Fracture characterization of grid-reinforced asphalt pavements

Presentation · June 2016

DOI: 10.13140/RG.2.2.12537.67681

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Fracture characterization of grid-reinforced asphalt pavements

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Paper N°: 67368

Outline

- Introduction
- Project description (Rilem TC-SIB)
- Materials and test methods
- Results and discussion
- Conclusion and Future work

Grid-reinforcement of asphalt layers

- Construction, maintenance and rehabilitation practice
  - New on New

New AC base course

Grid installation

Ready for takeoff/landing

Grid-reinforcement of asphalt layers

- Construction, maintenance and rehabilitation practice
  - New on New
  - New on old (distressed/cracked)

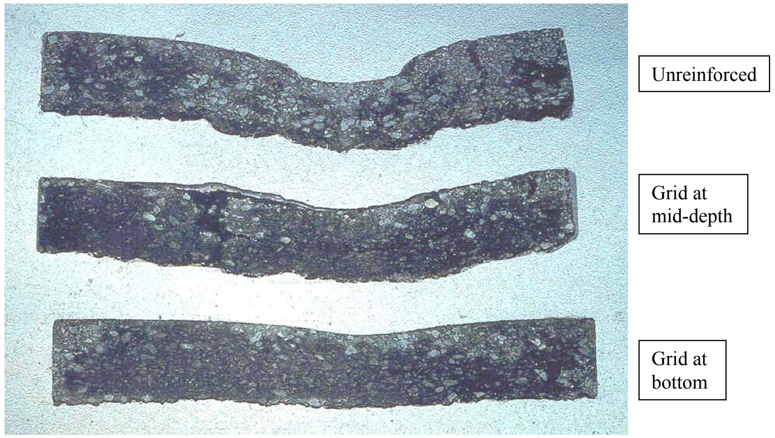
Milling of surface course

Leveling/regularization

Grid installation

Grid-reinforcement of asphalt layers

- Improvement in pavement performance
  - Improve rutting or fatigue resistance
  - Prevent or delay reflective cracking



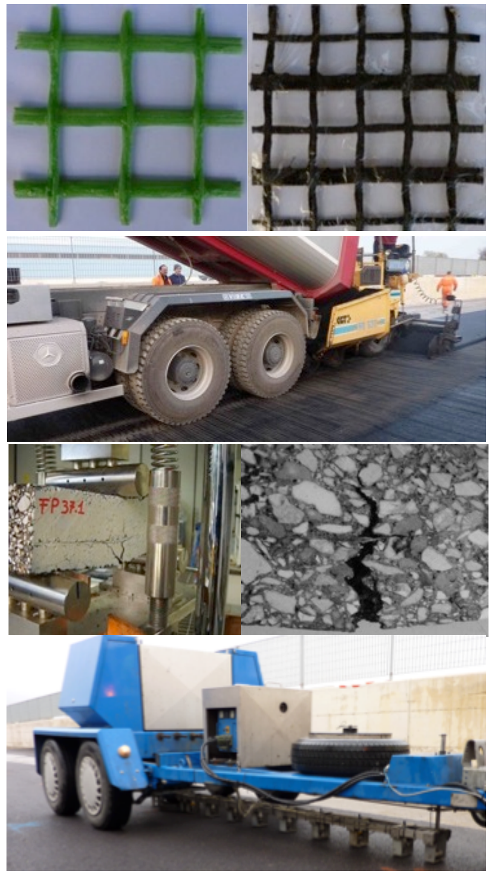
Brown et al. (1985), "Polymer grid reinforcement of asphalt", Proc. AAPT, Vol 54, 1985

Objective and methodology

- Characterize the fracture resistance of grid-reinforced asphalt concrete layers
- 3-Point bending tests on double-layered specimens
- Flexural toughness measured using energy based toughness indices

Rilem project (TC 237-SIB)

- Advanced Interface Testing of Geogrids in Asphalt Pavements
  - Interlaboratory test:
    - measure the properties of reinforced interfaces (de-bonding)
    - measure the properties of double-layered reinforced systems
  - Real-scale analysis
    - Measure pavement response using FWD tests and Real scale loads
    - Analyze the pavement performance under traffic (i.e. surface cracking evolution).



