



Use of rejuvenators in asphalt mixtures

10-11 September 2019
Padova (Italy)



RILEM TC-264 RAP Asphalt Pavement Recycling - Update on Rejuvenators

Dr. Martin Hugener



Empa

Materials Science and Technology

The RILEM Organization

www.rilem.net

RILEM - International Union of Laboratories and Experts in Construction Materials, Systems and Structures

The Mission

- The mission of the association is to advance scientific knowledge related to construction materials, systems and structures and to encourage transfer and application of this knowledge world-wide.

The Goals

- to promote sustainable and safe construction, and improved performance and cost benefit for society,
- to stimulate new directions of research and its applications, promoting excellence in construction,
- to favour and promote cooperation at international scale by general access to advanced knowledge.

The RILEM Topics

- Cluster A. Material Processing and Characterization
- Cluster B. Transport and Deterioration Mechanisms
- Cluster C. Structural Performance and Design
- Cluster D. Service Life and Environmental Impact Assessment
- Cluster E. Masonry, Timber and Cultural Heritage

Concrete

- **Cluster F. Bituminous Materials and Polymers (Convenor M. Wistuba)**

Technical Committees:

264-RAP
Asphalt
Pavement
Recycling

272-PIM : Phase and
Interphase behaviour
of bituminous
Materials

279-WMR :
Valorisation of Waste
and Secondary
Materials for Roads

278-CHA : Crack-
Healing of Asphalt
Pavement Materials

280-CBE : Multiphase
characterisation of
cold bitumen
emulsion materials

TC 264-RAP Asphalt Pavement Recycling

(Gabriele Tebaldi, Eshan Dave)

Working Groups

- TG 1: Cold Recycling (Daniel Perraton and Alan Carter, ÉTS Montreal Canada)
- TG 2: Non-Cold (Warm and Hot) Recycling (Paul Marsac, IFSTTAR France and Mayca Rubio, University of Granada, Spain)
- **TG 3: Asphalt Binders and Additives for RA** (Martin Hugener, Empa Switzerland and Augusto Cannone Falchetto, University of Braunschweig Germany)
- TG 4: Life Cycle Assessment for Optimal RA Usage (T. Parry, University of Nottingham, UK and Y. Qiao, University of New Hampshire, USA)
- TG 5: Degree of Binder Activation (Davide Lo Presti, University of Palermo Italy and Kamilla Vasconcelos, University of São Paulo Brazil)

Original work plan of TG 3

The final outcome of this TG will be to evaluate and standardize tools to properly validate a rejuvenator for the use in asphalt pavements

- Defining methods and parameters apart from rheological values to better characterize rejuvenators (Quality control)
- Methods to characterize aging of rejuvenators and bitumen rejuvenator mixes. Compare different aging methods (RTFOT, ...)
- Testing the compatibility between RAP binder and rejuvenator
- The topic of repeated recycling, which is especially interesting but complex for modified binders.

Rejuvenators - Open questions

- What is a «good» rejuvenator? How to assess the properties of a rejuvenator?
- How does the rejuvenator effect the binder and mix properties on short and long term?
- Best formula for calculation of the required rejuvenator amount? Is it the same for all types of rejuvenators? What is the reference method for this (Pen, Ring and Ball, DSR, stiffness modulus of mix, fatigue,)?
- What is the reference for rejuvenation? A standard non-modified bitumen, a (polymer) modified bitumen or ? ...
- **Quality control**: How to verify, we get always the same rejuvenator quality? How to determine the type and amount of a rejuvenator in an asphalt mix.
- How to produce larger amounts of aged binder? Can we use a hard bitumen 10/20 instead of an aged RAP-binder?

