Evaluation of Testing & Variability of Various Testing Geometries with Recycled Tire Rubber Modified Binder Specifications

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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.

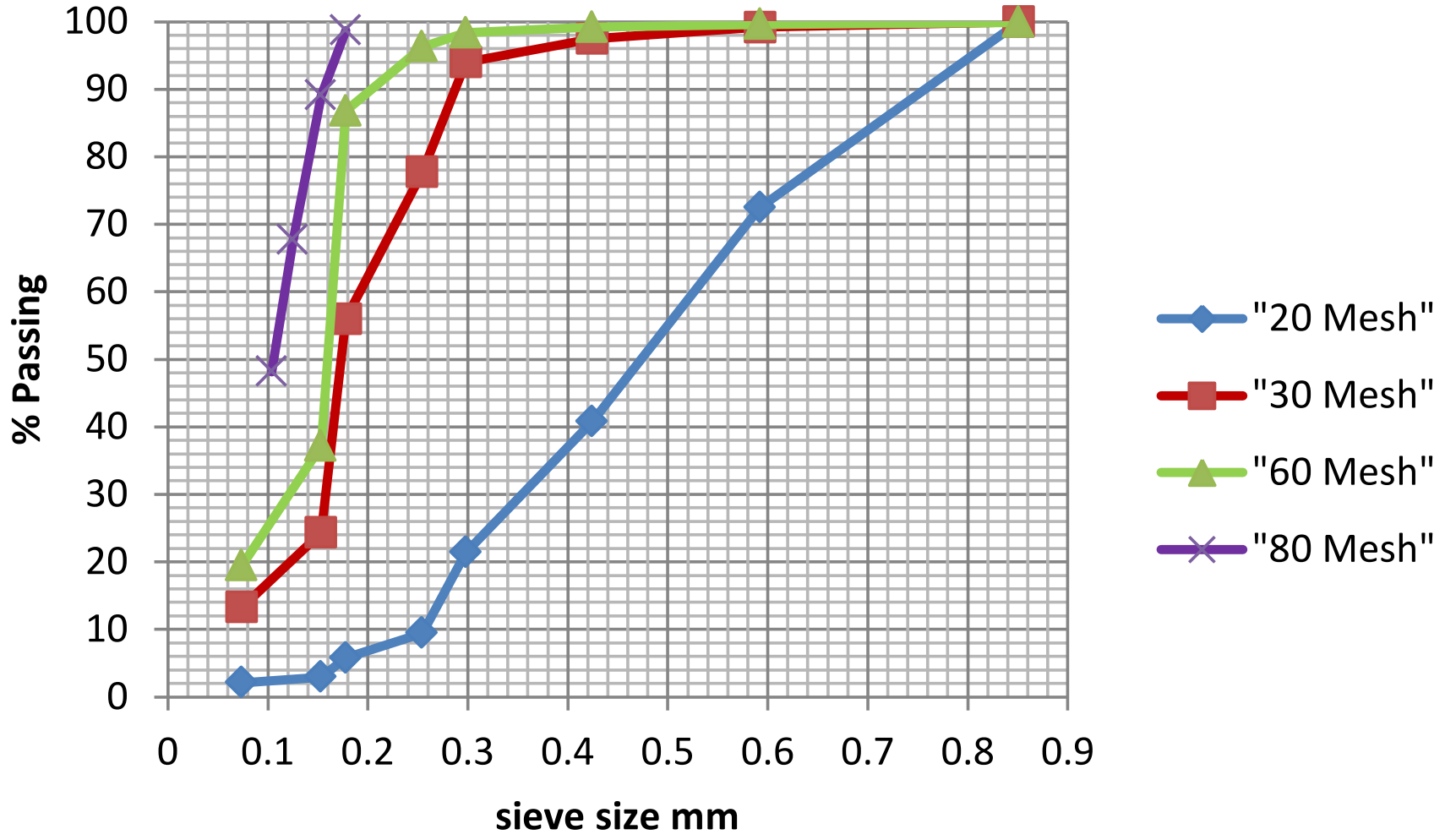
Variability of RTR Modified Binder

- Do RTR modified binder provide similar variability of testing results as conventional binder?
- Does the new Cup and Bob geometry provide similar variability of test results as the parallel plate geometry.

Experimental Design

- Full M 320 and M 332 classification of binders
  - Compare M 320 to M 332 properties
- One base asphalt with 3 RTR sizes and 4 RTR concentrations.
  - PG 64-22; 60, 30 and 20 mesh RTR
  - 5, 10, 15, and 20% RTR concentrations
- Vary geometries for RTR modified binders
  - Parallel Plate and Cup and Bob
  - Run Triplicate specimens for each sample

RTR Sizes Used in Study



Testing Geometries

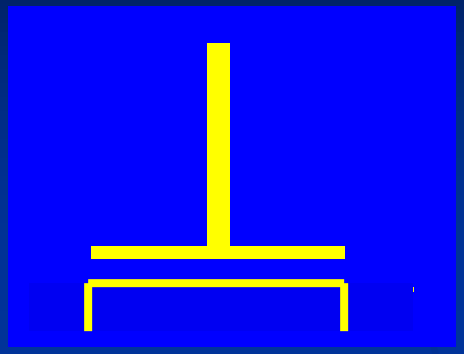
Typical Parallel Plate

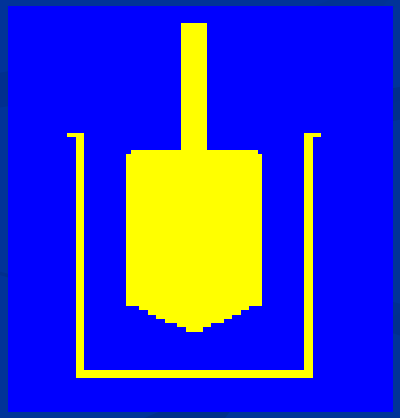
Cup & Bob Geometry

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

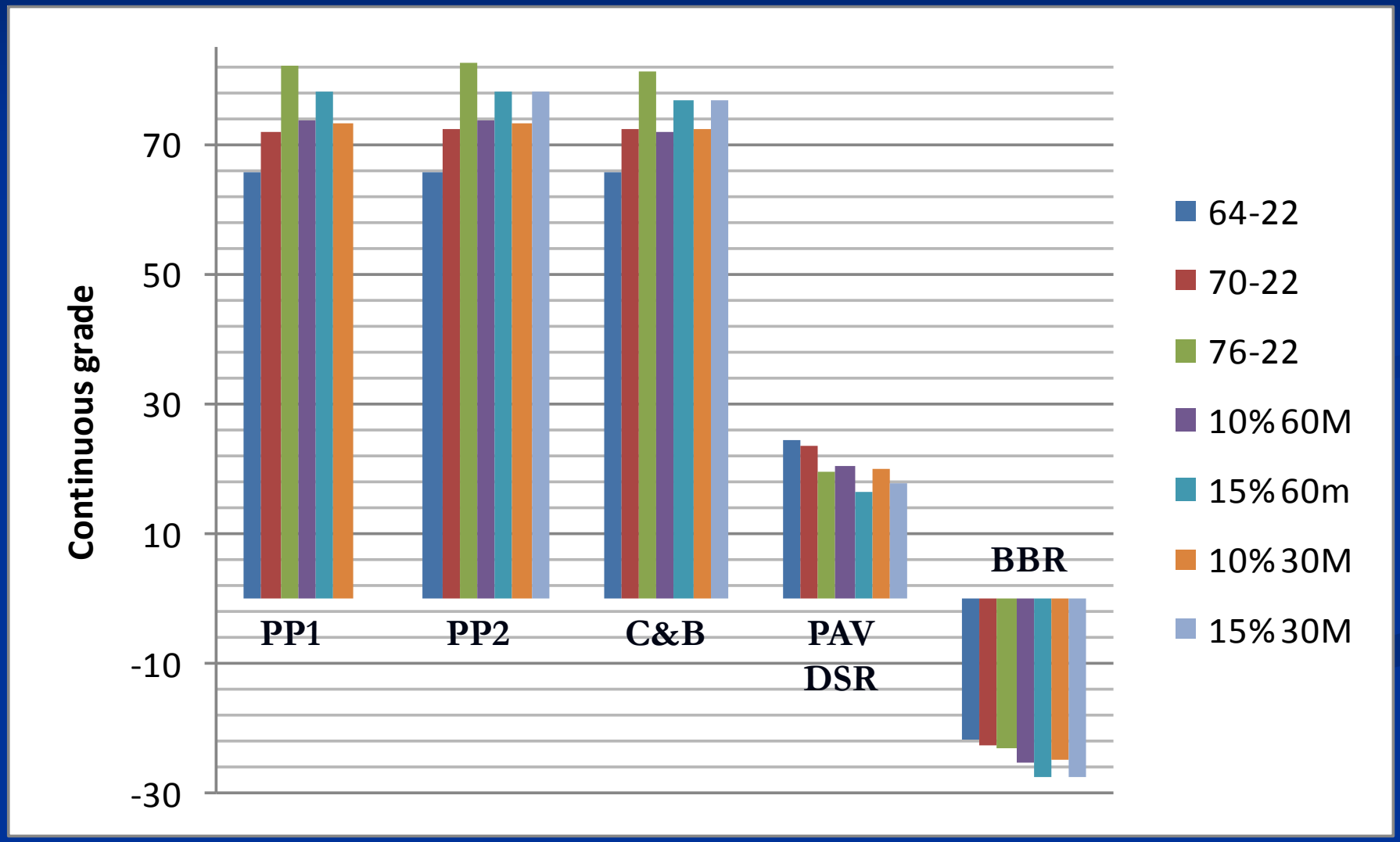
Geometries Used

- Parallel Plate
  - Plate Diameter: 12.5 mm
  - Gap: 2 mm
- Searle Set (Cup and Bob)
  - Cup Diameter: 27 mm
  - Bob Diameter: 14 mm
  - Effective Gap: 6.5 mm

