Evaluation of Recycled Tire Rubber Modified Binder to Polymer Modified Binders for Performance Specifications

John A. D'Angelo Ph.D. P.E.
8528 Canterbury Drive
Annandale, Virginia 22003
571-218-9733
johndangelo@dangeloconsultingllc.com

Gaylon Baumgardner
Paragon Technical Services

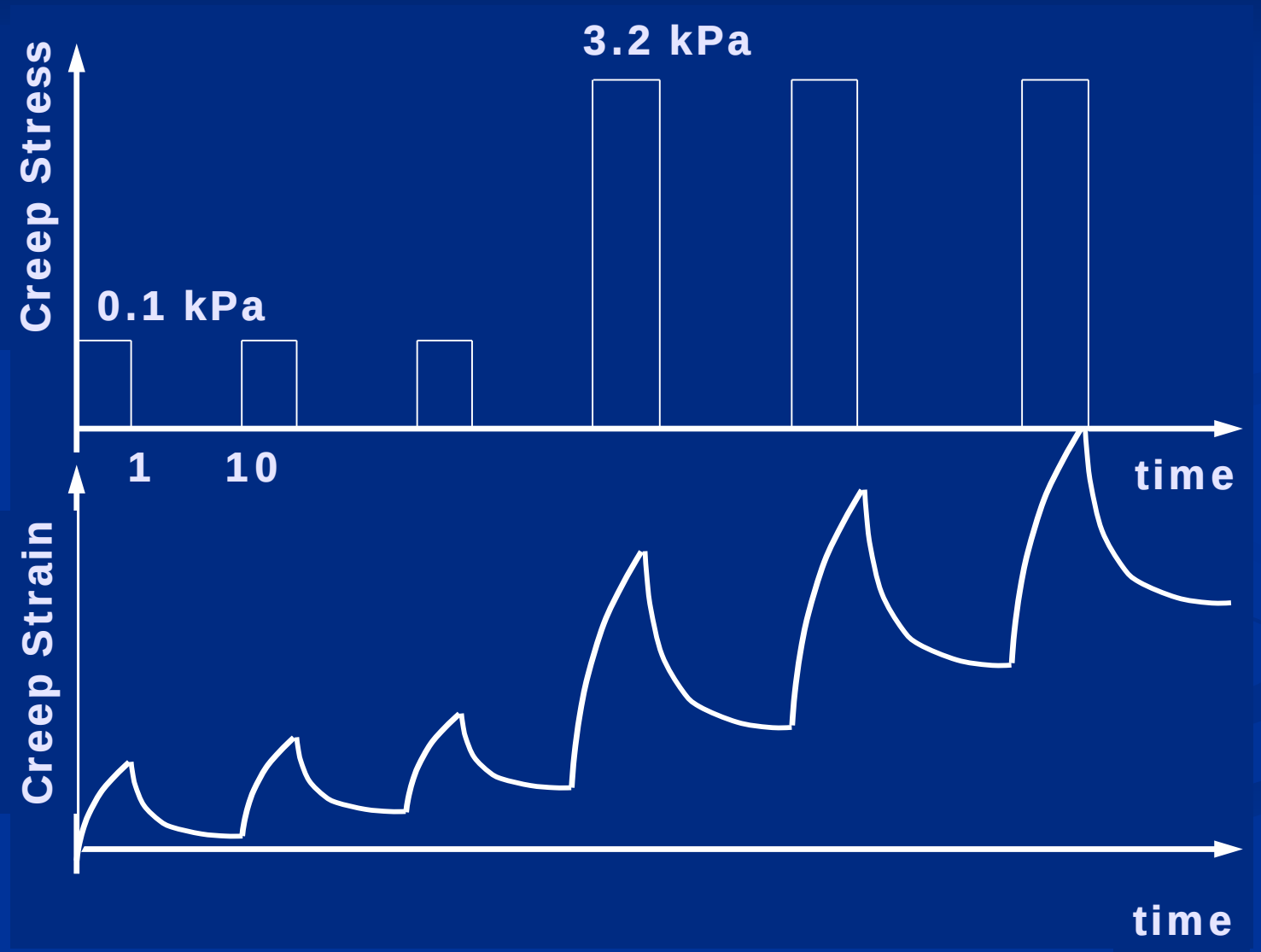
So Why Ground Tire Rubber in Asphalt?

- Used for over 40 years
- Structural Benefits
  - Modification helps to increase viscosity, thereby improving rutting resistance
  - Modification helps to reduce cracking
    - Increases resiliency of mixture
    - Increases asphalt content and film thickness
    - Higher film thickness also provides greater resistance to aging
    - Less aging due to anti-oxidants already in the scrap tire rubber

Performance Specifications

- Current Binder Specifications Evaluated
  - AASHTO M 320
  - AASHTO M 332 MSCR
- Highway agencies are implementing existing binder specs for RTR modified binders.
- Do these specifications provide equivalent results for RTR binders

Multi Stress Creep and Recovery



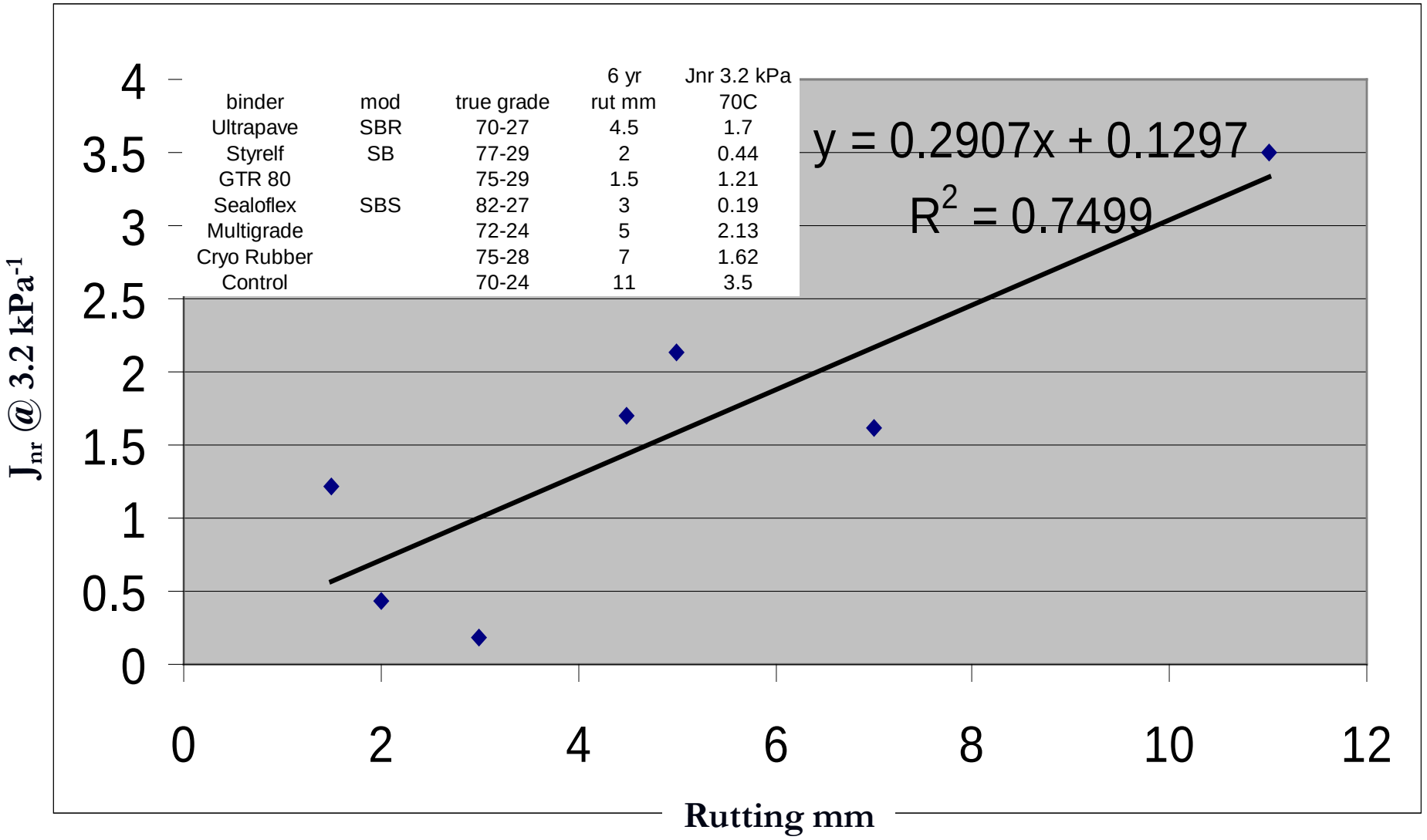
Test using the DSR applying a 1 sec creep stress followed by 9 sec recovery.

New MSCR Binder Spec AASHTO M 332

Original					
DSR G*/sinδ Min 1.0	64				
RTFOT					
64 Standard MSCR3.2 <4.0	[(MSCR3.2 – MSCR 0.1)/ MSCR 0.1] < .75	64			
64 Heavy MSCR 3.2<2.0		64			
64 Very heavy MSCR3.2 <1.0		64			
PAV					
S grade DSR G*sinδ Max 5000	28	25	22	19	16
H & V grade DSR G*sinδ Max 6000	28	25	22	19	16