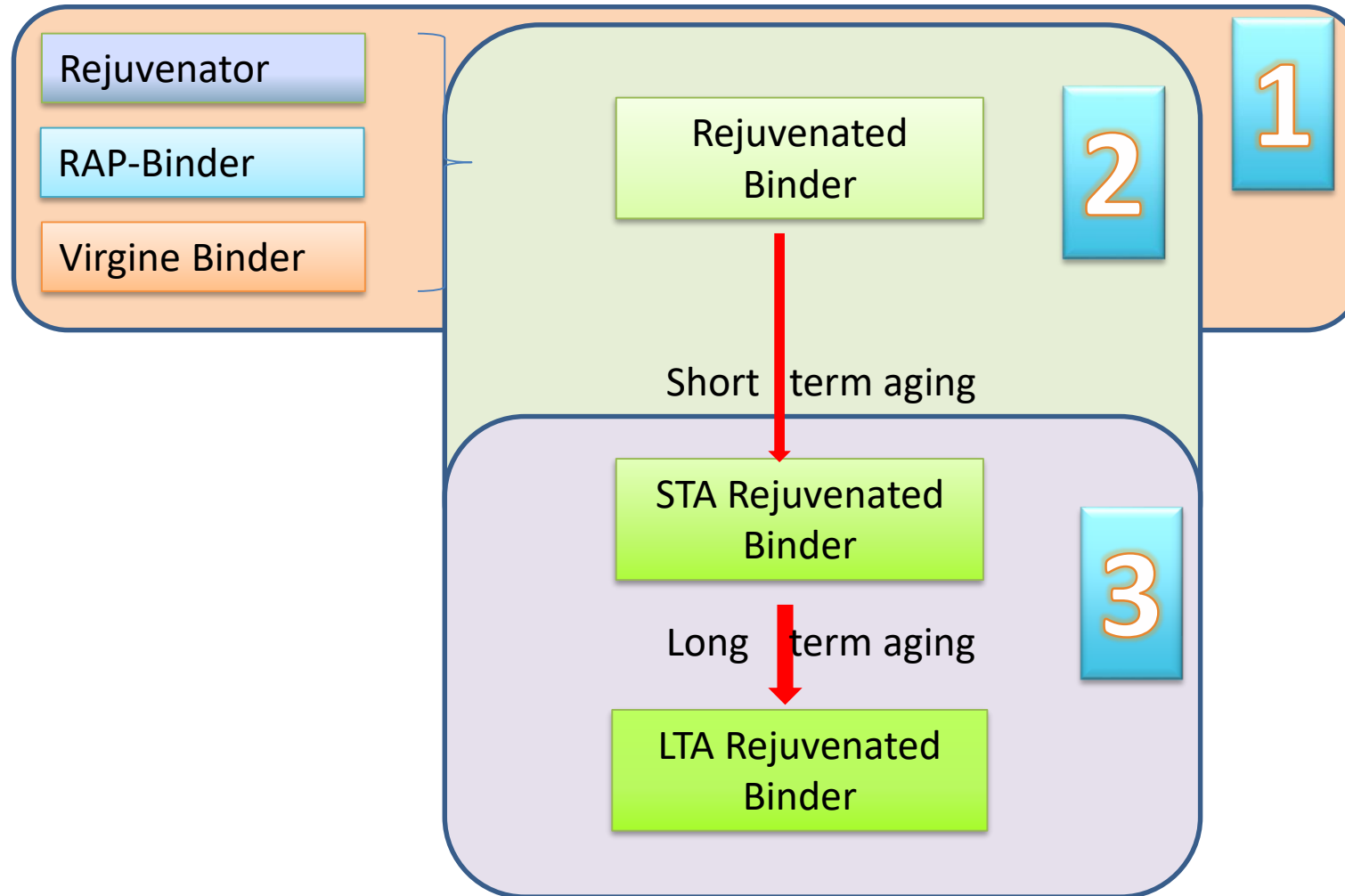
Aging of rejuvenator – bitumen blends

- Bitumen and rejuvenator can be of totally different chemistry (bio-based rejuvenator) \Rightarrow aging mechanism will be different (double bonds of vegetable oils)
- Bitumen aged + Rejuvenator aged = (Bitumen/Rejuvenator mix) aged?
- How will the aging of the rejuvenator effect the bitumen?
- Aging simulation tests have been developed for bitumen. Will they work for bitumen-rejuvenator mixes as well? Will it be similar to the field?

