

DEVELOPMENT OF RUBBER BINDER SPECIFICATIONS IN CALIFORNIA: PROJECT UPDATE

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Pacific Coast Conference on Asphalt Specifications (PCCAS)

26th April 2017.



Outline

- **California rubber binder**
- High temp. performance-related testing
- Short-term aging of AR asphalt binder
- Long-term aging of AR binders
- Int. temp. performance-related testing
- Low temp. performance-related testing
- **Work in progress**
- **Conclusions**



Asphalt Rubber Binder

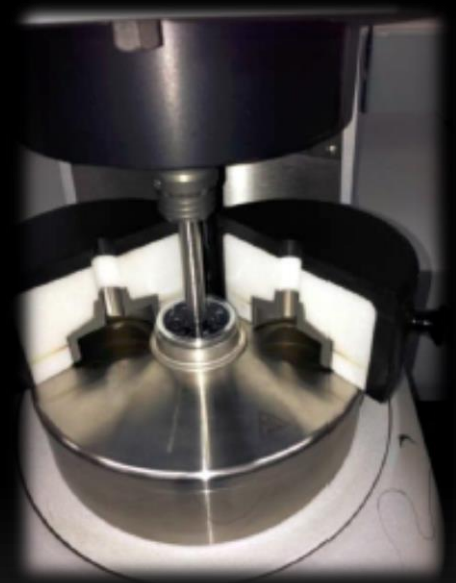
▪ Caltrans Definition:

- A combination of asphalt binder, crumb rubber modifier (CRM), and asphalt modifier (i.e., Ext. oil).
- Must have at least **18 to 22 percent CRM** by weight in total blend.
- CRM must contain **25.0±2.0 percent high natural crumb rubber**.
- **Only ambient grinding process** is allowed for producing CRM. Fiber and metals can be taken out cryogenically.
- **2% to 6% extender oil** must be used by weight of base binder.

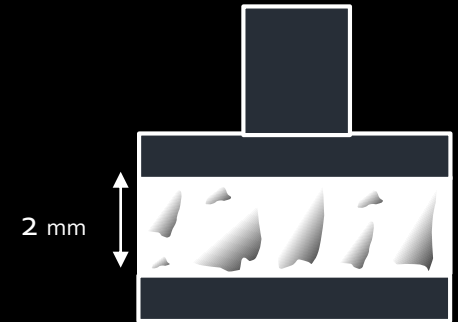
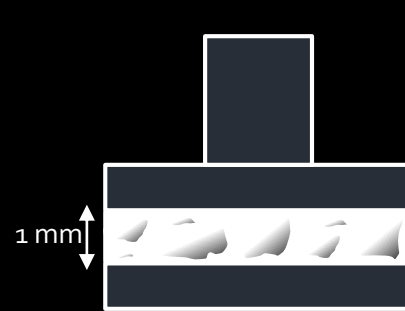
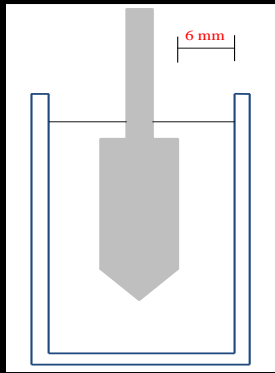
High Temperature Performance-Related Testing

AR Binder High Temp. Testing

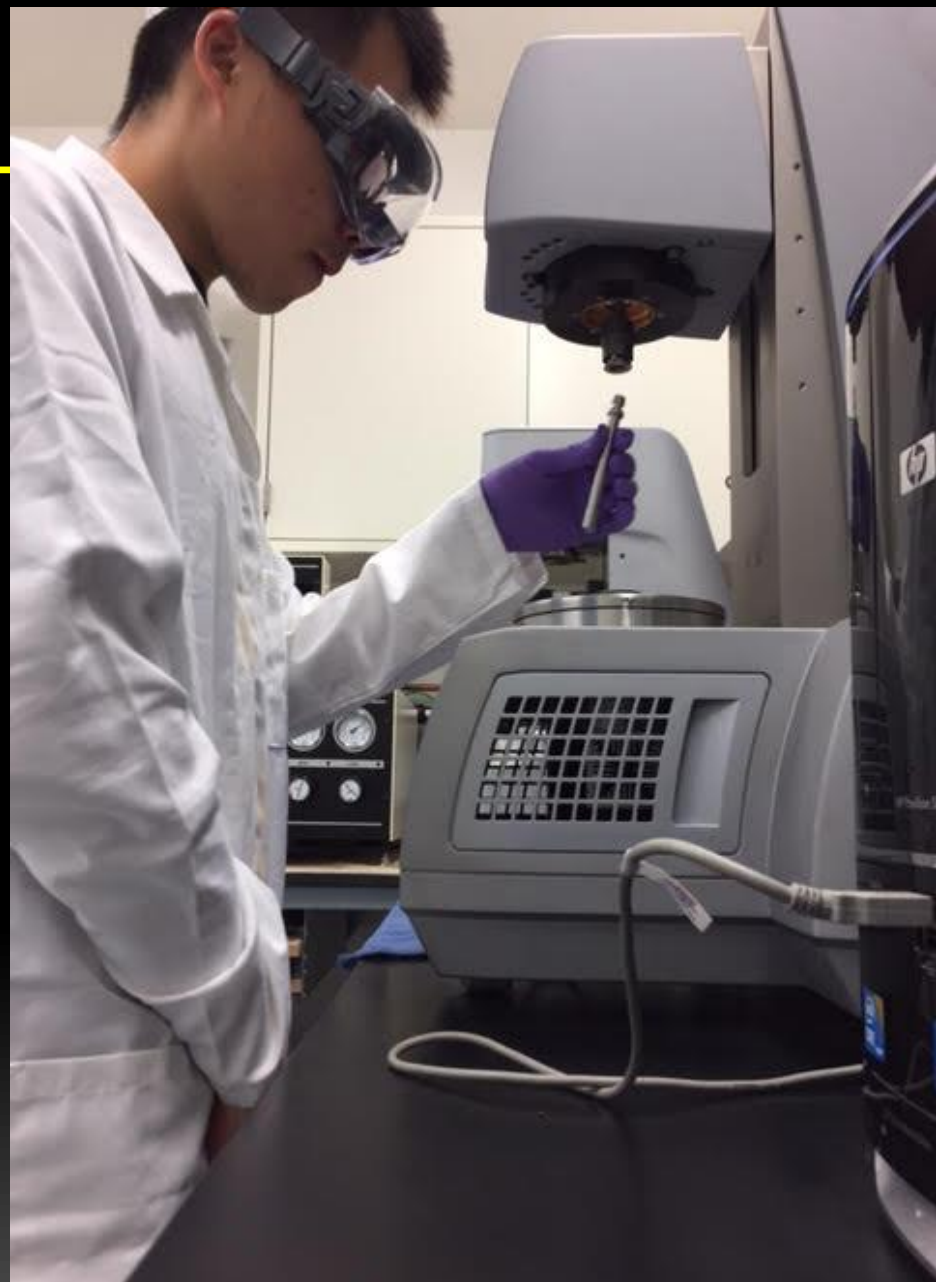
- Selecting appropriate testing geometry
 - Concentric cylinder with 6mm gap considered more appropriate than parallel plate
- Selecting test methods
 - AR binder viscosity (for workability)
 - PG grade conv. test
 - MSCR test
 - Frequency sweep test
- Tests must be performed on both original and short-term aged binders
 - Selecting realistic short-term aging test method



