Belgian Road Research Centre
Together for sustainable roads

# Balanced Performance Validation of the RA Cracking-Based Brittleness Index (CBI) for Recycled Asphalt Mixtures

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# Content

- Background – Goal

- **C**racking-Based **B**rittleness **I**ndex-CBI approach

- Level 1: RA screening/assessment

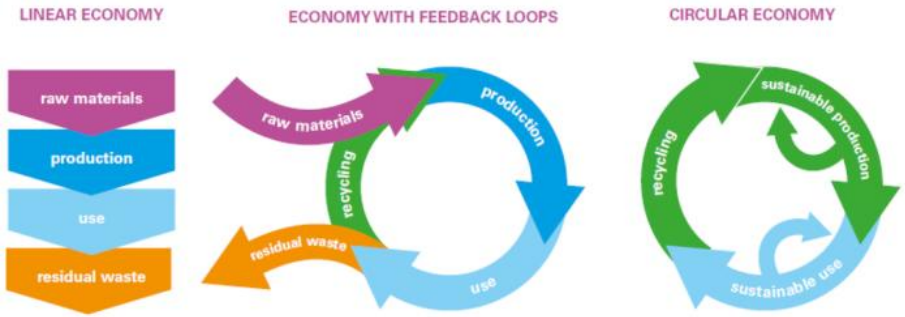
- Level 2: Mixture level performance assessment

- Concluding points

# Why Reclaimed asphalt (RA)?

## ❖ Enhance recyclability

- Increase (re)use of reclaimed asphalt (RA) (also in **surface layers**)
- Retain/increase durability while enhancing circularity
- Environmentally friendly bituminous mixtures and testing techniques.




*Source: Rli, Circular Economy: From Wish to Practice*

# Background - Goal

- (More) RA in surface layers
- All RA materials suitable?
- Durability concerns when include (high content) RA in surface layers?

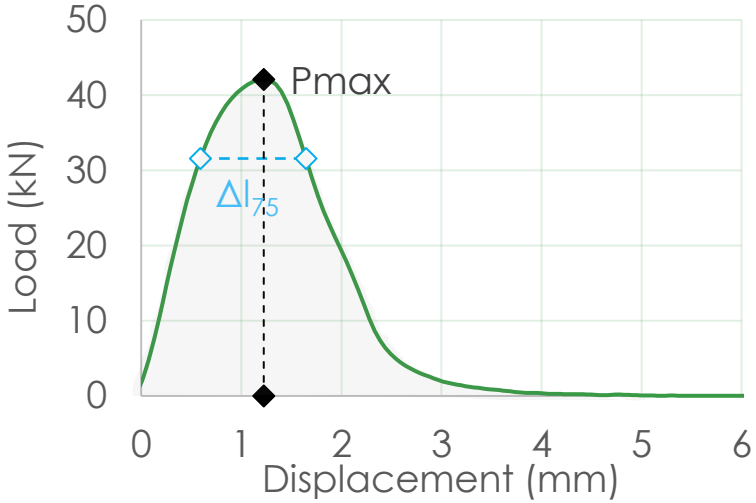
 Need for a **framework** to detect **risky RA materials** & **risky mixtures with RA**

- **Goal: Durable high RA containing surface layer mixtures**
  - **Level 1 (RA level): RA characterization (CBI)**
  - **Level 2 (Mix level): Balanced-Mix Design (BMD) approach**

