Evaluation of Performance Properties of Asphalt Mixes Containing RAP Produced with Re-refined Heavy Vacuum Distillate Bottoms Modified Binder

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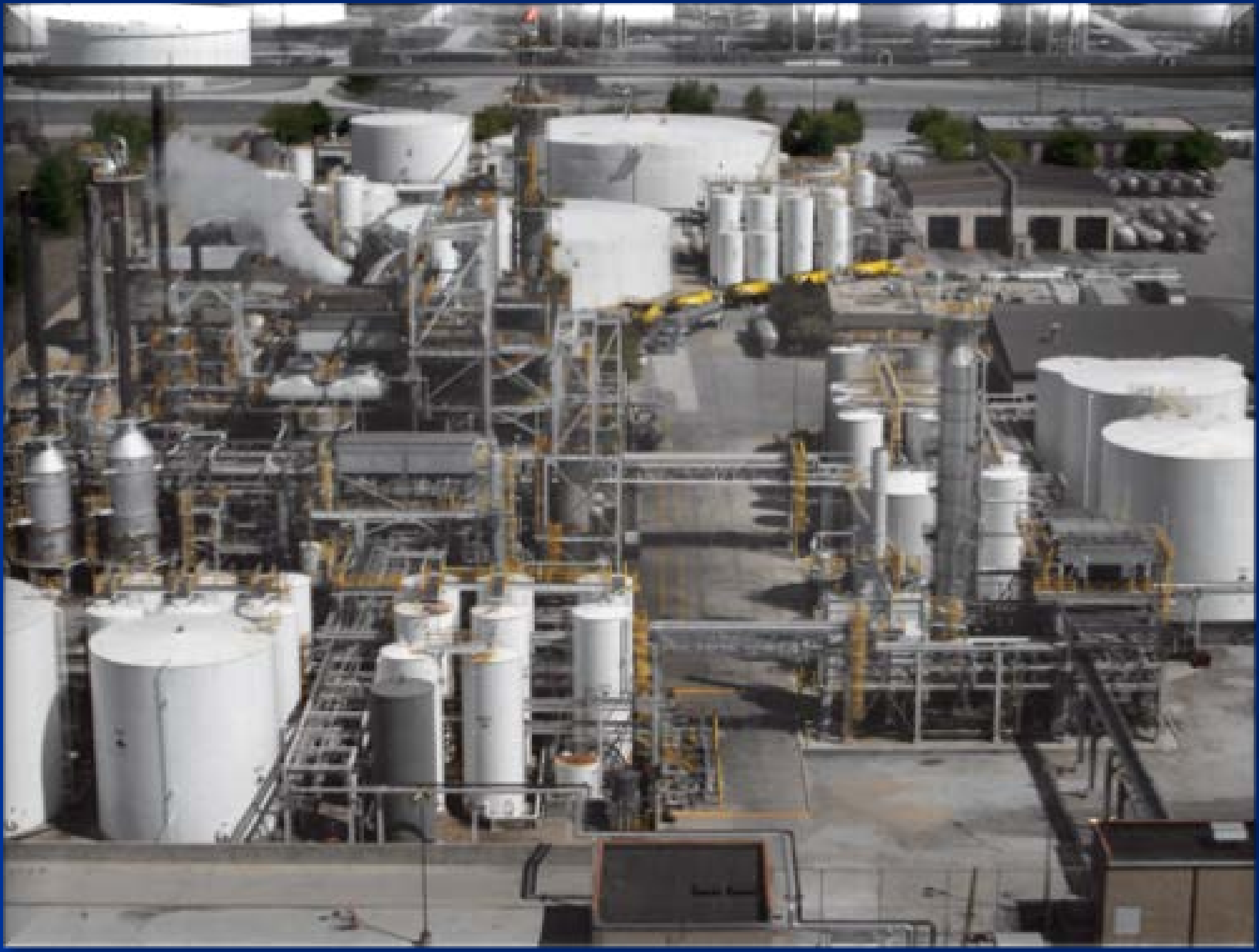
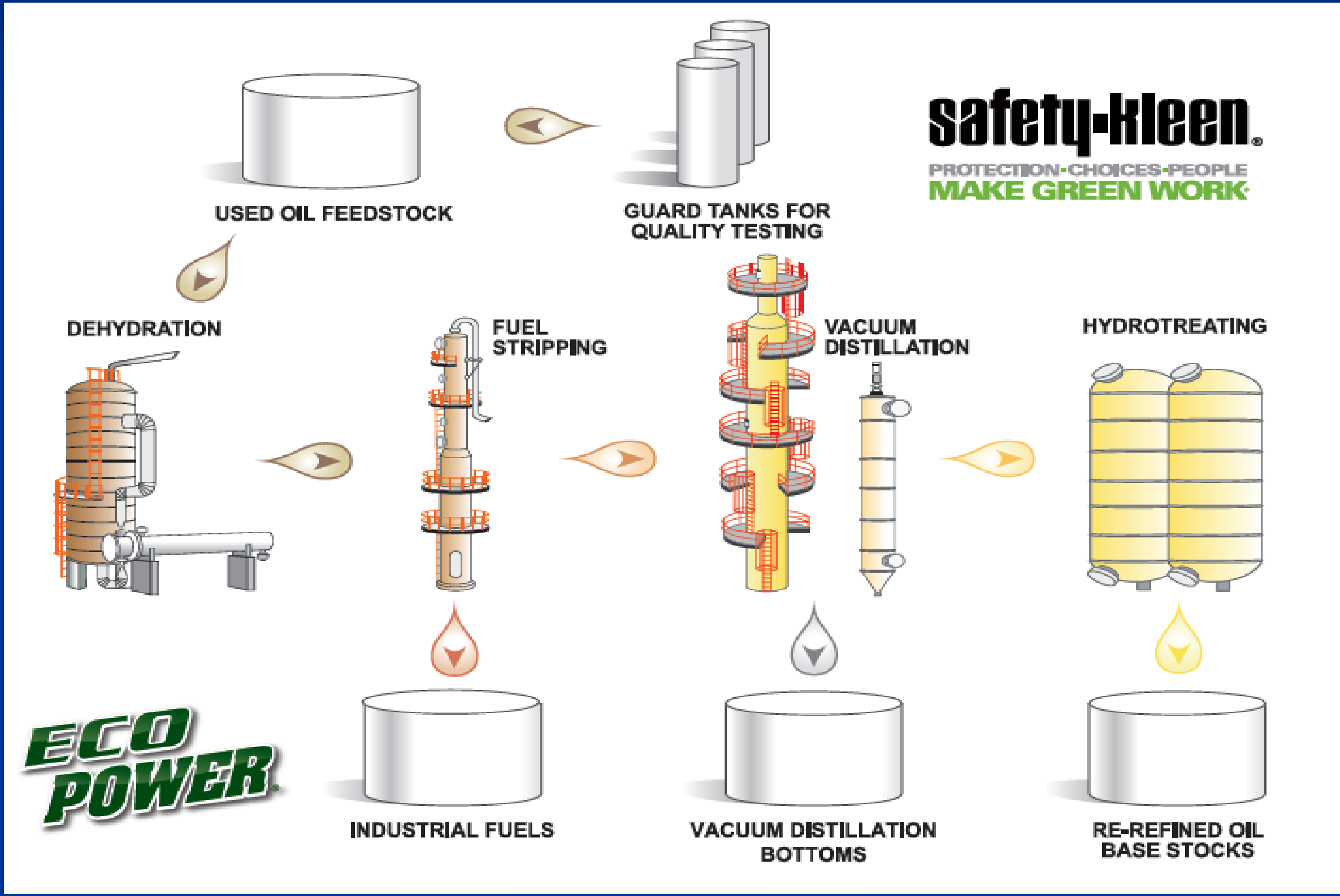
The Refinery



