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Influence of a recycling agent of vegetable origin on complex modulus and fatigue performances of bituminous mixtures produced with RAP

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Outline

Introduction

Tested materials

Experimental procedure

Results and analysis

- Complex modulus
- Fatigue

Conclusions

Introduction

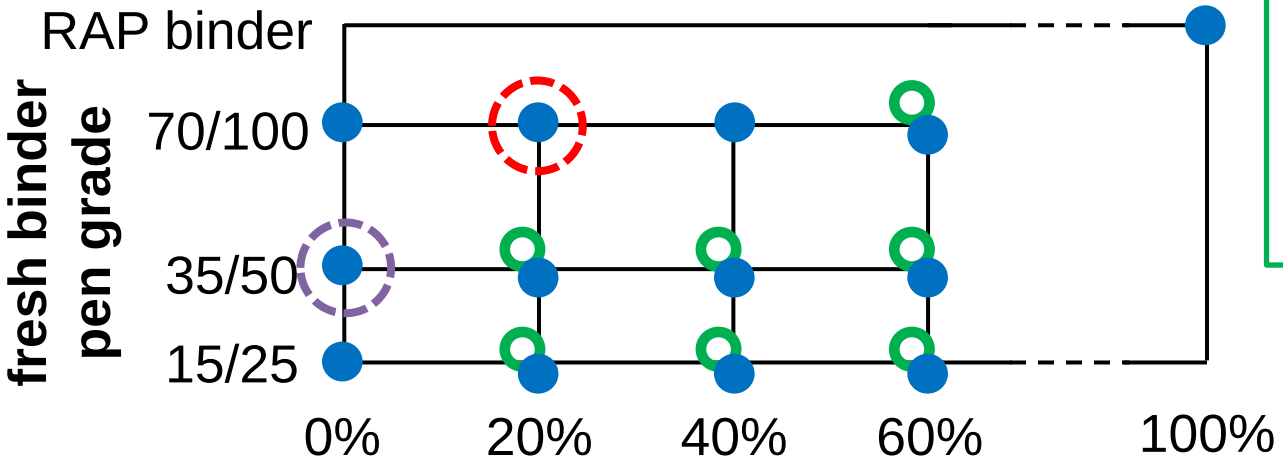
Bituminous mixtures produced with RAP

Rejuvenators:
- reactivating aged RAP binder
- → recuperate properties of aged binder
- → helping binder blending ?
- → reducing final mixture stiffness at fixed temperature?

Main literature findings:

- not a real “rejuvenation”
  → microstructure of rejuvenated aged binder ≠ virgin binder
- effects on complex modulus and fatigue properties
- dosage more important than nature/origin

Tested materials



Recycling agent content
=
3.5% by weight
of RAP binder

% RAP (by wt. of aggregates and RAP)

