100
	1/2"	100	100	100	100
	3/8"	94-100	100	100	99
	#4	28-42	35	37	35
	#8	8-20	14	12	10
	#16	--	9	7	7
	#30	2-12	7	6	5
	#50	--	3	4	4
	#100	--	3	3	3
	#200	0-4.0	2.3	2.4	2.5
Asphalt binder grade		PG58-24			
Bitumen content (% by mass of aggregate)		5.5-6.5	6	6	6
Crushed particles (%)		>90	92	92	92
Los Angeles Abrasion at 100 repetitions (%)		≤10	4	--	--
Los Angeles Abrasion at 500 repetitions (%)		≤40	17	--	--
Tons produced			---	1,000	1,200
WMA technology application rate (% by weight of binder)			-	N/A	1.5
Production temperature (°C)			---	163	138-143
Production temperature (°F)			---	325	280-290
Moisture content before production			N/A	N/A	N/A
Moisture content after production			-	N/A	N/A

Haul distance from the plant to the site was approximately 96 km (60 mi) with a haul time of about 2.5 hours. Construction details are summarized in Table 5.2.

Interviews with the plant personnel indicated that no problems were experienced with the mix production at the lower temperatures. The paving Foreman considered construction to be satisfactory and commented that odors and smoke were less than that typically experienced.

Table 5.2: Construction Details for Control and Gencor UltraFoam WMX on CA-1

Parameter	Control	Gencor
Tons produced	500	1,200
Period stored in silo	N/A	N/A
Average temperature at load out	163°C (325 F)	154°C (310°F)
Mat thickness (mm [in.])	25 (1.0)	25 (1.0)
Paving date	06/28/10	06/30/10
Paving start time	08:30	08:30
Paving end time	15:00	15:00
Temperature behind paver at start (°C [°F])	138 (280)	127 (260)
Temperature after rolling at end (°C [°F])	110 (230)	102 (215)

Performance

The experiment was monitored by the University of California Pavement Research Center. Only visual assessments were undertaken. The first assessment was undertaken immediately after construction to obtain baseline measurements, and thereafter at approximately six-monthly intervals. A summary of the observations from each visit is provided in Table 5.3.

Table 5.3: Summary of Monitoring Observations for CA-1, Mendocino

Parameter	Control			Gencor UltraFoam		
	June 10	**Nov 10**	**May 11**	**June 10**	**Nov 10**	**May 11**
Overall performance	Good	Good	Good	Good	Good	Good
Texture	Good	Good	Good	Good	Good	Good
Void clogging	No	No	No	No	No	No
Mechanical damage	No	No	No	No	No	No
Other damage	No	No	No	No	No	No
Bleeding/flushing	No	No	No	No	No	No
Surface cracks	No	No	No	No	No	No
Binder condition	Good	Good	Good	Good	Good	Good
Aggregate loss	No	No	No	No	No	No
Cracks - block	No	No	No	No	No	No
Cracks - longitudinal	No	No	No	No	No	No
Cracks - transverse	No	No	No	No	No	No
Cracks - alligator	No	No	No	No	No	No
Pumping	No	No	No	No	No	No
Rutting	No	No	No	No	No	No
Ravelling/stone loss	No	No	No	No	No	No
Undulation/settlement	No	No	No	No	No	No
Edgebreak	No	No	No	No	No	No
Potholes	No	No	No	No	No	No
Delamination	No	No	No	No	No	No
Patching	No	No	No	No	No	No
Other repairs	No	No	No	No	No	No
Riding quality	Good	Good	Good	Good	Good	Good
Skid resistance	Good	Good	Good	Good	Good	Good
Surface drainage	Good	Good	Good	Good	Good	Good
Side drainage	Good	Good	Good	Good	Good	Good
Noise reduction	Good	Good	Good	Good	Good	Good

June 2010

The Control (Figure 5.1 and Figure 5.2) and Gencor Ultrafoam (Figure 5.3 and Figure 5.4) sections both resembled a typical open-graded friction course and were given an overall rating of good. No evidence of compacted binder strings was recorded. No early stone loss was noted. No other problems were observed.

November 2010

No deterioration was noted on either section after five months of traffic.

May 2011

No deterioration was noted on either section after 12 months of traffic (Figure 5.5 through Figure 4.11).

Figure 5.1: Control 06/2010: General view.

Figure 5.2: Control 06/2010: Close-up view.

