



Activity of RA bitumen in cold-recycled mixes

CONFERENCE ASPHALT PAVEMENTS 2015

Dr.-Ing. Konrad Mollenhauer

Universität Kassel

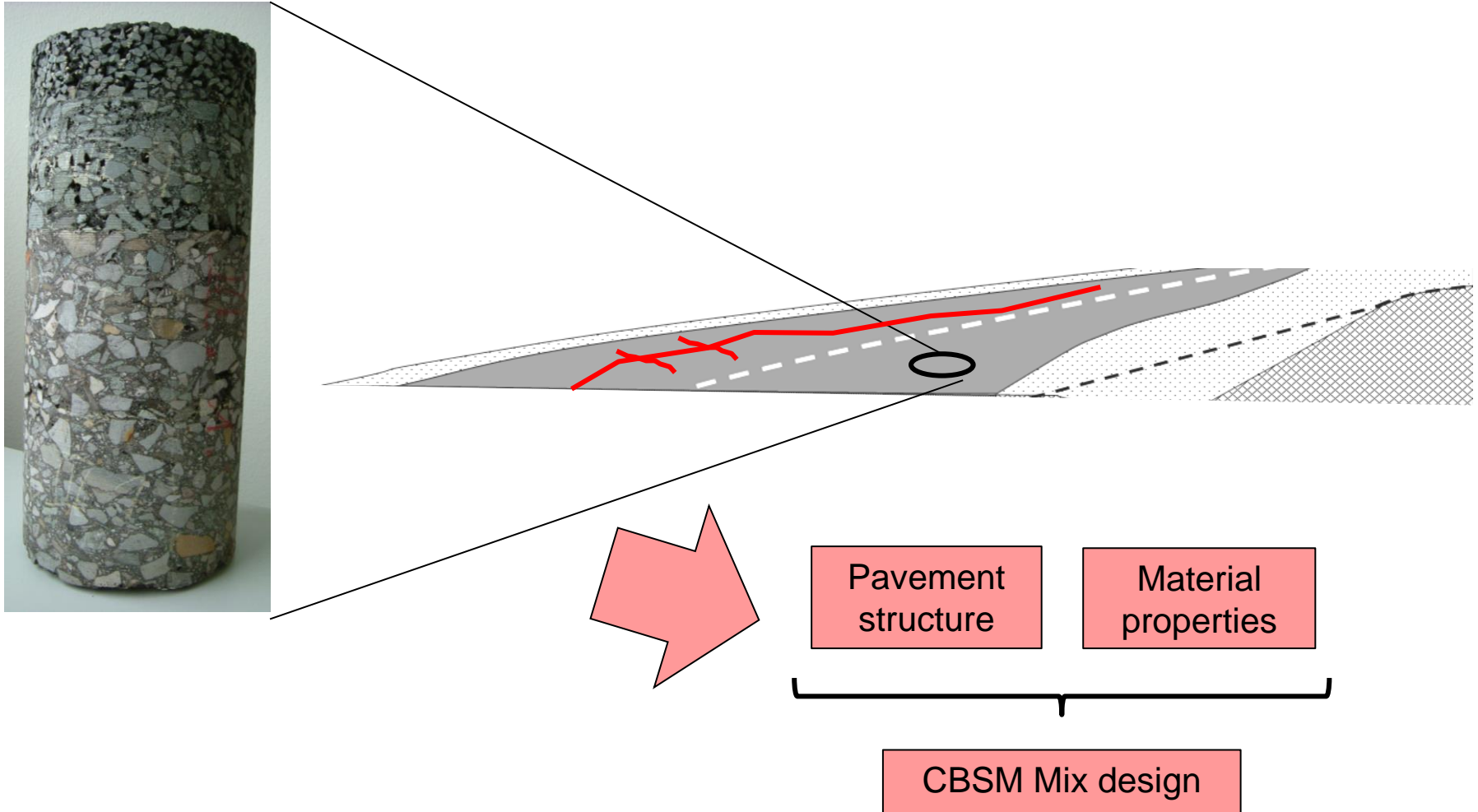
Engineering and Maintenance of Road Infrastructure

Acknowledgements

- **Co-Authors:**
 - Diana Simnofske
 - Jan Valentin
- **Project partners:**
 - Jan Valentin (Coordinator)
 - Ciaran McNally
 - Fatima Batista
 - Michael Engels
- **Funding body and program**

