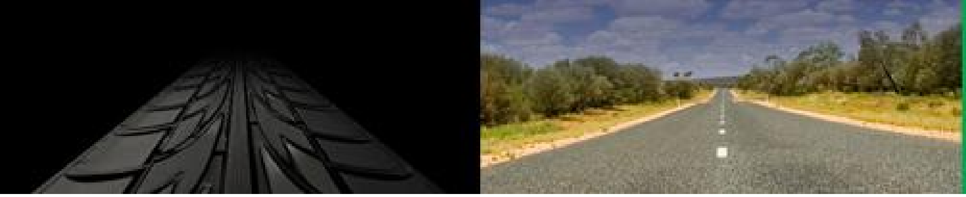
Pretreated Rubber Technologies

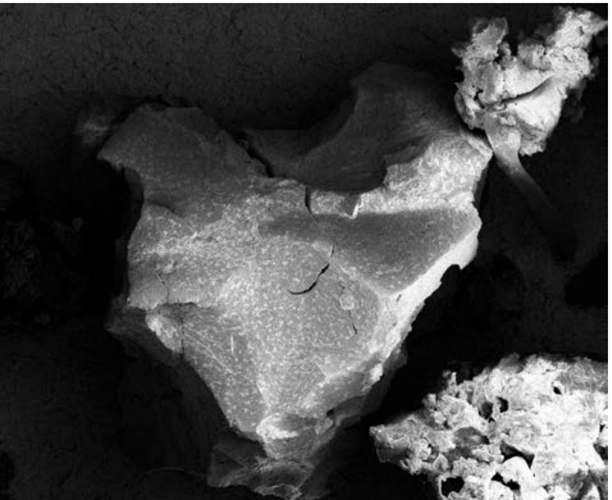
Arizona Pavements/Materials Conference
Arizona State University
Tempe, AZ
Nov 19-20, 2014

Doug Carlson
VP Asphalt Products

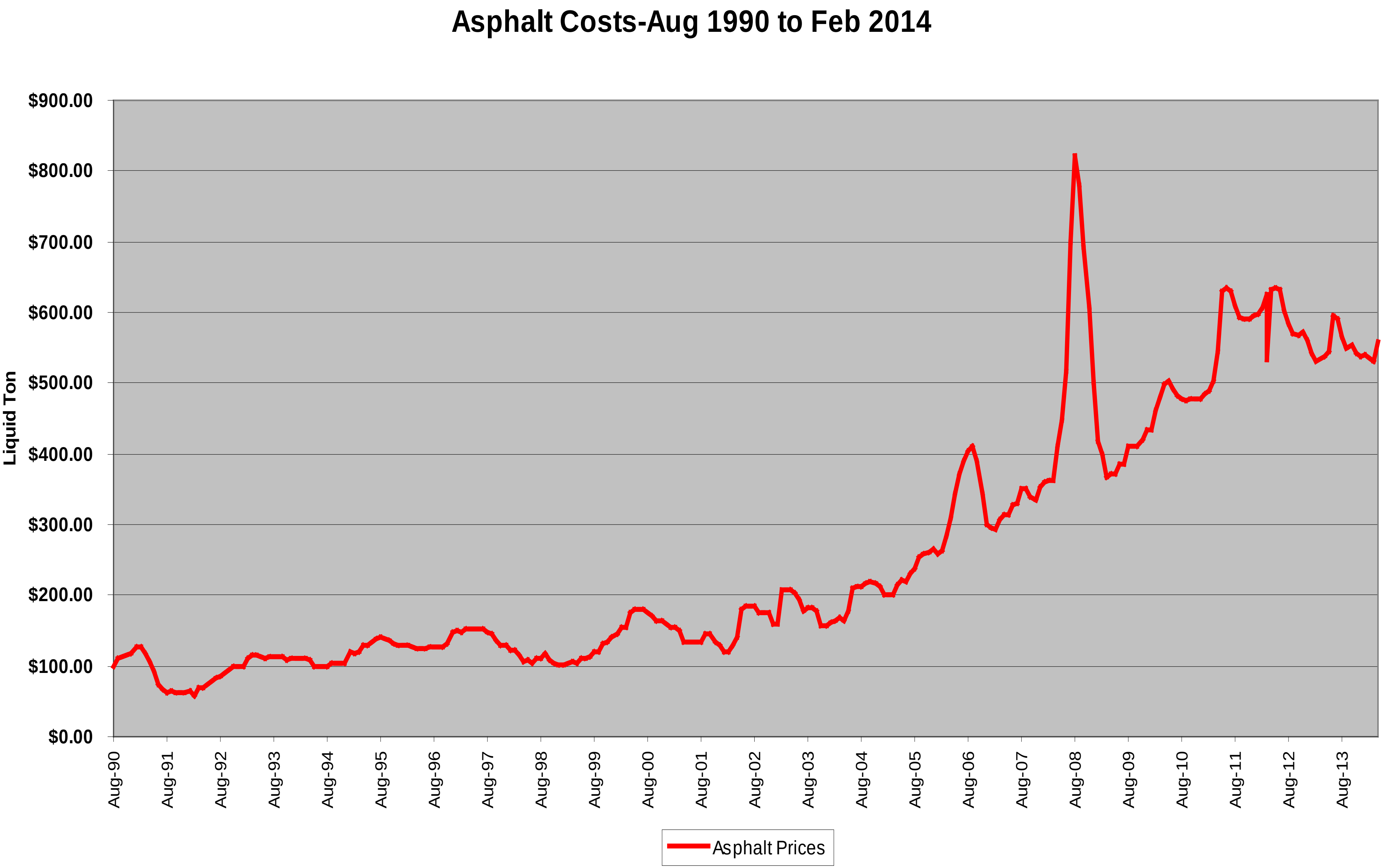


What is it?

- Recycled Tire Rubber
- 10 minus (1.8 mm and smaller) or 30 minus (0.6 mm) in size
- Value added technology included in and on rubber
- Or, has been pre-reacted, pre-swelled, “activated”, or pelletized



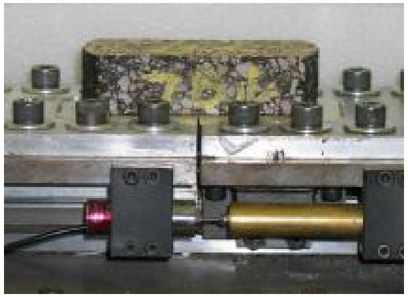
Asphalt Costs Have Surpassed RTR Costs

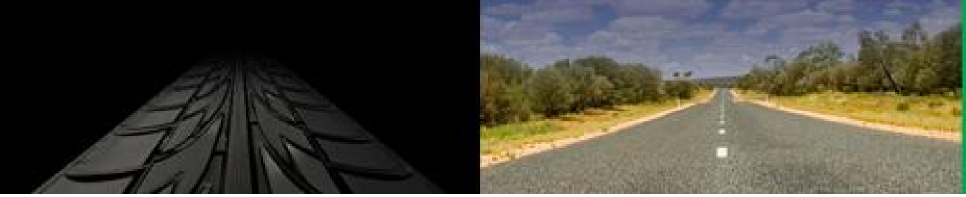



MIX PERFORMANCE

- Increased use of RAP has lead to mix acceptance testing
- Instead of tasting the batter before you bake the cake, taste the cake





UMASS Project

The main objective of this study was to evaluate and compare the effects of <u>two treated RTR</u> technologies that can be <u>added at the asphalt mix plant</u> (dry process) versus adding the RTR untreated to the asphalt binder (wet process) in mix performance testing on <u>dense graded and a gap graded mixtures</u>.

Conducted by:

Dr. Walaa Mogawer

Highway Sustainability Research Center

Project Scope

Untreated RTR

Treated RTR

Added to Binder
(Wet Process)

__Two Types of Mixtures__

Dense Graded Mixture

Gap Graded Mixture

Added to Mixture During Mixing
(Dry Process)