Low temp BBR and DTT remain unchanged

Miss I55 6yr rut Jnr 3.2 kPa



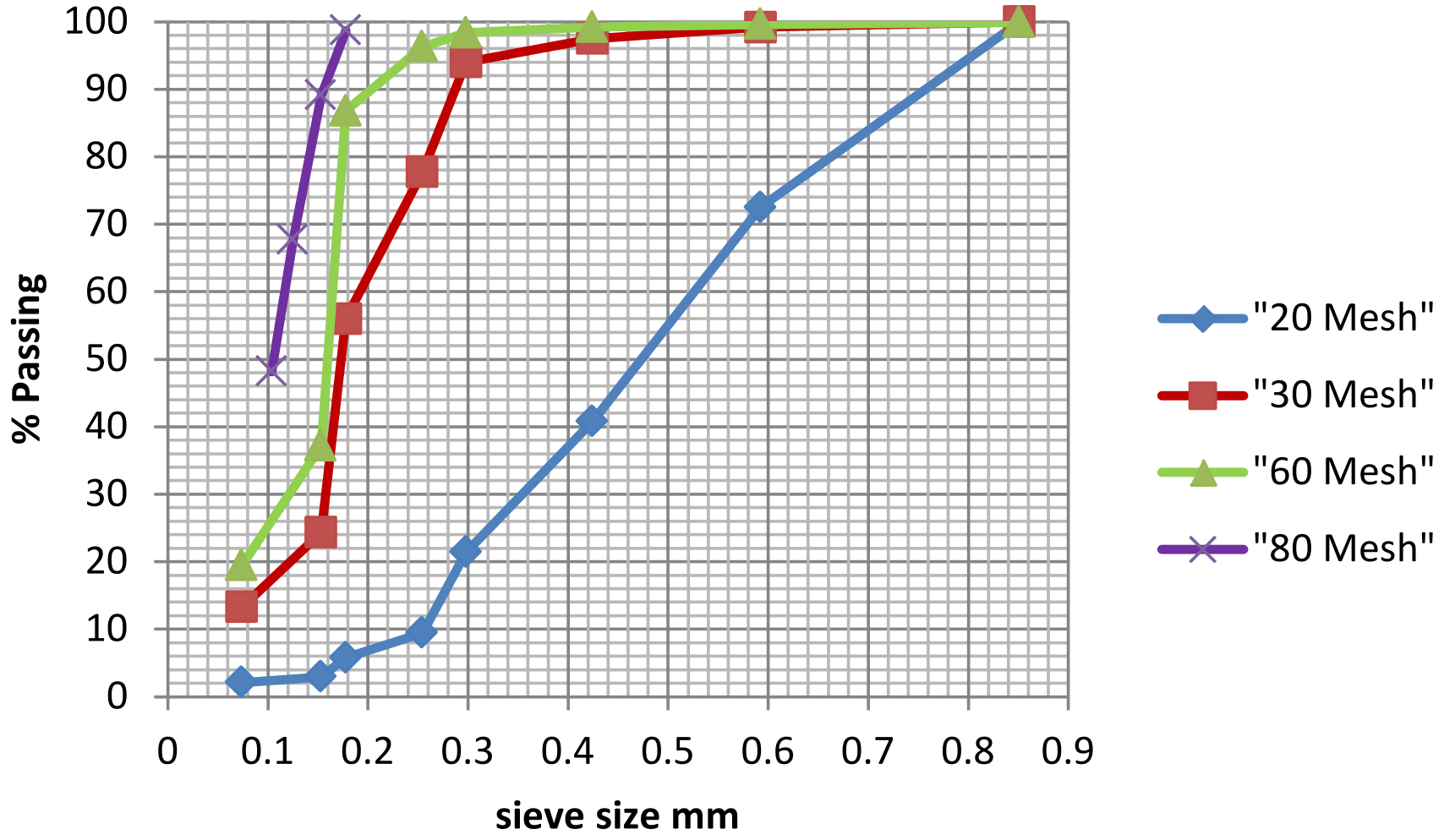
Experimental Design

- Compare SBS modified binder properties to RTR modified binder properties
  - SBS typical PG 76-22 grade
  - Hybrid SBS + RTR
  - RTR one base binder PG 64-22
  - RTR 4 mesh sizes 20, 30, 60, 80
  - RTR 5, 10, 15, 20 % concentrations

Experimental Design

- Full M 320 and M 332 classification of binders
  - Compare M 320 to M 332 properties
- Vary geometries for RTR modified binders
  - Parallel Plate and Cup and Bob
  - For this presentation C&B not fully complete

RTR Sizes Used in Study



Testing Geometries

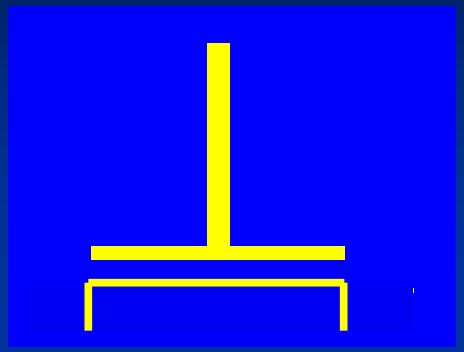
Typical Parallel Plate

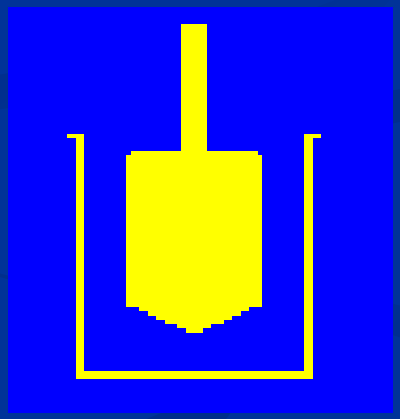
Cup & Bob Geometry

Both geometries can perform the same testing oscillatory, creep and rotational

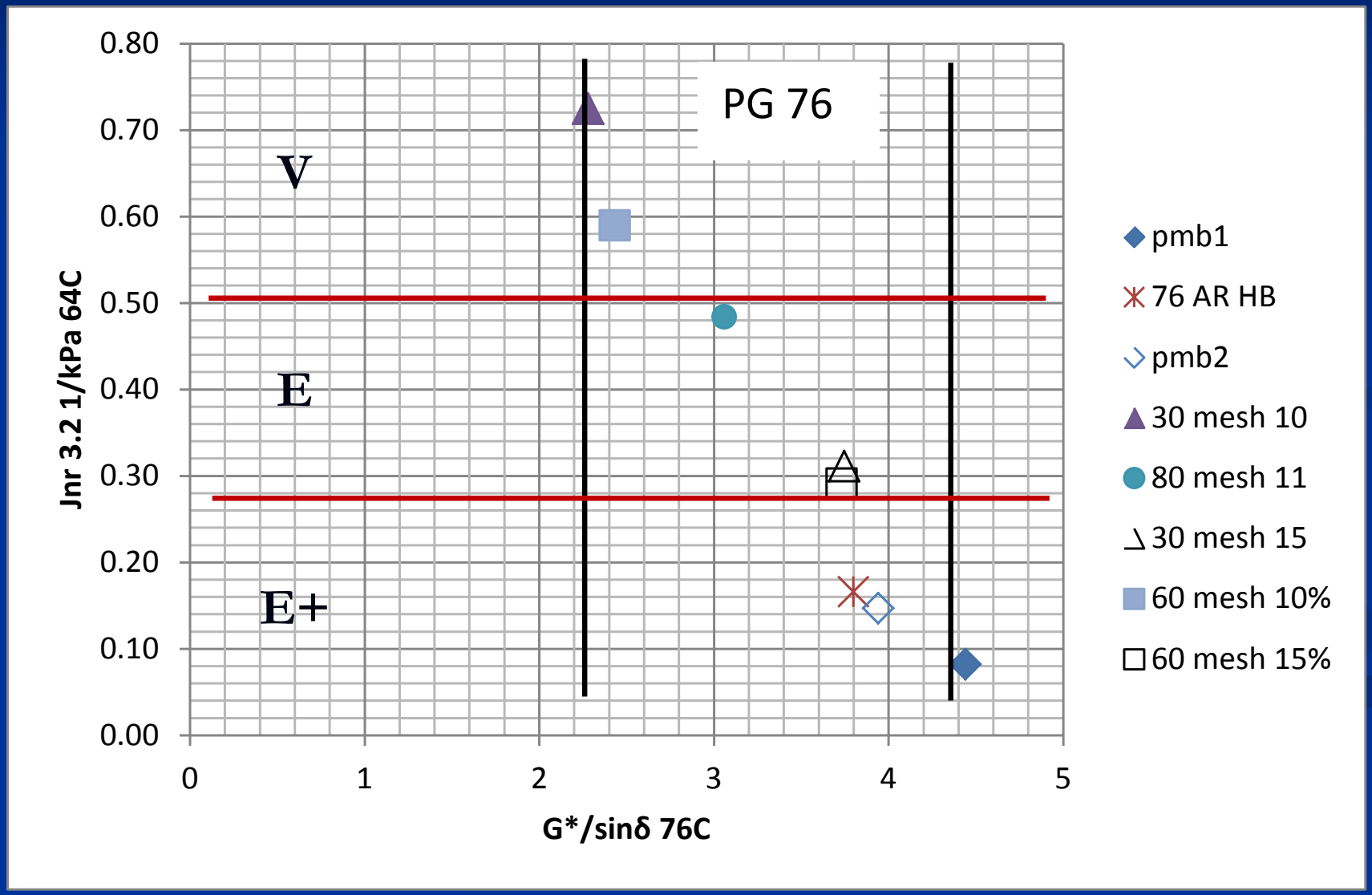
Geometries Used

- Parallel Plate
  - Plate Diameter: 12.5 mm
  - Gap: 2 mm
- Searle Set (Cup and Bob)
  - Cup Diameter: 27.5 mm
  - Bob Diameter: 14 mm
  - Effective Gap: 6.75 mm