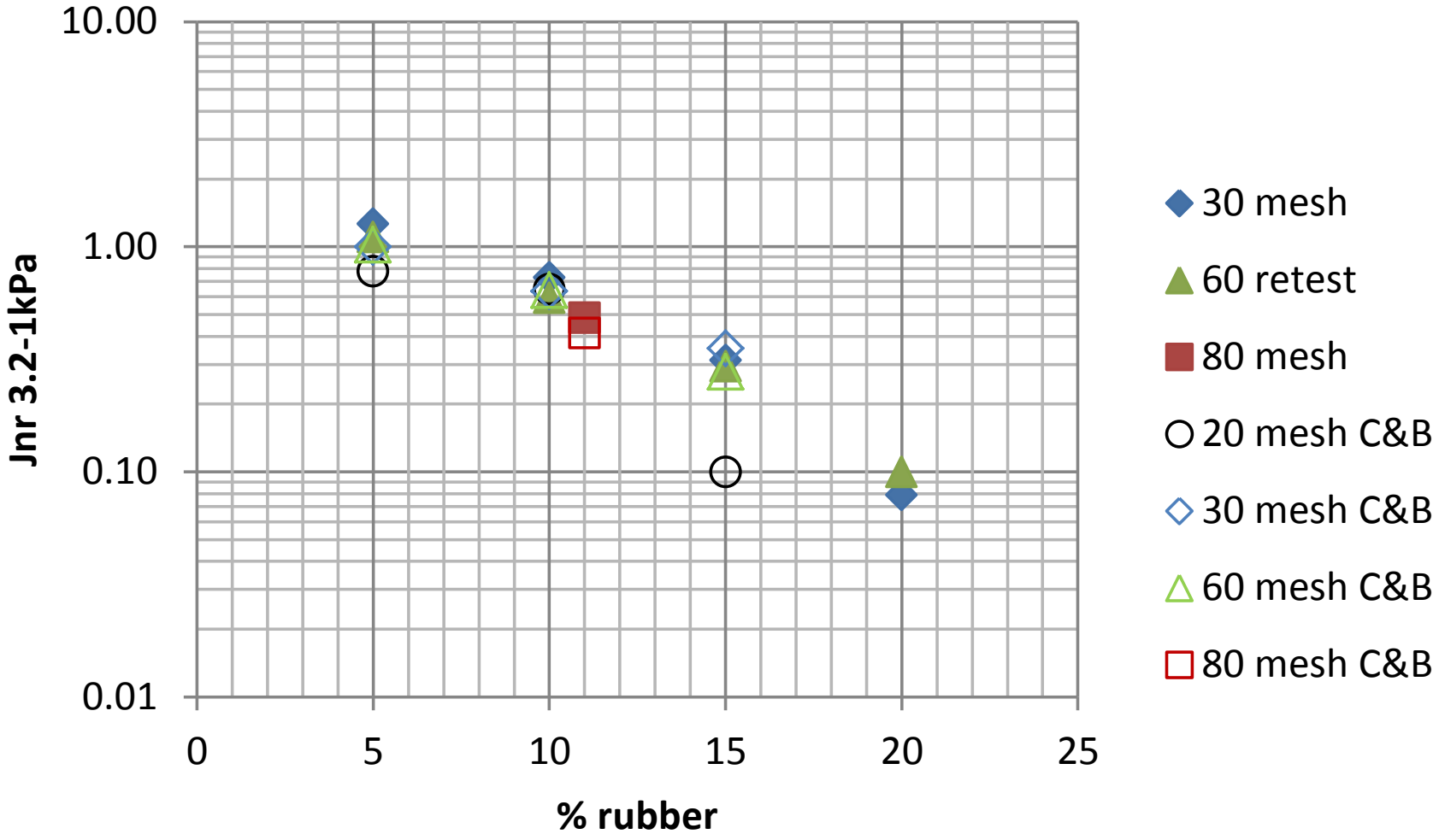




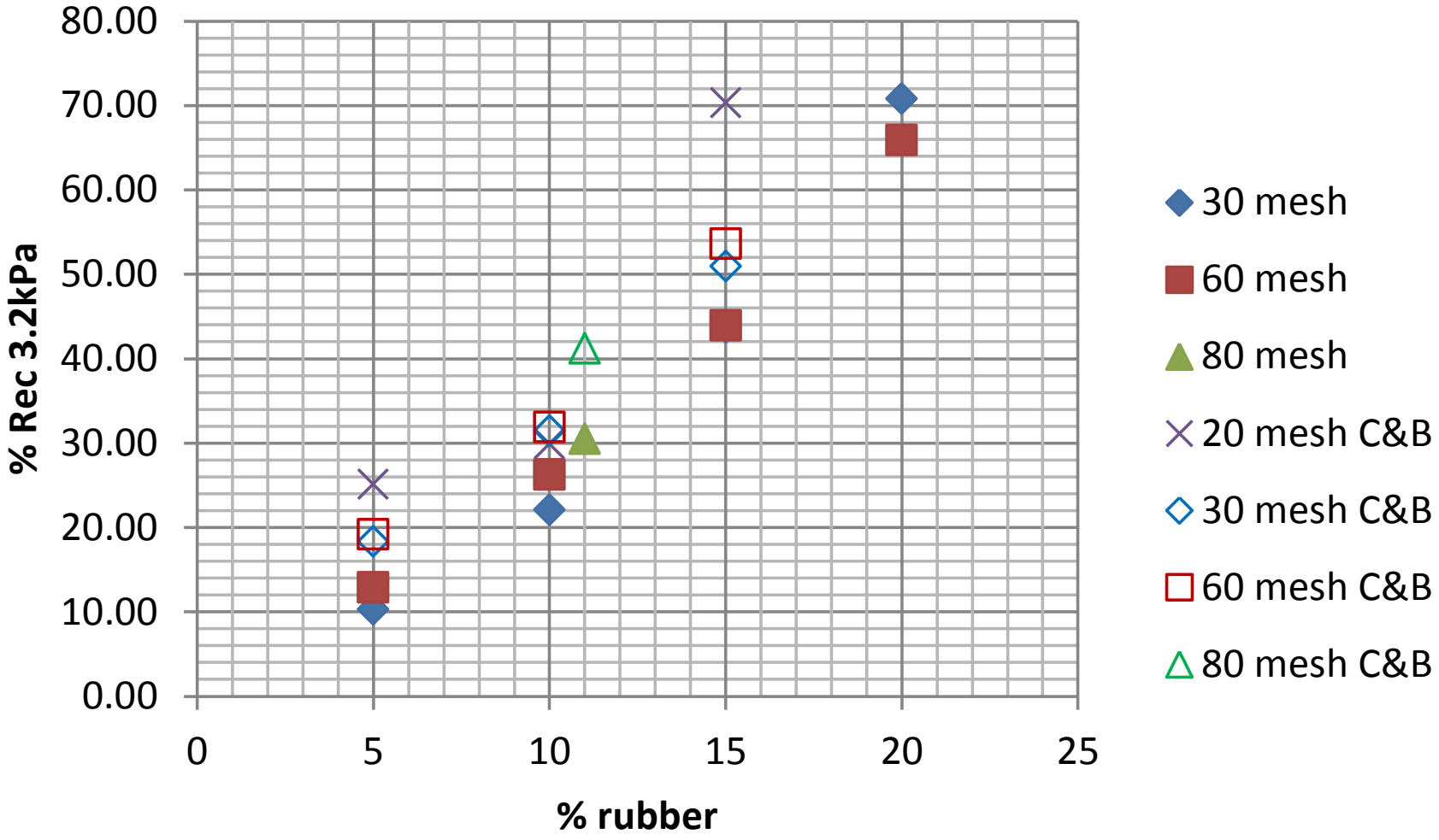
PG Continuous grading for blends using different Geometries



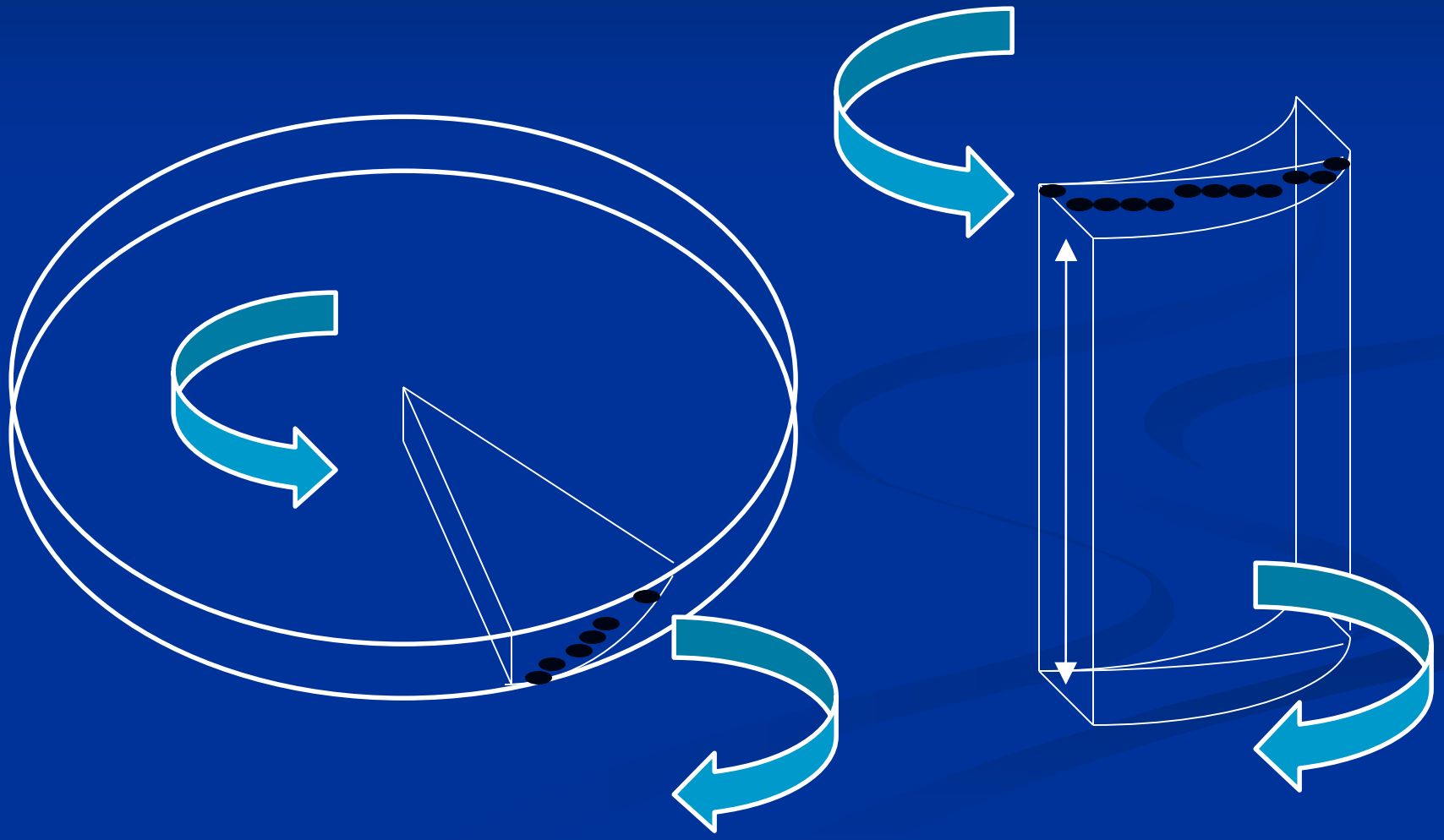
Jnr Changes with %RTR and Geometry @ 64C