Modified working plan

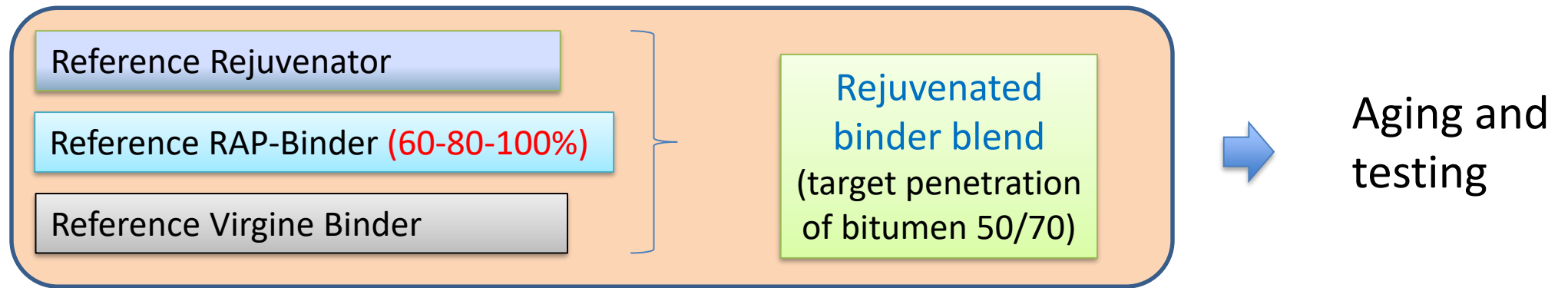
- A pure Round Robin Test, where everybody tests the same material with the same test methods doesn't make sense, as this is not (yet) about a validation of a test method or a protocol.
- Still, the limitation of the used **materials** for, I call it “**core experiments**”, could make sense. So, what is proposed is more some kind of joint-laboratory test program with the same target, but some variations of materials and methods. In that way a maximum of information with our limited resources is possible.
- In the beginning we will consider binders only, in a later stage, hot mixes are an option.

Modified working plan



Modified working plan

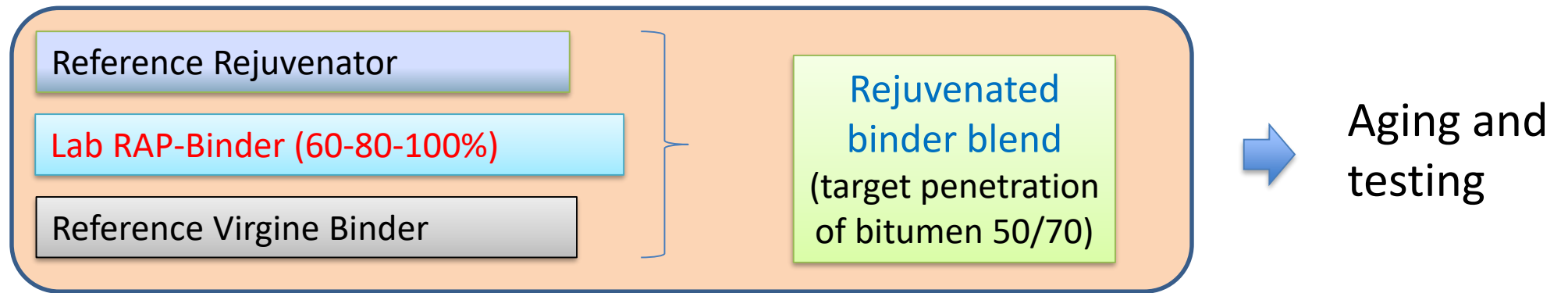
Stage 1: Core experiment



- Blend with same materials but **varying concentrations** to simulate recycling with 60% - 80% - 100% RAP
- **Different set of testing methods** due to limited amount of reference RAP binder: Complex modulus by DSR, softening point ring and ball done by **all** labs; penetration, BBR, FTIR testing by selected labs