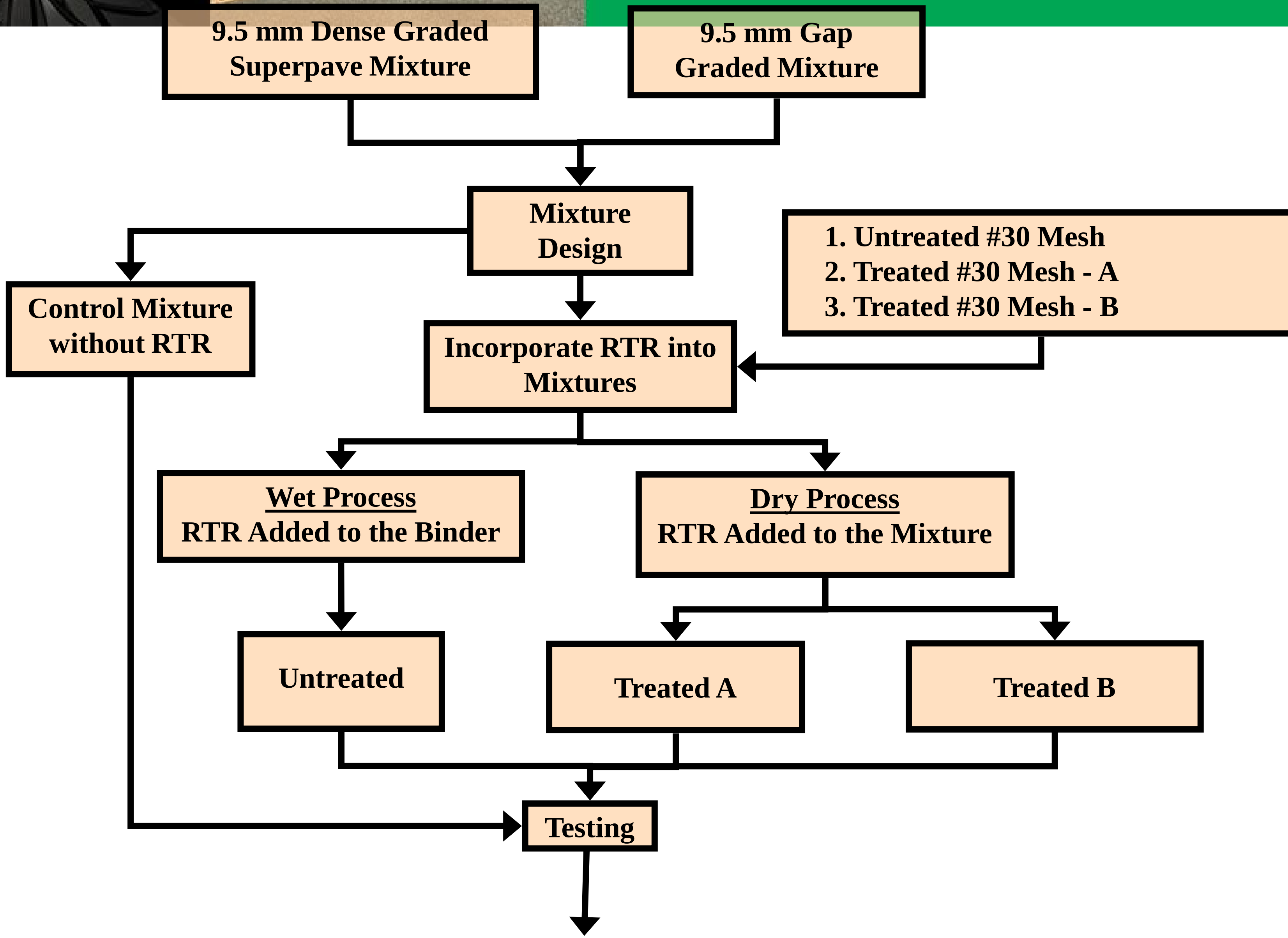

Project Objectives

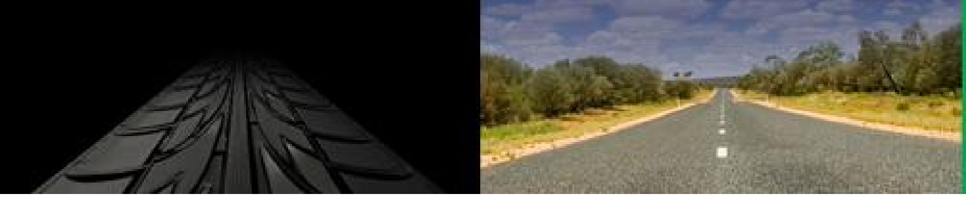
1. **Design a 9.5 mm Superpave and a 9.5 mm gap graded asphalt mixture using RTR modified asphalt binder.**

2. **Redesign the same two mixtures using two types of treated RTR added during the mixing process.**

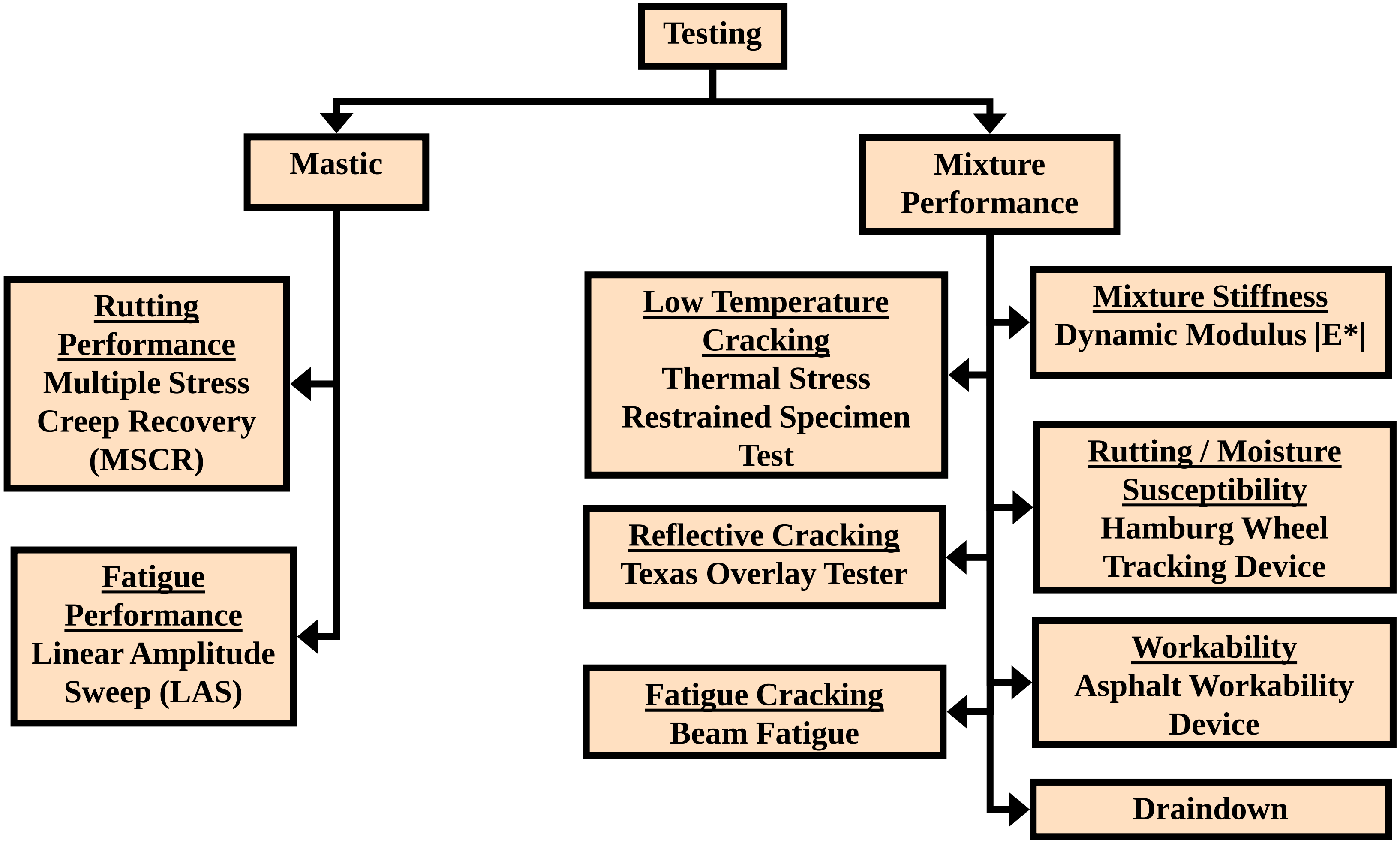
3. **Determine the effect of using the RTR in a wet process versus adding treated RTR in a dry process on the mixture stiffness, performance (rutting, moisture damage, low temperature cracking, reflective cracking, and fatigue cracking), mixture workability and draindown characteristics.**

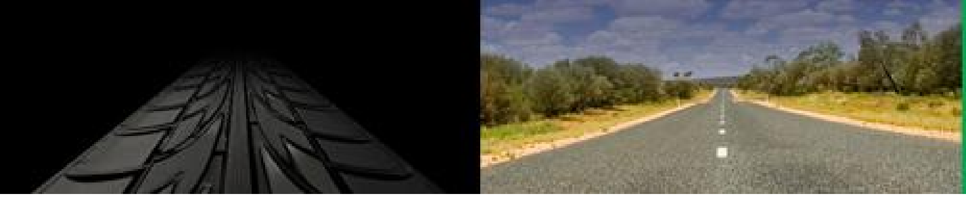
Experimental Plan





Experimental Plan





Treated RTR

- The untreated Liberty Tire Recycling #30 mesh RTR was sent to two different research groups (Sonneborn LLC and Polymer Consultants Inc.) who then treated the RTR.

- This yielded two distinct treated RTR to be incorporated into the mixture through a dry process.

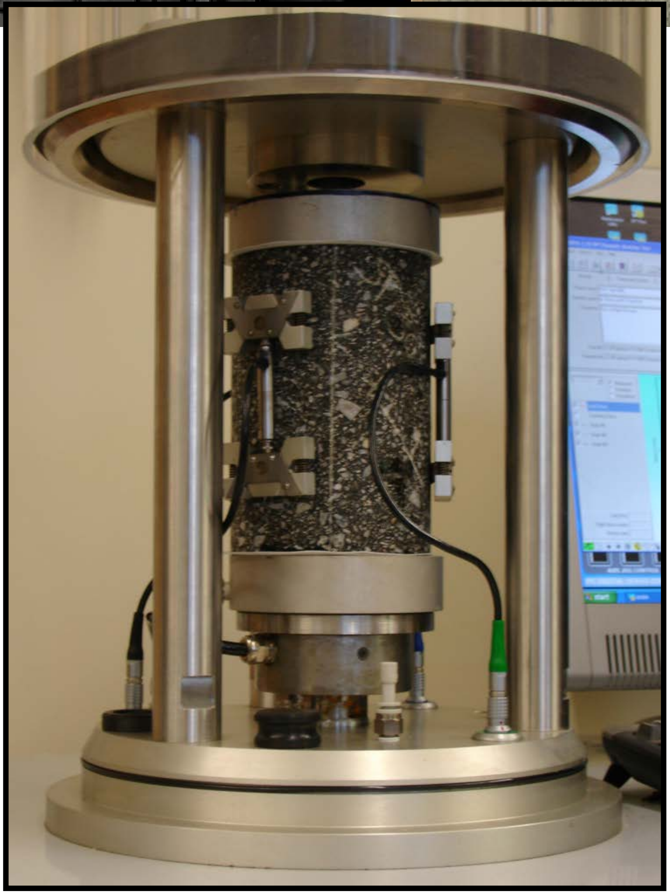
  Sonneborn LLC = Treated RTR A
  Polymer Consultants Inc= Treated RTR B

Mixture Design

Sieve Size	9.5 mm Superpave Dense Graded	9.5 mm Superpave Specification	9.5 mm Gap Graded	9.5 mm Gap Graded Specification
12.5 mm	100.0	100 min	100	100
9.5 mm	97.1	90-100	92.4	91-95
4.75 mm (No. 4)	66.8	90 max	44.2	40-45
2.36 mm (No. 8)	47.8	32-67	25.9	22-26
1.18 mm (No. 16)	33.5	-	17.3	-
0.600 mm (No. 30)	23.0	-	12.0	9-12
0.300 mm (No. 50)	13.3	-	8.0	6-8
0.150 mm (No. 100)	7.1	-	6.1	-
0.075 mm (No. 200)	4.4	2-10	4.0	4.0
Binder Content, %	6.0%	-	7.5%	6.0% Min.