Materials (TC 237-SIB)

- Double-layered slabs obtained from experimental test section
    - Real scale paving equipment and grid installation techniques

Materials (TC 237-SIB)

- Double-layered slabs obtained from experimental test section

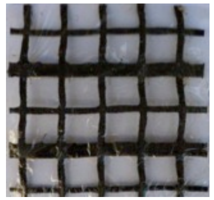
Upper layer AC12 surf

Interface: 3 types →

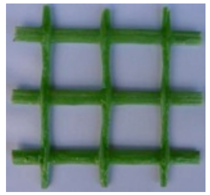
Lower layer AC12 surf

UN - Unreinforced (tack-coat)

CF - Carbon Fiber (pre-coated)



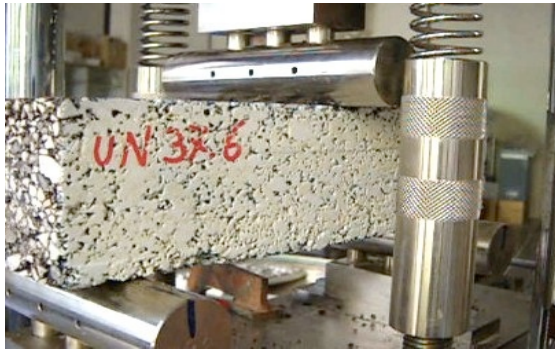
FP - Glass-fiber reinforced Polymer



Testing methods

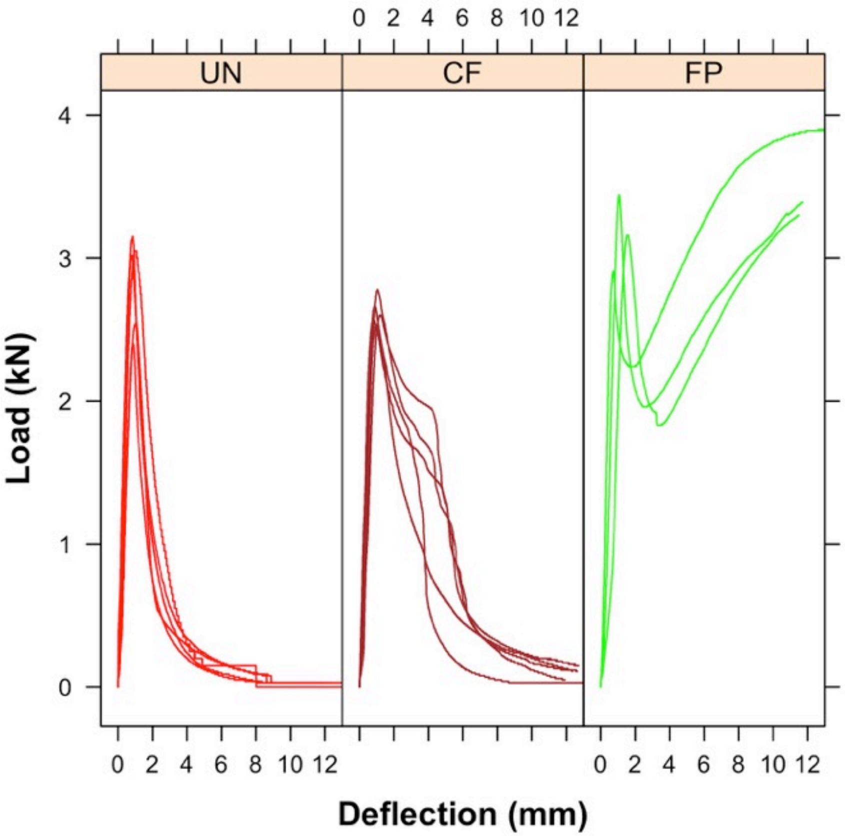
- **3PB monotonic (UniBO)**
  - H = 90 mm (45+45)
  - D = 100 mm, L = 400 mm
  - h_{notch} = 20 mm
  - Speed = 5 mm/min
  - T = 10 °C