Modified working plan

Stage 2: additional experiment with **lab** RAP binder



- Principle: Change one material at the time for better comparison

Stage 3: additional experiments with **lab** RAP binder and **other variation** (rejuvenator or virgin binder)

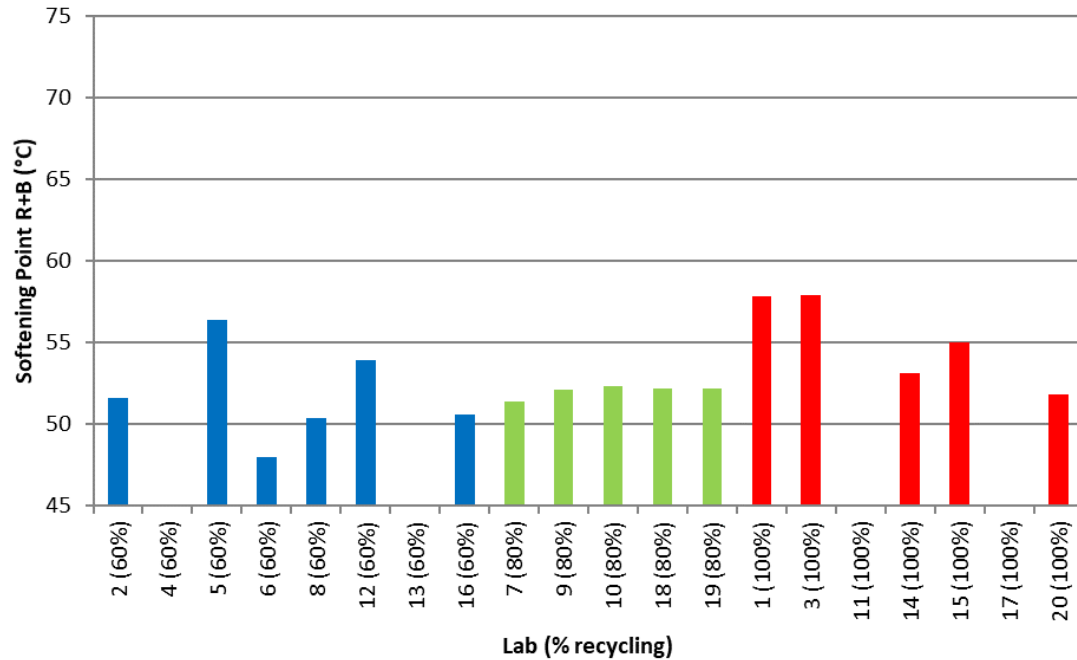
Challenges

20 Laboratories from different continents committed to participate
(14 universities, 4 private companies, 2 road authorities)

