Behaviour of Asphalt Mixes Incorporating Recycled Asphalt Shingles

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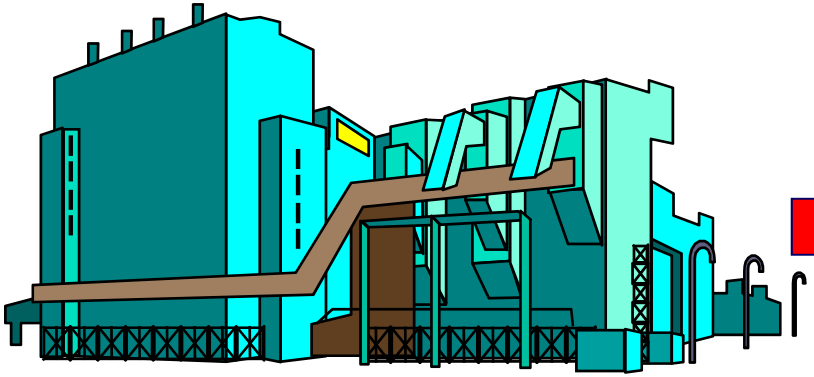
Presentation Outlines

- *Historical background*
- *Experimental approaches*
- *Experimental results and discussion*
- *Conclusions*

Historical Background



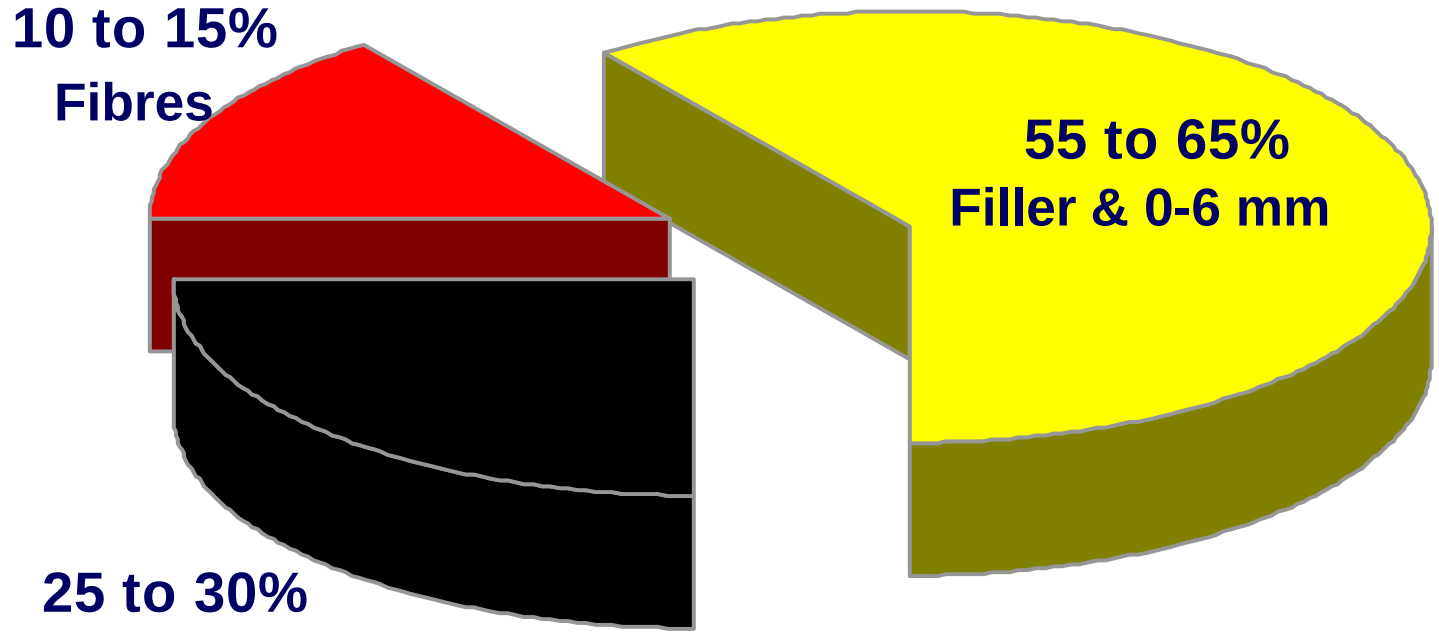
13,000,000 Tons

Good Environmental Conscience


RECYCLING


What to do ?

Asphalt Shingle (AS)



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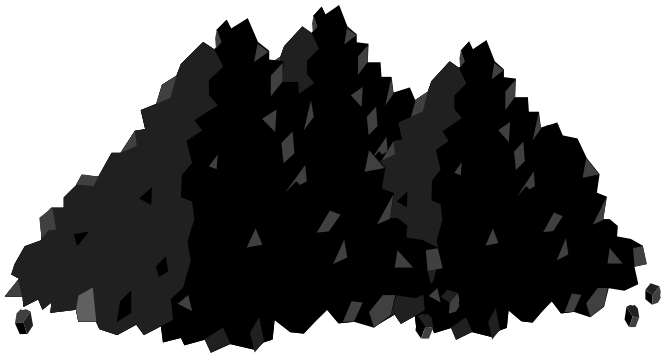
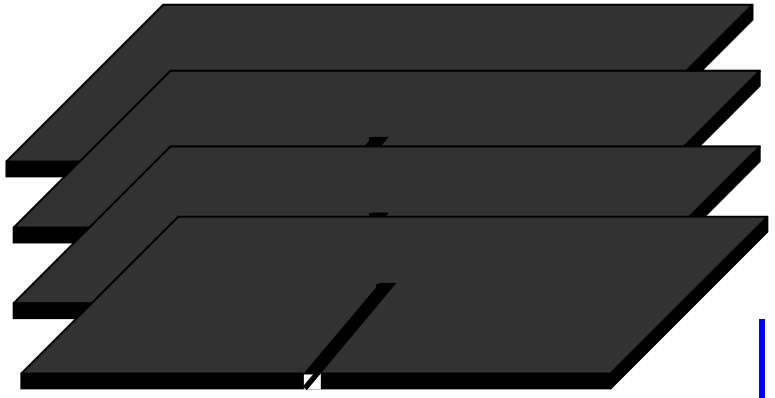
Asphalt Mixed Modified with Asphalt Shingles





Aggregates **Binder** **Asphalt Shingles**


Scrap Asphalt Shingles
SMA - 4% asphalt shingles

In order to be incorporated in the AC mixes

Asphalt Shingles need to be shredded and grinded (Max. 12.5 mm)

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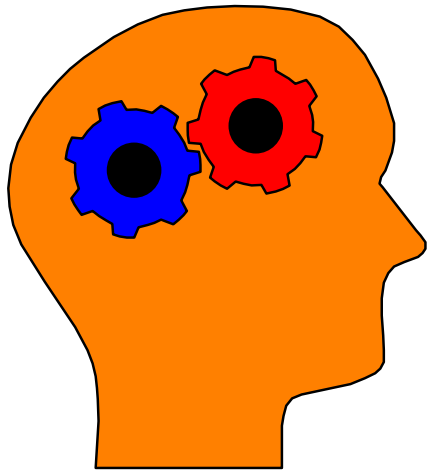
Experimental Study

EXPERIMENTAL STUDY

Objective of this research

To contribute to the understanding of the behaviour of Asphalt Mixes incorporating Particles of Recycled Asphalt Shingles



EXPERIMENTAL STUDY

Objective of this research

Evaluate the resistance to cracking at low temperature

EXPERIMENTAL STUDY

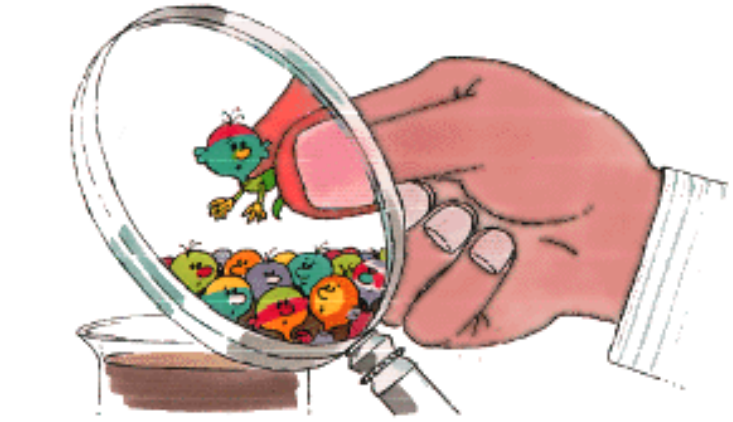
Objective of this research

Study the rheological behaviour of the different materials

EXPERIMENTAL STUDY

Objective of this research

Evaluate the effectiveness of the components of Recycled Shingles in the Asphalt Mix



EXPERIMENTAL STUDY

It is the necessary to

Establish an adequate testing program

Select appropriate experimental approaches and scientific methods

Conduct the experimental program rigorously

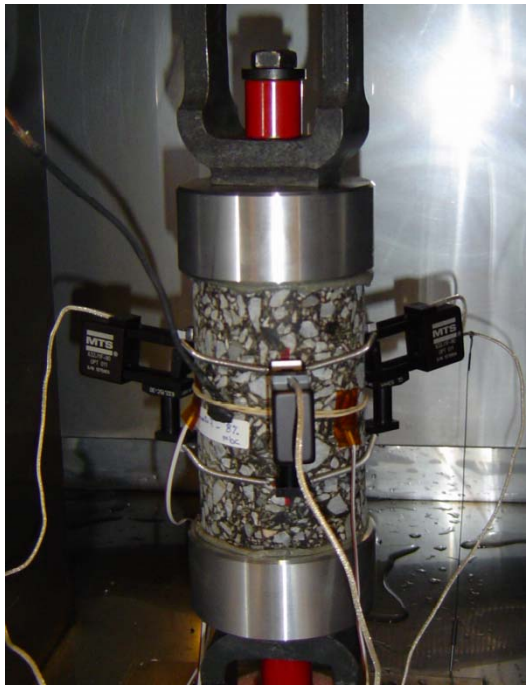
EXPERIMENTAL STUDY

Low temperature resistance

TSRST

Rheological behaviour

Complex Modulus

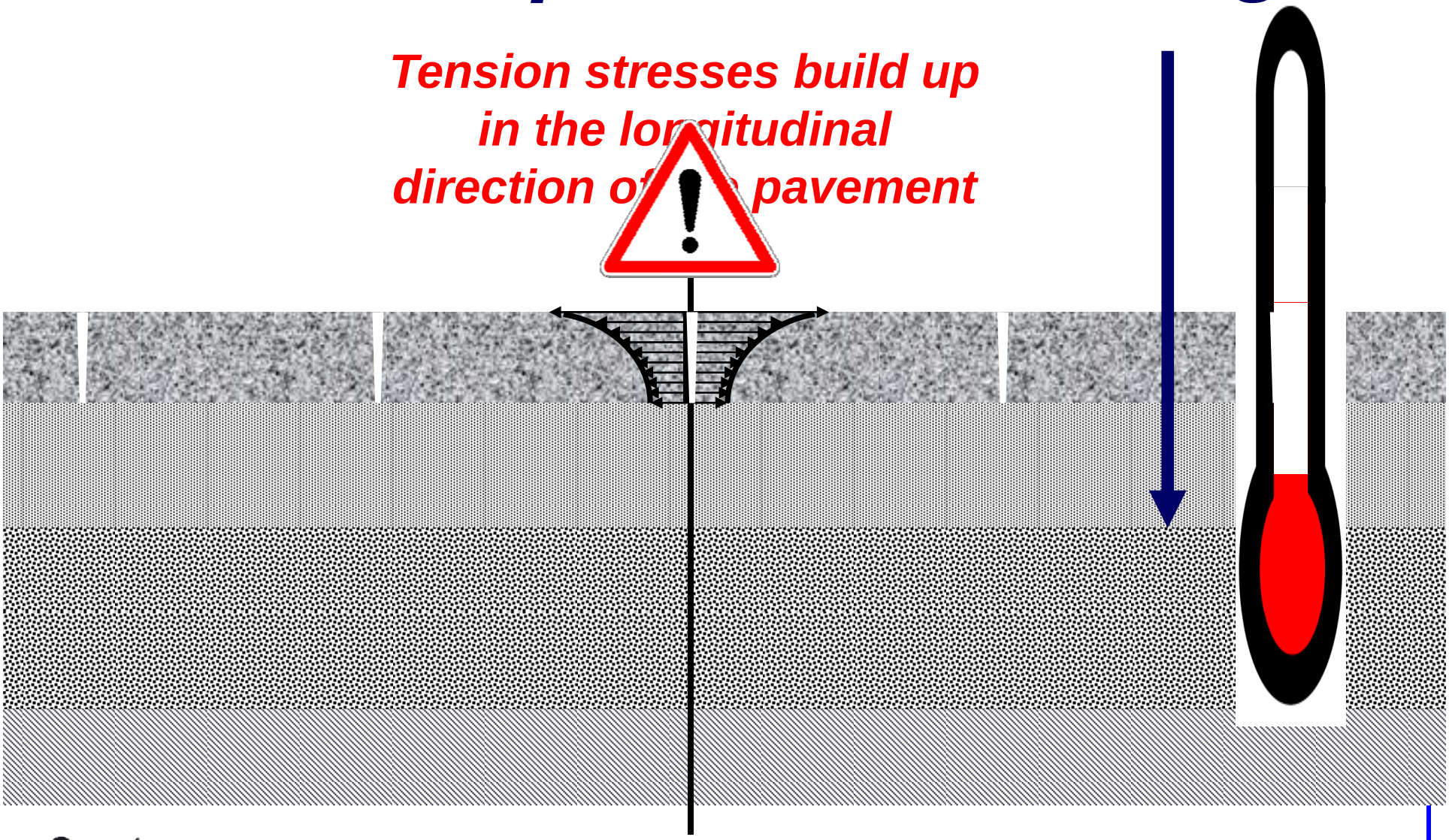


*T*hermal *S*tress *R*estrained *S*pecimen *T*est

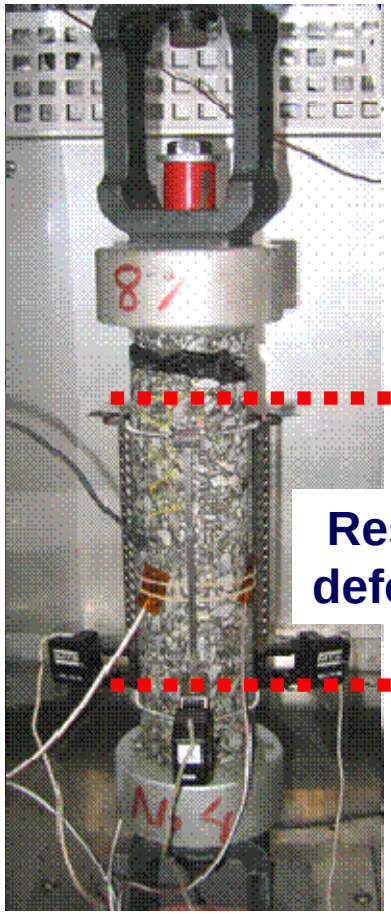
AASHTO TP10-93

Low temperature Cracking

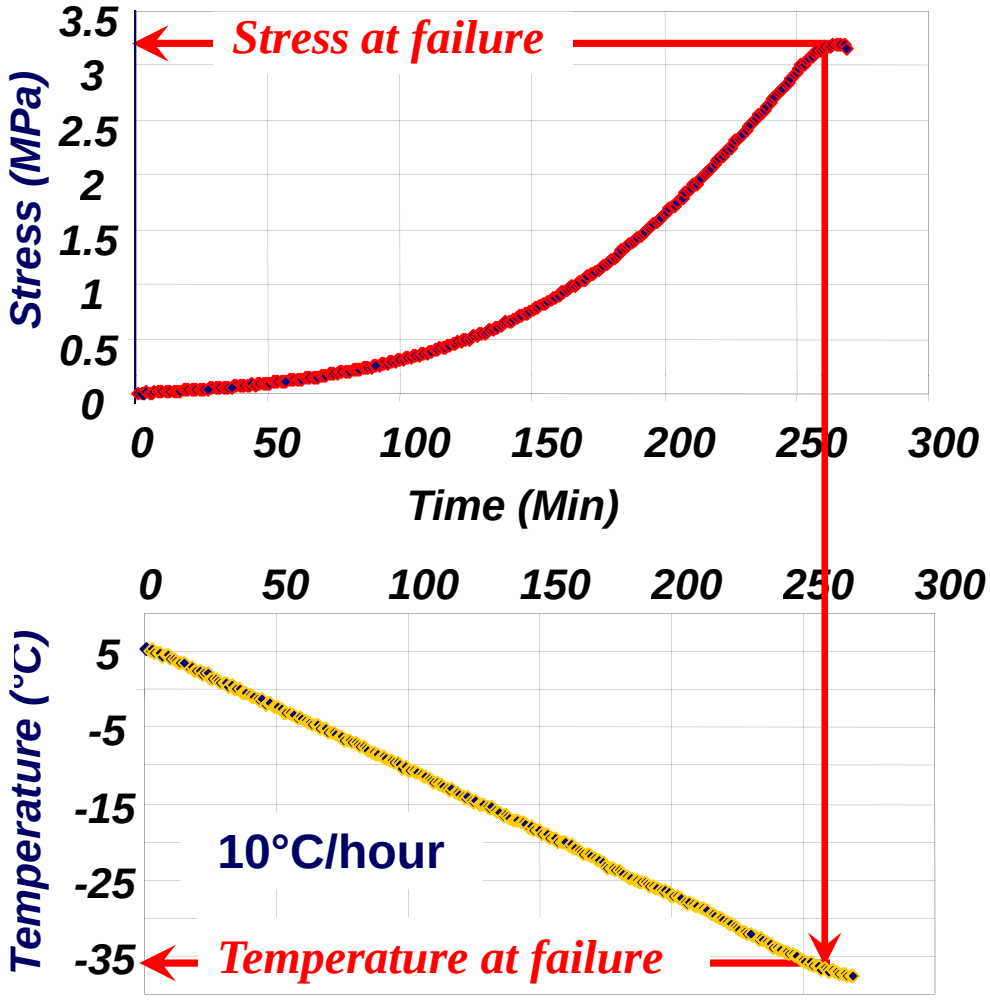
Tension stresses build up in the longitudinal direction of the pavement



Low temperature cracking (TSRST)