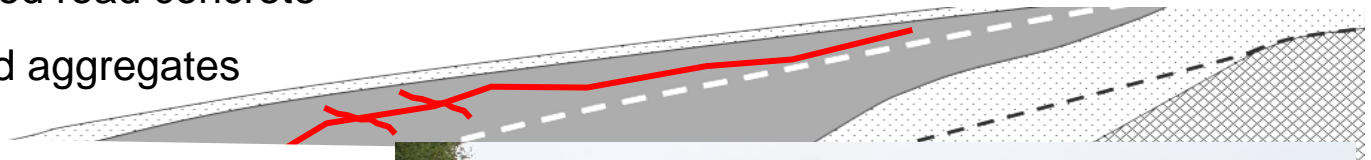


Pavement structure (in theory)



Pavement structure (in theory **and in reality**)

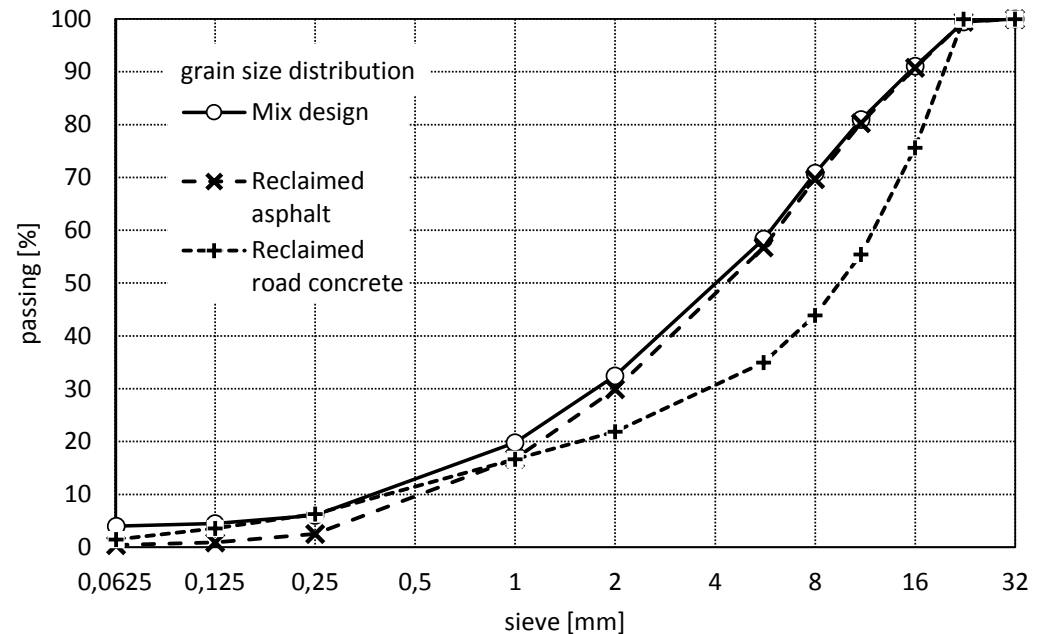
- Real structure often shows non-homogen structure
- What are the effects on mechanical properties when using the same mix design
 - Reclaimed asphalt
 - Reclaimed road concrete
 - Unbound aggregates



Question 1: What is the role of RA in cold recycled material?

Laboratory study on the effects of various mix granulates in cold recycled material

- **3 mix granulates:**
 - Reclaimed asphalt (RA)
 - Reclaimed road concrete
 - Natural aggregates
(e. g. from unbound base layers)
- **Same grading**
- **Residual bitumen content: 4 %**
 - Bitumen emulsion (Cationic, 60 % bitumen, 50/70)
 - Foamed bitumen 50/70;
Foaming @ 180 °C, 5.5 bar, 4,5 % water
- **Active filler: 2 % portland cement**
- **Mixing water content (total): 7.8 %**

