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COMPLEJO FERIAL CÓRDOBA - CIUDAD DE CÓRDOBA . ARGENTINA

Recycled Asphalt Pavement

Gerald Huber
Heritage Research Group

IX CONGRESO INTERNACIONAL ITS
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SEMINARIO INTERNACIONAL DE PAVIMENTOS DE HORMIGÓN

www.congresodevialidad.org.ar

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Two Objectives

Effect of Reclaimed Asphalt on Mixture Properties

How much RAP can be put through plant?

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Historical Review

Where have we been?

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1970s and 1980s

- High percentages of recycled asphalt used
  - 50 to 80%
- Hot Mix acceptance based on
  - Bitumen content
  - Gradation
- Air voids typically not measured

Strategic Highway Research Program

- Superpave developed
- No clear guidance for recycled asphalt

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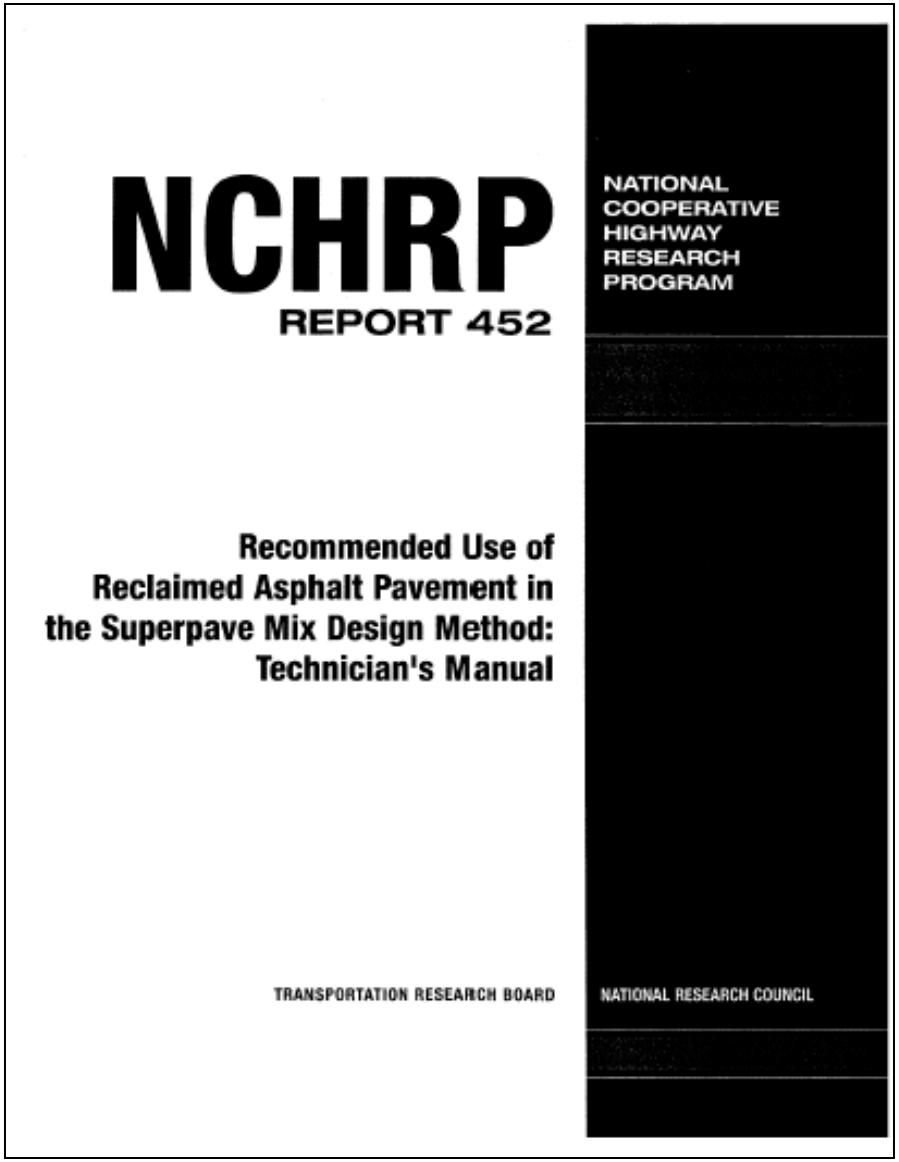
Mix Design Guidelines

- AASHTO Specification Based on NCHRP Research Project (late 1990s)



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AASHTO SPECIFICATIONS

- 0 to 15% No change in base bitumen grade
- 15 to 25% Reduce one grade
- >25% Bitumen evaluation (recovery, blending, etc.)

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FIELD EXPERIENCE

- <15% most common
- >15% brings increased cost
  (PG 58-28 instead of PG 64-22)
- >25% almost never used
  Extraction and recovery too cumbersome

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FIELD EXPERIENCE cont'd

- Commercial Mixes
  - Commonly 30% RAP
  - Sometimes 40% RAP

- Acceptable performance

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Research on Mixes from Hot Mix Plants

- Used existing design
- Designed five additional mixes
- Tested properties of materials used
  - RAP
  - New aggregates
  - Asphalt mixture properties
  - Bitumen

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Experimental Design

	RAP			
Bitumen Grade	0%	15%	25%	40%
PG 64-22	X Mix A	X Mix B	X Mix C	X Mix D
PG 58-28			X Mix E	X Mix F

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Hot Mix Plant

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Fine RAP

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Coarse RAP

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Samples Taken from Truck


Samples

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North Central Superpave Center Tests

- Stiffness of Bitumen
- Dynamic Modulus, E*
- Indirect Tensile Creep
  - Low Temperature Cracking
- Study included five hot mix plants

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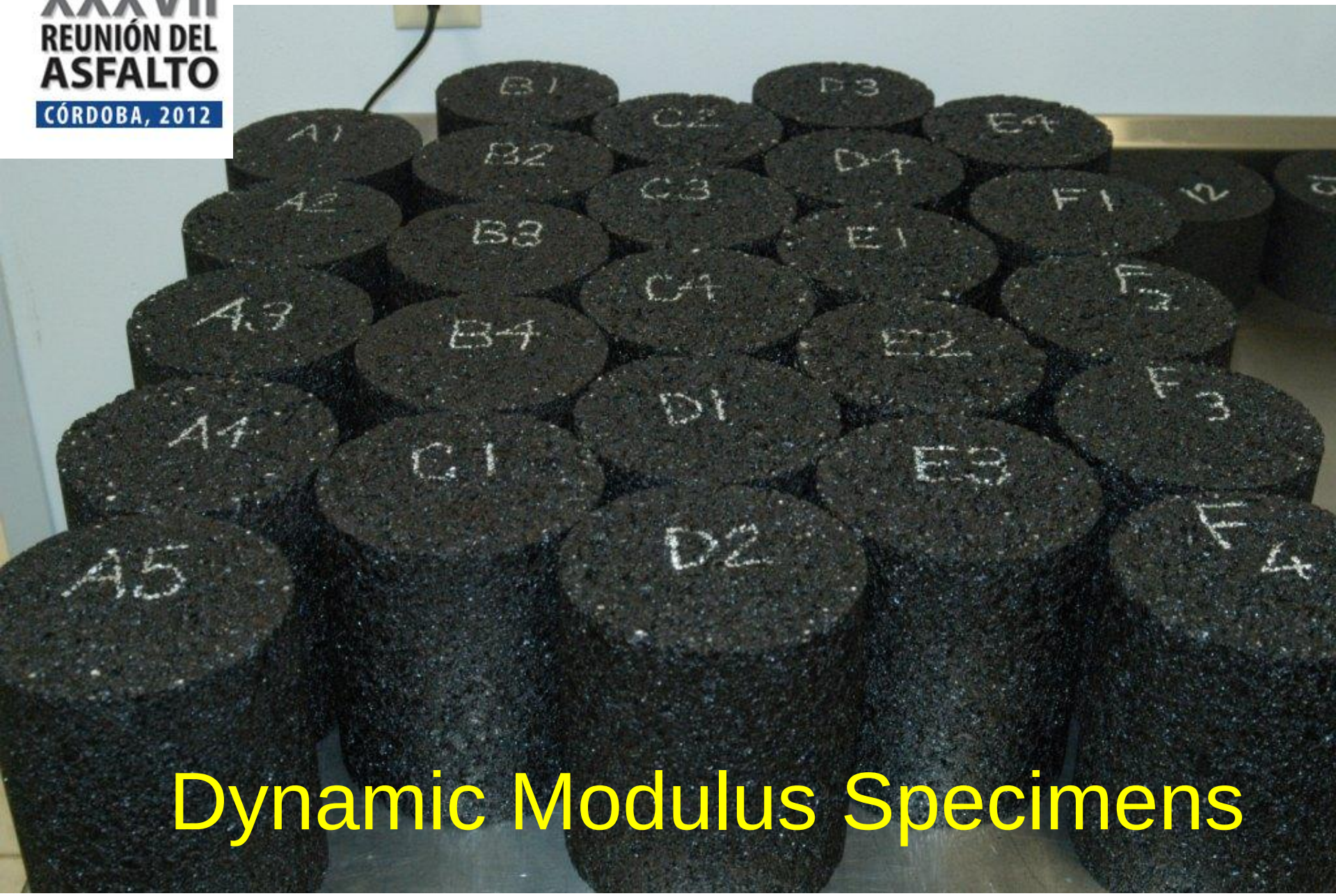

Dynamic Modulus Specimens

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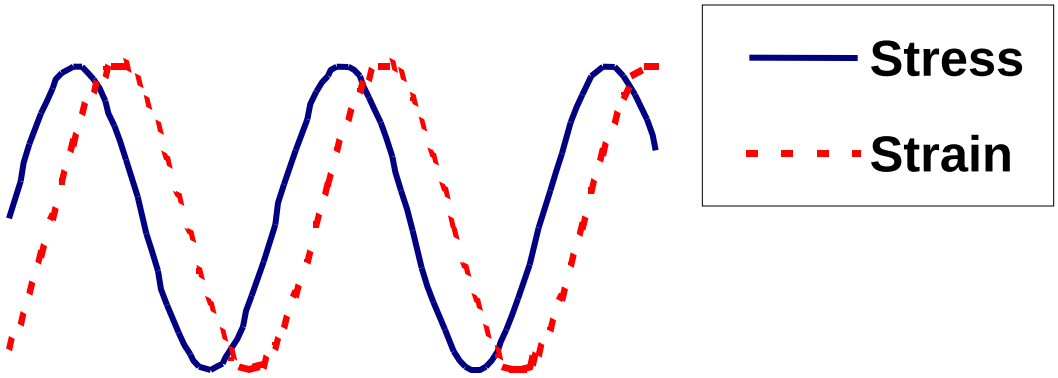
Dynamic Modulus Test