Restrained deformation



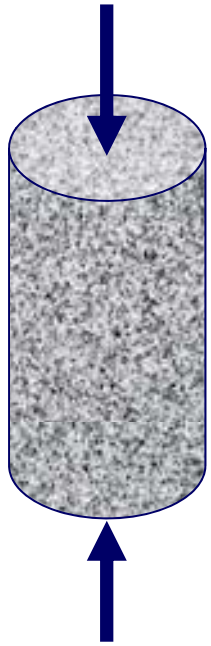
COMPLEX MODULUS

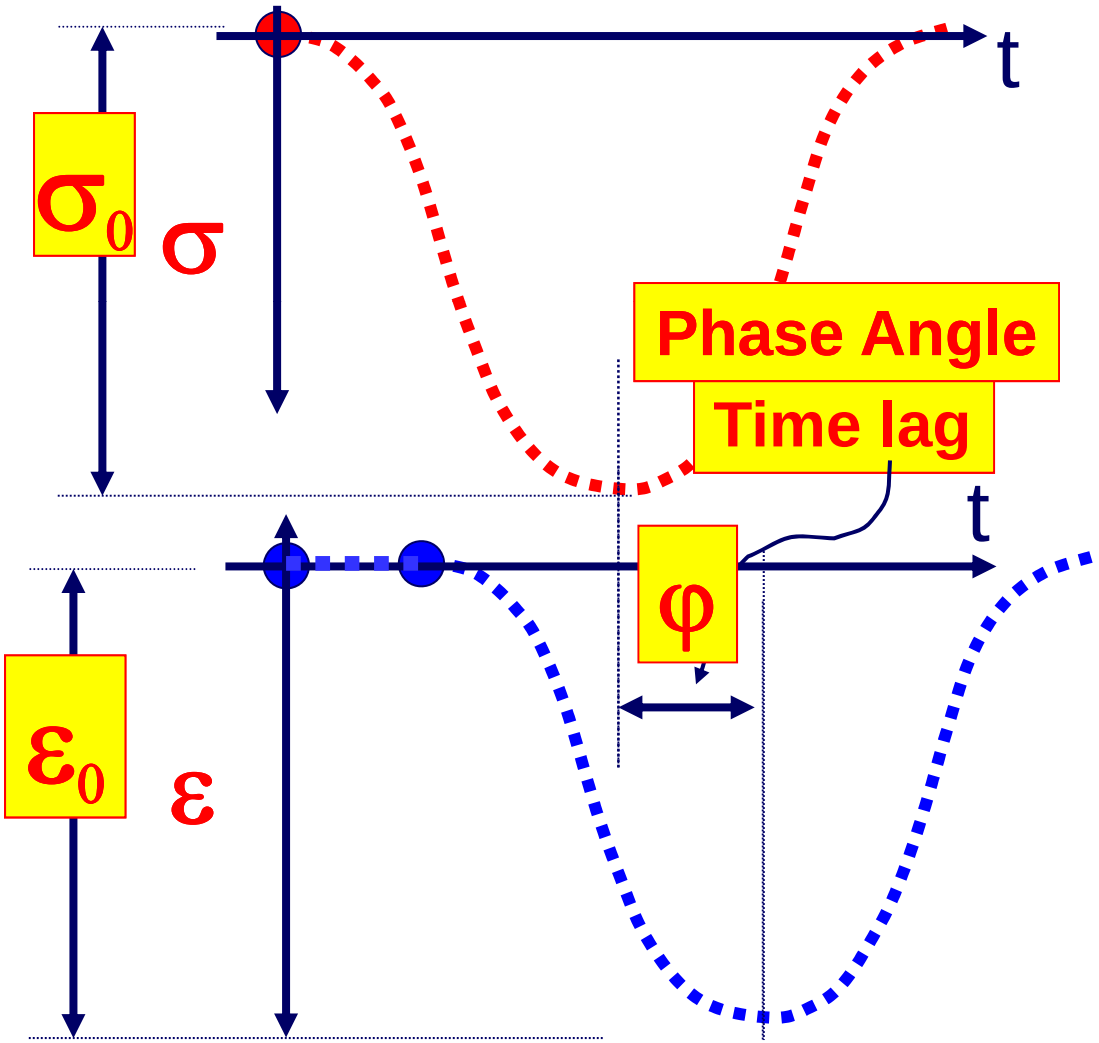
Complex modulus concept

Complex Modulus

NORM of the Complex Modulus $|E^*|$

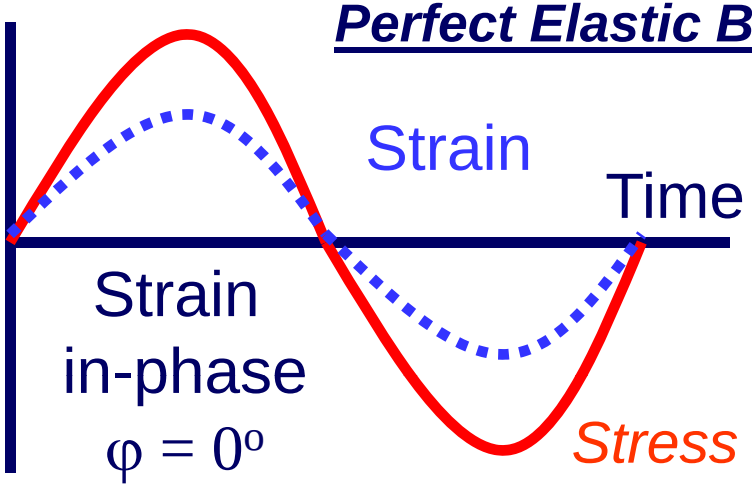
$$|E^*| = \frac{\sigma_0}{\varepsilon_0}$$



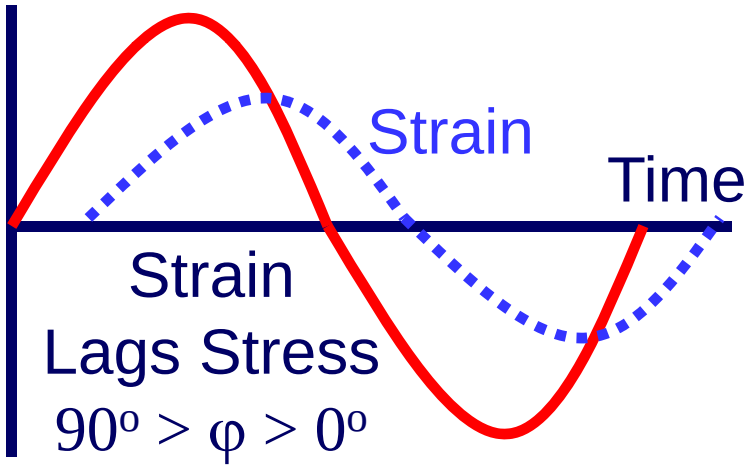


Complex modulus concept

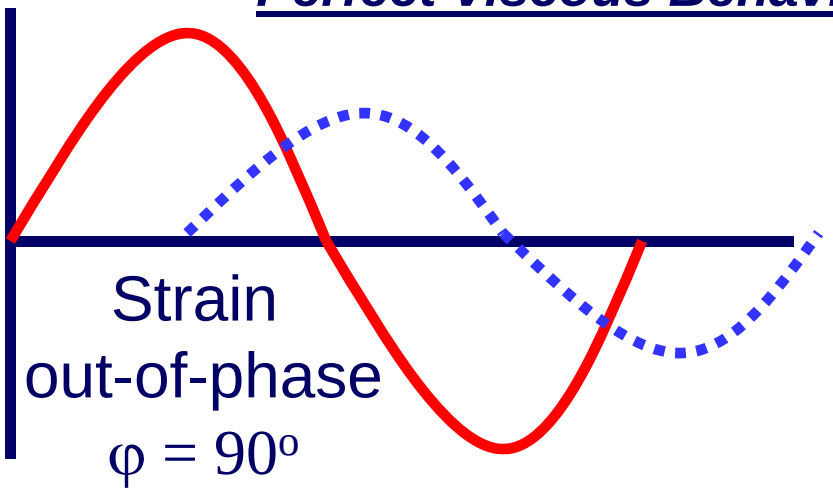
Perfect Elastic Behavior



Visco-Elastic Behavior

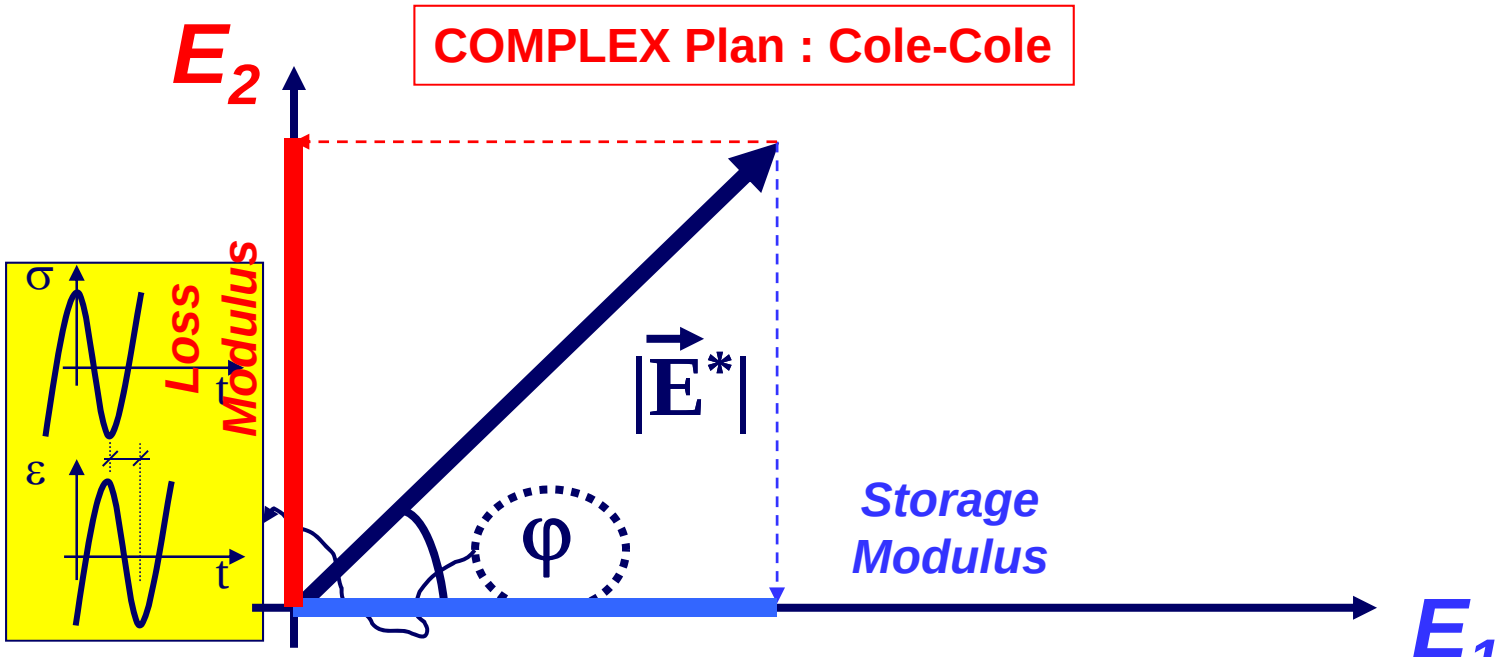


Perfect Viscous Behavior

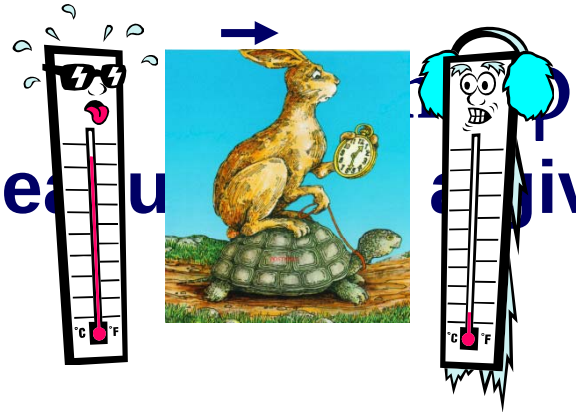


Complex Modulus concept

The Complex Modulus is a VECTOR



Complex Modulus concept



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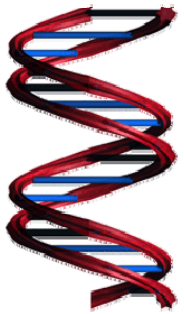


E_2

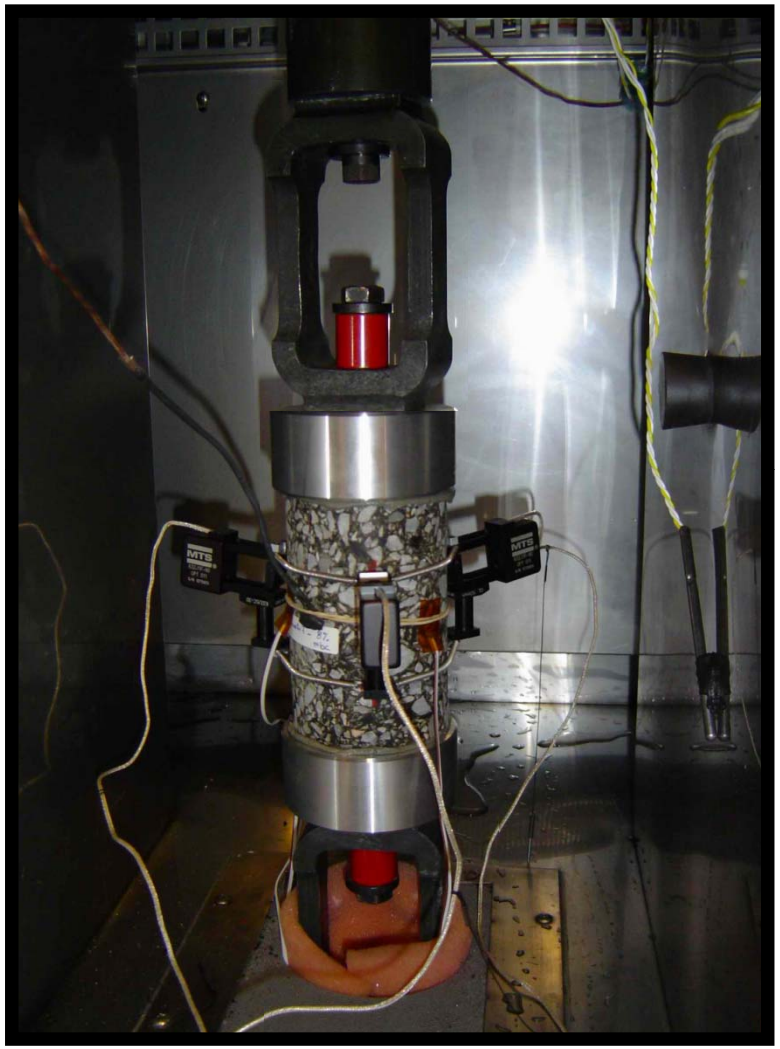
Identify and distinguish the materials

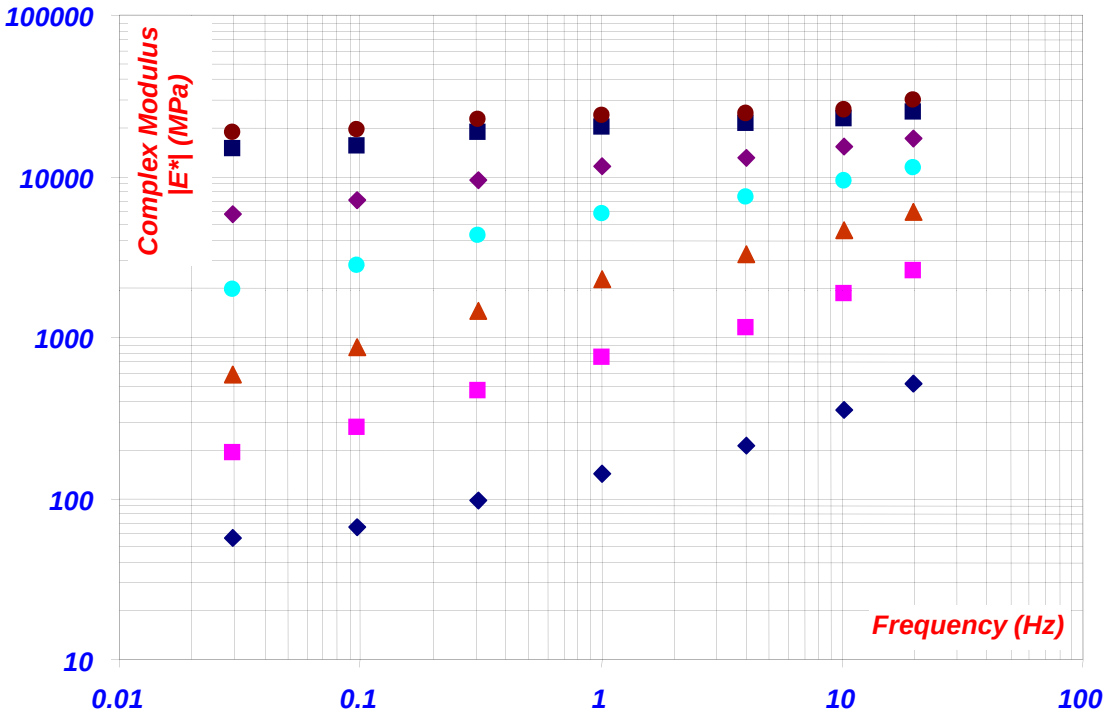
Predict the behaviour under different conditions

Global Rheological behaviour

E_1

Complex Modulus Measurements

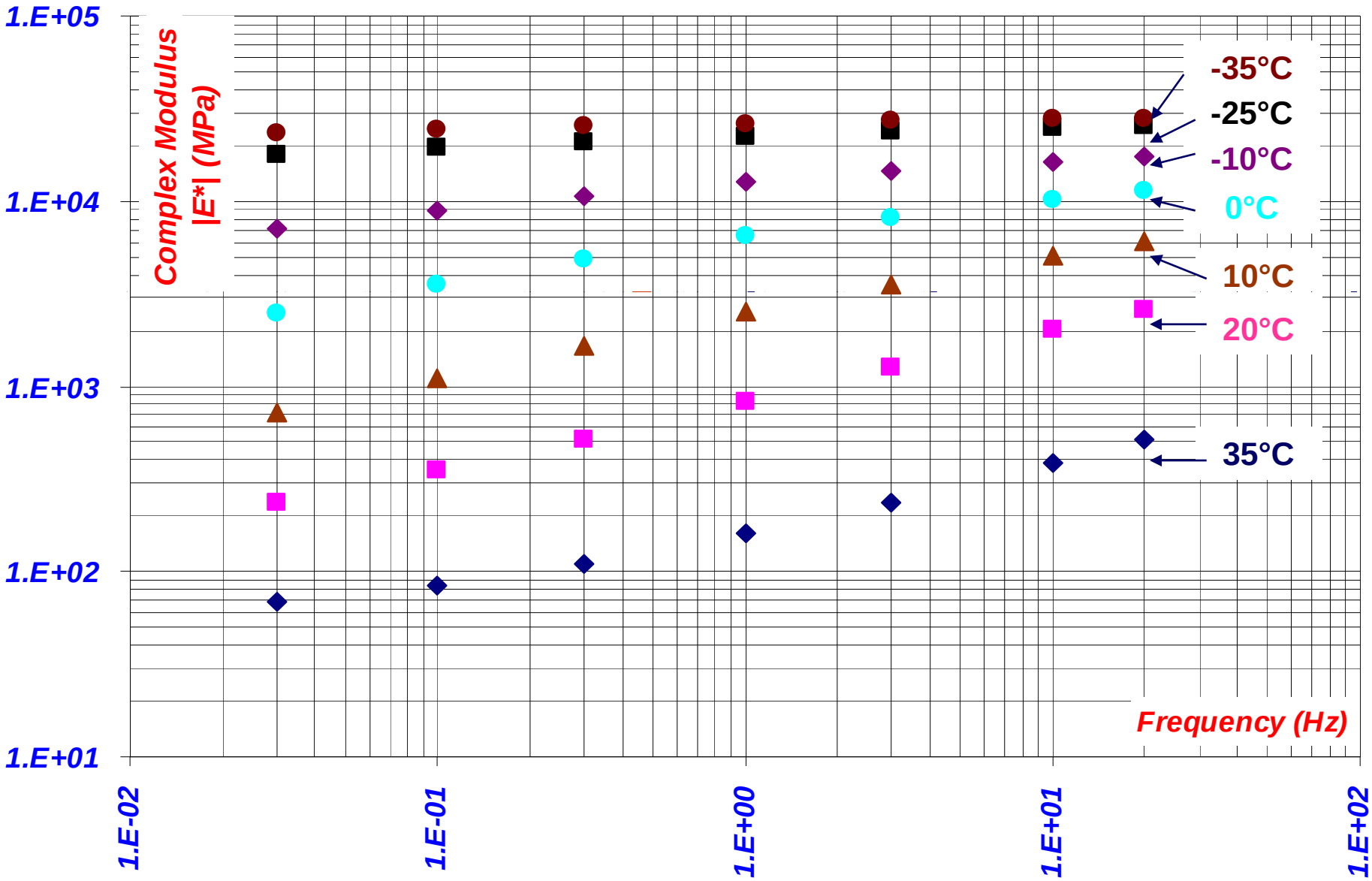




Temperatures (°C): -35, -25, -10, 0, 10, 20, 35

Frequencies (Hz): 20, 10, 3, 1, 0.3, 0.1, 0.03, 0.01

Complex Modulus - Master Curve



TESTING PROGRAM

11

mixes

Type EB10-S

2Virgin Binders

PG52-34 and PG58-28

NEW RESULTS

4 different AC contents %

4.80%, 4.55%, 4.30% and 4.05%

5 different levels of Asphalt Shingles modification 0.0%, 2.0%, 4.0%, 6.0% and 8.0%