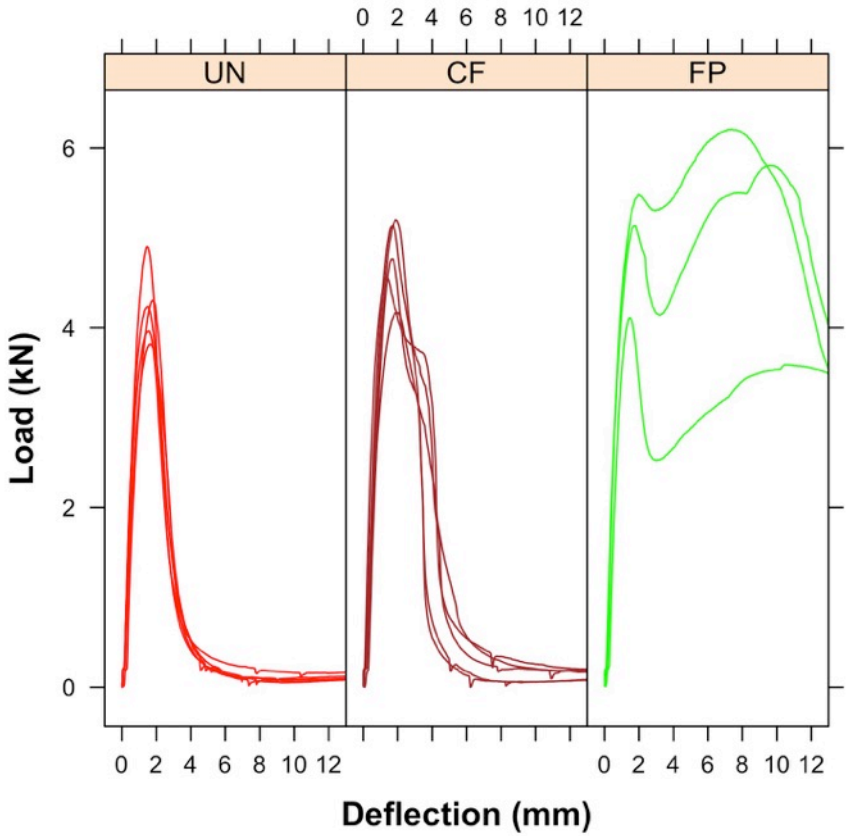
- **3PB monotonic (UniAN)**
  - H = 75 mm (45+30)
  - D = 90 mm, L = 240 mm
  - No notch
  - Speed = 50 mm/min
  - T = 20 °C