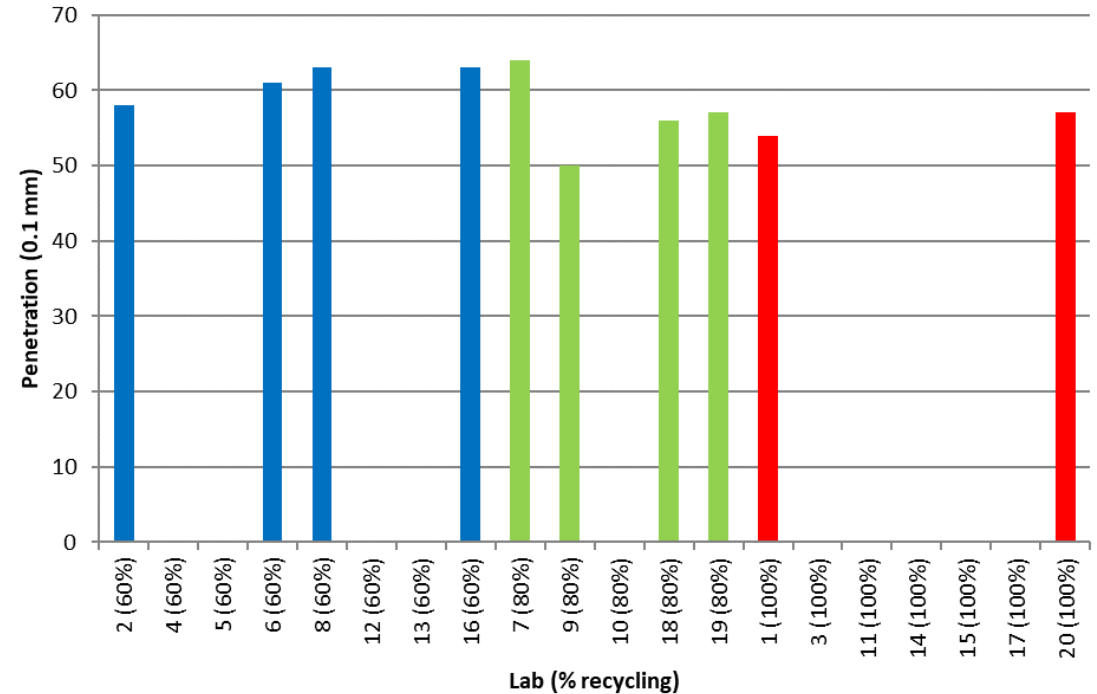
- No budget: shipping and preparatory work
- Time and workforce: Rilem has often low priority
- Unified testing procedures (EN, ASTM, ...) → testing protocol
- Equipment and testing experience
- Skype meetings with very different time zones America – Europe – Asia

First results of Stage 1 (Core experiments)