TESTING PROGRAM

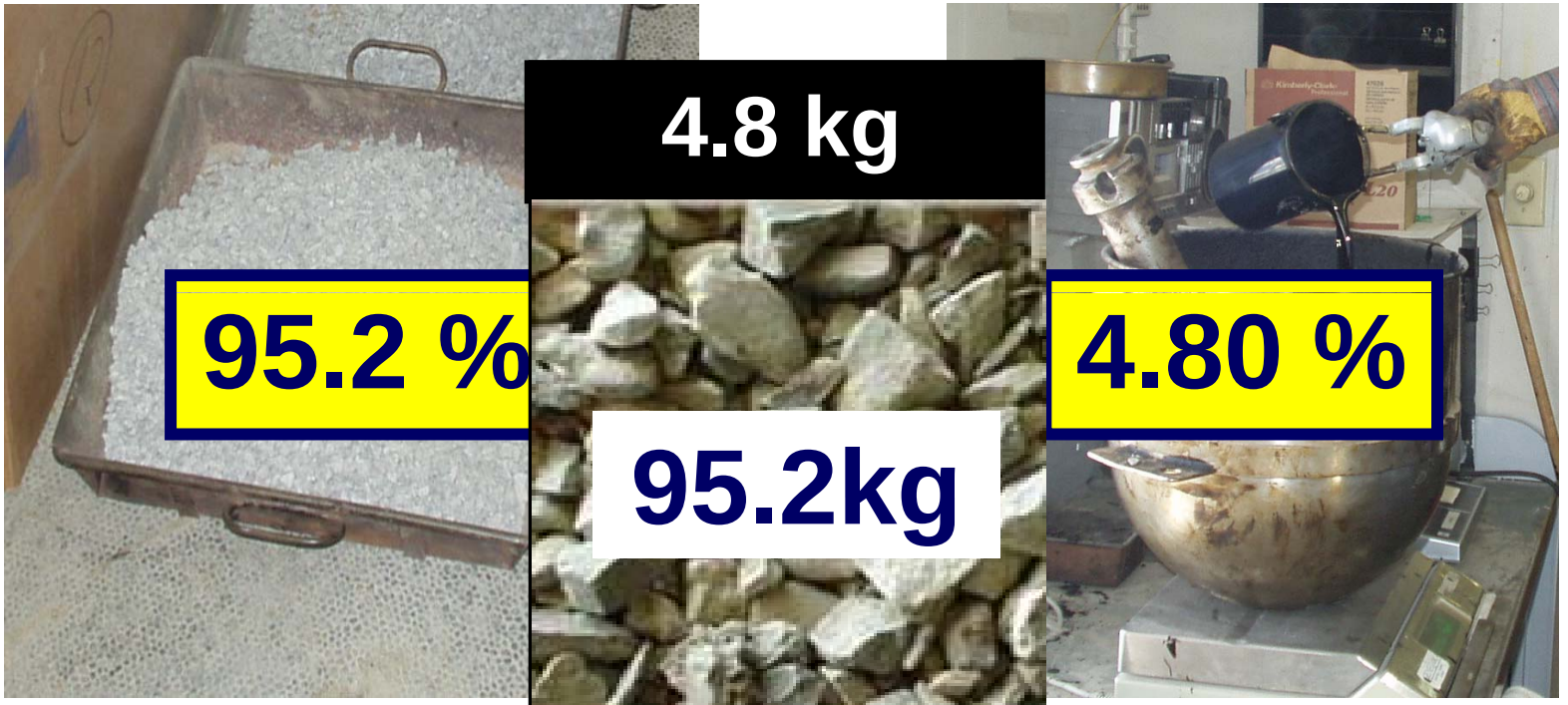
Series I
Asphalt Shingles as ADDITIVE

Series II
Asphalt Shingles as MODIFIER

Special mix

TESTING PROGRAM

Control mix



Virgin Aggregates

0-10mm

TOTAL 100kg

Virgin Binder

PG58-38 or PG52-34

TESTING PROGRAM

Control mix

Series I
Asphalt Shingles as ADDITIVE

Series II
Asphalt Shingles as MODIFIER

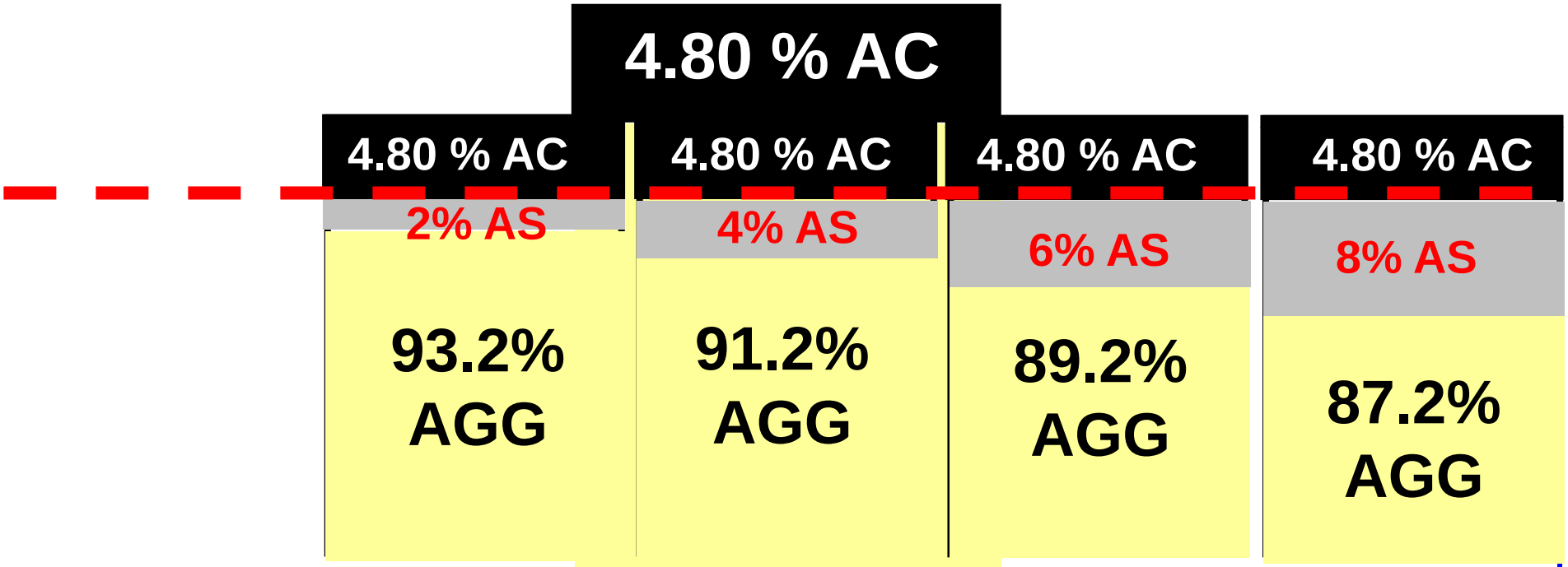
Special mix

TESTING PROGRAM

SERIES I

Asphalt Shingles added as ADDITIVE

PG52-34



TESTING PROGRAM

Control mix

Series I
Asphalt Shingles as ADDITIVE

Special mix

Series II
Asphalt Shingles as MODIFIER

TEST PROGRAM

SERIES II

Asphalt Shingles added as MODIFIER

PG52-34

4.80 % AC

4.80 % AC	4.55 % AC	4.30 % AC	4.05 % AC
4% AS	4% AS	4% AS	4% AS
91.2% AGG	91.45% AGG	91.7% AGG	91.95% AGG
4%AS – 4.80%AC	*4%AS – 4.55%AC*	*4%AS – 4.30%AC*	*4%AS – 4.05%AC*
From series I	*Control mix*		

TESTING PROGRAM

Control mix

Series I
Asphalt Shingles as ADDITIVE

Special mix

Series II
Asphalt Shingles as MODIFIER

TESTING PROGRAM
Special Mix

The idea is to add the components of Asphalt Shingles separately

Particles of Grinded Asphalt Shingles

100 %

Recovered AC binder

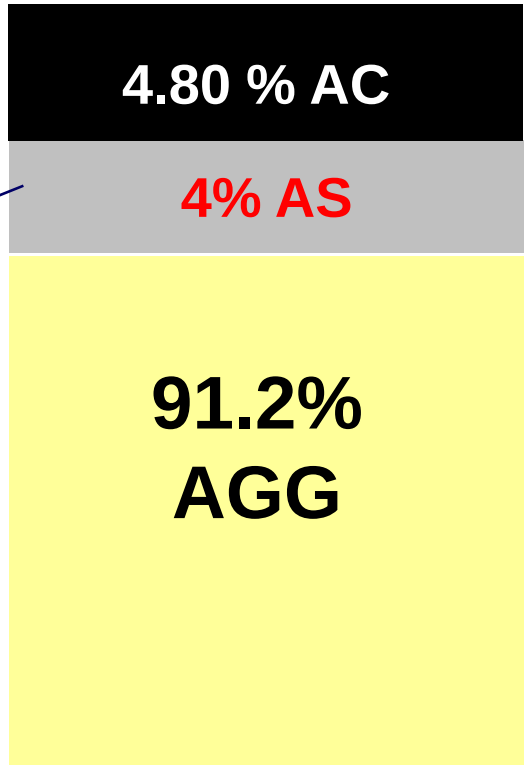
25 %

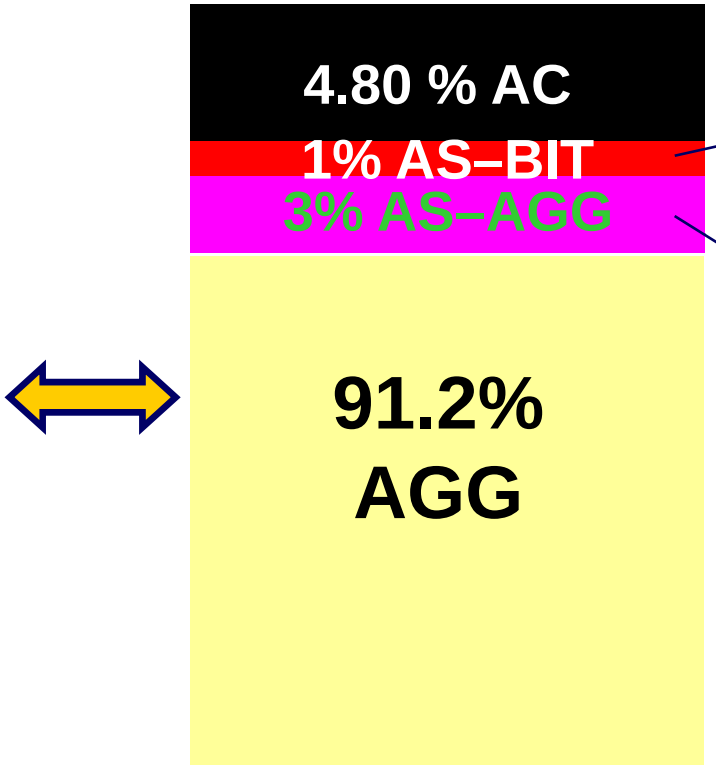
75 %

TESTED MATERIALS

Preparation of a reconstituted mix

PG52-34





4%AS–
4.80%AC

4%AS–
4.30%AC
(REC)

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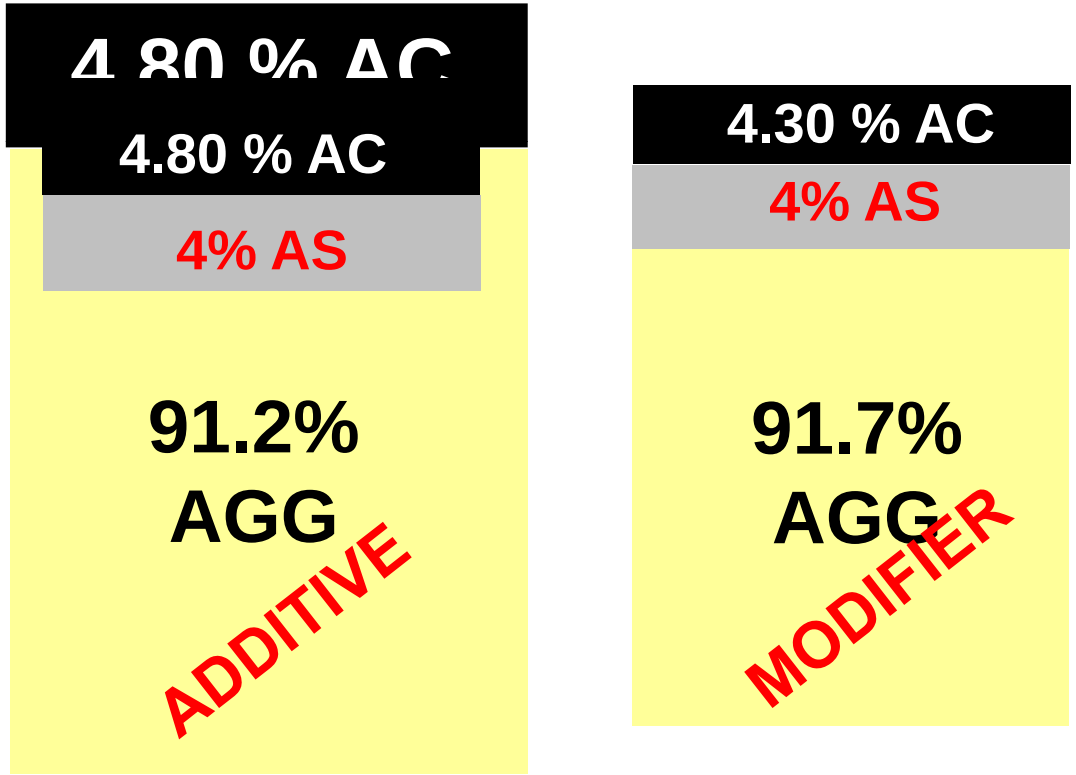
TEST PROGRAM