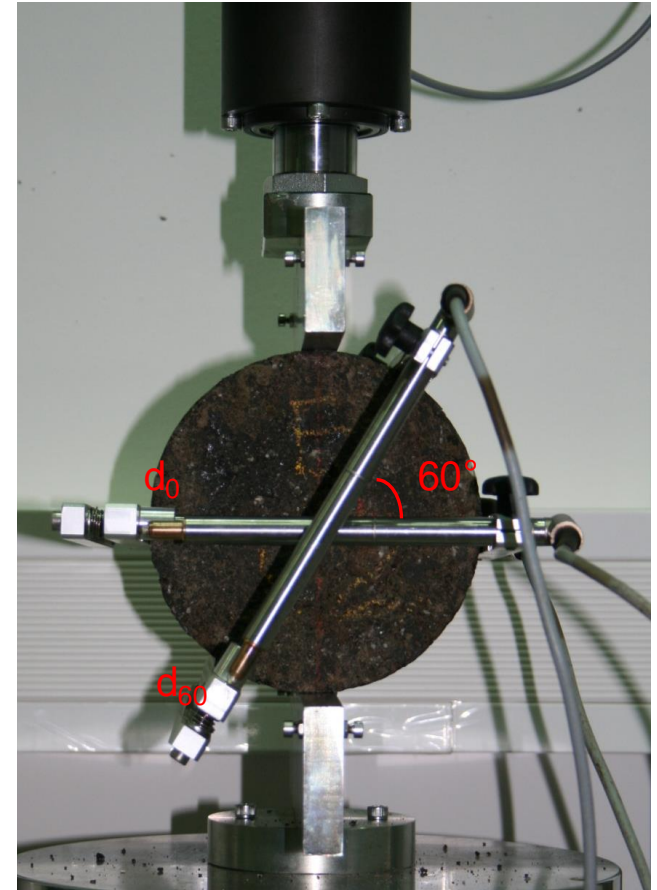


Sample mixtures (same grading)

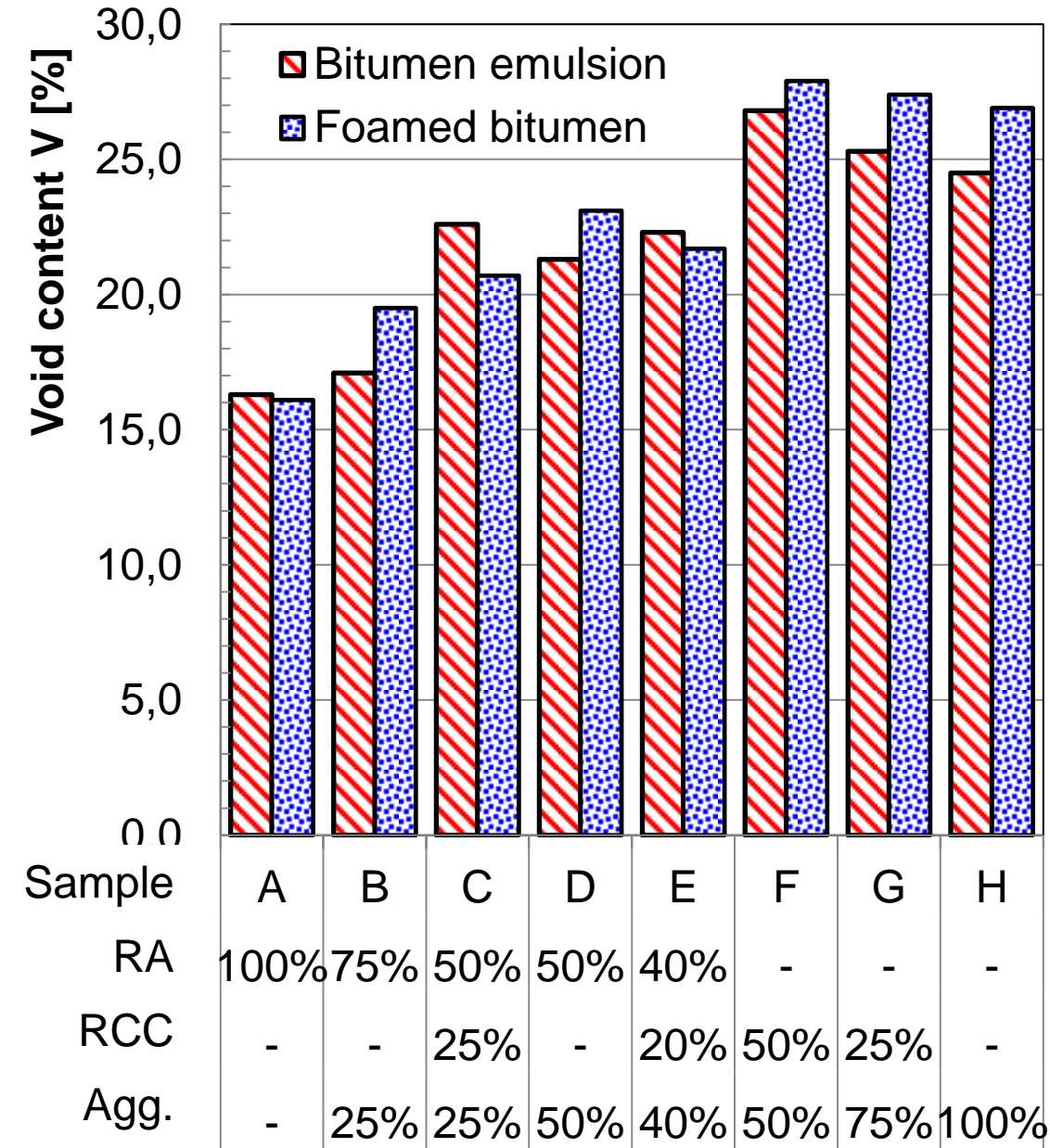
Mix variations		Reclaimed asphalt (RA)	Reclaimed road concrete (RRC)	Crushed natural aggregates (agg.)	Pavement structure (example) Asphalt / hydraulically bound / unbound
A	100/0/0	100%	-	-	24 cm / 0 / 0
B	75/0/25	75%	-	25%	18 cm / 0 / 6 cm
C	50/25/25	50%	25%	25%	12 cm / 6 cm / 6 cm
D	50/0/50	50%	-	50%	12 cm / 0 / 12 cm
E	40/20/40	40%	20%	40%	9 cm / 6 cm / 9 cm
F	0/50/50	-	50%	50 %	0 cm / 12 cm / 0 cm
G	0/25/75	-	25%	75%	Control samples
H	0/0/100	-	-	100%	Control samples
Each variation: + 2 % cement, + 4 % residual bitumen (foamed bitumen or bitumen emulsion)					