# Cracking-Based Brittleness Index-CBI

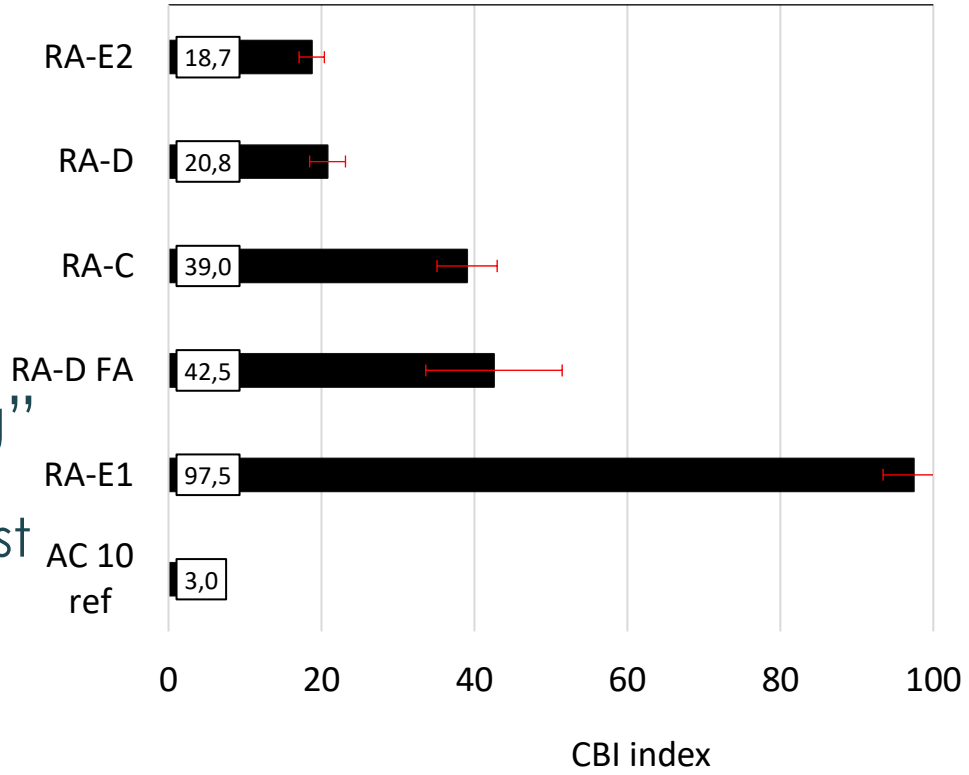
- RA ageing state (current practice):
  - Based on **extracted RA binder properties** (pen or $T_{R\&B}$)
- **Alternative: CBI** as a solvent-free "**mechanistic test**" captures bulk (RA) response
- Indirect tensile test (IDT) principle
- Specimens made of 100% RA
  - 7% air voids target
- **Higher CBI values** indicate more **brittle mixture**

$$CBI = \frac{P_{max}}{\Delta l_{75}}$$



# Level 1: RA characterization
## *CBI results*

- Several RA materials tested
  - pen ranging from 7 to 20 dmm
  - RA "further aged"(denoted FA)
- Generally ranking reflects well "binder ageing"
  - RA E1 and RA D FA : very aged binders show highest value
  - RA D and E2 : less aged, highest pen , lowest CBI
  - AC 10 ref (unaged) the lowest



# Level 2: Mix level
## *The BMD approach*

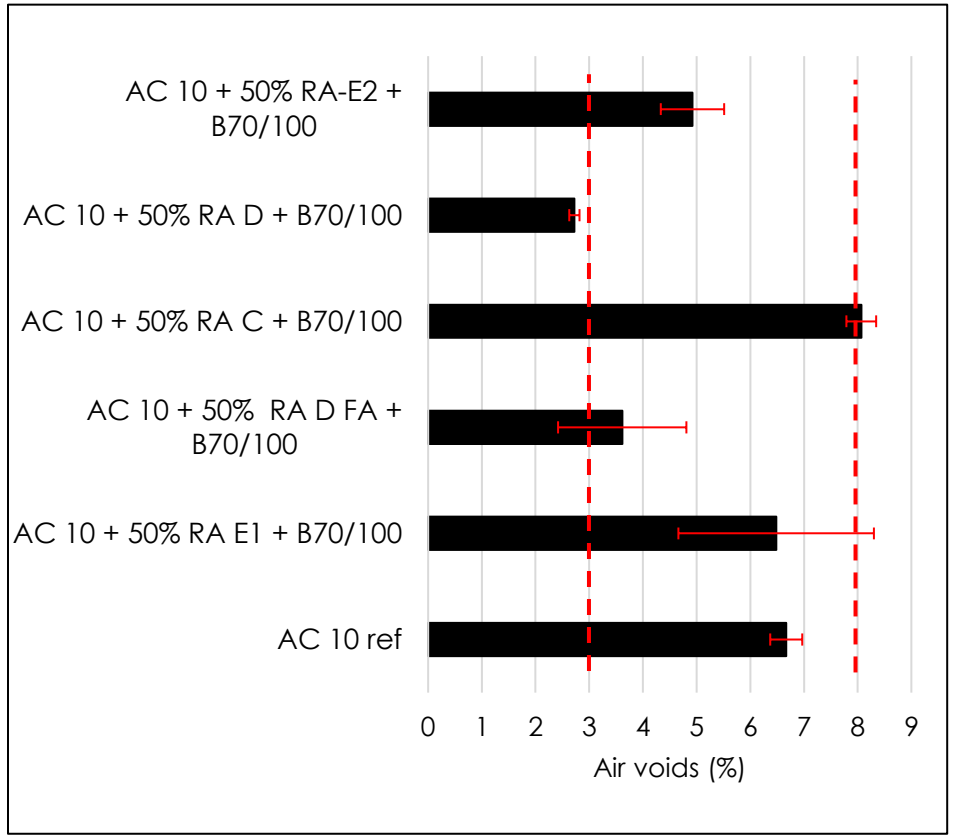
- 5 RA materials tested in AC-10 surf
  - 50% RA-binder replacement
- BMD approach
  - Compactability assessment: voids – gyrator 60 G - EN 12697-31
  - Performance assessment (ITT):
    - Wheel tracking @ 50°C – EN 12697-22
    - Water sensitivity : EN126987-12 + 23
    - Raveling: CEN- TS 12697- 50
  - Strength assessment: ITS-test @ 25°C – EN 12697-23
  - Cracking assessment: SCB test @ 15°C – EN 12697-44