$$|E^*| = \frac{\sigma_0}{\varepsilon_0}$$

- Stiffness of Hot Mix Asphalt

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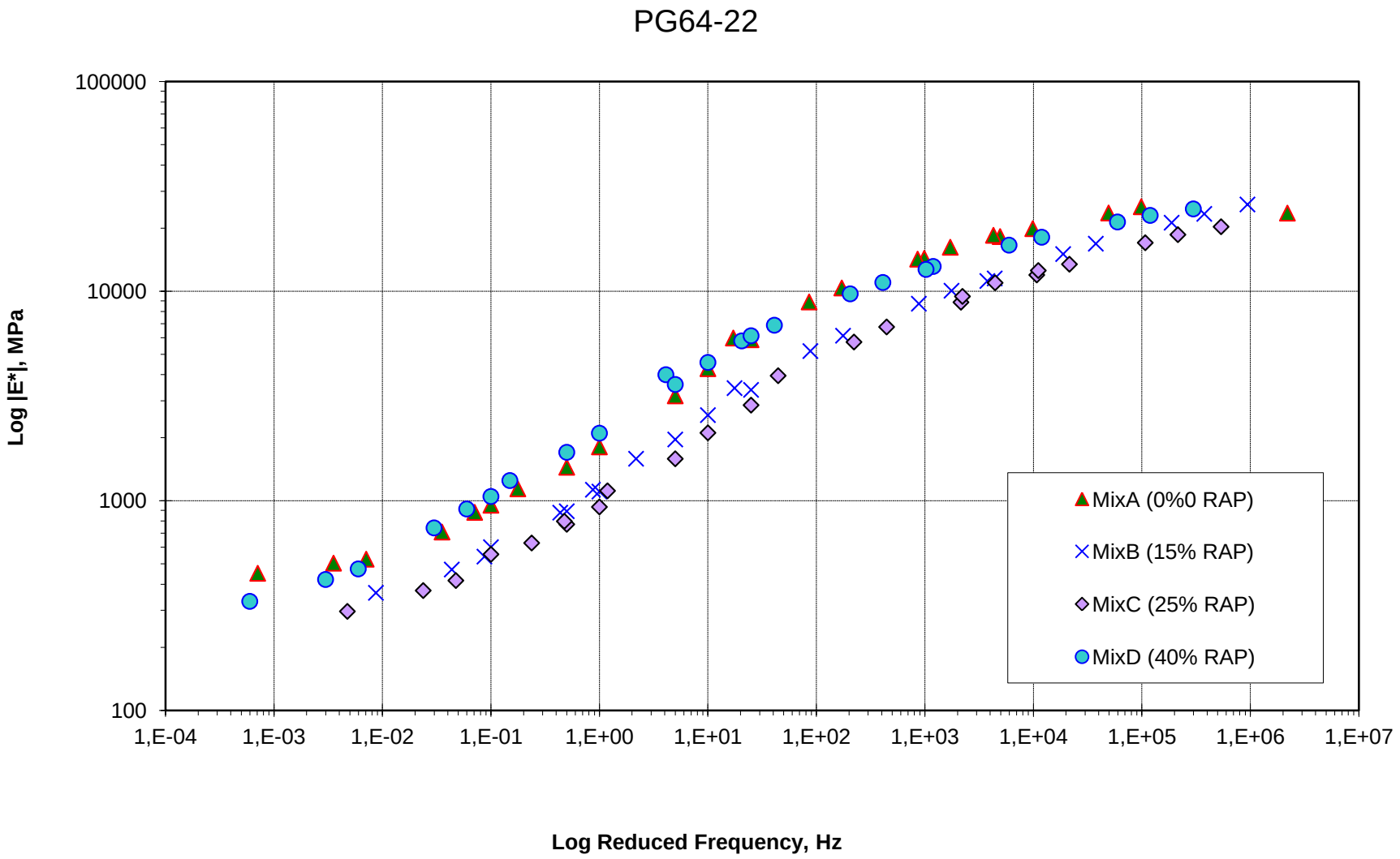
MS PG 64-222 Mix (E*)



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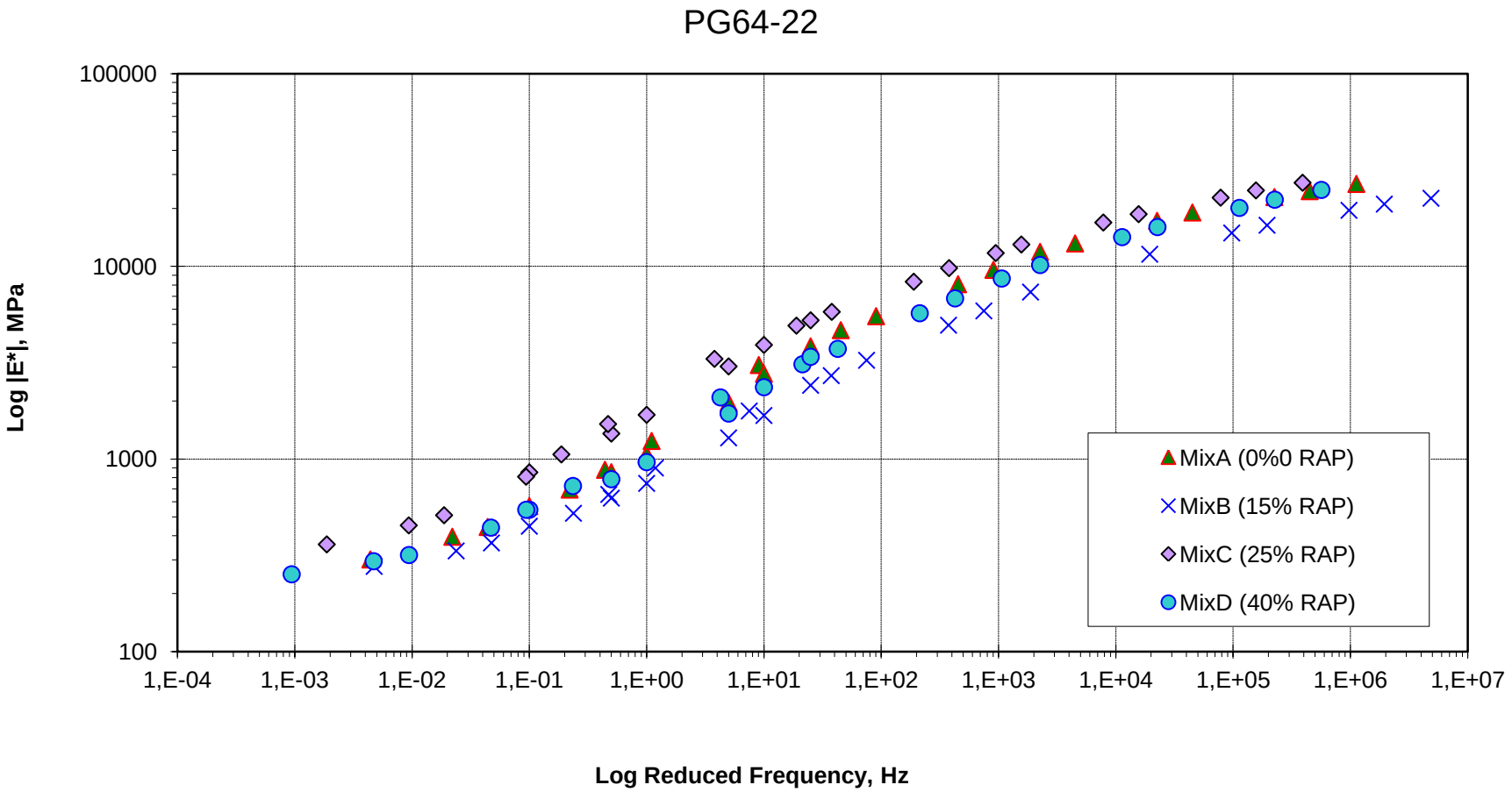
E&B PG 64-22 Mix (E*)



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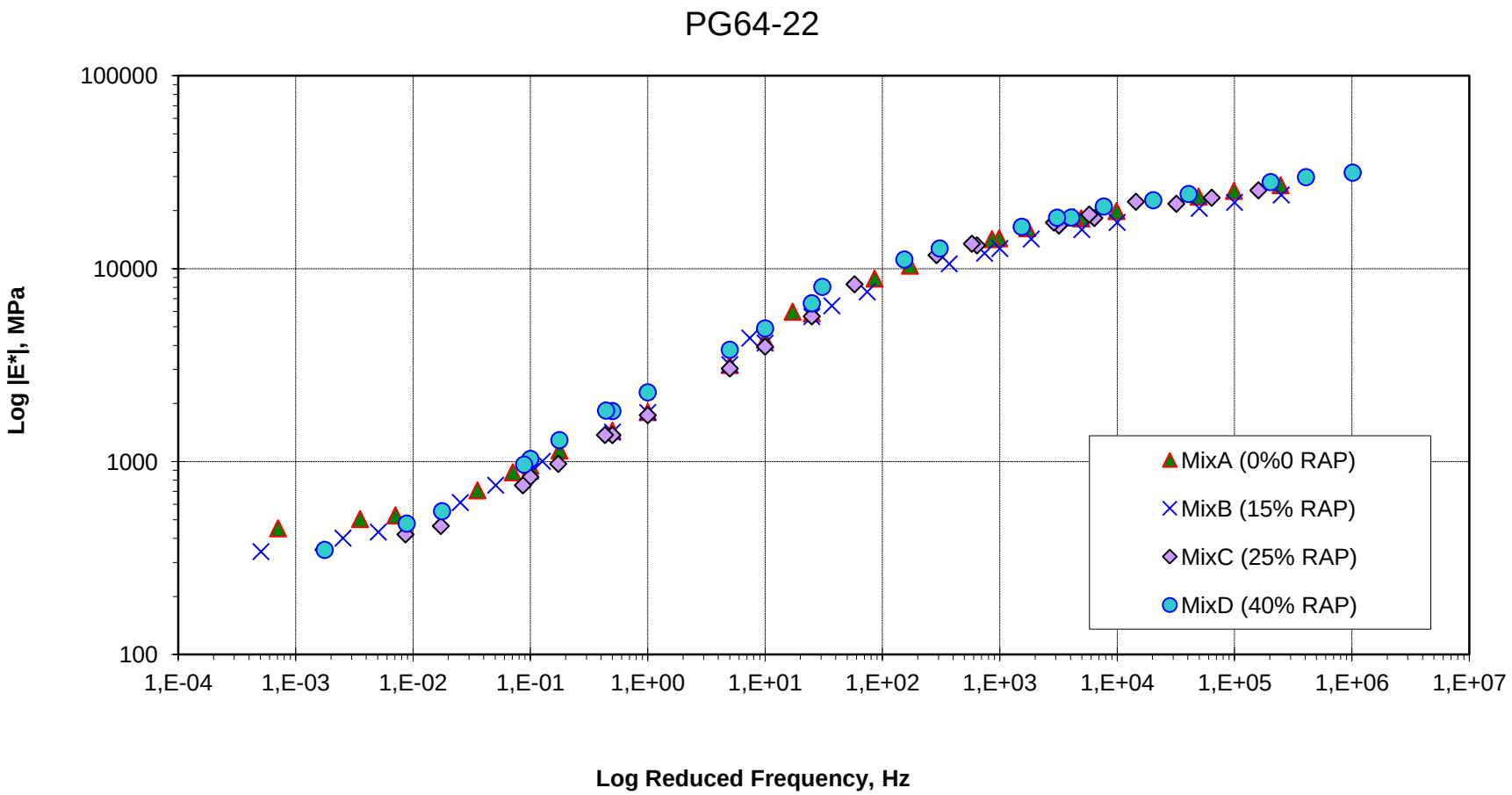
JHR PG 64-22 Mix (E*)



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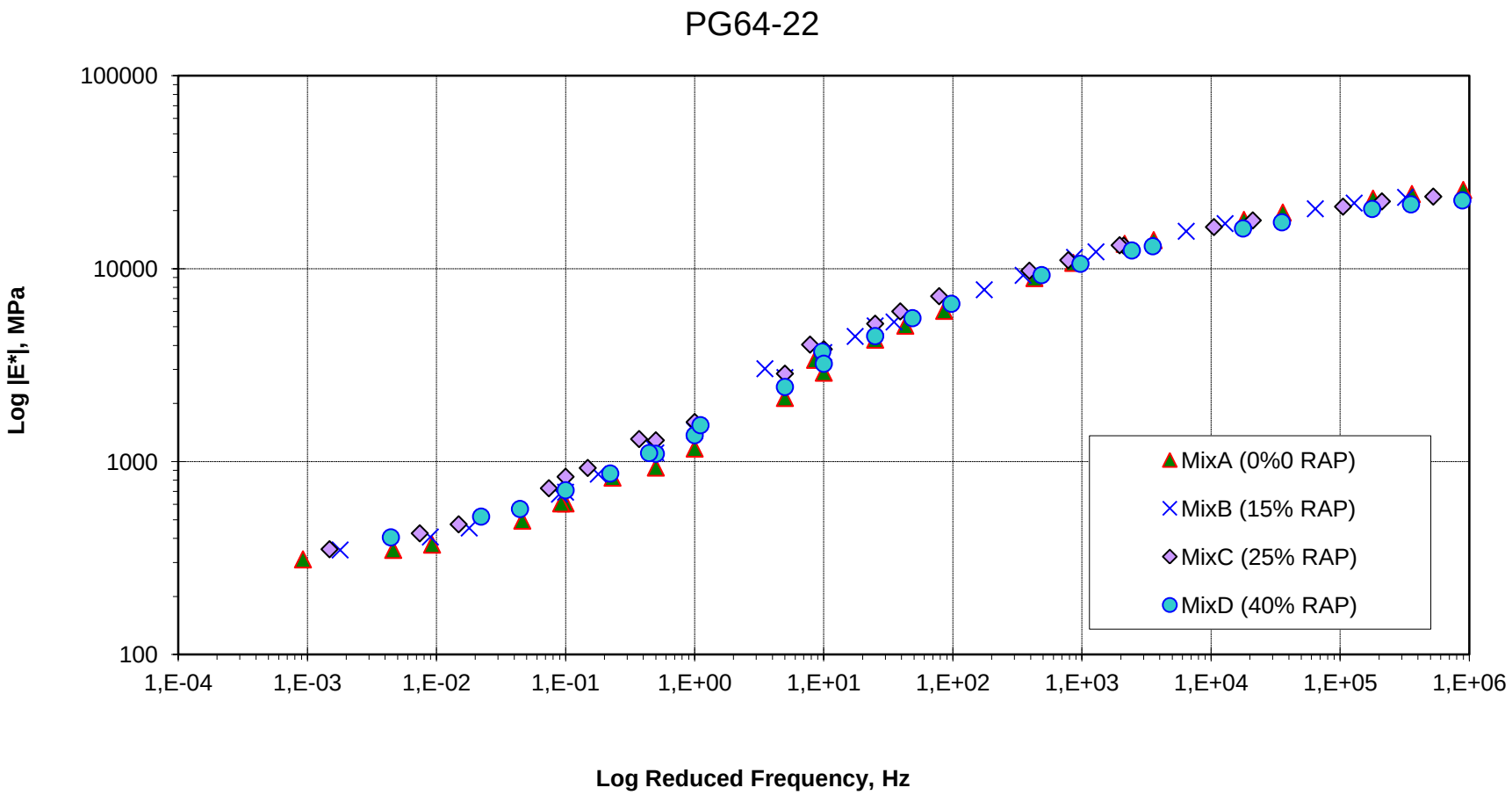
P&B PG 64-22 Mix (E*)