Laboratory tests

- **Static compaction (30 s à 45.9 kN)**
- **Specimen curing:**
 - 1 day in mould
 - 2 days demoulded @ 20 °C, 80 % humidity
 - 25 days at room conditions
- **Tests**
 - Bulk density & void content
 - Indirect tensile strength (5 °C)
 - 7 day, 28 days, 14 days in water
 - CBR dry

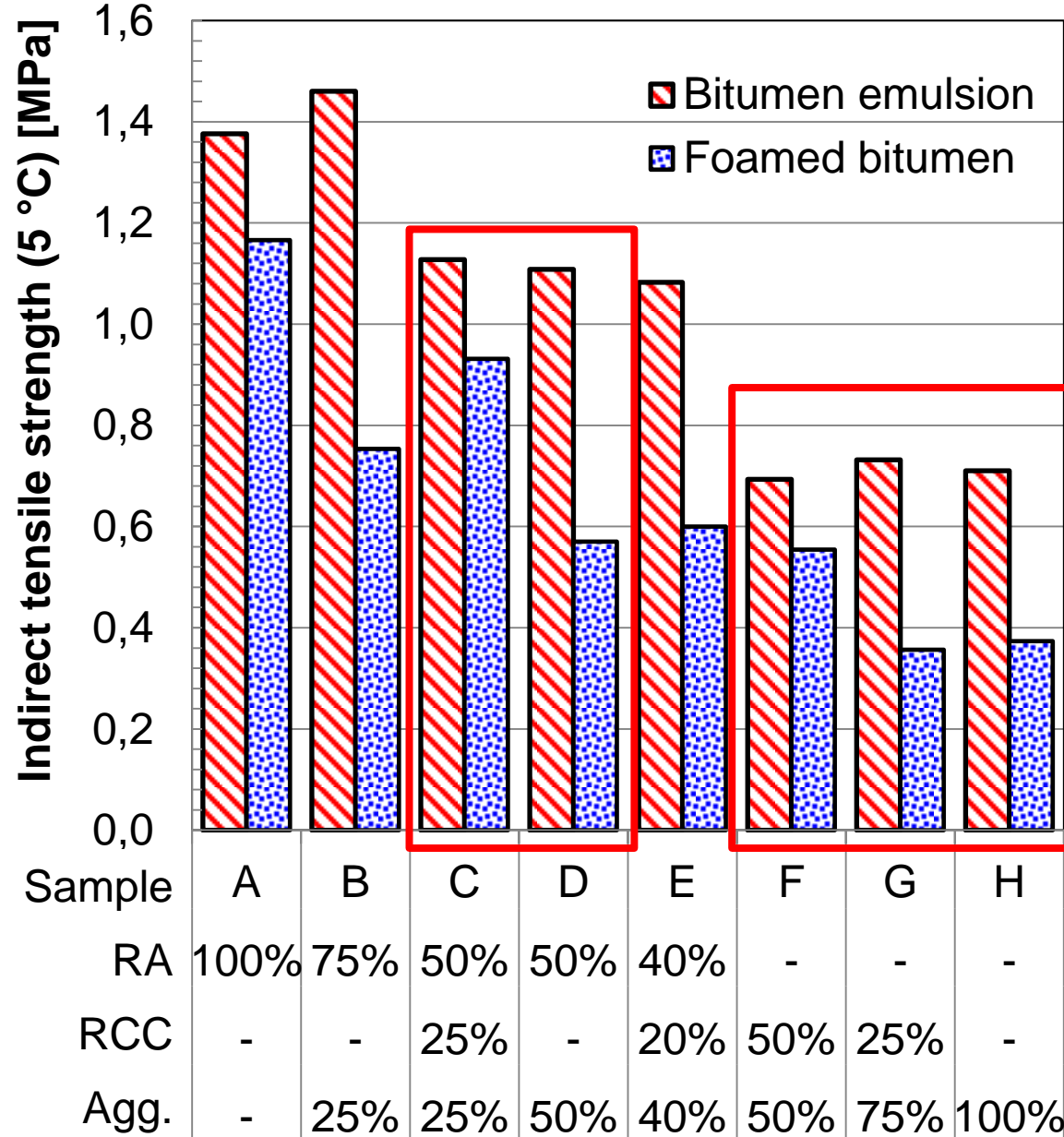


Void content