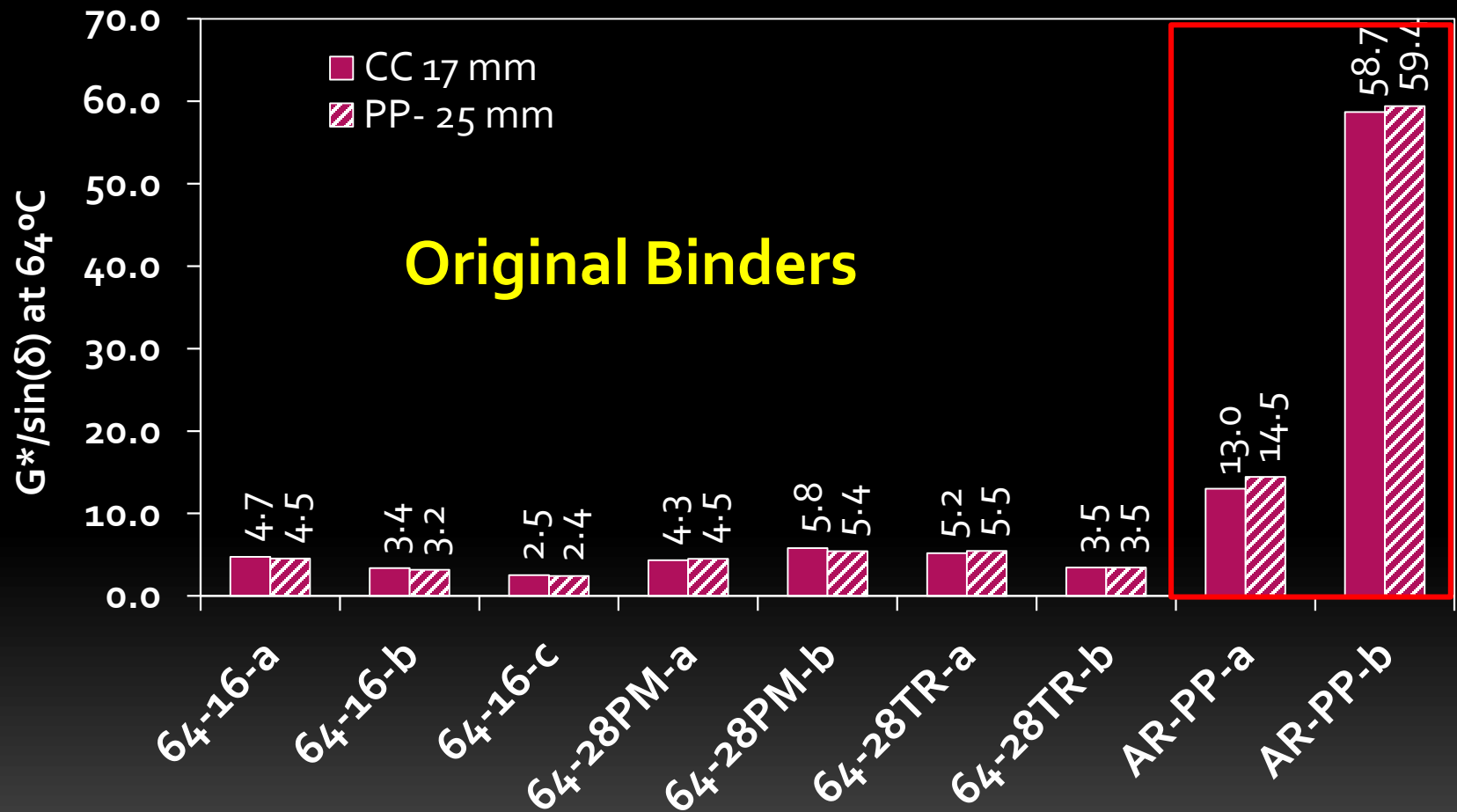
Concentric-Cylinder vs. Parallel Plate



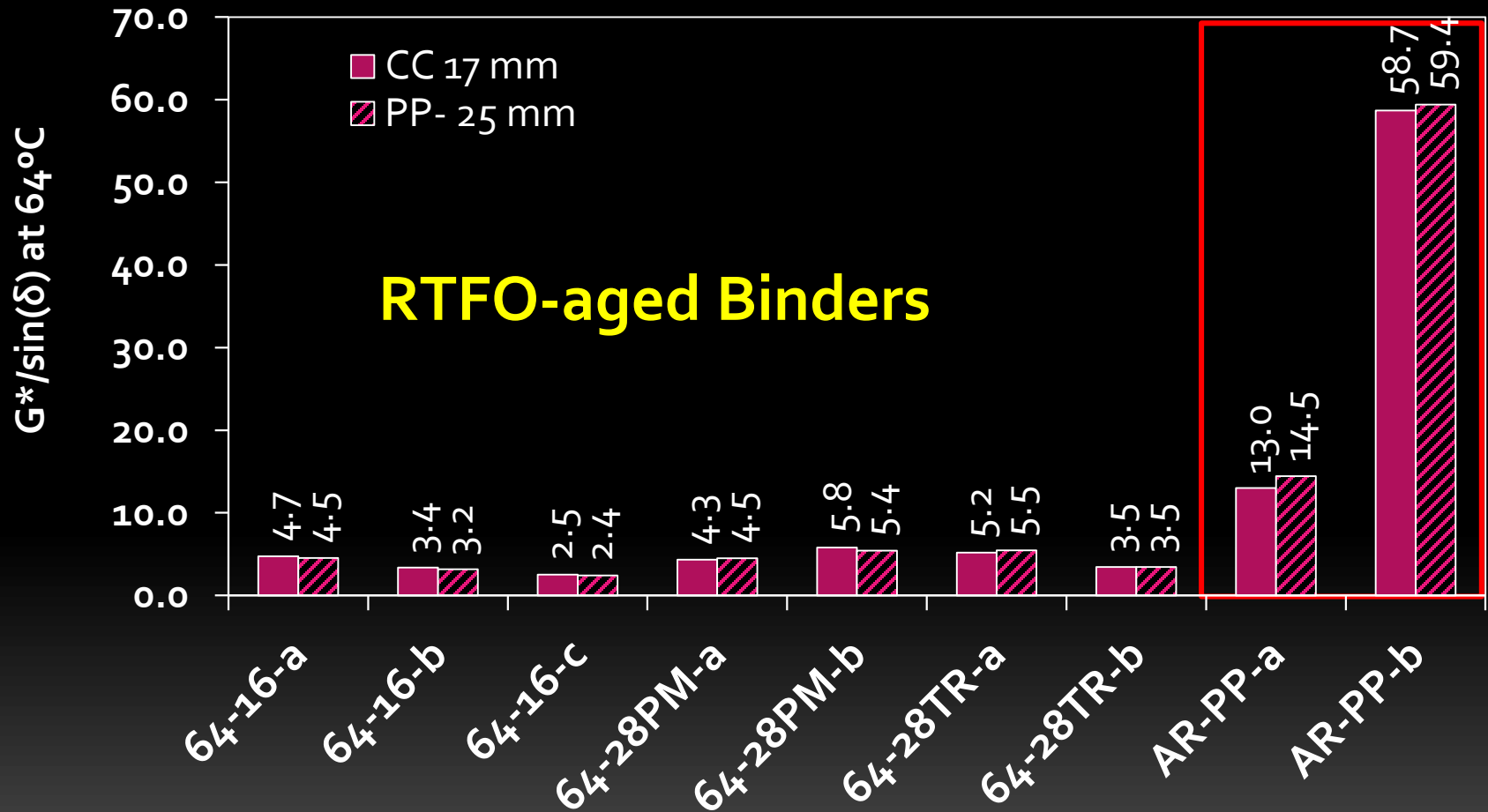
Critical factor	Concentric cylinder (CC)	Parallel plate (PP)
Sample trimming	No	Yes
Testing duration	Long	Short
Testing temperature	High	High and intermediate
Required material	Large volume	Little volume
Standard test method	Not available	AASHTO T315, ASTM D7175