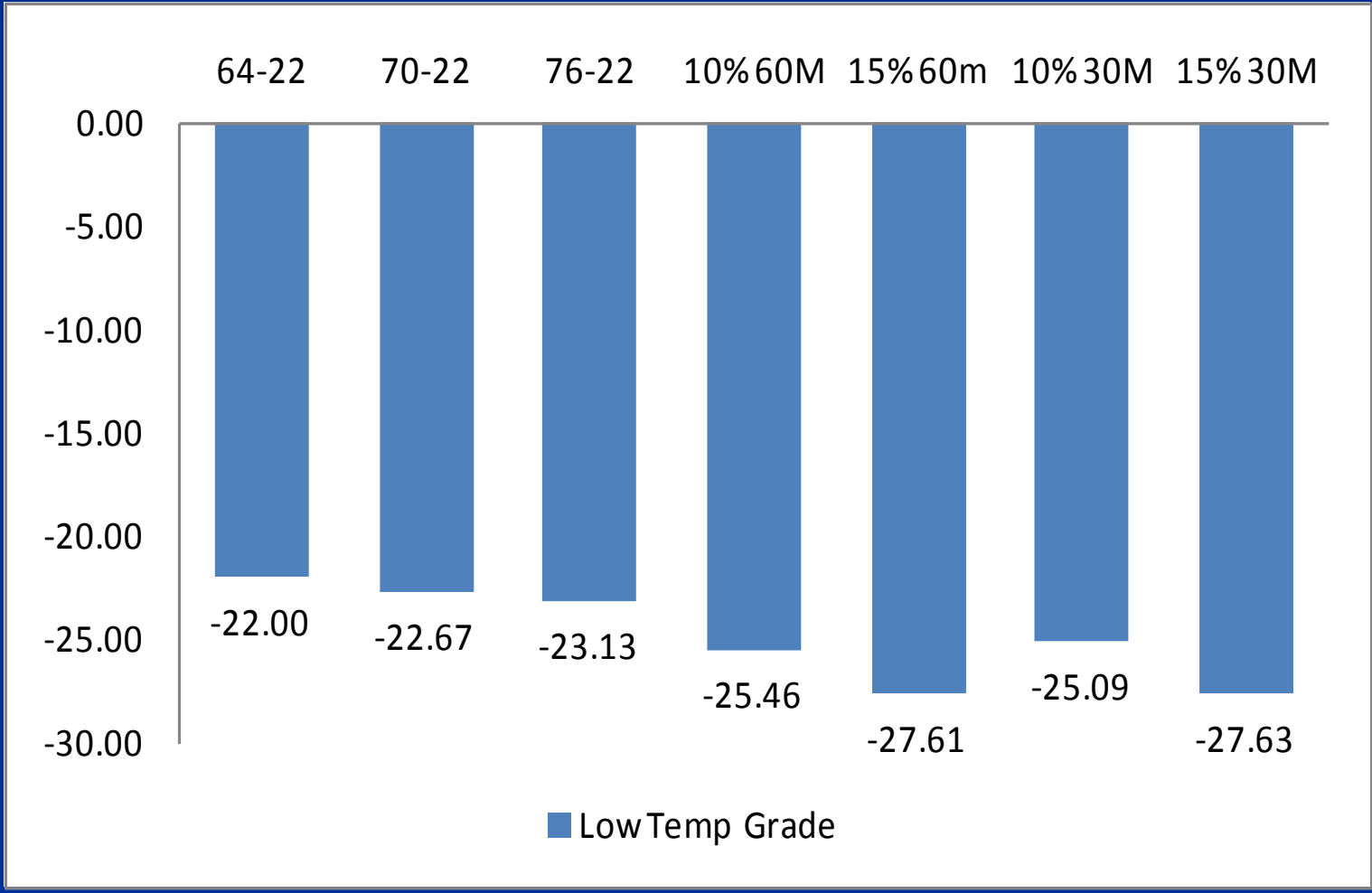


High Temperature Binder Properties Comparing PG 76 Binders



Effect of CRM on Low Temperature Grade

Low Temp Continuous Grade Improved with rubber



High Temperature Binder Properties

- M 320 indicates most of the binders are PG 76. Wide range in $G^*/\sin\delta$ from the low end of the grade to the top end.
- MSCR indicates that the binder vary over three grades from a 64V to a 64E+.
- M320 indicated equivalent properties while M 332 indicates variations in properties.
- This may be why Louisiana requires PG 82 AR to be equivalent to PG 76 PMB

Modifier Structure in the Binder

- Polymers like SBS set up networks in the binder to improve elasticity and toughness to reduce cracking
- RTR may provide some networking, but primarily provides an elastomeric filler which also improves elasticity and toughness to reduce cracking.
- Current recovery measurement systems may not identify RTR properties.

Polymer Structures

Linear

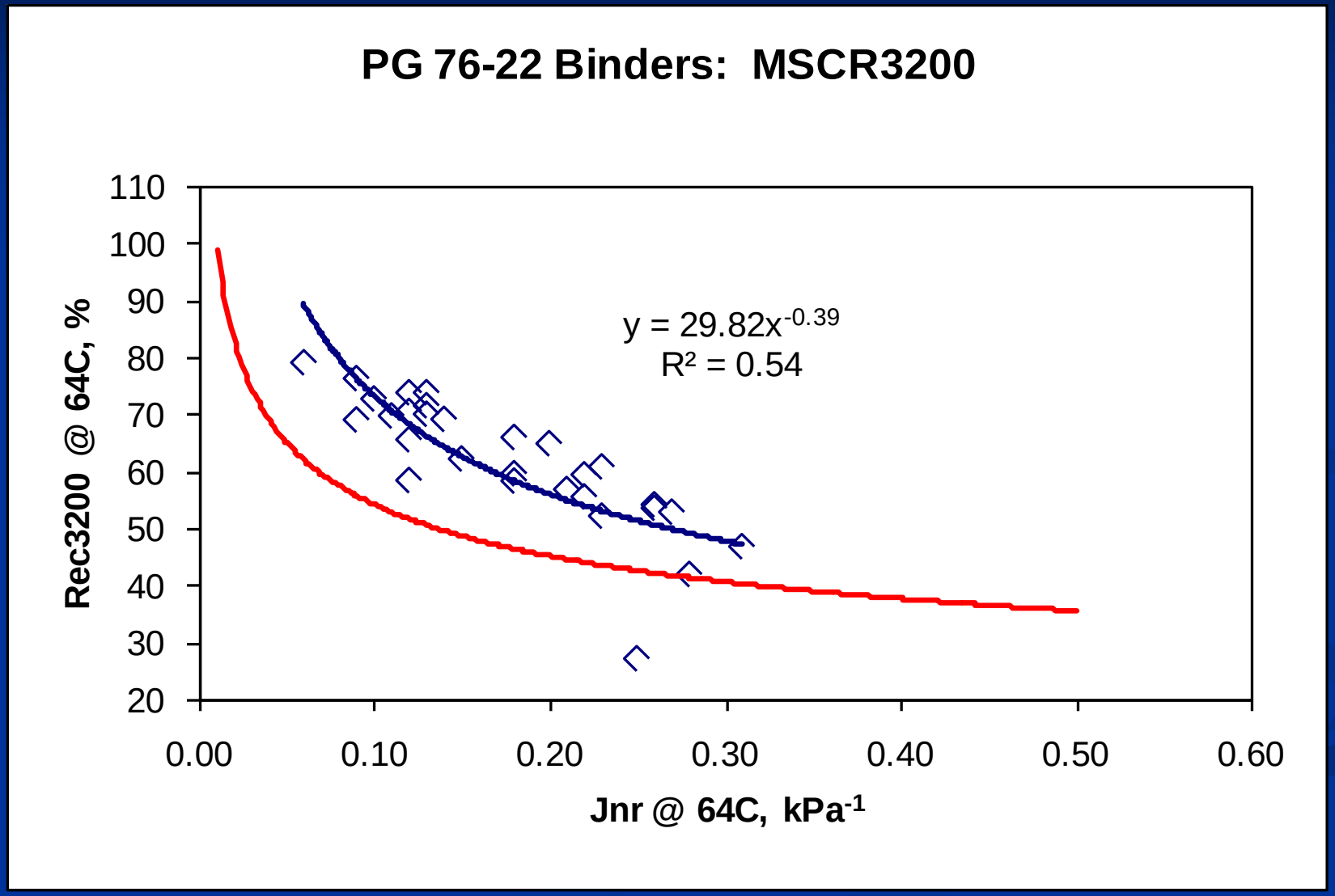
Branched

Cross-linked

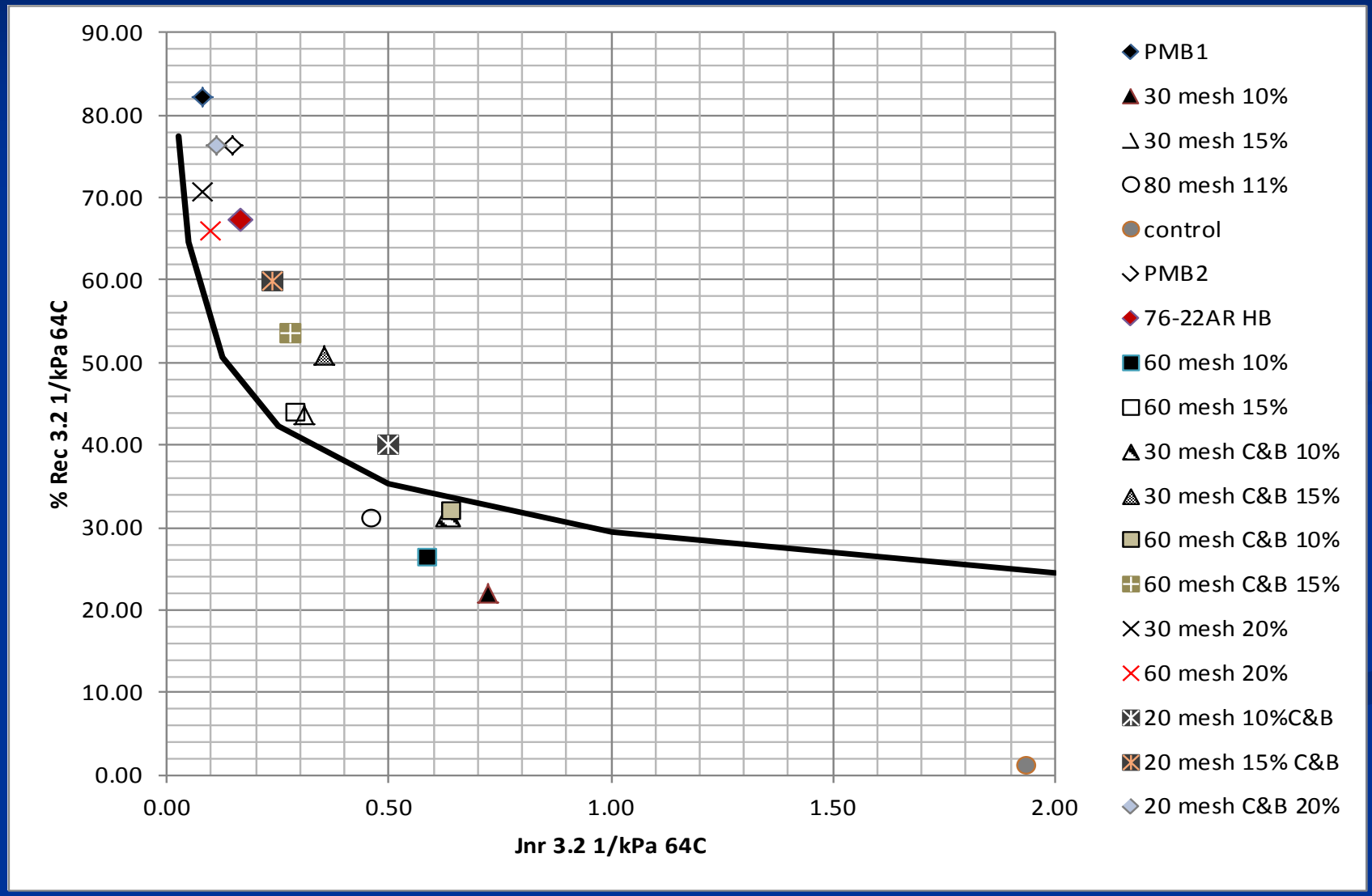
Modified Structure in the Binder

- Rubber has shown good performance in cracking but may not provide % recovery responses in current testing procedures.