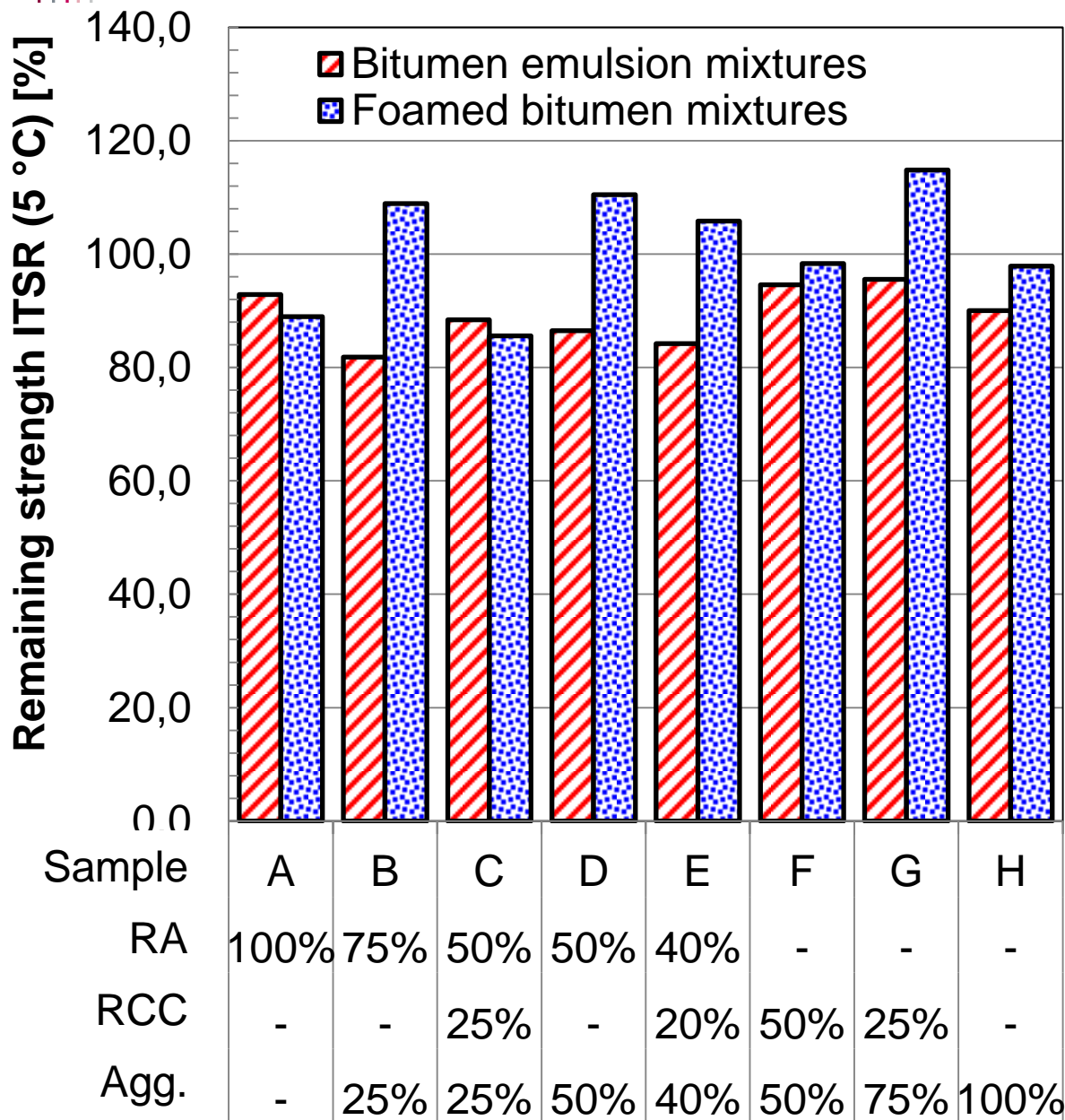
- **Insufficient compaction**
(German requirement: $< 15\%$)
 - Reasons:
 - Coarse mix, low fines
 - Low compaction energy
- **The higher RA content in mix granulate, the lower the void content**
 - At same grading, RA allows for better compaction
 - Similar results for emulsion and foamed bitumen mix