Softening Point R&B Unaged binder

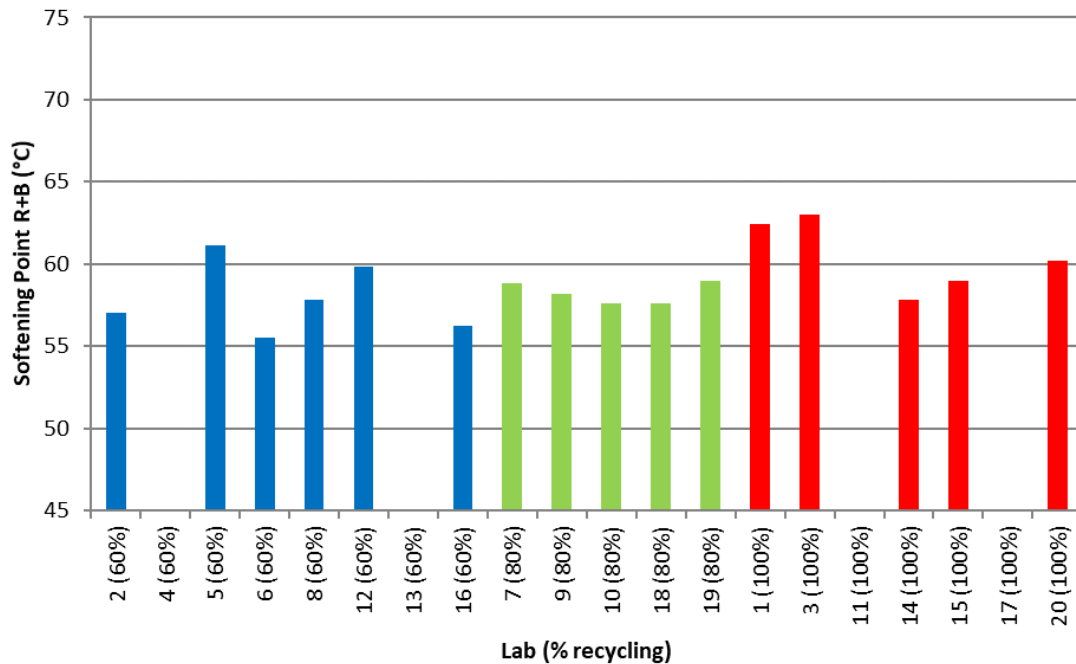


Penetration Unaged binder

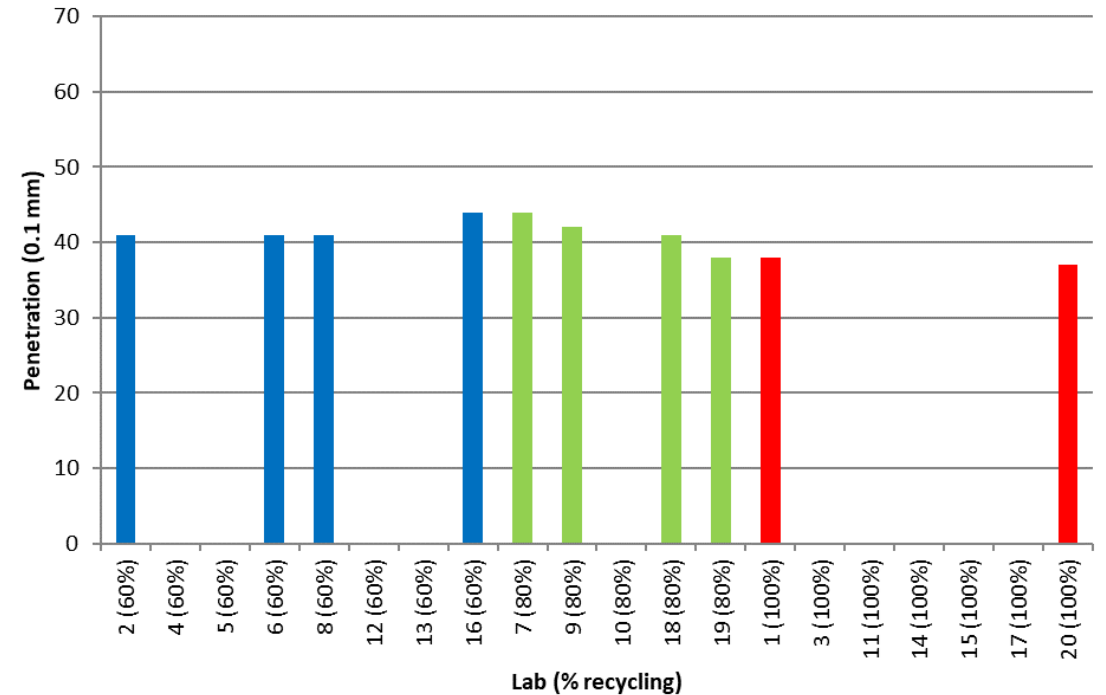


First results of Stage 1 (Core experiments)