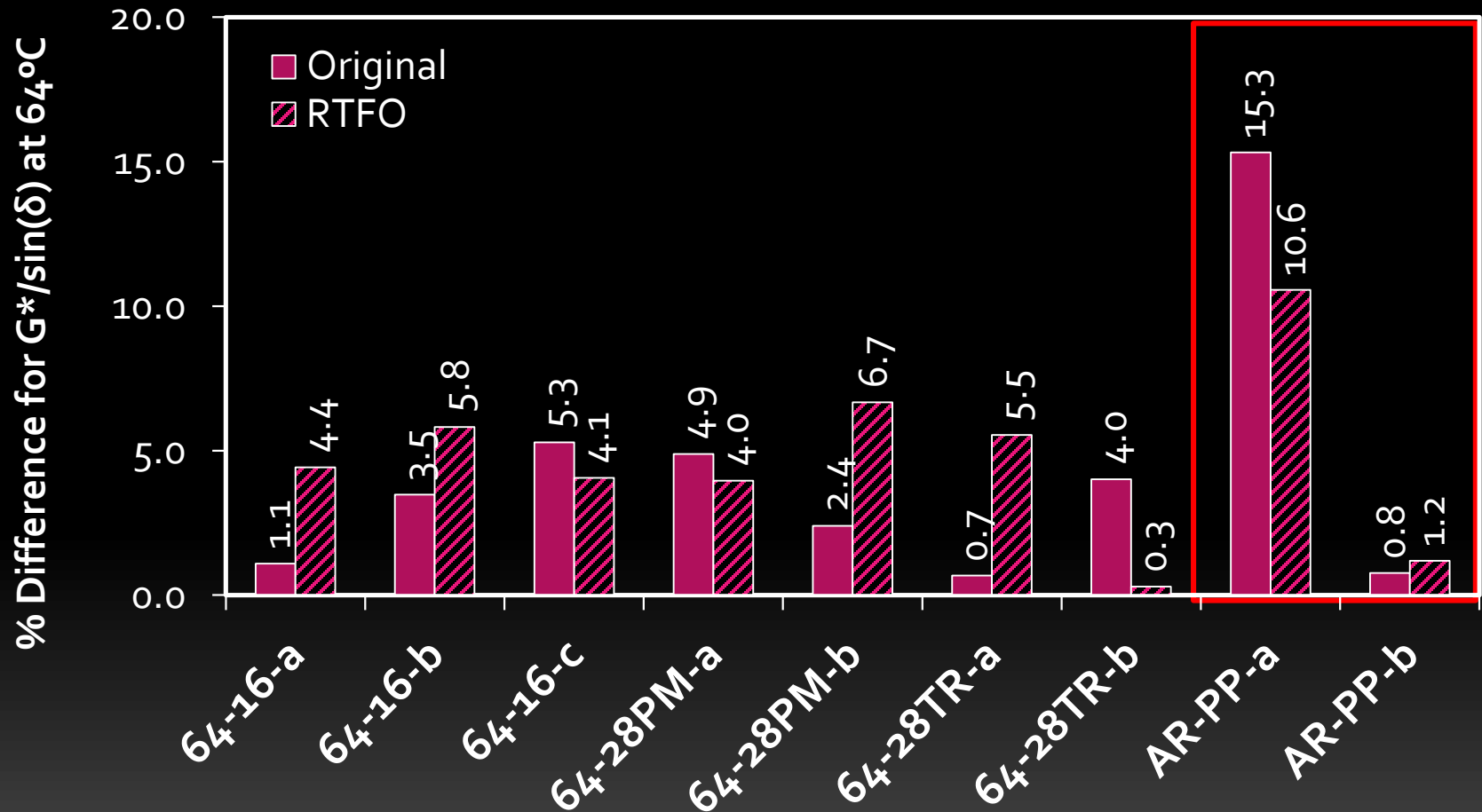
Concentric-Cylinder vs. Parallel Plate



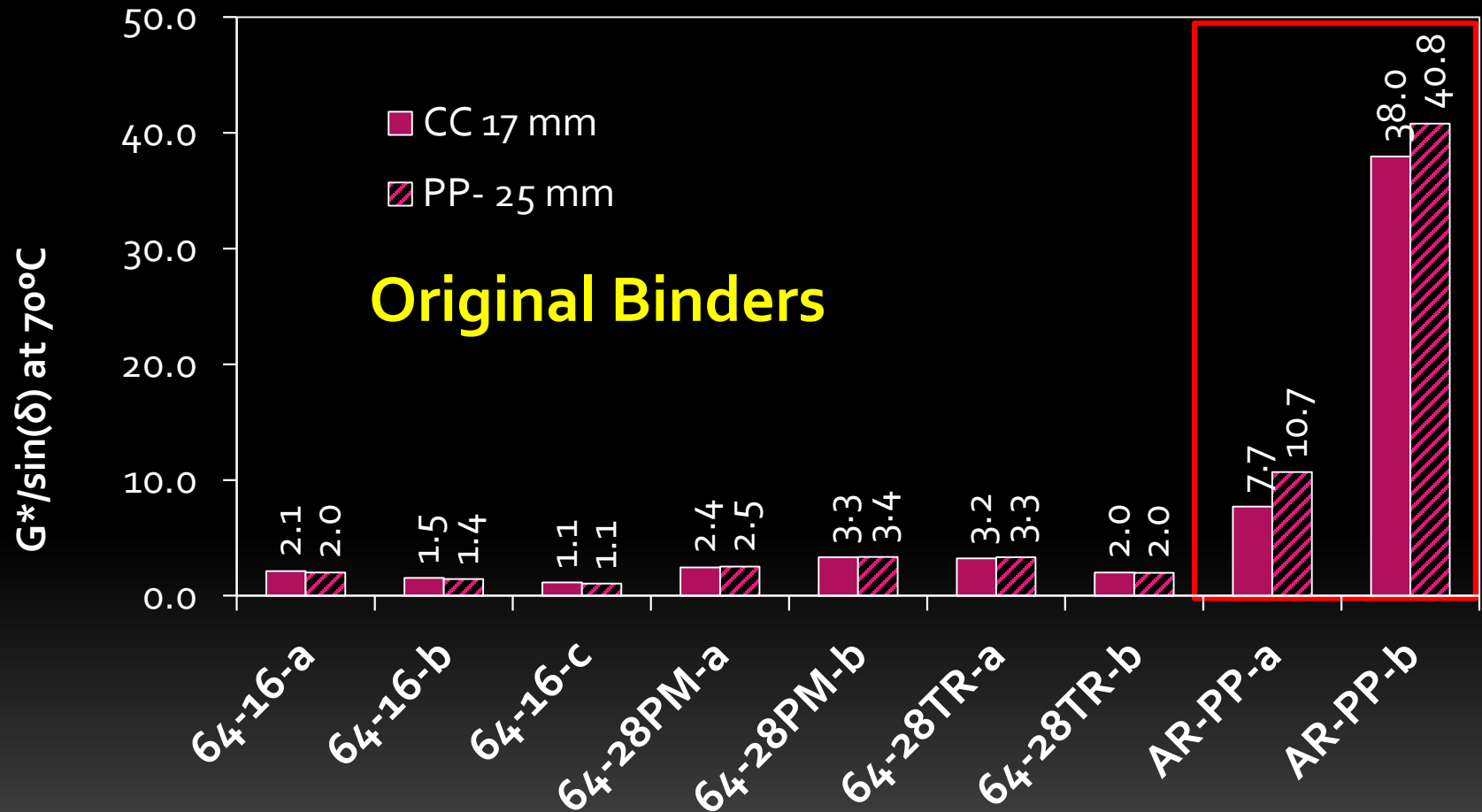