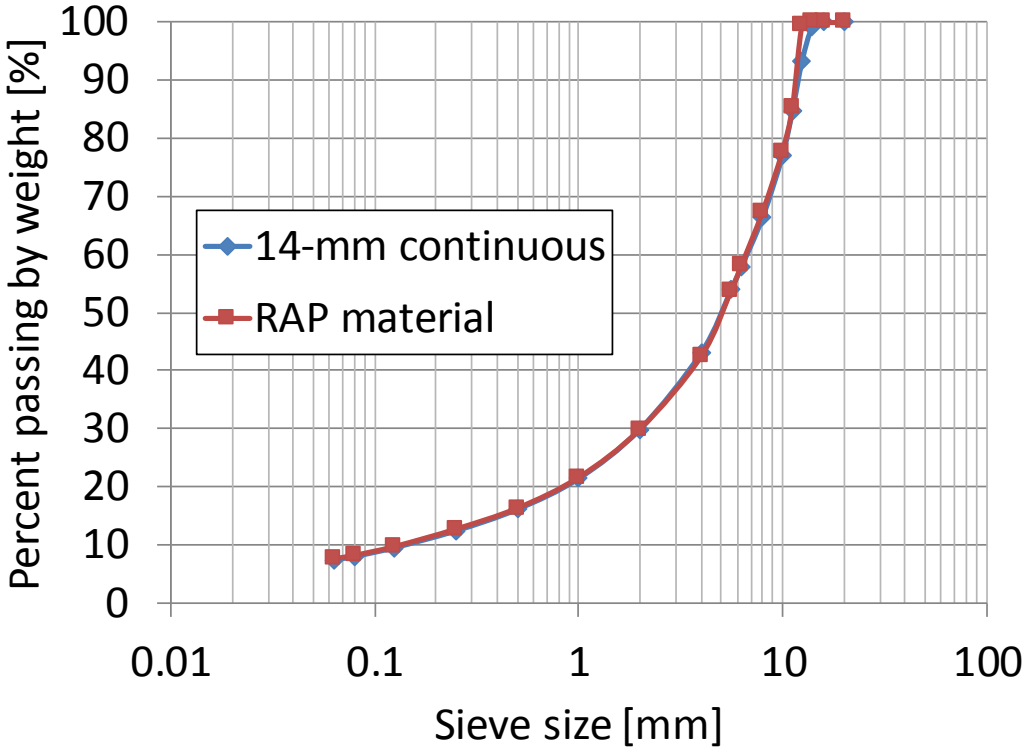
example: 35/50

example: 70/100 + 20% RAP

13 mixtures
7 mixtures
20 mixtures

- regular procedure
- regular procedure with recycling agent of vegetable origin

Tested materials

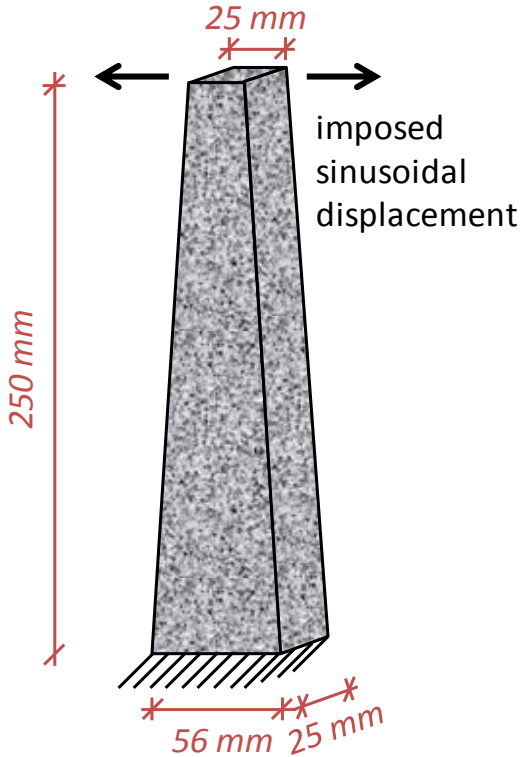


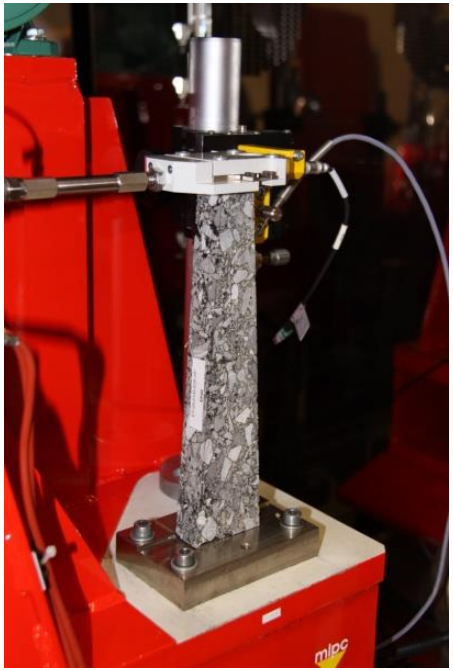
- same grading curve
- High modulus mixtures ("Enrobé à Module Élevé", EME)
- 5.35% total bitumen content