Mixes prepared with the virgin binder

PG58-28

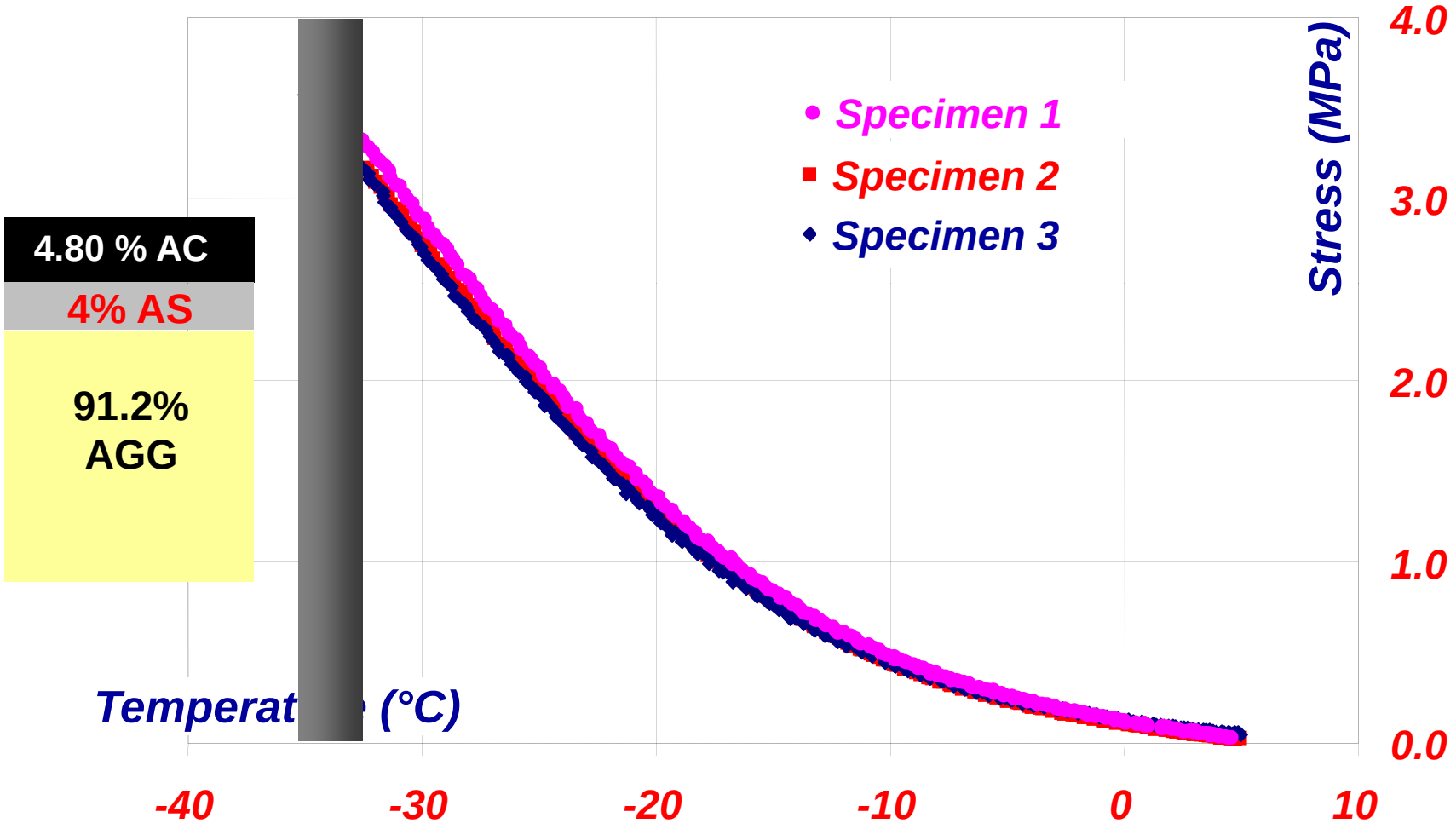


Control mix

Results and discussion

*T*hermal *S*tress *R*estrained *S*pecimen *T*est

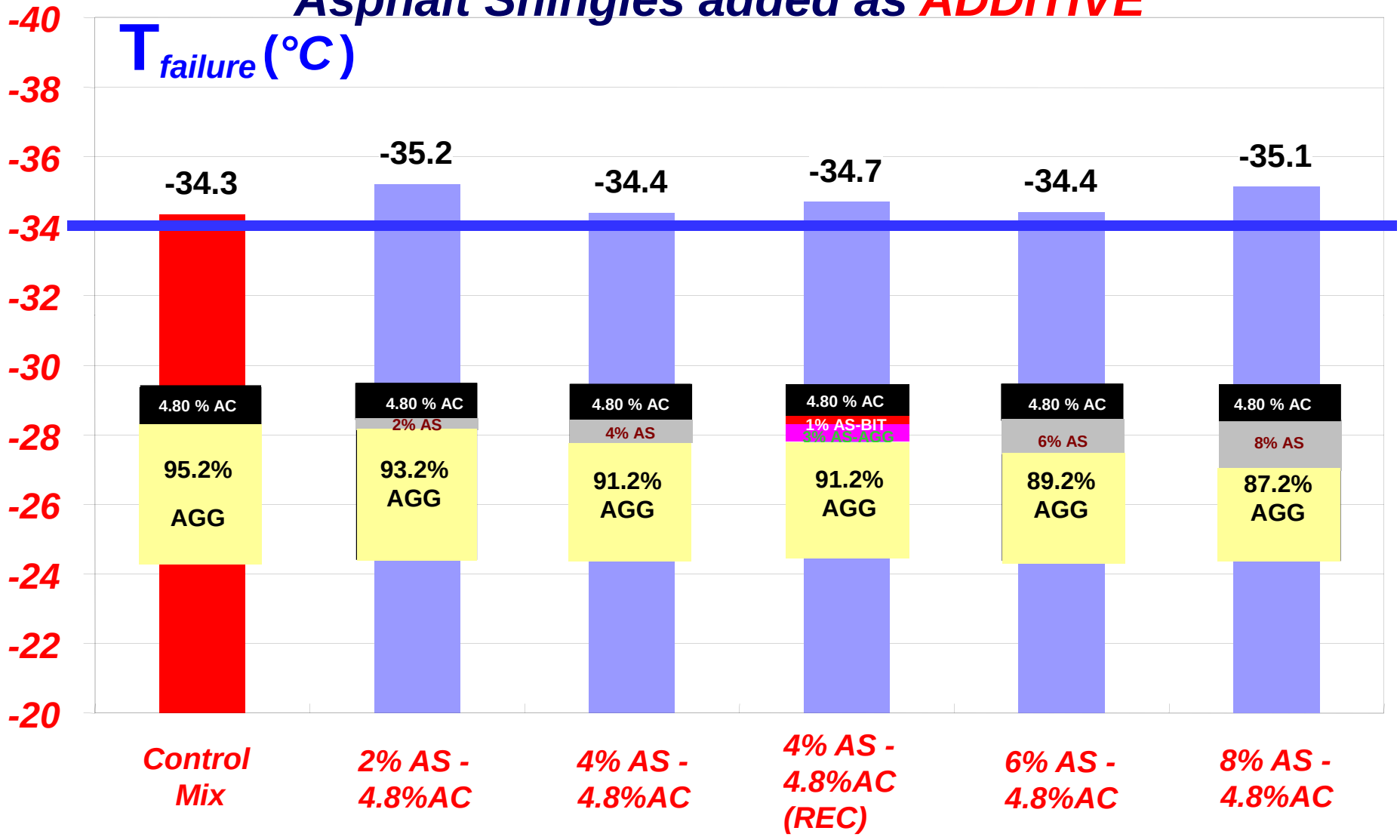
TSRST Results – Graphical presentation



VIRGIN BINDER PG 52-34

SERIES I

Asphalt Shingles added as ADDITIVE



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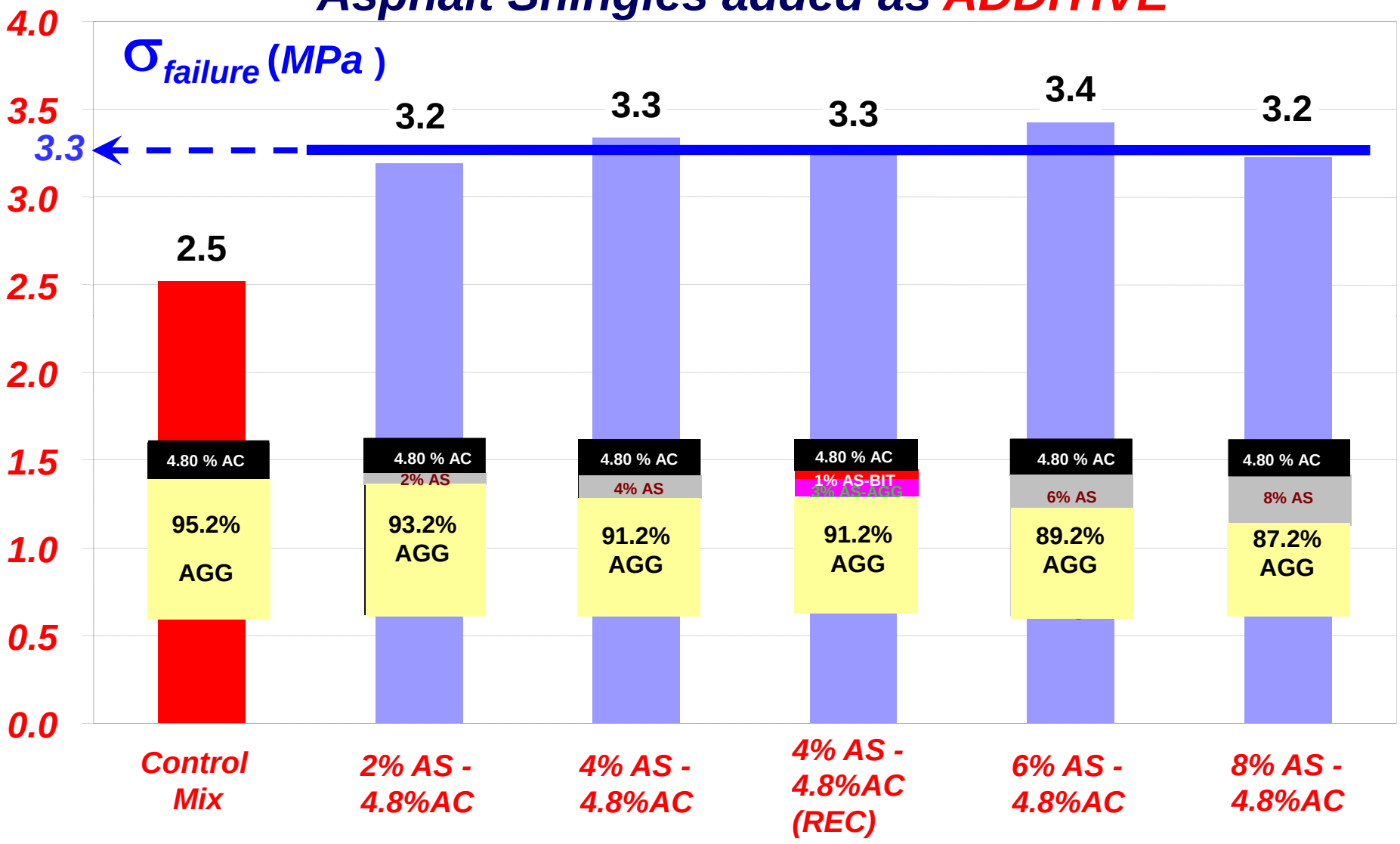
SERIES I

Asphalt Shingles added as ADDITIVE



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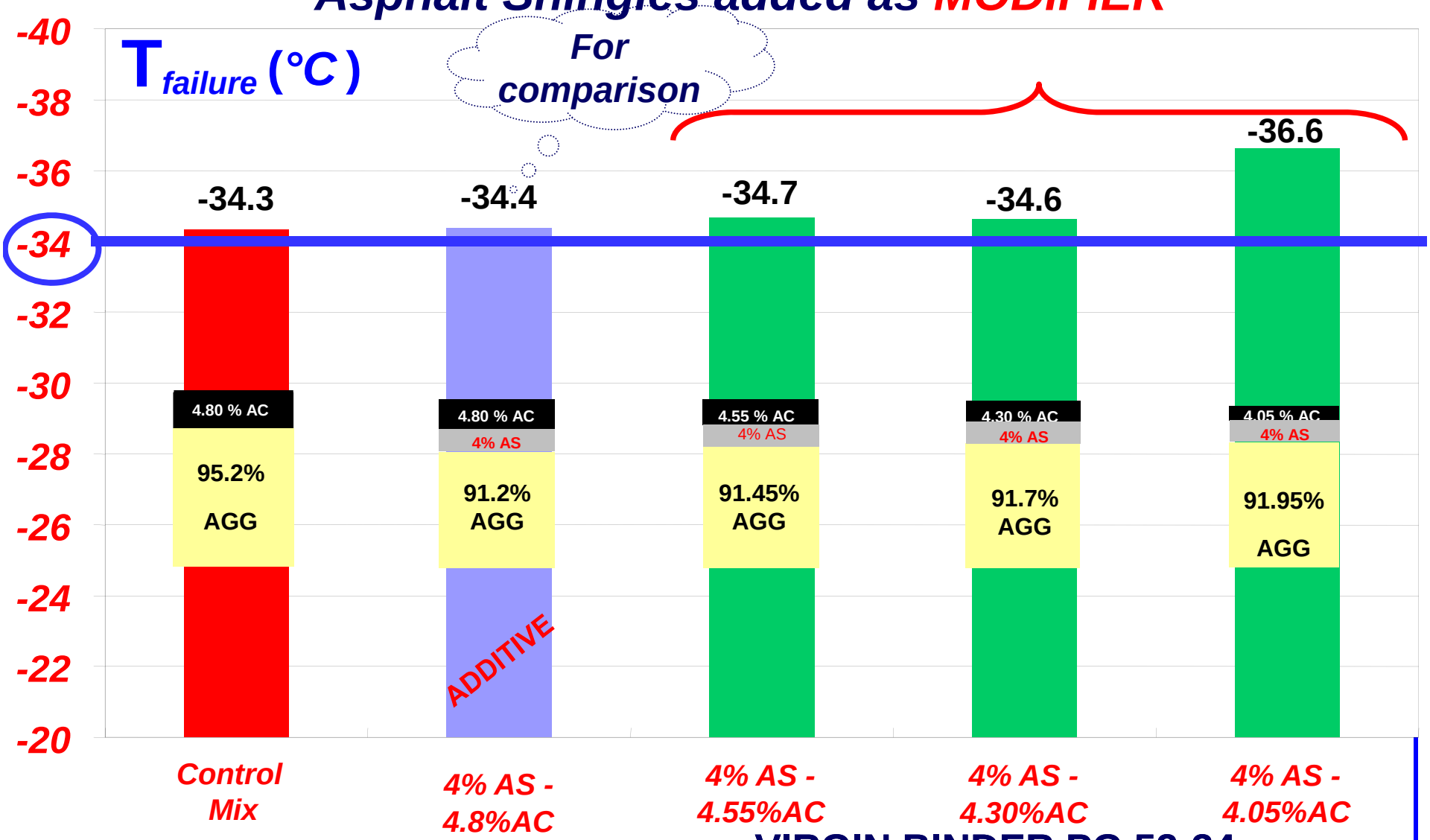
SERIES II

Asphalt Shingles added as MODIFIER



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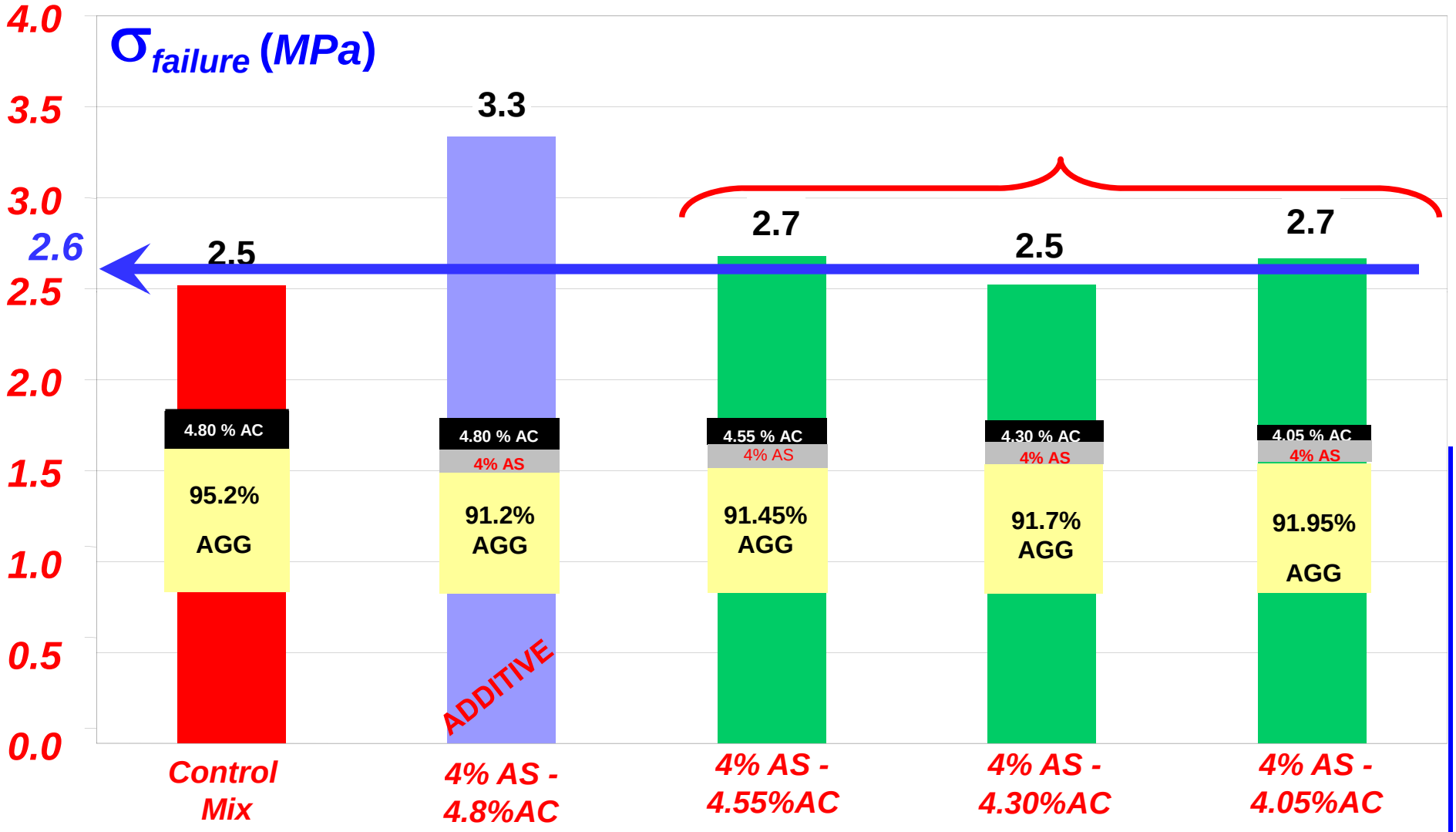
SERIES II

Asphalt Shingles added as MODIFIER



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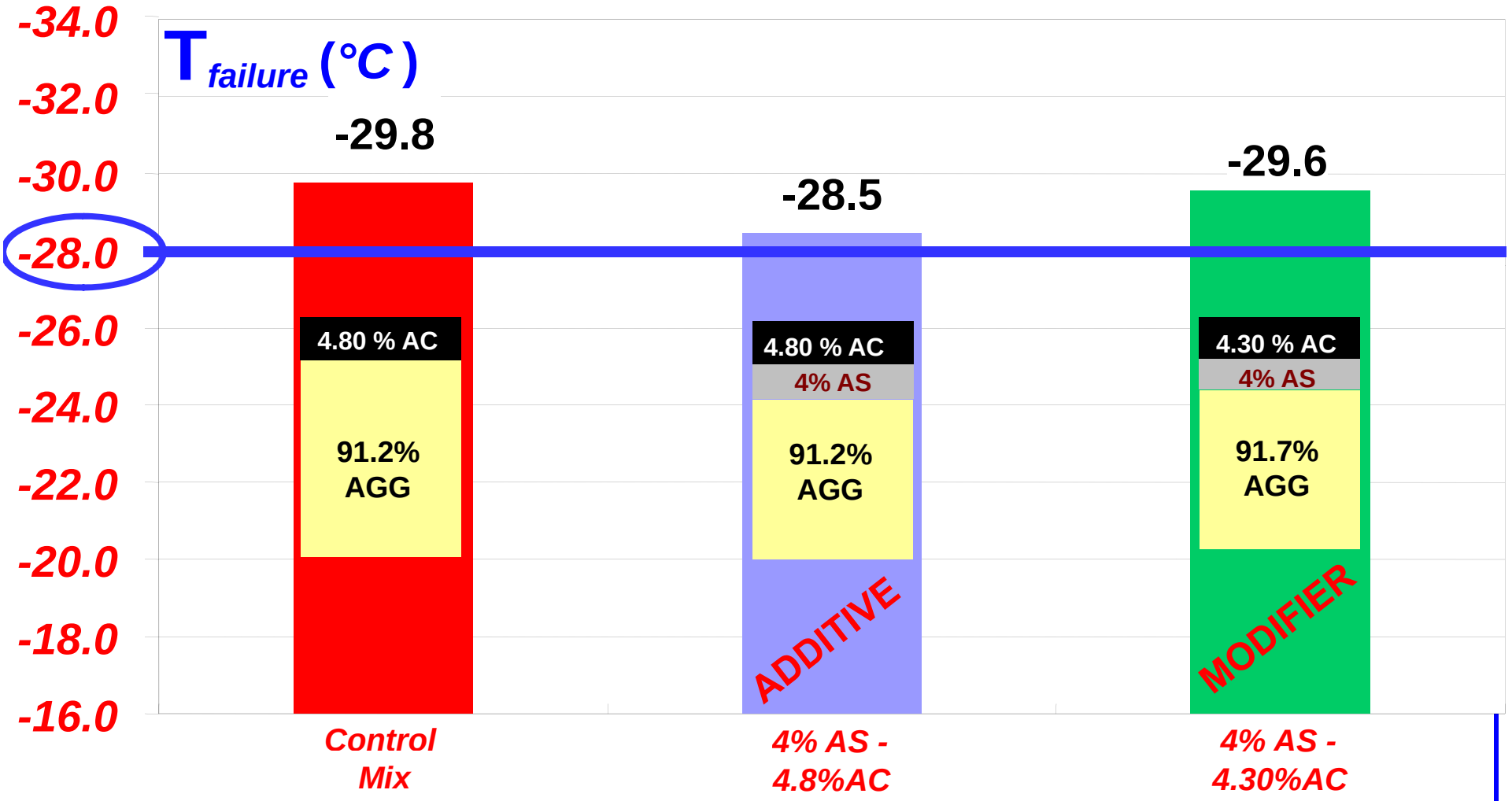
VIRGIN BINDER PG 58-28