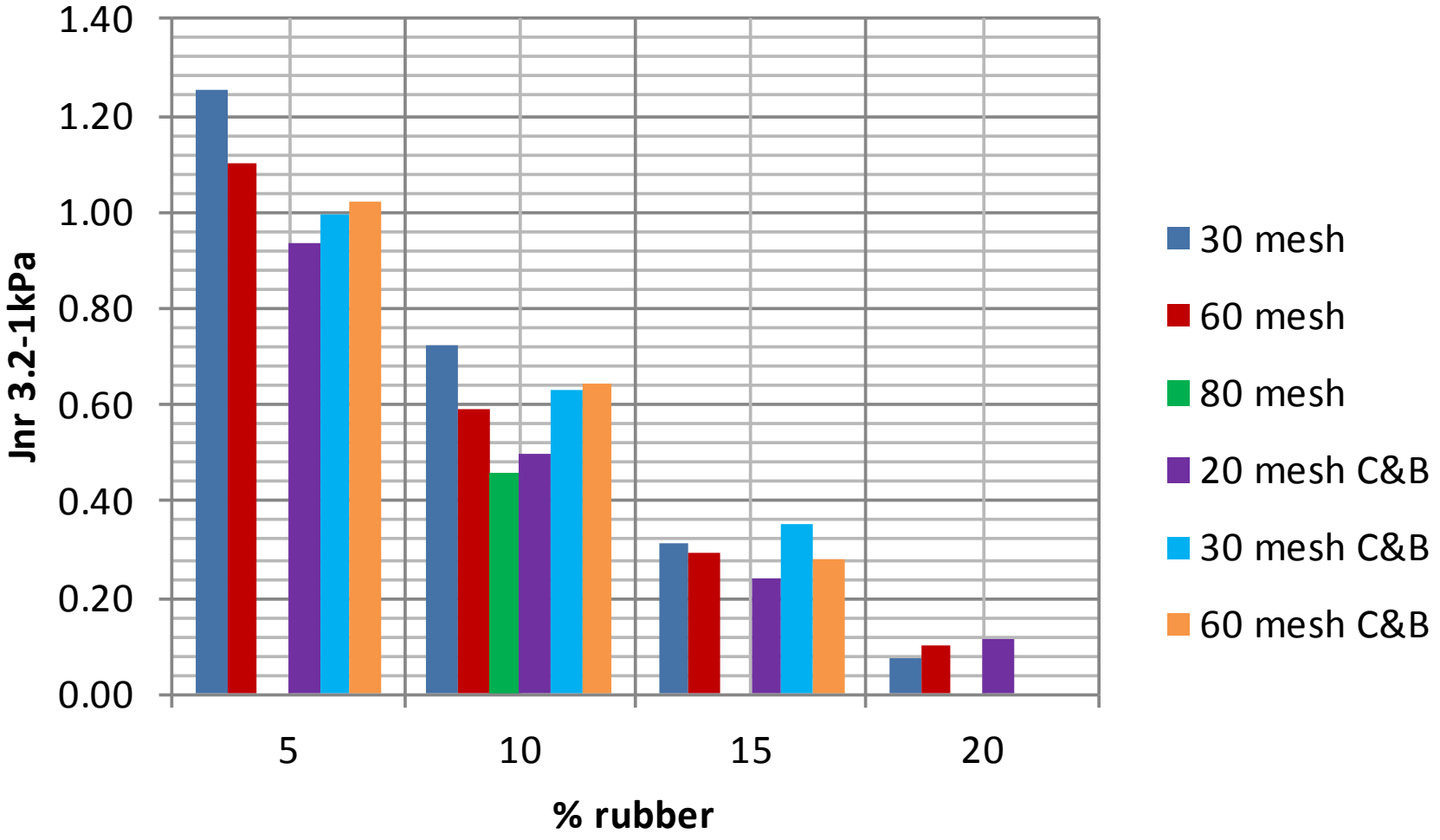
Validate Polymer Modification AI Study



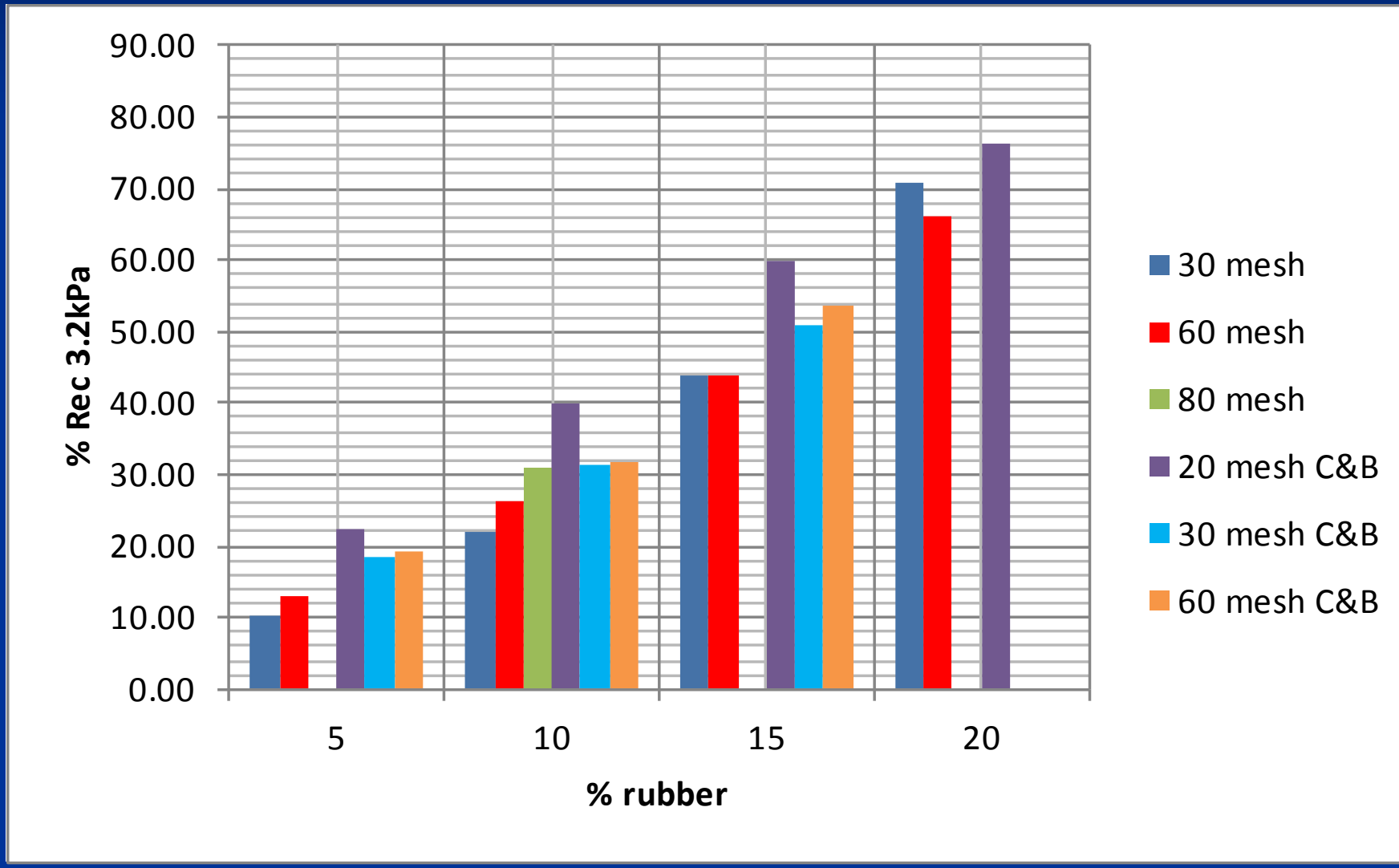
Jnr vs % Recovery for PMB and rubber blends