# Level 2: Mix level
## *Compactability assessment*

- Results voids @ 60G
- AC 10 surf: 3–8% void (Flemish requirement)

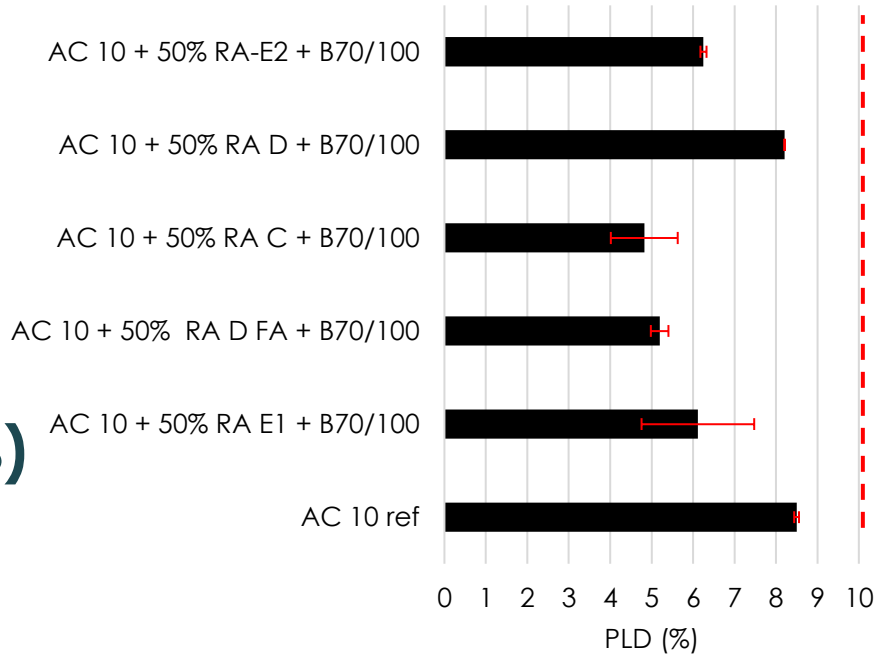
**=> Different RA's (can/may) introduce risk**

- 3 mixtures with 50% RA **meet requirement**
- **2 risky mixtures:**
  - Mix with 50% RA D exhibited over-compaction,
  - Mix with 50% RA C (marginally) exceeded the upper limit.



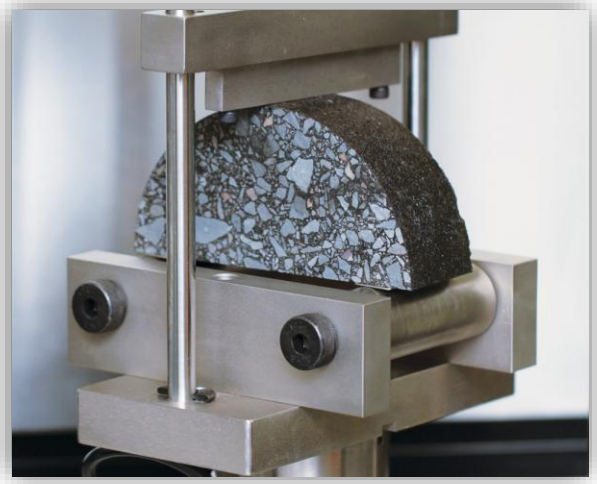
# Level 2: Mix level
## *Rutting resistance assessment*