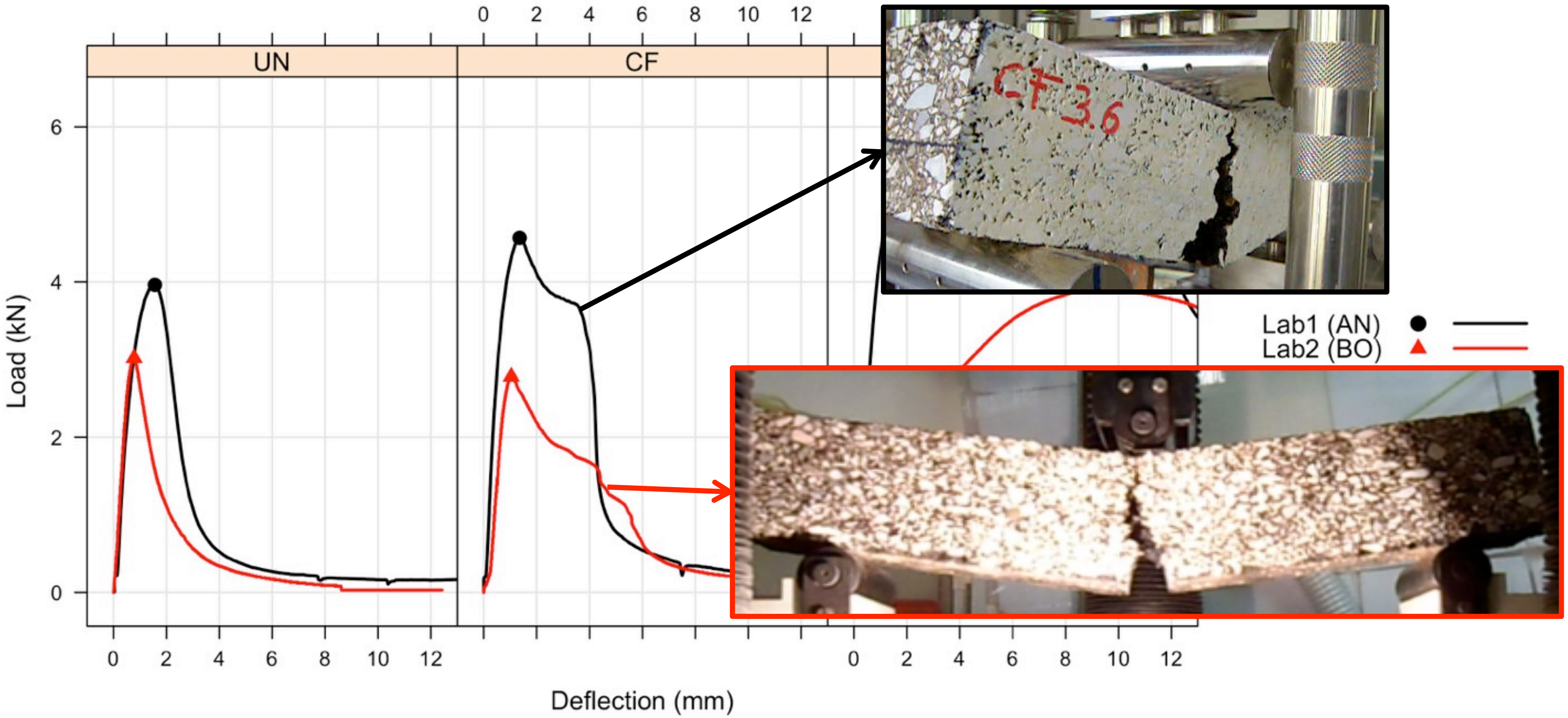
Testing results

- **3PB monotonic (UniBO)**
- **3PB monotonic (UniAN)**

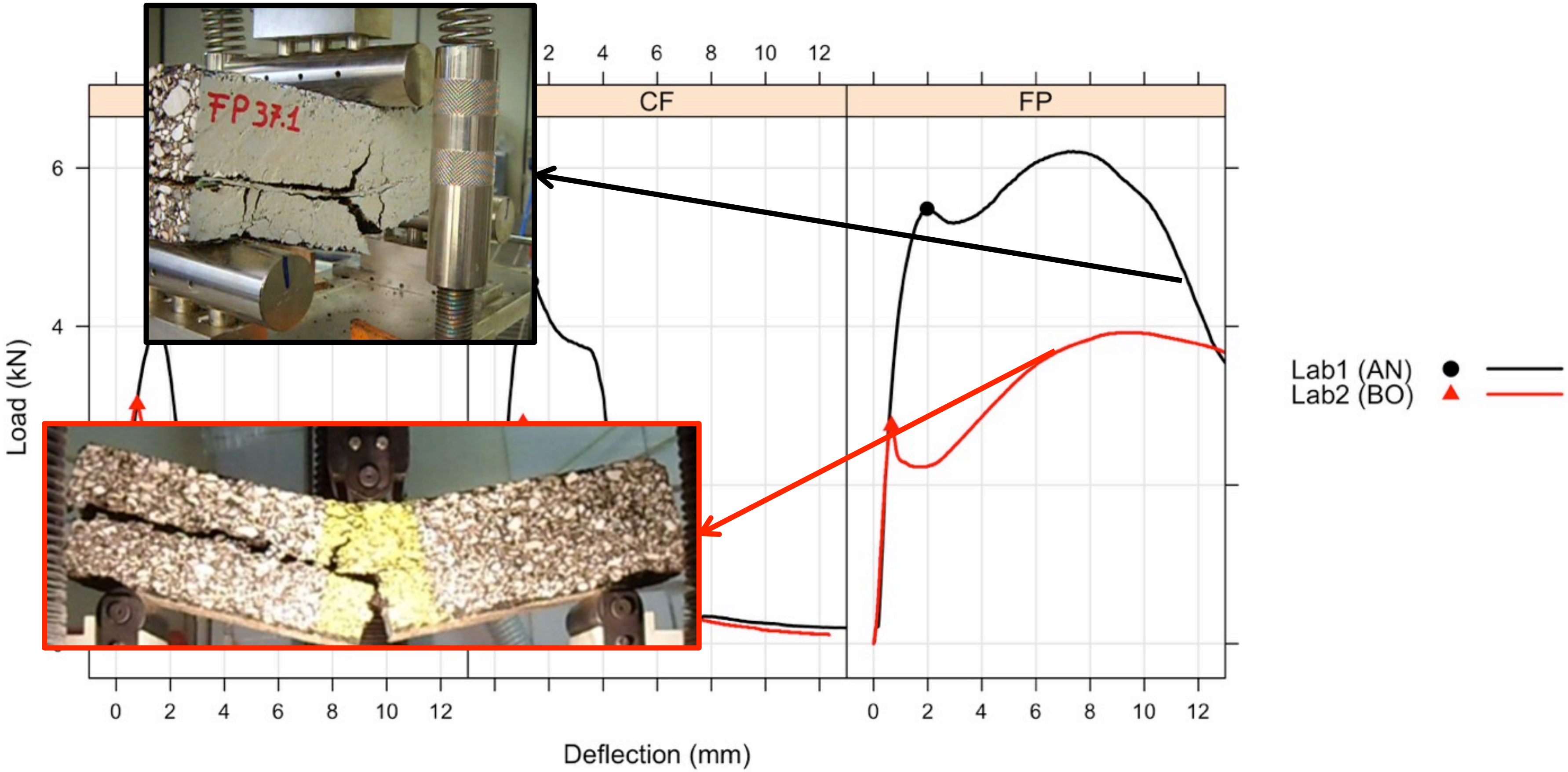




Testing results: CF crack propagation



Testing results: FP crack propagation

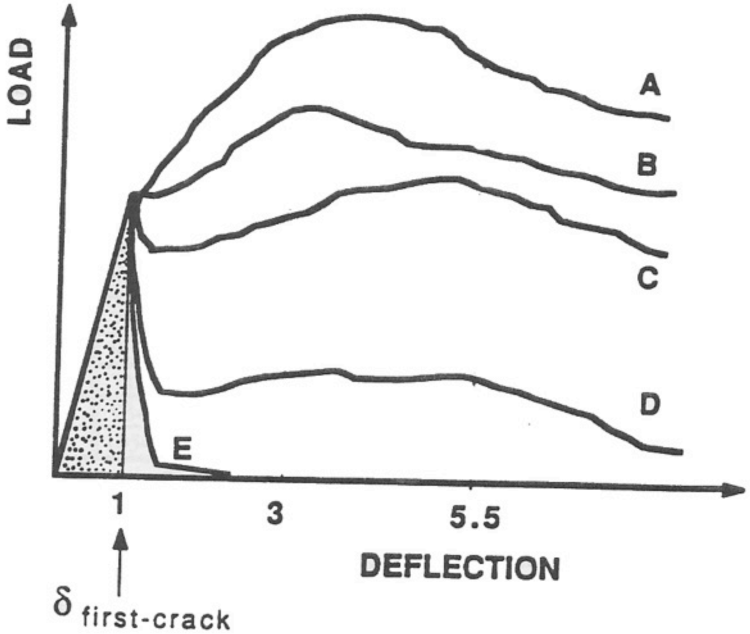


Results: first crack load and deflection