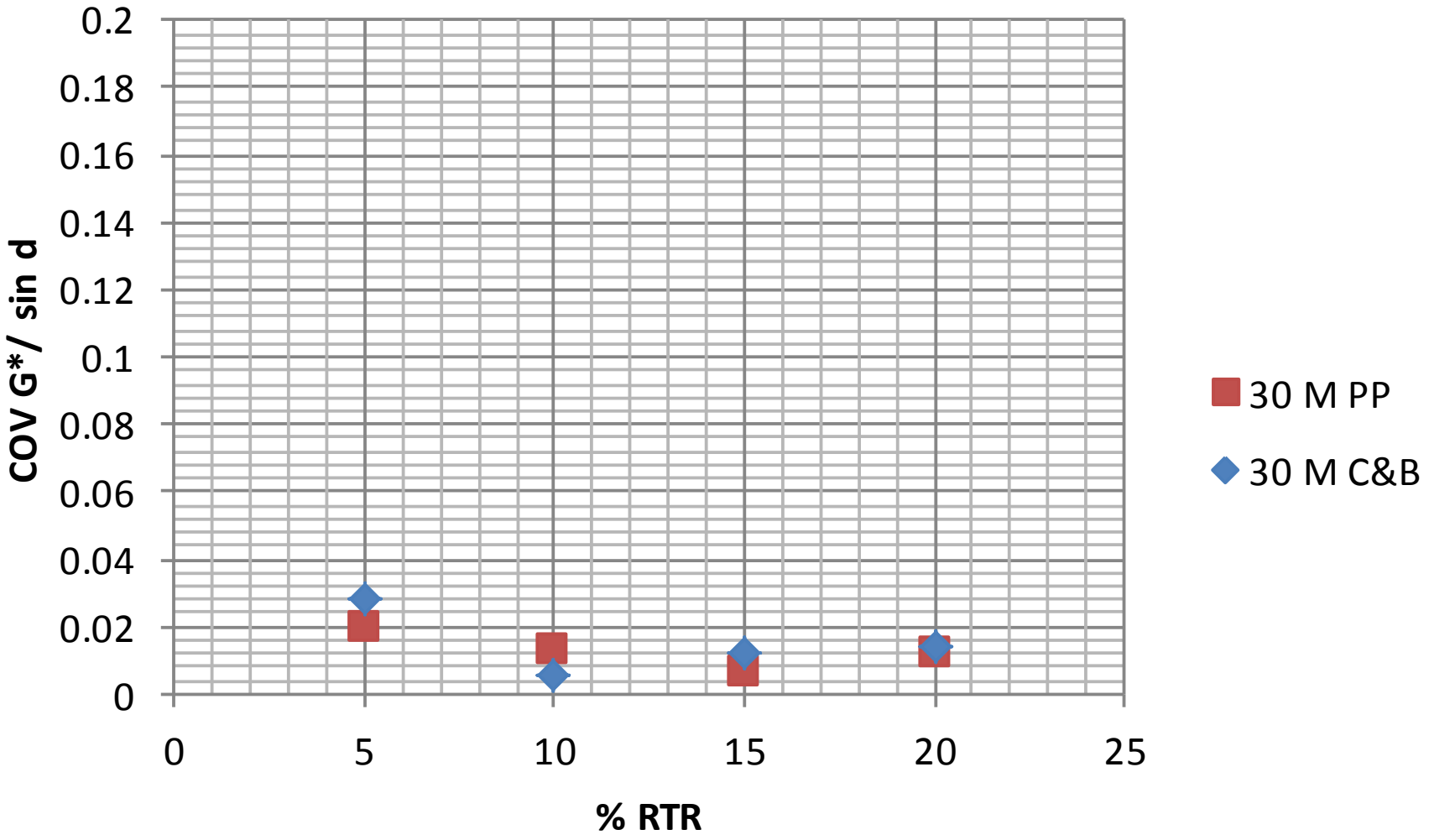
Change in % Recovery with %RTR and Geometry



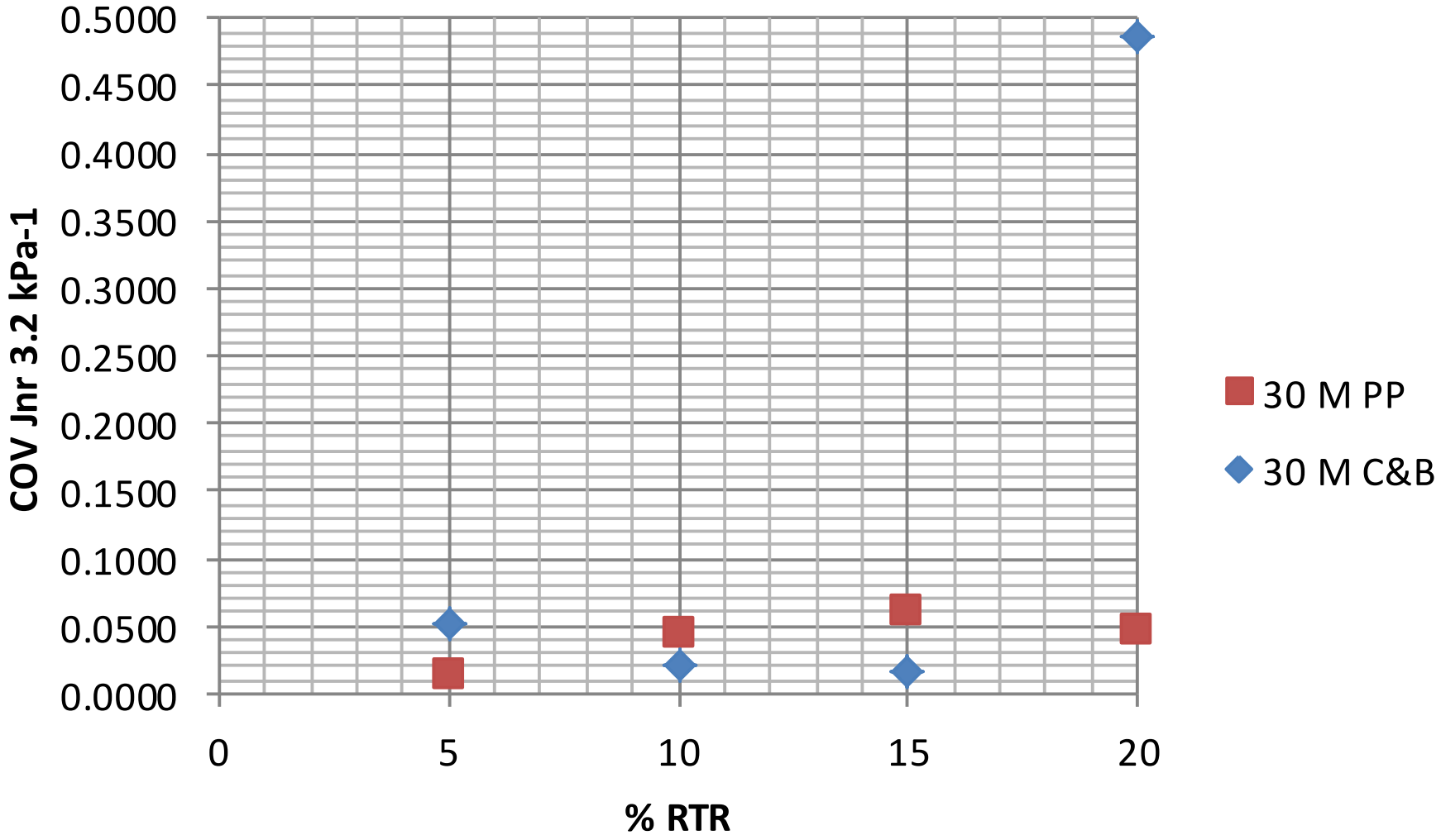
Cup and Bob has significantly more particle interaction than Plate-Plate Geometry