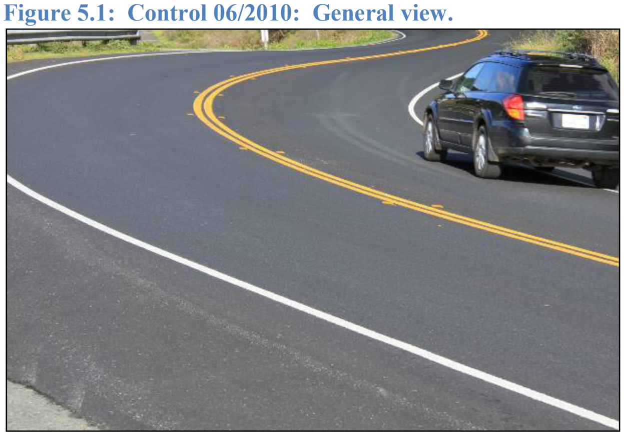

Figure 5.3: Gencor Ultrafoam 06/2010: General view.

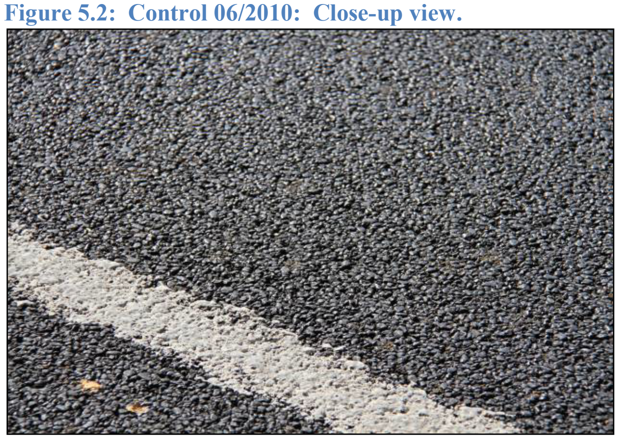

Figure 5.4: Gencor Ultrafoam 06/2010: Close-up view.

Figure 5.5: Control 05/2011: General view.

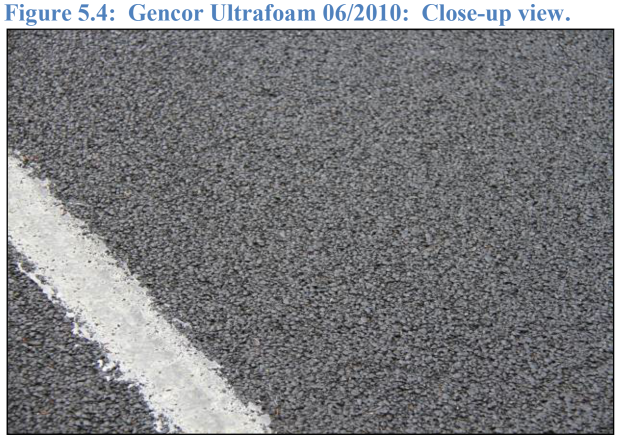

Figure 5.6: Control 05/2011: Close-up view.

Figure 5.7: Gencor Ultrafoam 05/2011: General view.

Figure 5.8: Gencor Ultrafoam 05/2011: Close-up view.

Project 4: Accelerated Pavement Testing on Rubberized Mix – University of California

Mix Design

The rubberized HMA mix design was prepared by Granite Construction and met the specifications for Caltrans "Half-Inch Maximum Gap-Graded Type II Rubberized Hot-Mix Asphalt (RHMA-G)". The mix design was not adjusted for accommodation of the warm-mix additives. A PG 64-16 binder was used and the crumb-rubber content was 18 percent. The water application rate was set at 1.5 percent by mass of binder.

Plant Modifications

No modifications were required to the plant.

Mix Production

Production began with the Control mix, followed by the warm mixes. At least 100 tonnes of each mix was produced and then stored in insulated silos. The first approximately 20 tonnes of each mix was "wasted" to ensure that a consistent mix was used on the test track. The Control and Gencor mixes were produced at 160°C (320°F) and 140°C (284°F) respectively. Water was added to the mix at 1.5 percent by mass of binder. Haul time from the asphalt plant to the test track was approximately 60 minutes.

Quality Control

<u>Asphalt Mix</u>

Quality control of the mixes produced for the test track was undertaken by Granite Construction on mix sampled from the trucks at the silos. The results are summarized in Table 1.