- LPC wheel-compacted slabs
- trapezoidal samples cut from slabs

Experimental procedures

Two-point bending tests on trapezoidal samples





complex modulus tests (2 samples)
only $|E^*|$ @ 15°C, 10 Hz
(EN 12697-26:2012)

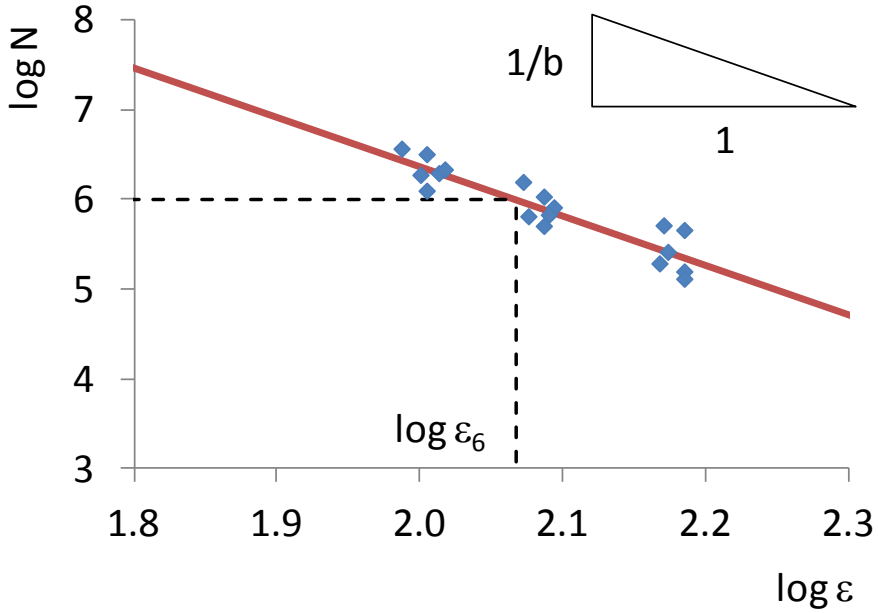
fatigue tests (18 samples)
10°C, 25 Hz
(EN 12697-24:2012)