Mixture Stiffness - Dynamic Modulus

Conducted to determine changes in mixture stiffness due to wet and dry process RTR utilized.

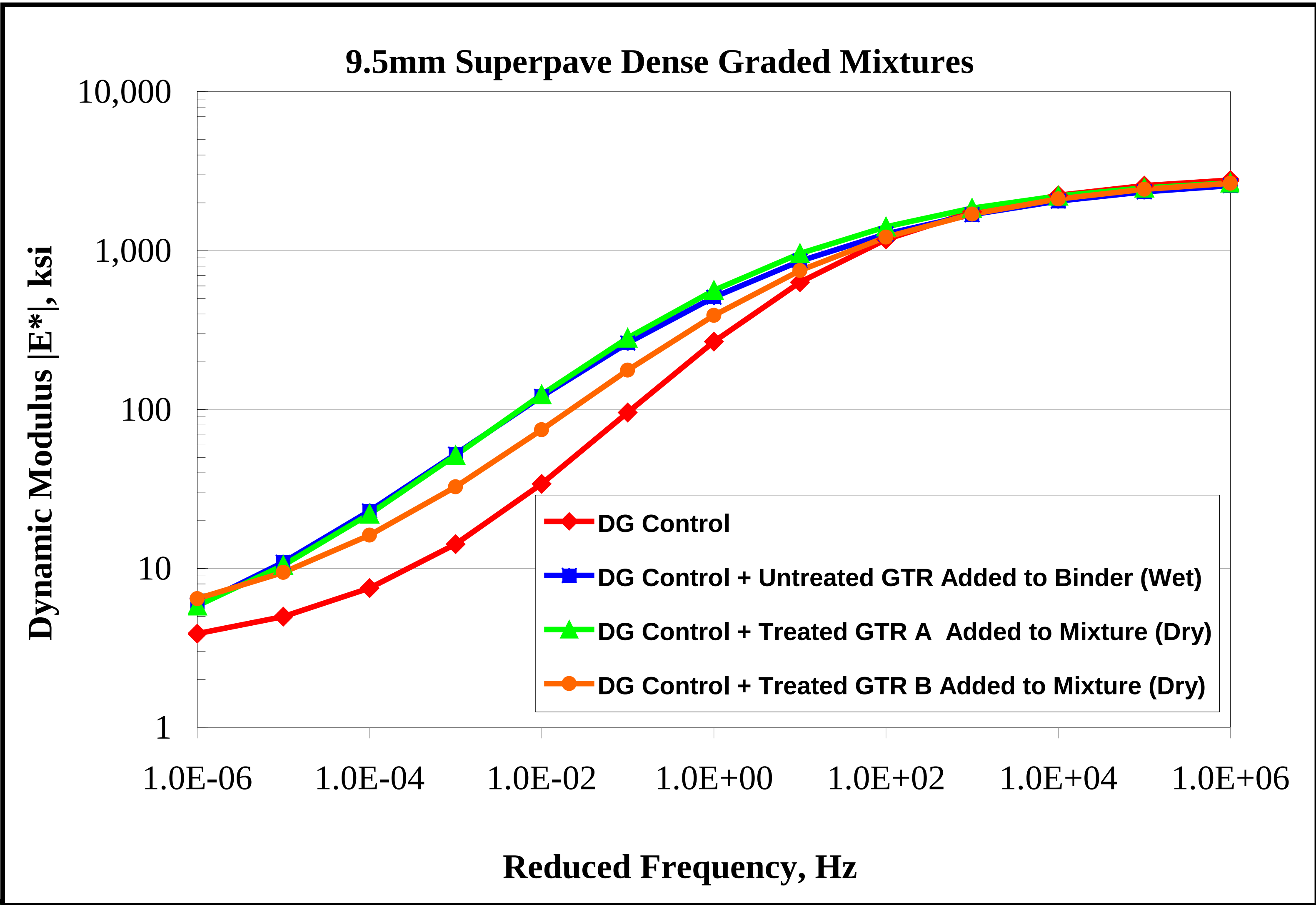


AASHTO TP62 in Asphalt Mixture Performance Tester
(AMPT)

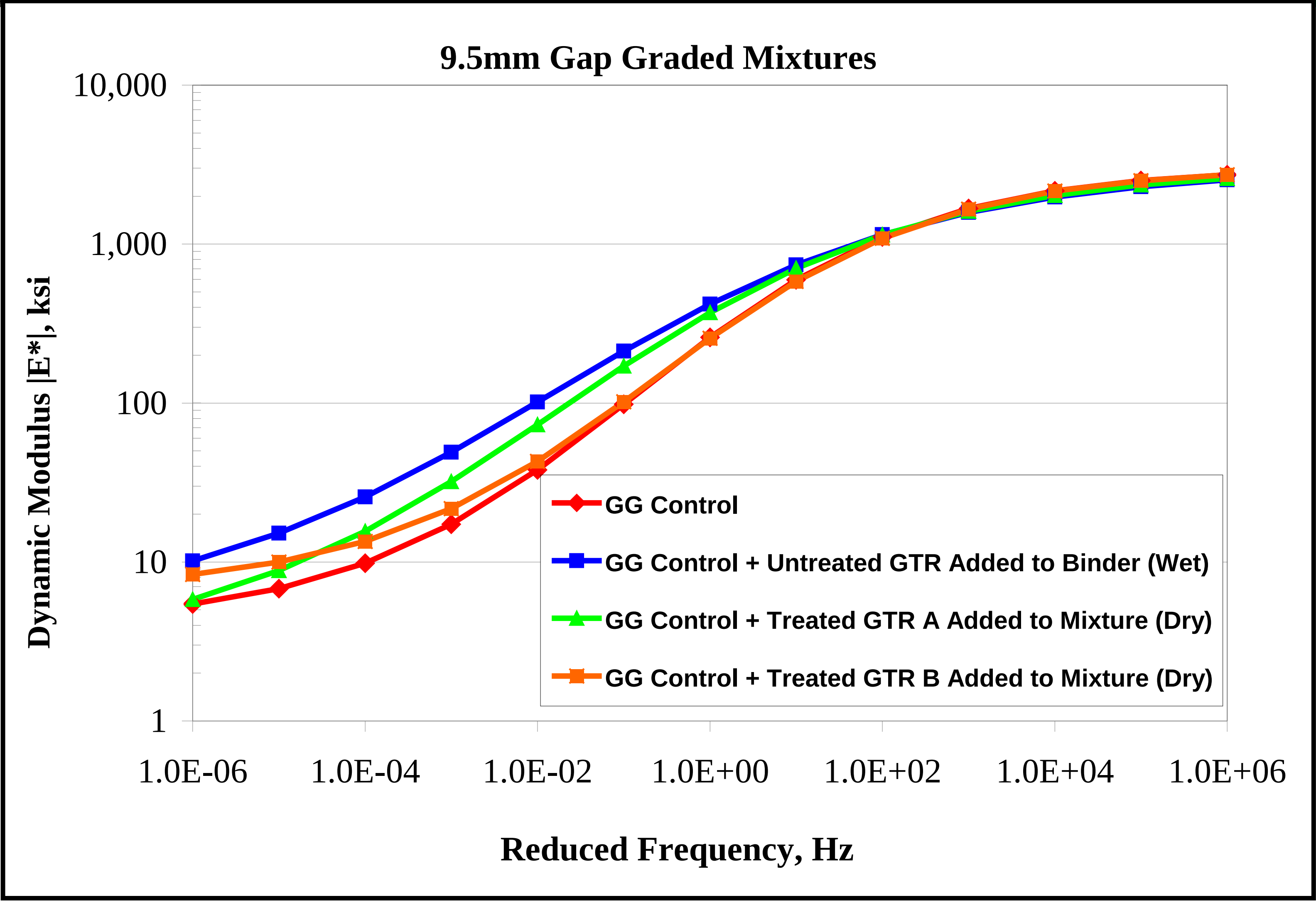
Temperature	Frequency
4°C	10 Hz, 1Hz, 0.1Hz
20°C	10 Hz, 1Hz, 0.1Hz
40°C	10 Hz, 1Hz, 0.1Hz, 0.01Hz

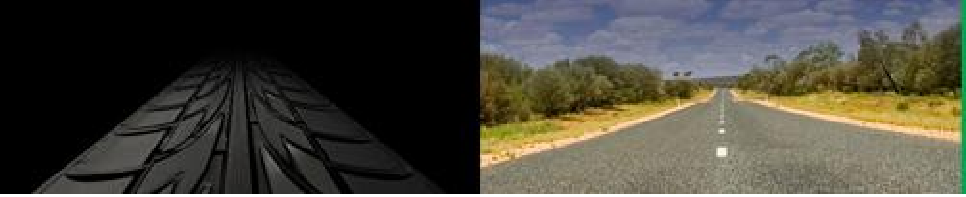
Specimens were fabricated at a target air void level of 7.0 ± 1.0%.