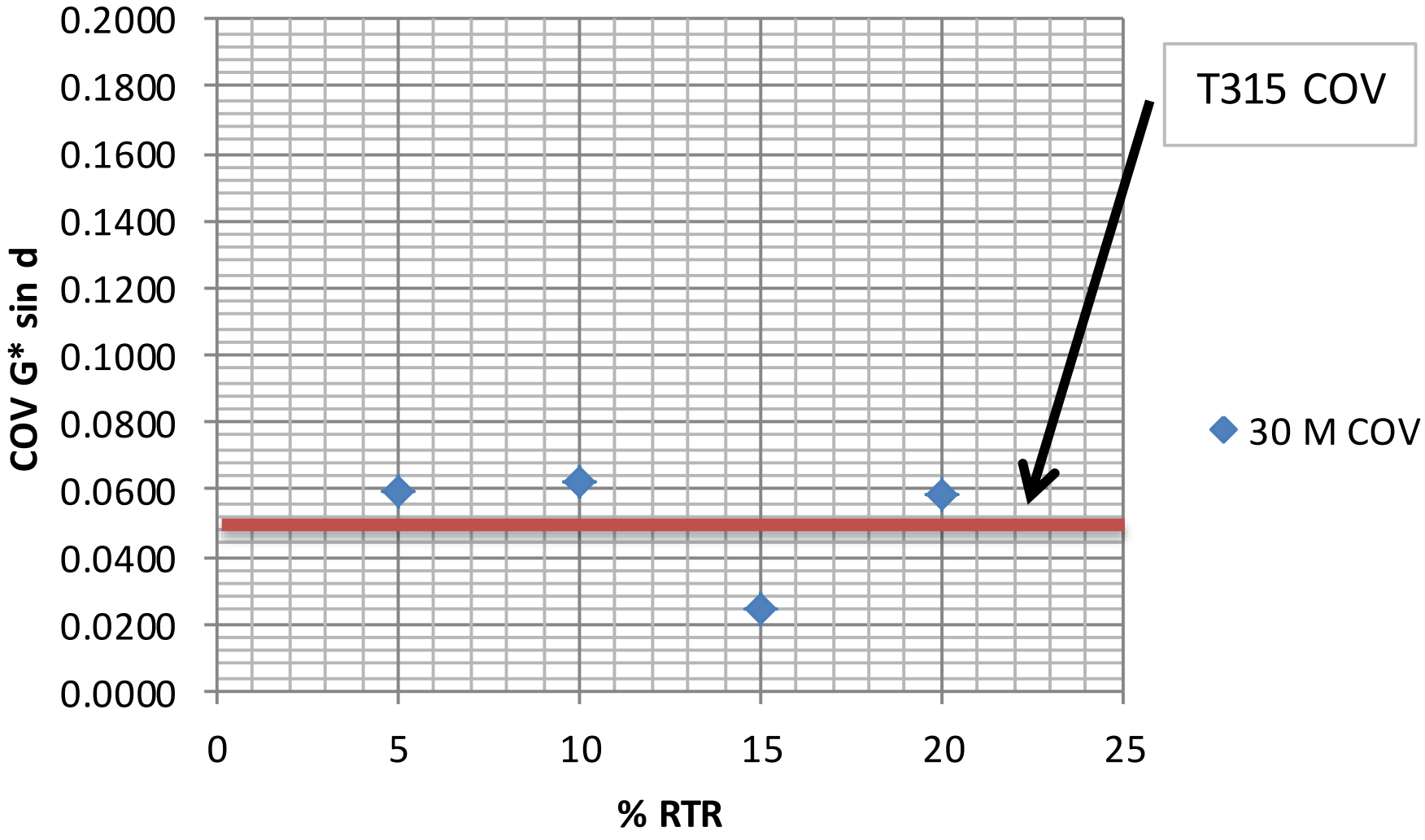
30 Mesh COV for RTFOT G*/sinδ Parallel Plate and C&B



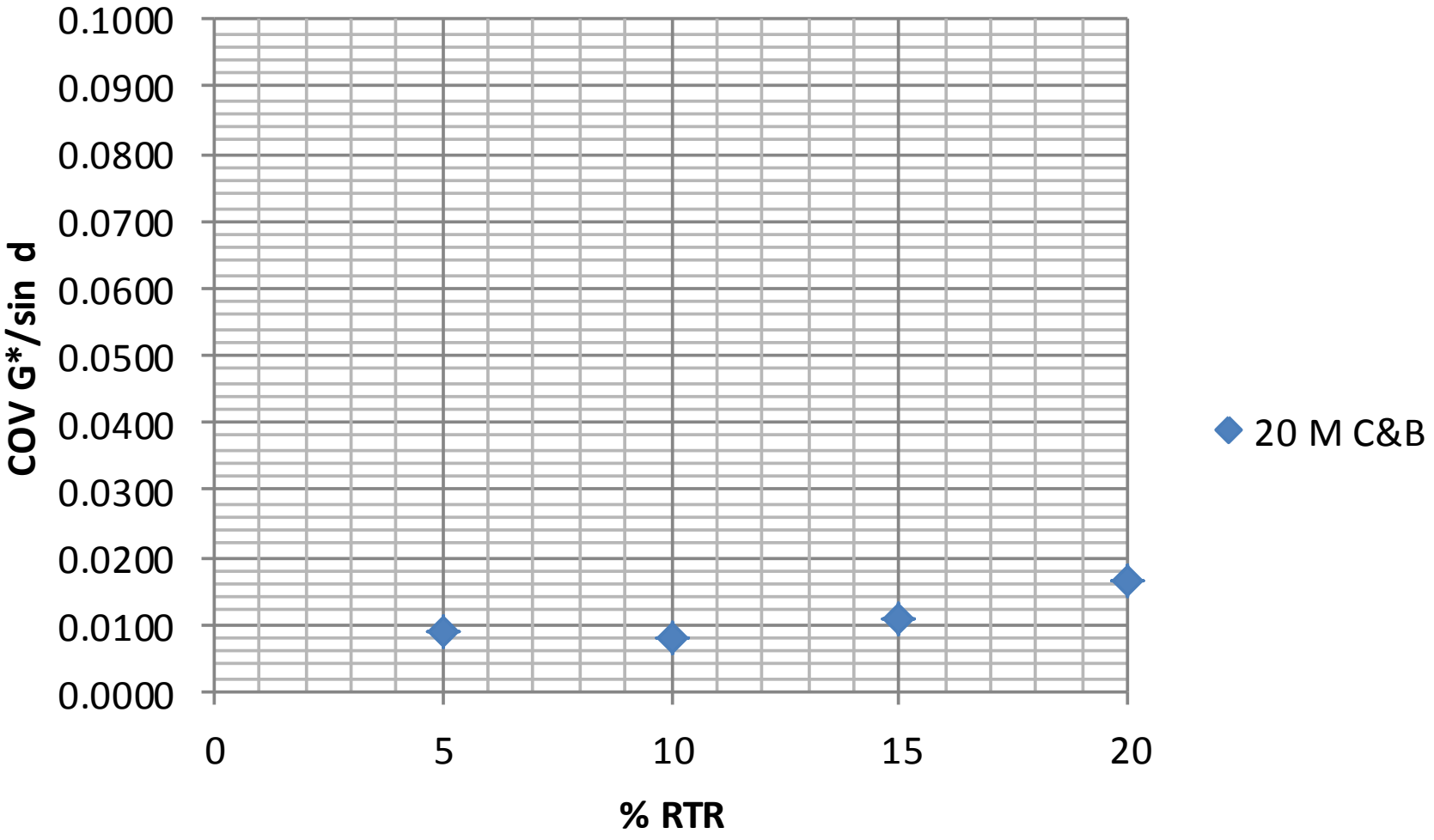
30 Mesh COV MSCR Jnr Parallel Plate and C&B