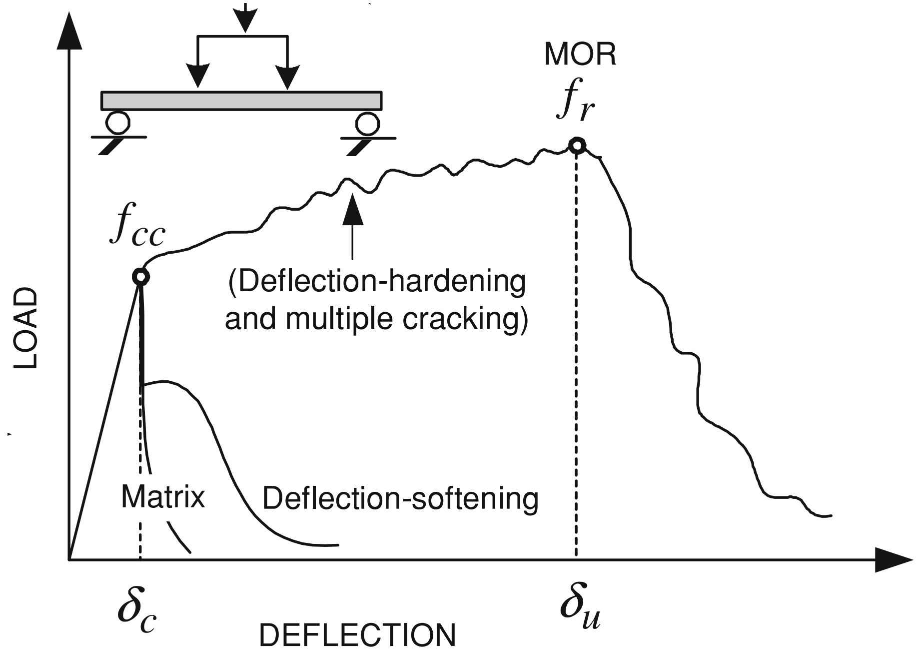
UNIVPM						
	Max load Pmax			Deflection @Pmax		
	Average	Std. Dev.	CoV (%)	Average	Std. Dev.	CoV (%)
UN	4.24	0.42	9.82	1.59	0.13	8.05
CF	4.77	0.42	8.91	1.73	0.25	14.28
FP	4.91	0.71	14.54	1.75	0.25	14.51

UNIBO						
	Max load Pmax			Deflection @Pmax		