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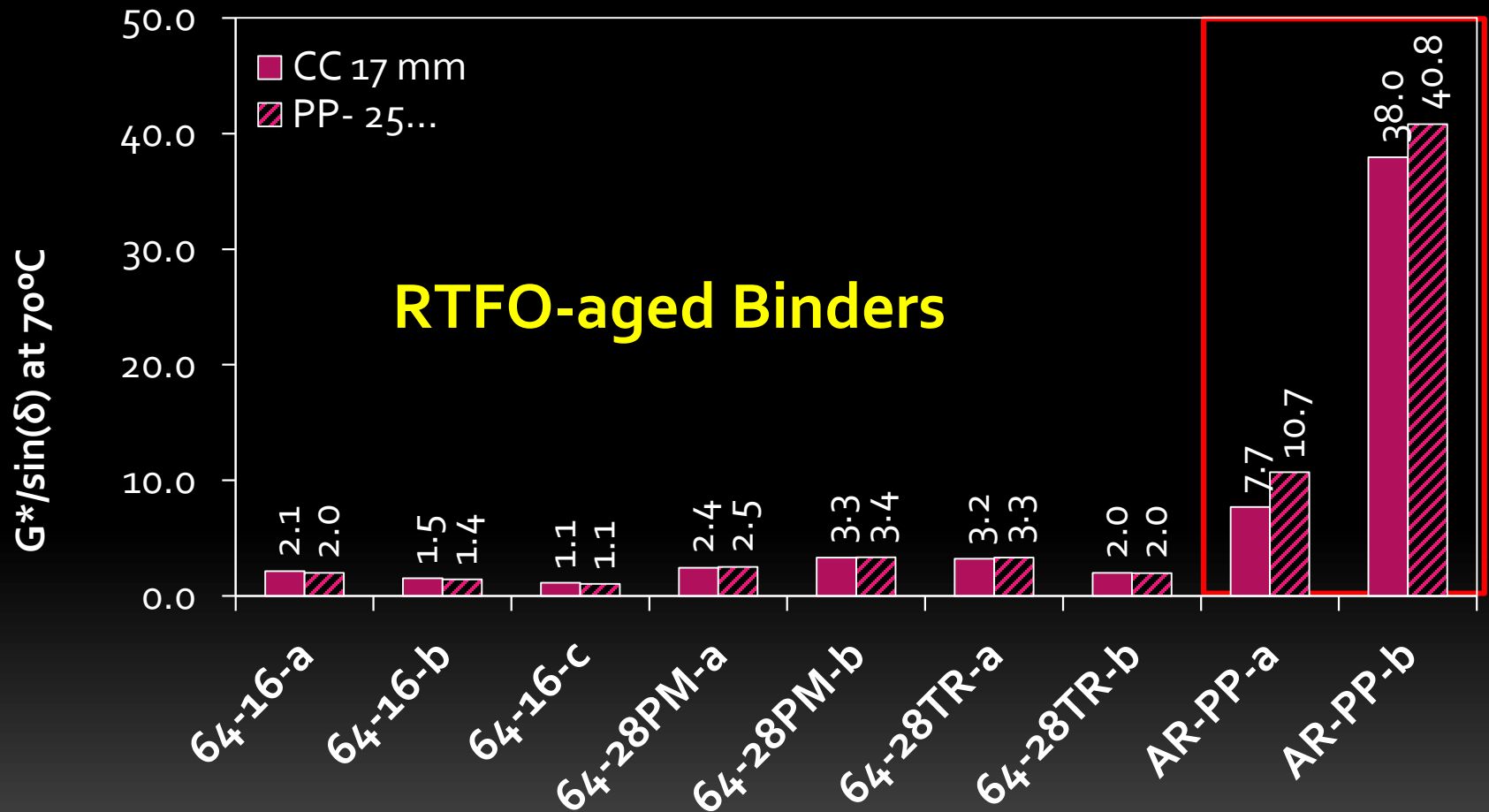
Concentric-Cylinder vs. Parallel Plate