Mixture Master Curves – Dense Graded



Mixture Master Curves – Gap Graded





Mixture Stiffness - Discussion

- **The control mixture had the lowest stiffness.**
- **Generally, wet process mixtures yielded the highest increase in stiffness at all testing temperatures relative to the control mixtures with no RTR.**

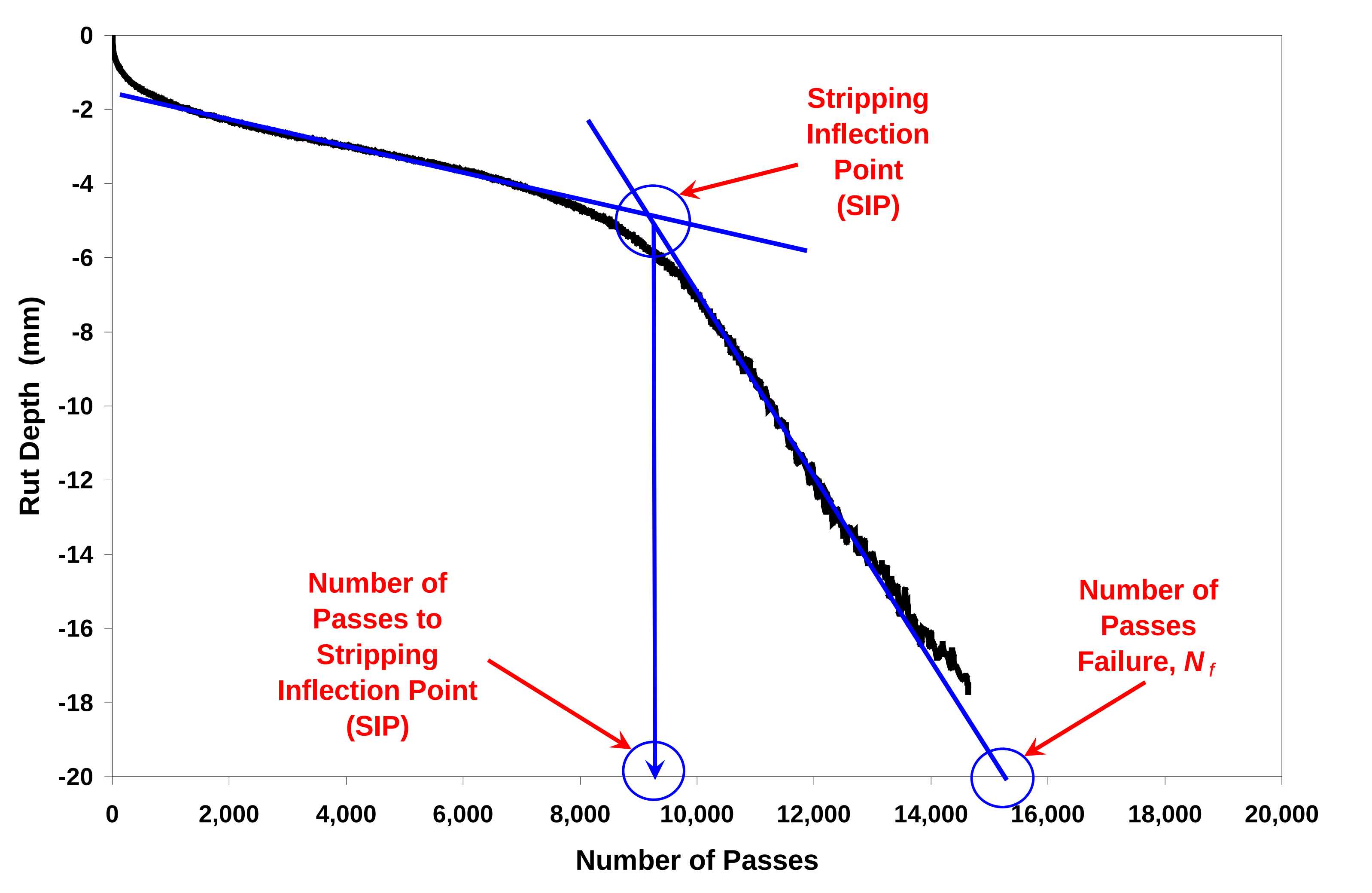
Rutting/Moisture Susceptibility

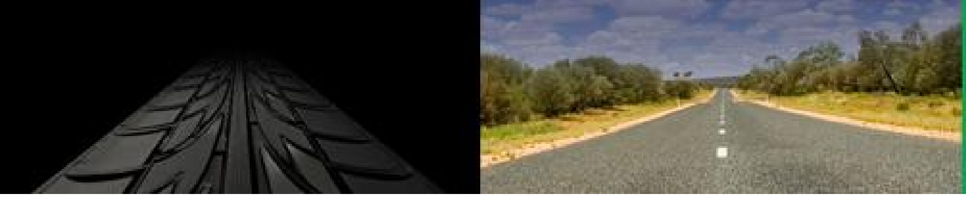
HWTD testing conducted in accordance with AASHTO T324

Water temperature of 50ºC (122ºF)

Test duration of 20,000 cycles

Stripping Inflection Point (SIP)





Rutting/Moisture Susceptibility

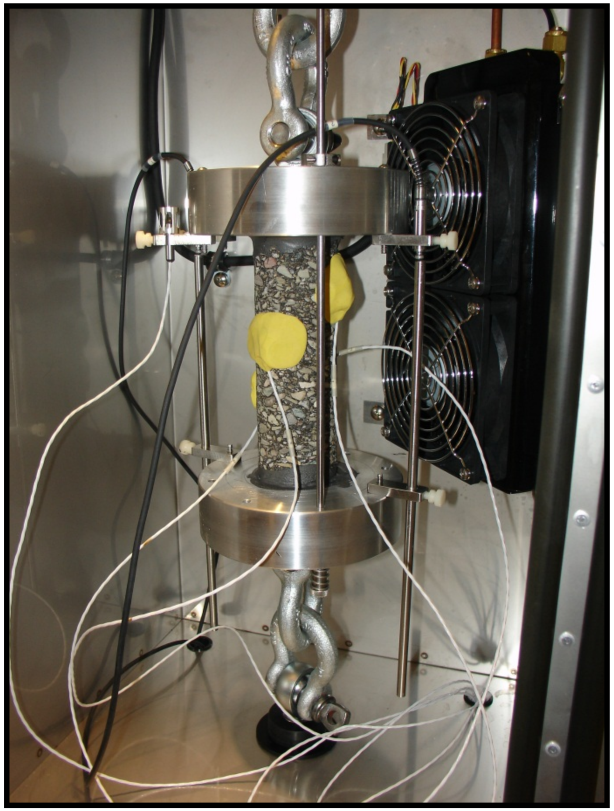
Dense Graded Mixtures	RTR Introduction Method	Stripping Inflection Point	Rut Depth at 10,000 Passes (mm)	Rut Depth at 20,000 Passes (mm)
DG Control	n/a	5,300	>20	>20
DG Control + Untreated RTR (Wet)	Added to Binder	NONE	0.70	0.85
DG Control + Treated RTR A (Dry)	Added to Mixture	NONE	1.22	2.00
DG Control + Treated RTR B (Dry)	Added to Mixture	NONE	1.60	2.76
Gap Graded Mixtures	**RTR Introduction Method**	**Stripping Inflection Point**	**Rut Depth at 10,000 Passes (mm)**	**Rut Depth at 20,000 Passes (mm)**
GG Control	n/a	3,100	>20	>20
GG Control + Untreated RTR (Wet)	Added to Binder	NONE	1.76	2.31
GG Control + Treated RTR A (Dry)	Added to Mixture	14,750	2.93	>20
GG Control + Treated RTR B (Dry)	Added to Mixture	16,400	3.35	9.01

Rutting/Moisture Susceptibility

- **For dense graded mixtures, the wet and dry process RTR mixtures passed the test.**

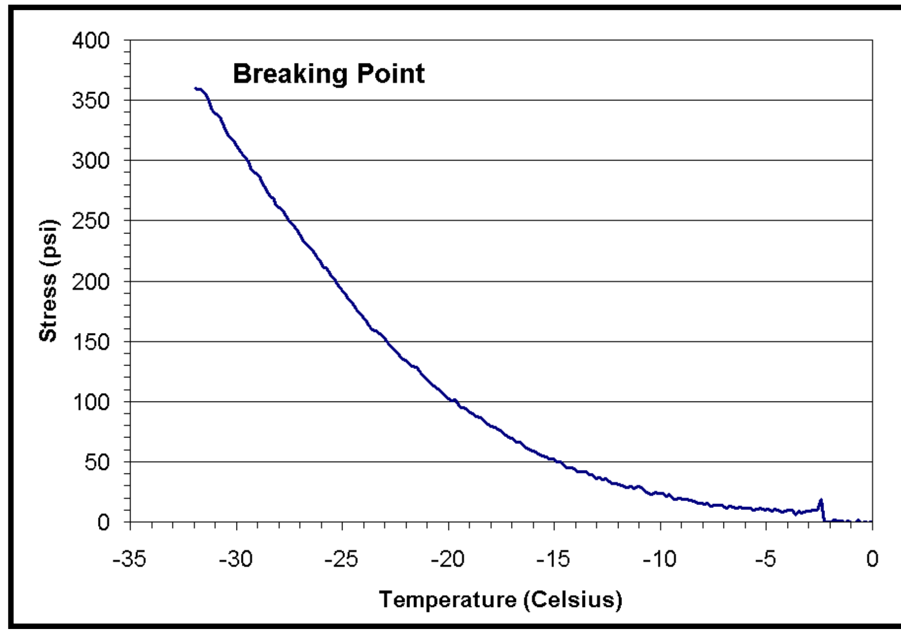
- **For gap graded mixtures, the wet process mixture was more effective in improving the moisture and rutting resistance and as compared to the dry process treated RTR mixtures.**

