DEVELOPMENT OF ASPHALT RUBBER BINDER SPECIFICATIONS IN CALIFORNIA: PROJECT UPDATE

Zia Alavi, PhD and David Jones, PhD

University of California Pavement Research Center, Davis

FHWA ETG Meeting, Ames, Iowa

May, 03, 2017

Caltrans

UCPRC UNIVERSITY of CALIFORNIA Davis • Berkeley | PAVEMENT RESEARCH CENTER

Outline

- Background
- Short-term aging
- High temperature tests
- Intermediate temperature tests
- Low temperature tests
- Way forward

UCPRC

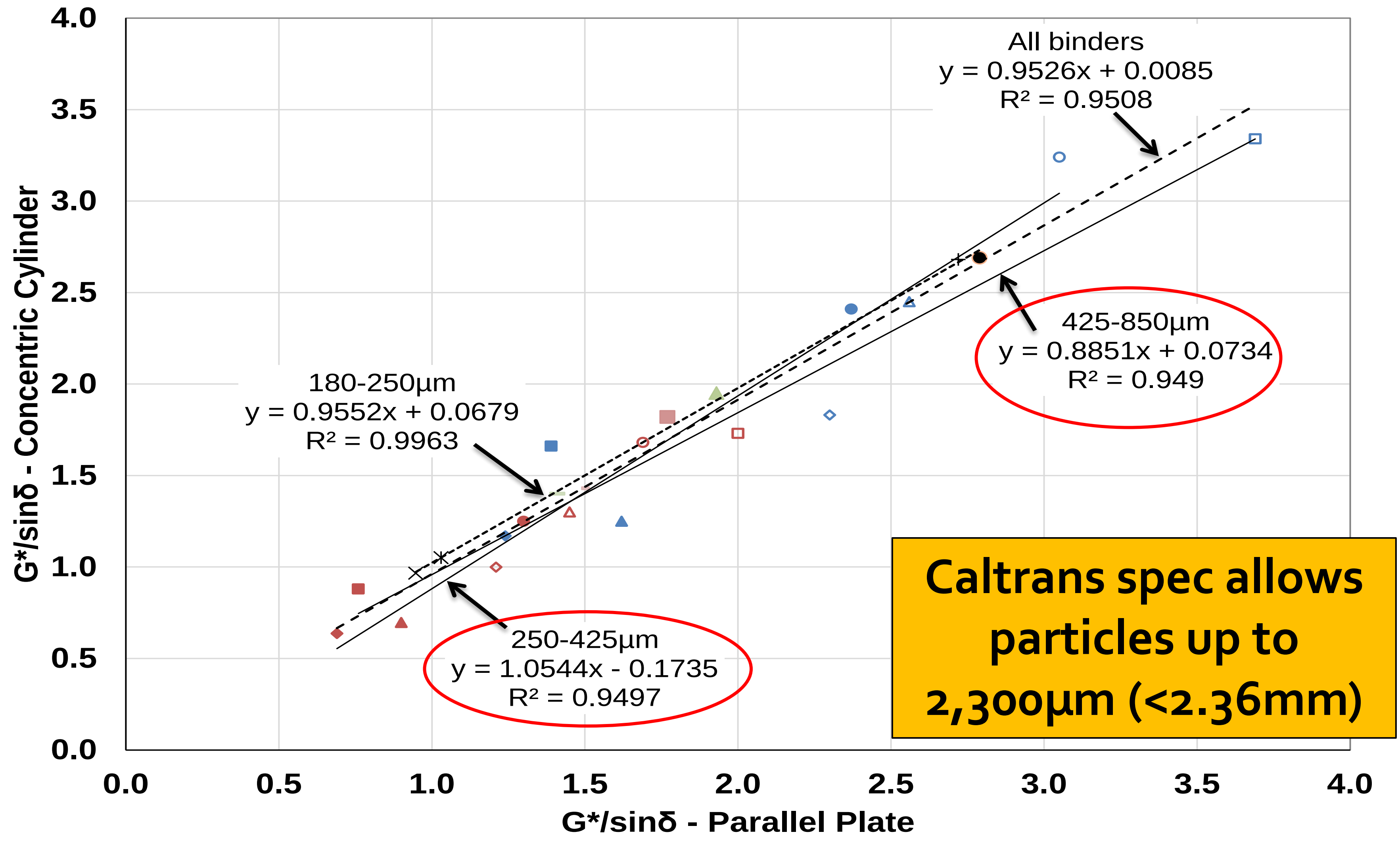
Background

- Update on the update given at the September 2014 ETG meeting (Phase 1, lab-produced binder)
- Recap on asphalt rubber in California
  - AB338 (2005) requires Caltrans to use asphalt rubber in at least 35% of all AC placed
    - Asphalt rubber defined as 18-22% CRM by weight of binder
    - CRM is 100% passing #8 (2.36mm)
    - Termed "wet process", used in gap- & open-graded mixes
    - Binder QC essentially only viscosity (handheld viscometer)
  - "Terminal blend" rubber binder considered in PG-M spec
  - Caltrans 2015 mandate requires that all surface courses placed below 3,000ft are asphalt rubber mixes
- SB1 funding

Background

- Phase 1 study compared concentric cylinder with parallel plate on laboratory-produced AR binders
  - Concern about ratio between rubber particle size and gap influencing the result
  - Plate gap was 1mm or 2mm depending on particle size
  - Limited testing on 3mm and 4mm gaps due to trimming and slump issues

Phase 1 CC vs. PP



Caltrans spec allows particles up to 2,300µm (<2.36mm)

Background

- Phase 2 study on plant- produced binders and mix
  - AR binders tested with 3mm gap on 25mm and 8mm plates
  - Conventional binders tested with 1mm gap on 25mm plates and 2mm gap on 8mm plates
  - Mix testing to interpret rheological properties
- Parallel studies
  - Caltrans/Industry task group study on 3mm parallel plate gap
  - Round robin testing by 16 laboratories completed
  - UCPRC tested with concentric cylinder as well
  - Task group report in preparation
- Caltrans will decide which approach to use

UCPRC

Phase 2 Experiment Plan

Parameter	Number	Progress
AR binder source	5 (statewide)	Tested 2
Base binder[1]	??	Tested 3
AR mixes[2]	5	Tested 2
PM Binders (PG-M spec)[1]	2	Tested 2
TR Binders (PG-M spec)[1]	2	Tested 2

[1] Control testing

[2] Beam fatigue, SCB, dynamic modulus, flow number, TSRST, etc.

UCPRC

Outline

- Background
- Short-term aging
- High temperature tests
- Intermediate temperature tests
- Low temperature tests
- Way forward

AR Mixing & Production Temps.

- Temperature when CRM is added to asphalt binder plus extender oil
  - **375°F to 440°F** (190°C to 225°C)
- Mix production temperature
  - **375°F and 425°F** (190°C to 218°C)
  - Conventional mixes typically between 290°F and 320°F (143°C to 160°C)
- Current RTFO testing temperature (163°C) is based on short-term aging of unmodified binders with no particulates

RTFO Test Method Limitations

- Current method not considered appropriate for AR binder, because:
  - Aging temperature does not simulate AR binder temperature during mix production
  - Aging of the AR binder is non-uniform due to incomplete coating of the bottles
  - Quantity of binder available after aging is often insufficient for DSR and BBR testing

Proposed Changes

Test Parameter	Current	Proposed
Temperature (°C)	163	190
Duration (minutes)	85	85
Sample size (g)	35	= to 35 of base binder[1]
Oven tilt (°)	zero	zero