The Refining Process



Re-refined Product

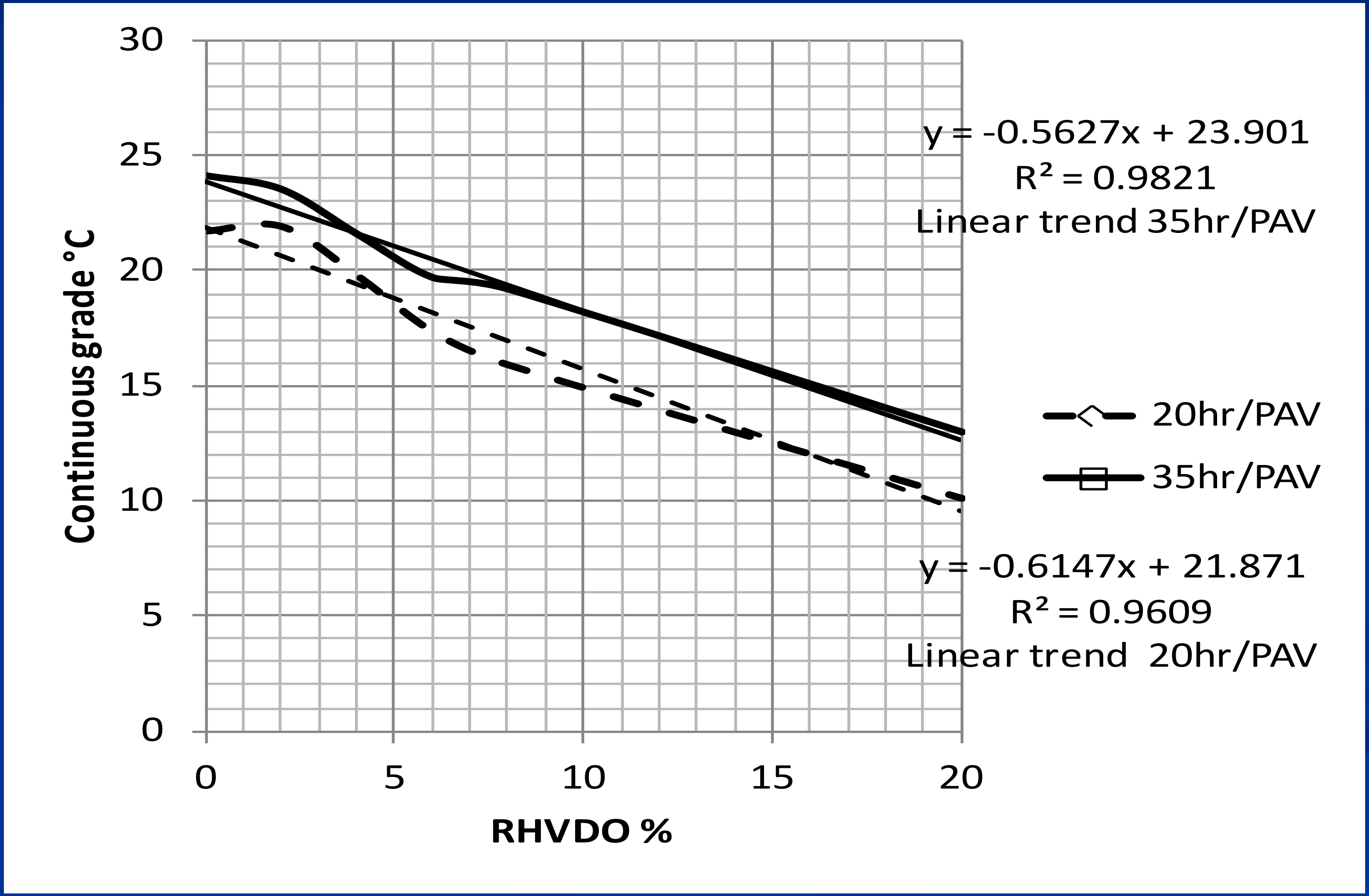
Results from Previous Studies

- RHVDB has been shown effective in reducing high and low temperature properties of a binder.
- Mixes produced with RHVDB modified binder have shown improved fatigue and low temperature fracture properties.

Component makeup of RHVDB's

Property		Test Method	Results	
			RHVDO 1	RHVDO 2
Basic Composition: As Received				
Ash, %		AASHTO T 111	5.7	8.8
Component Fractions, %	Asphaltenes	ASTM D 4124, SARA Fractions by Iatroscan	2.6	6.6
	Polar Aromatics		44.7	51.9
	Naphthene Aromatics		0	0
	Saturates		52.7	41.5
Wax, %		EN 12606-1	0.28	0.1
Solubility, %		ASTM D 2042	99.3	98.7

RHVDB affect on Intermediate DSR Marathon & RHVDB 1



RHVDB affect on Intermediate DSR properties

- RHVDB reduced the Intermediate DSR values.
- Linear relationship between % RHVDB and reduction.
- Rate of aging is controlled by the base asphalt.
- RHVDB does not increase aging.

Can EcoAddz be used as a Rejuvenator for RAP Mixes

- How will the EcoAddz Affect RAP Mix Properties?
- How will EcoAddz Affect Aging of RAP Mixes?

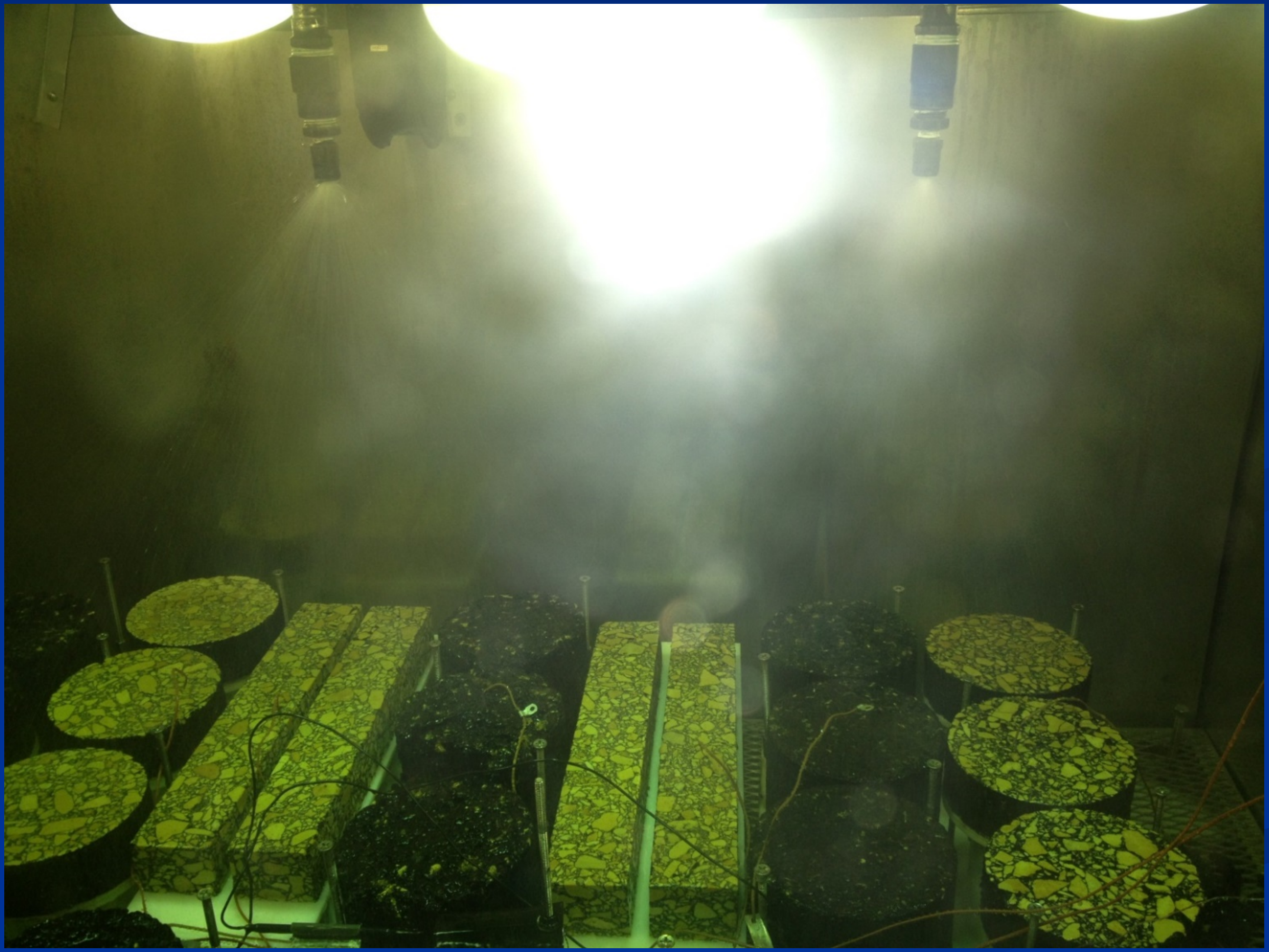
Mix Testing of EcoAddz Modified Material with RAP

- Use mix from U. Illinois Moisture damage study N70, 70 gyration Mix
- Use Illinois stone, Dolomitic Limestone
- RAP Local Florida Mix Tampa
  - Recovered binder PG 92.1-14.3
- Control binder BP PG 64-22
- Modify BP PG 64-22 with 2, 6 & 10 % EcoAddz

Mix Testing of RHVDB Modified Material

- High temperature testing Hamburg Wheel tracking
- Intermediate temperature testing 4 Point Bending Beam
- Dynamic Modulus testing
- Low temperature testing Disk Shape Compact Tension
- Short term and long term aging of mix