Mixture Low Temperature Cracking - TSRST



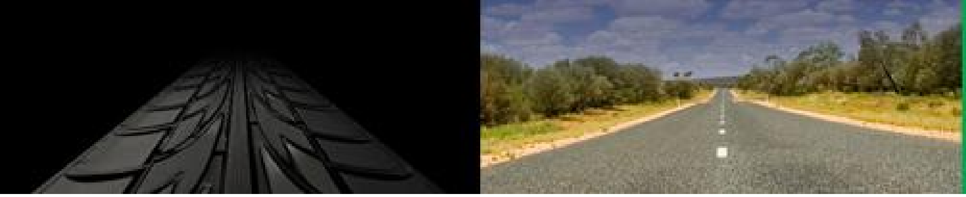
Cooling Rate of -10°C/hour

Testing in accordance with AASHTO TP10-93



TSRST Low Temperature Results

Dense Graded Mixtures	RTR Introduction Method	TSRST Specimen Temperature at Failure, °C
DG Control	n/a	-24.3
DG Control + Untreated RTR (Wet)	Added to Binder	-28.7
DG Control + Treated RTR A (Dry)	Added to Mixture	-26.8
DG Control + Treated RTR B (Dry)	Added to Mixture	-29.3
Gap Graded Mixtures	**RTR Introduction Method**	**TSRST Specimen Temperature at Failure, °C**
GG Control	n/a	-24.3
GG Control + Untreated RTR (Wet)	Added to Binder	-28.0
GG Control + Treated RTR A (Dry)	Added to Mixture	-25.2
GG Control + Treated RTR B (Dry)	Added to Mixture	-28.5



TSRST Low Temperature Discussion

- **The wet process mixtures low cracking temperatures were significantly colder than those for the control and Treated RTR A mixtures.**

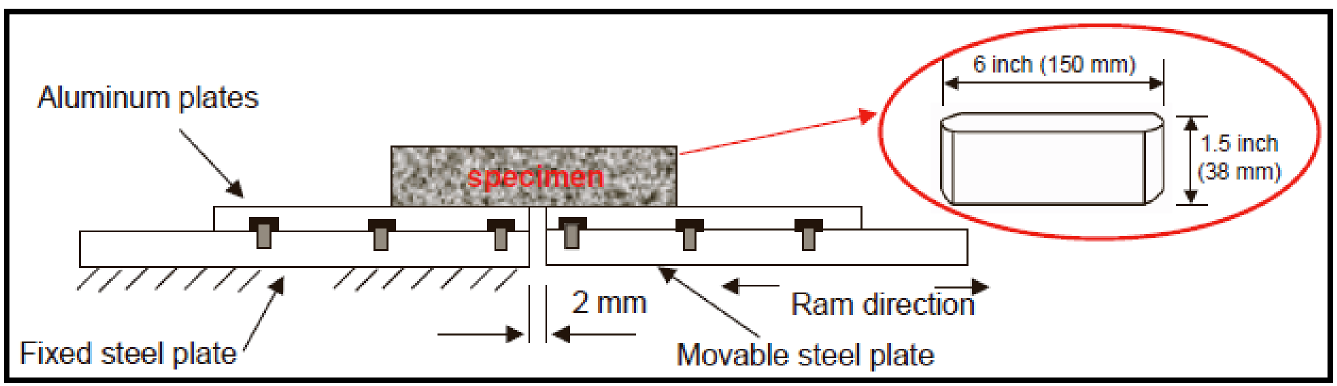
- **The wet process and Treated RTR B mixtures were not significantly different. This indicates that the wet and dry process could be comparable.**

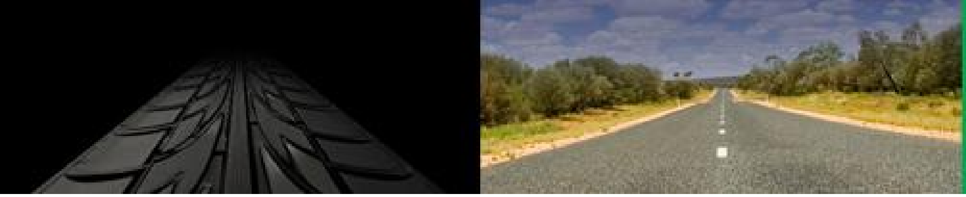
Reflective Cracking - Overlay Tester

Test Temperature = 15ºC (59ºF)

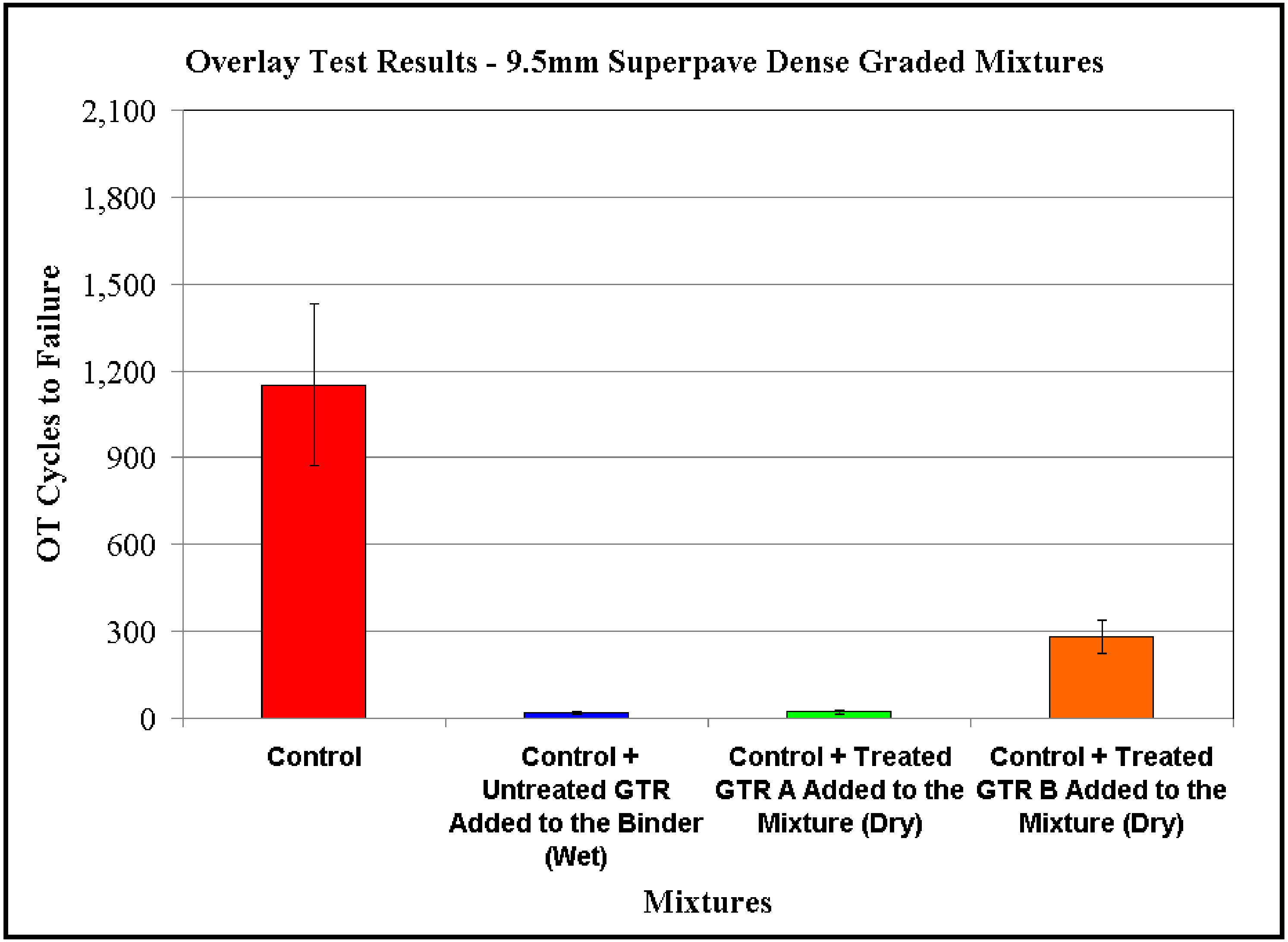
Test Termination at 2,000 cycles or 93% Load reduction