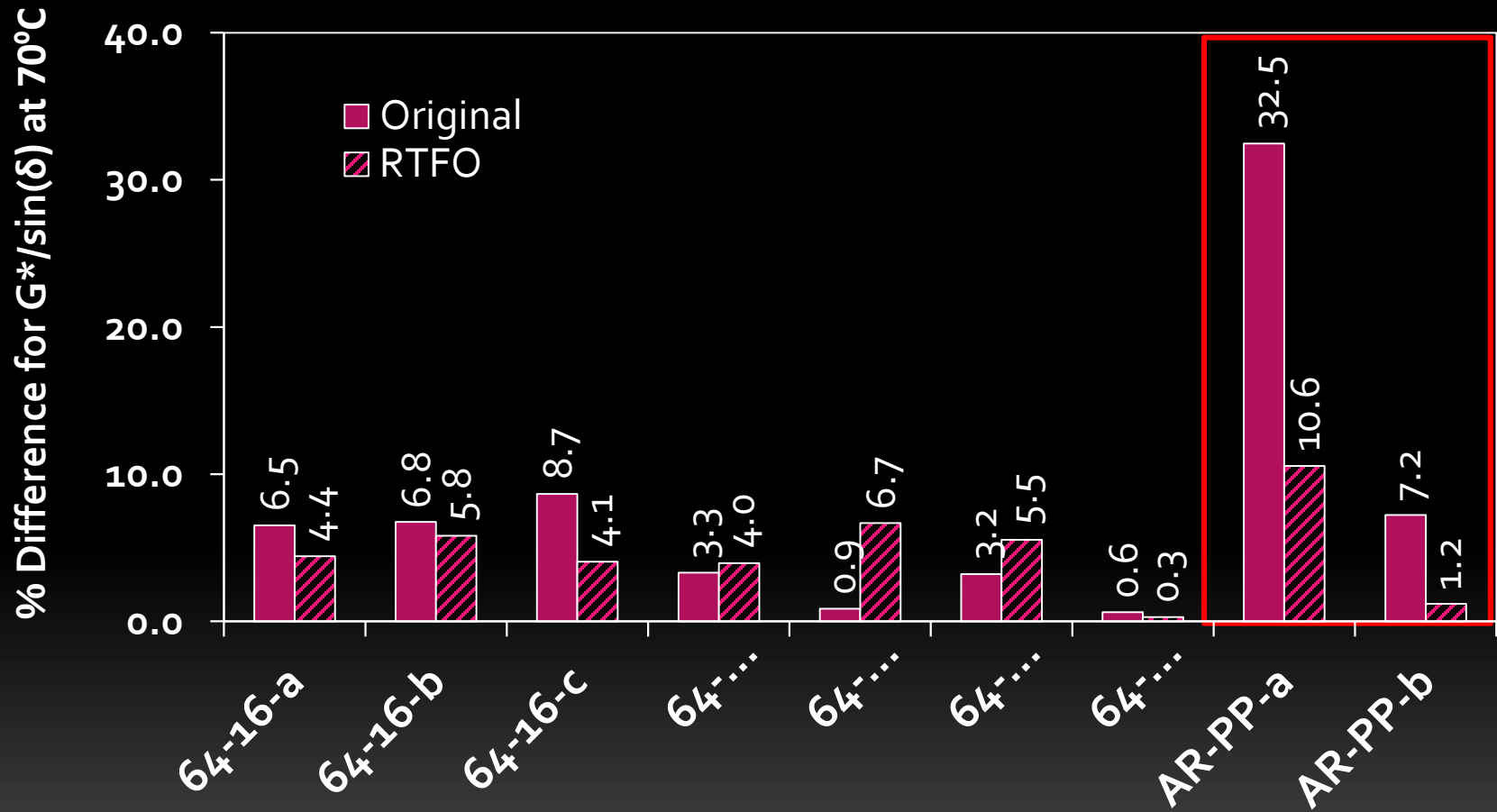
Concentric-Cylinder vs. Parallel Plate



Concentric-Cylinder vs. Parallel Plate



Concentric-Cylinder vs. Parallel Plate



Short-term aging of asphalt rubber binders

AR Binder Preparation in CA

- When adding CRM, the asphalt binder plus extender oil temperature must be between **190°C (375°F)** and **225°C (440°F)**.
- Mixing/interaction duration must be **at least 45 minutes**.
- During mixing/interaction period the temperature of asphalt rubber binder must be between **177°C (350°F)** and **218°C (425°F)**.

Mixing Temp. for AR Binder

- Caltrans Section 39-1.08B Mixing

“Asphalt rubber binder must be between 190°C (375°F) and 218°C (425°F) when mixed with aggregate.”

Conventional binder:

“Asphalt binder must be between 135°C (275°F) and 190°C (375°F) when mixed with aggregate.”

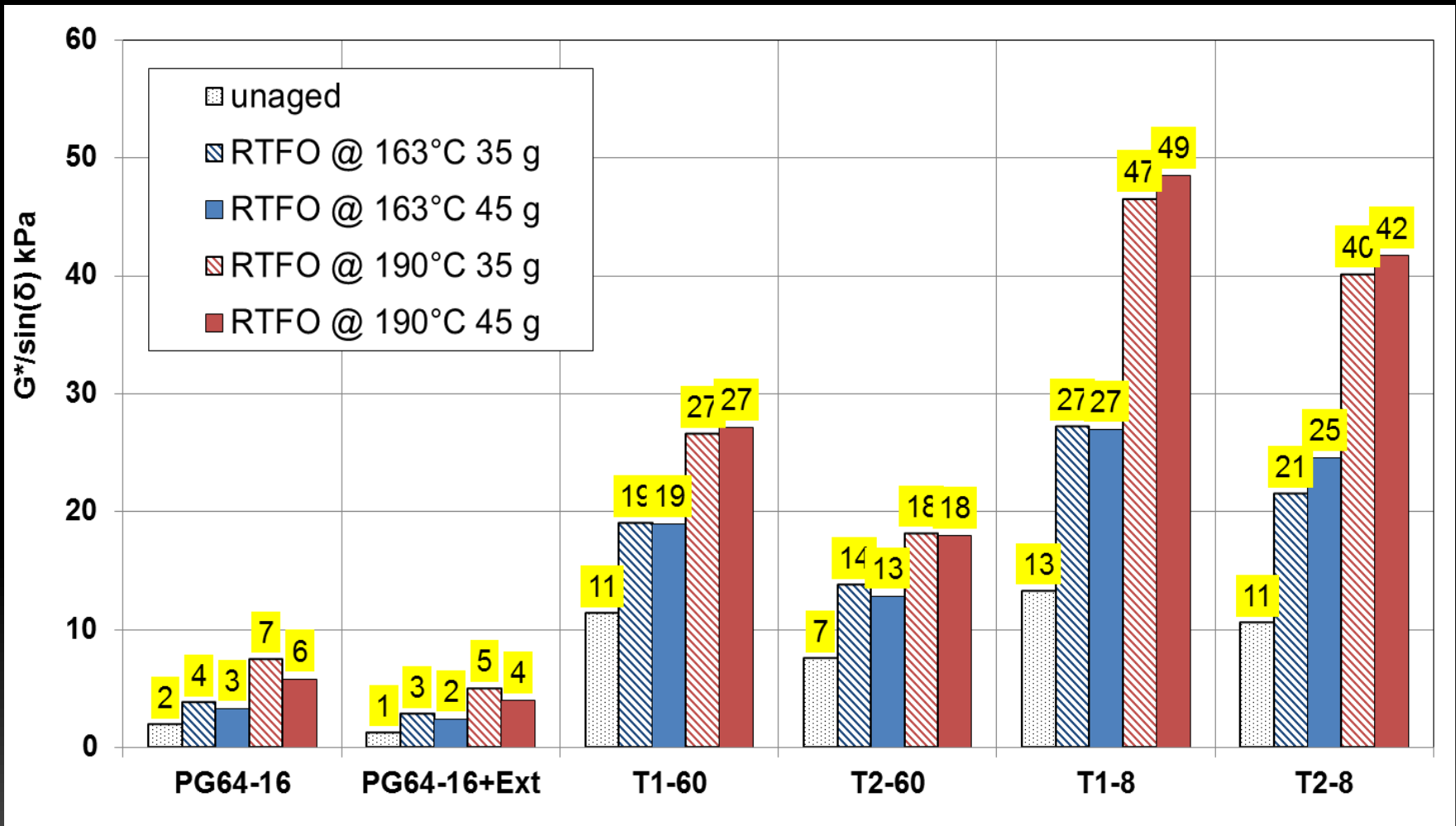
RTFO Test Method Limitations

- RTFO testing temperature and time is developed based on short-term aging of neat binders.
- It is not appropriate for AR binder, because:
 - a) Aging temperature is not simulating AR binder temperature during mix production.
 - b) Non-uniform aging of AR binder. (the RTFO bottles are not fully coated while testing).
 - c) It is difficult to obtain sufficient amount of AR binder from the bottles after testing.