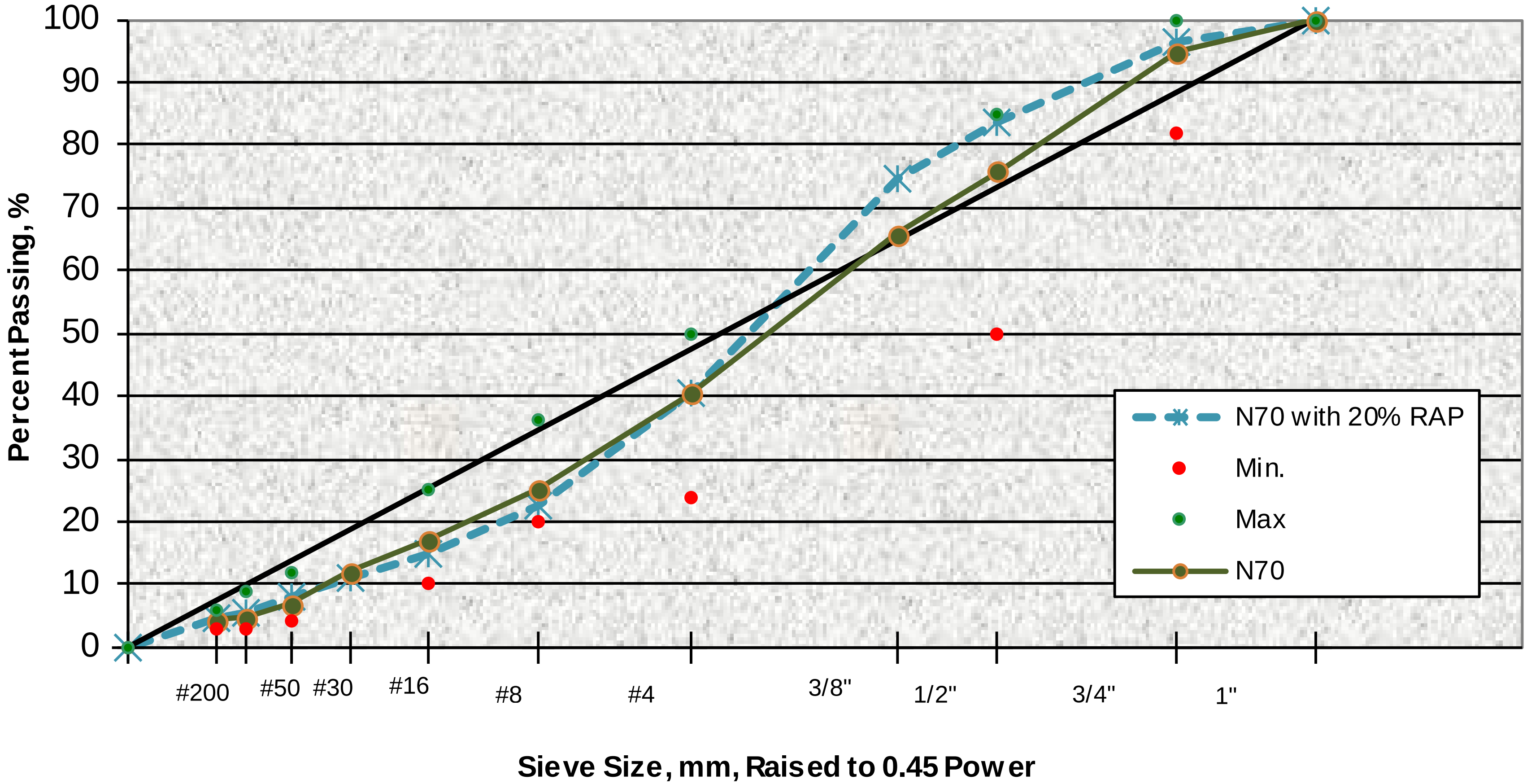
Accelerated Pavement Weathering System (APWS)



Aging

- Compare short-term aged to long-term aged performance properties and the asphalt performance grade
- Short-term aged:
  - 2 hours at 135°C prior to compaction
- APWS Aged
  - 3,000 hours total (≈ 15+ years)
  - High Temperature = 60-65°C (simulated pavement surface temperature)
  - Continuous sunlight
  - 1 cycle = 51 minutes dry, 9 minutes wet ('rain')
    - Thermal shock = Δ temperature ≈ 30-40°F
  - 24 cycles each day

N70, and N70 + 20% RAP Mix Gradation

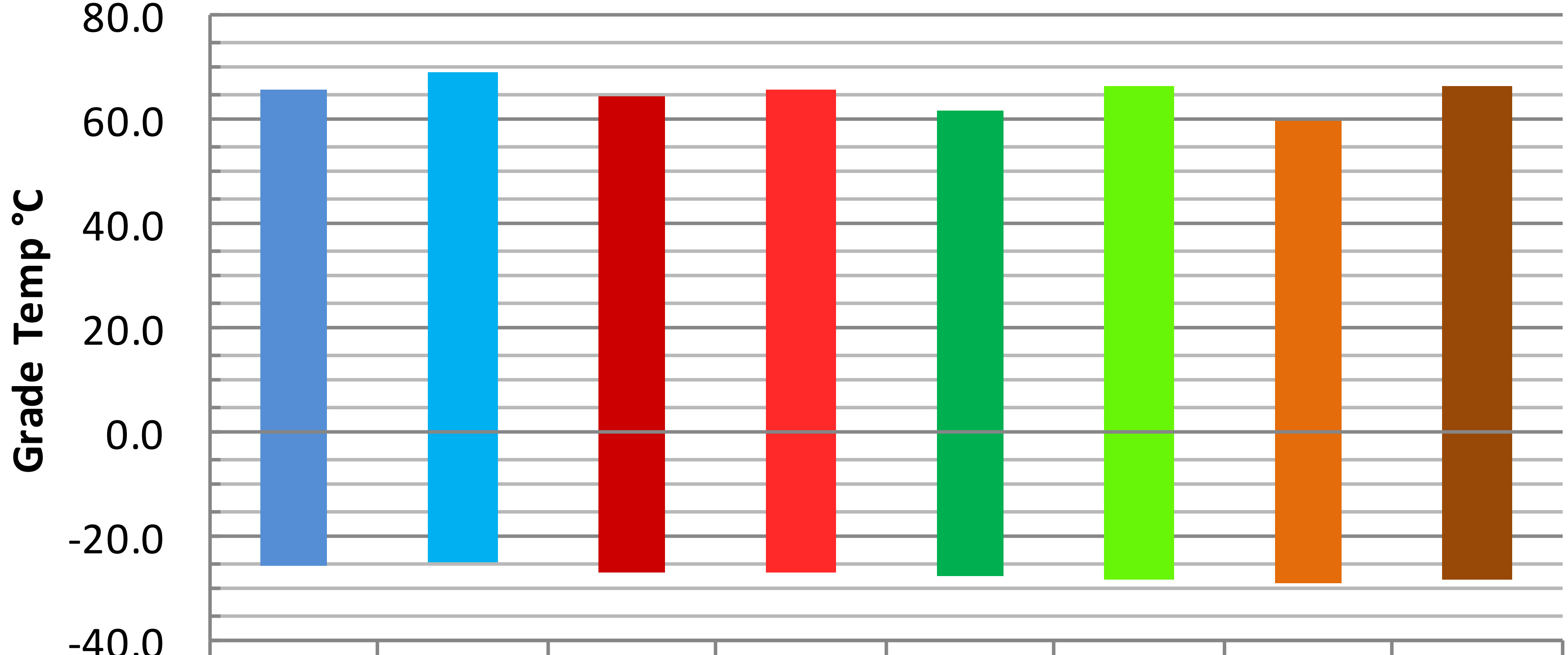


N70 RAP Mix Properties

N70 with 20% RAP Volumetric Properties					
Parameters	Illinois Standard Specification	Control	2% EcoAddz	6% EcoAddz	10% EcoAddz
Design Gyrations	70	70	70	70	70
True PG Grade Recovered	--	69.3-24.8	66.0-26.8	66.3-27.8	66.7-28.2
Percent Binder, Pb(%)	4.0 to 7.0	5.4	5.4	5.4	5.4
Absorbed Asphalt, Pba, %	--	1.2	1.1	1.1	1.1
Effective Asphalt Content, Pbe, %	--	4.2	4.4	4.4	4.4
Air Voids in Compacted Mixture, Va, %	--	4.0	3.6	4.0	4.0
Volume of Voids in Mineral Aggregate, VMA, %	13 minimum	13.8	13.8	14.1	14.1
Dust Proportion, DP, %	1.4 max	1.0	1.0	1.0	1.0