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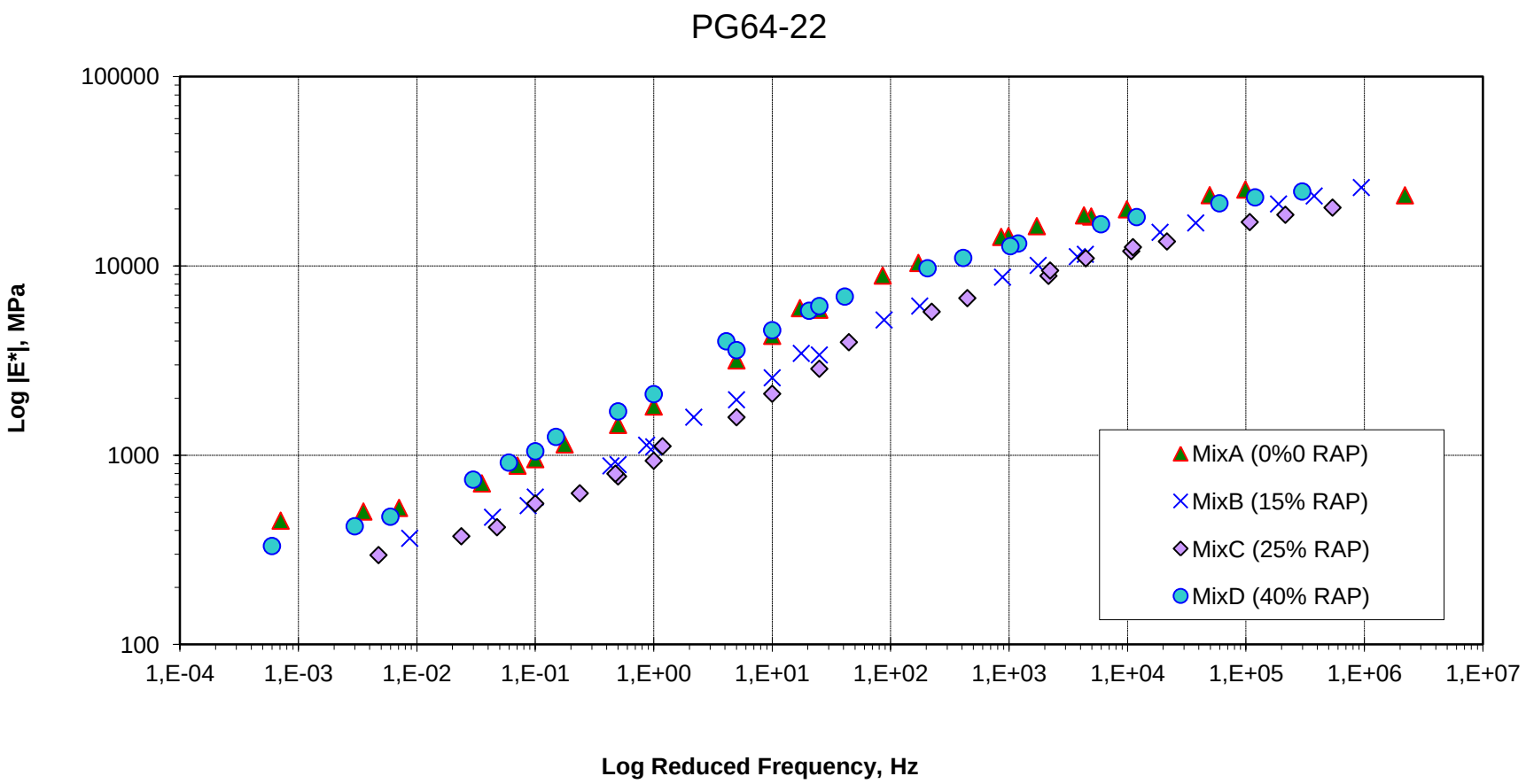
RR PG 64-22 Mix (E*)



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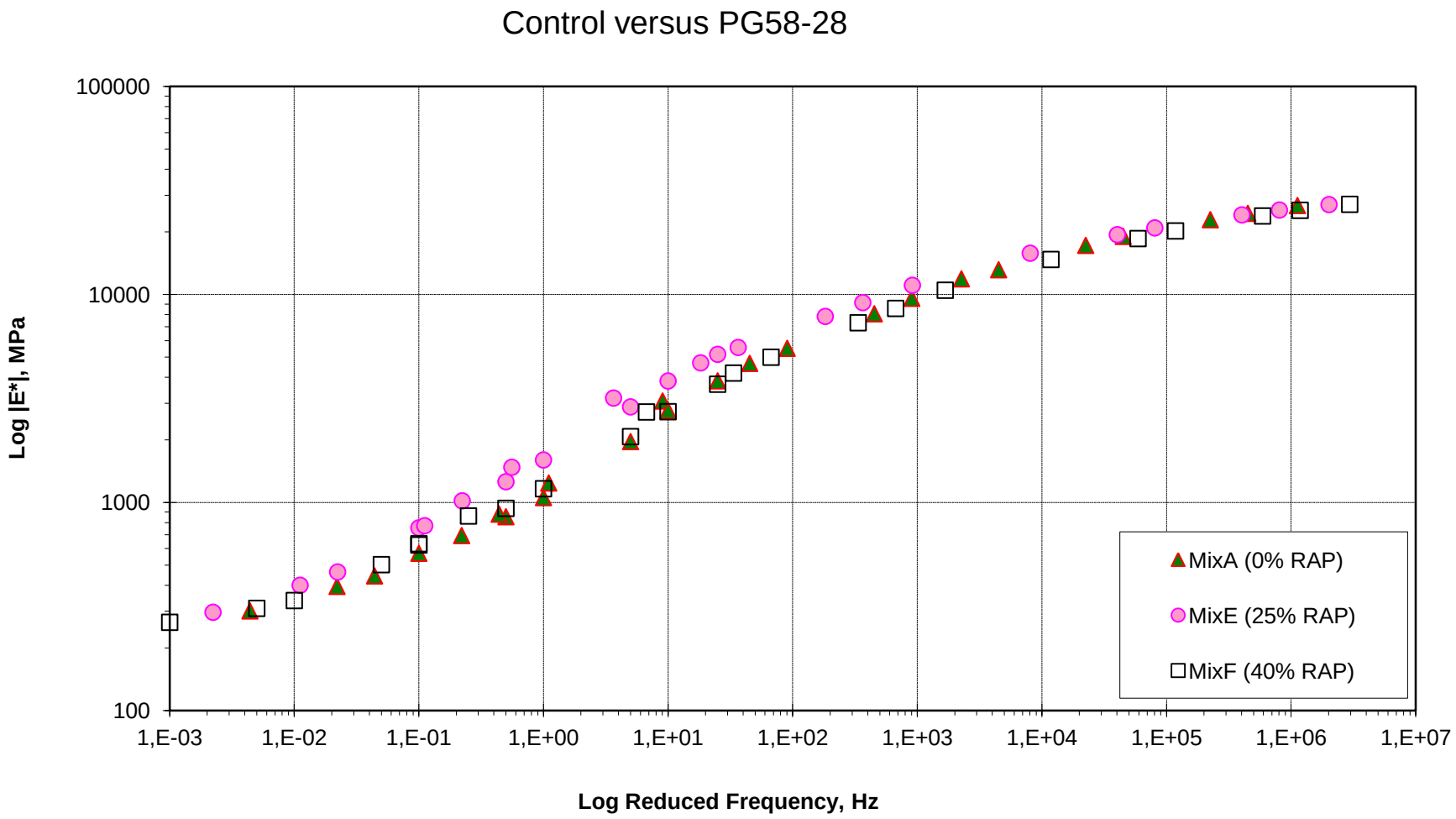
E&B PG 58-28 Mix (E*)



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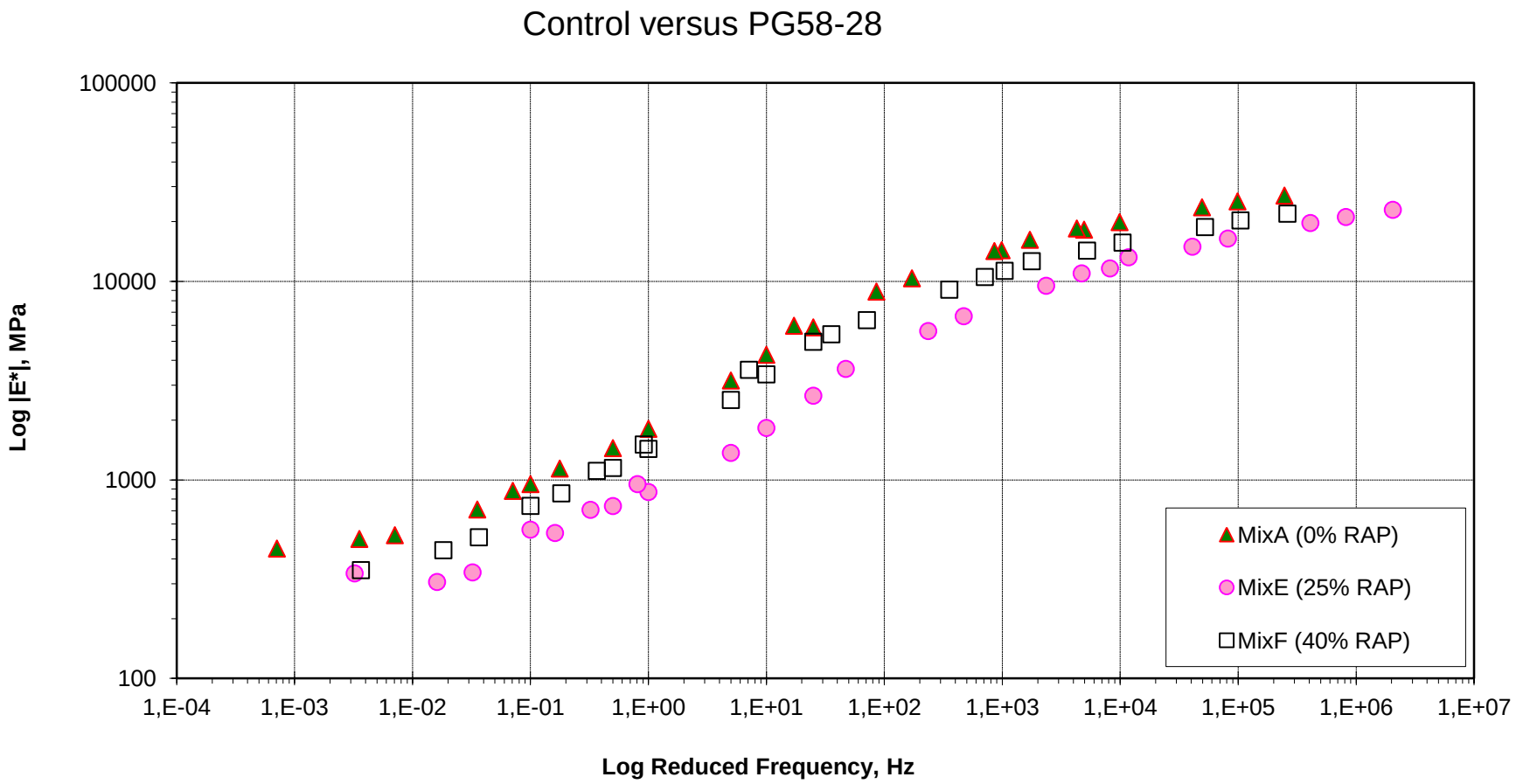
JHR PG 58-28 Mix (E*)