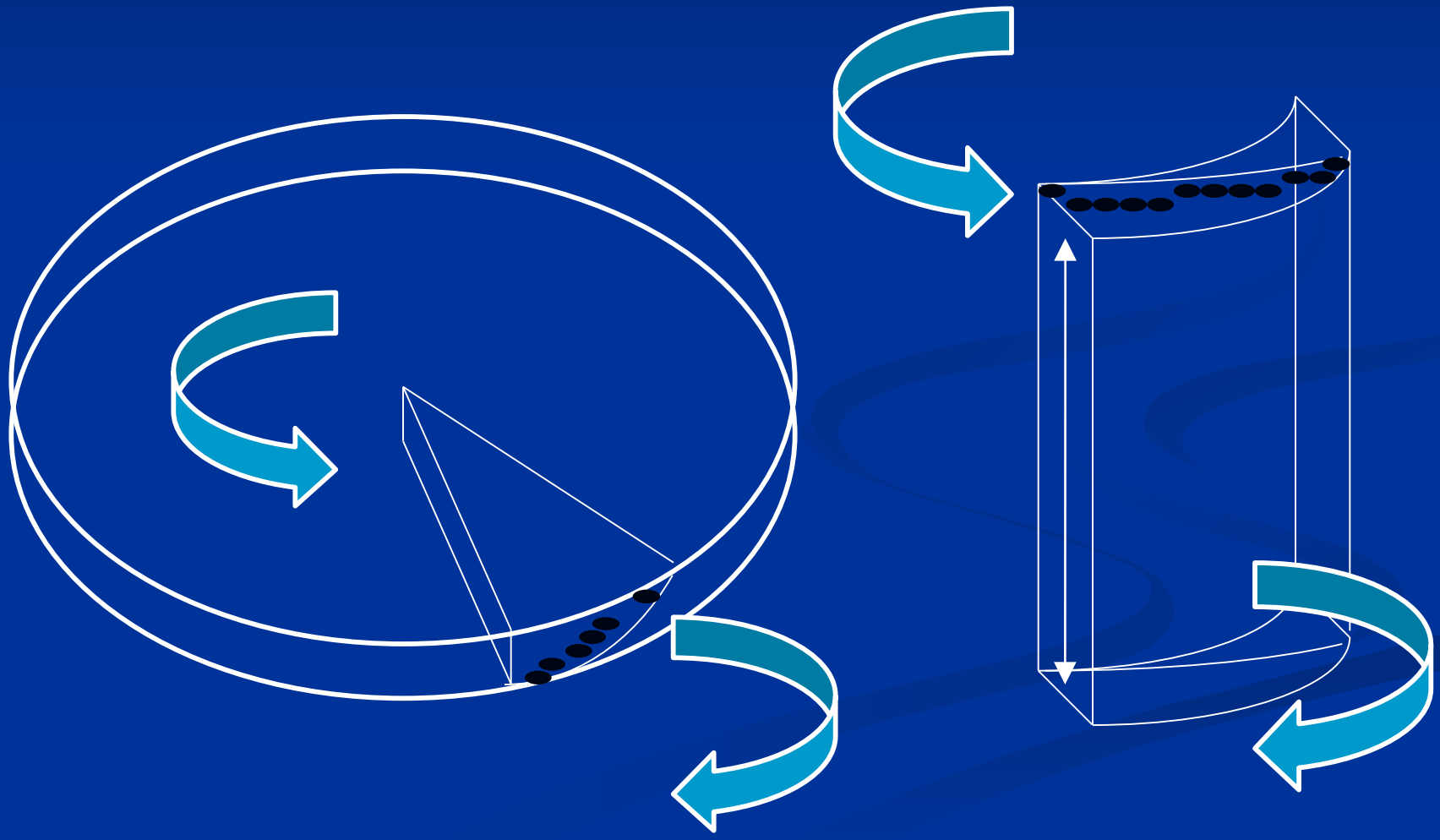
Jnr Changes with %RTR and Geometry @ 64C



Change in % Recovery with %RTR and Geometry



Cup and Bob has significantly more particle interaction than Plate-Plate Geometry



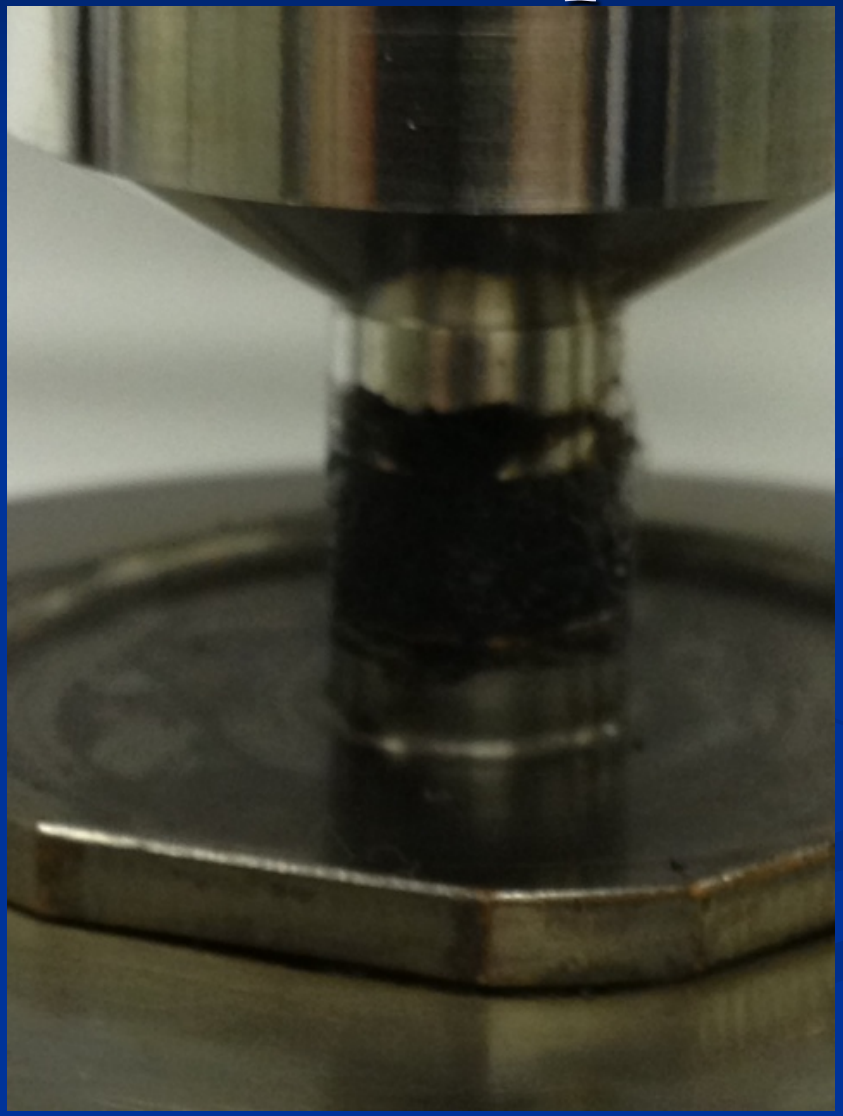
Recovery Properties of RTR

- RTR does not provide equal % recovery to PMB. This is not necessarily a performance characteristic.
- Cup & Bob indicates more recovery than Parallel Plate.
- RTR does not set up a network in the binder, however it has been shown to provide crack pinning and improve durability.
- We may need to reevaluate how to determine how much recovery is required for RTR

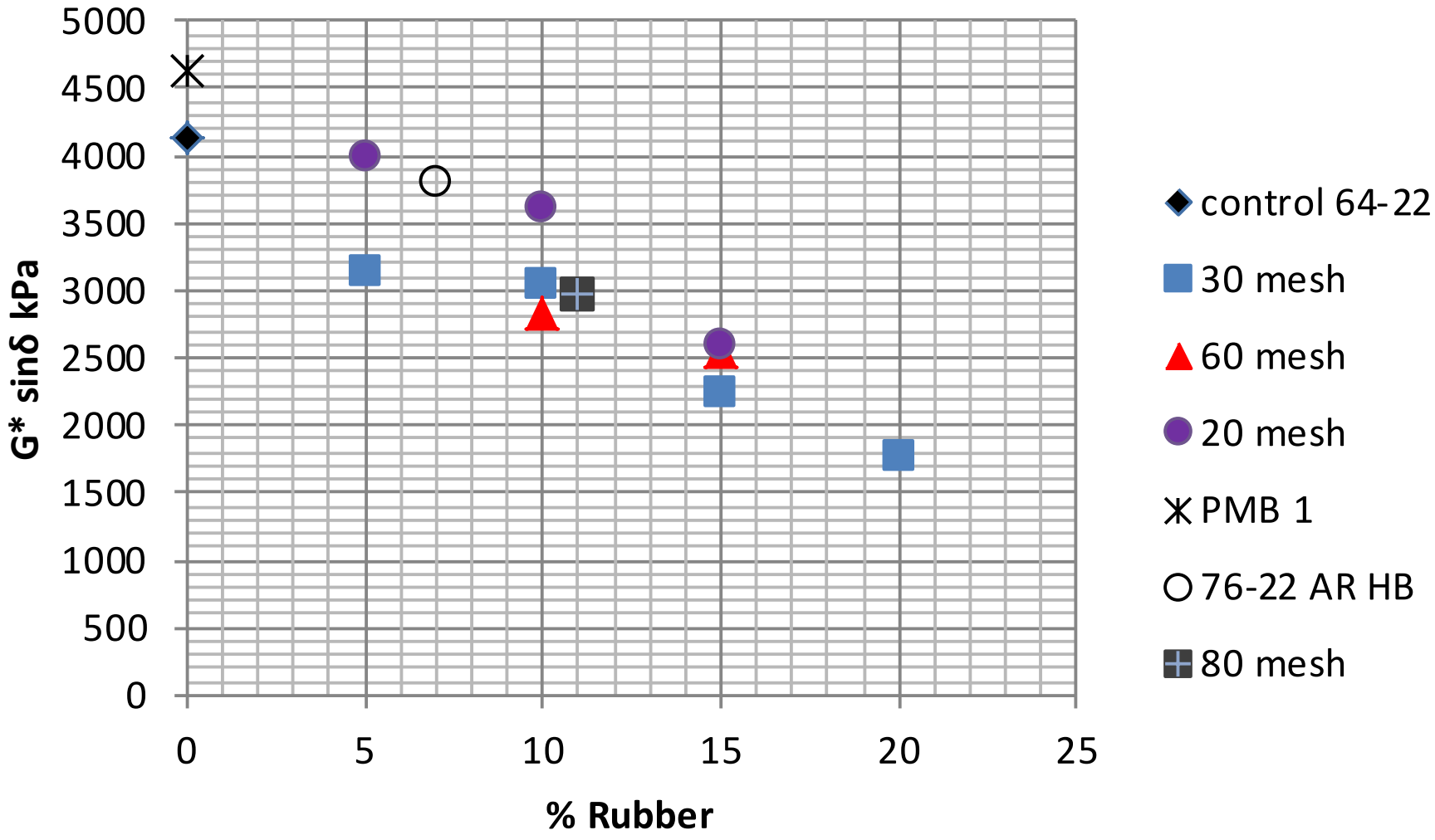
Intermediate DSR testing of RTR Binders

- Previous studies indicated that the cup & bob geometry had compliance issues with intermediate DSR testing.
- Large gap sizes needed for larger mesh size rubber.
- Large gap sizes at high temps resulted in sagging of sample, but at intermediate temps it may work.

8 mm plates with 4 mm gap at intermediate temperatures



Change in Intermediate DSR with size and % RTR



Summation

- At high temperature M 320 and MSCR do not provide equivalent results for the rubber and PMB binders. MSCR has been verified to more closely relate to high temp performance of binders.