EIFFAGE Travaux Publics laboratory, Ciry-Salsogne

Experimental procedures

Fatigue parameters ε_6 and 1/b

Example of Wöhler curve for mixture 35/50



ε_6 = 117 µm/m

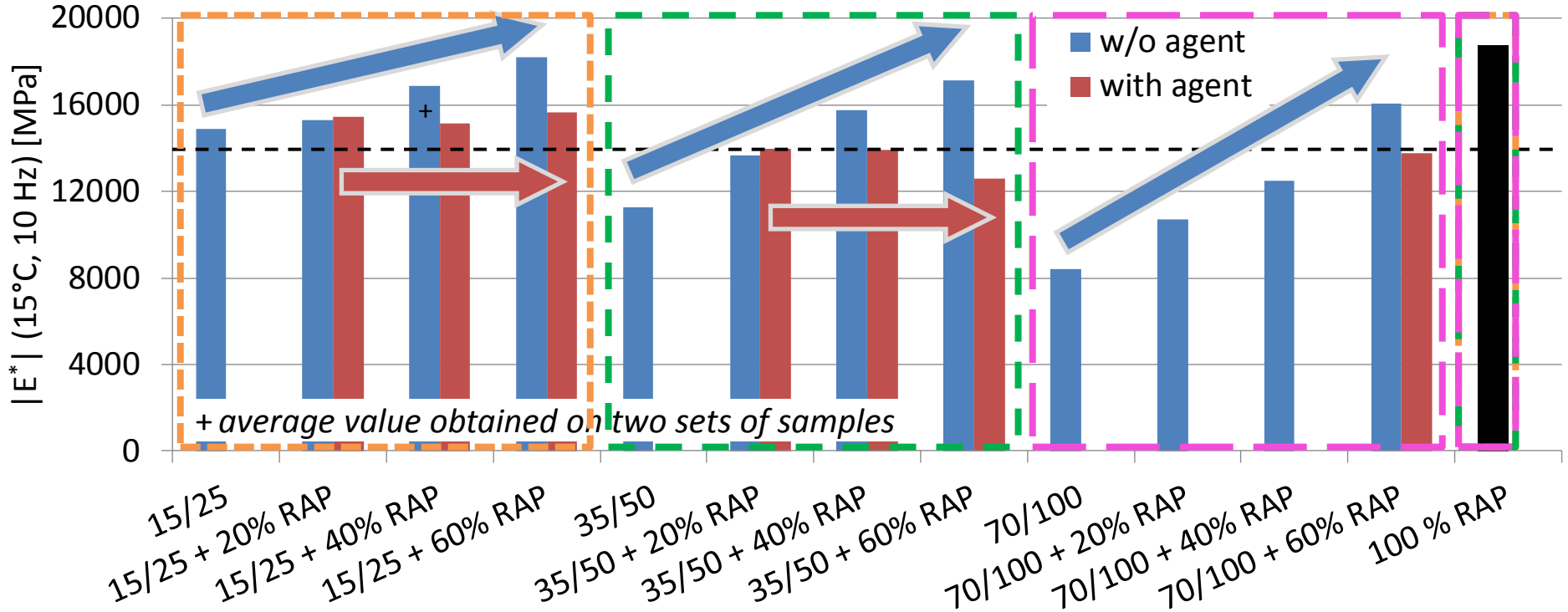
1/b = -5.49

$$\log N = a + \frac{1}{b}\log \varepsilon$$

$$\varepsilon_6 = 10^{b(6-a)}$$

parameter 1/b not treated
in the rest of the presentation:
for more details,
please refer to the paper

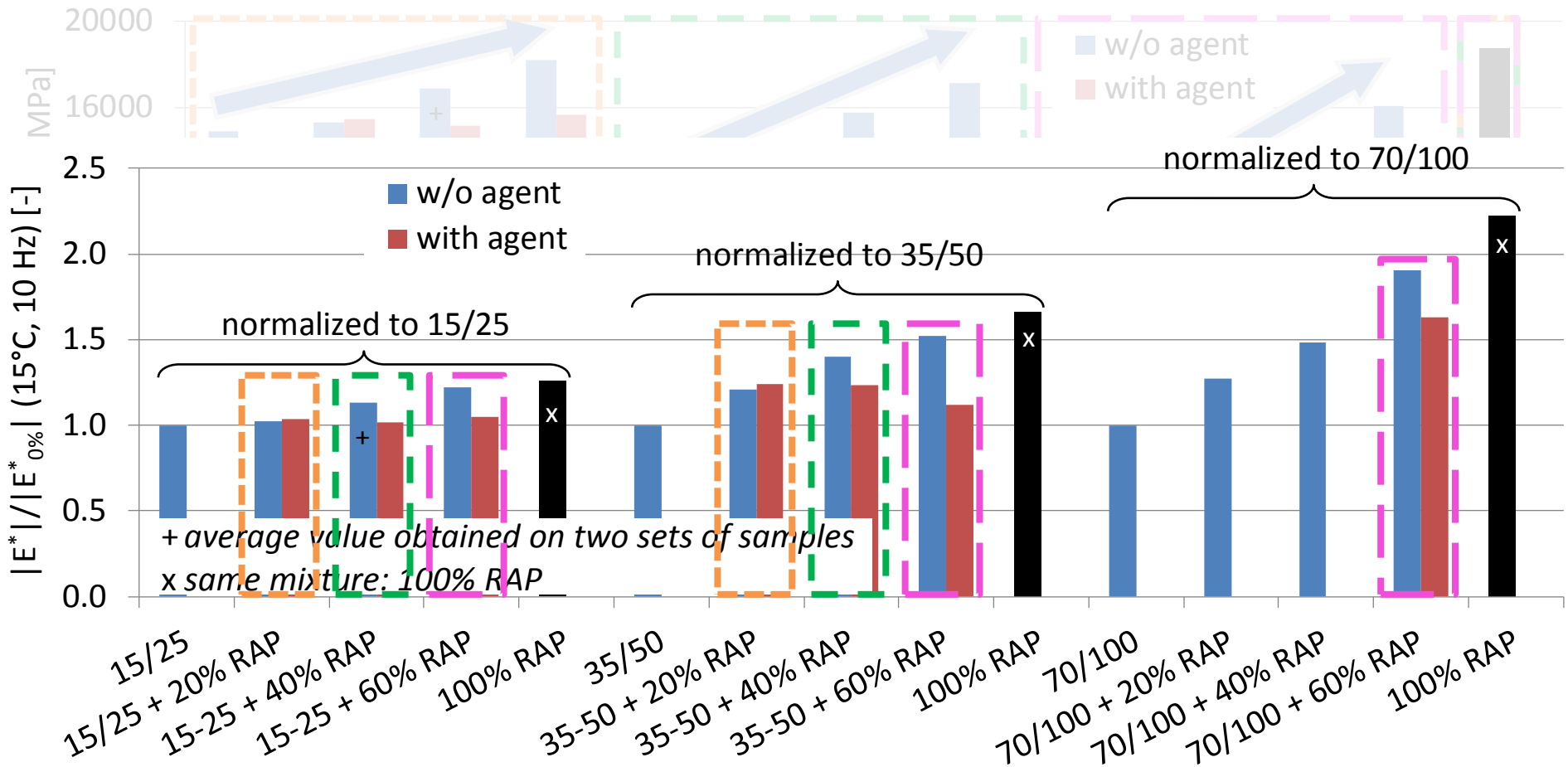
Res. & analysis: |E*|(15°C, 10 Hz)