Indirect tensile strength (after 28 days of curing)



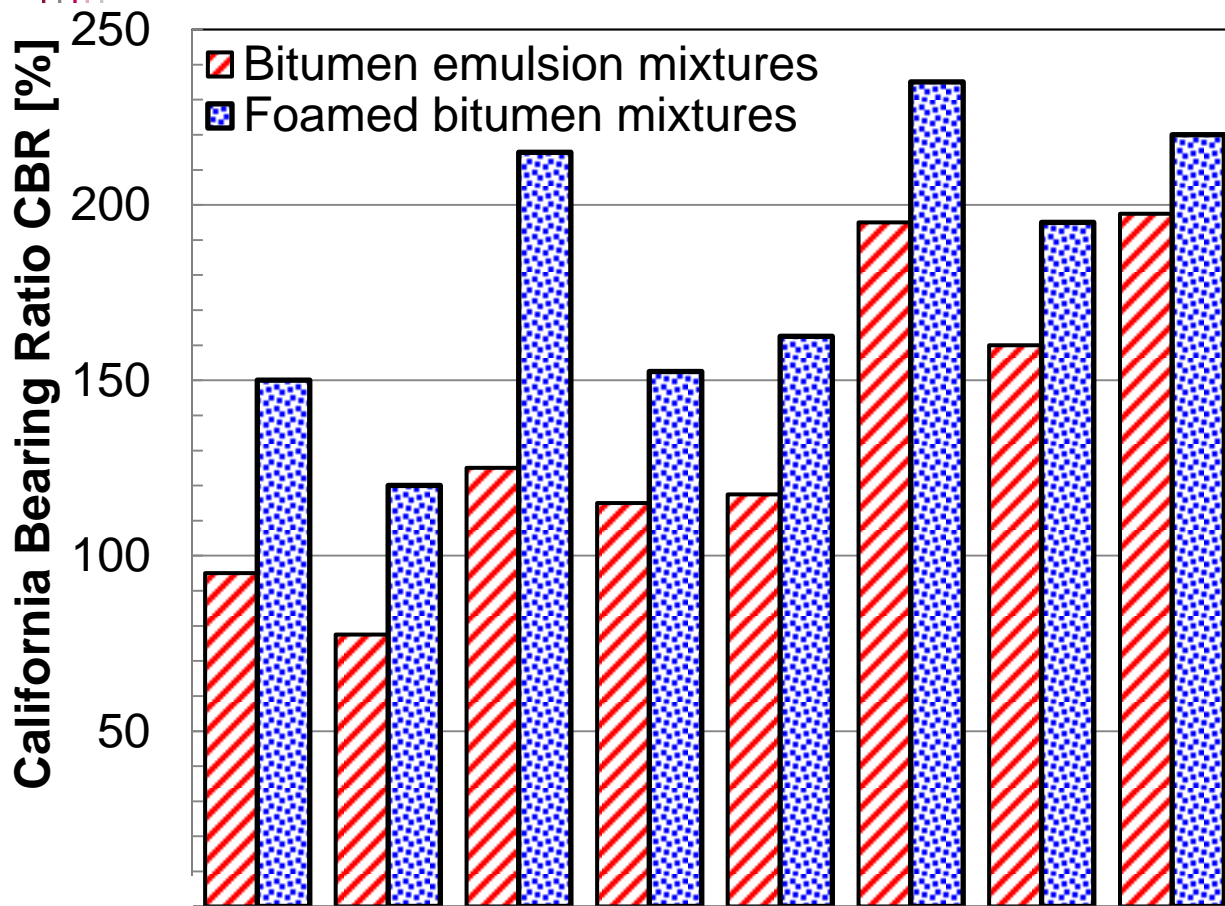
- The higher RA content, the higher the ITS obtained
 - Reduced Void content
 - Increased flexibility
- RA content has stronger effect on foamed bitumen mixtures compared to bitumen emulsion mixtures
- Difference between crushed concrete and crushed natural aggregates at same RA content:
 - No effect for emulsion mixtures
 - Higher RCC content results in higher ITS for foamed bitumen mixtures
- Bitumen emulsion mixtures have higher strength compared to foamed bitumen mixtures