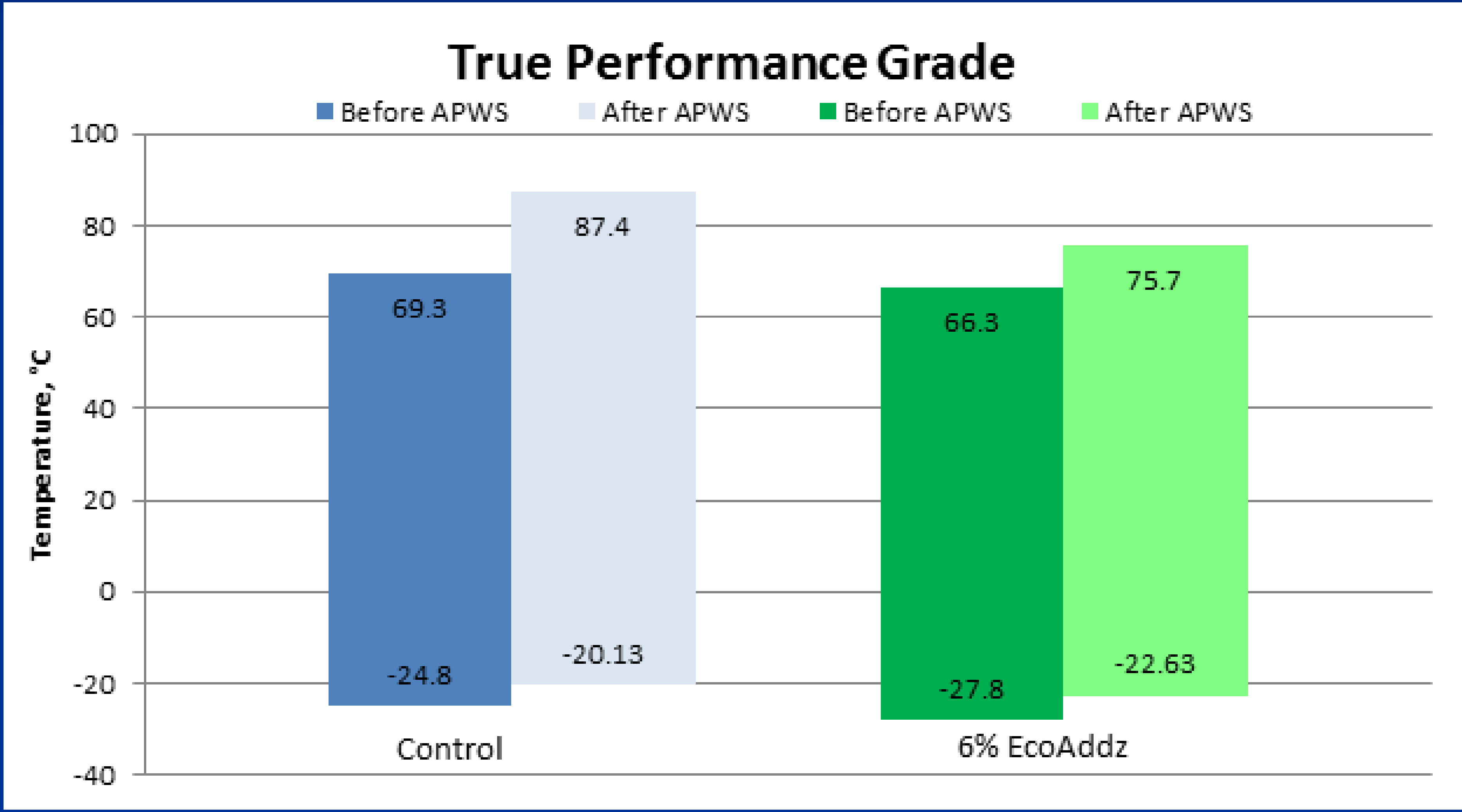
Blends Continuous Grades

Original and Recovered



	Control	Control + RAP	2% EcoAddz	2% EcoAddz + RAP	6% EcoAddz	6% EcoAddz + RAP	10% EcoAddz	10% EcoAddz + RAP
Series1	66.2	69.3	64.6	66.0	62	66.3	59.8	66.7
Series2	-25.6	-24.8	-26.9	-26.8	-27.5	-27.8	-28.8	-28.2