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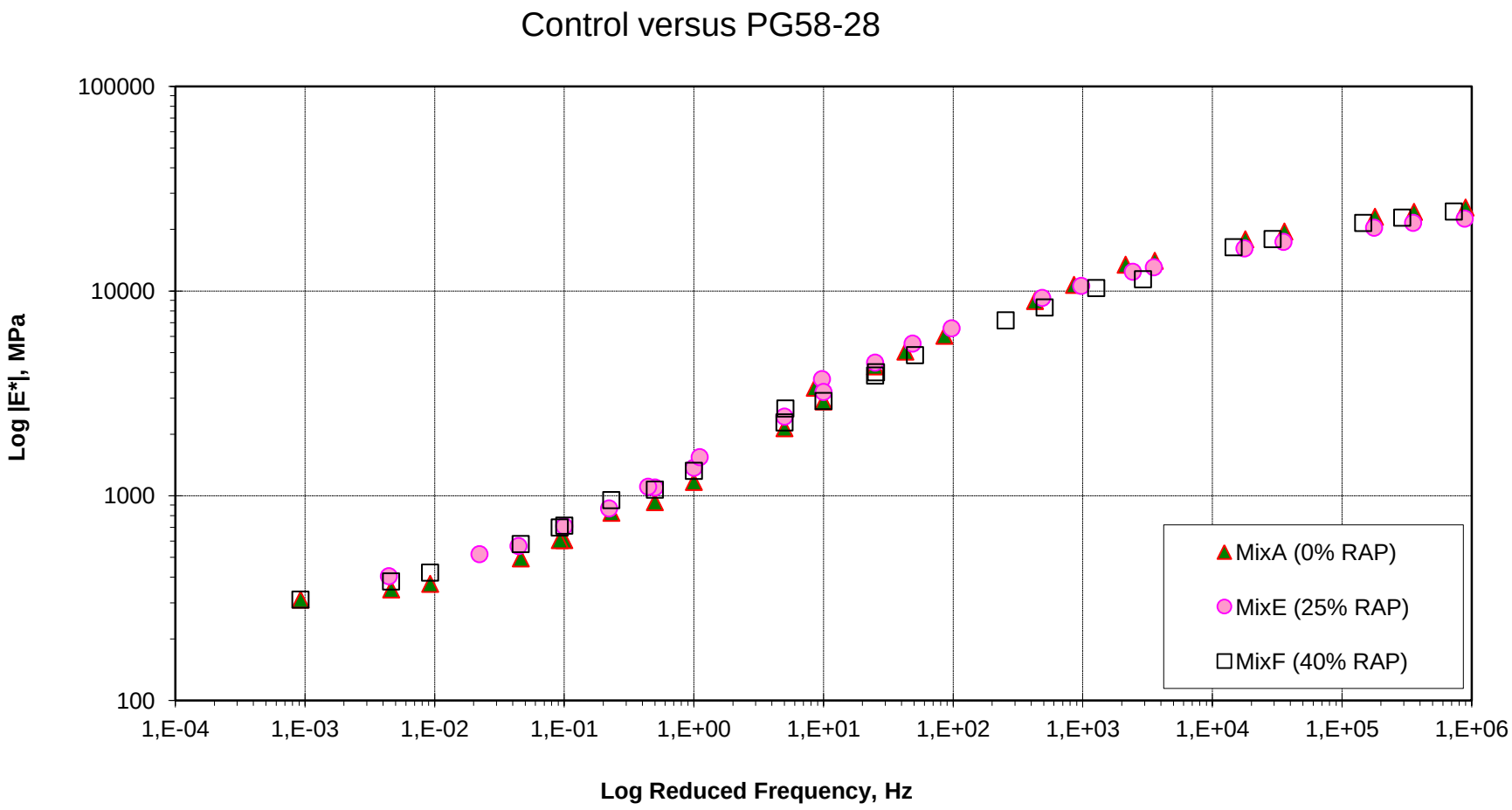
P&B PG 58-28Mix (E*)



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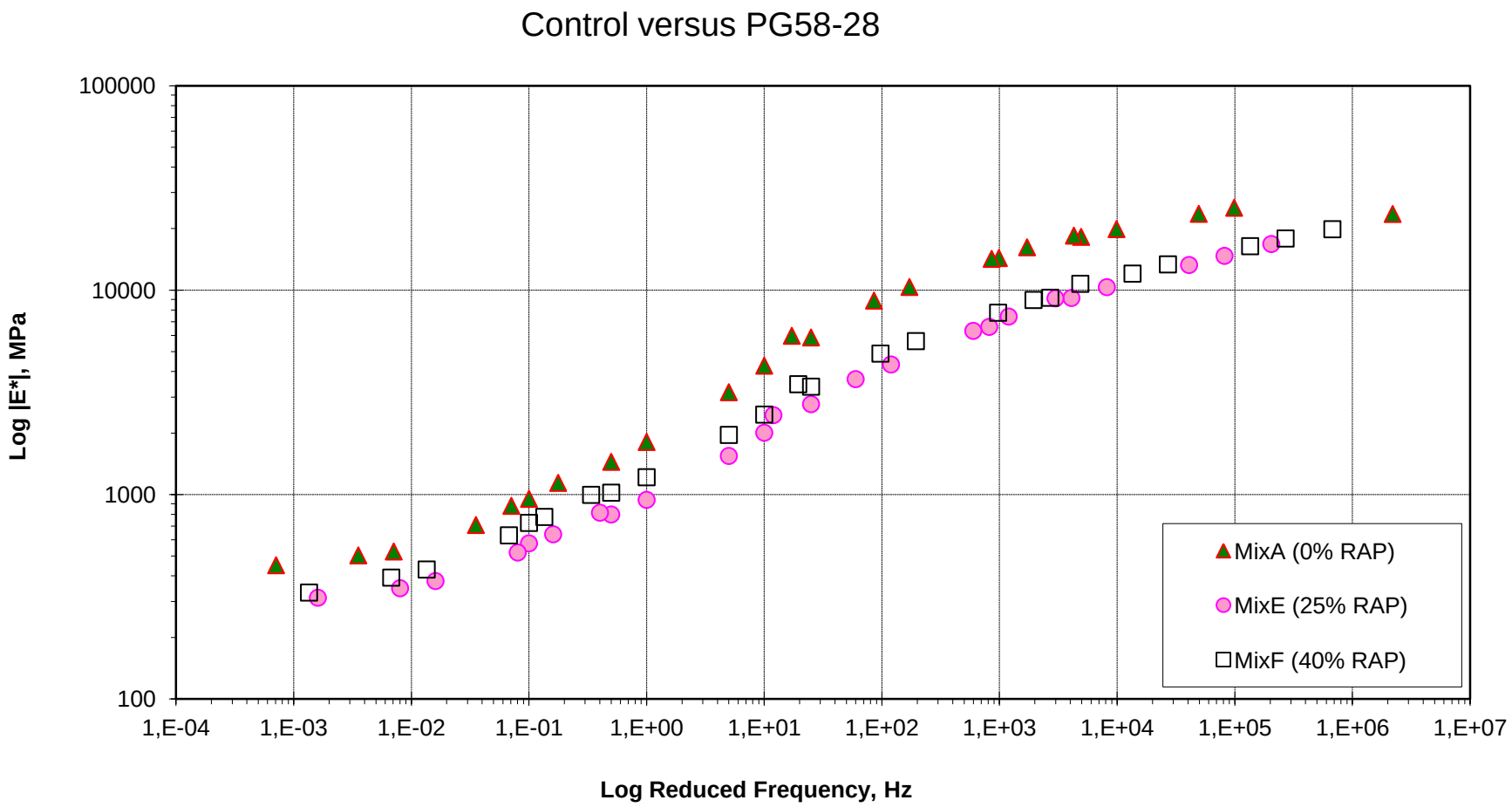
RR PG 58-28 Mix (E*)



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Mix Not Hardening As Much As Expected

But, what about cracking??

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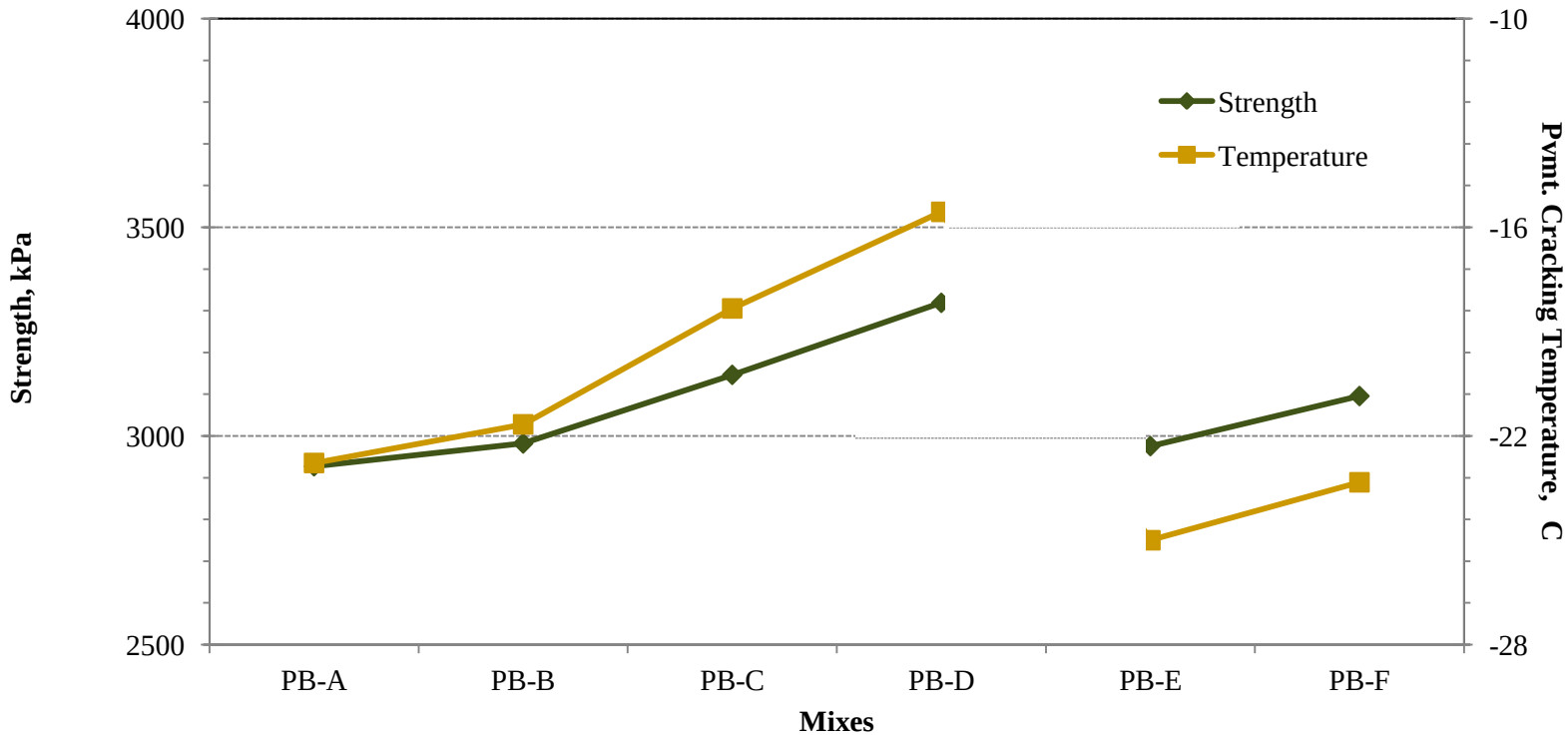
Indirect Tensile Strength Example 1