Table 1: Quality Control of Mix after Production

Parameter	Target	Specification	Actual	
			Control	Gencor
Grading				
3/4"	100	100	100	100
1/2"	84	88-100	99	99
3/8"	72	79-91	78	78
#4	49	31-45	31	31
#8	36	14-22	19	19
#16	26	-	13	13
#30	18	-	10	10
#50	11	-	7	7
#100	7	-	6	6
#200	4	0-4	4	4
Sand equivalent	-	>47	68	68
AC Binder Type	PG 64-16	-	PG 64-16	PG 64-16
AC Binder Content (%)	7.3	7.1 – 7.5	7.7	7.9
Hveem Stability (no cure)	-	>23	27	28
Rice Specific Gravity	-	-	2.483	2.489
Air-void Content (%)	-	-	1.0	1.3
Moisture (before plant) (%)	-	-	Not tested	Not tested
Moisture (after silo) (%)	<1.0	-	0.1	0.1

The following observations were made:

- The aggregate gradations of the Control and Gencor mixes were similar and met the specification requirements.
- The binder content of the Gencor mix (7.9 percent) was slightly higher than the target (7.3 percent), and the Control mix (7.7 percent) binder contents.
- The Rice specific gravity of the Gencor mix was essentially the same as the Control mix.
- The air-void content of the Gencor mix (1.3 percent) was slightly higher than the Control mix (1.0 percent).
- The Hveem stability of the Gencor mix (28) was marginally higher than the Control mix (27). The stabilities of both mixes were above the minimum limit of 23.

Asphalt Concrete Placement

The test track sections were constructed in the same order as asphalt production, using conventional equipment and following conventional procedures. Haze/smoke was visible during construction of both sections, but was considerably worse on the Control section compared to the Gencor section. Ambient temperatures during placement of the Control and Gencor sections were 10°C (50°F) and 12°C (50°F), respectively. Breakdown compaction temperatures for the Control and Gencor mixes were 154°C (309°F) and 128°C (262°F), respectively. Construction procedures and final pavement quality of the Gencor section did not appear to be influenced by the lower construction temperatures. Compaction on the Control section (air-void content of 9.5 percent) was better than on the Gencor section (air-void content of 11.2 percent), despite using the same rolling pattern. This was attributed to the lower mix temperature and rapid cooling of the mix due to the low ambient temperatures. Interviews with the paving crew after construction revealed that they did not note any significant differences in placement and compaction between the two mixes and no problems were experienced with construction at the lower temperature. Improved working conditions were identified as an advantage.

HVS Testing

Heavy Vehicle Simulator (HVS) test section layout, test setup, trafficking, and measurements followed standard UCPRC protocols. An average maximum rut of 12.5 mm (0.5 in.) over the full monitored HVS test section was set as the failure criteria for the experiments.

The pavement temperature at 50 mm (2.0 in.) was maintained at 50°C±4°C (122°F±7°F) to assess rutting potential under typical pavement conditions. Infrared heaters inside a temperature control chamber were used to maintain the pavement temperature. The pavement surface received no direct rainfall as it was protected by the temperature control chamber.

The HVS loading program for each section is summarized in Table 4.4. Equivalent Standard Axle Loads (ESALs) were determined using the following Caltrans conversion (Equation 4.2):

(4.2) $ESALS = (\text{axle load}/18000)^{4.2}$

Table 4.4: Summary of HVS Loading Program

Section	Overlay	Wheel Load[1] (kN)	Repetitions	ESALs[2]
620HB	Control	40 60 80	43,000 0 0	43,000 0 0
		Total	43,000	43,000
621HB	Gencor	40 60 80	112,000 0 0	112,000 0 0
		Total	112,000	112,000

[1] 40 kN = 9,000 lb. 60 kN = 13,500 lb 80 kN = 18,000 lb
[2] ESAL: Equivalent Standard Axle Load

All trafficking was carried out with a dual-wheel configuration, using radial truck tires (11R22.5- steel belt radial) inflated to a pressure of 720 kPa (104 psi), in a channelized, unidirectional loading mode. Load was checked with a portable weigh-in-motion pad at the beginning of each test and after each load change.

Rutting was measured with a laser profilometer and pavement temperatures were monitored using thermocouples imbedded in the pavement. A dedicated nearby weather station monitored ambient temperature, rainfall, relative humidity, wind speed and direction, and solar radiation.

Phase 3 Test Results Summary

Rutting behavior (average maximum rut) for the two sections is compared in Figure 1. The duration and the rut depth of the embedment phase (in terms of load repetitions) on the Gencor section was slightly less than the Control, indicating that the lower production temperature did not influence early rutting behavior. Rutting behavior on the Gencor section followed a similar trend to the Control, but at a lower rut rate (rutting per load repetition) after the embedment phase. The Gencor section required approximately 70,000 more load repetitions than the Control to reach the failure point. The results indicate that the use of the Gencor system and lower production and compaction temperatures did not negatively influence the rutting performance of the mix in this test.