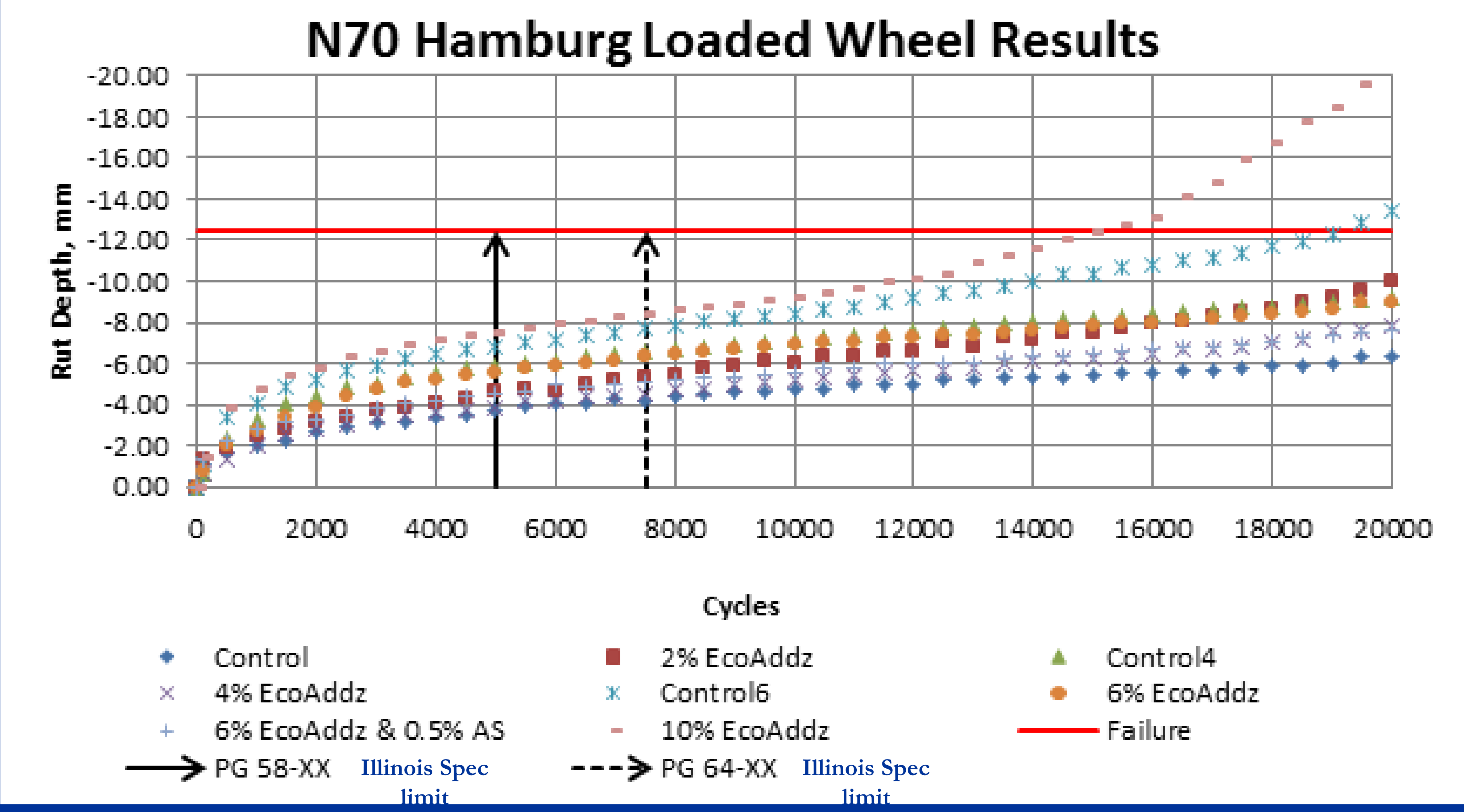
Recovered Binder after APWS N70 RAP Mix



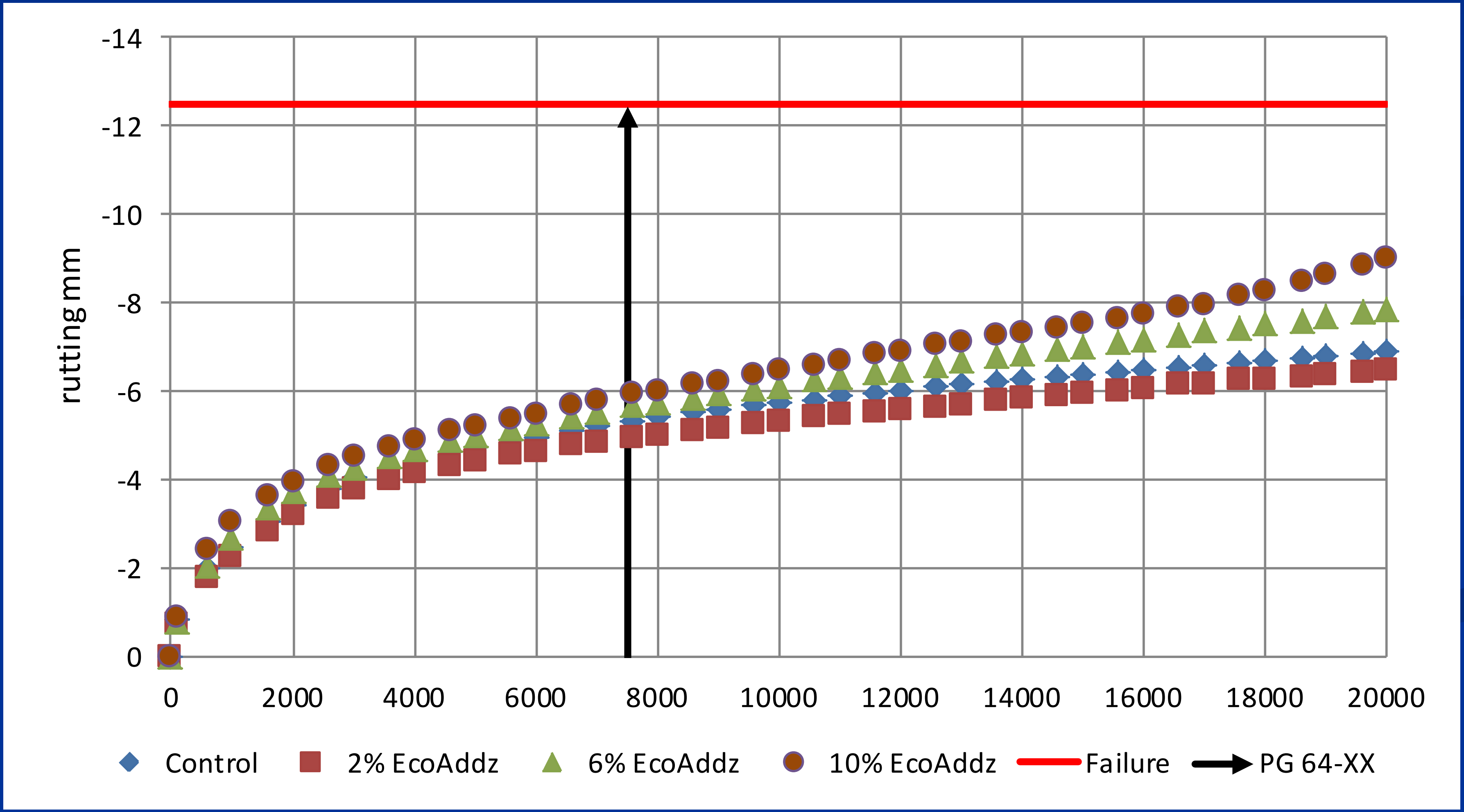
Recovered Binders

- The addition of 20% RAP only had a minor affect on recovered binder grades.
- EcoAddz modified binders had almost no loss of low temperature properties for the recovered binders.