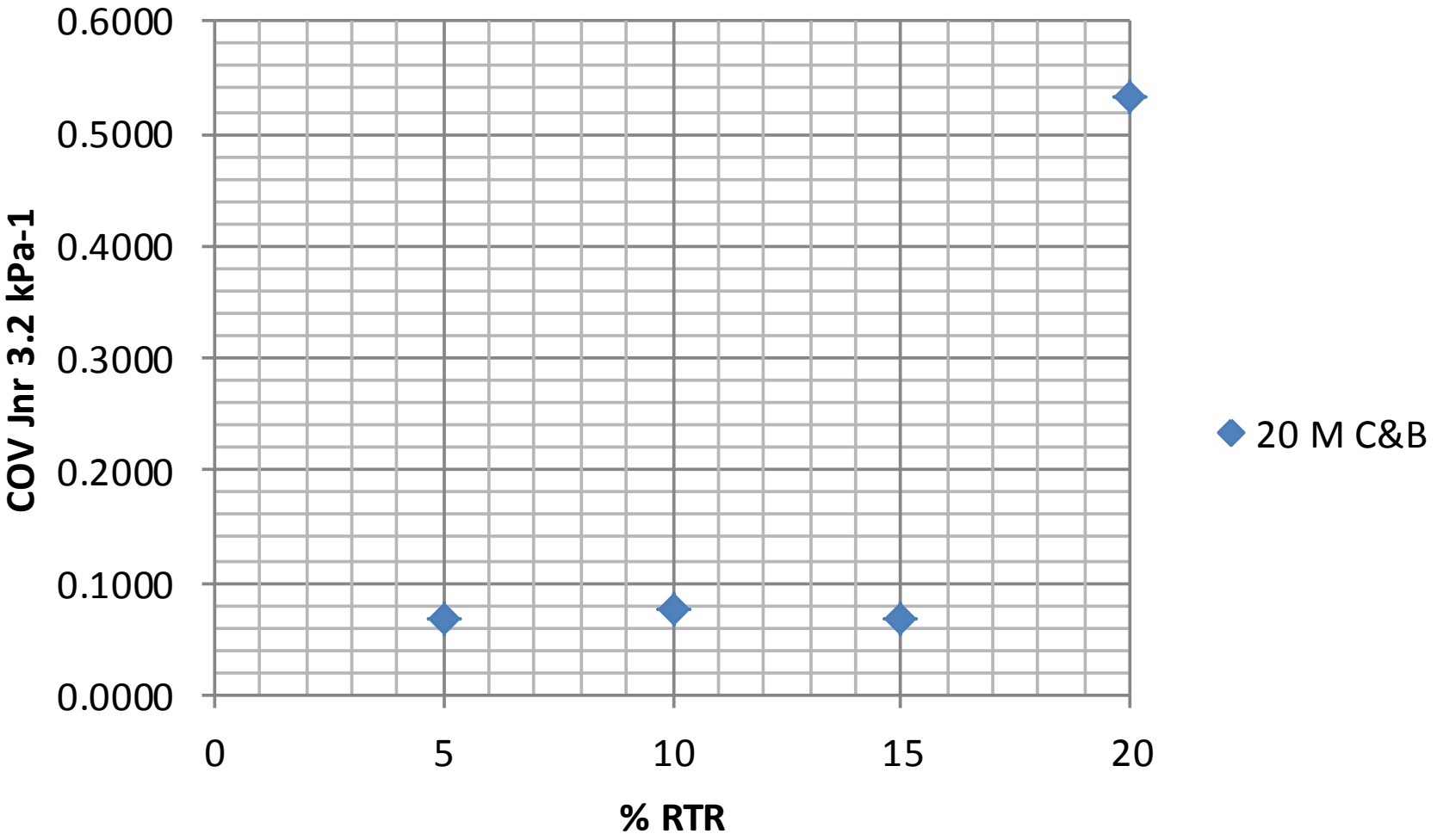
30 Mesh COV POV G* sinδ 4mm gap



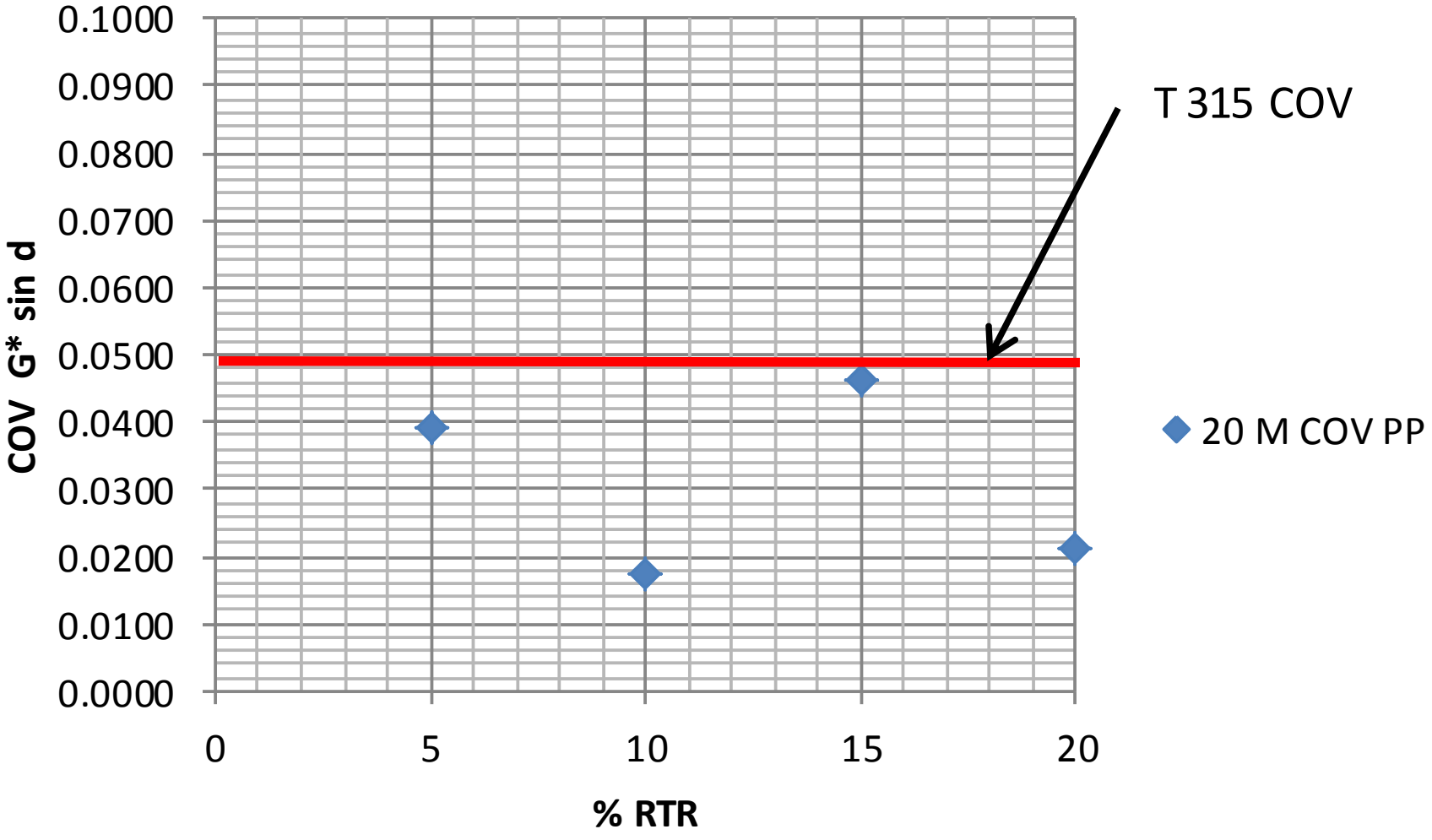
20 Mesh COV for RTFOT G*/sinδ C&B



20 Mesh COV MSCR Jnr C&B



20 Mesh COV POV G* sinδ 4mm gap



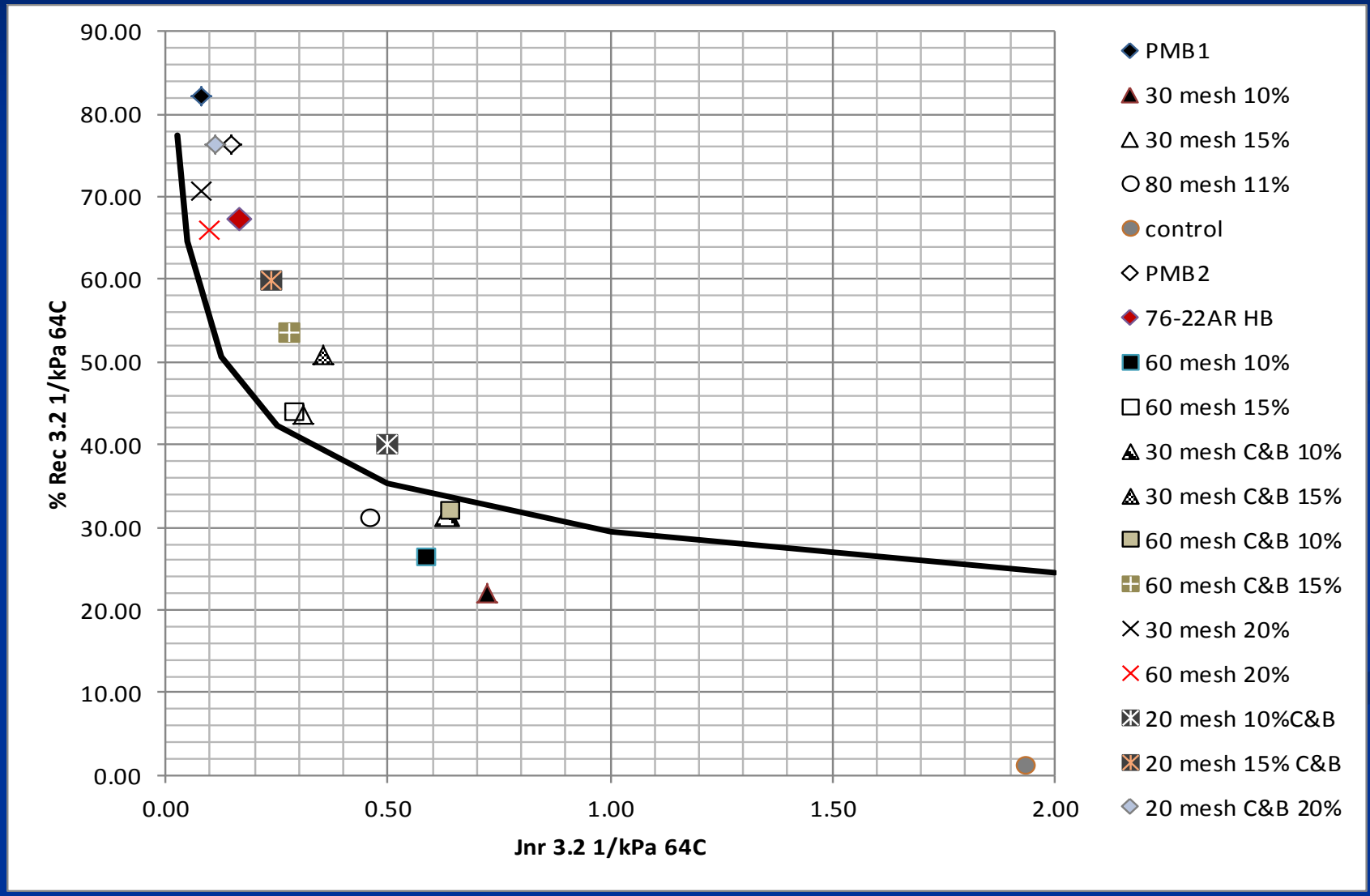
Summary of Variability Study

- For M 320 high temp test Parallel Plate and C&B RTR binders provide similar COV to AASHTO reported results.
- For M 320 intermediate temp test 4mm gap PP RTR binders provided similar COV to AASHTO reported results.

Summary of Variability Study

- For M 332 MSCR high temp test Parallel Plate and C&B RTR binders provide similar COV to AASHTO reported results.
- For M332 MSCR there was some concentration effects. At 20% concentrations the C&B shows very high variability compared to 5 to 15% concentrations.