Softening Point R+B RTFOT-aged binder

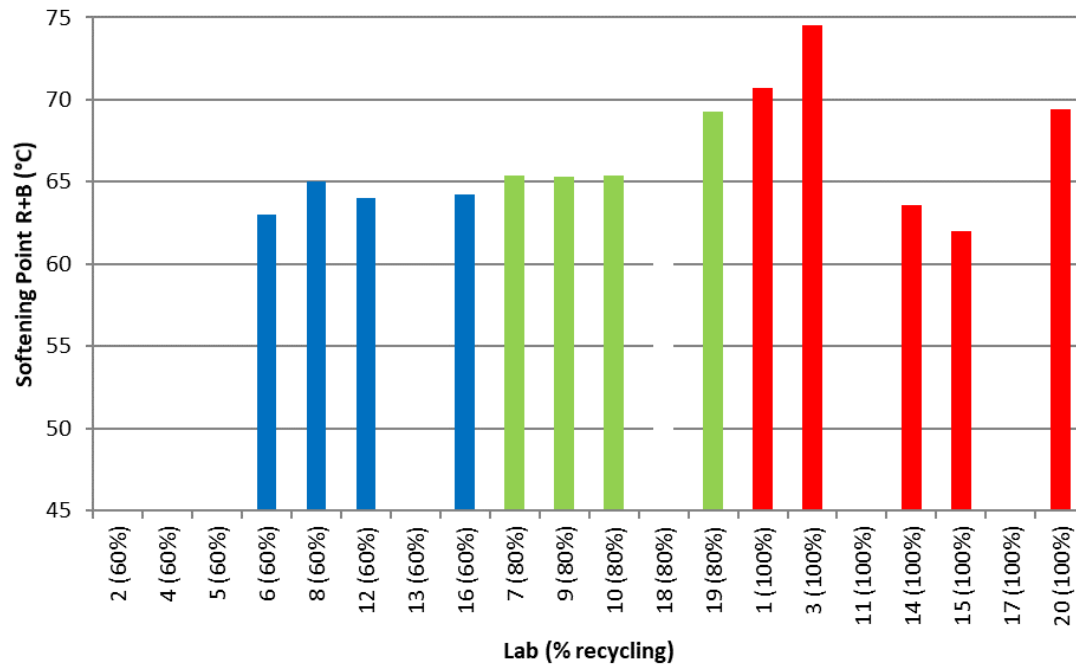


Penetration RTFOT-aged binder

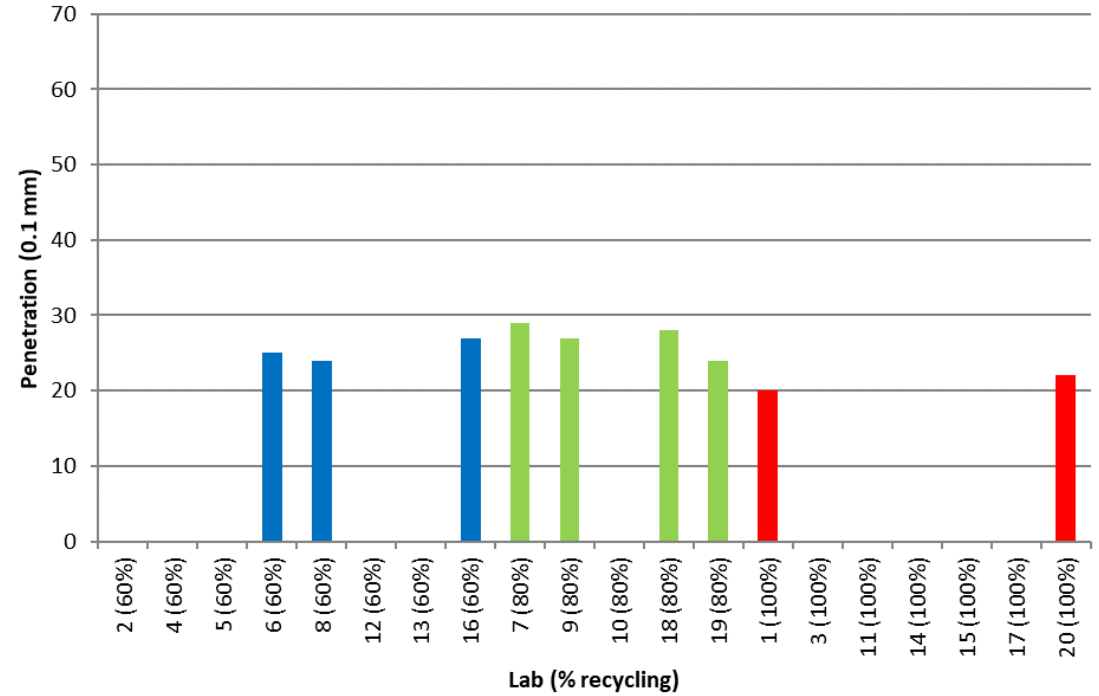


First results of Stage 1 (Core experiments)