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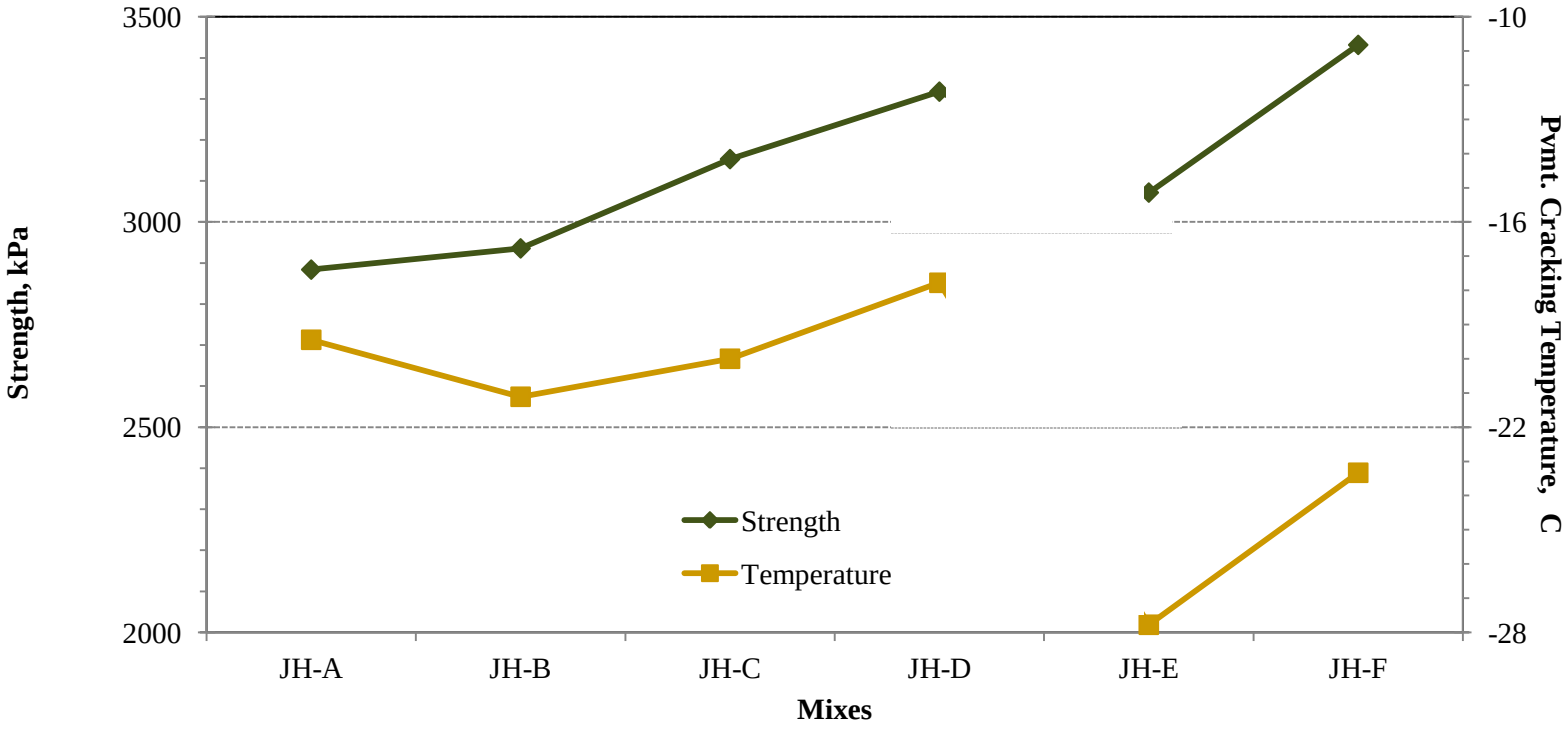
Indirect Tensile Strength Example 2



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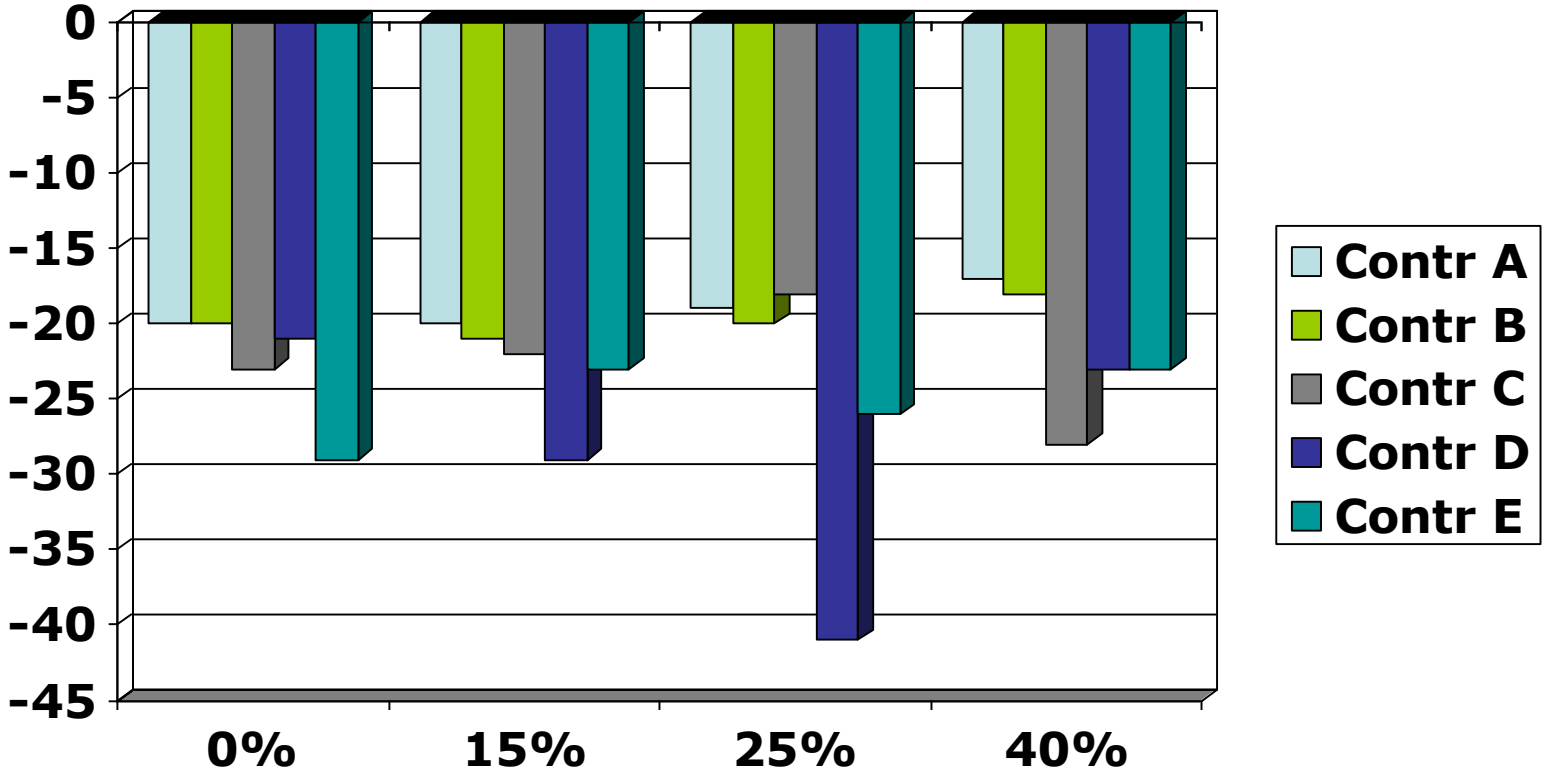
Low Temperature Cracking PG 64-22



Data from North Central Superpave Center

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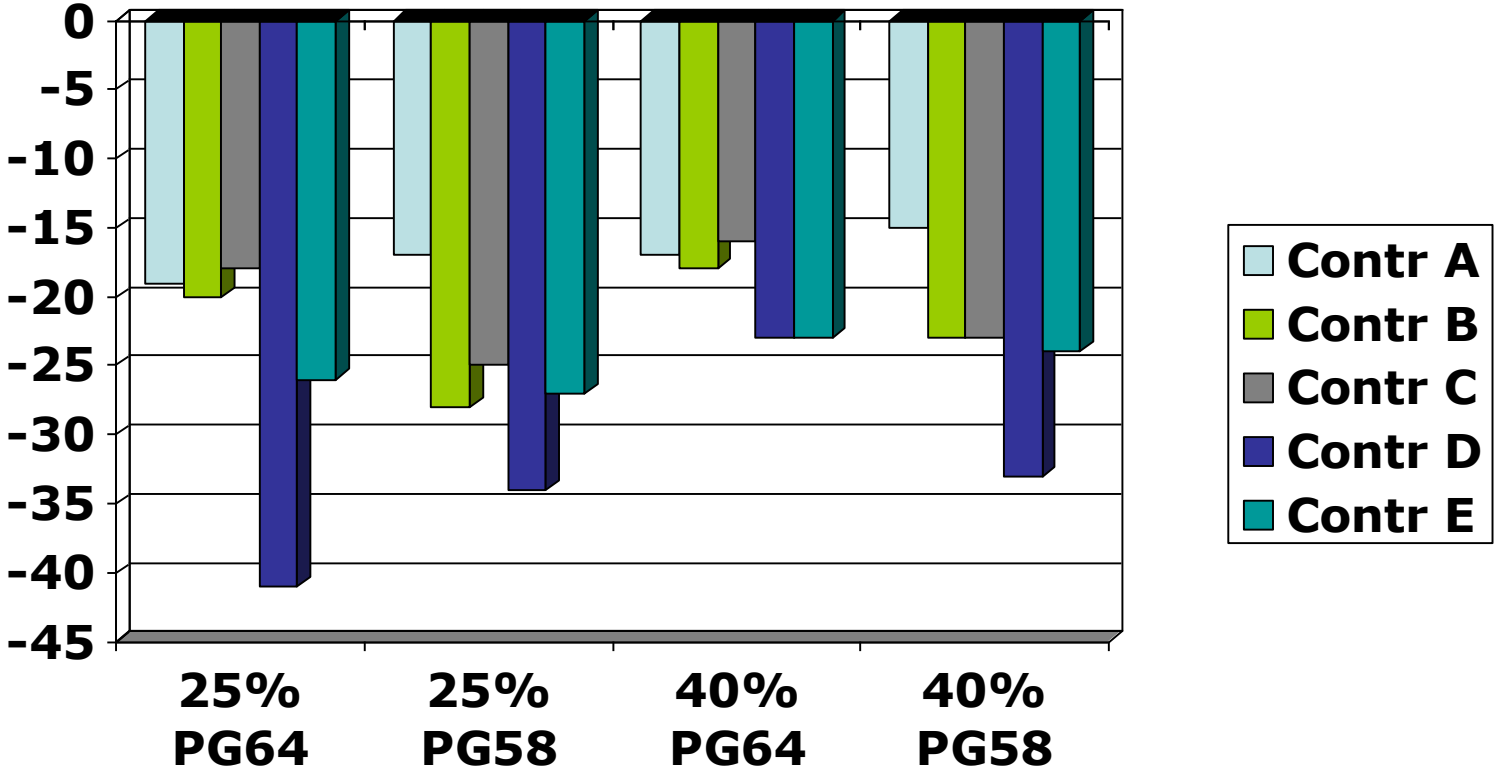
Low Temperature Cracking PG64-22 and PG58-28



Data from North Central Superpave Center

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Conclusions

- Adding hard bitumen
  - More effect bitumen
  - Less effect on mix properties
- Up to 25% bitumen replacement
  - No change in virgin grade
- 25 to 40%
  - Change high and low one grade softer

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Objective

- How much RAP can be used?

- Considerations
  - Quality product
  - Mixing plant
  - Placement
  - Compaction

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Experiment

- Field Experiment
- Focus on High Bitumen Replacement
  - RAP
  - Post Consumer Asphalt Shingles

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Scope

- How much RAP can go through a plant?
  - Trials up to 70%
- Produce and Place on Low Volume Road
  - Measure quality
  - Measure properties

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Is RAP Available?