[1] 45 grams of AR binder with 20% CRM

Modified RTFO Procedure

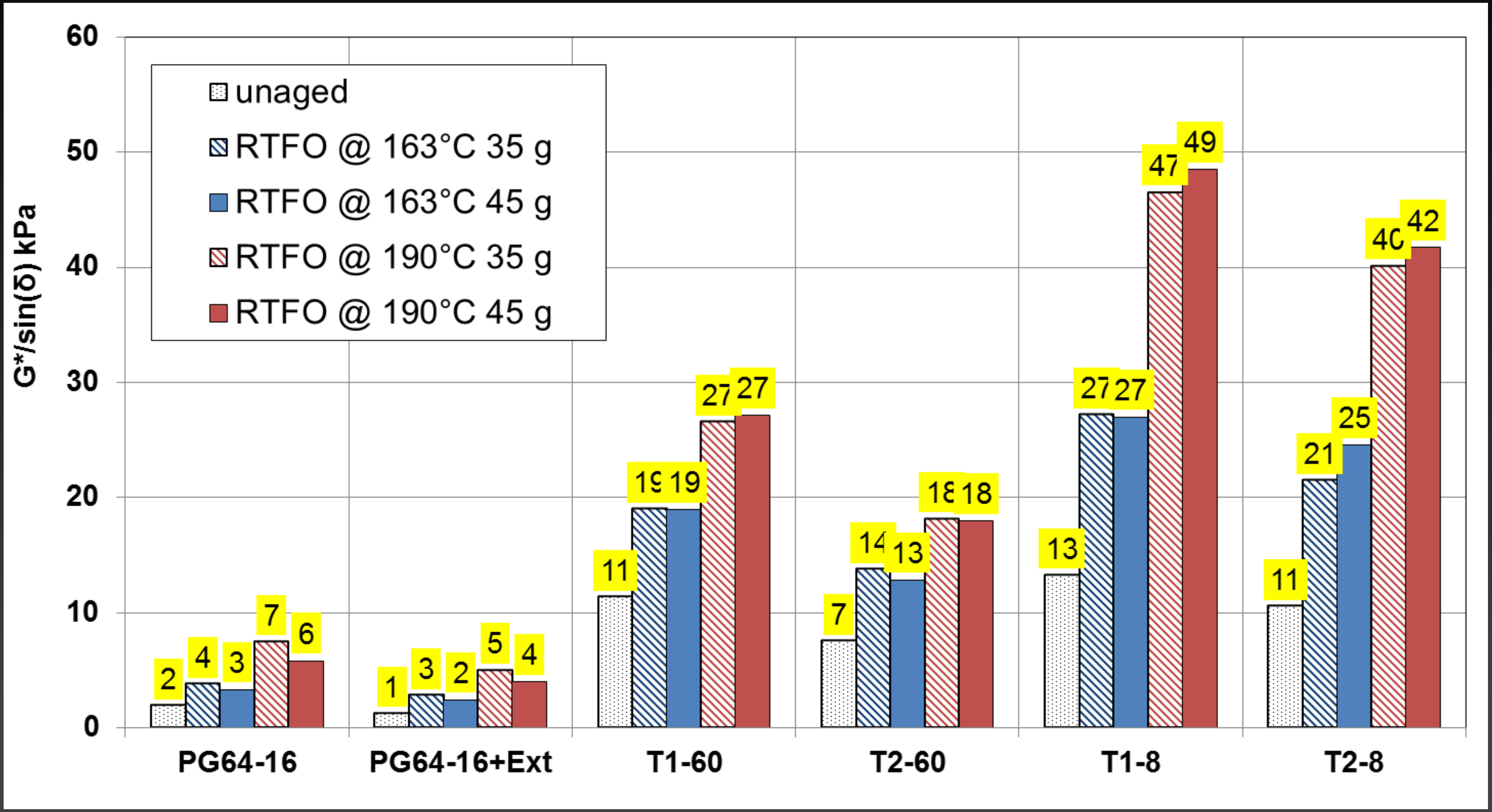
35 g

45 g

163°C

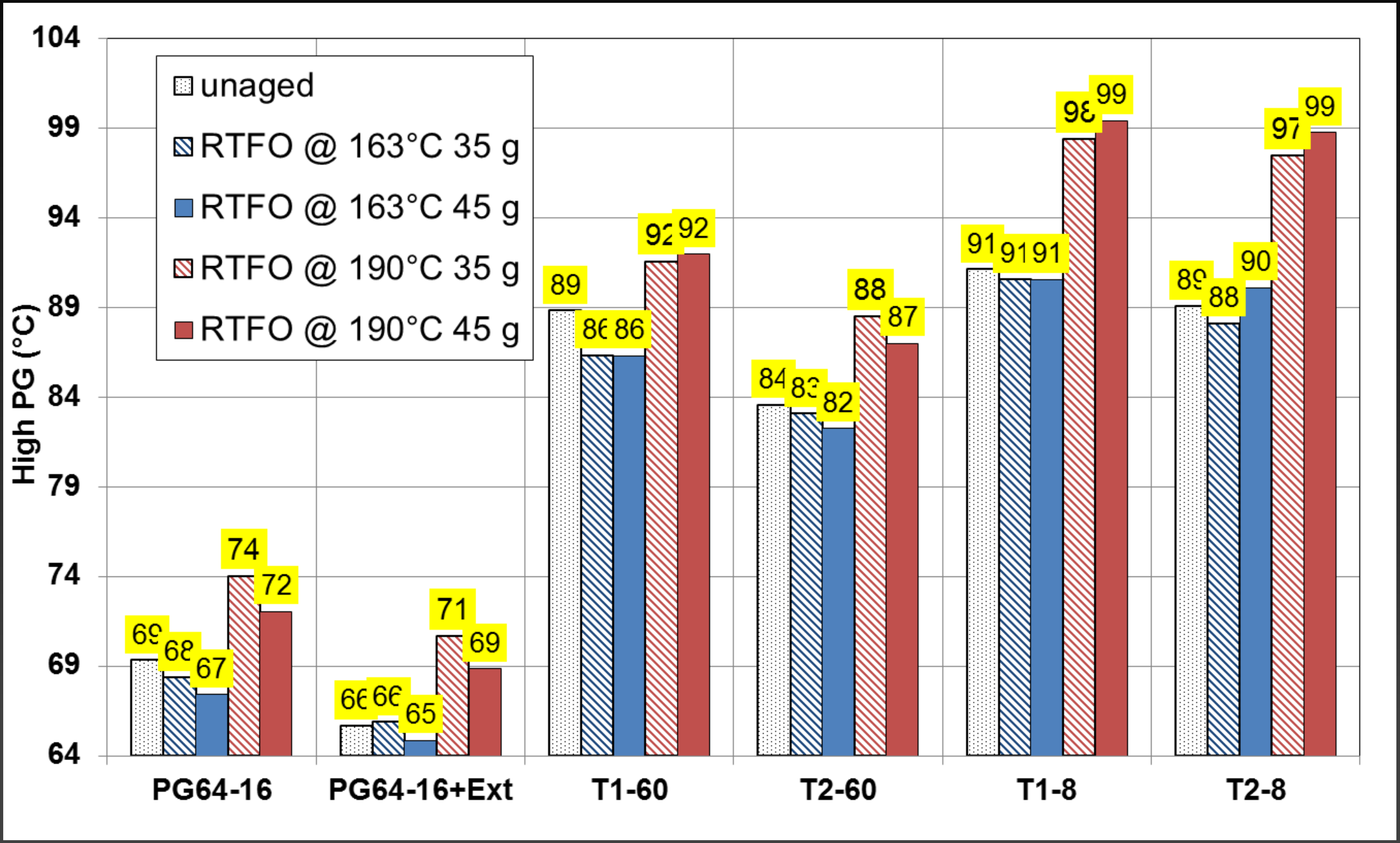
190°C

G*/sin(δ) at 64°C



G*/sin(δ) kPa
0
10
20
30
40
50
60
unaged
RTFO @ 163°C 35 g
RTFO @ 163°C 45 g
RTFO @ 190°C 35 g
RTFO @ 190°C 45 g
2
4
3
7
6
1
3
2
5
4
11
19
19
27
27
7
14
13
18
18
13
27
27
47
49
11
21
25
40
42
PG64-16
PG64-16+Ext
T1-60
T2-60
T1-8
T2-8

High PG Limit



UCPRC

Summary

- Key findings
  - Testing at 163°C does not appear to be appropriate for AR binders due to poor bottle coating; testing at 190°C considered to be more representative
  - Higher binder stiffnesses at 190°C, as expected (increased high PG temperature by up to 9°C)
  - Larger sample volume did not significantly effect results, but did help for DSR/BBR test requirements (can be adjusted to suit)
  - No spillage noted with 45 gram sample (oven not tilted)
- Likely recommendation
  - Dependent on remaining tests, but will probably suggest doing RTFO test at 190°C