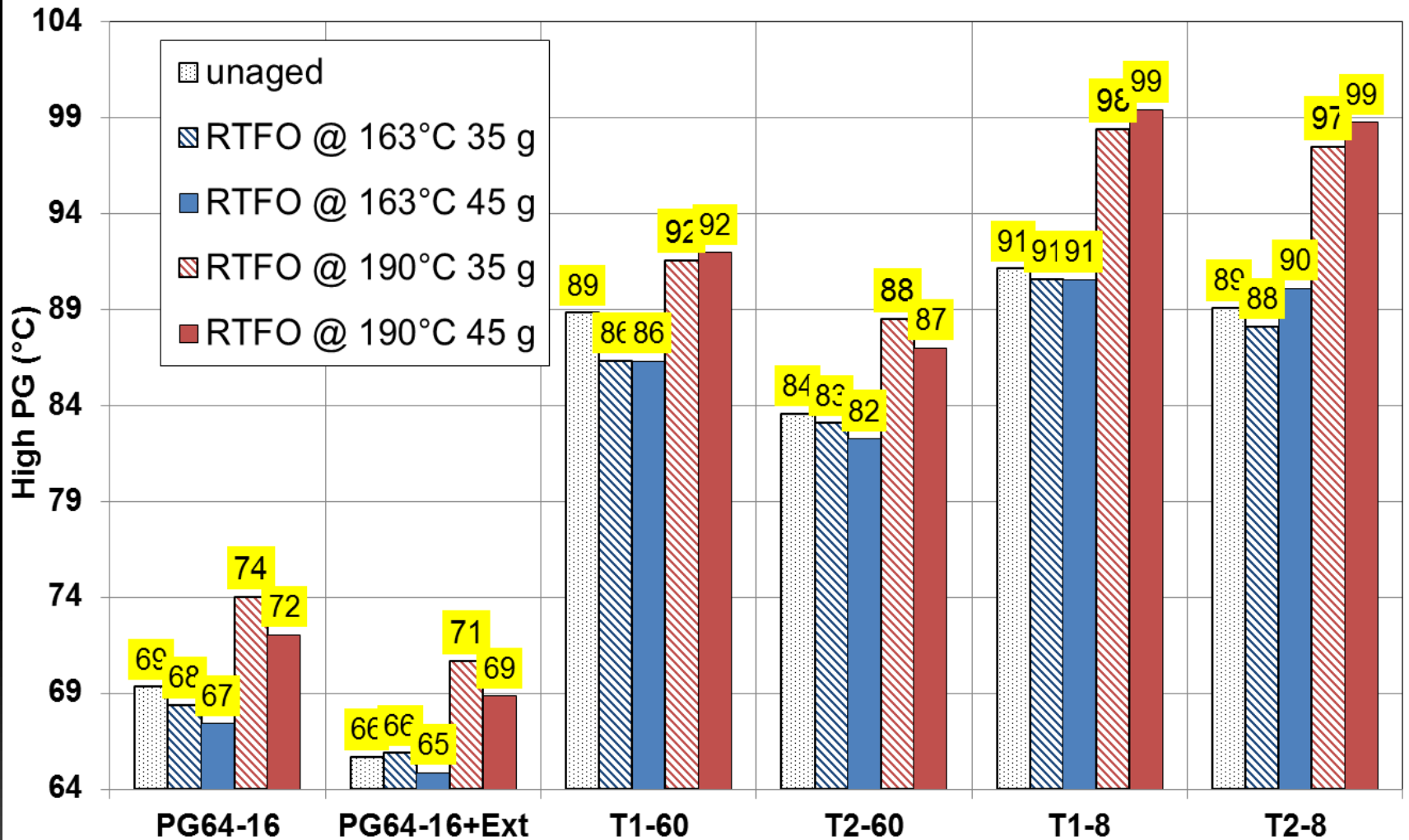
Realistic Short-Term Aging Condition

- Current RTFO testing condition:
 - Temperature: 163°C.
 - Duration: 85 min.
 - Sample size: 35 g of binder per bottle.
- Proposed modification for asphalt rubber binder:
 - **Increase testing temperature to 190°C** to simulate rubberized mix production temperature.
 - **Modify the amount of binder sample** (corresponding to 35 g of base binder in each bottle.)
 - **Change testing time ???**

$G^*/\sin(\delta)$ at 64°C



High PG Limit



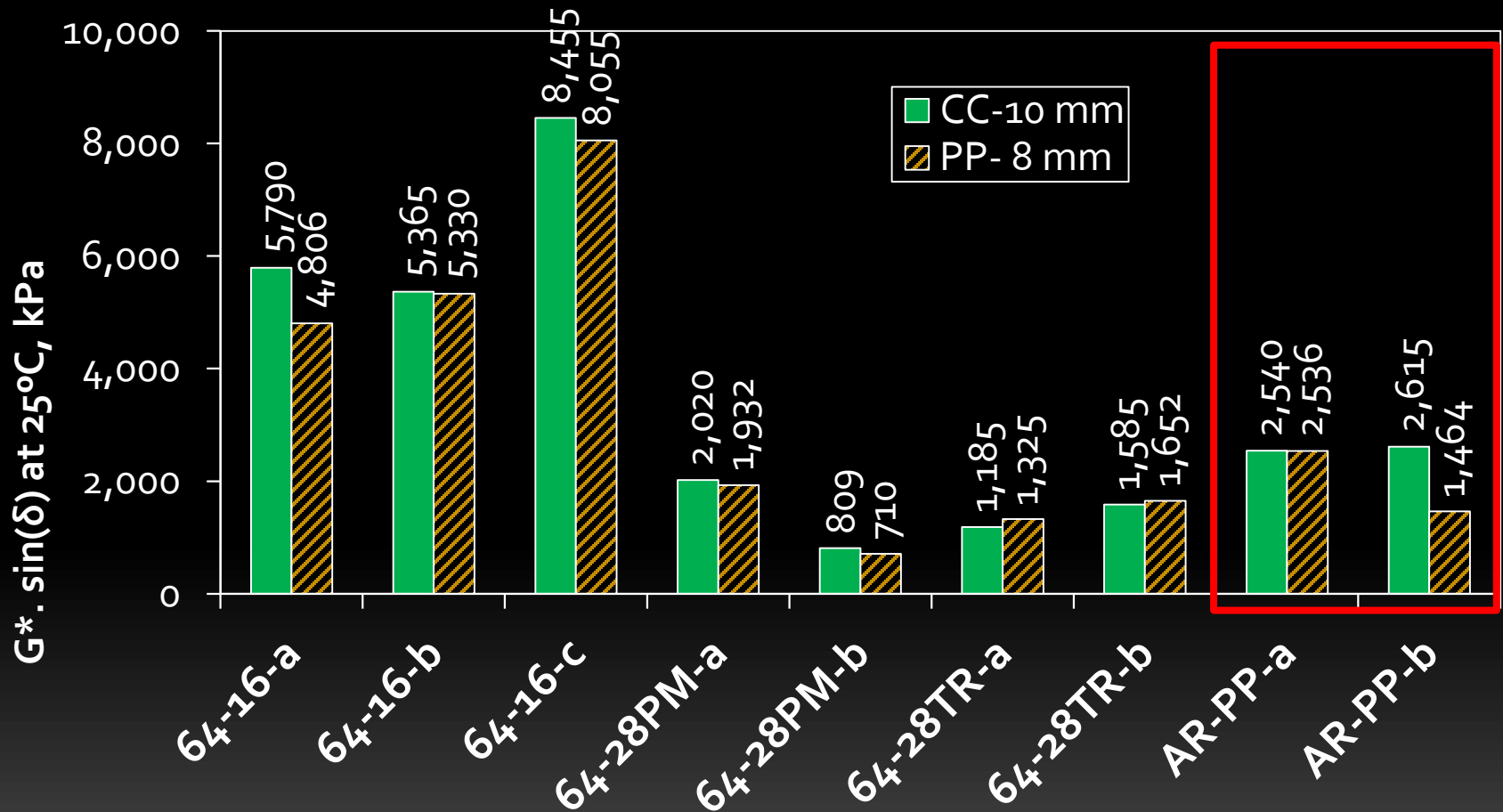
Intermediate Temperature Performance-Related Testing