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Phase One Mixes

Mix	Size	RAP	RAS	AC	BR
1	25.0	70	0	6.0	33
2	25.0	60	0	4.1	41
3	12.5	60	0		(47)
4	12.5	50	3	5.6	29
5	12.5	50	3	7.1	31
6	12.5	50	3	6.6	33

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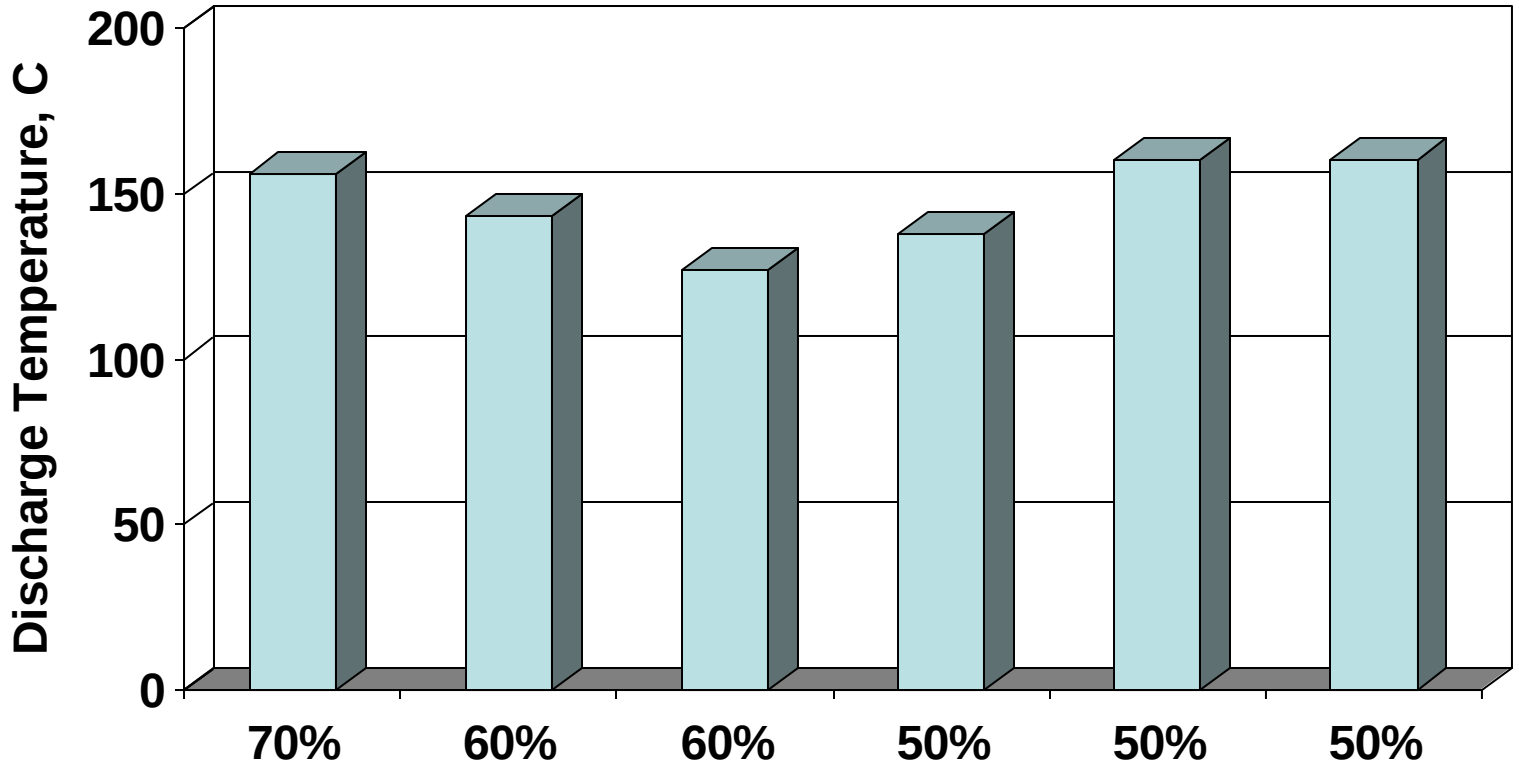
Discharge Temperature



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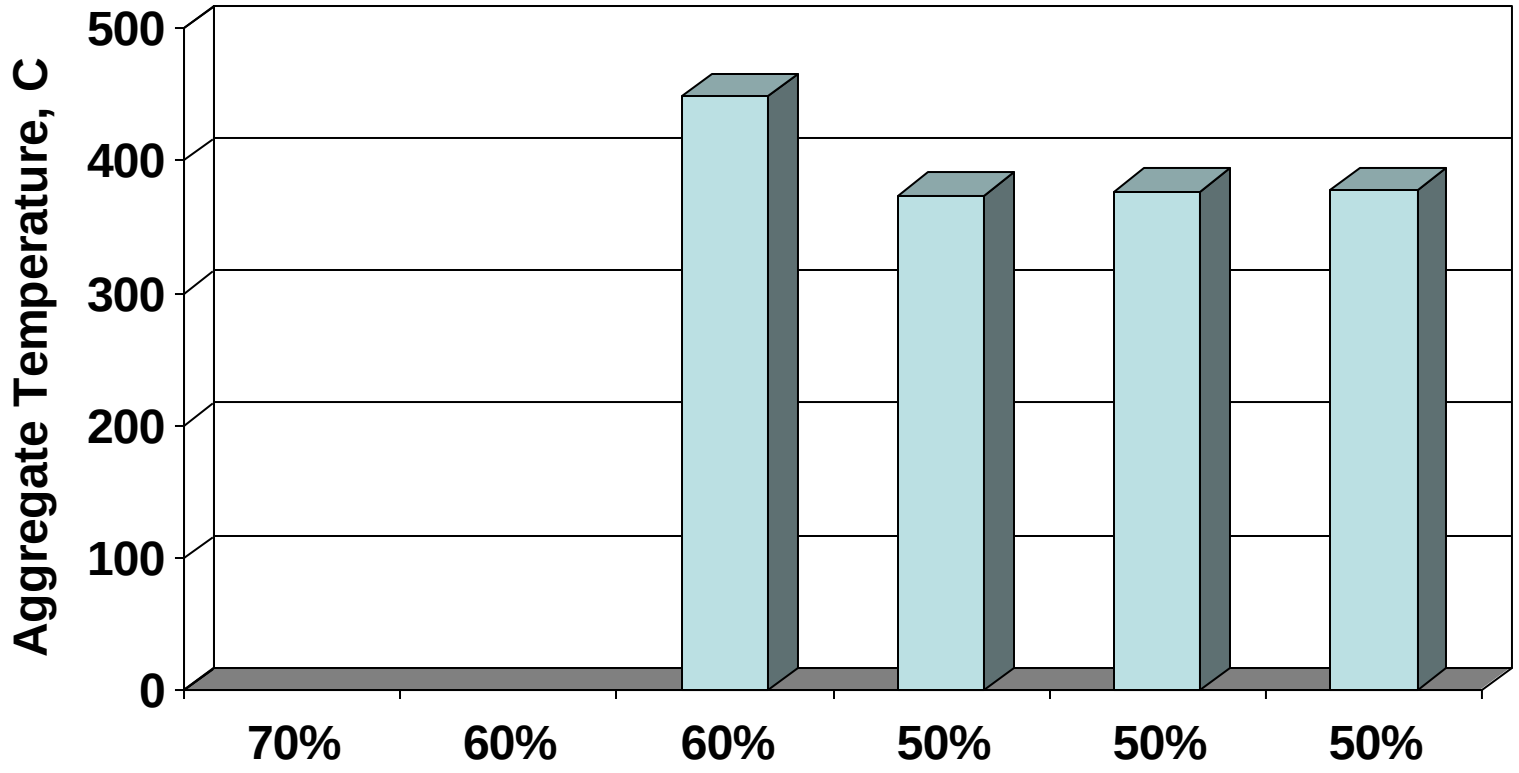
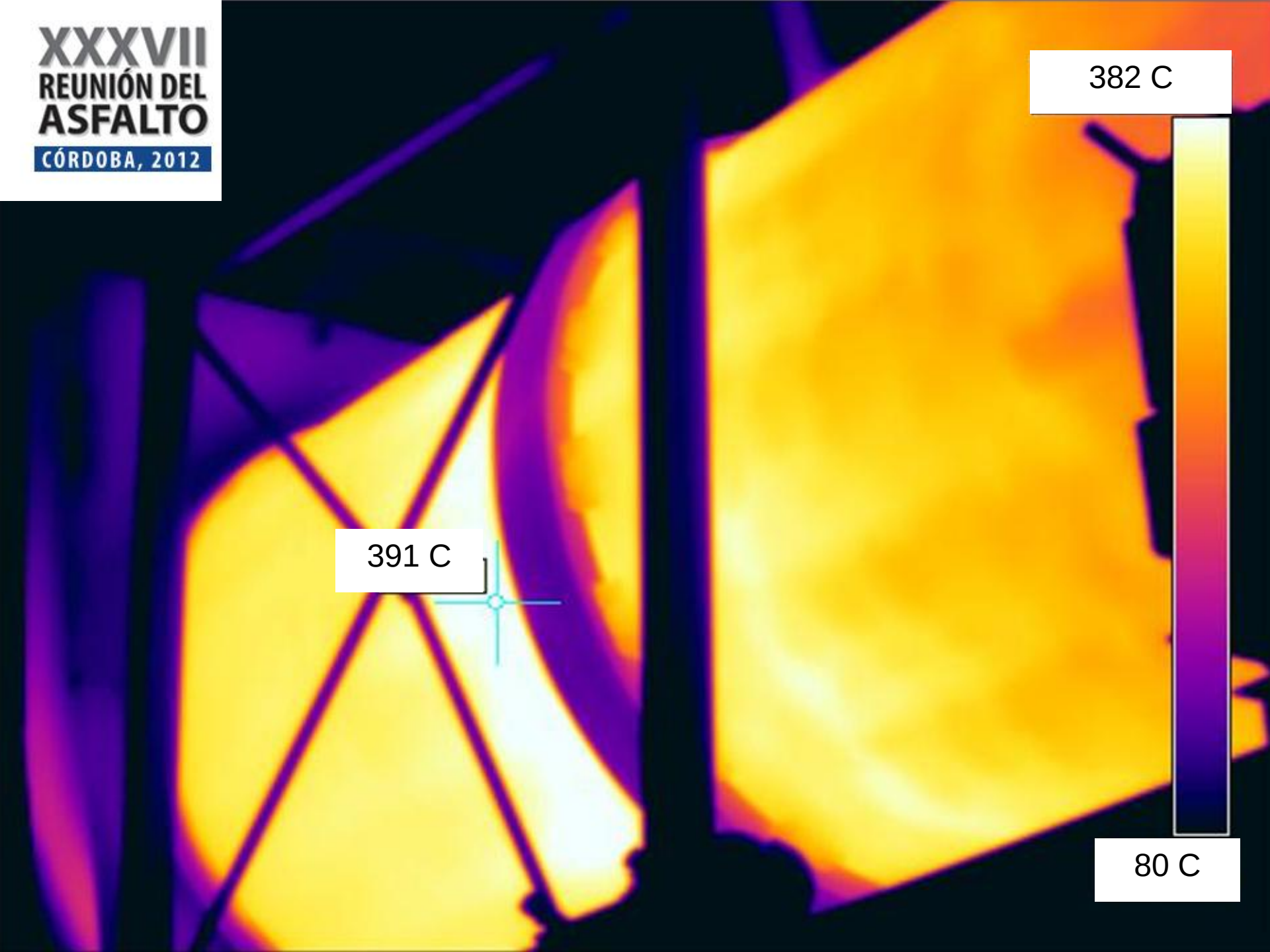
Aggregate Temperature




382 C
391 C
80 C

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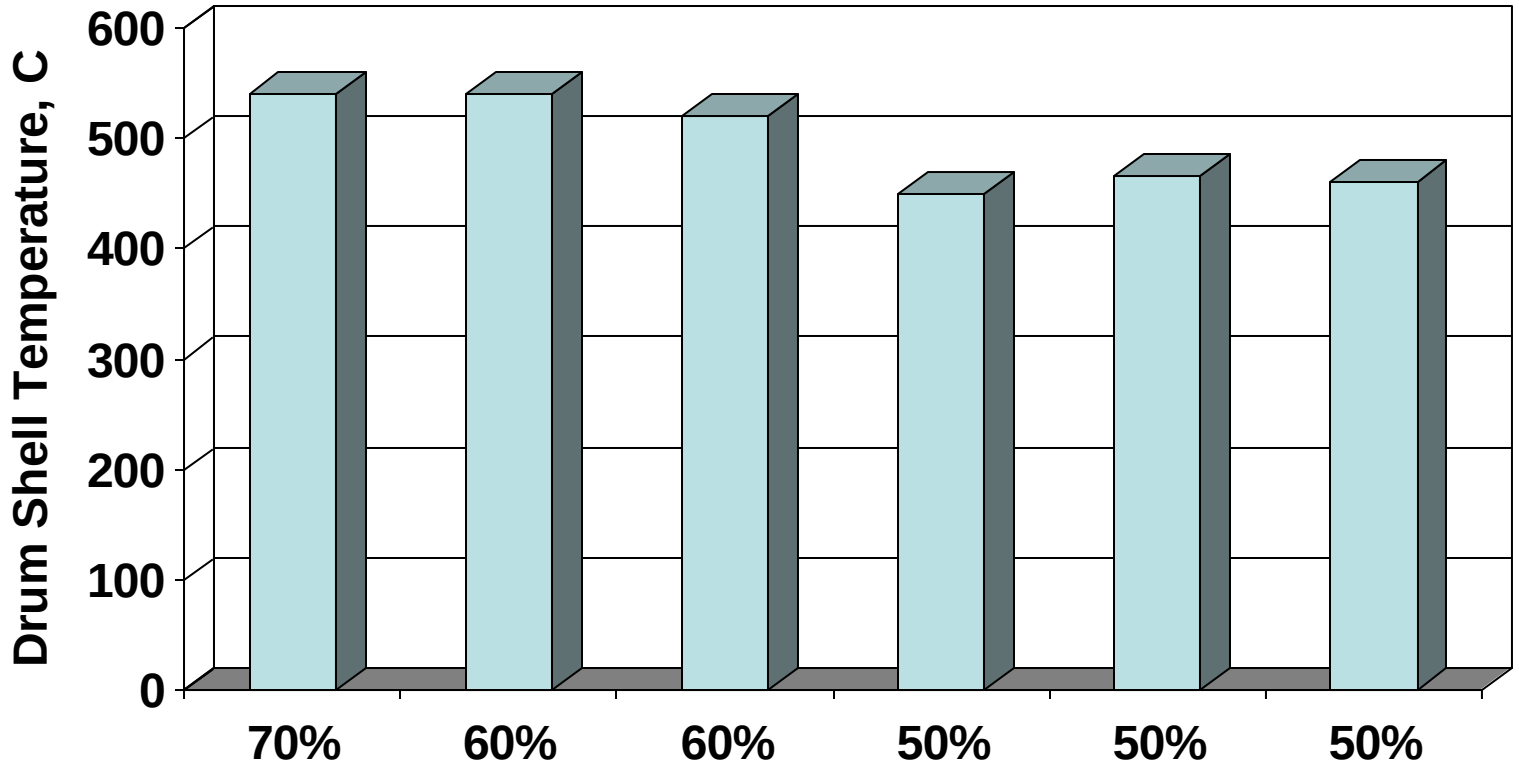
Drum Temperature