- Results: %PLD @ 50 °C – 30000 cycles
- AC 10 surf: < 10% rut depth (Flemish requirement)
- **Rutting resistance: no risks for all mixes (< 10%)**
  - AC surf + RA : Better than ref mix (stiffer)
  - Result influenced by void content for the extremes



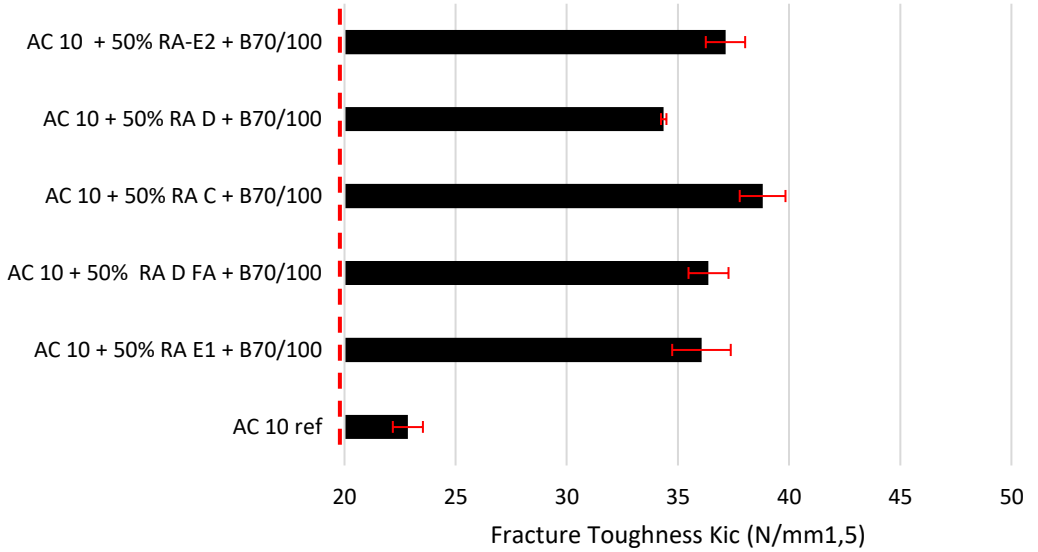
# Level 2: Mix level
## *Cracking resistance – strength assessment (SCB)*

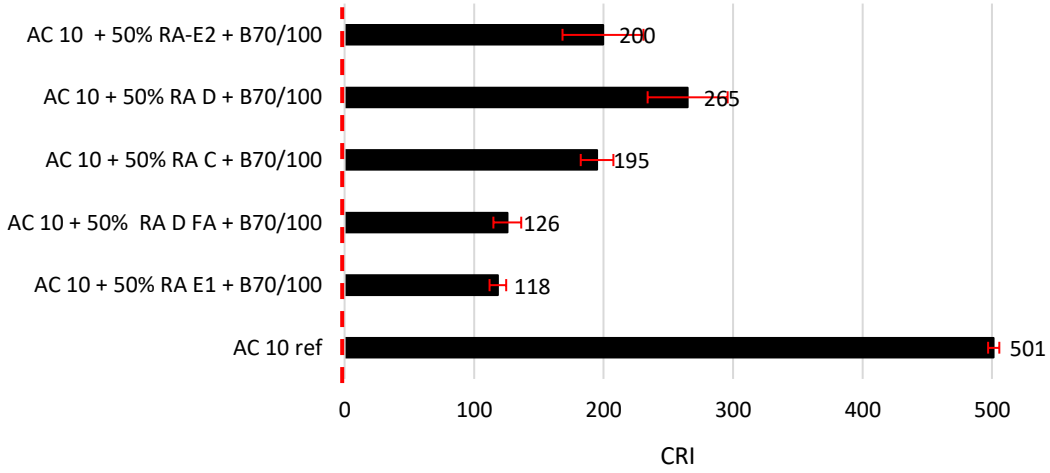
- Semi-Circular Bending (SCB) approach
- SCB samples: H=75mm – W=150mm – 7% air voids
- Test parameters: EN12697-44
  - 10 mm notch
  - 15°C
  - 5 mm/min
- Test result analysis approach:
  - Fracture toughness $K_{IC}$
  - Cracking Resistance Index (CRI)