	Average	Std. Dev.	CoV (%)	Average	Std. Dev.	CoV (%)
UN	2.83	0.34	11.92	0.87	0.08	9.68
CF	2.63	0.10	3.80	0.96	0.15	15.61
FP	3.03	0.27	8.91	0.94	0.36	38.74

Flexural behavior of fiber-reinforced concrete (FRC)



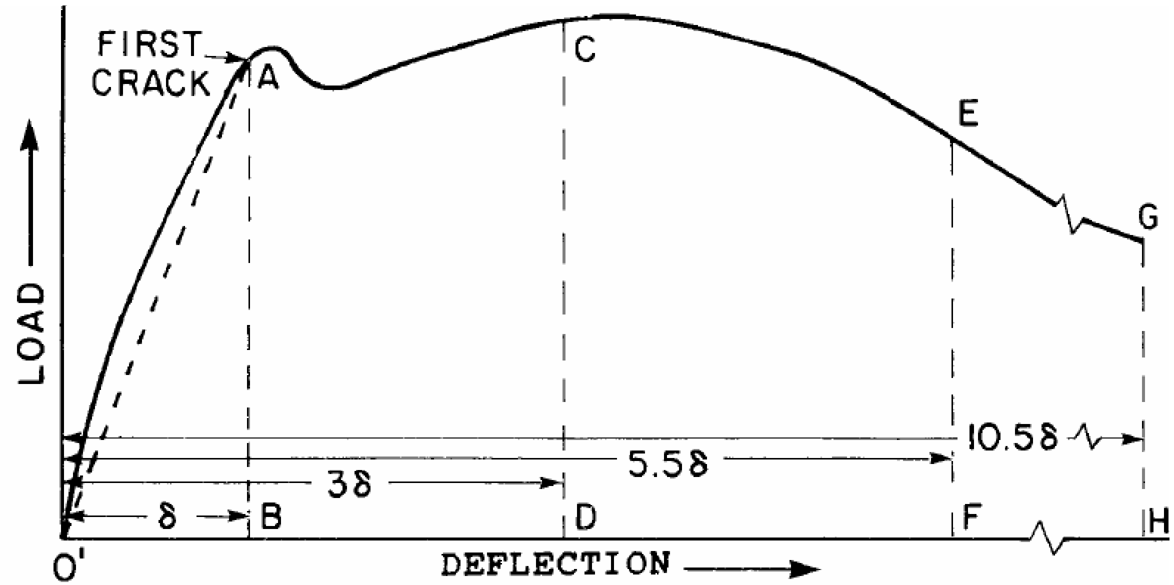
Naaman, et al. (1993) Mechanical behavior of High performance concrete, Volume 6, SHRP-C-366