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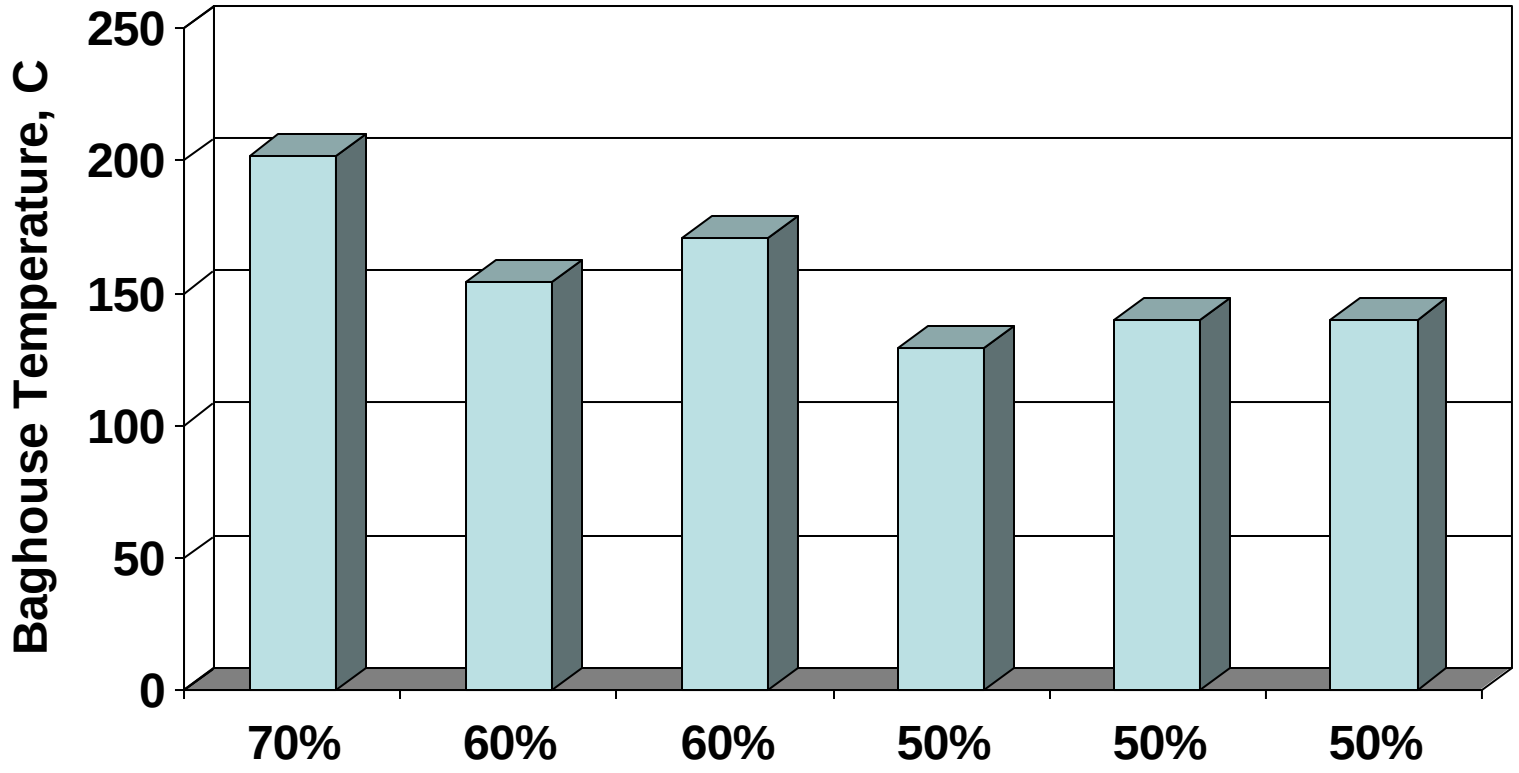
Exhaust Temperature



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Decisions from Phase One

- Maximum 50% RAP
- Drum Shell Temperature
  - max 425 C
- Aggregate Temperature
  - max 370 C
- Exhaust Temperature
  - min 105 C
  - max 200 C

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Phase Two Experiment

- Counterflow drum mix plant
  - With mixing drum
- 19 mm NMPS
  - 25 mm crushed gravel
  - 12.5 mm crushed limestone
  - 12.5 mm pea gravel
  - Natural sand


Counter Flow Drum
RAP Feeder
Mixer Drum

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Phase Two Recycled Materials

- Fine RAP
- Coarse RAP
- Post Consumer Shingles


Coarse RAP (12.5 to 25 mm)


Fine RAP (minus 12.5 mm)

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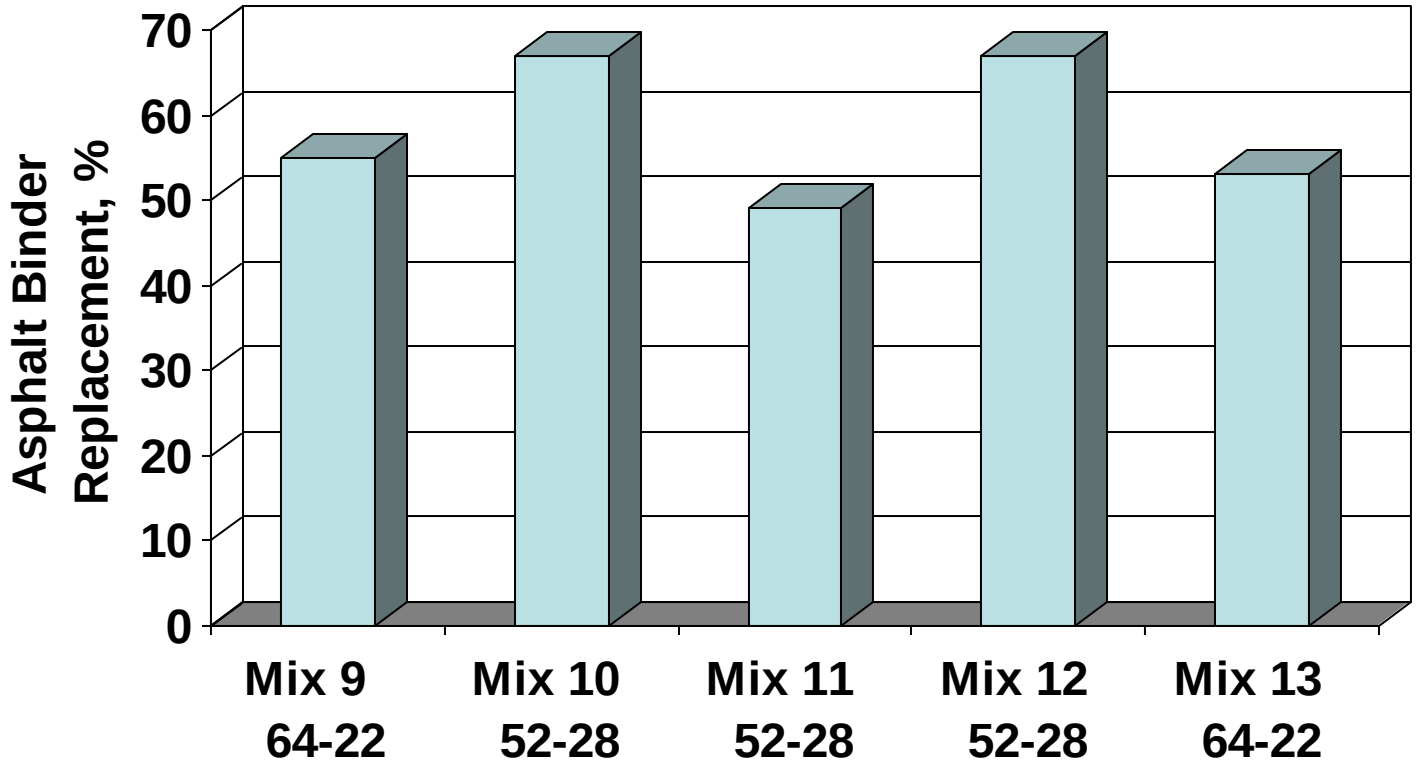
Bitumen Replacement



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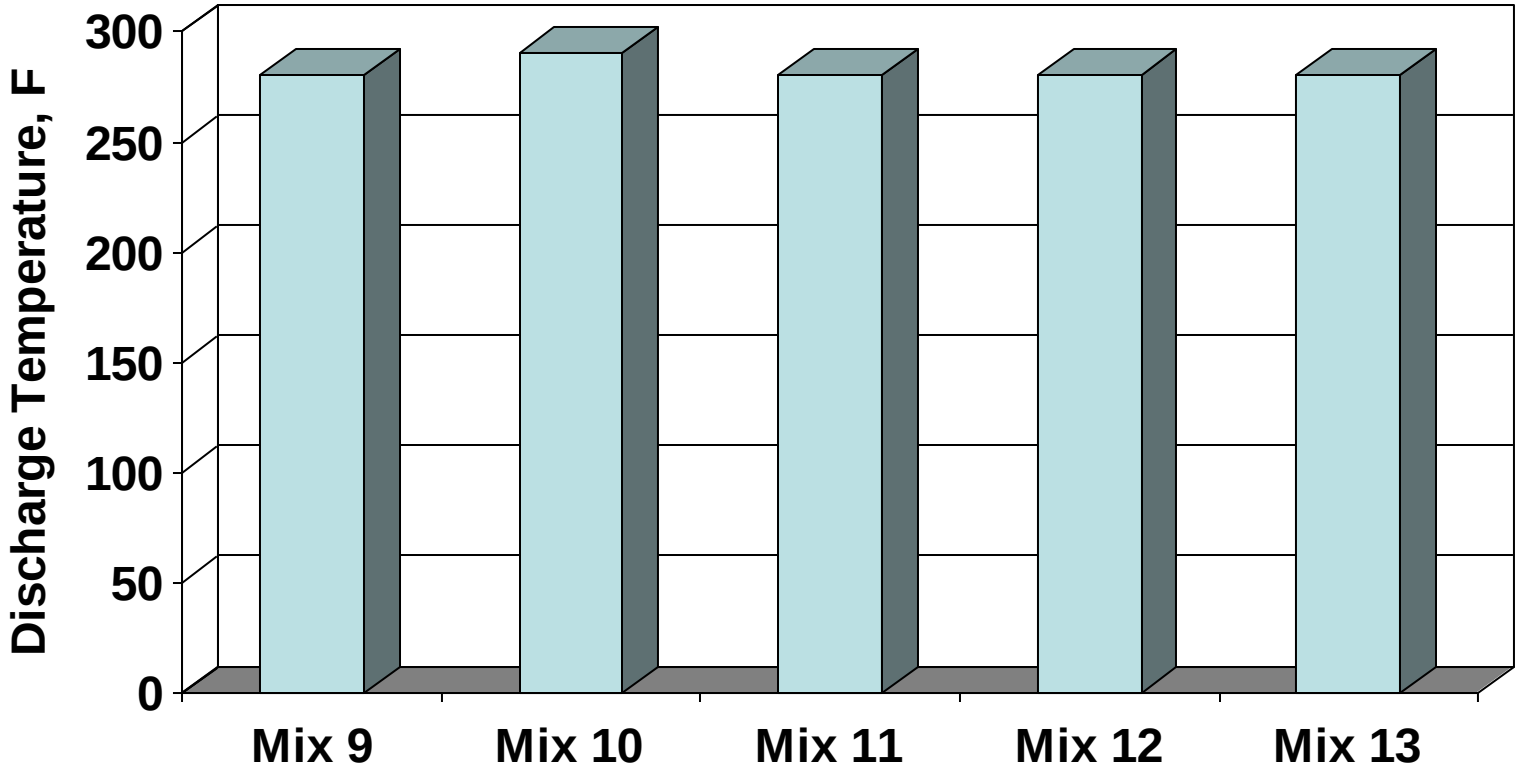
Discharge Temperature