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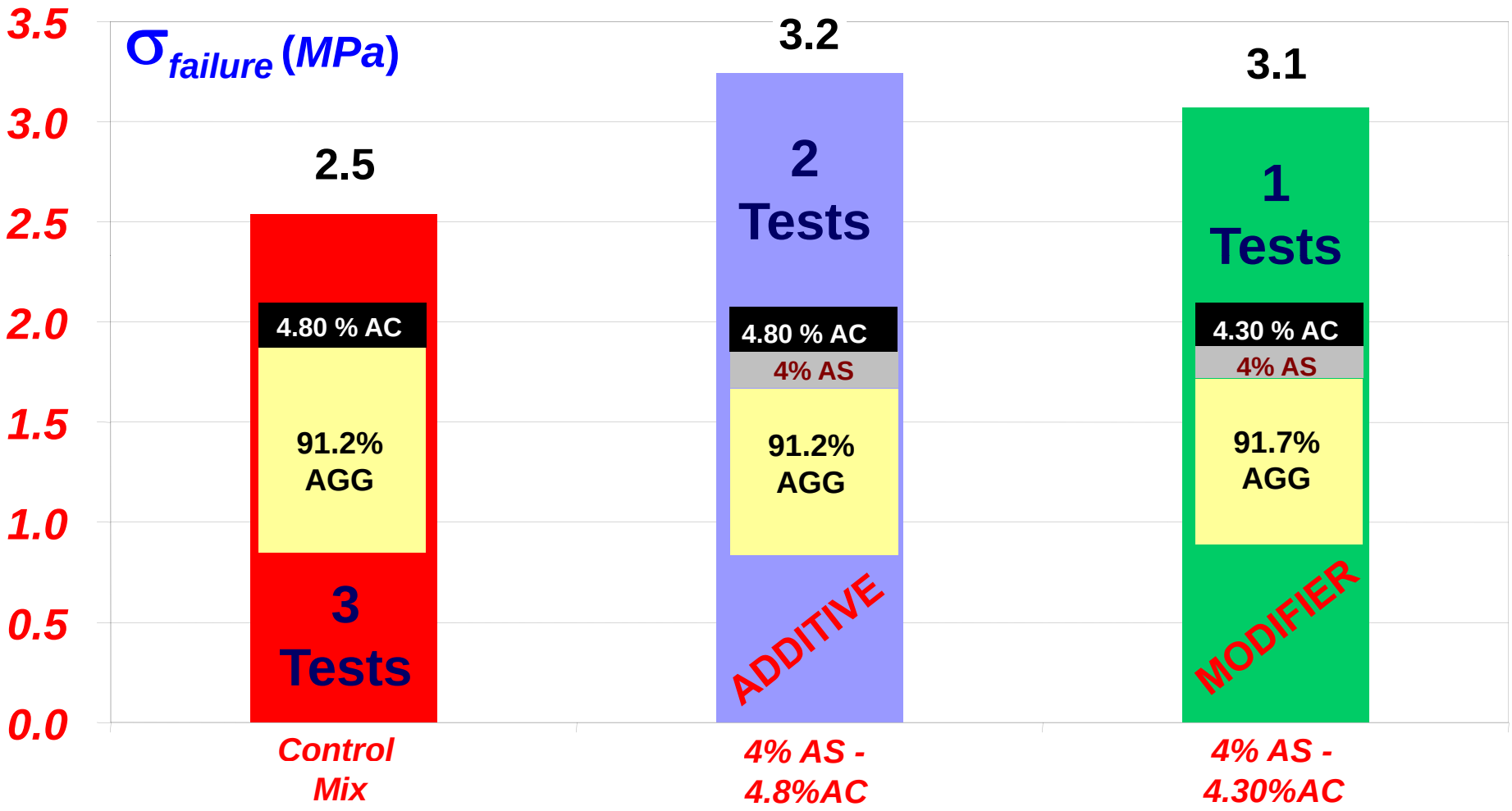
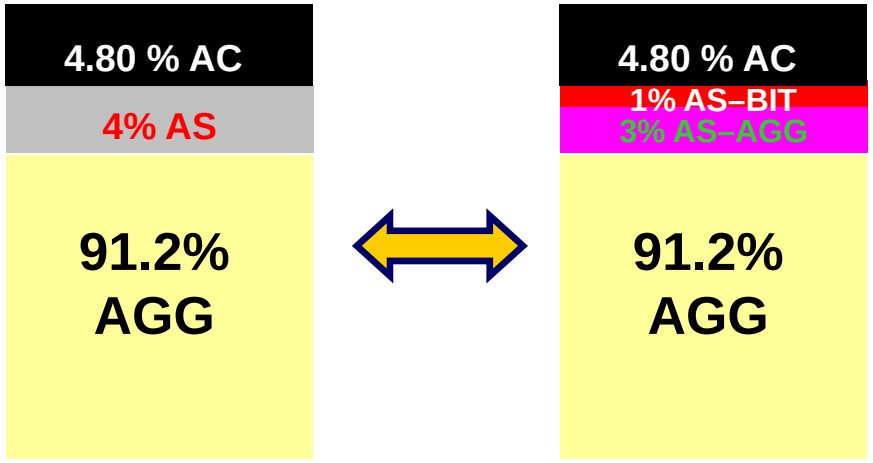
VIRGIN BINDER PG 58-28



HIGHLIGHTS

1) The repeatability of TSRST ➔ Satisfactory

2) Identical low temperature resistance for both mixes

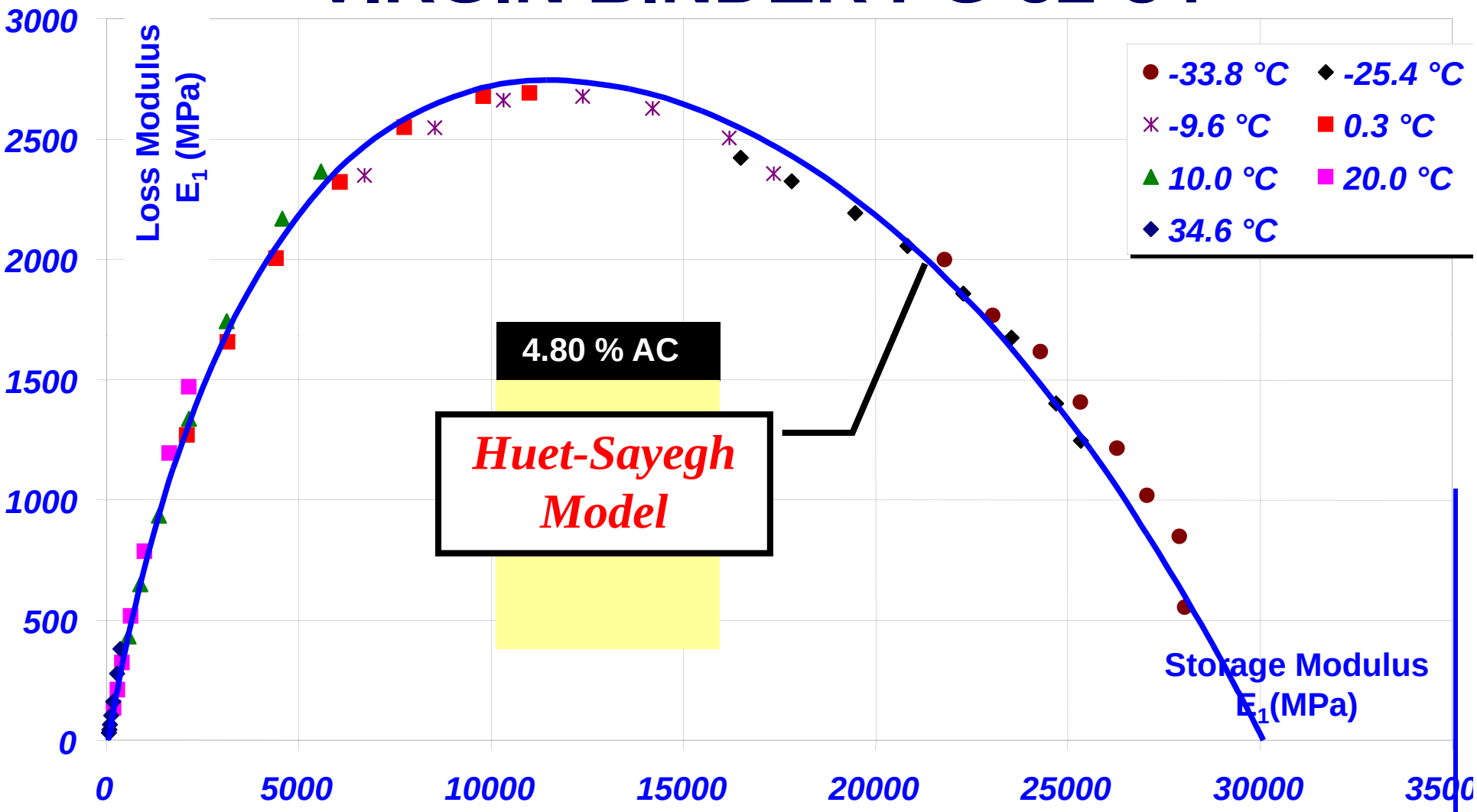


3) Incorporation of AS do not influence the low cracking TSRST temperatures

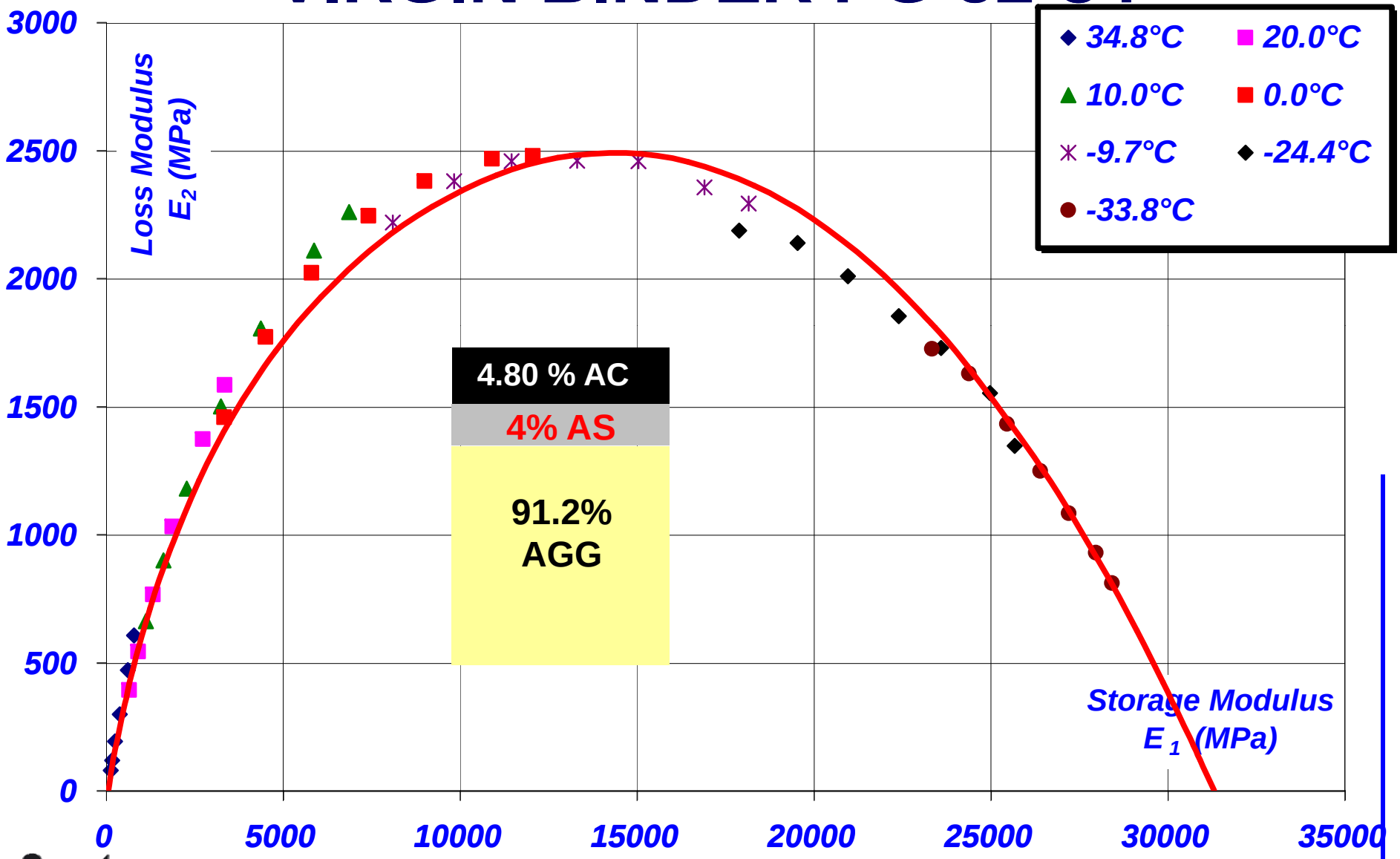
COMPLEX MODULUS MEASUREMENTS

- Exploration the influence of Recycled Asphalt Shingles on the behaviour
- Evaluation of effectiveness of Asphalt Shingles components in the Asphalt Mix
- High temperature behaviour
- Fatigue behaviour
- Pavement design based on Complex Modulus values