AR Binder Int. Temp. Testing

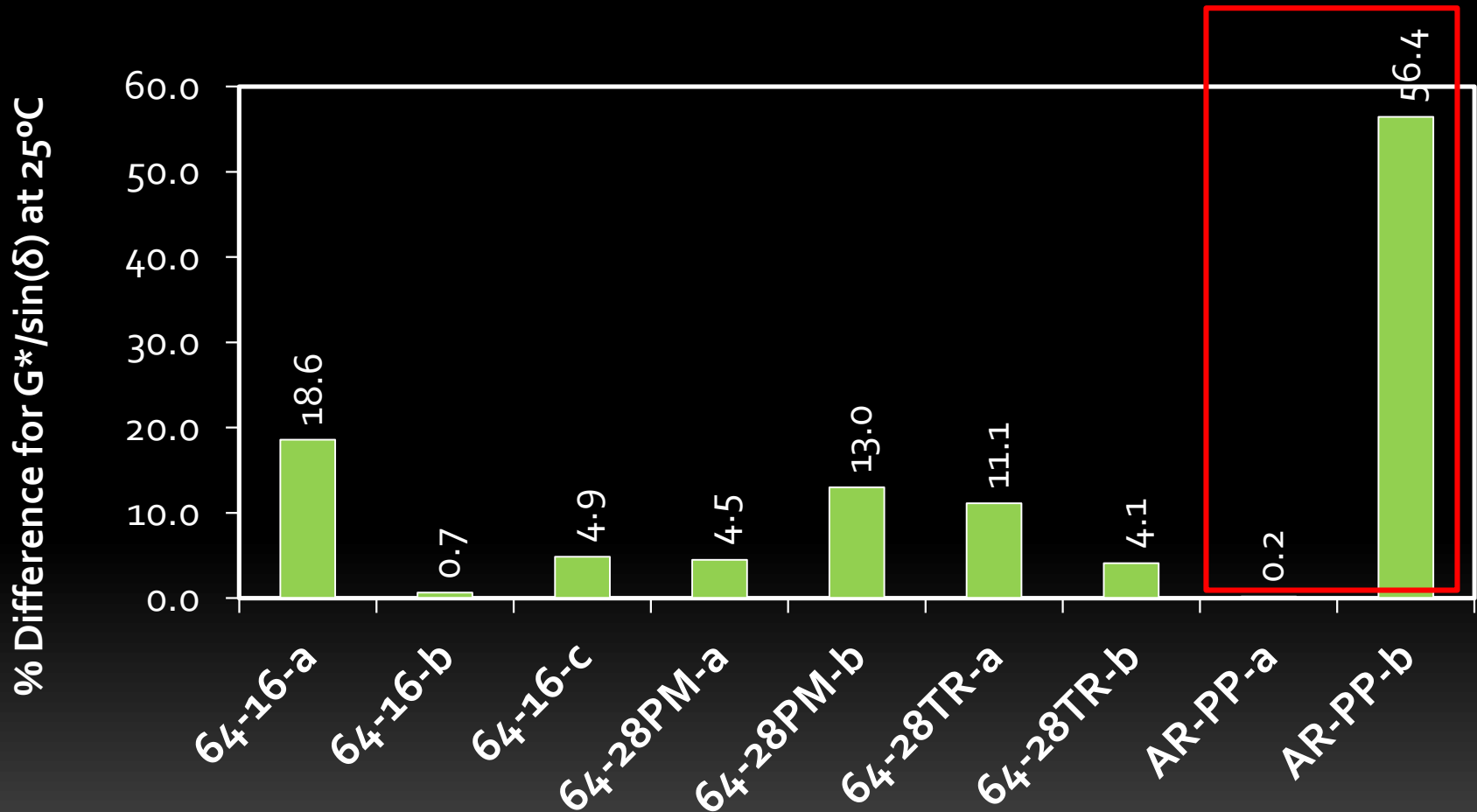
- Using modified concentric cylinder geometry
 - spindle with 10 mm diameter
 - Binders can be tested at temperature higher than 16°C
 - Tests are performed on RTFO+PAV aged binder
- Possible modification of PAV test condition
 - testing time, temperature, and sample size
- Evaluating the effect of rubber particle sizes

Concentric-Cylinder vs. Parallel Plate

RTFO+PAV Aged Binders



Concentric-Cylinder vs. Parallel Plate



Low Temperature Performance-Related Testing

AR Binder Low Temp. Testing

- Modification of BBR mold
 - Remedy some of the issues associated with pouring the binder and preparing a uniform shape binder beam

Modified mold is proposed!

- Tests will be performed on RTFO+PAV aged binder (considering possible modification)
- Evaluating the effect of rubber particle sizes

Modified BBR Mold for AR Binder

- Conventional BBR mold
 - Requires pre-heating of mold
 - Requires oven conditioning mold after pouring AR binder
 - Requires high amount of AR binder
 - Difficulties in de-molding the specimen

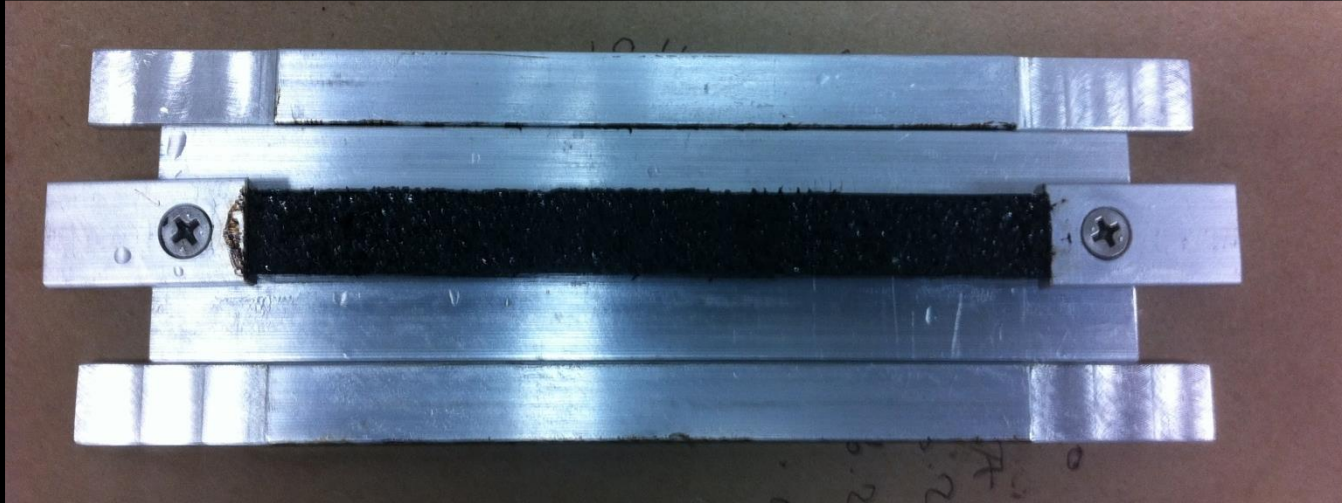


Modified BBR Mold for AR Binder

- **Modified BBR mold**
 - Preheating of the mold is not necessary
 - Oven conditioning is not necessary
 - Sample size is acceptable
 - Sample trimming is easy
 - Demolding is not difficult