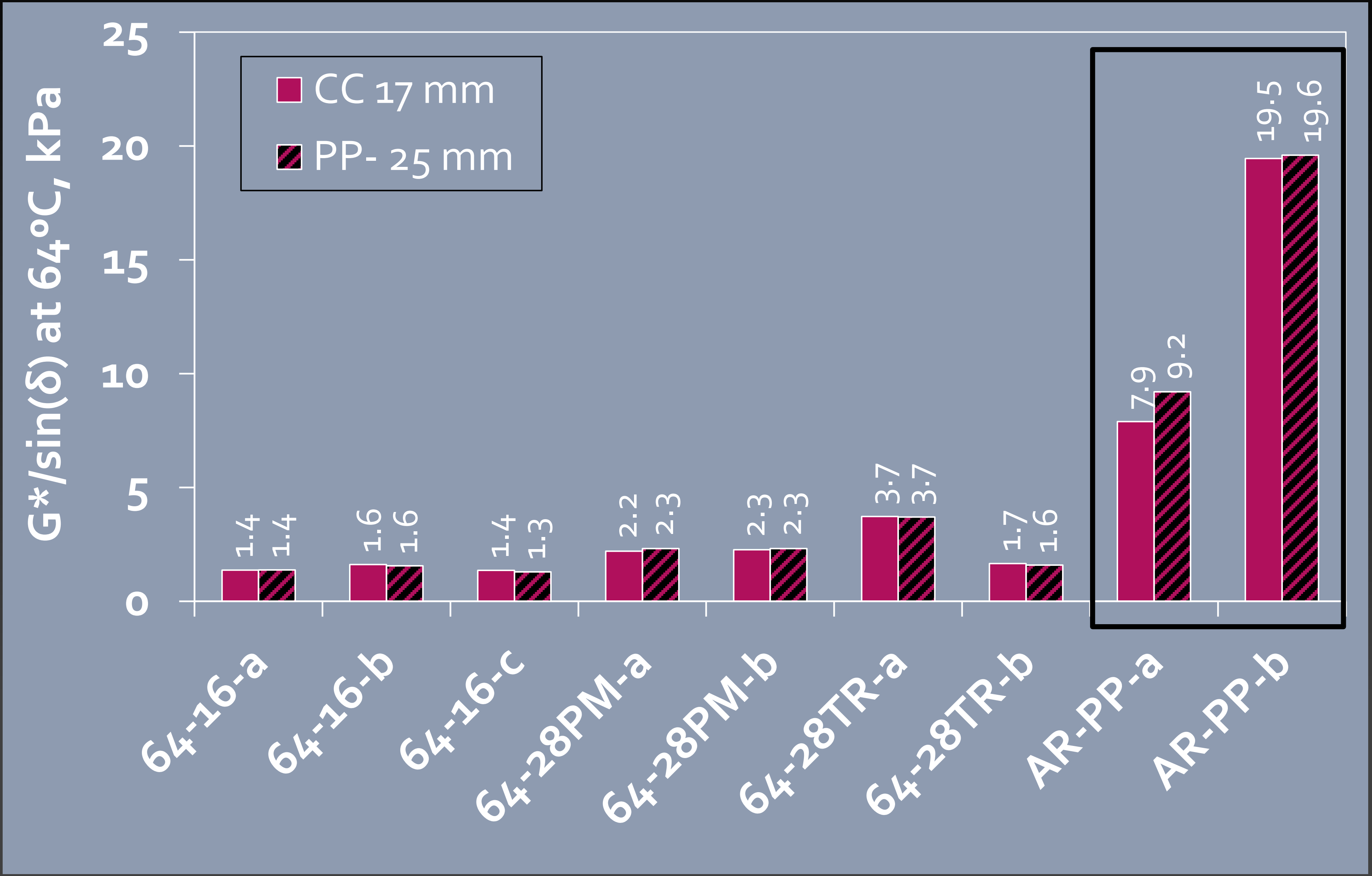
Outline

- Background
- Short-term aging
- High temperature tests
- Intermediate temperature tests
- Low temperature tests
- Way forward

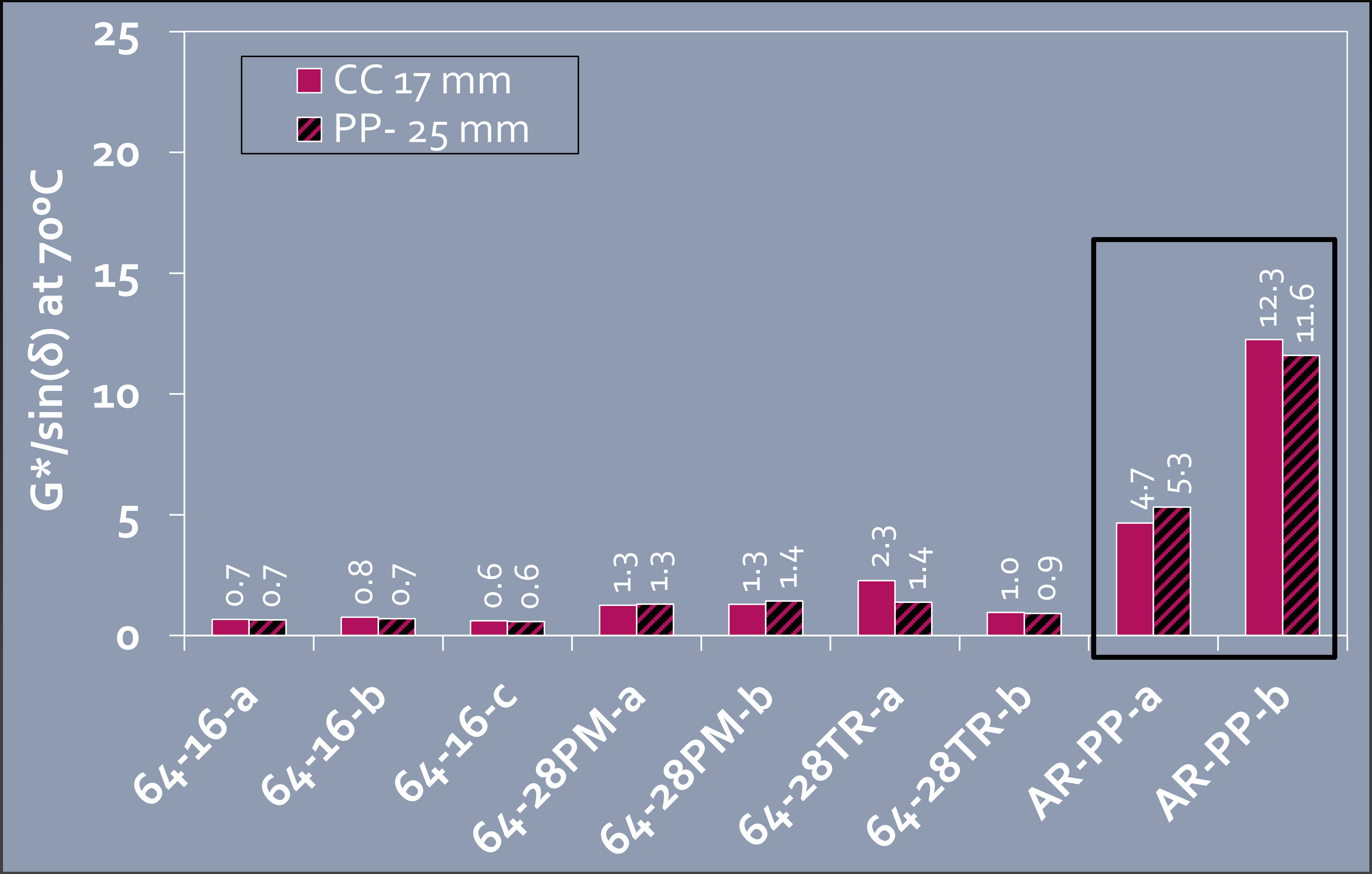
High Temperature Tests

- Testing geometry
  - Concentric cylinder with 17mm bob and 6mm gap
- Test methods
  - Binder viscosity (for workability)
  - PG grade
  - MSCR test
  - Frequency sweep test
- Tests on both original and short-term aged binders

CC vs. PP (Unaged at 64°C)