Summation

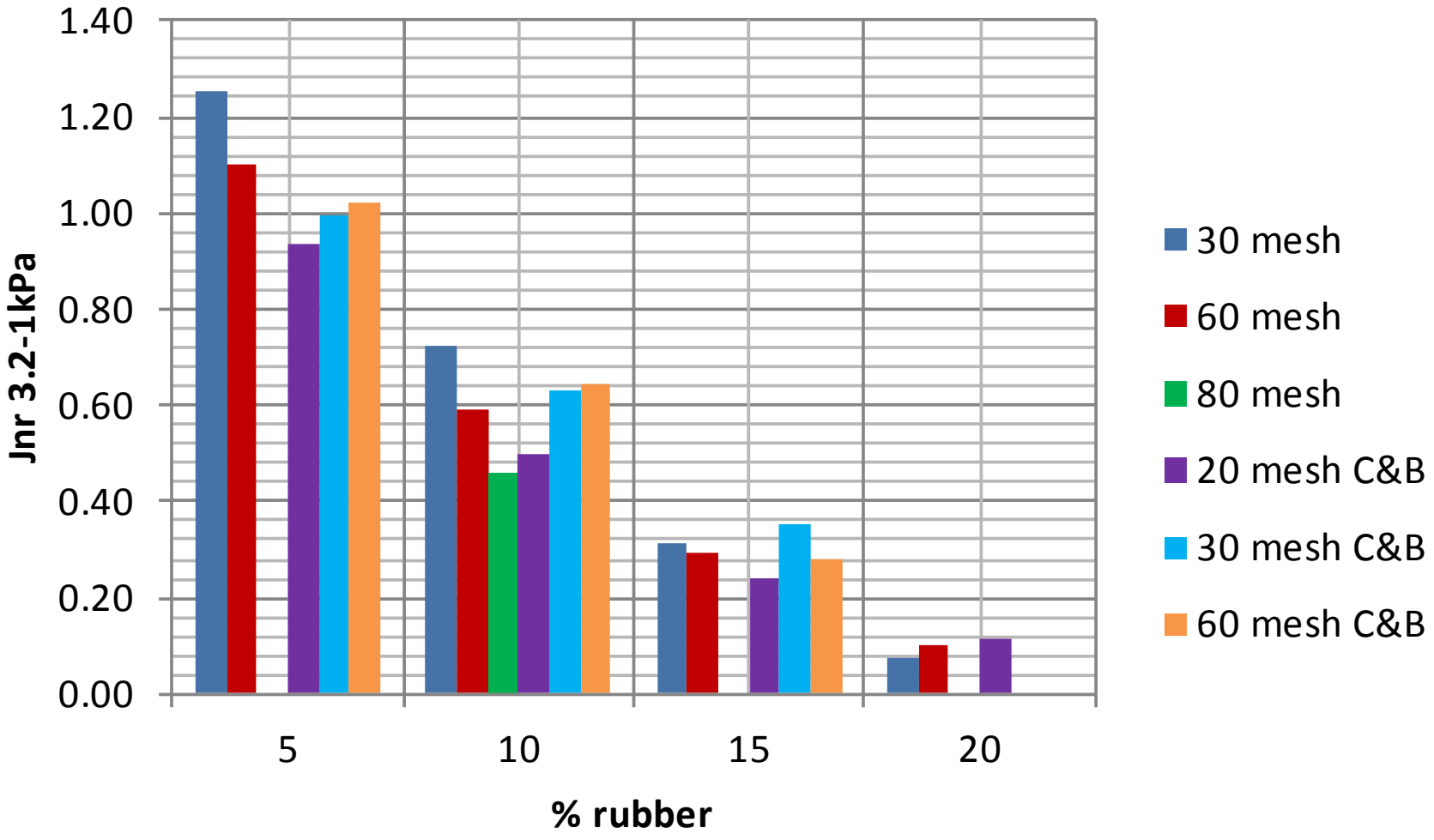
- MSCR % recovery different for PMB and RTR.
- % recovery relates to internal structure not directly to performance.
- May need to develop new relationship for RTR to determine internal structure.

Summation

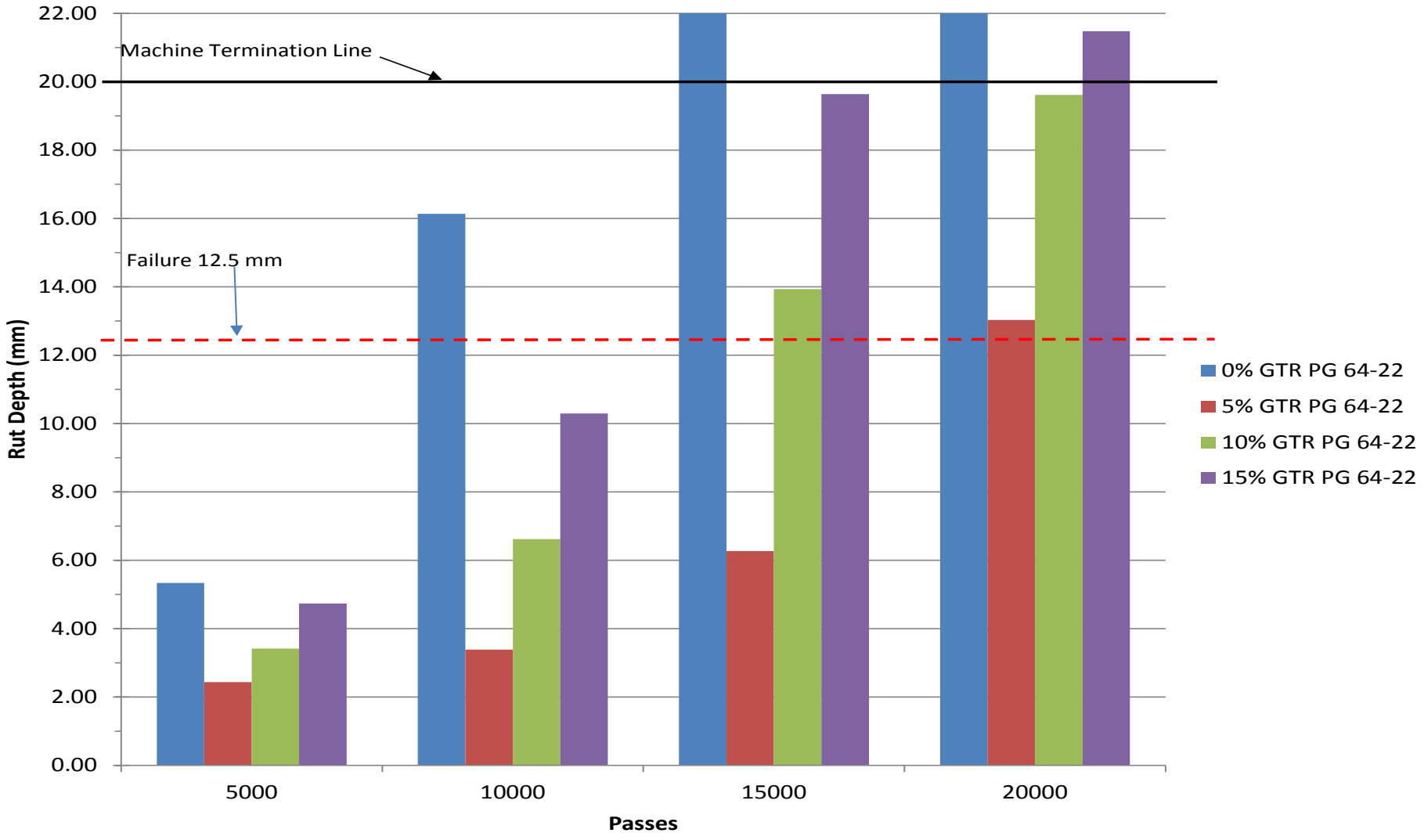
- RTR binders can be produced to be equivalent to PMB binders.
- MSCR is more discriminatory than the M 320 spec.
- More work is needed to determine internal structure of RTR and relationship to improved performance.
- RTR improves intermediate DSR properties but affect is size dependent.

Preliminary Mix testing to verify RTR PG grading

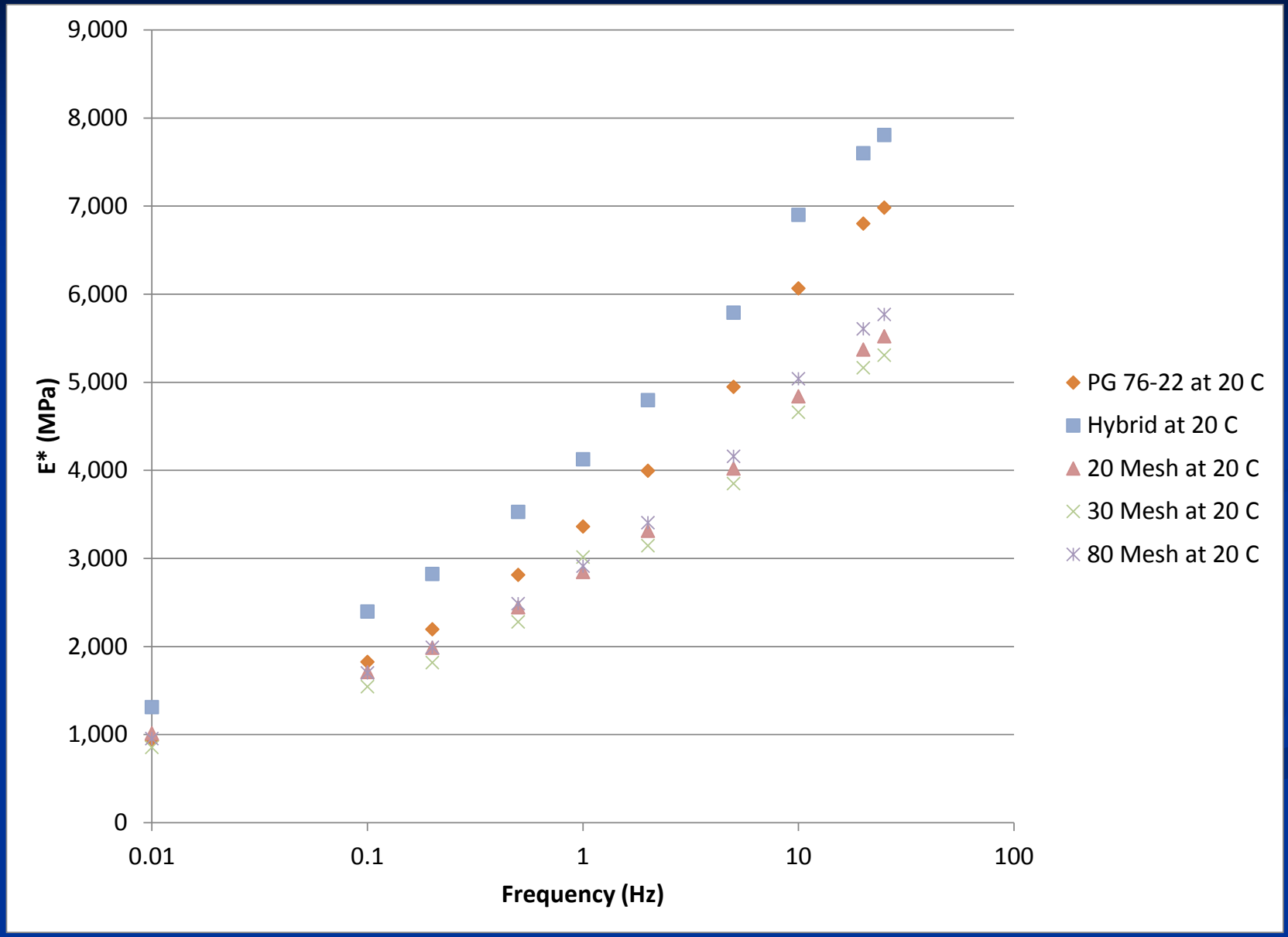
Jnr Changes with %RTR and Geometry @ 64C