# Level 2: Mix level
## *Cracking resistance – strength assessment (SCB)*

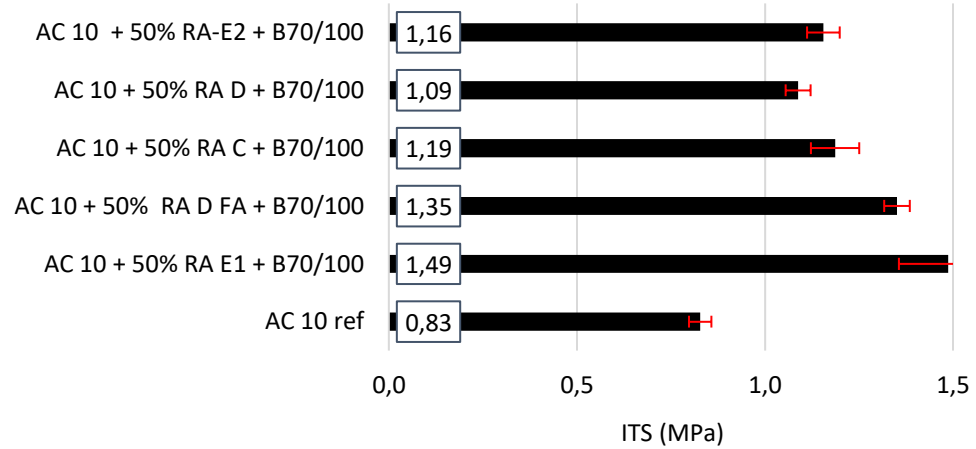
- Higher $K_{IC}$ → higher strength
- Higher CRI → higher cracking resistance
  - AC ref: lowest $K_{IC}$ and high CRI
  - Mixes with RA ranking:
    - RA D: low $K_{IC}$ and highest CRI
    - RA C : highest stress + $K_{IC}$
    - RA D-FA and E1: most aged, lowest CRI
- Ranking confirms CBI values of pure RA

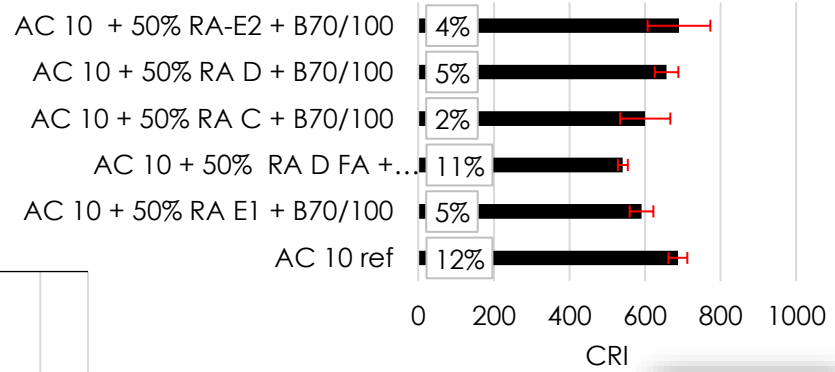


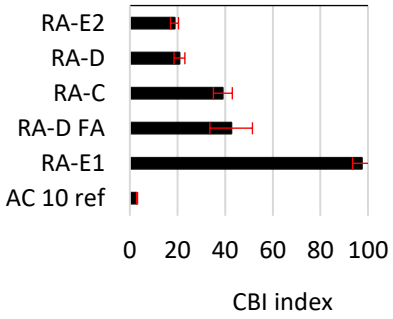



# Level 2: Mix level
## *Cracking resistance – strength assessment (IDT/ITS)*

- Indirect tensile test **(IDT/ITS)** principle
- IDT samples: Ø150 mm – H=66 mm – 7% air voids
- Mixes with highly aged binder, have highest ITS and lowest CRI (RA E1 and D-FA)
- Mix with RA C: Higher ITS value compared to other
- Ranking confirms CBI values of pure RA




# Level 2: Mix level
## *Other performance requirements/considerations*

**Water sensitivity:**

- AC surf : ITS-R > 80% (Flemish requirement)
- All mixes > 80%

**Raveling**

- DSD – 25°C – 2 kN – 50 cycles
- studied mixtures quite resistant (< 120 g/m²)
  - even with the inclusion of a very aged RA material (RA E1)

# General take-away points

Introduction of a 2-level framework to evaluate durability of high recycled surface layer mixtures

- **Level 1: RA characterization (100 % RA)**
  - **CBI  a solvent-free method**; captures **global response** of **RA**-material
  - **Higher CBI**  RA materials with **more brittle** behaviour & **higher ageing severity**
- **Level 2: BMD Performance approach on mix level (50% RA inclusion)**
  - No (or limited) risks detected for water sensitivity, rutting, and raveling
  - **Risky mixtures identified** regarding compactability and cracking resistance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