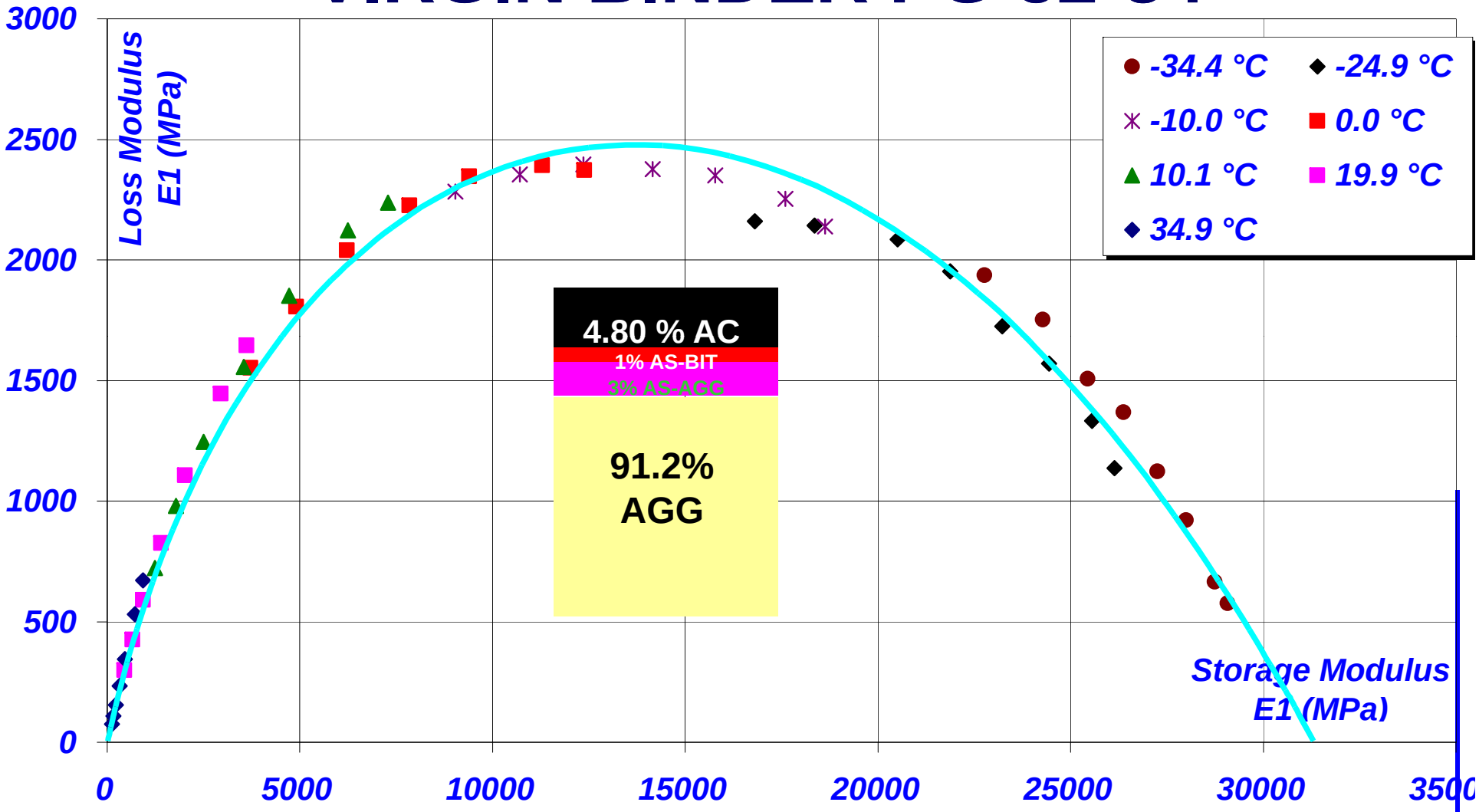
VIRGIN BINDER PG 52-34



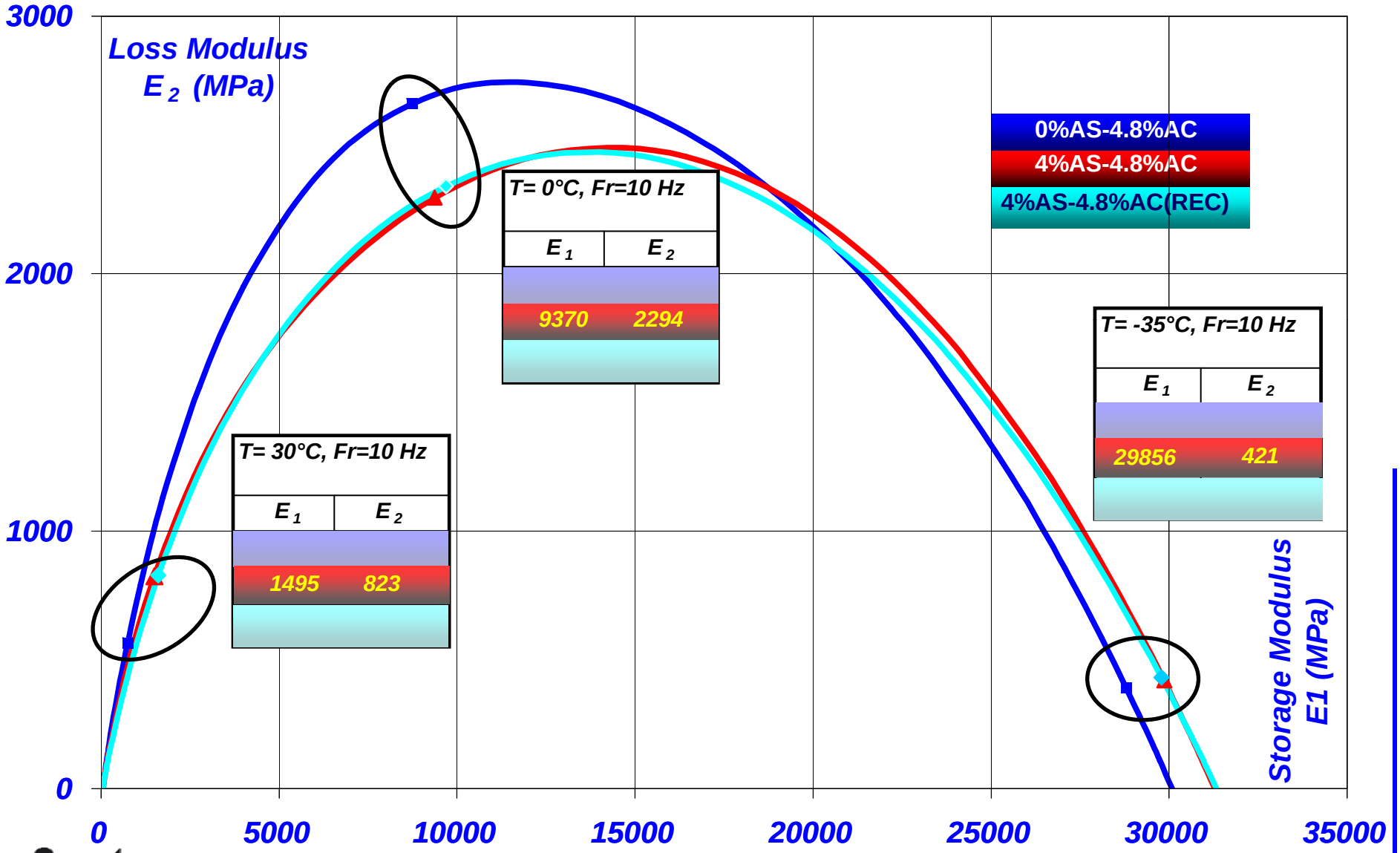
VIRGIN BINDER PG 52-34



VIRGIN BINDER PG 52-34



VIRGIN BINDER PG 52-34



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HIGHLIGHTS

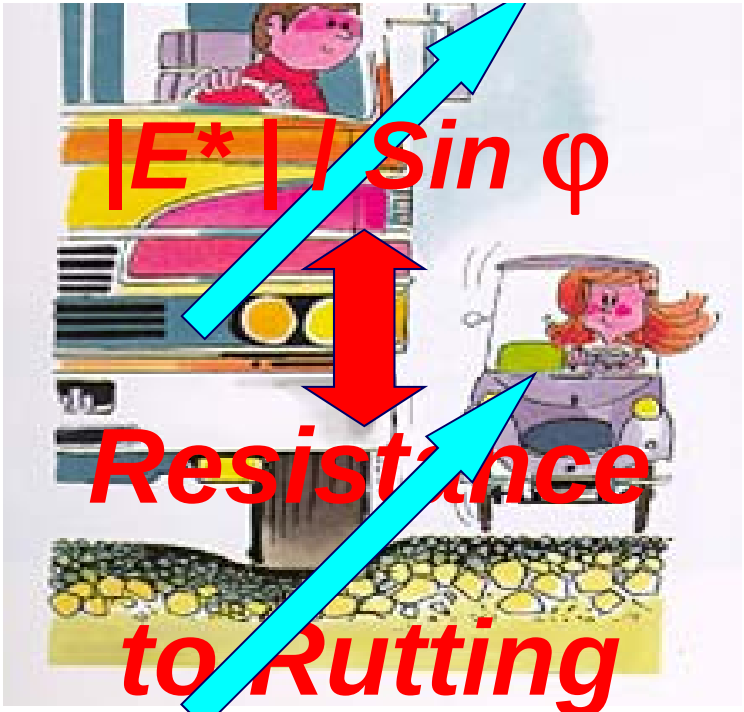
- ***Asphalt Shingles particles modify clearly the Global Rheological Behaviour of Asphalt Mixes ➔ Asphalt Shingles do not behave as BLACK ROCK***

- ***Incorporation of Asphalt Shingles as particles or as separate components leads to Identical Rhelogical Behaviour in both cases***

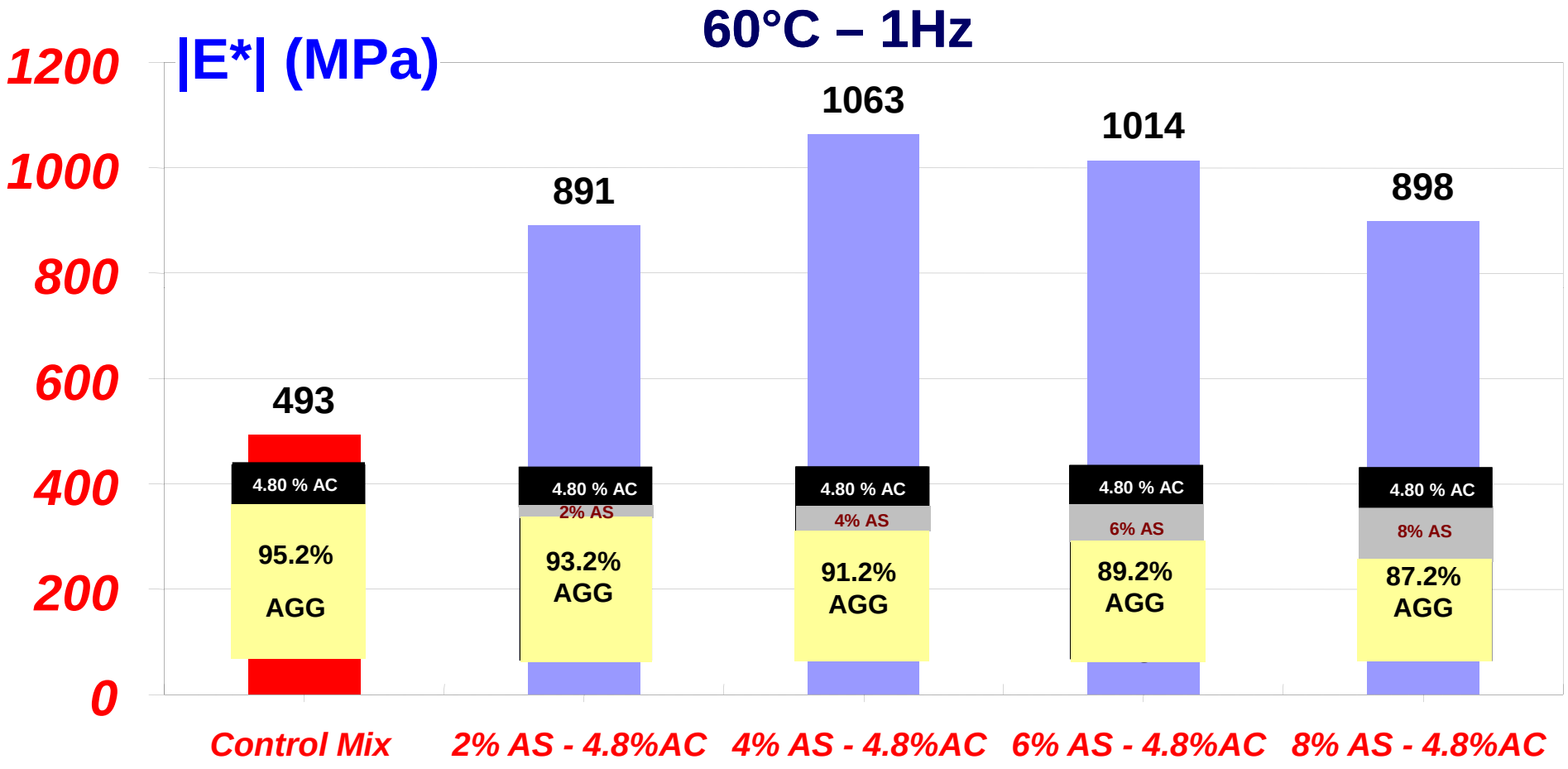
RESISTANCE TO RUTTING

Complex Modulus values

@ (60°C – 1Hz)



VIRGIN BINDER PG 52-34



SERIES I

Asphalt Shingles added as ADDITIVE

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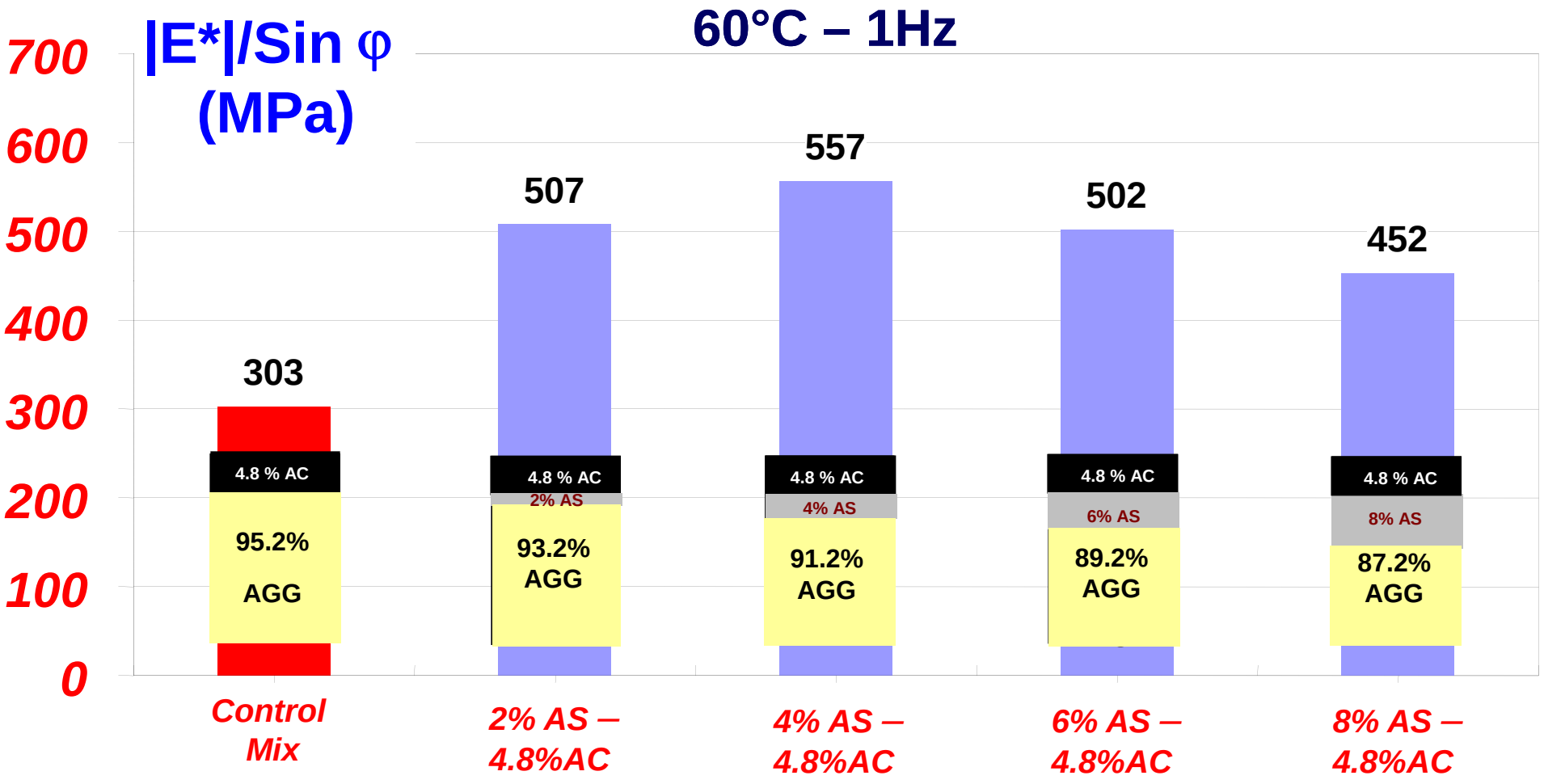
VIRGIN BINDER PG 52-34



SERIES I

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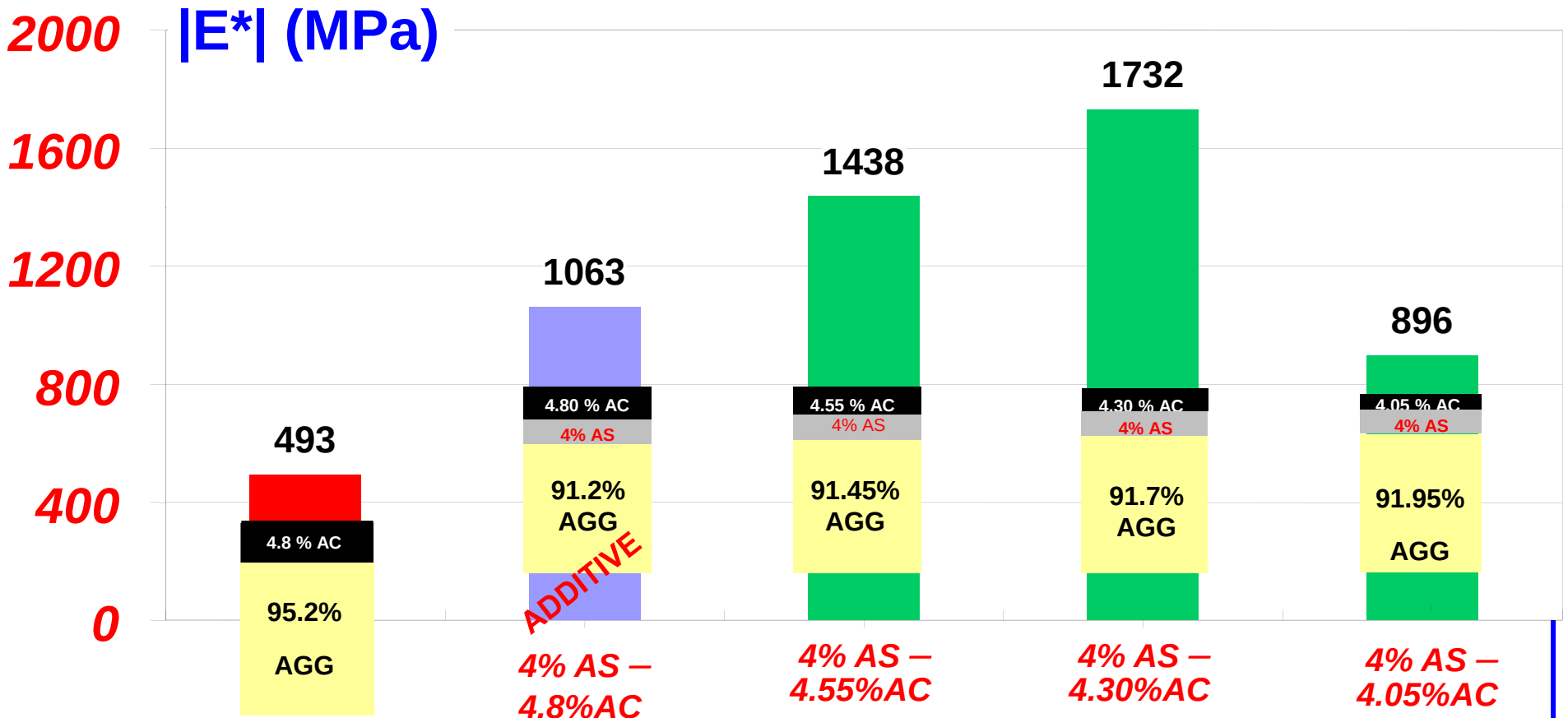
VIRGIN BINDER PG 52-34

60°C – 1Hz



SERIES II

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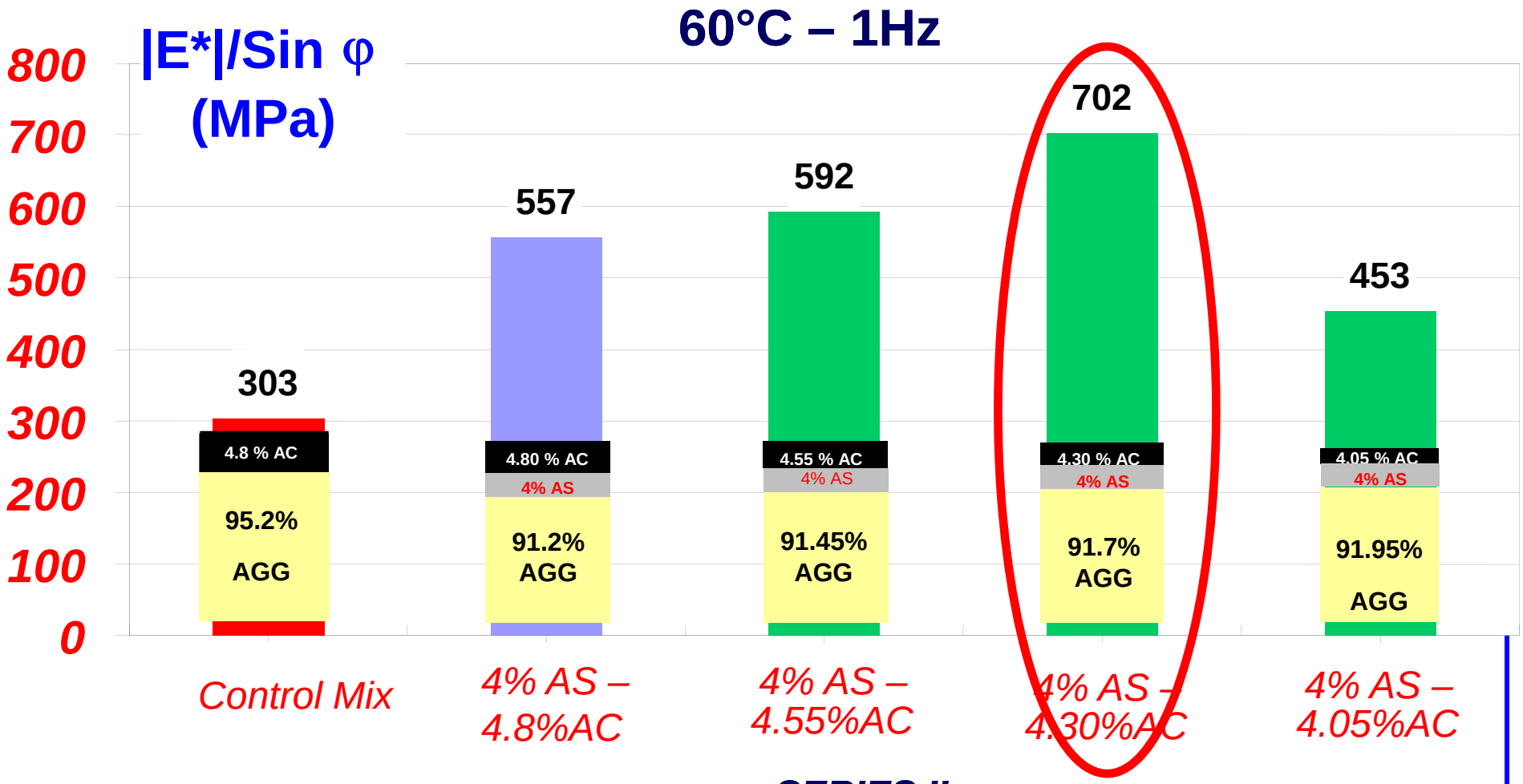
VIRGIN BINDER PG 52-34