Modified vs Standard BBR Molds

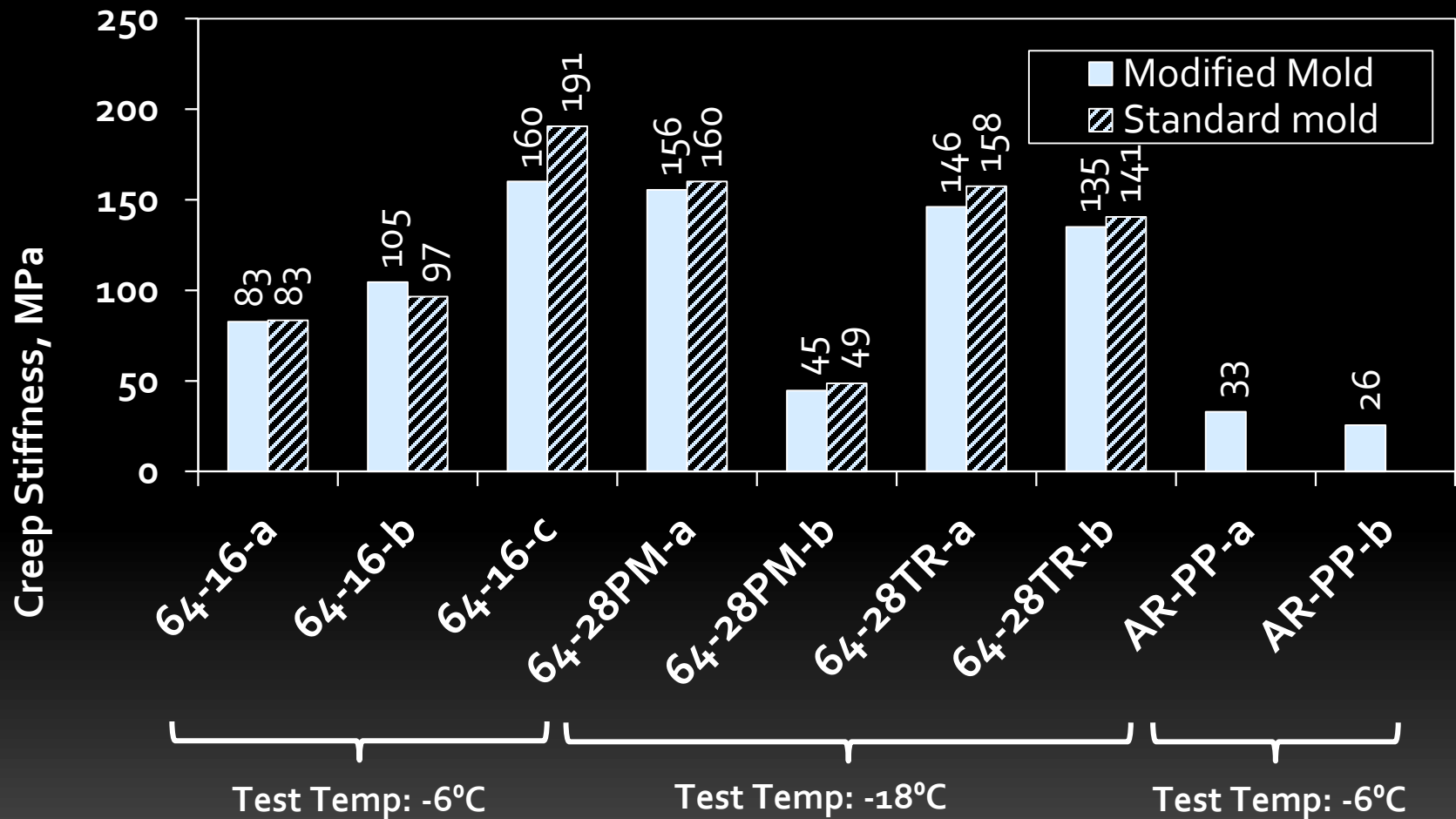


From St.
mold

From Mod.
mold

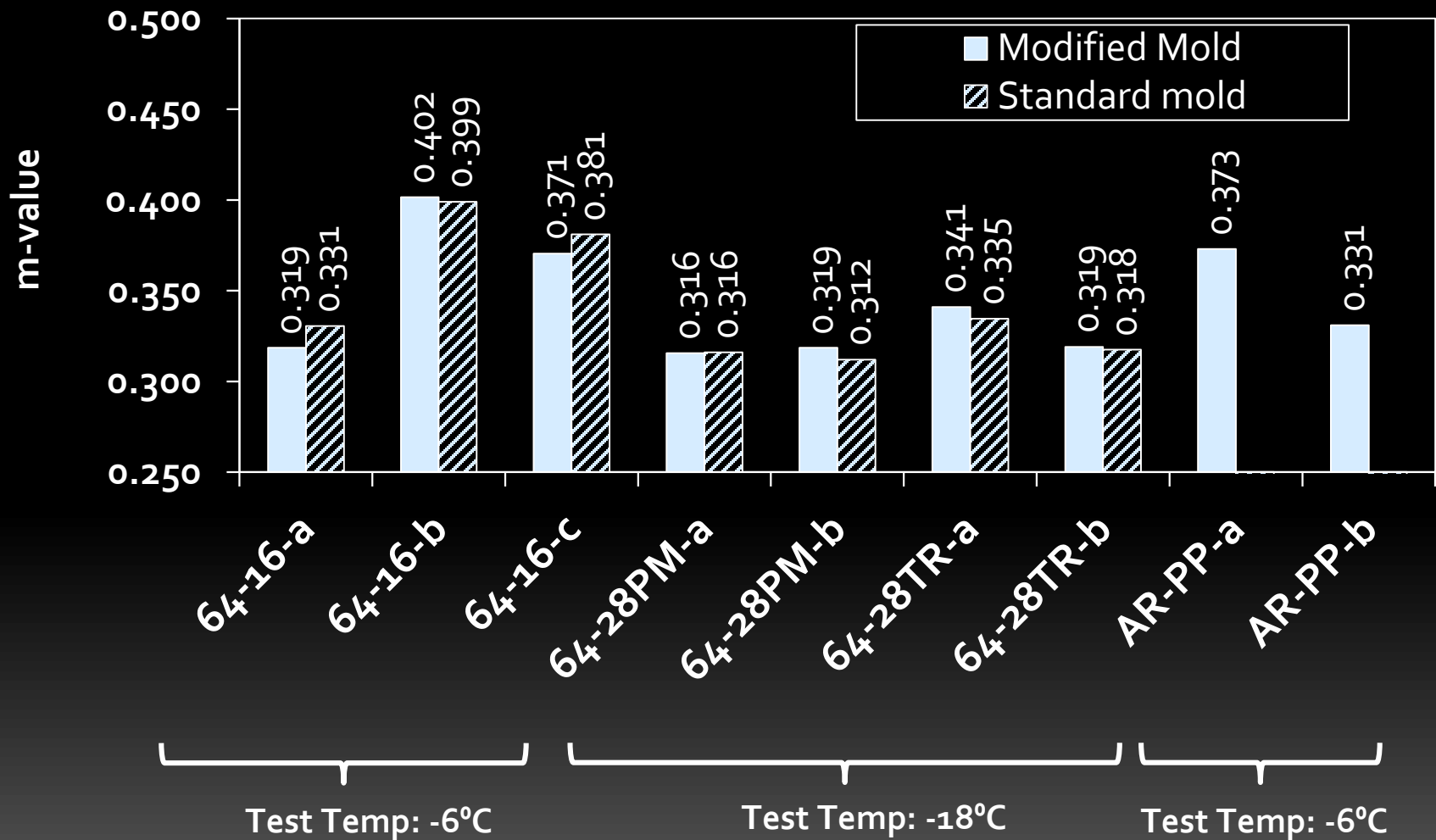
Modified vs. Standard BBR Mold

RTFO+PAV Aged Binders



Modified vs. Standard BBR Mold

RTFO+PAV Aged Binders



Summary of Findings

- bob spindle with 17-mm diameter is the proposed alternative geometry for testing AR binders at high temp. range.
- bob spindle with 10-mm diameter is the proposed alternative geometry for testing AR binders at intermediate temp. range.
- Using modified BBR mold successfully remedied most of the limitations associated with the AR binder beam preparation.
- Increasing RTFO temperature to 190°C increased the high PG temperature by up to 9°C.

Work in Progress...

- Compare RTFO and TFO test results
- Collect field produced AR samples and test them according to the proposed approaches.
- Test rubberized mixes and compare the performance-related properties of mixes with rheological properties of their corresponding binders.
- Evaluate and adjust PG grading criteria for AR binders.



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THANK YOU!

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Photo courtesy Caltrans