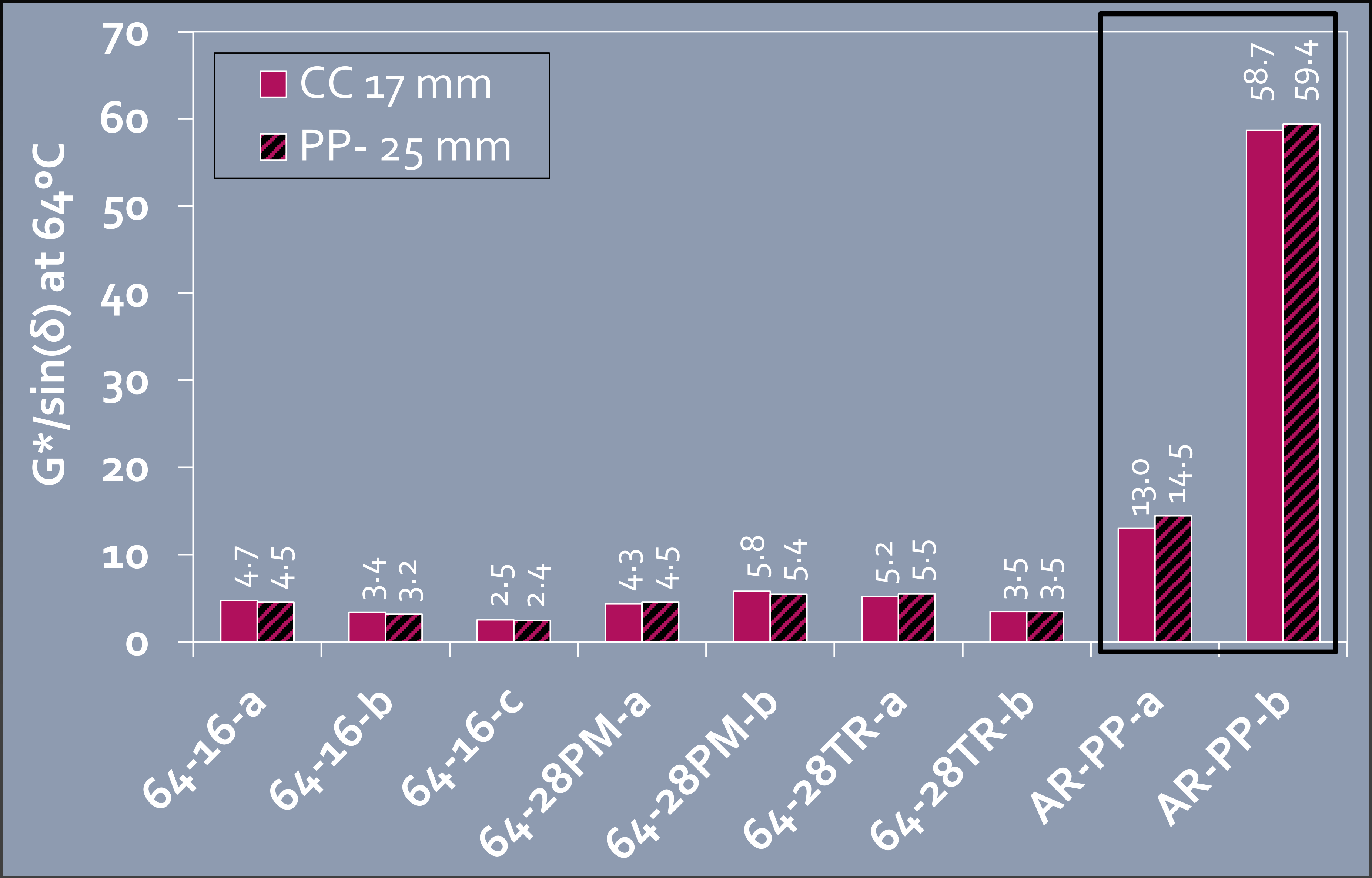


CC vs. PP (Unaged at 70°C)



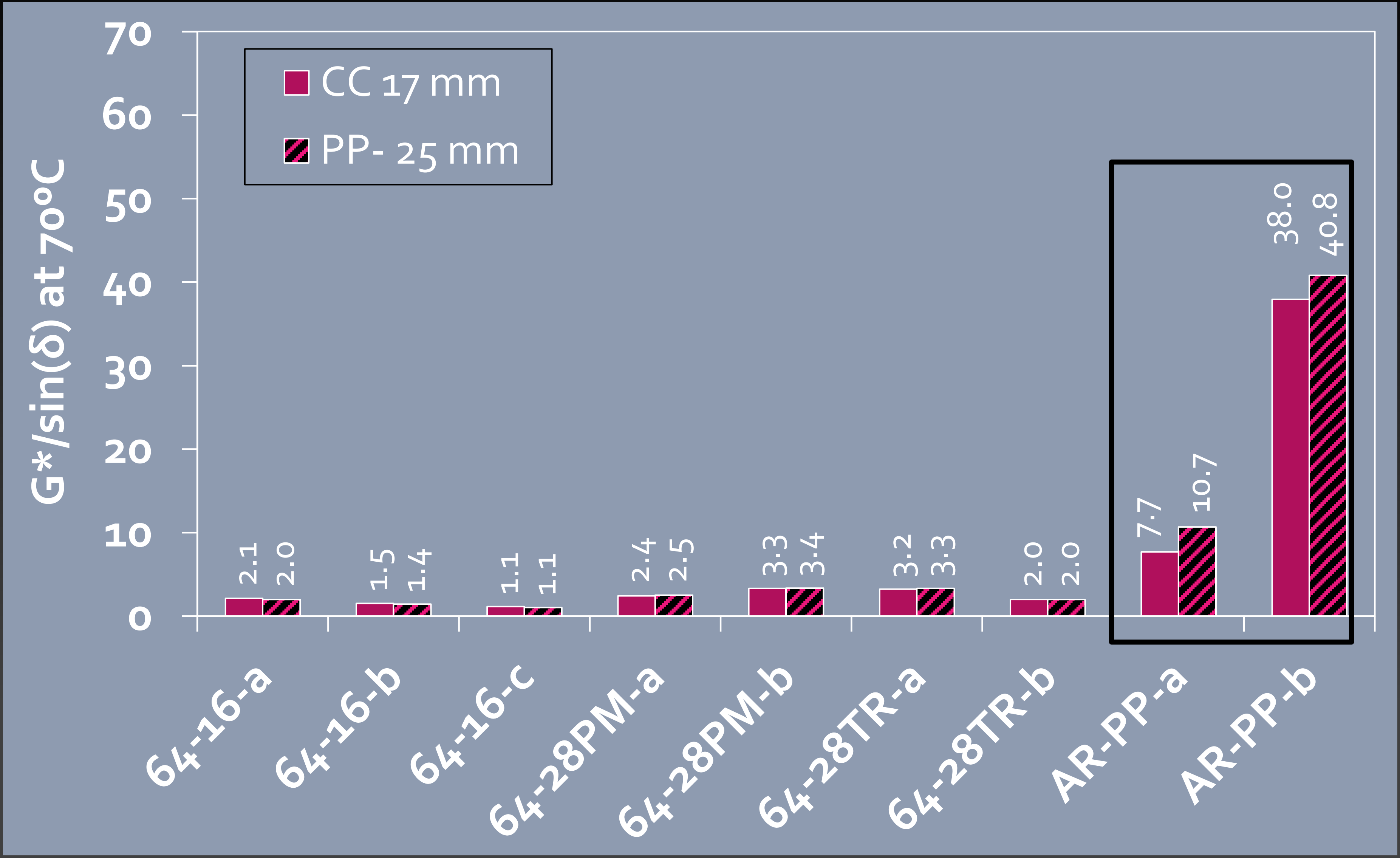
UCPRC

CC vs. PP (RTFO-Aged at 64°C)