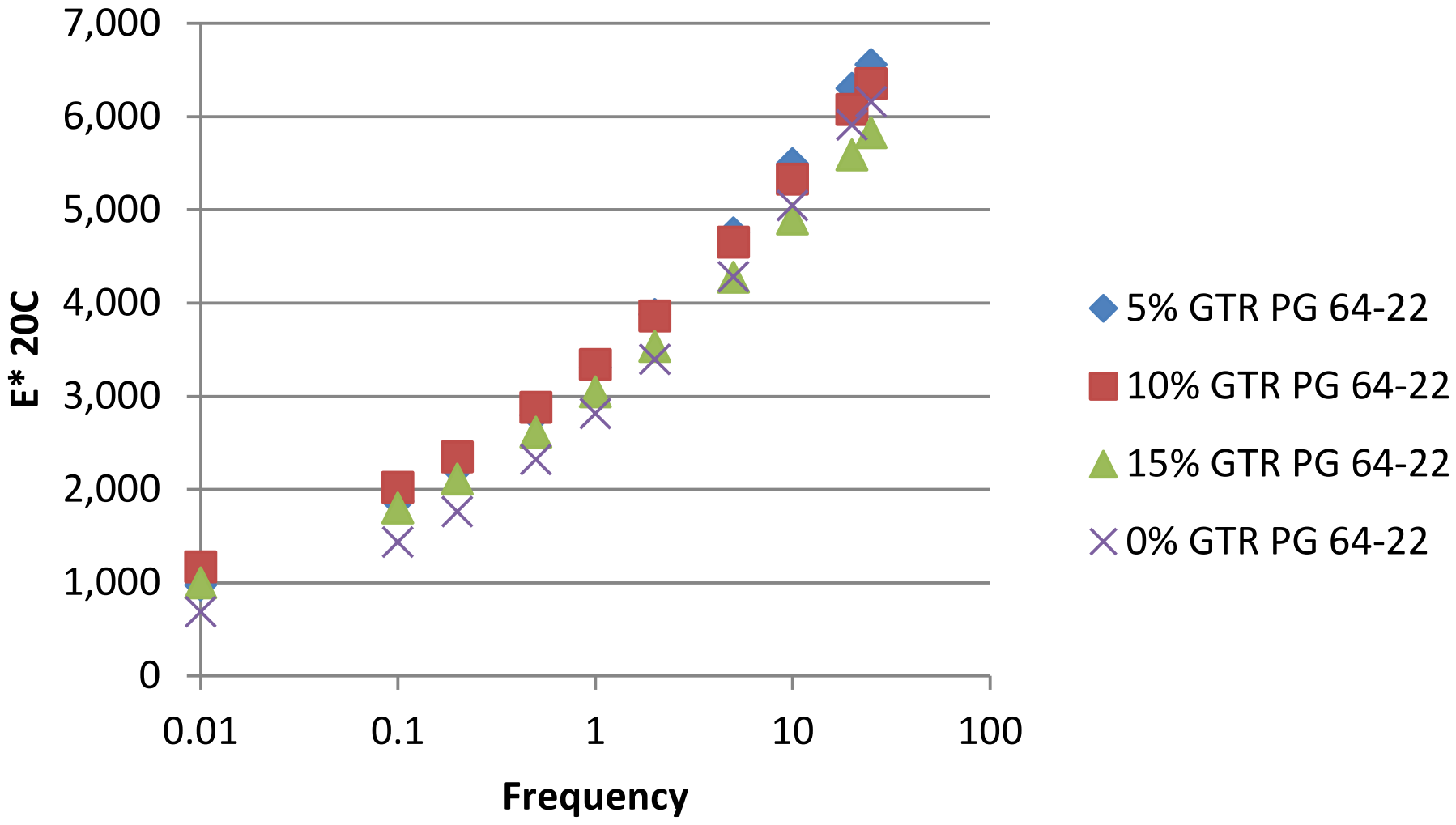
HWT Mix testing of RTR study



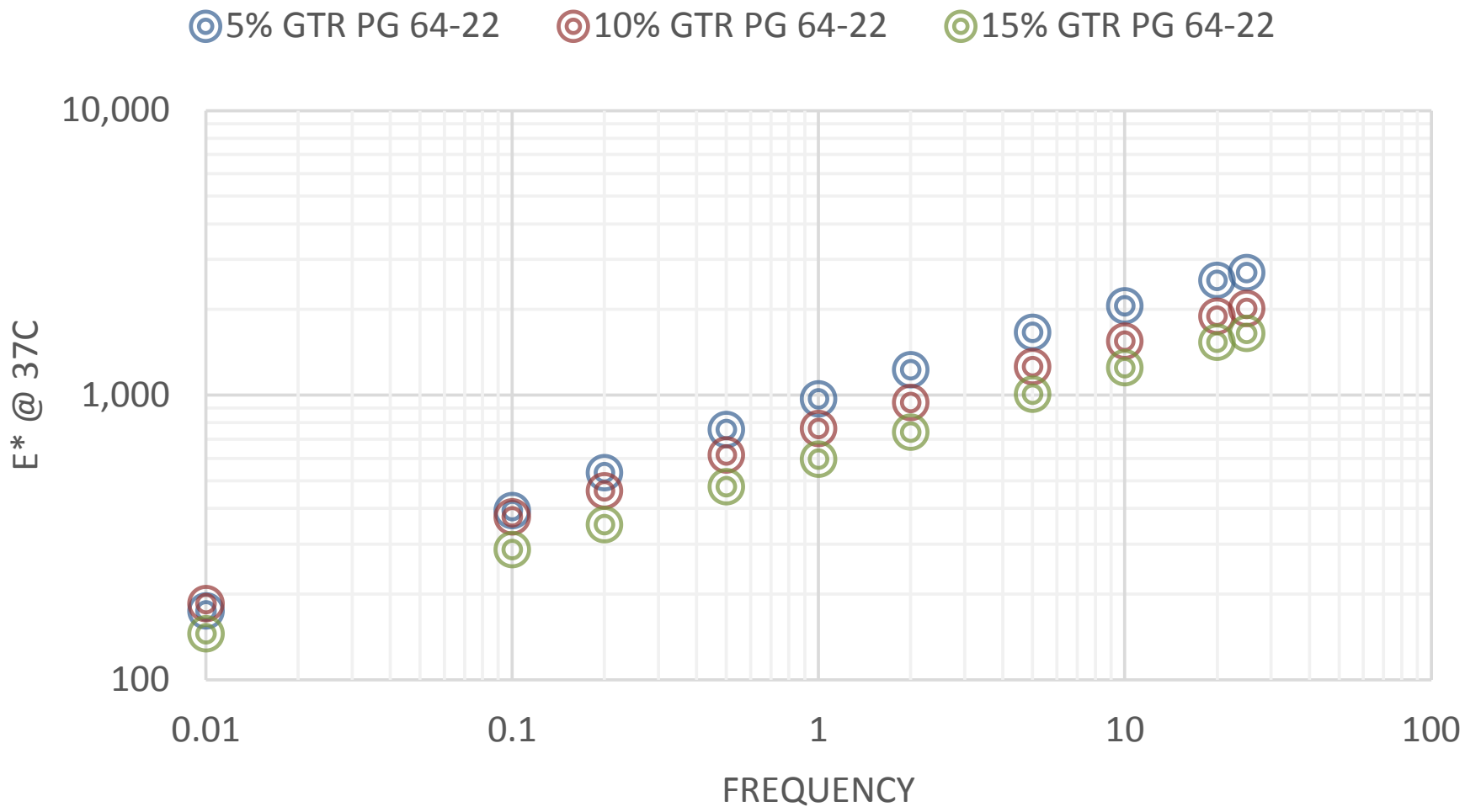
E* 20C for RTR Mix study



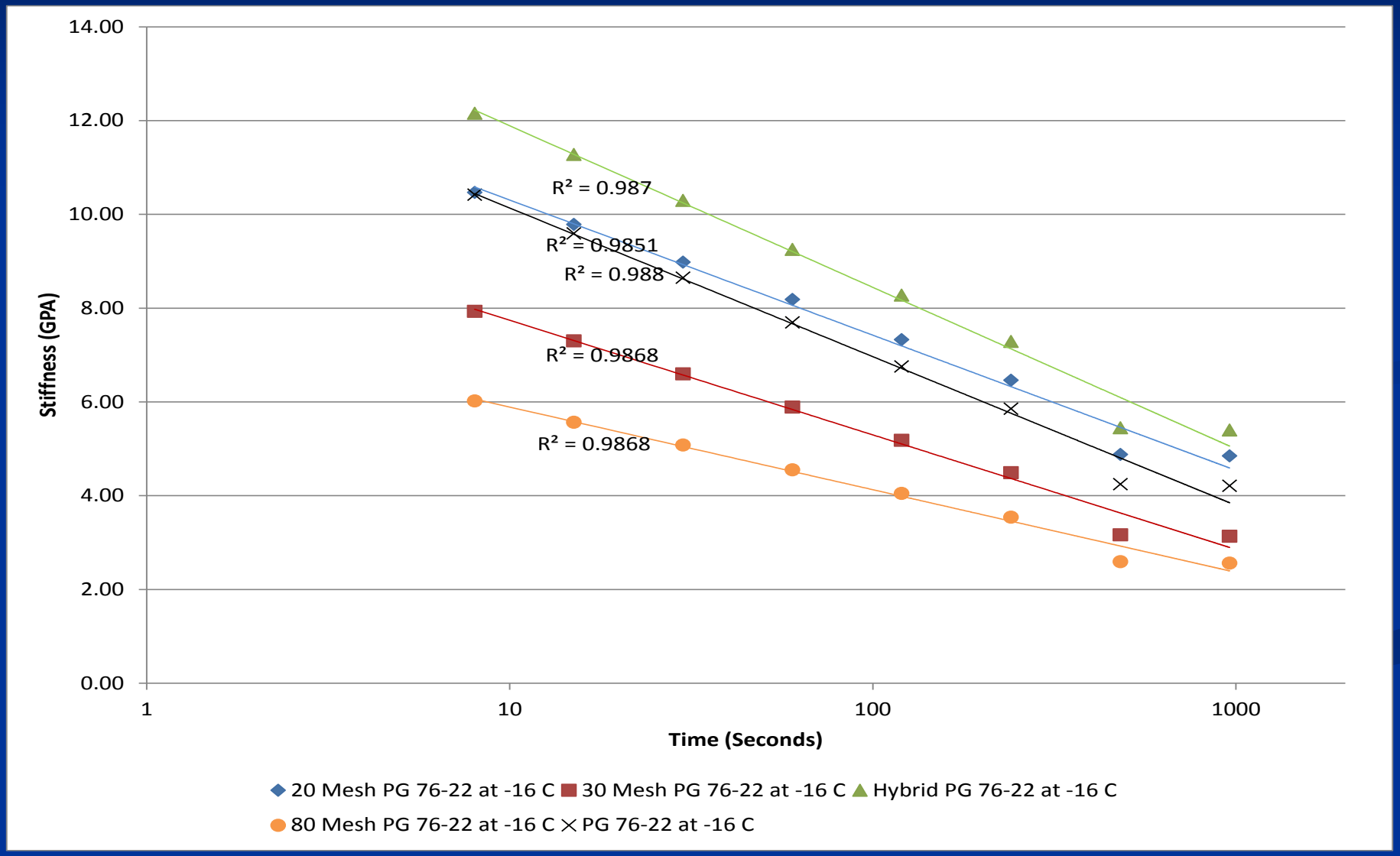
E* 20 C Mix comparing varying % RTR