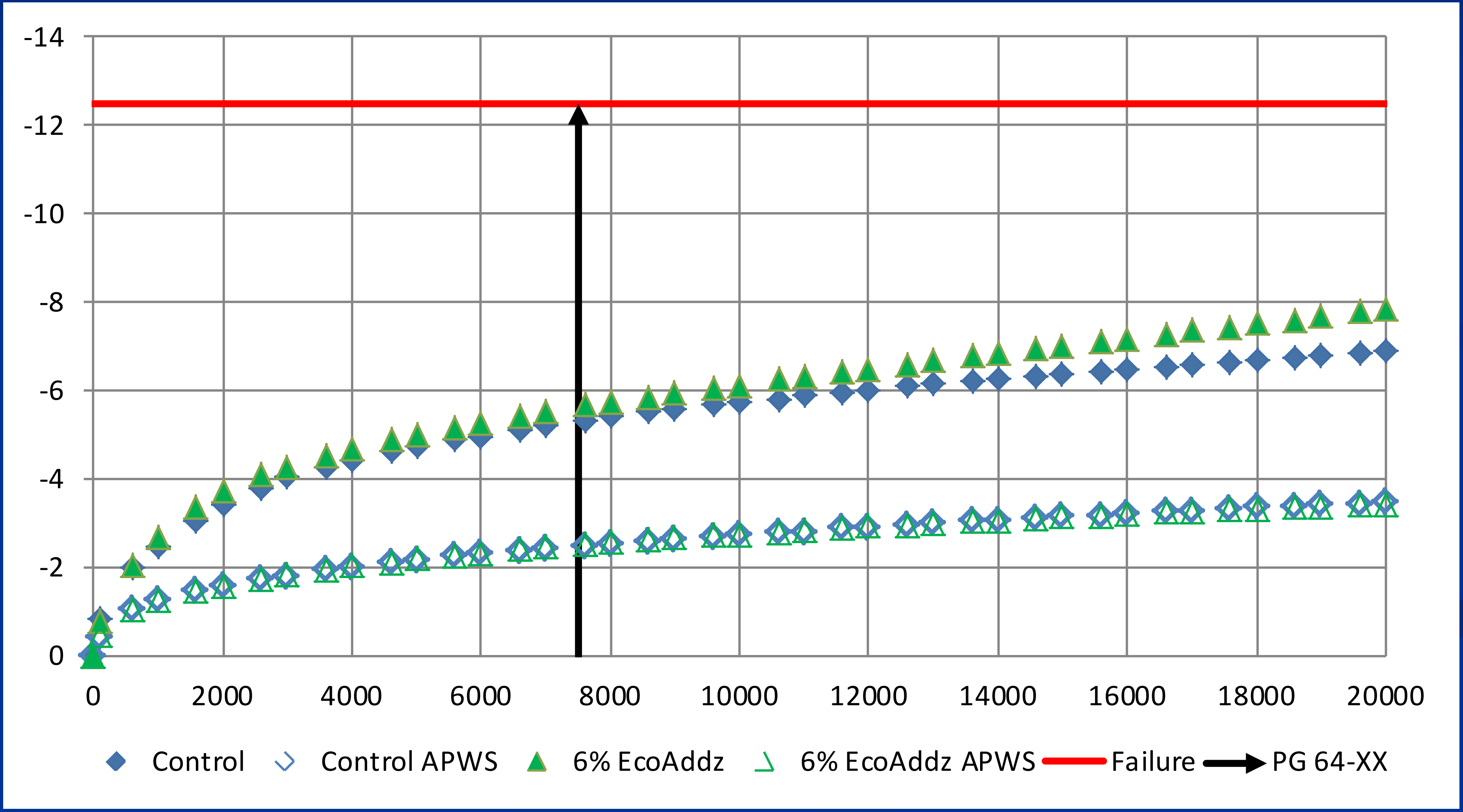
RHVDB Blend Results



N70 Mix 20% RAP HWT



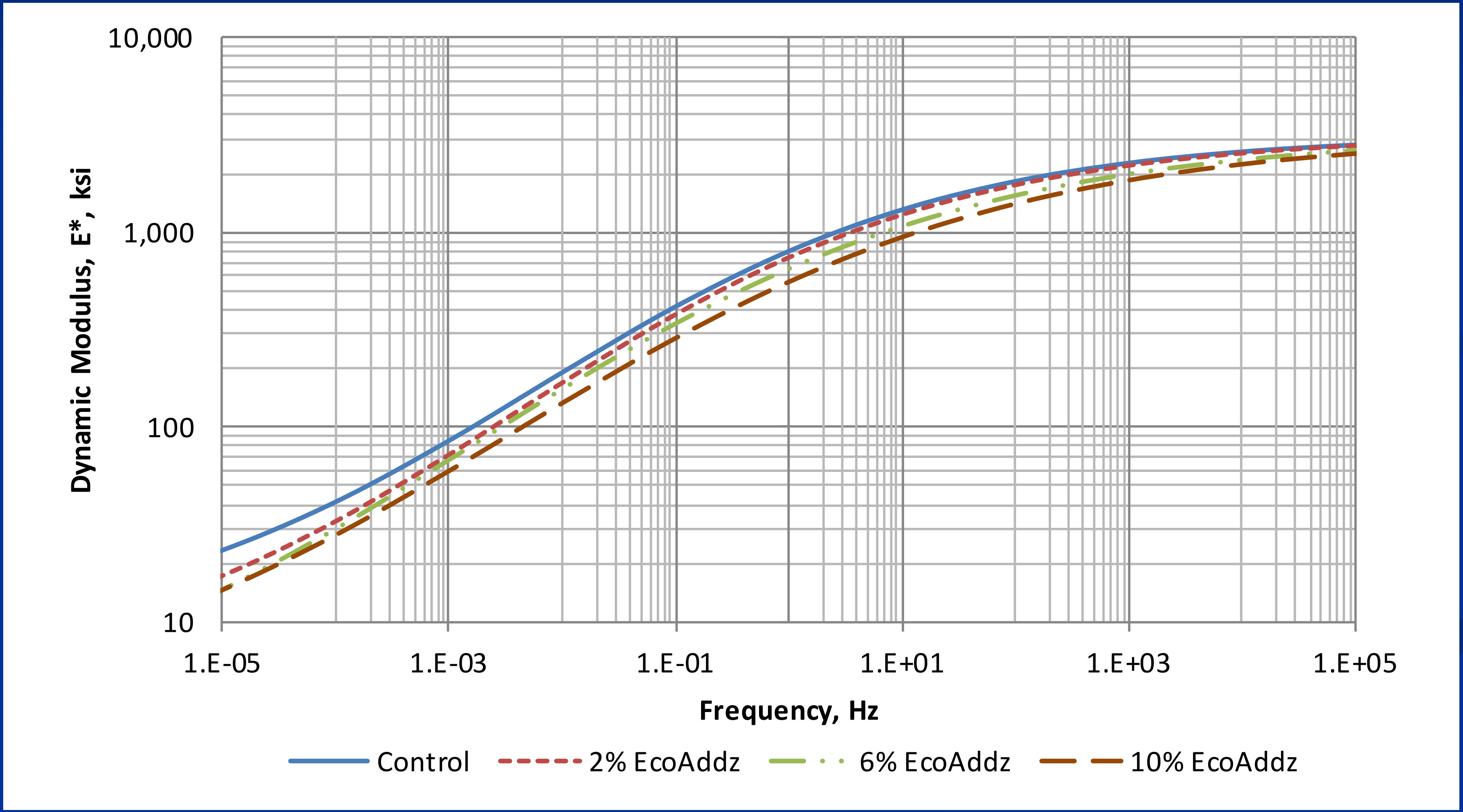
N70 RAP mixes After APWS



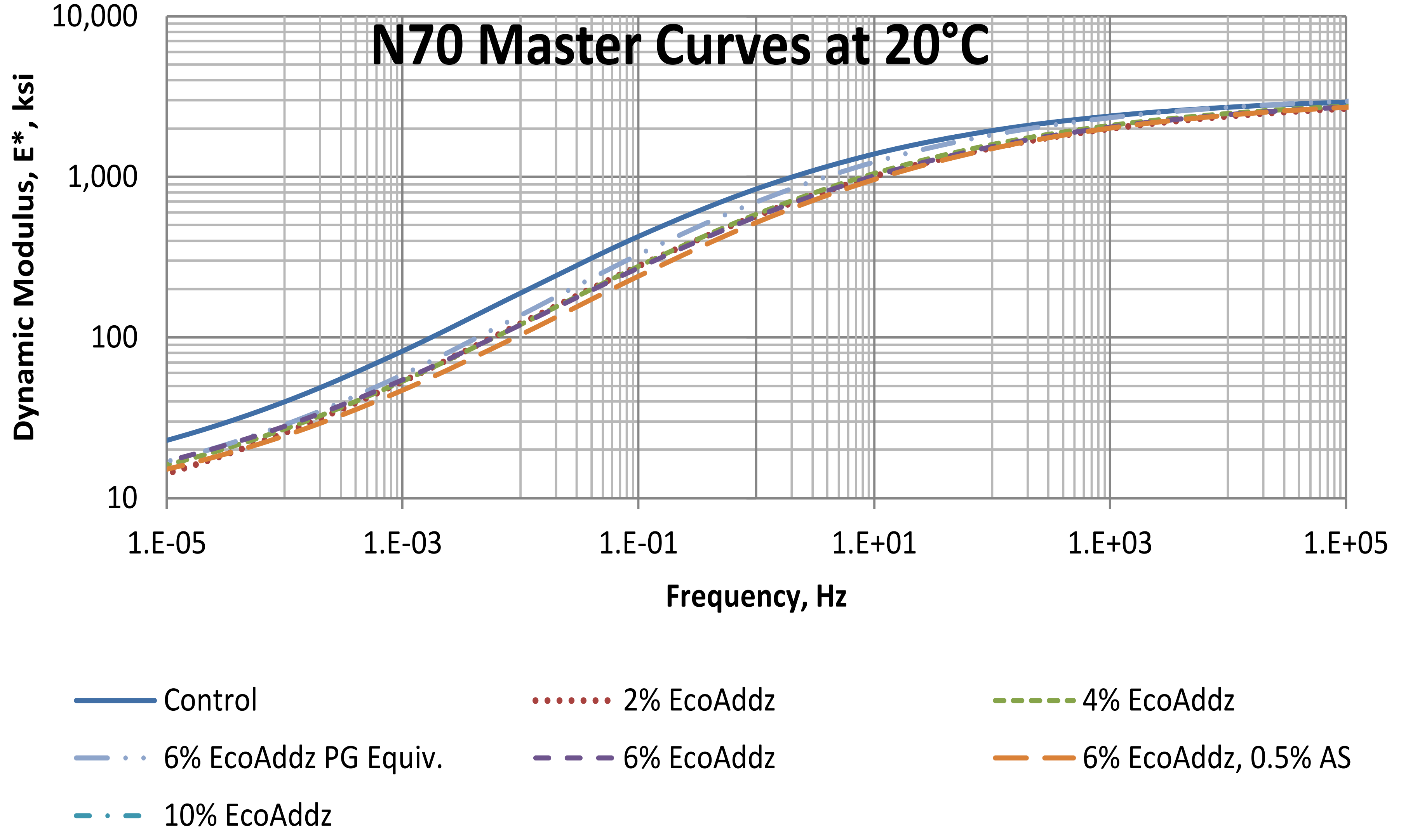
Hamburg LWT

- The addition of RAP only caused minor increases in stiffness and minor reduction rutting.
- The RHVDB mixes did not cause significant reduction of the high temperature properties.
- Long term aging provided similar increased stiffness of control and 6% EcoAddz mixes