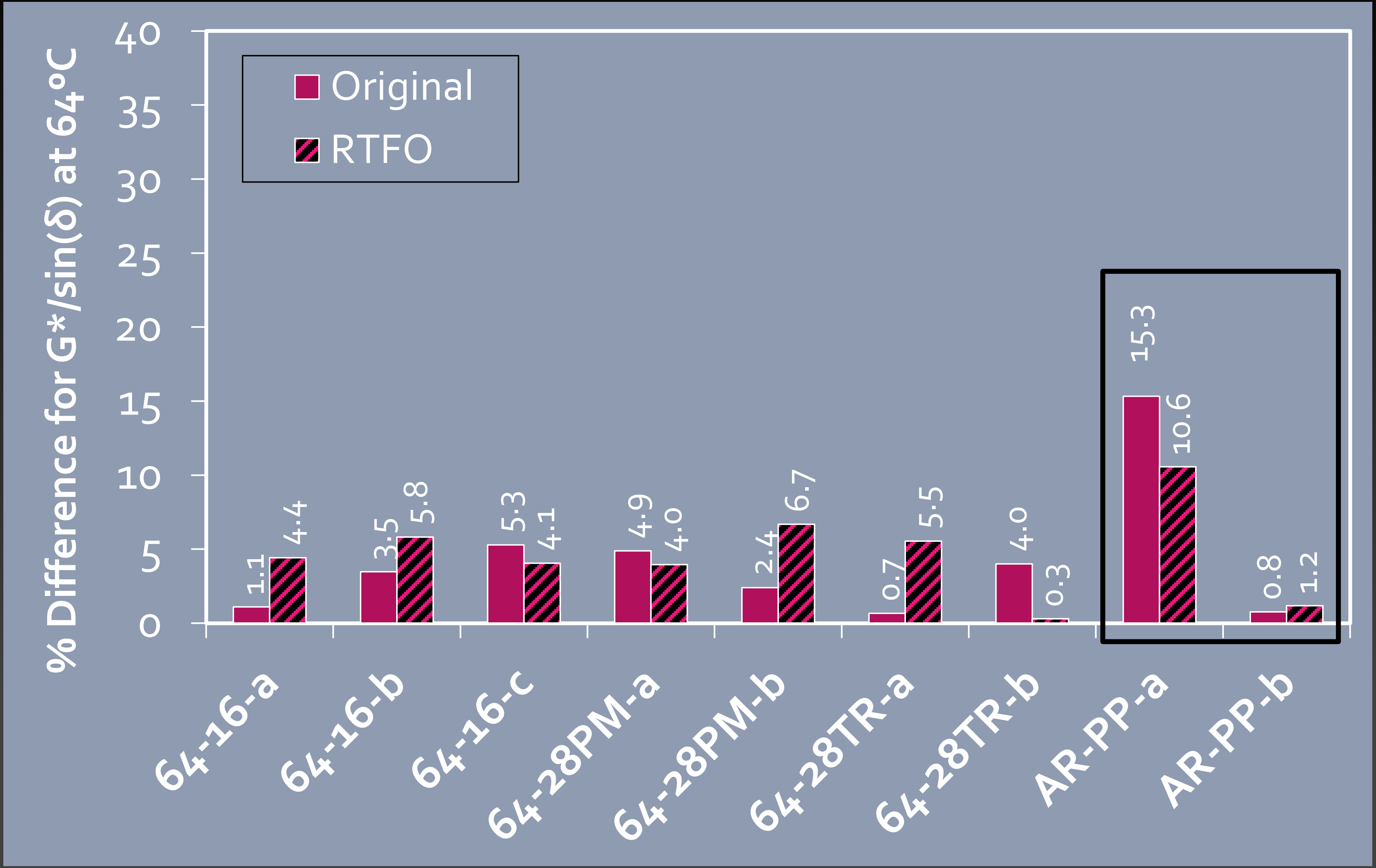


UCPRC

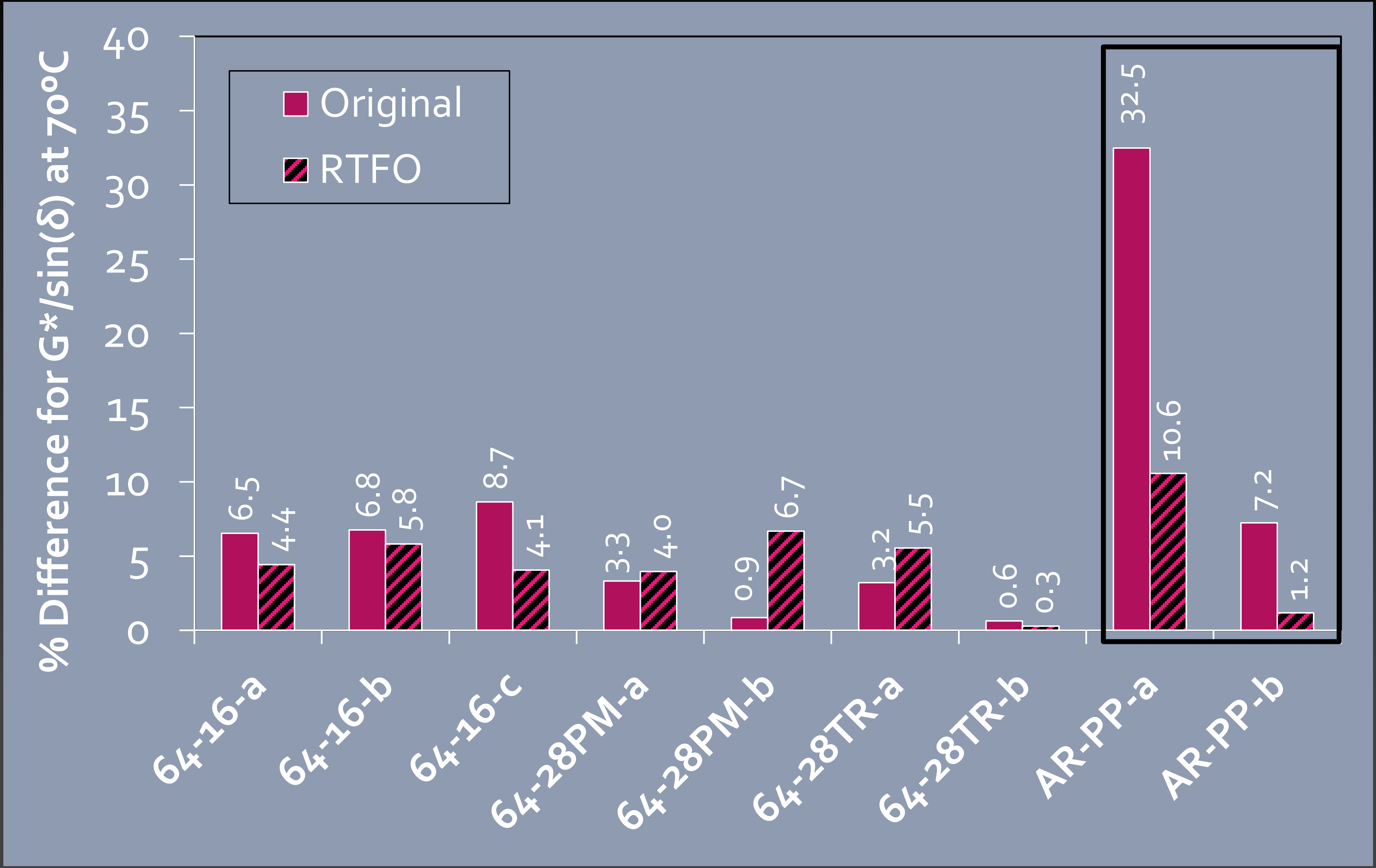
CC vs. PP (RTFO-Aged at 70°C)



CC vs. PP (% Difference @ 64°C)



CC vs. PP (% Difference @ 70°C)



Summary

- Key findings
  - Difference between CC and PP, as expected on 2 out of 5 samples
  - Difference/variability appears to depend on rubber particle size
- Likely recommendation
  - No recommendation until binder and mix testing is complete

Outline

- Background
- Short-term aging
- High temperature tests
- Intermediate temperature tests
- Low temperature tests
- Way forward