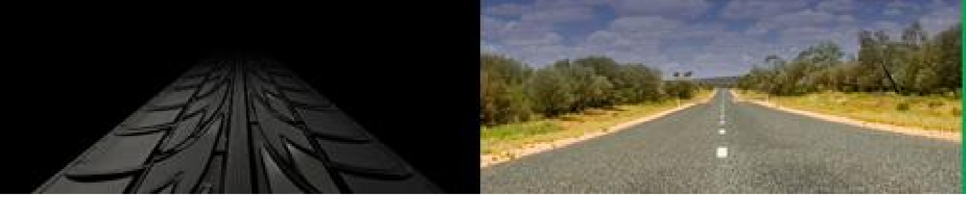
Testing in accordance with Tex-248-F



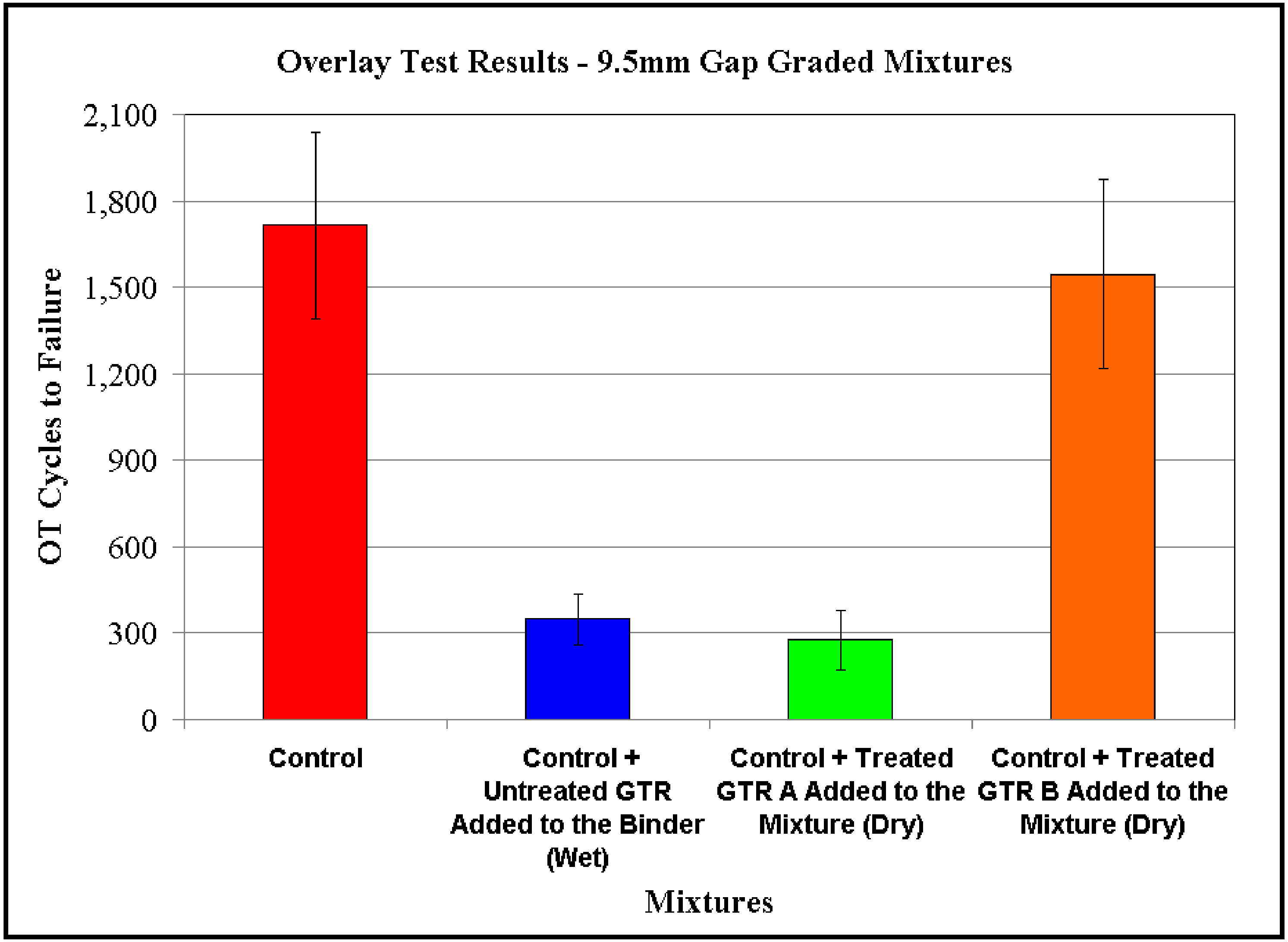


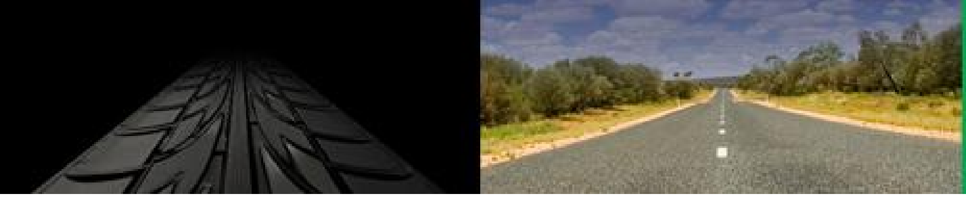
Overlay Tester Results – Dense Graded





Overlay Tester Results – Gap Graded

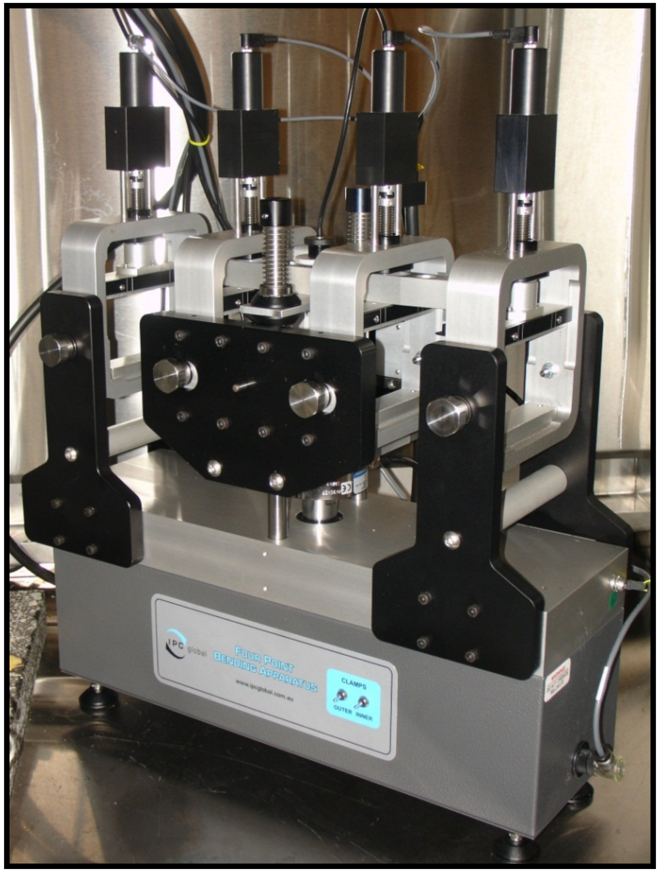




Reflective Cracking Discussion

➔**For both mixture types, the control and Treated RTR B mixtures exhibited the most cycles to failure which correlated well with the mixture stiffness testing. Mixture stiffness testing indicated that these were the least stiff mixtures.**

Fatigue – Four Point Bending Beam



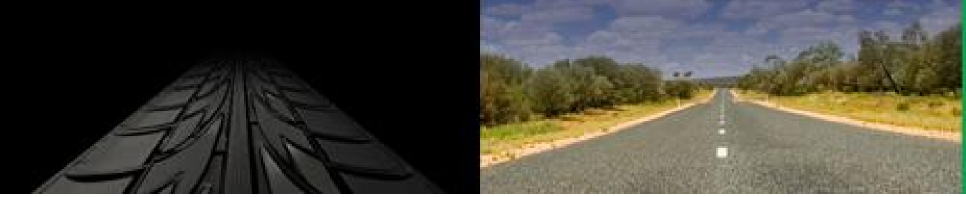
Testing in Accordance with AASHTO T321

- **Specimens were fabricated at a target air void level of 7.0 ± 1.0%**
- **Testing conducted in strain control mode**
- **Loading Frequency = 10Hz**
- **Sinusoidal Wave Form**
- **Failure Criteria = 50% reduction in initial stiffness per AASHTO T321 method**

Temperature	Strain Level
15°C (59°F)	900με

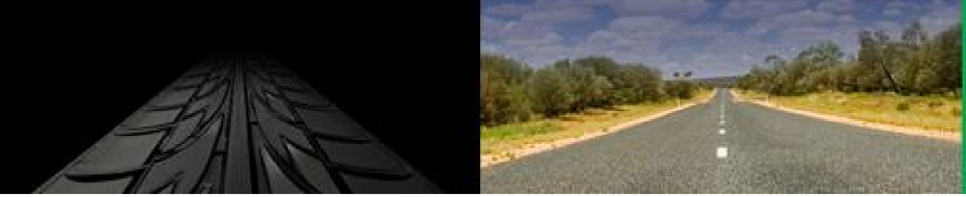
Beam Fatigue Results

<u>Dense Graded</u> Mixtures	RTR Introduction Method	Average Number of Cycles to 50% Initial Stiffness, N_f
		900με
DG Control	n/a	31,616
DG Control + Untreated RTR (Wet)	Added to Binder	56,756
DG Control + Treated RTR A (Dry)	Added to Mixture	25,042
DG Control + Treated RTR B (Dry)	Added to Mixture	79,836
<u>Gap Graded</u> Mixtures	RTR Introduction Method	Average Number of Cycles to 50% Initial Stiffness, N_f
		900με
GG Control	n/a	NT
GG Control + Untreated RTR (Wet)	Added to Binder	60,972
GG Control + Treated RTR A (Dry)	Added to Mixture	30,791
GG Control + Treated RTR B (Dry)	Added to Mixture	88,176



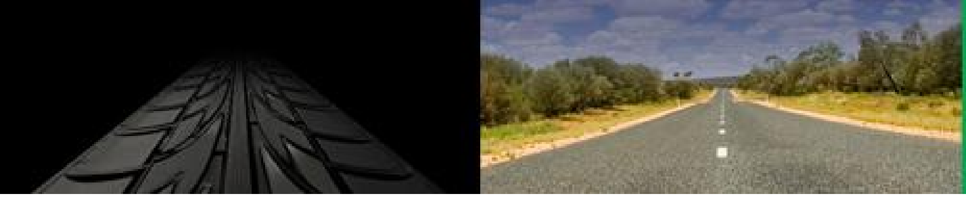
Beam Fatigue Discussion

- The wet process and Treated RTR B dry process mixtures had similar fatigue cracking performance. This suggests that a wet or dry process can provide comparable fatigue characteristics of the mixtures.