N70 Mix 20% RAP Master Curves 20C



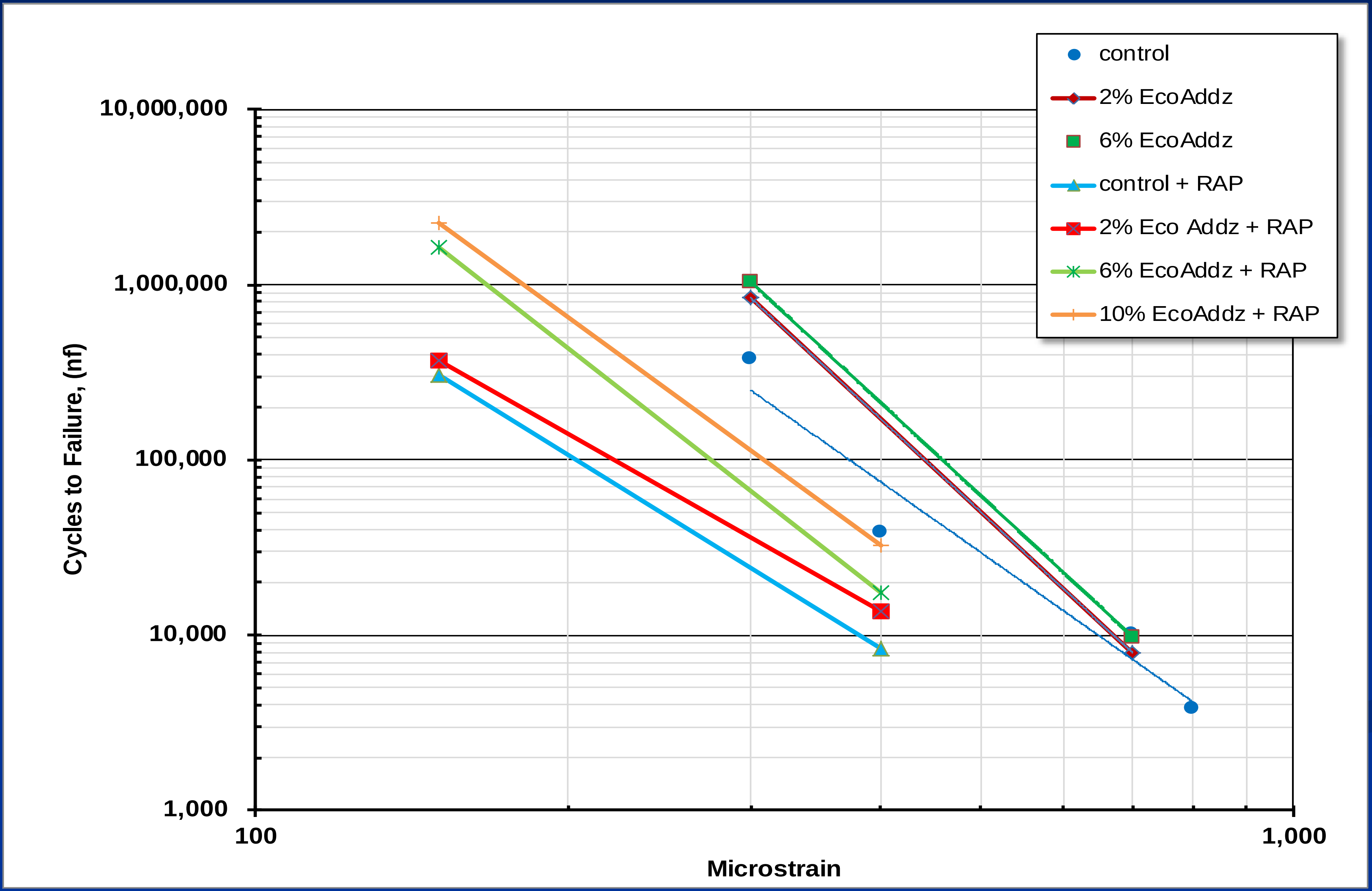
N70 Mix no RAP Master Curves 20°C



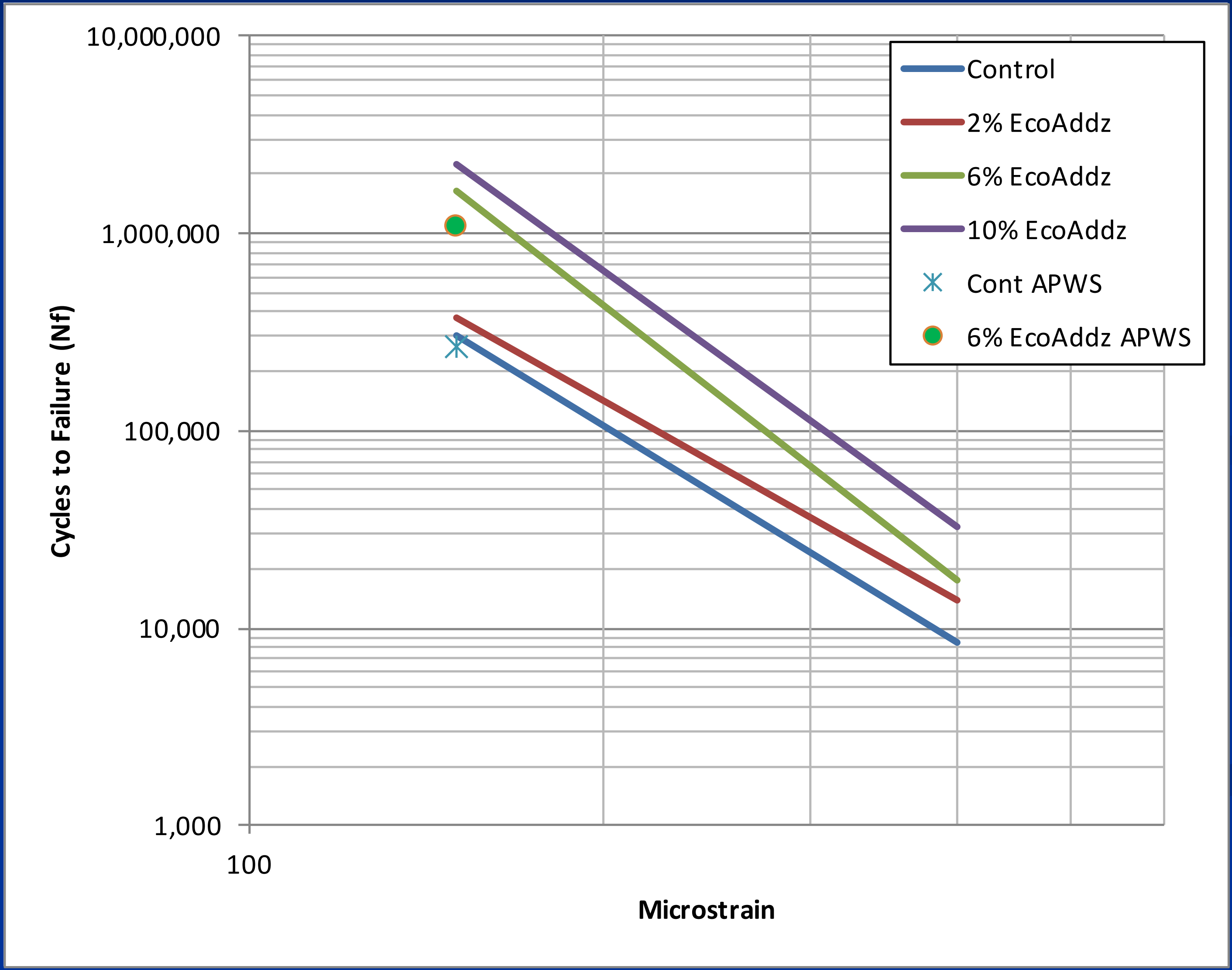
Master Curves

- The master curve data strictly matches binder PG grade.
- Softer binder lower E* data.
- RAP only shows minor increase in mix stiffness.

N70 Mix 4 Point Bending Beam



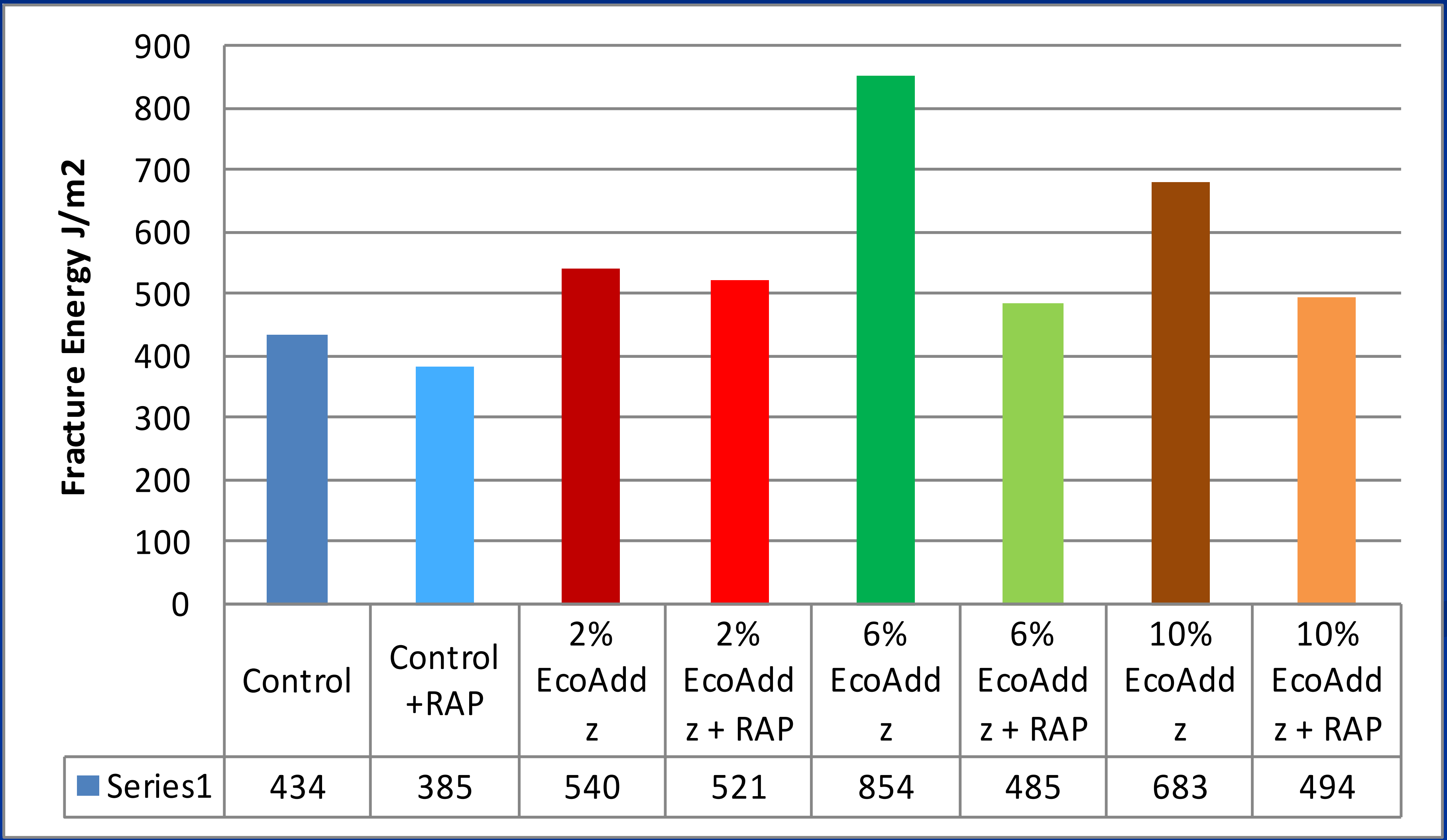
N70 Mix + RAP 4 Point Bending Beam Before and After APWS