SERIES II

Asphalt Shingles added as MODIFIER

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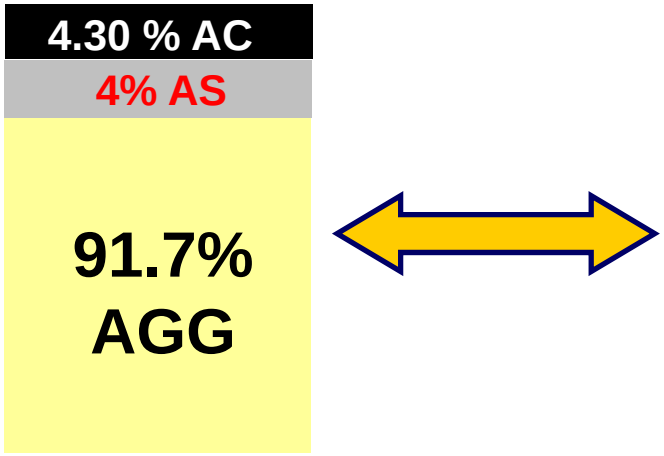
HIGHLIGHTS

According to SHRP concepts for rutting

<u>The use of recycled Asphalt Shingles as ADDITIVE or as MODIFIER enhances the rutting resistance</u>



Higher rutting resistance

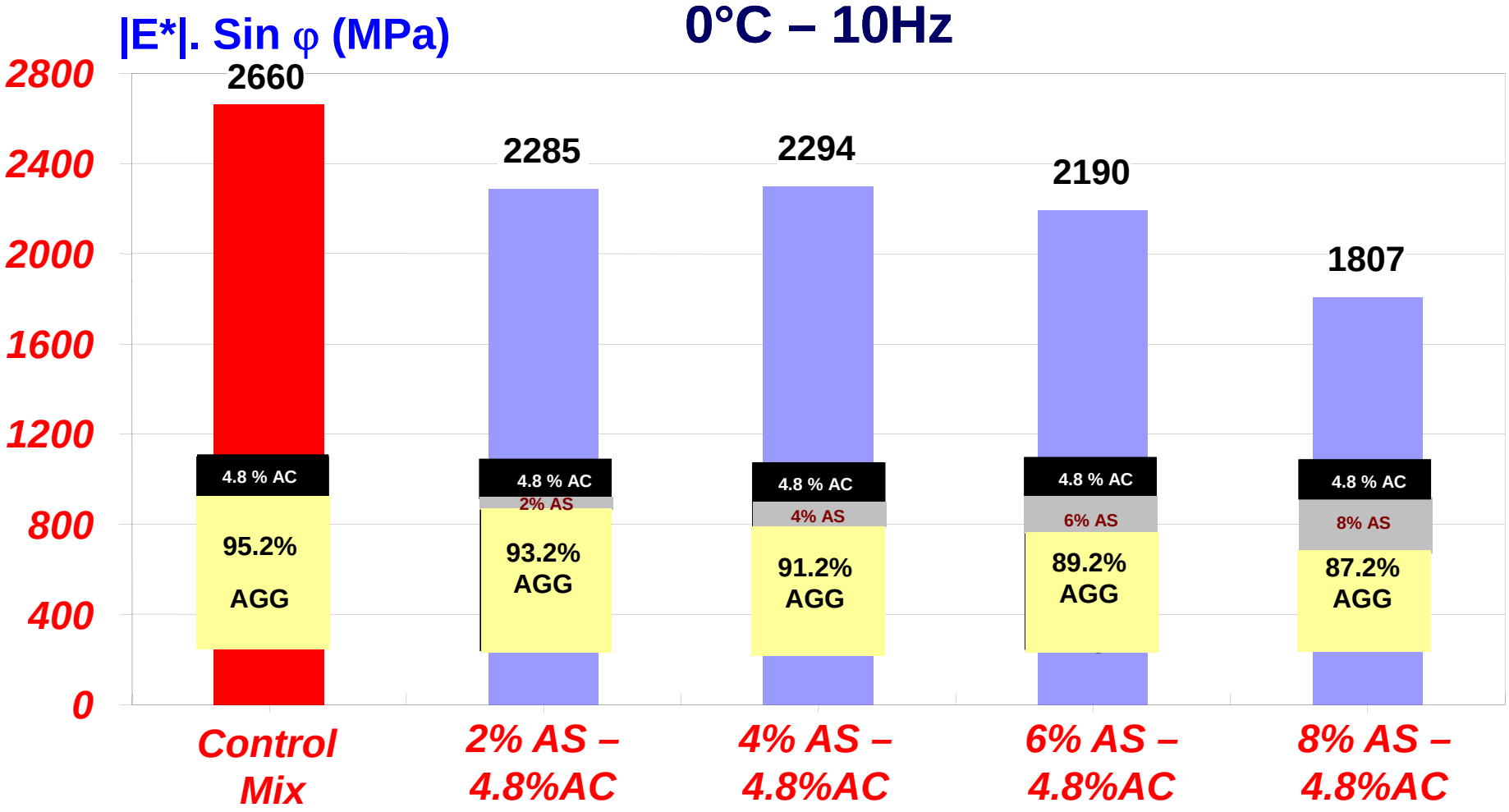
This conclusion lies well with the literature

RESISTANCE TO FATIGUE

Complex Modulus values

@ (0°C – 10Hz)

VIRGIN BINDER PG 52-34



SERIES II

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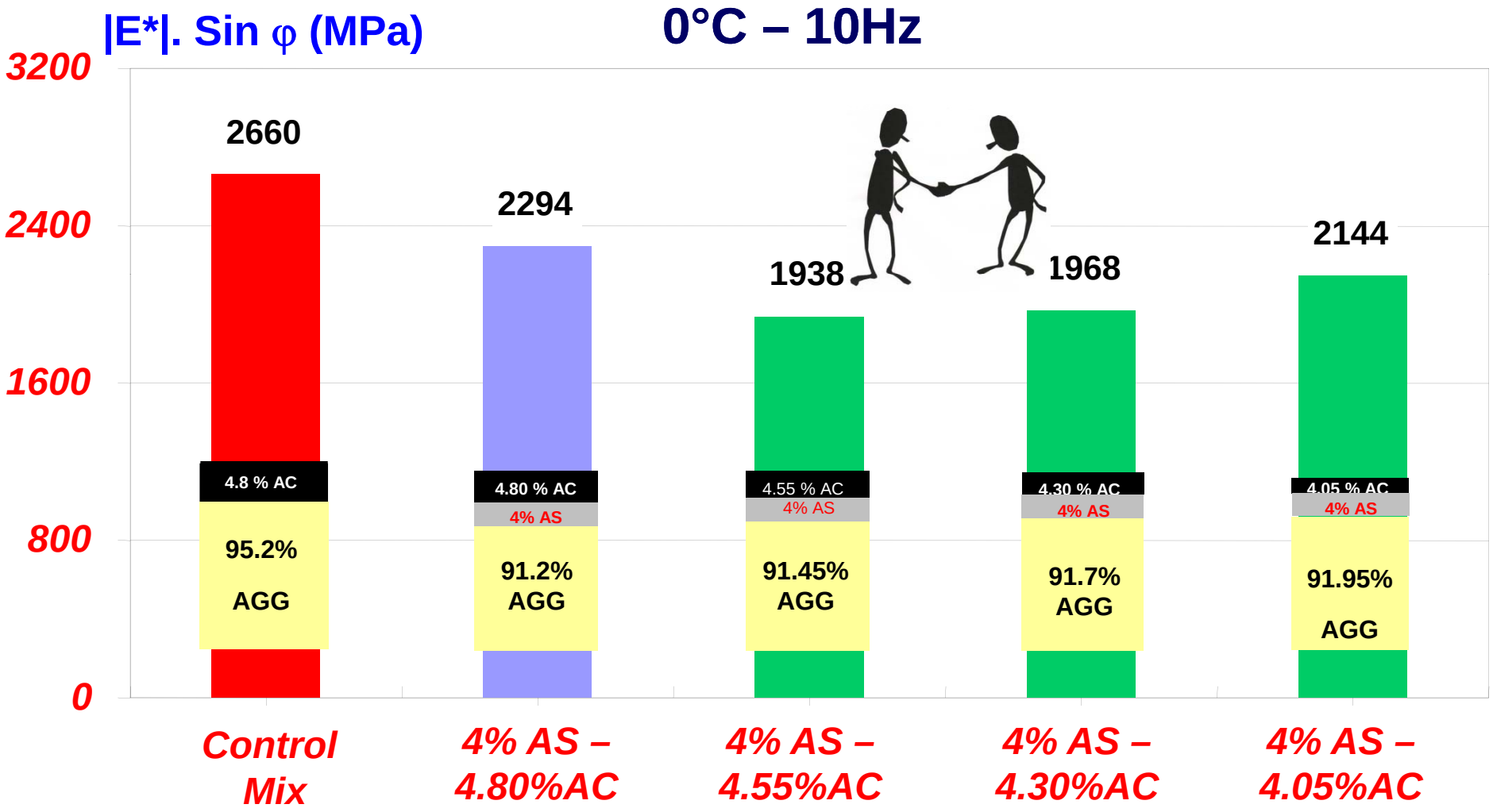

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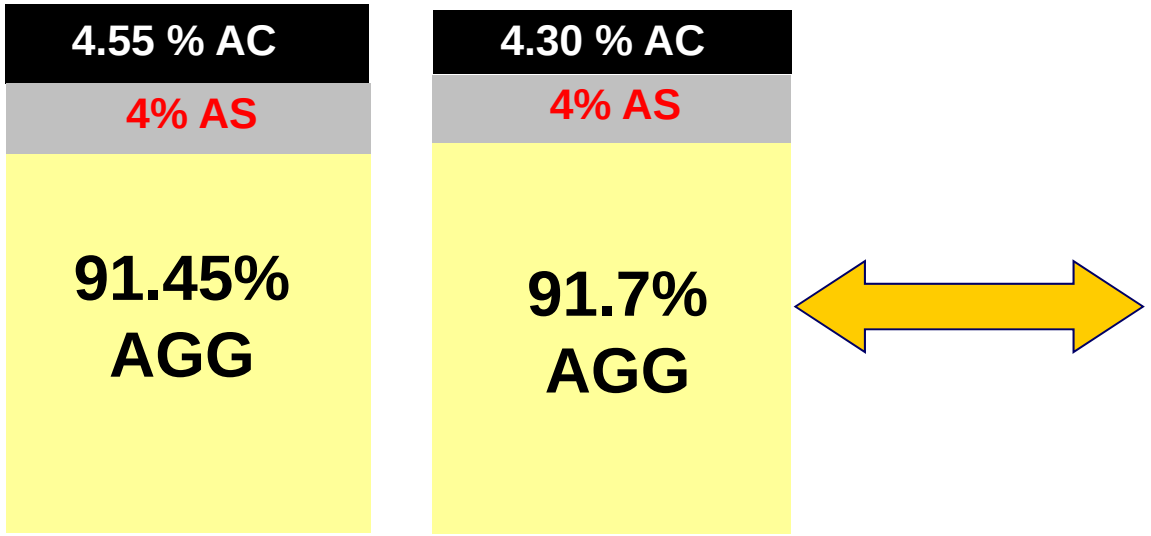
HIGHLIGHTS

According to SHRP concepts for fatigue

The use of recycled Asphalt Shingles as ADDITIVE or as MODIFIER enhances the fatigue resistance



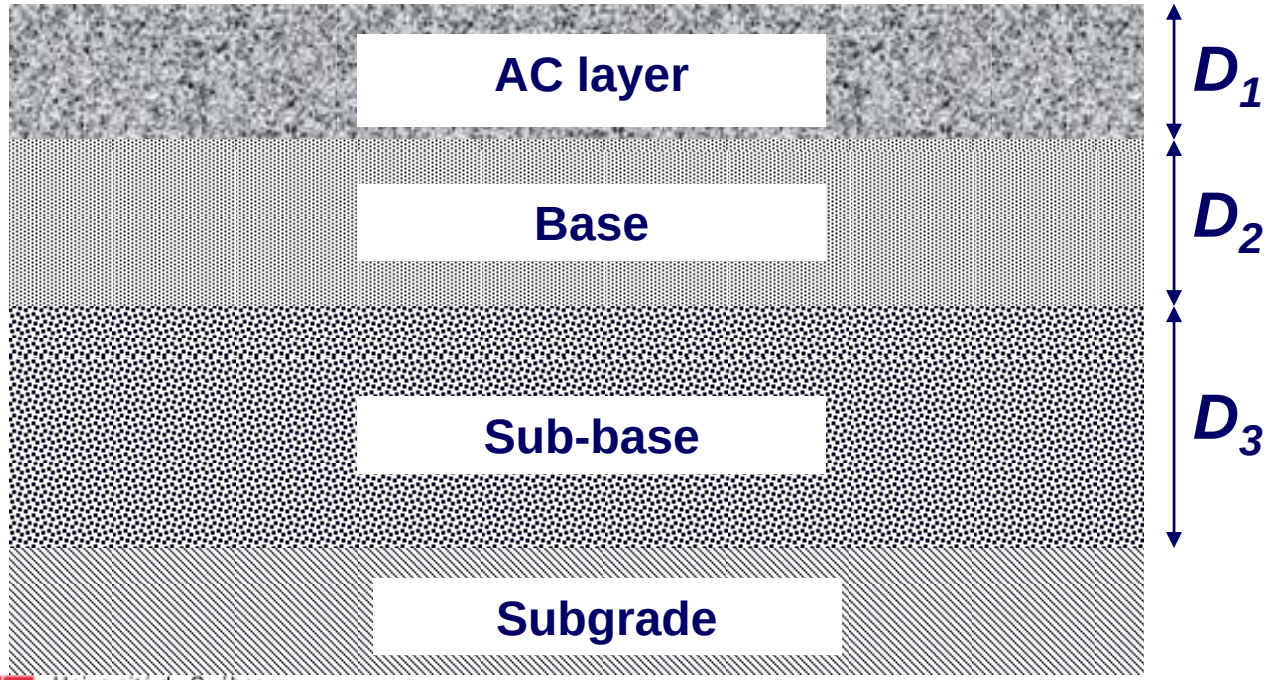
Higher fatigue resistance

Asphalt Pavement Design - Layer Thickness

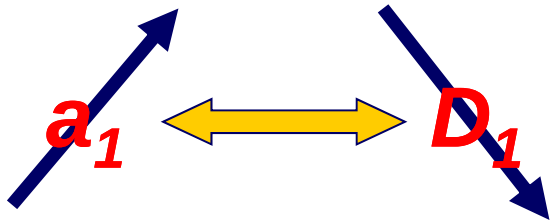
The AASHTO method for determining the thickness of flexible pavement layers

$$SN = D_1a_1 + D_2a_2m_2 + D_3a_3m_3$$

a_1 is the structural coefficient or strength coefficient of the AC layer



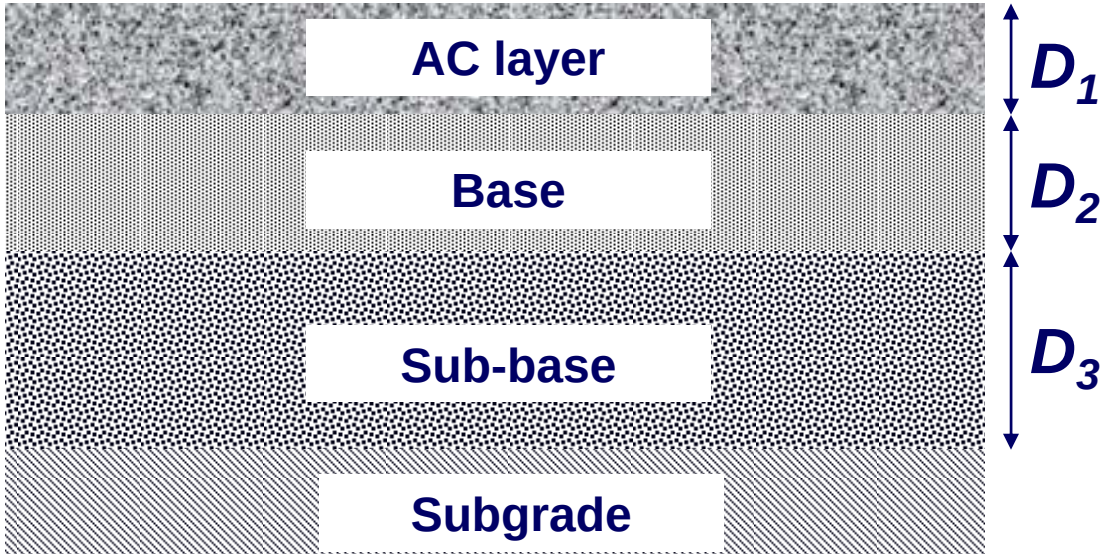
Asphalt Pavement Design - Layer Thickness