Draindown Results

Gap Graded Mixtures	RTR Introduction Method	Draindown at Mixing Temperature	Draindown at Mixing Temperature +15ºC
GG Control	n/a	1.1%	1.3%
GG Control + Untreated RTR (Wet)	Added to Binder	0.1%	0.1%
GG Control + Treated RTR A (Dry)	Added to Mixture	0.1%	0.2%
GG Control + Treated RTR B (Dry)	Added to Mixture	0.1%	0.1%



Draindown Discussion

- The draindown using the wet process was 0.1% which was much lower than the control mixture. This might be due to the viscous gel that the RTR forms when added to the asphalt binder.

- The draindown for the dry process was 0.2% or less which was also much lower than the control mixture.

- This might indicate that the dry process using the two treated RTR led to the same formation of a viscous gel in the mixture.


Conclusions

- Overall, the data analysis indicated that treated RTR added in a dry process can yield mixtures that have similar performance characteristics to the same mixtures designed using the wet process.

RuBind™
Innovating and Improving Asphalt Mixes

Gap Graded Test Road Section Construction

St. Petersburg
October 06, 2013

What Is This?

- RTR
- Bitumen ~20%
- Heat ~350 F
- Mineral Additive
- Cooled – reaction suspended
- Kind of a micro-pellet

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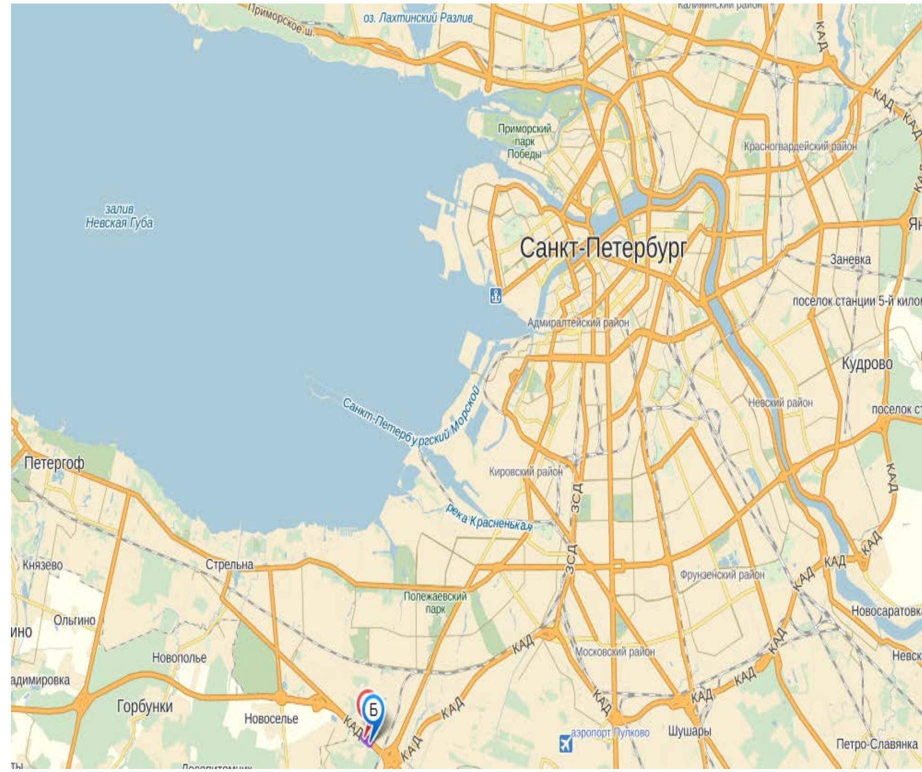
TEST ROAD SECTION LOCATION AND CONSTRUCTION INFORMATION

Project Location: St. Petersburg, Russia, Ringway (south)
Date and time: 06/10/2013 13:00-15:00
Producer and contractor:
    "Asphaltobetonny Zavod N1"
Plant: BENINGHOFEN
    Pug Mill Capacity – 4 tones
Length of section: 300 m
The layer thickness: 5 cm
Type of mixture: GAP Grade
    Bitumen content: 5,6%
    RuBind content: 3,4%
Ambient temperature: +7C to +9C
Temperature of the mixture:
    at the plant: 180C
    during compaction: 160C

St. Petersburg, Russia



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MIX PRODUCTION

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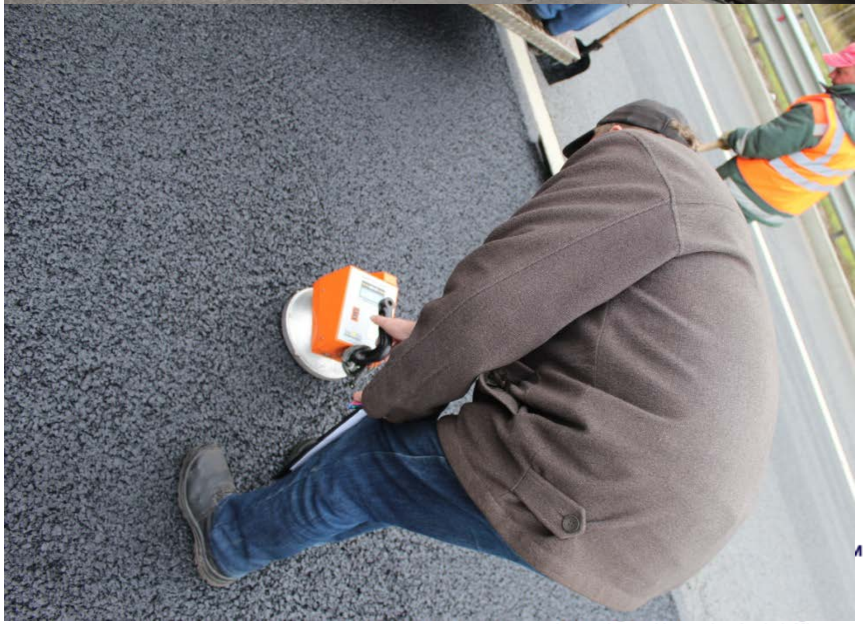
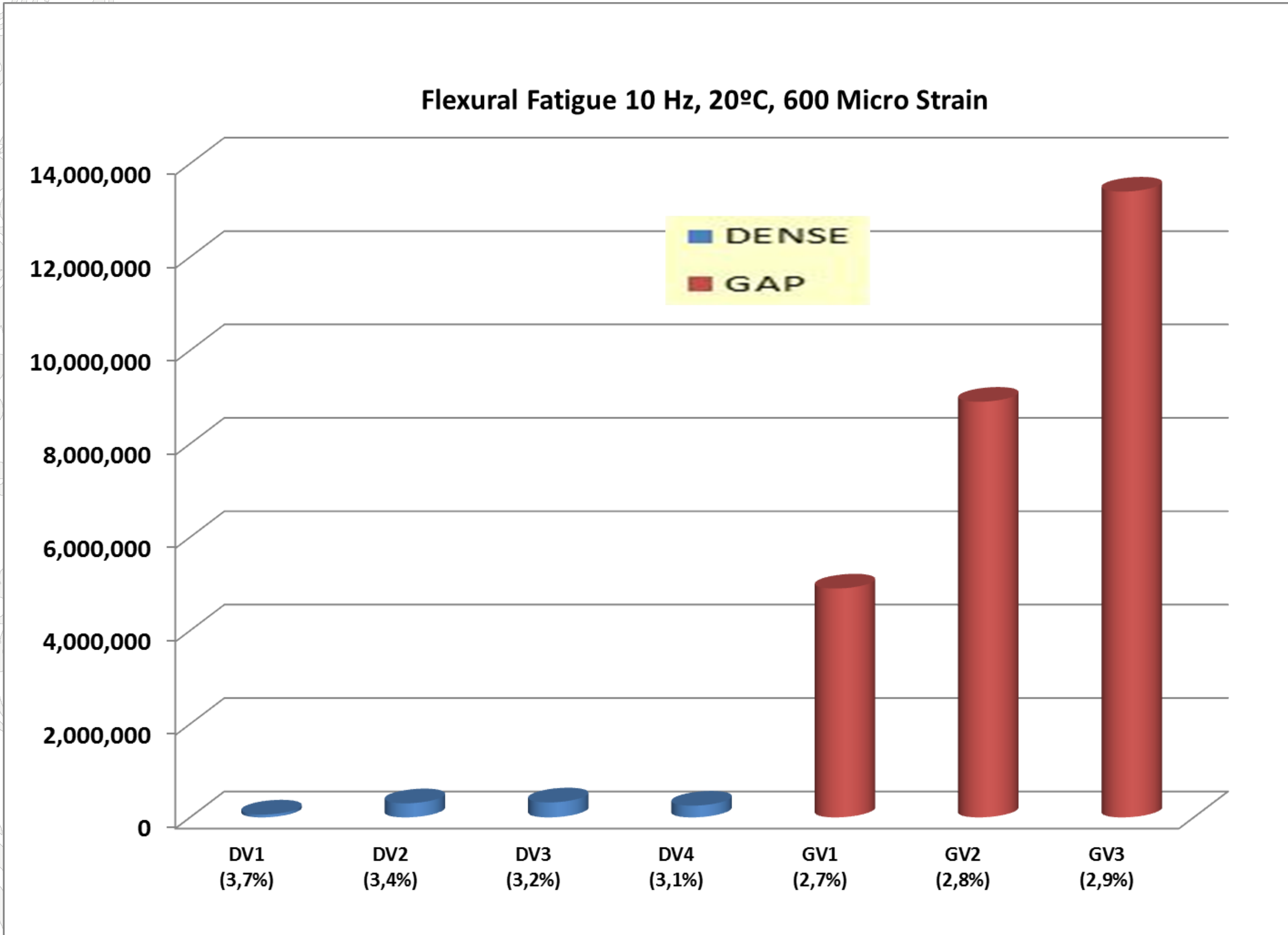
PLACEMENT AND COMPACTION