1) Reduction of stiffness when recycling agent is used

2) Mixes with agent show approx. constant stiffness with increasing RAP content
   → dosage depends on RAP binder content: the more RAP, the more agent

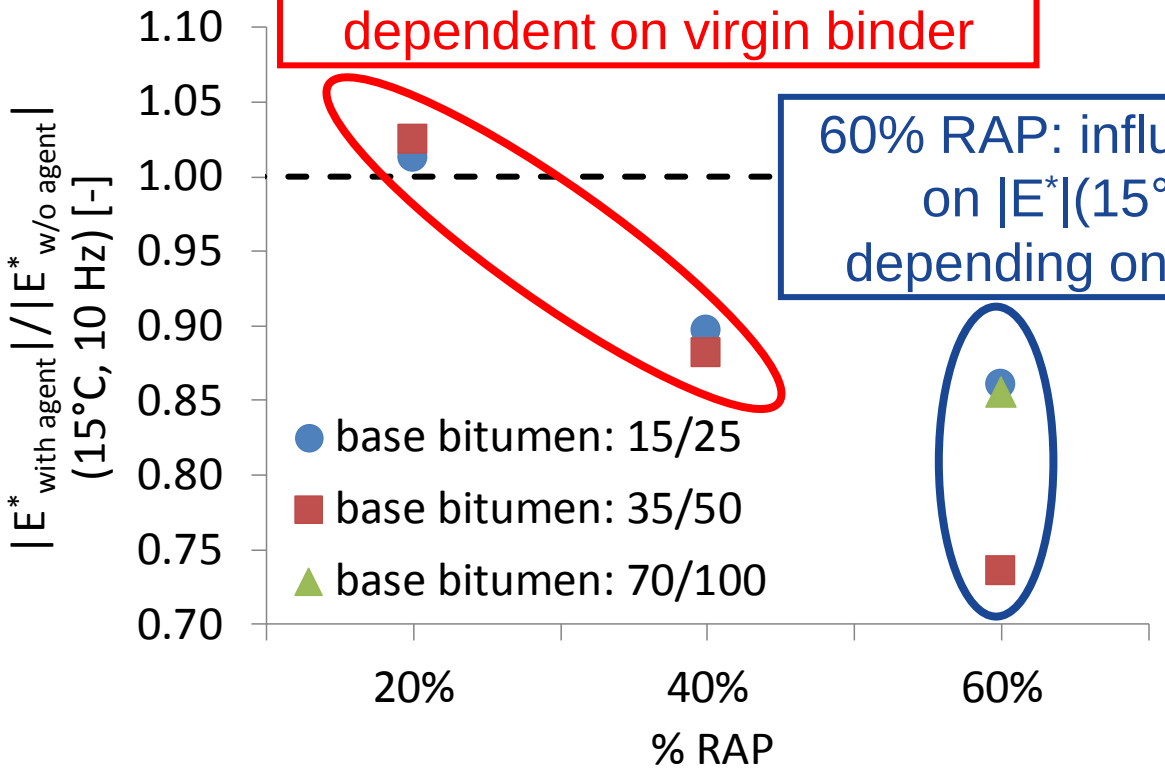
Res. & analysis: |E*|(15°C, 10 Hz)