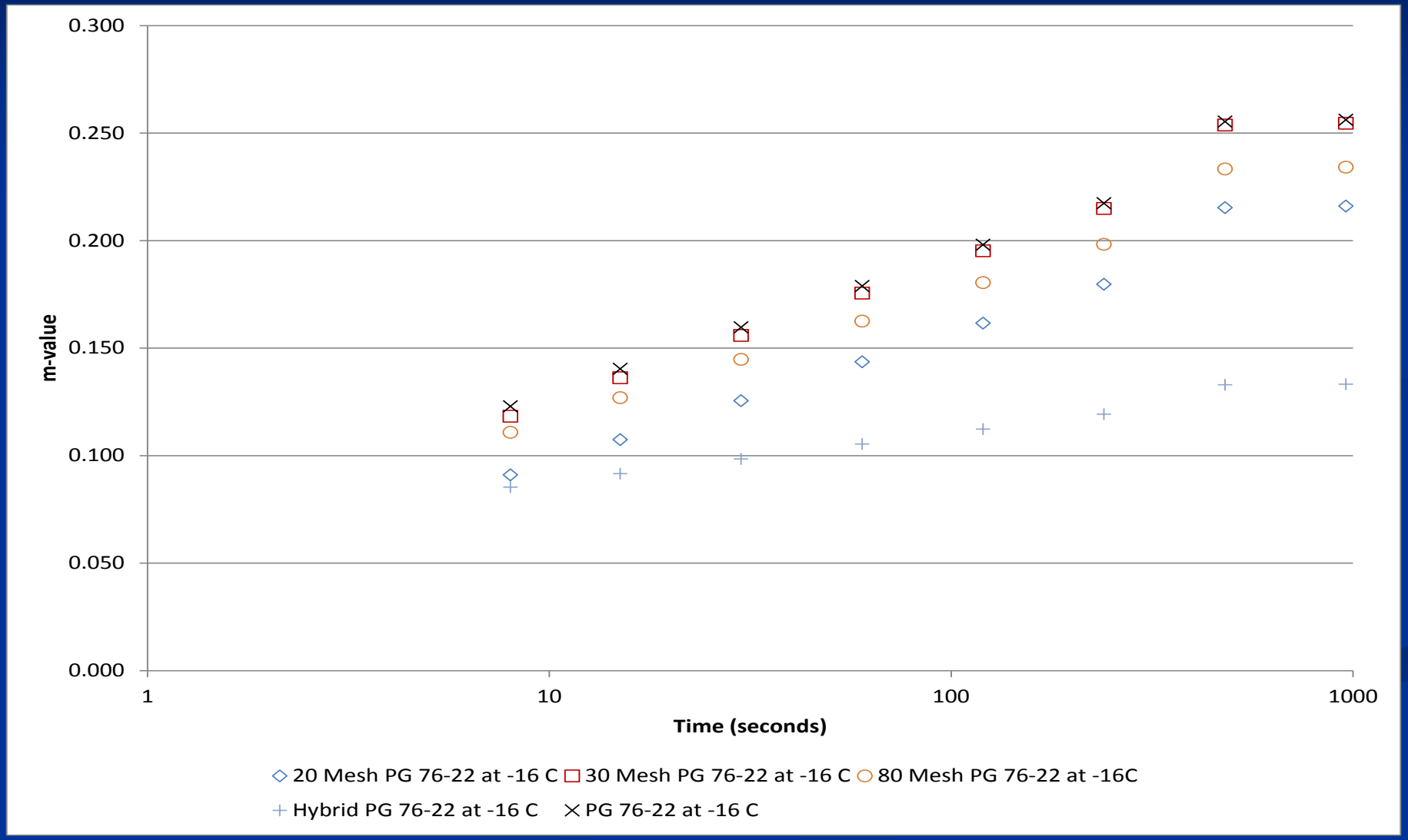
E* 37 C Mix comparing varying % RTR



BBR Mix Slivers Stiffness



BBR Mix Slivers m value



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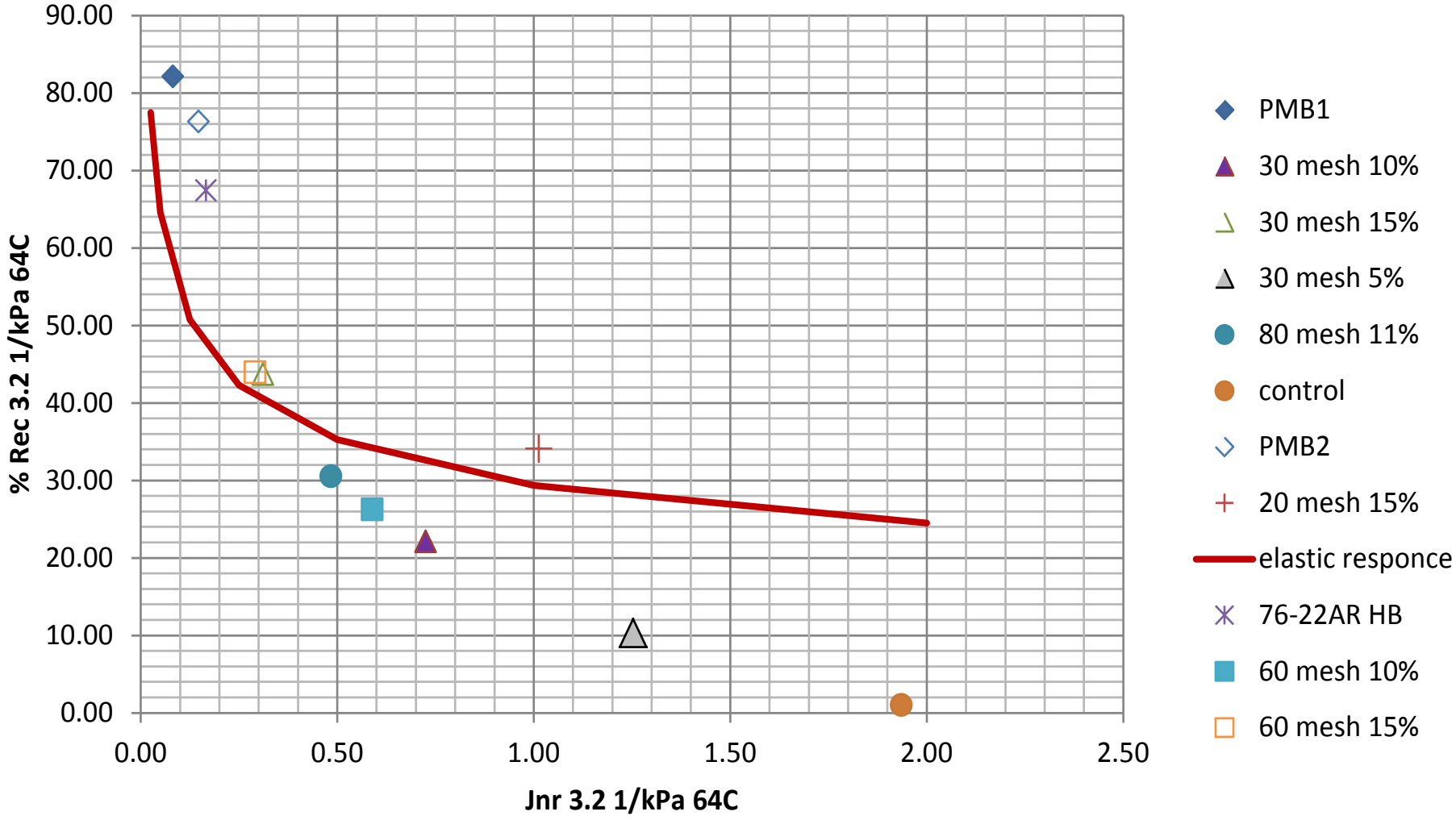

Thank You