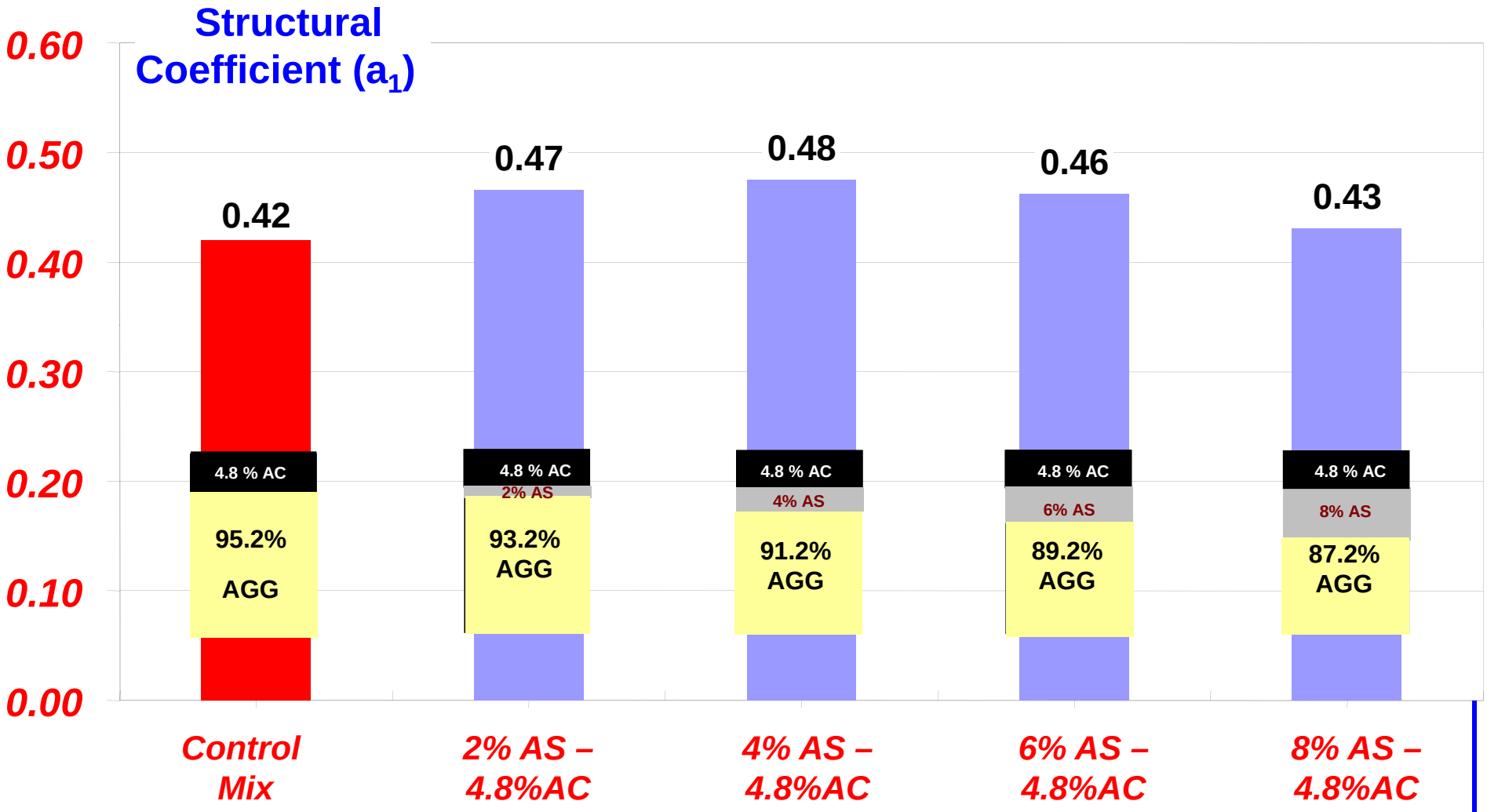
$$a_1 = 0.414*LOG(145.04*M_R)-1.896$$

MTQ Model

We considered values of E* at 20°C (68°F) and 30 Hz



VIRGIN BINDER PG 52-34



SERIES I

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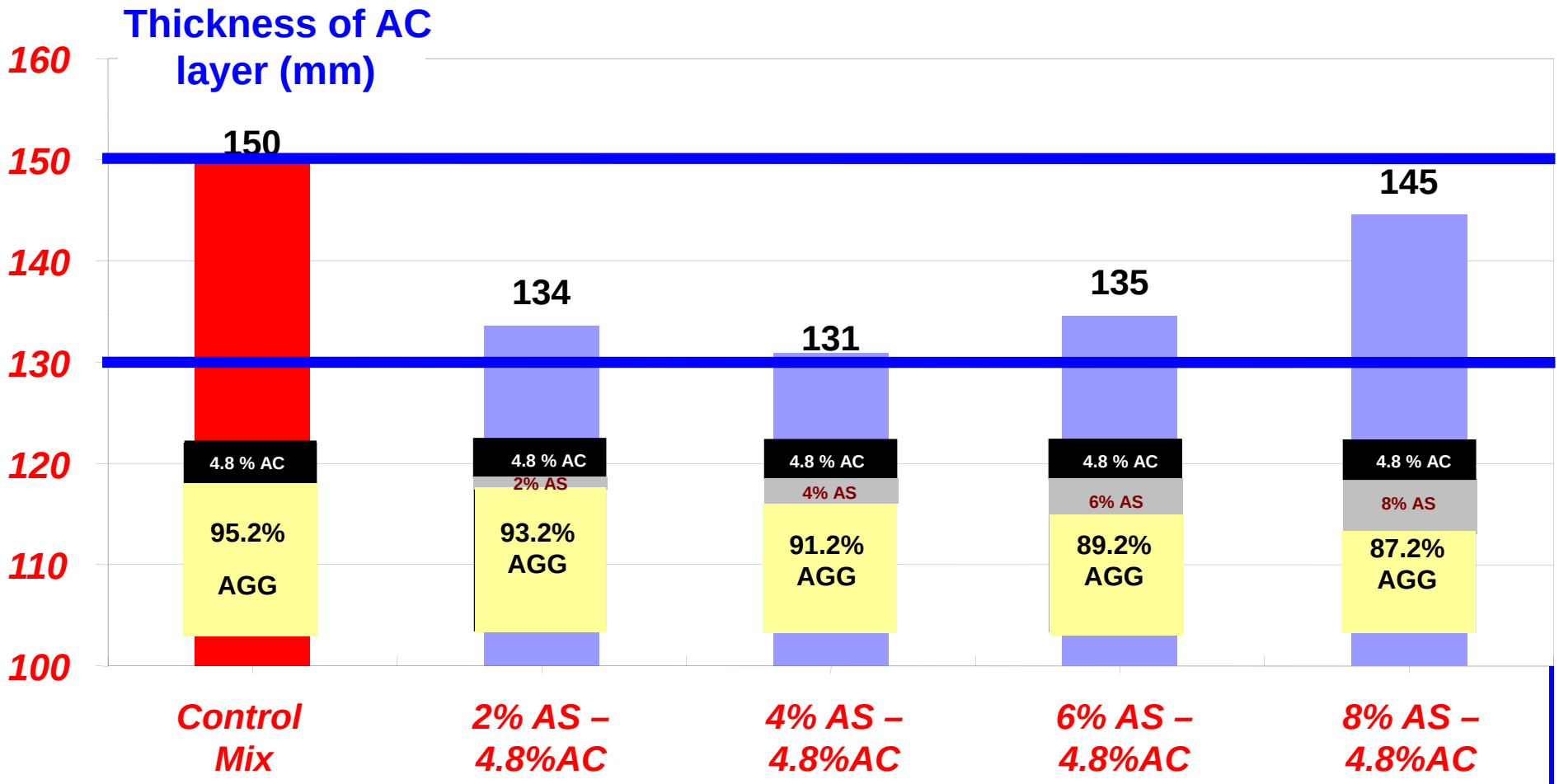

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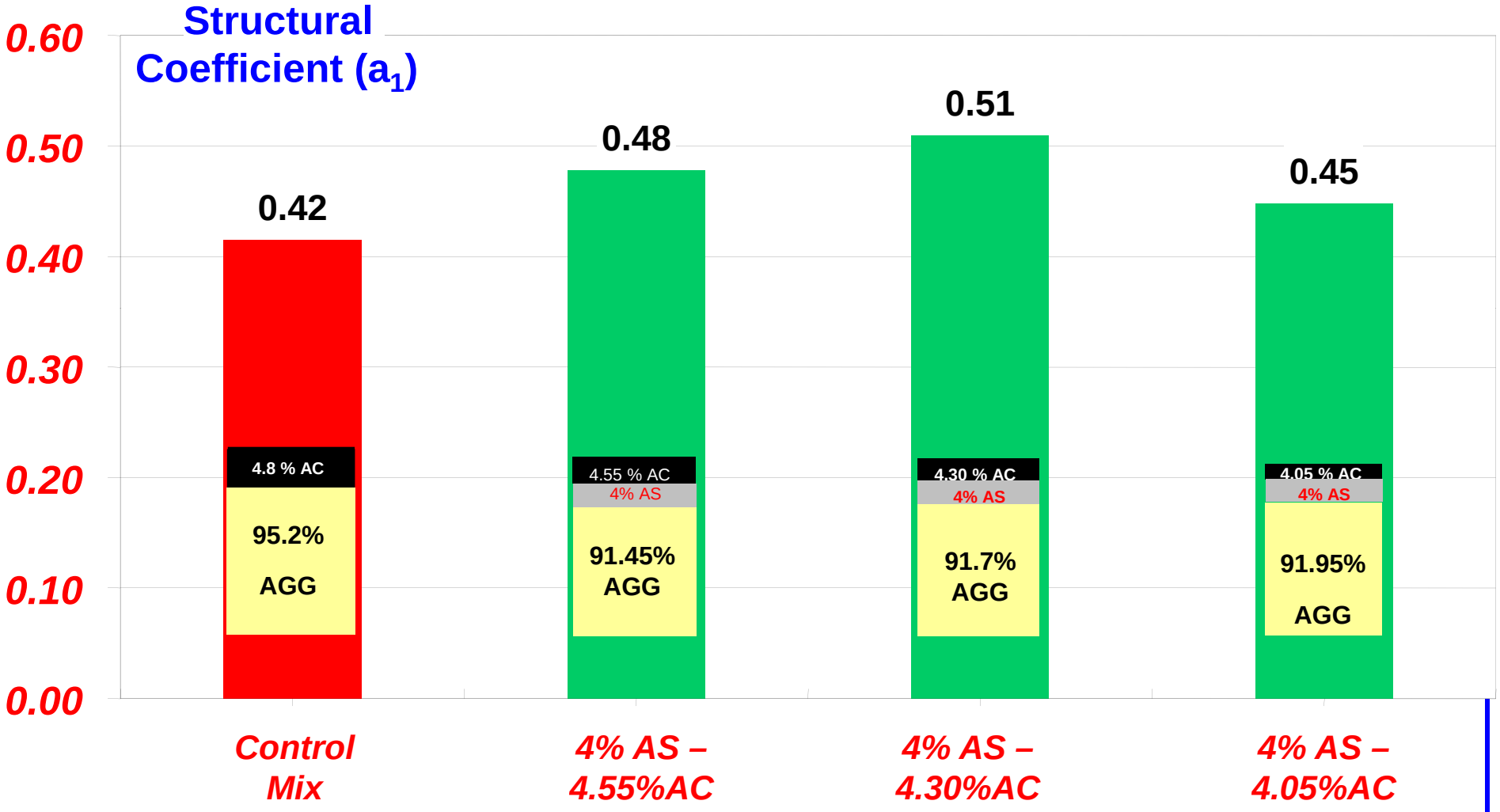

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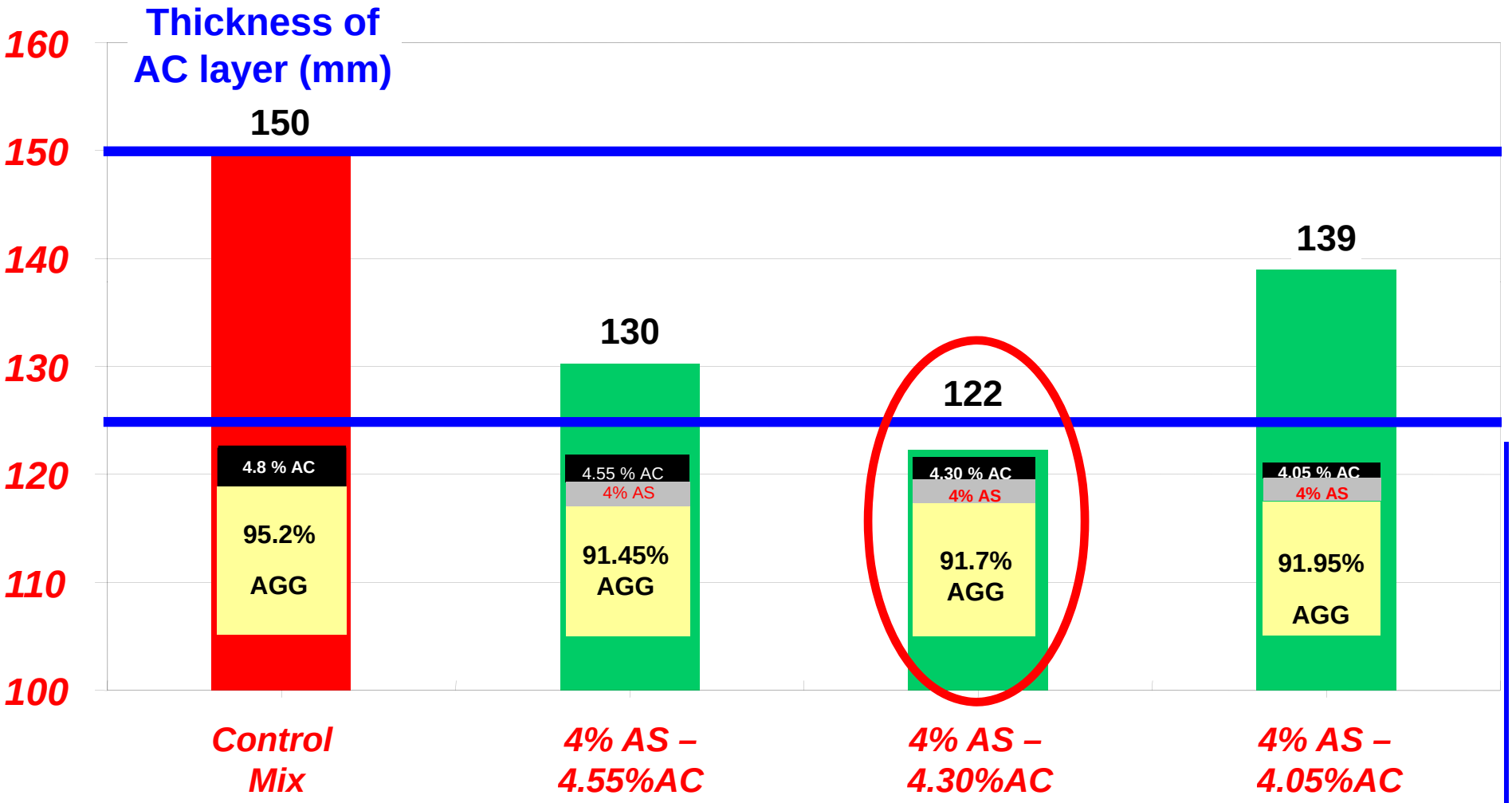

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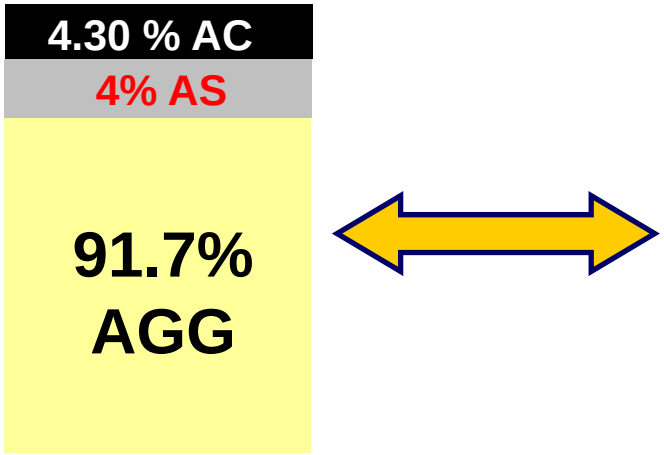
HIGHLIGHTS

AASHTO PAVEMNENT DESIGN METHOD

The use of recycled Asphalt Shingles as ADDITIVE or as MODIFIER permits to consider the use of thinner Asphalt Concrete layers



Better mix for pavement design

Conclusions

CONCLUSION 1

RECYCLED ASPHALT SHINGLES

≠

BLACK ROCK

CONCLUSION 2

COMPONENTS OF RECYCLED ASPHALT SHINGLES

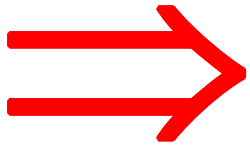
(AC BINDER – AGGREGATES – FIBRES)

PARTICIPATE ACTIVELY IN THE BEHAVIOUR OF THE MIX WHATEVER THE INCORPORATION PROCESS

CONCLUSION 3

ASPHALT SHINGLES AS

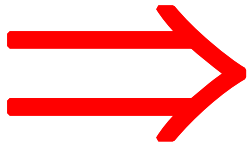
ADDITIVE



GOOD RESISTANCE TO LOW TEMPERATURE CRACKING

CONCLUSION 4

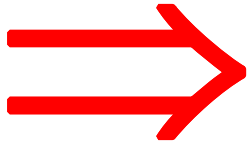
ASPHALT SHINGLES AS MODIFIER



GOOD RESISTANCE TO LOW TEMPERATURE CRACKING

CONCLUSION 5

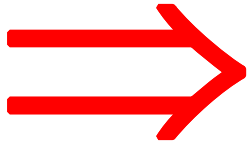
SHRP FATIGUE AND RUTTING PREDICTION



HIGHER RESISTANCE 4% ASPHALT SHINGLES AS MODIFIER

CONCLUSION 6

AASHTO PAVEMENT DESIGN



HIGHER STRUCTURAL VALUE
4% ASPHALT SHINGLES AS MODIFIER

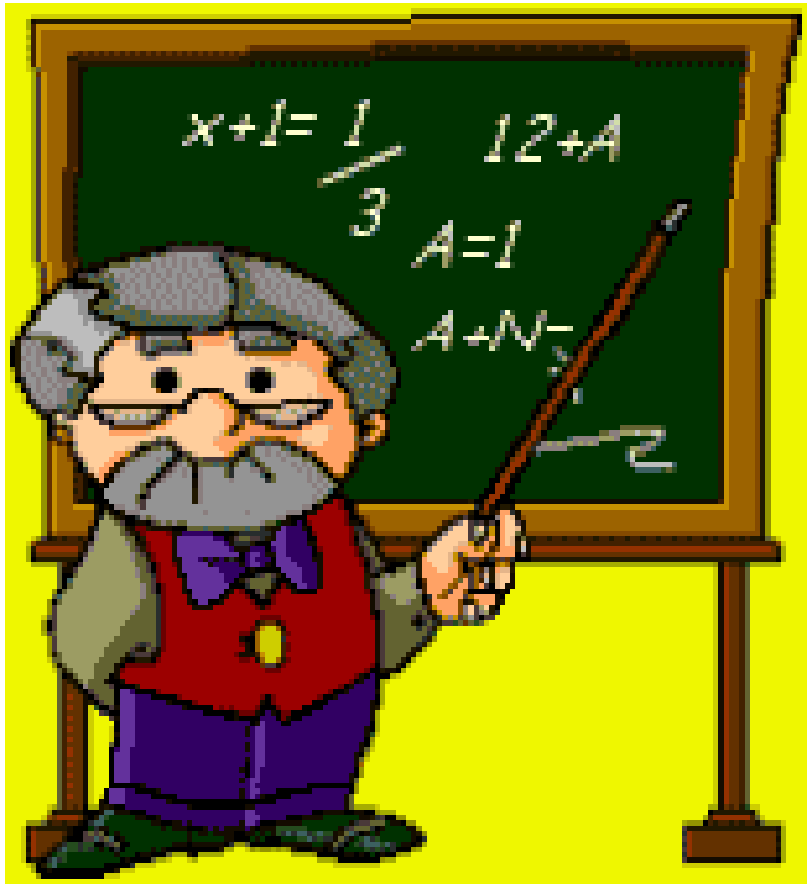
FINAL CONCLUSION

Modified Asphalt Mixes with Recycled Asphalt Roofing Shingles

ECOLOGICAL

ECONOMICAL

PERFORMANT



QUESTIONS ?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