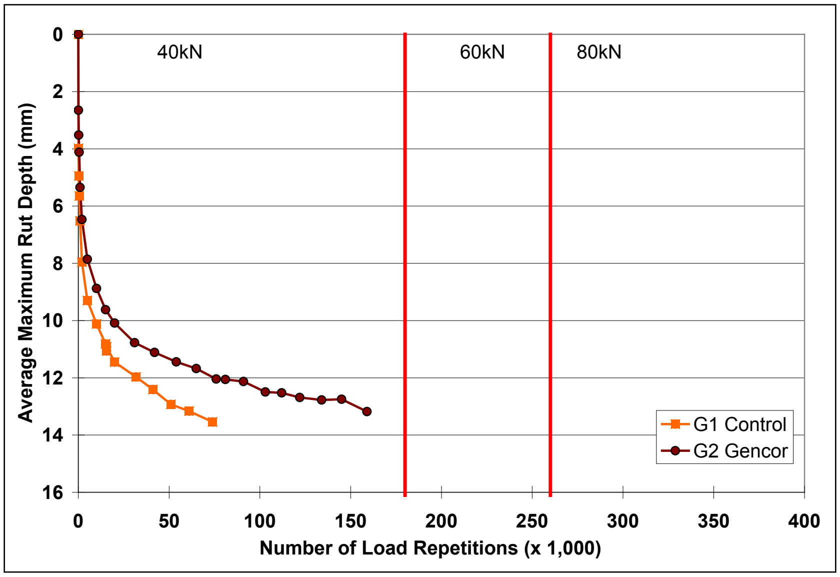

Figure 1: Comparison of average maximum rut for HVS testing.

Paving WMA Rubber mix

Paving WMA Rubber mix

HVS teat unit

Reference

1. JONES, D. and Wu, R. 2010. **Warm-Mix Asphalt Study: Summary of Phase 3 HVS Testing on Rubberized Mixes using *Gencor Ultrafoam GX™*.** Davis and Berkeley, CA: University of California Pavement Research Center. (TM-2010-08).

Additional Projects done in 2009

Company Name	WMA PROJECT ROADS	Date	Tons
Egge Sand and Gravel	Roosevelt Blvd. Seneca to Beltline in Eugene, OR	May-09	5,500
Egge Sand and Gravel	Danebo Ave -W 11th to Royal Ave in Eugene, OR	May-09	6,000
Egge Sand and Gravel	Royal Ave Bertelsen Rd to Danebo Ave in Eugene, OR	Jun-09	6,700
Egge Sand and Gravel	Bailey Hill Rd W 18th to Bertelsen Rd-Eugene, OR	Jul-09	8,000
Egge Sand and Gravel	Hwy 242 Old McKenzie Pass East of Springfield, OR	Aug-09	15,000
Egge Sand and Gravel	Lancaster St off Irving Rd in Eugene, OR	Aug-09	1,500
Phend and Brown	7.68 Two Lane on State Rd 14, Fulton County, North Central Indiana	May-09	11,000
Milestone Contractors	14.93 Mile Section, State Hwy SRS-31805-A, Indiana State Rd from 46 from 446 to 135 in Brown and Monroe Counties	Aug-09	22,000

States that the **Gencor Ultrafoam GX™** is approved and regularly used:

Alabama, 1409 Coliseum Blvd, Montgomery 36110 334-206-2395 Randy Mountcastle
Indiana, 100 N. Senate Ave Indianapolis 46204 317-610-7251 Mike Prather
Florida, 5007 NE 39th Avenue Gainesville, FL 32609
Mississippi, 401 North West Street Jackson 39201 601-359-1666 James Williams
Ohio, 1980 West Broad St Columbus43223 614-275-1387 Dave Powers
Pennsylvania, 1101 South Front Street Harrisburg 17104 717-783-6602 Tim Ramirez
Texas, 125 East 11th Street Austin 78701 512-506-5836 Dale Rand
Virginia, 1401 E. Broad Street Richmond 23219 540-860-2495 Trenton Clark
FHWA, Matthew Corrigan, P.E. 1200 New Jersey Ave. S.E. HIPT, E73 - 465
Washington, DC 20590 email: matthew.corrigan@dot.gov