Beam Fatigue Testing

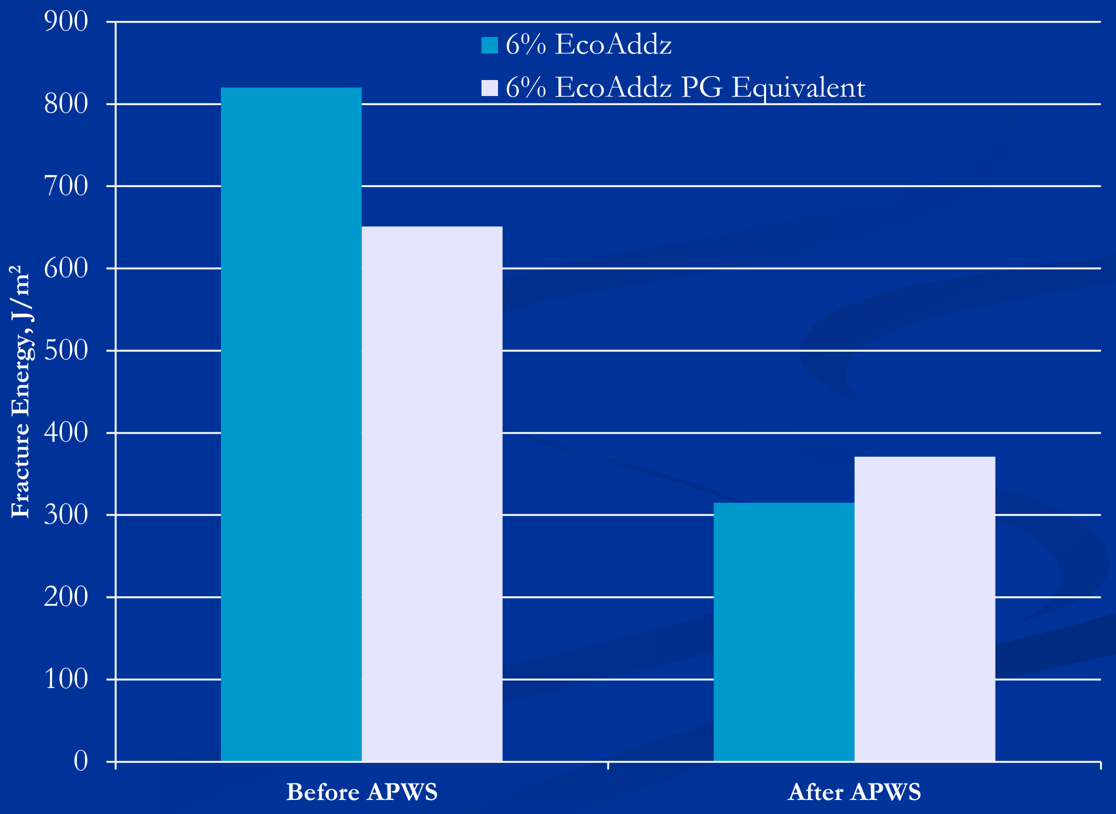
- The four point bending beam data clearly shows the mixes produced with RHVDB have better fatigue response than control binder
- The Addition of RAP Clearly reduces fatigue response. EcoAddz improved Fatigue response of the RAP mix.
- Accelerated aging only showed minor loss in fatigue response.

DCT Fracture Energy N70 Mix

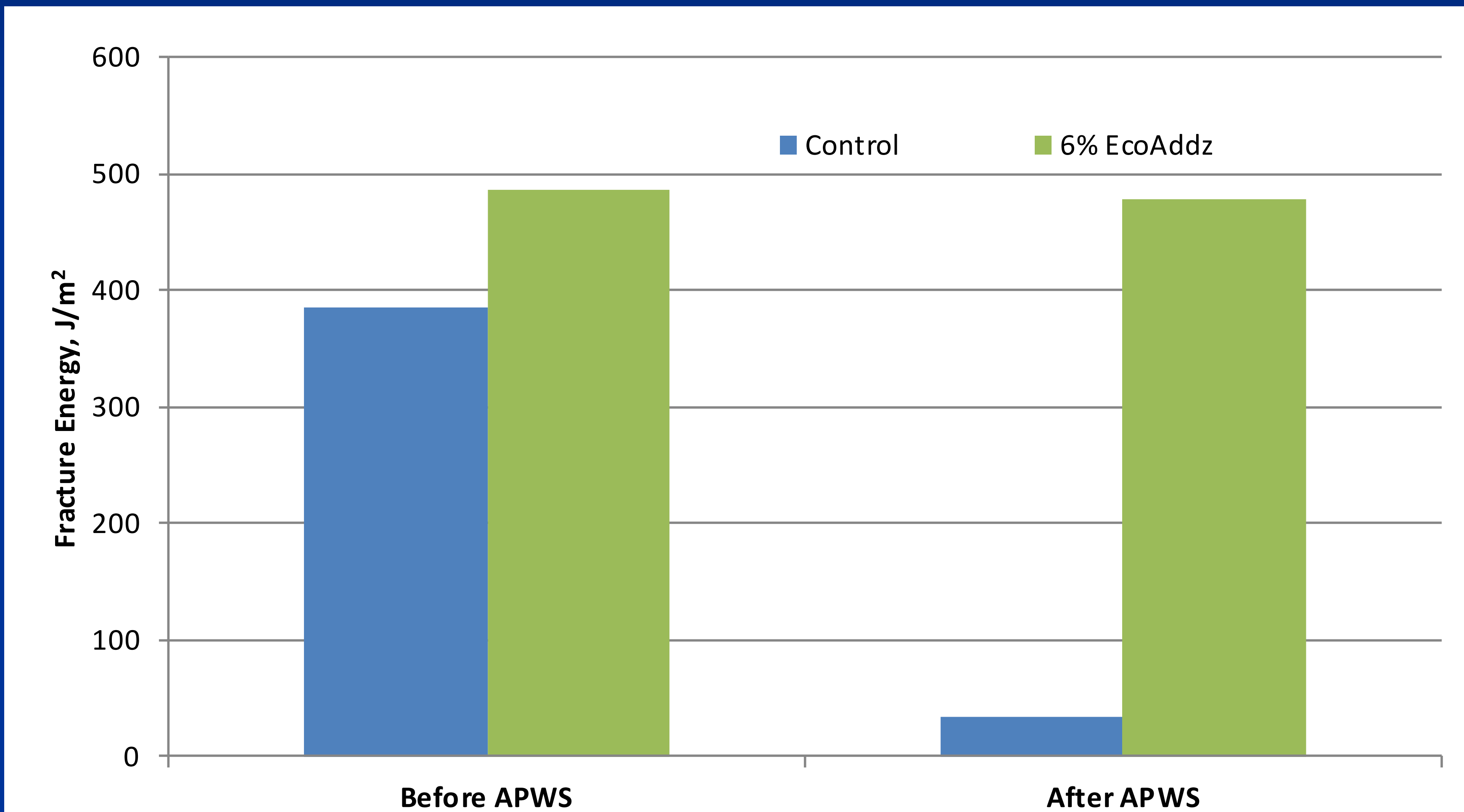


Results- Fracture Energy; ASTM D 7313

- Fracture Energy tested at -12°C
- MN Research indicates 400 J/m^2 to be an acceptable minimum Fracture Energy for Unaged Samples



N70 RAP Mixes Fracture Energy -12 C



Fracture Energy Results

- On unaged samples the addition of RAP created a smaller reduction in Fracture Energy on base binder than EcoAddz modified binder.
- On long term aged mix RAP caused significant loss in Fracture Energy of base binder. EcoAddz modified binder indicated only minor loss of fracture energy.

Summary

- The recovered binder of RAP mixes indicate that the RAP has only minor affect on binder properties. EcoAddz provides minor improvement.
- Mix properties correlate well recovered binder properties on unaged samples.
- Long term aging indicates significant change in properties of mix with RAP.
- EcoAddz modified binder mitigated some of the long term aging effects.

Thank you

Questions