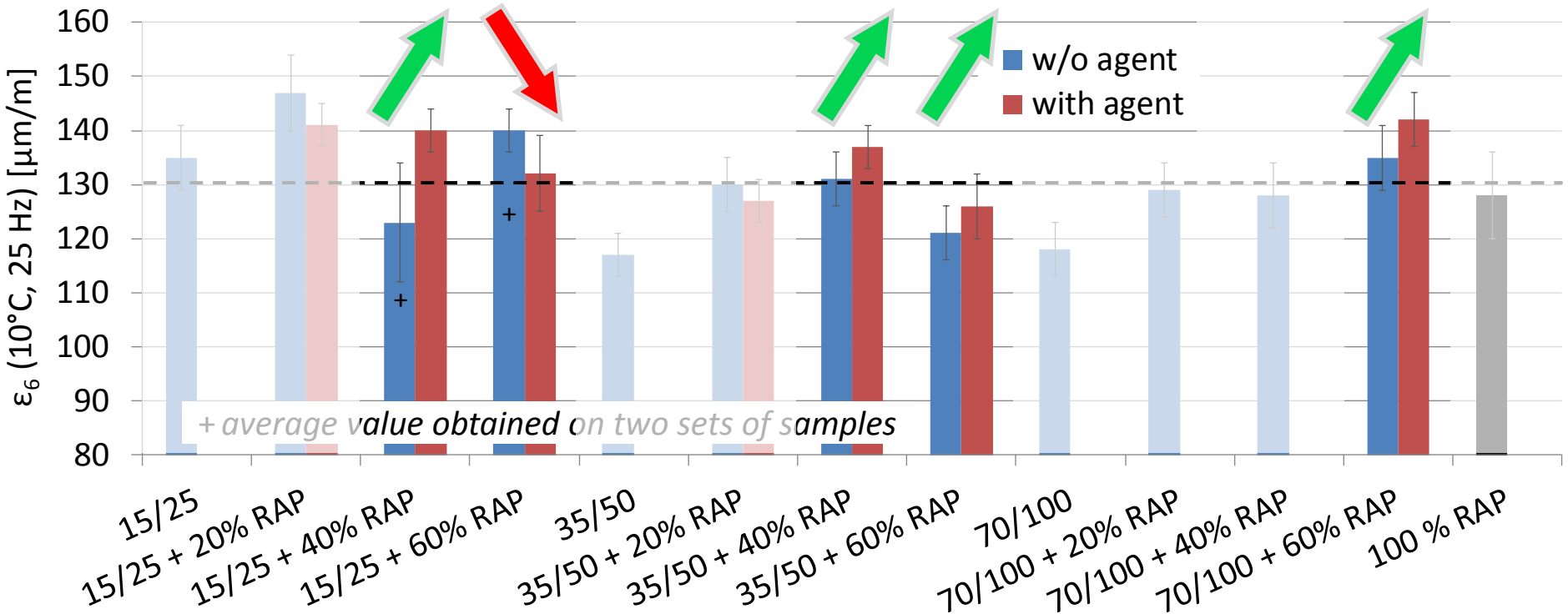
Res. & analysis: |E*|(15°C, 10 Hz)