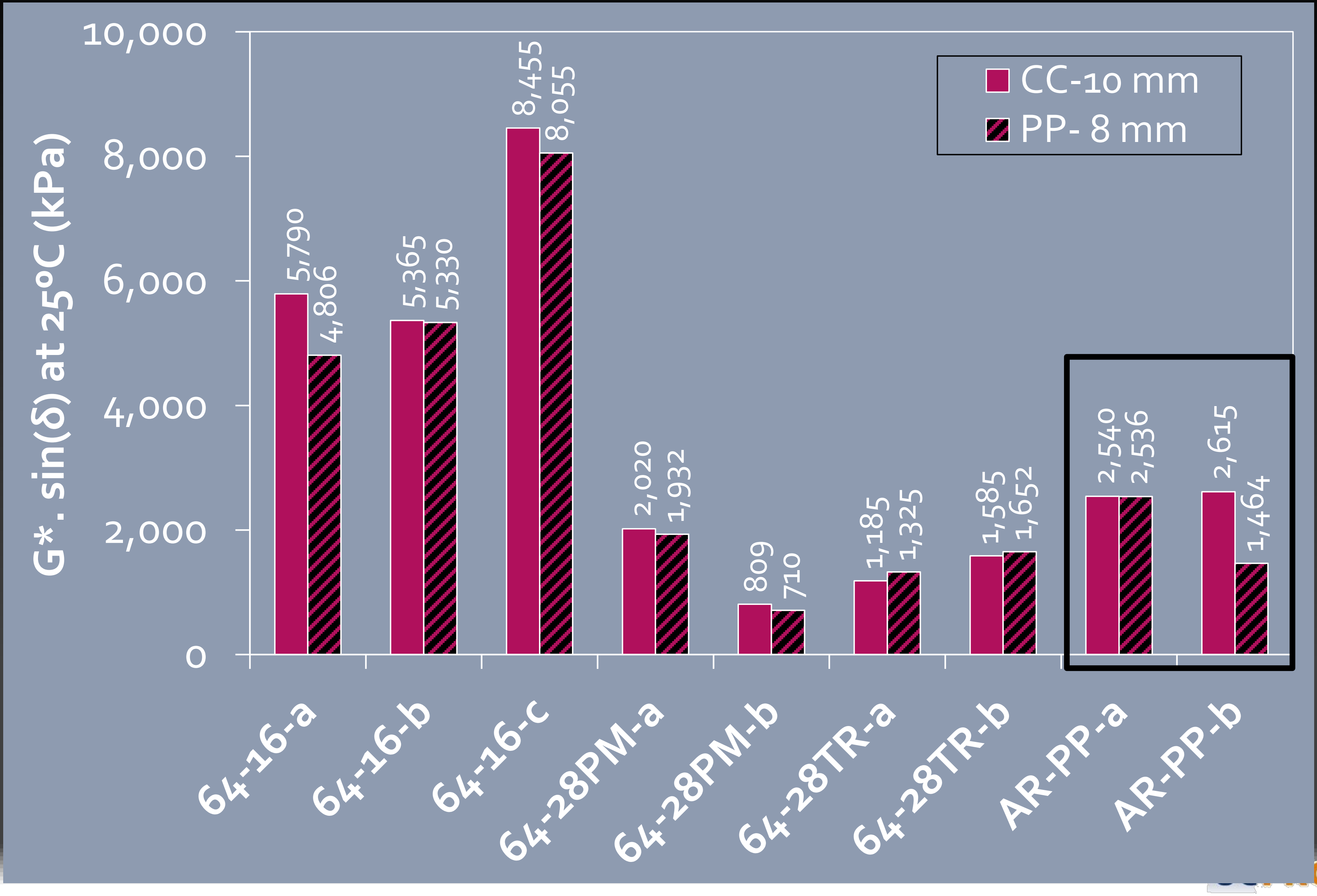
UCPRC

Intermediate Temperature Tests

- Modified concentric cylinder geometry based on study with Anton Paar
  - Spindle with 10 mm diameter
  - Test temperatures > 16°C (machine limits)
  - Tests are performed on RTFO+PAV aged binder
  - Separate study to check whether PAV test conditions (testing time, temperature, sample size, etc.) need to be adjusted to account for rubber particles

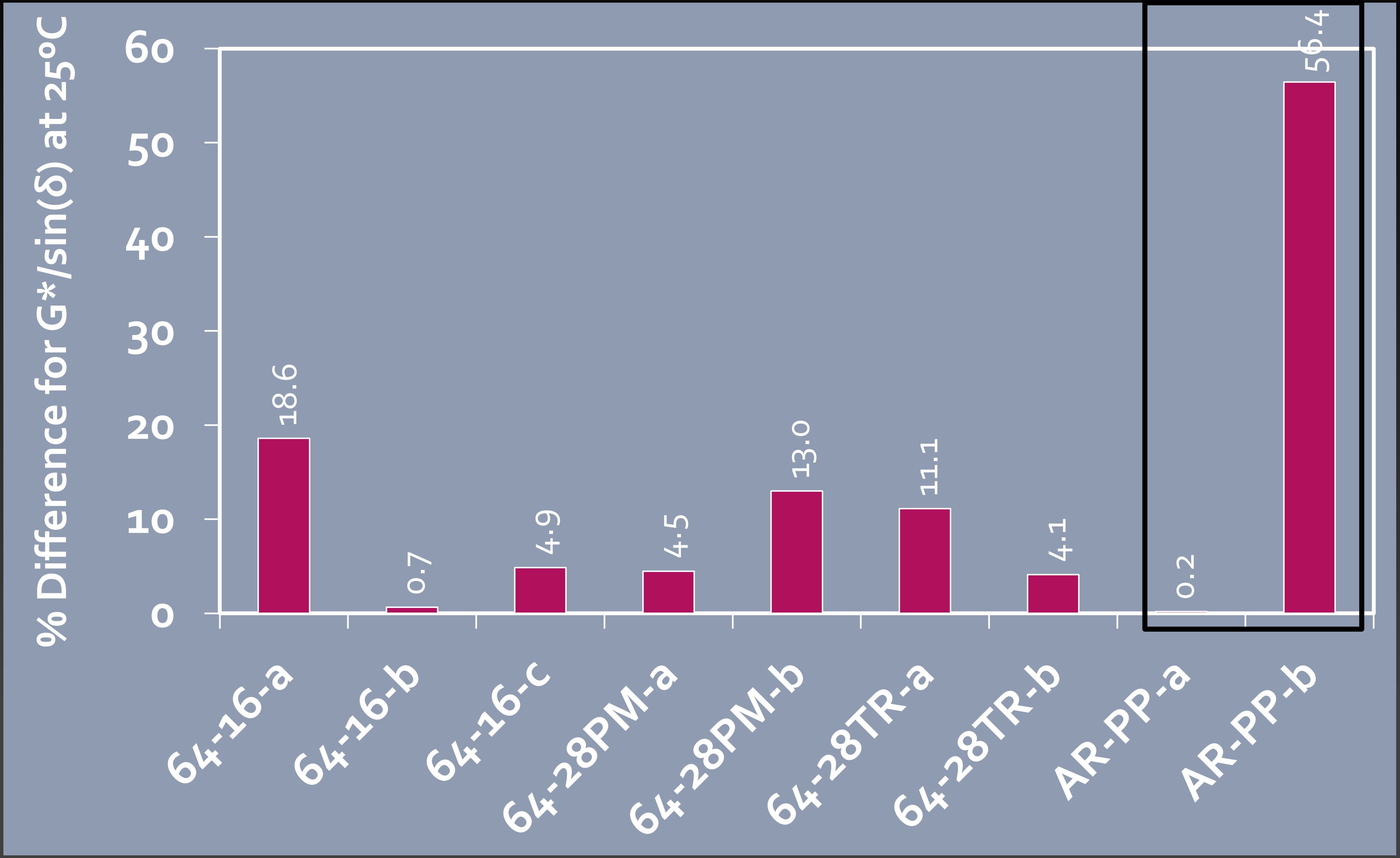
UCPRC

CC vs. PP (Aged)



G*. sin(δ) at 25°C (kPa)
10,000
8,000
6,000
4,000
2,000
0
CC-10 mm
PP- 8 mm
5,790
4,806
5,365
5,330
8,455
8,055
2,020
1,932
809
710
1,185
1,325
1,585
1,652
2,540
2,536
2,615
1,464
64-16-a
64-16-b
64-16-c
64-28PM-a
64-28PM-b
64-28TR-a
64-28TR-b
AR-PP-a
AR-PP-b

CC vs. PP (Percent Difference)



UCPRC

Summary

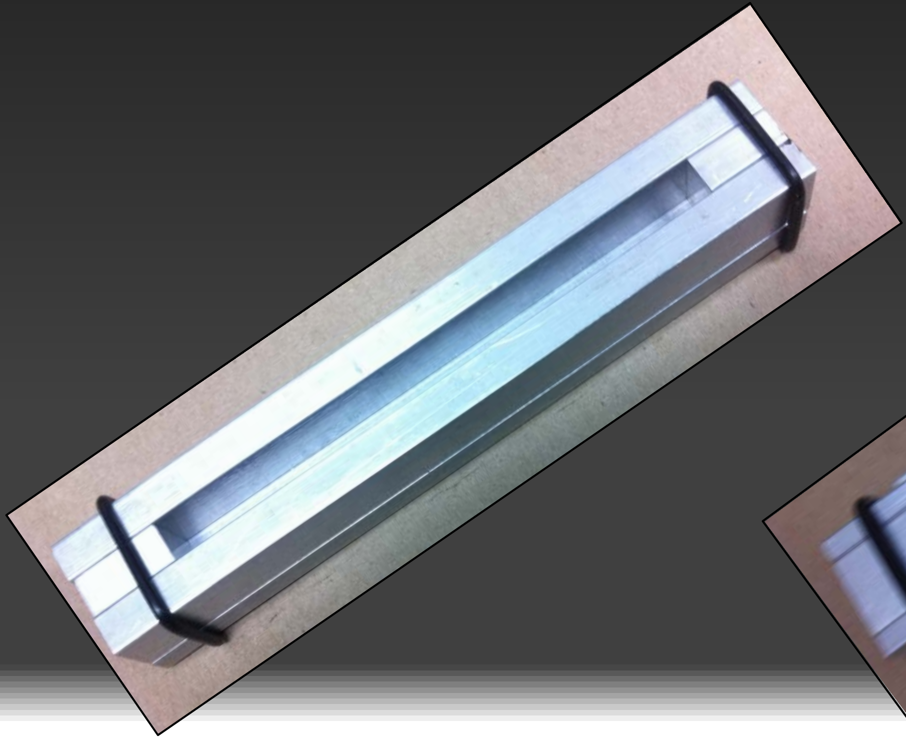
- Key findings
  - Difference between CC and PP on all binders tested
    - Shrinkage, confinement in CC?
    - Trimming in PP?
  - Further testing required before conclusions can be drawn
  - Refinement of test method may be required
- Likely recommendation
  - No recommendation until binder and mix testing is complete