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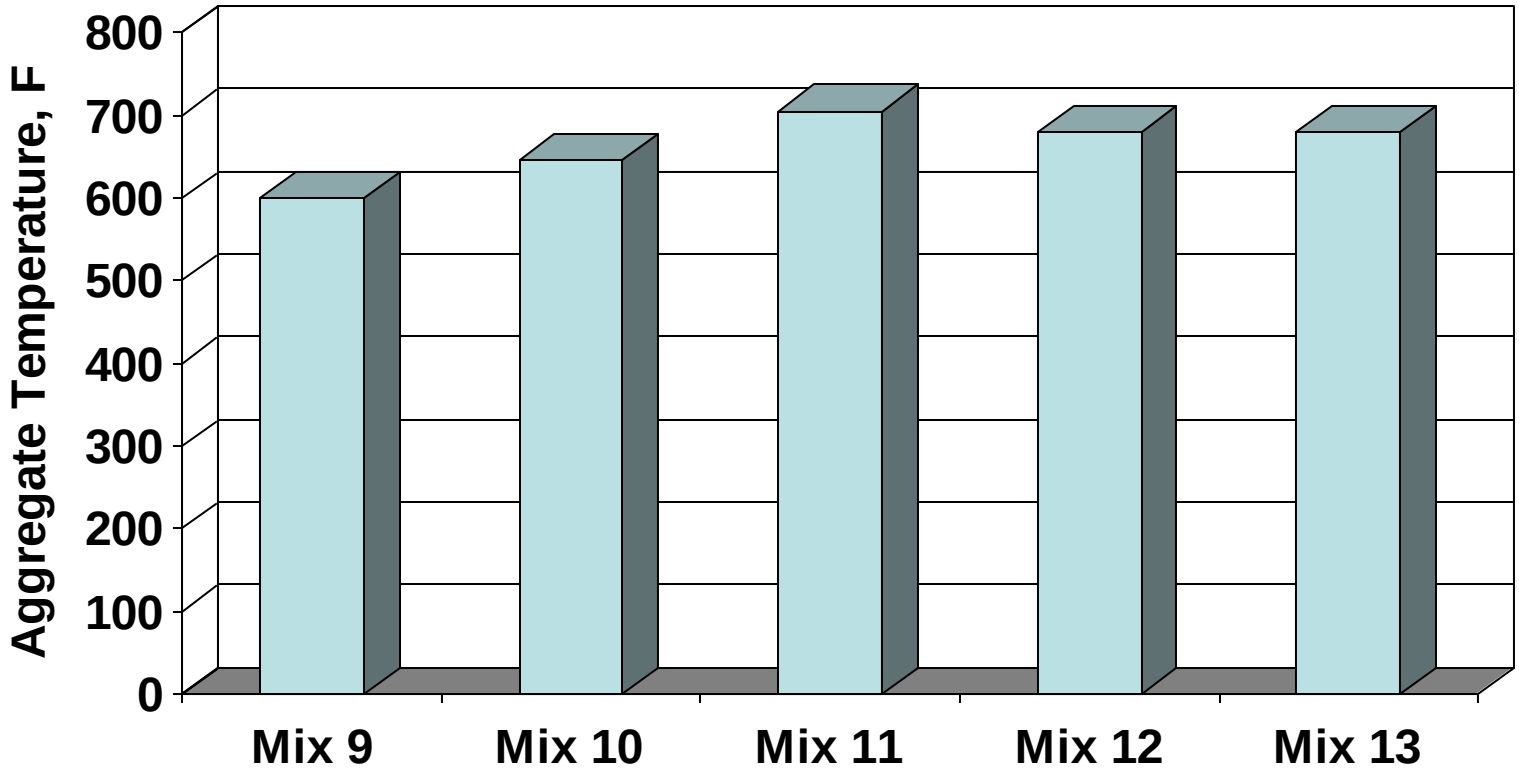
Aggregate Temperature



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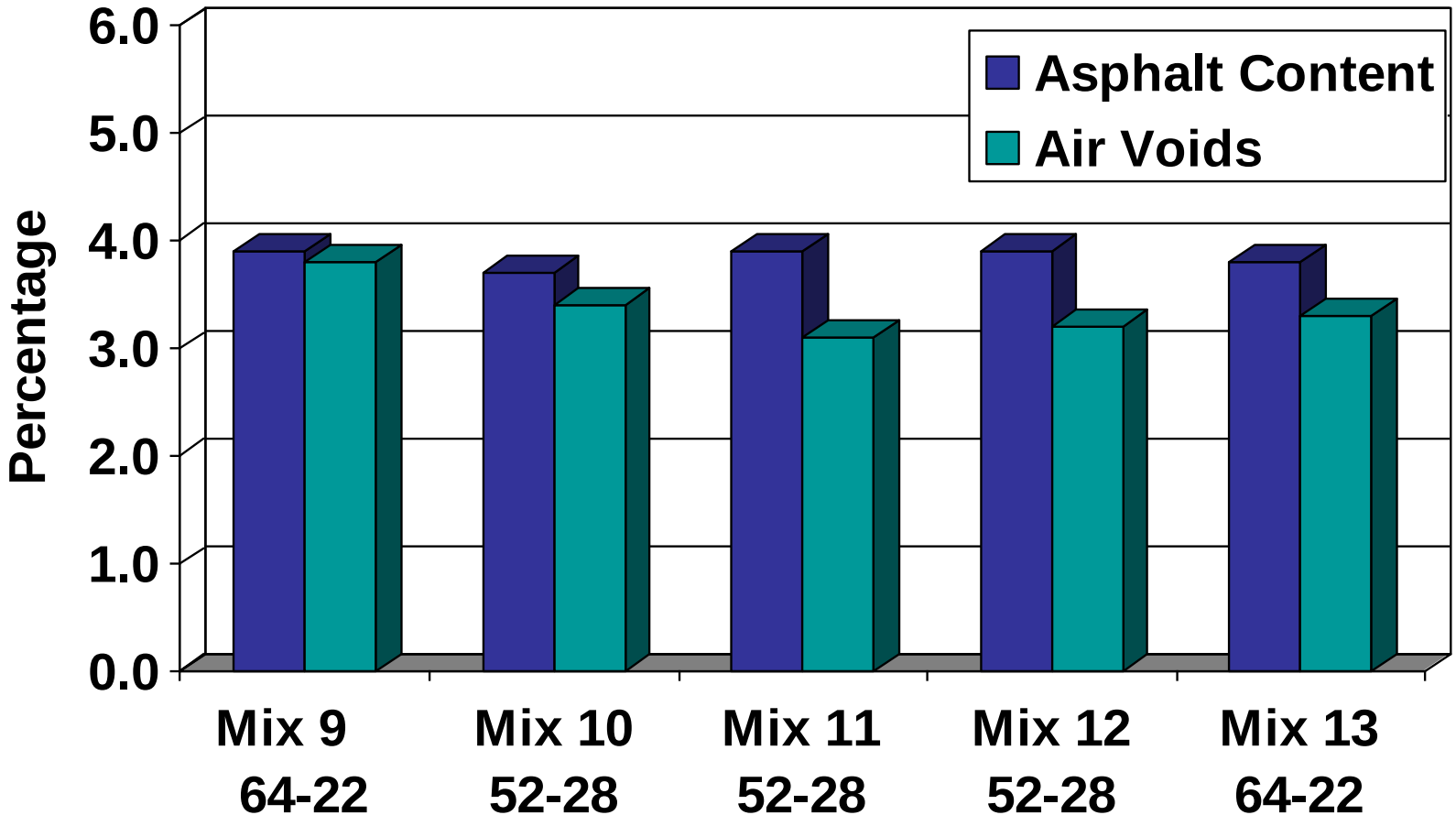
Air Voids and Bitumen Content



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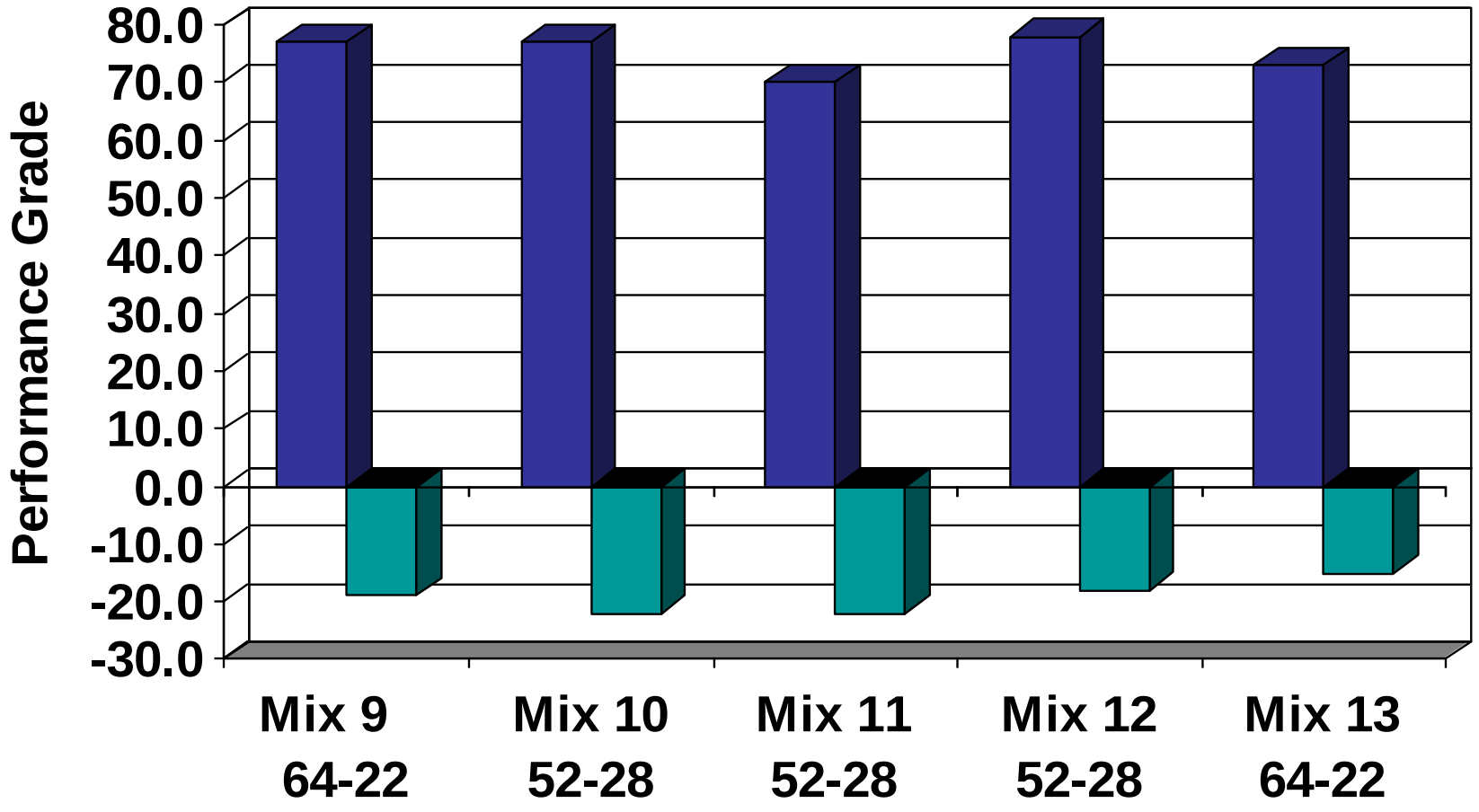
Bitumen Grade




Road Existing
Condition
05.31.2011

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Placing Mix

Uncompacted Mix

Compaction

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Conclusions

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Phase 1 Conclusions

- 50% RAP is reasonable maximum
- Criteria selected for
  - Drum shell temperature
    - 425˚C maximum
  - Virgin aggregate temperature
    - 375˚C maximum
  - Bag house exhaust
    - 105˚C minimum
    - 200˚C maximum

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Phase 2 Conclusions

- 50% RAP is reasonable maximum
- Volumetric Properties Can Be Controlled
- Durable Mixtures Can Be Produced

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RAP Green As The Wind

Thanks