≤ 40% RAP: influence of agent on |E*|(15°C, 10 Hz) not dependent on virgin binder

60% RAP: influence of agent on |E*|(15°C, 10 Hz) depending on virgin binder



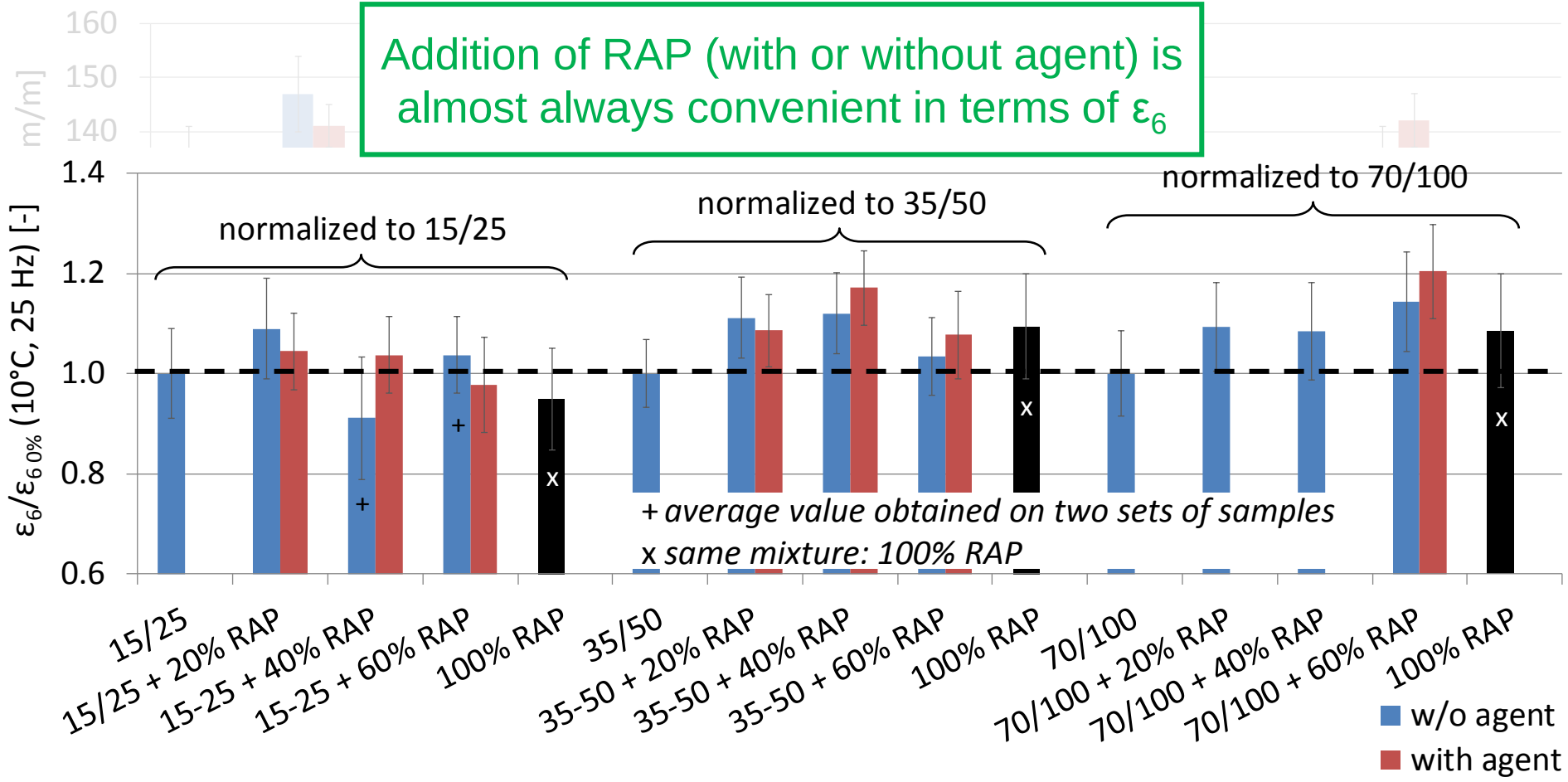
Res. & analysis: fatigue - ε_6



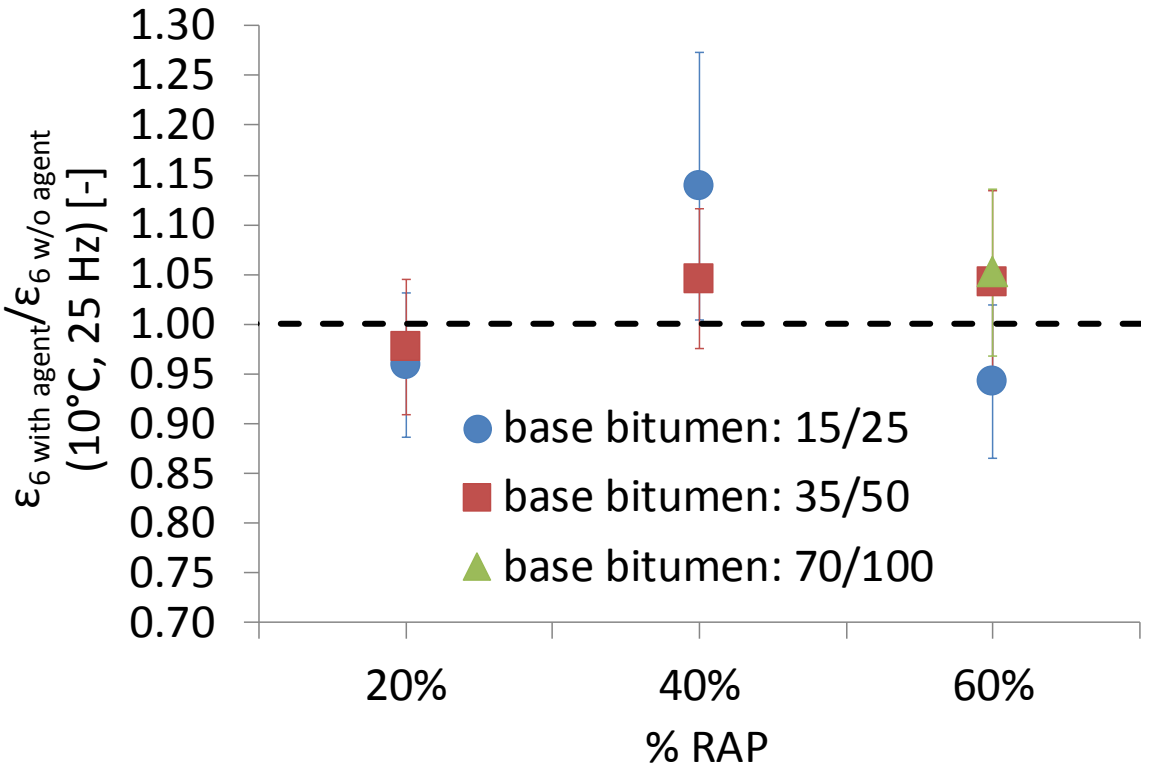
1) Higher variability than |E*|
2) Addition of agent helps fulfilling 130 µm/m requirement for EME mixtures
3) Increase of ε_6 when recycling agent is used with high RAP contents (≥ 40%)

Res. & analysis: fatigue - ε_6

Addition of RAP (with or without agent) is almost always convenient in terms of ε_6



Res. & analysis: fatigue - ε_6



Conclusions

- Addition of recycling agent causes reduction of $|E^*|$(15°C, 10 Hz)
- $|E^*|$(15°C, 10 Hz) of mixtures with increasing RAP content remains approximately constant: dosage of recycling agent depends on RAP binder content
- Influence of agent on $|E^*|$(15°C, 10 Hz) depends on virgin binder at 60% RAP content
- Addition of recycling agent with high RAP contents (≥ 40%) causes increase of ε_6
- Addition of recycling agent can help fulfilling 130 µm/m requirement for EME mixtures

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Thank you for your attention