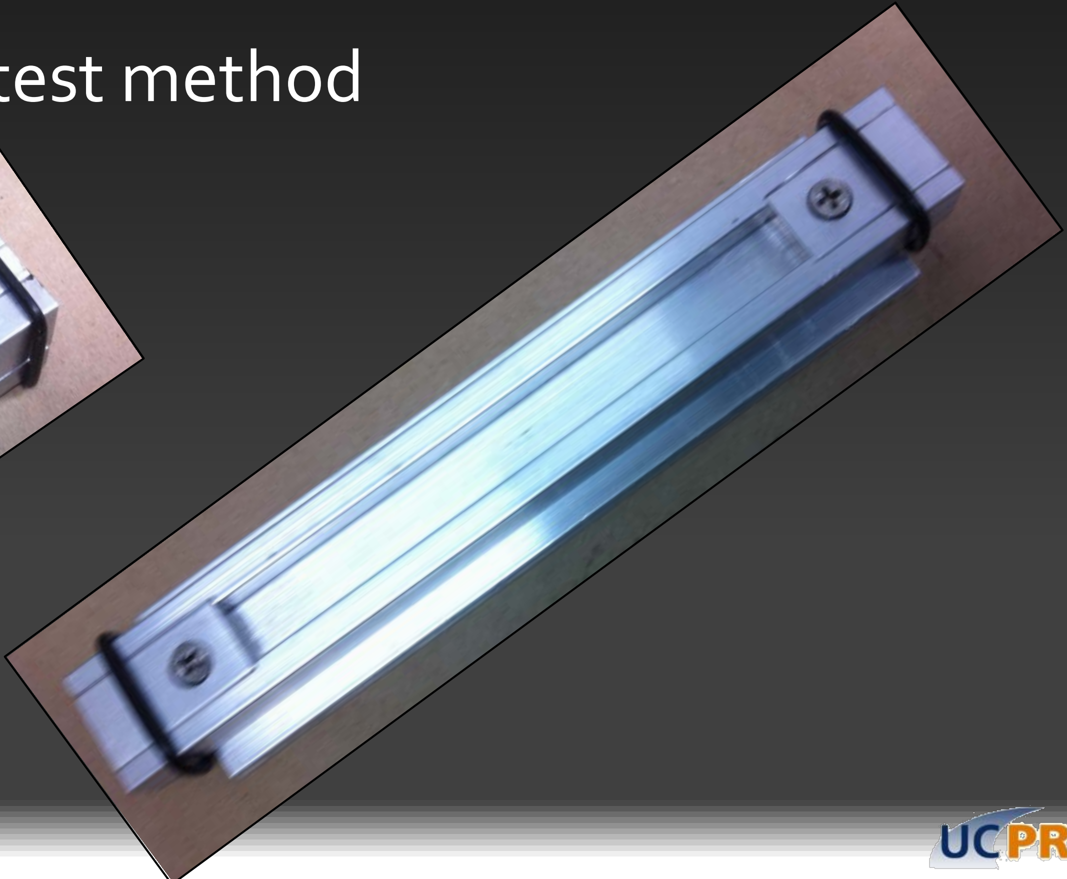
Outline

- Background
- Short-term aging
- High temperature tests
- Intermediate temperature tests
- Low temperature tests
- Way forward

Low Temperature Tests

- Test method modification
  - Use modified BBR mold to remedy issues associated with pouring the AR binder and preparing a uniformly shaped beam
  - Use revised RTFO test method