Jnr vs % Recovery for PMB and rubber blends



Intermediate DSR testing of RTR Binders

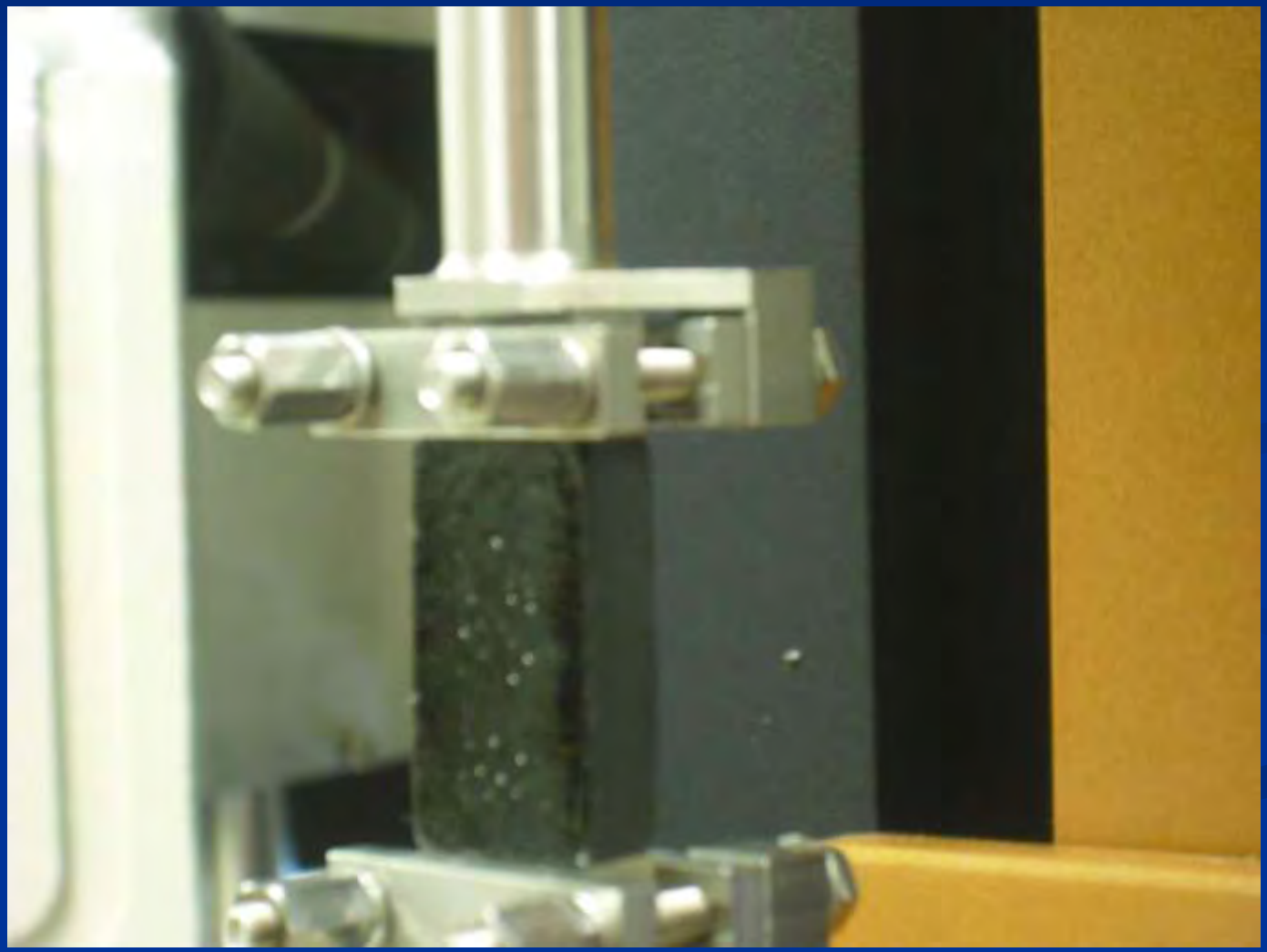
- Previous studies indicated that the cup & bob geometry had compliance issues with intermediate DSR testing.
- Large gap sizes needed for larger mesh size rubber.
- Large gap sizes at high temps resulted in sagging of sample, but at intermediate temps it may work.

8 mm plates with 4 mm gap at intermediate temperatures

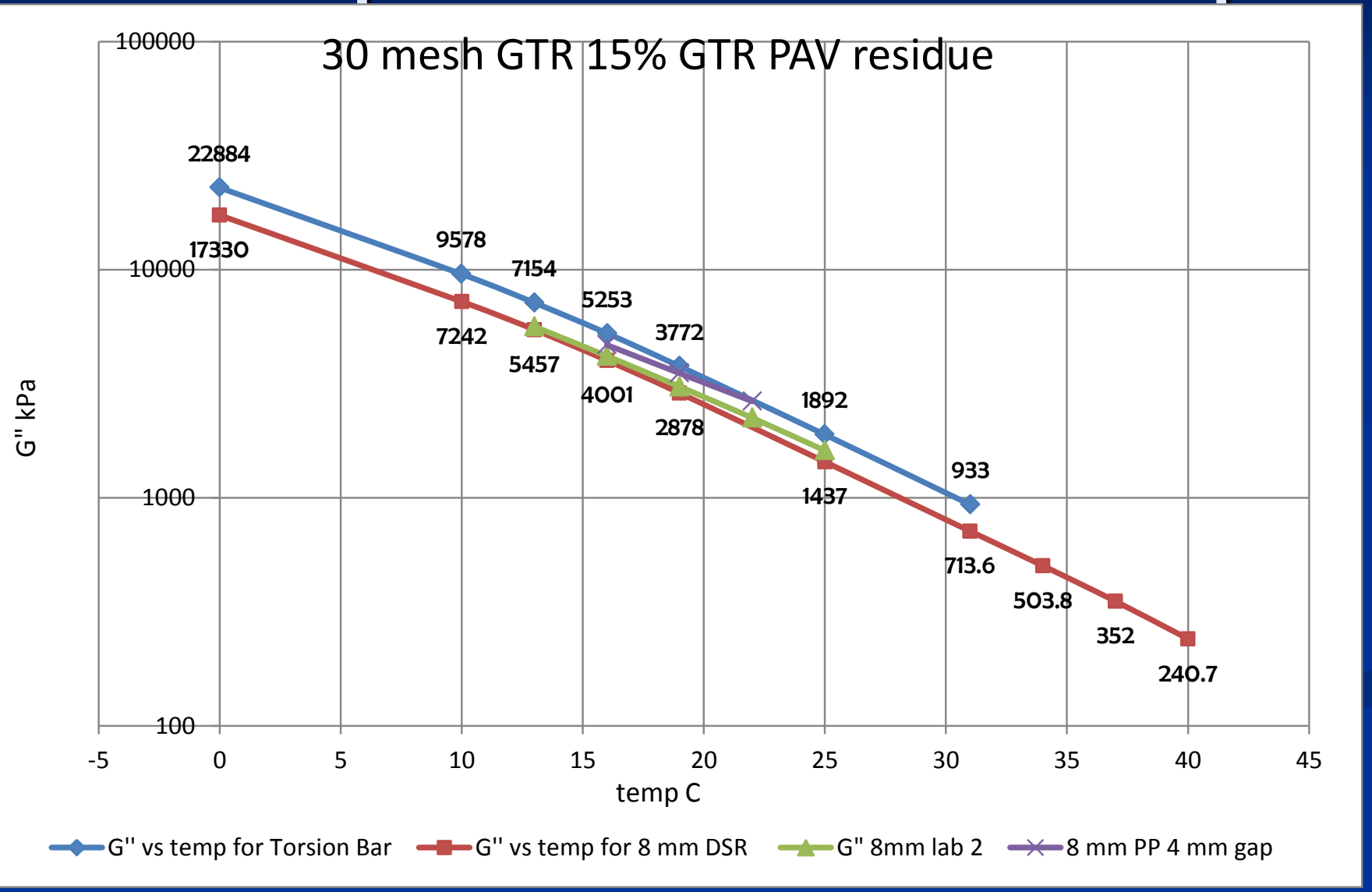
Intermediate DSR testing

- If particle size is an issue with test results how to develop control to validate gap size results.
  - Torsion bar testing at low and intermediate testing has been used historically.
  - Torsion bar geometry reduces or eliminates particle interaction issues. This can be used as a control to compare to parallel plate testing.

Picture of Asphalt torsion bar loaded in DSR



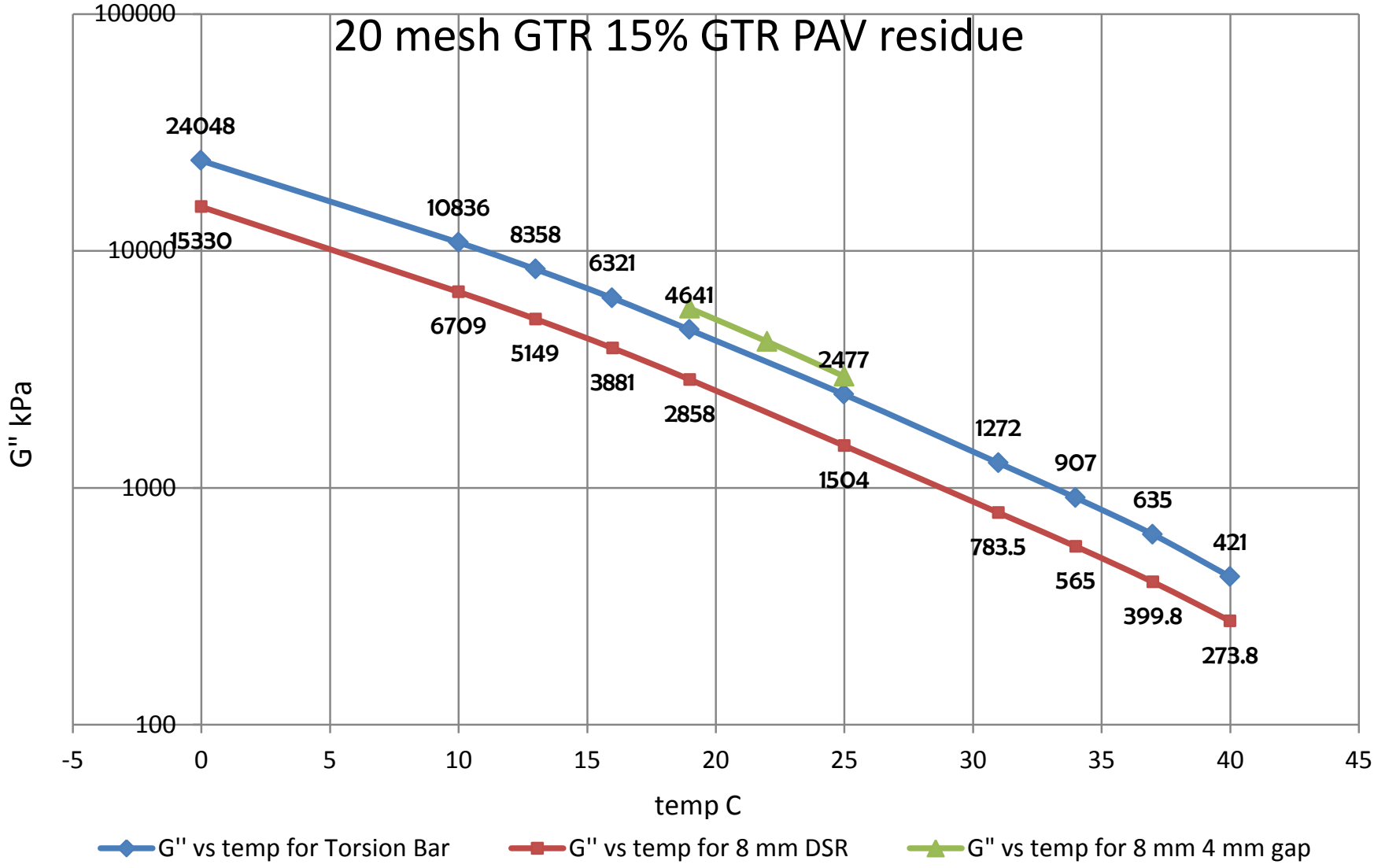
Torsion bar results compared to Parallel plate 2mm & 4mm Gap