Softening Point R&B PAV-aged binder

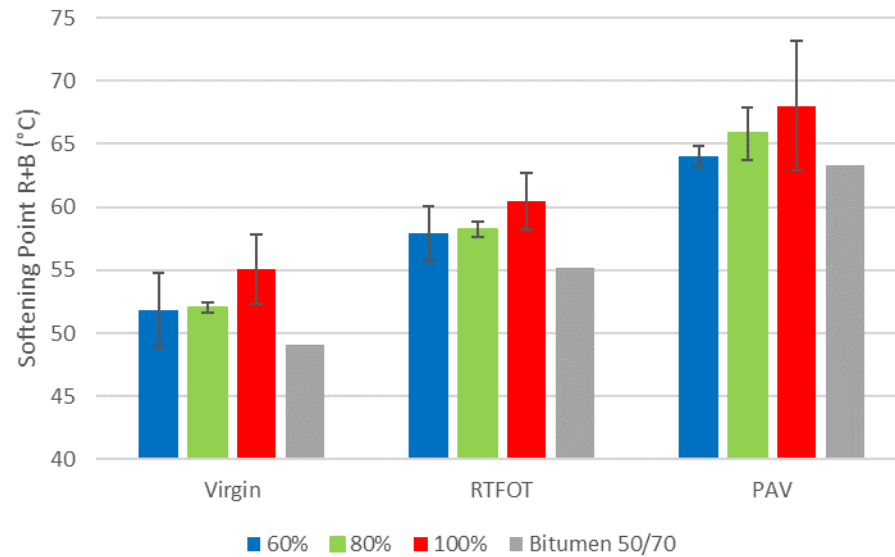


Penetration PAV-aged binder

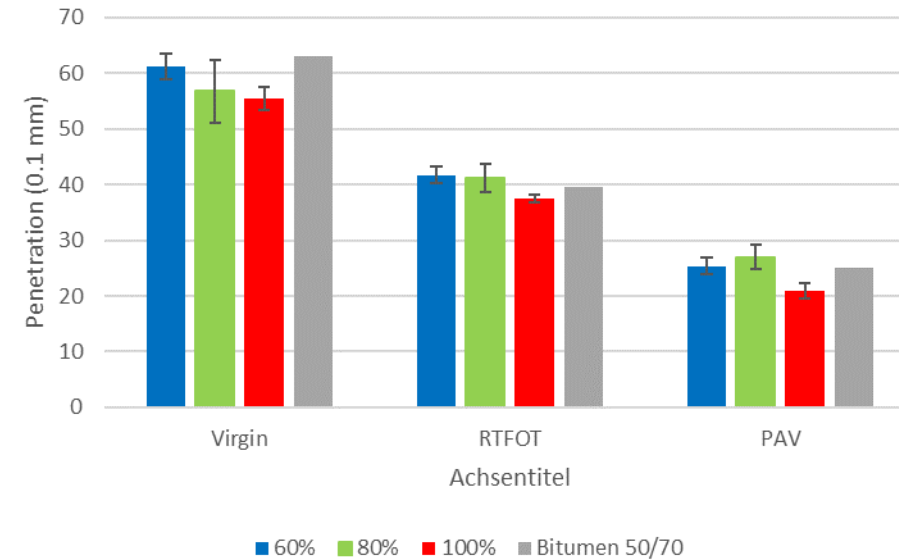


First results of Stage 1 (Core experiments)

Softening point ring and ball - Mean values



Penetration - Mean values



Conclusions

- Penetration of the blend was equal to the virgin bitumen but the softening point ring and ball of the blend was lower → some properties show a difference
- There is no significant difference between the blends with 60%, 80% or 100% of RAP binder
- The rejuvenator bitumen blend showed a similar aging behaviour like the virgin bitumen
- In some cases large scattering of the results was observed → a deeper analysis of the results is needed

Future activities

- Analysis and publication of the results at conferences and in papers
 - RILEM STAR report, literature overview on rejuvenator aging
 - Conferences: E&E2020 Madrid, Marepaiv 2020 Zurich, RILEM 2020 Lyon
- Planning of future work:
 - Bitumen aging with other rejuvenators (stage 3)
 - Aging impact on mastic and asphalt mixture
 - Comparison of different test methods for rejuvenator characterization

Active members of the inter-laboratory testing

Thank you all!

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Thank you



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