Standard Mold

Modified Mold

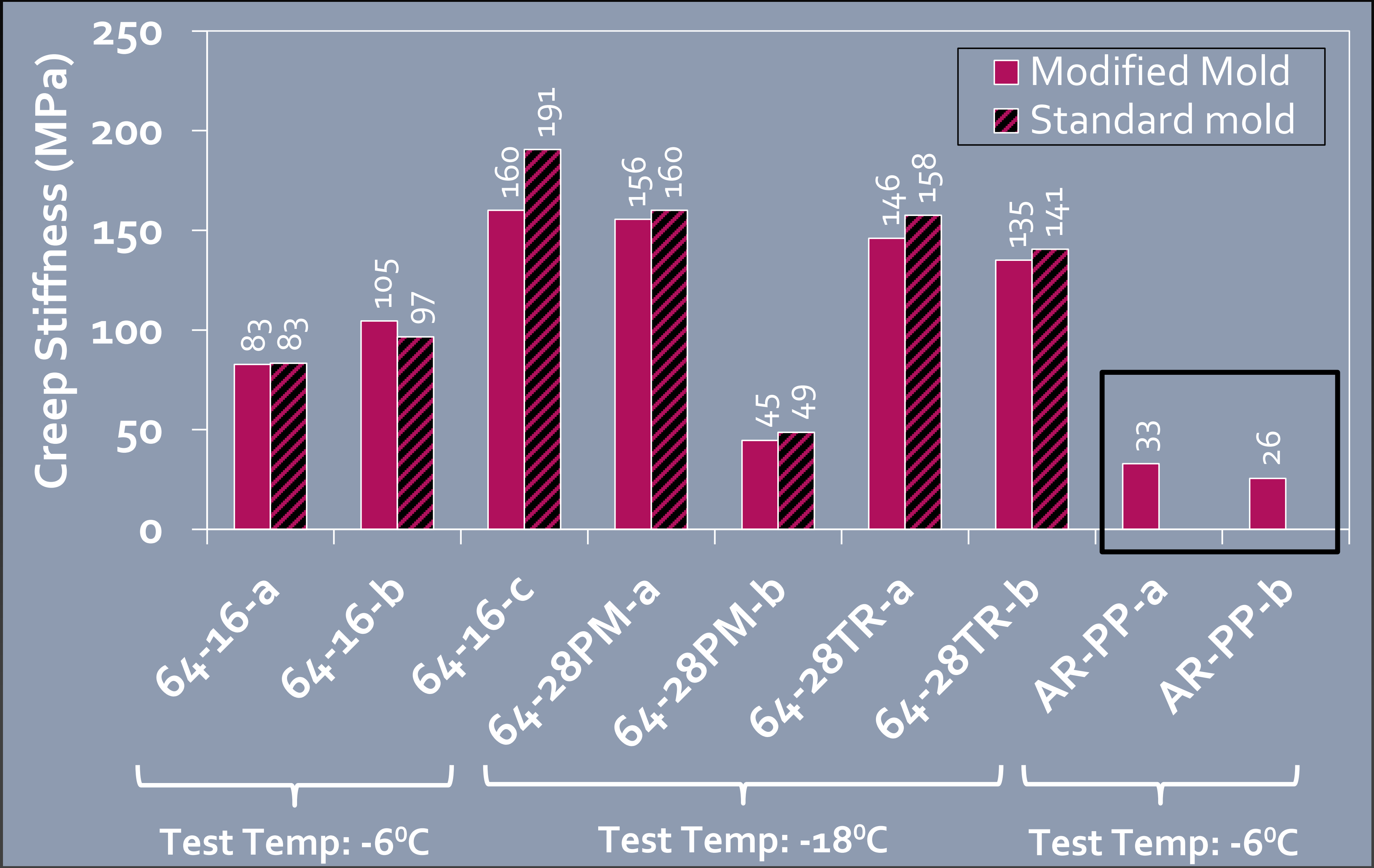
UCPRC

Modified Mold

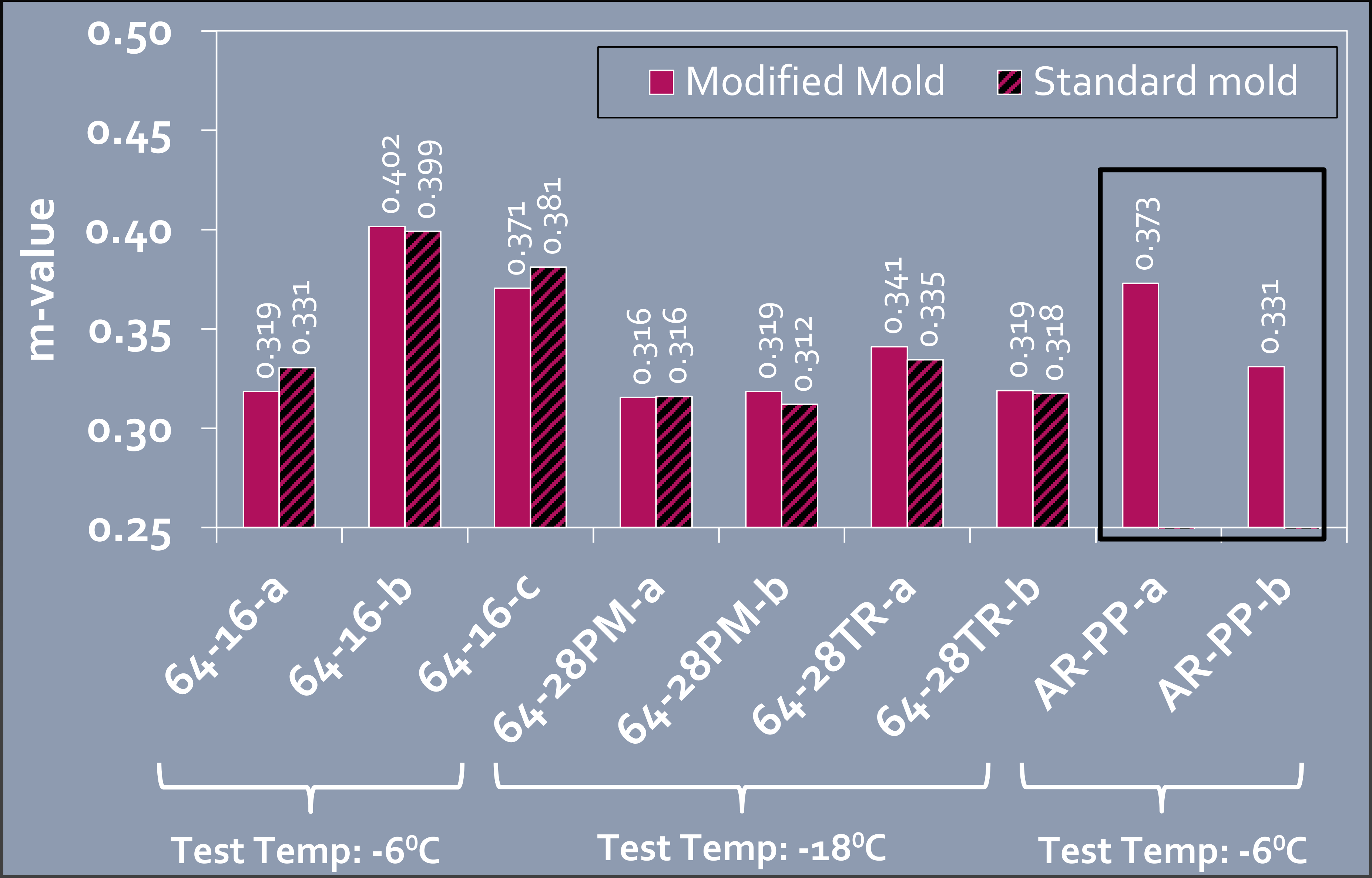
Standard mold

Modified mold

Mod. vs. Std. (Creep Stiffness)



Modified vs. Std. (m-value)



UCPRC

Summary

- Key findings
  - Modified mold much easier to use and it produces better quality specimens than conventional mold
  - Results appear to be realistic
- Likely recommendation
  - Consider modified mold for AR binders

Outline

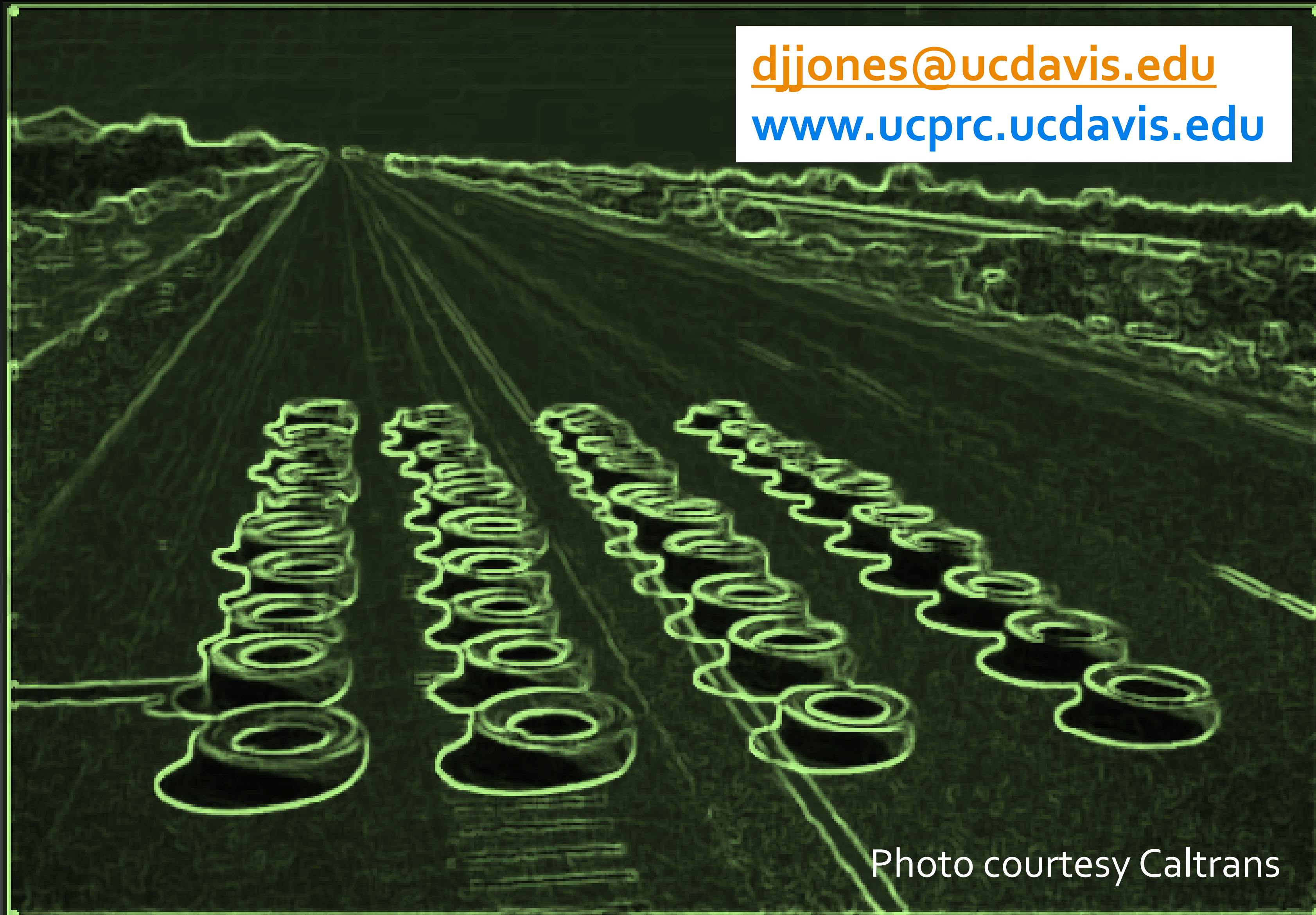
- Background
- Short-term aging
- High temperature tests
- Intermediate temperature tests
- Low temperature tests
- Way forward

UCPRC

Way Forward…

- Complete testing of plant-produced AR binders and mixes (3 complete, 2 in progress)
- Compare performance-related properties of mixes with rheological properties of their corresponding binders (3 complete, 2 in progress)
- Evaluate PG grading criteria for AR binders (i.e., what do the numbers mean?)
- Report, provisional test methods, interpretation, and suggested specification language (Sept. 2017)

Thank-you



djjones@ucdavis.edu
www.ucprc.ucdavis.edu

Photo courtesy Caltrans