Torsion bar results compared to Parallel plate 2mm Gap

- Torsion bar test provides higher modulus results than the 2 mm gap parallel plate even for 30 mesh rubber at 15% concentration.
- At higher rubber concentration a larger gap may be needed for accurate results.

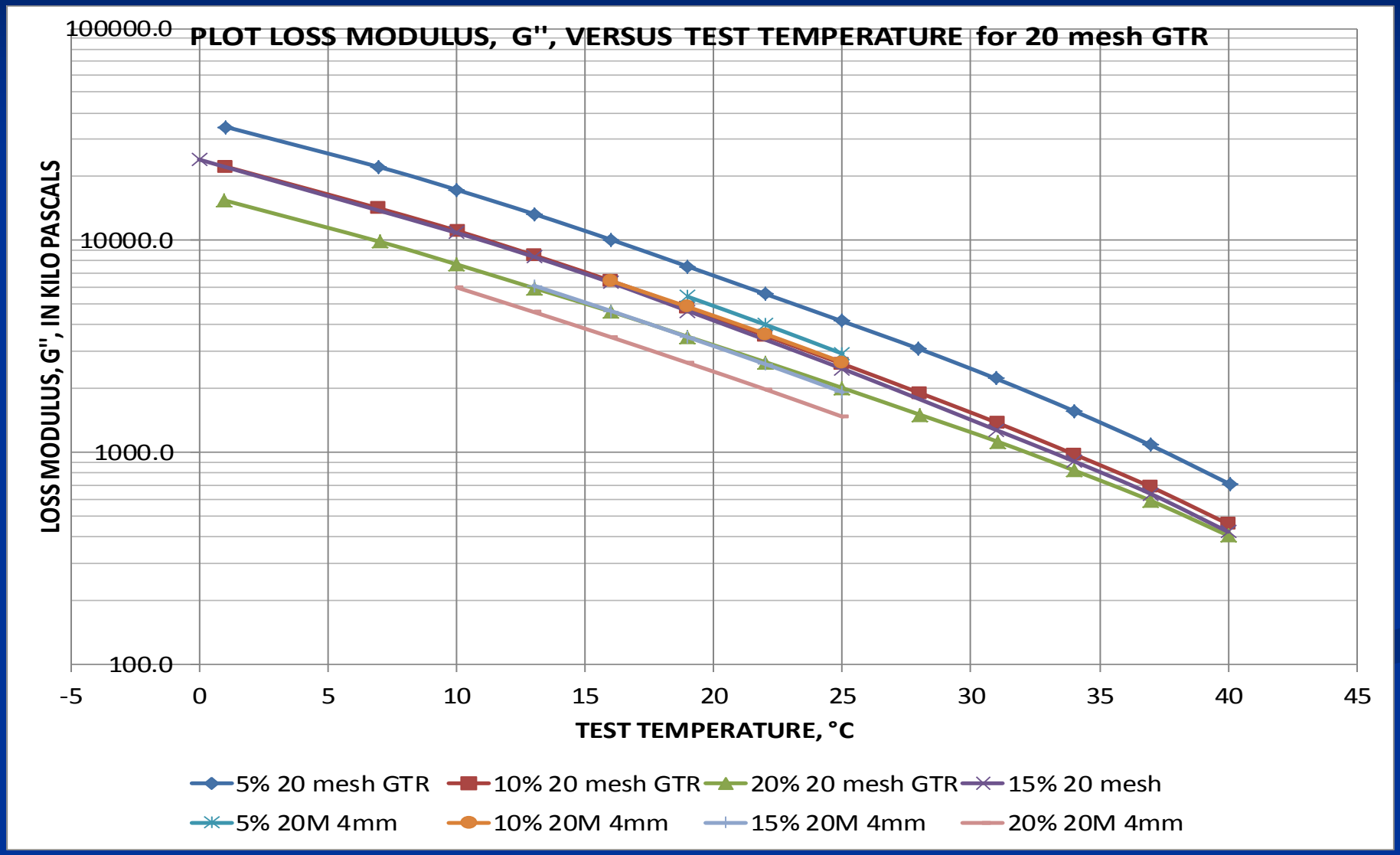
Comparison of Intermediate DSR for Torsion Bar and 2 and 4 mm gap



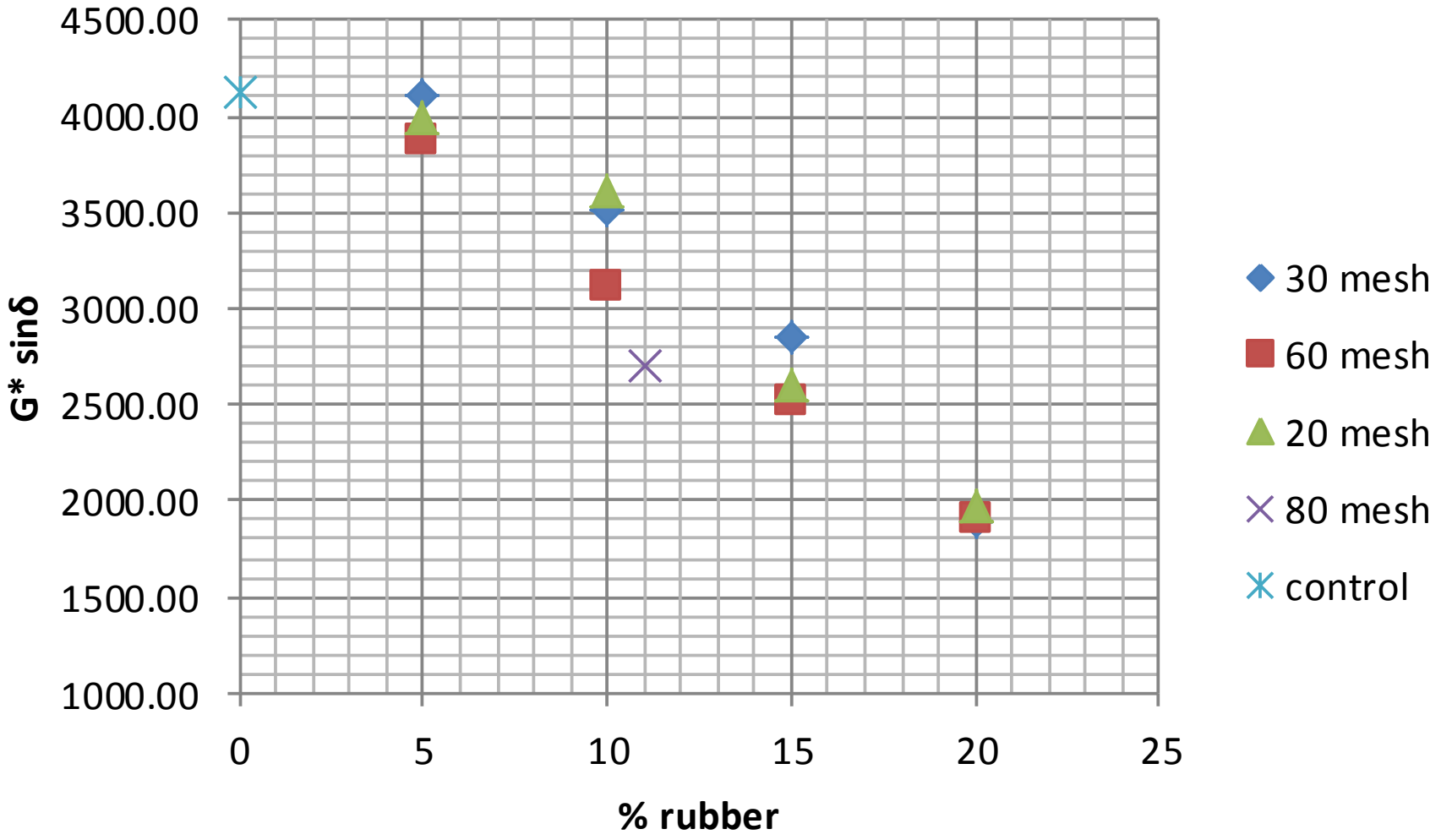
Torsion bar results compared to Parallel plate 2 and 4 mm Gap

- Torsion bar test provides higher modulus results than the 2 mm gap parallel plate even for 20 mesh rubber at 15% concentration.
- 4 mm gap Parallel plate provides equivalent results to the Torsion bar for 20 mesh RTR.