Water susceptibility (14 days @ 40 °C)



- Applied mix design results in feasible ITSR for all samples
- Emulsion mixtures:
Strength loss
- Foamed bitumen mixtures:
Often strength increase observed
(hydration of active binder)

CBR as a parameter for bearing capacity and resistance against permanent deformation



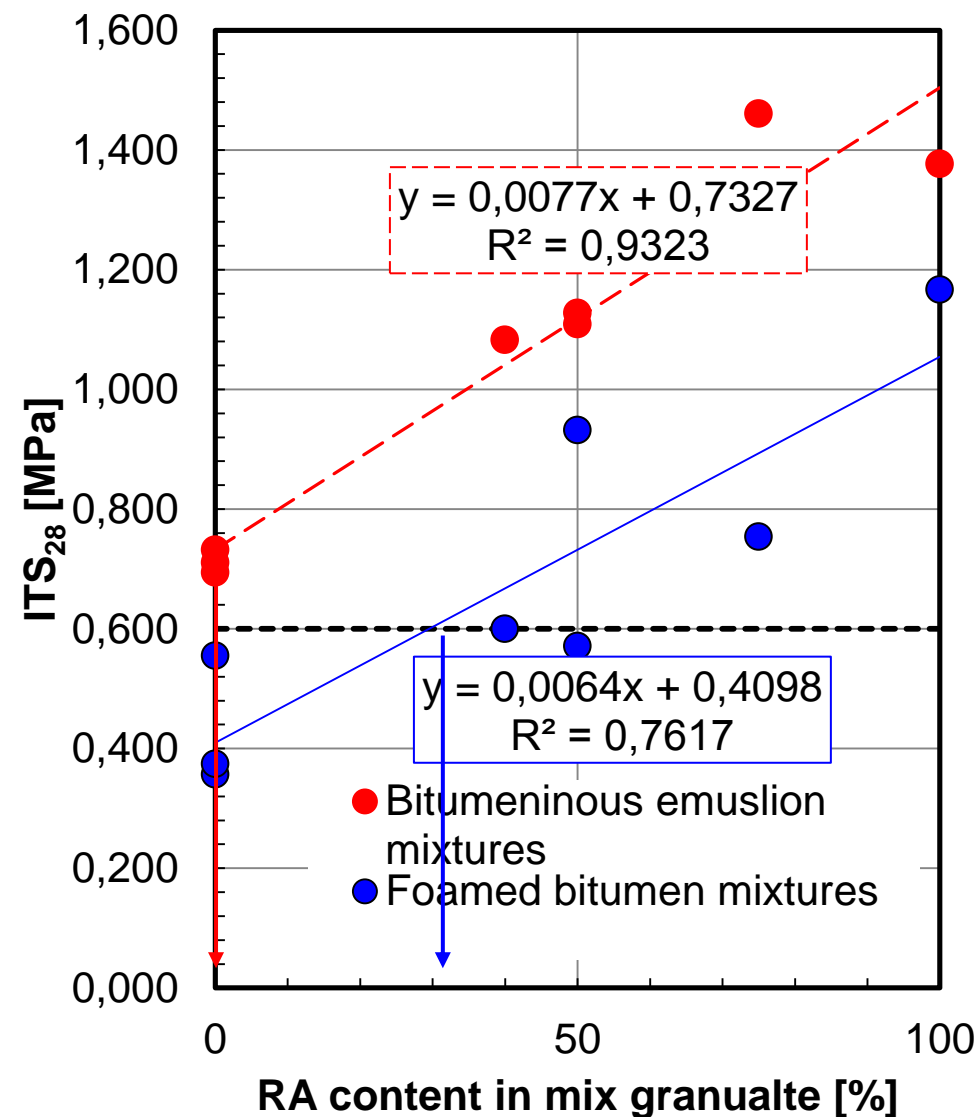
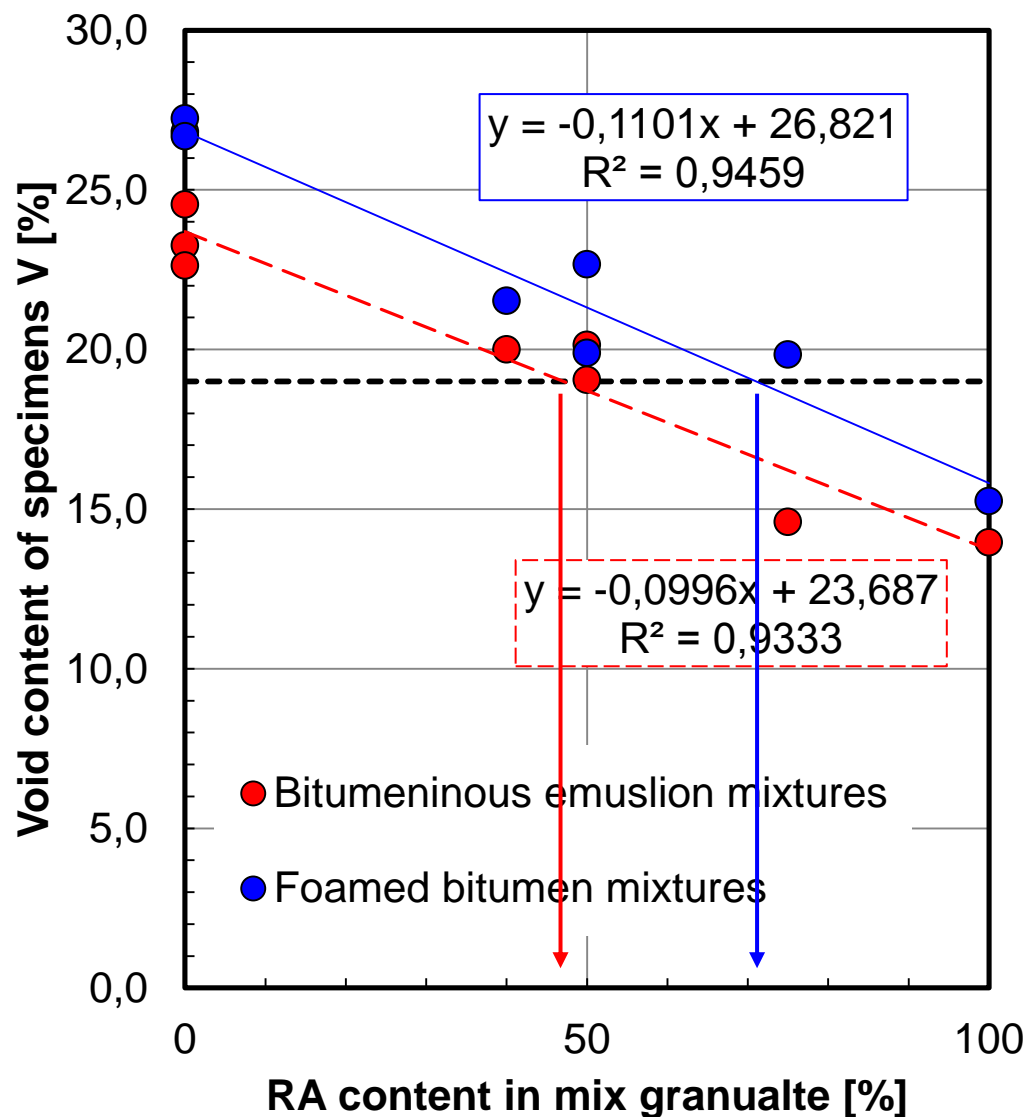
Sample	A	B	C	D	E	F	G	H
RA	100%	75%	50%	50%	40%	-	-	-
RCC	-	-	25%	-	20%	50%	25%	-
Agg.	-	25%	25%	50%	40%	50%	75%	100%

- **Increase of RA content will reduce CBR**
 - Increased flexibility
 - Increased viscoplastic properties
- **Foamed bitumen mixtures reach higher CBR**
 - Higher friction between granulate by discontinuous bitumen bonds

Conclusions on RA activity study

- **The content of RA controls the relevant parameters of CBSM. AN increase of RA content at same mix composition results in:**
 - Improved compactibility & decreased void content
 - Higher indirect tensile strength
 - Reduced bearing capacity and reduced resistance against permanent deformations
- Foamed bitumen mixtures are more sensitive to RA content (factor 3) compared to emulsin mixtures (factor 2)**
- **Binder in RA shows active (beneficial) role in the properties of cold recycled materials**

Conclusions for homogeneity requirement



Thank you very much for your attention!