PHYSICAL-MECHANICAL PROPERTIES OF ASPHALT CONCRETE MIX

PARAMETERS	Requirements of GOST 31015-2002	actual values	
		GAP Grade with RuBind	Common used SMA 15
Density, g/cm^3	-	2,51	2,64
Porosity,% by volume	1,0-4,0	2,0	2,1
Compressive strength, MPa, at temperatures: +20°C	≥2,2	6,1	2,8
+50°C	≥0,65	1,0	0,8
Draindown, %	≤0,2	-	0,20
Water resistance/ long-term water resistance	≥0,85	1,0 0,91	1,0 0,89
Abrasive wearing by the Prall method, ml, EN 12697-16)	-	11	20
The rut depth after 20,000 wheel passes, mm (+60°C) EN 12697.22	-	1,2	3,8



Innovating and Improving Asphalt Mixes

PelletPAVE™

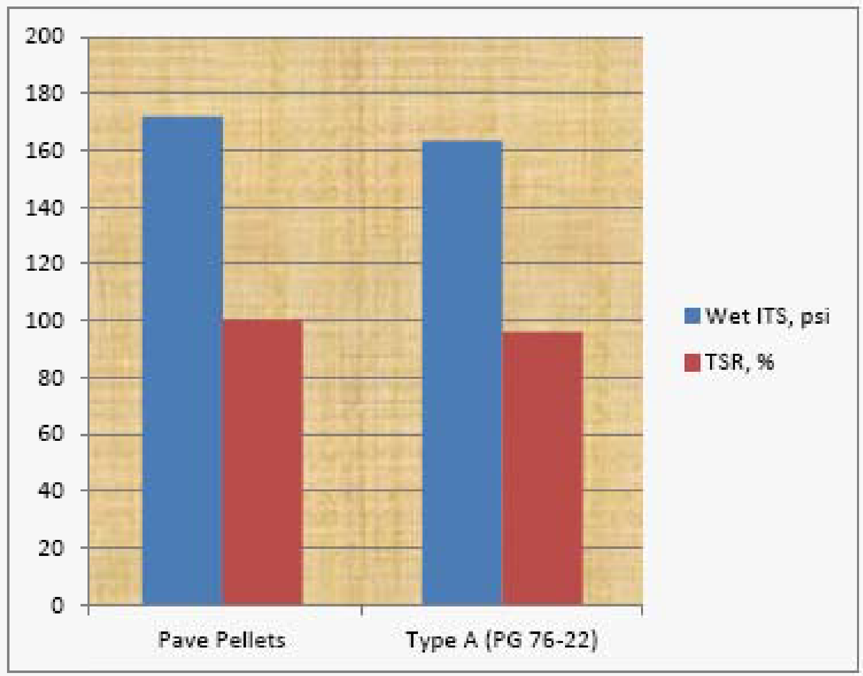
Providing Asphalt-Rubber Technology for Pavement Maintenance

Cost Effective and Convenient

Moisture Susceptibility Testing / AASHTO-T-283

PelletPAVE *ITS / TSR Analysis*

Sample	Load	ITS, psi	AVG ITS, psi	TSR, %
Dry 1 (F)	5676	163.8	171.8	100.2
Dry 2 (F)	6224	179.8		
Wet 1 (F)	6027	173.7	172.1	
Wet 2 (F)	5909	170.5		



Recent Projects with Pellet Pave

- Clark County Nevada 2013
  - 100% of binder from pellets

- New York City Oct 2014
  - Half of the Project used Pellets
  - 700 mix tons where pellets 100% of binder
  - 700 mix tons of A-R

October 2014 Demo Near New York City

October 2014 Demo Near New York City

There is Science in Everything!

Ooey-gooey: Add 2 cups more flour.

A nice tan: Set the oven higher than 350 degrees Fahrenheit (maybe 360). Caramelization, which gives cookies their nice brown tops, occurs above 356 degrees.

Crispy with a soft center: Use 1/4 teaspoon baking powder and 1/4 teaspoon baking soda.

Chewy: Substitute bread flour for all-purpose flour.

Just like store-bought: Trade the butter for shortening. Arias notes that this ups the texture but reduces some flavor; her suggestion is to use half butter and half shortening.

Thick (and less crispy): Freeze the batter for 30 to 60 minutes before baking. This solidifies the butter, which will spread less while baking.

Cakey: Use more baking soda because, according to Nyberg, it "releases carbon dioxide when heated, which makes cookies puff up.“

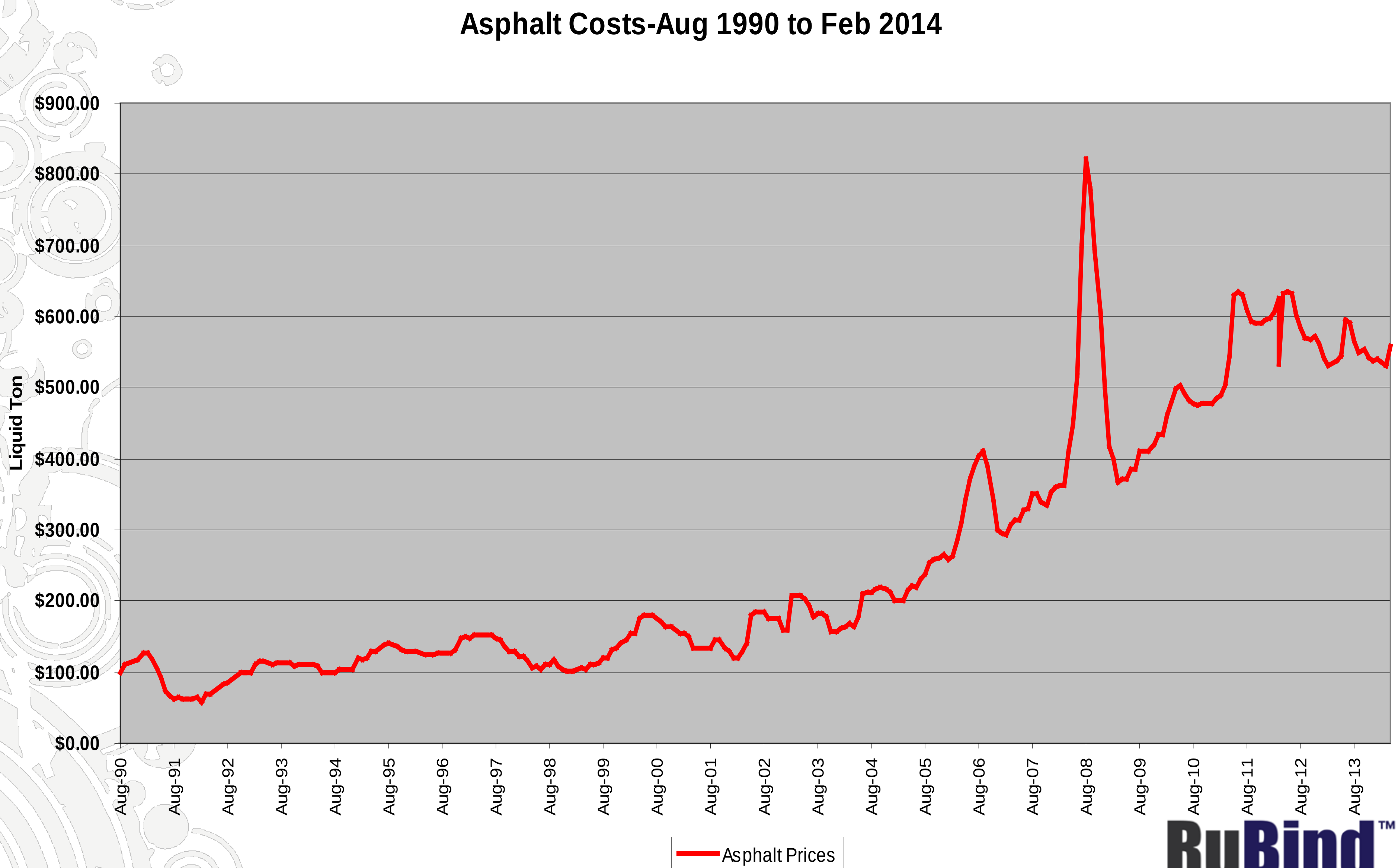
Butterscotch flavored: Use 3/4 cup packed light brown sugar (instead of the same amount of combined granulated sugar and light brown sugar).

Uniformity: If looks count, add one ounce corn syrup and one ounce granulated sugar.

More flavor: Chilling the dough for at least 24 hours before baking deepens all the flavors

The Science Behind Baking Your Ideal Chocolate Chip Cookie
by ANNE MILLER September 04, 201411:20 AM ET
http://www.npr.org/blogs/thesalt/2014/09/04/345530660/the-science-behind-baking-your-ideal-chocolate-chip-cookie

Asphalt Costs Have Surpassed RTR Costs



RuBind™
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Reduce Costs for Asphalt Mix Producers