Comparison of Intermediate DSR for Torsion Bar and 4 mm gap

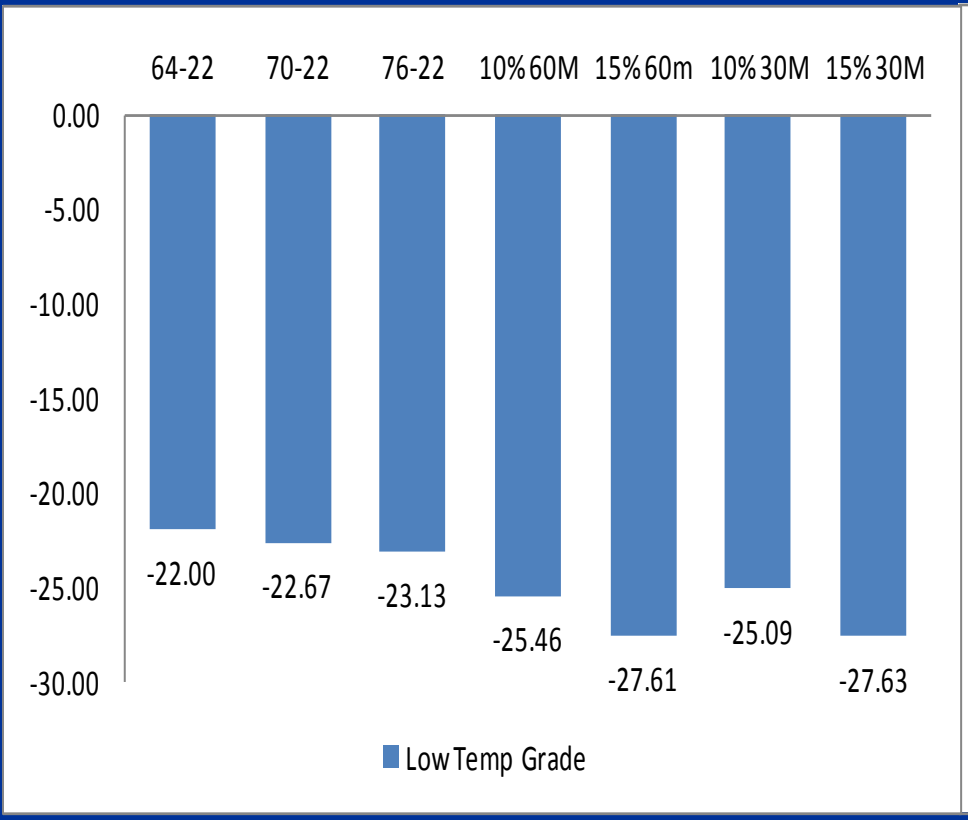


Change in Intermediate DSR with size and % RTR @ 22°C

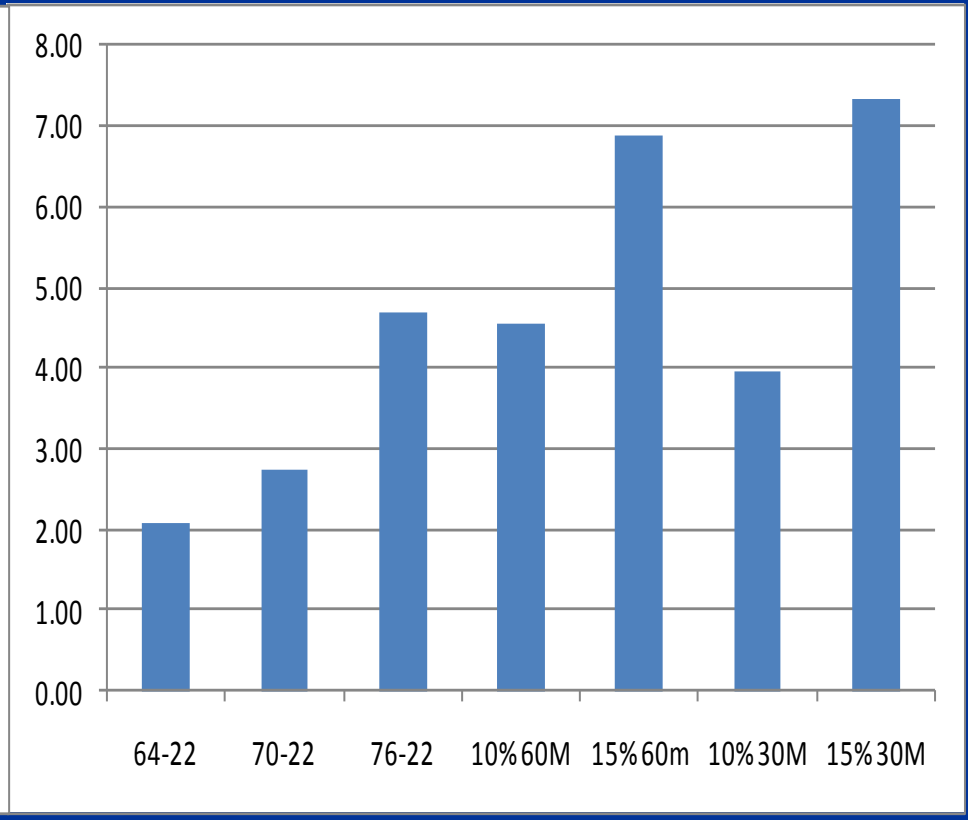


Effect of CRM on Low Temperature Grade

Low Temp Continuous Grade
All m controlled



Difference between S and M grade temp
All m controlled



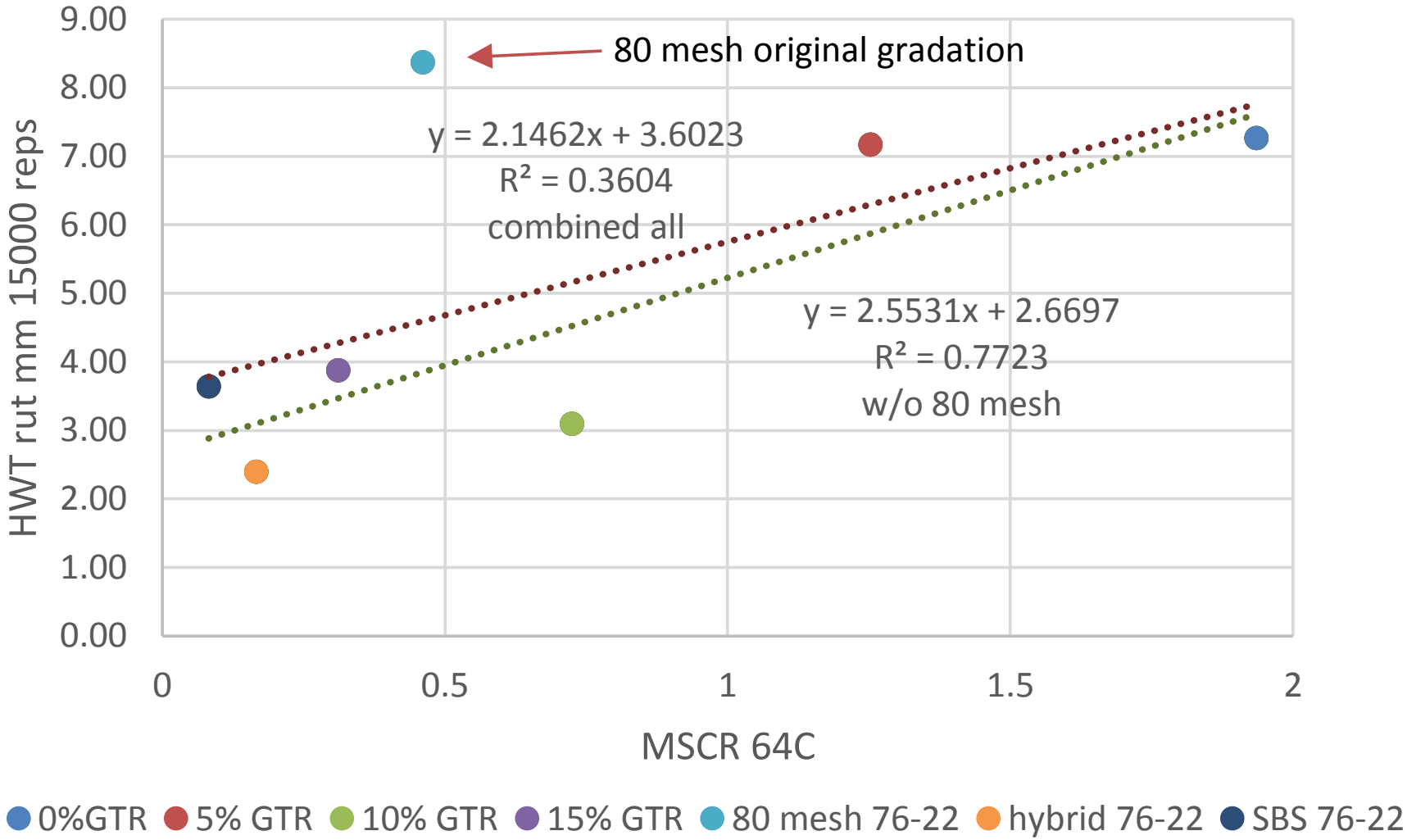
Summary Intermediate testing

- The torsion bar provides slightly higher values than the 2 mm gap for 8 mm plates.
- The 4 mm gap also provides slightly higher values than the 2 mm gap even for small RTR sizes.
- 4 mm gap provided very good COV over all sizes and concentration of RTR.

Summary

- The variability of RTR modified binders was very similar to AASHTO reported single lab COV for standard binders.
- The C&B provided similar results to parallel plate geometry.
- At concentrations over 15% RTR the MSCR C&B indicate higher variability.

HWT Test relation to MSCR



Thank You