Di Prisco et al. (2009). Fibre reinforced concrete: new design perspectives. Materials and Structures, 42(9)

Energy-based dimensionless indices

- ASTM C 1018
  - Standard test method for Flexural Toughness and first crack strength of Fiber-Reinforced Concrete (Using Beam with third Point Loading)



$$I_5 = \frac{\text{Area OACD}}{\text{Area OAB}}$$

$$I_{10} = \frac{\text{Area OAEF}}{\text{Area OAB}}$$

$$I_{20} = \frac{\text{Area OAGH}}{\text{Area OAB}}$$

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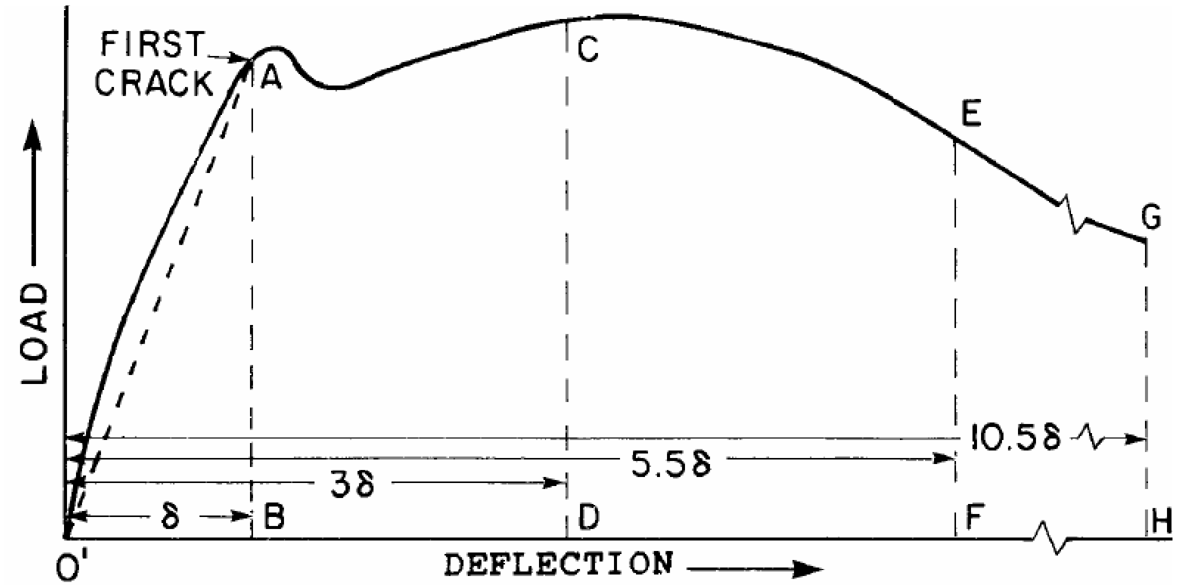

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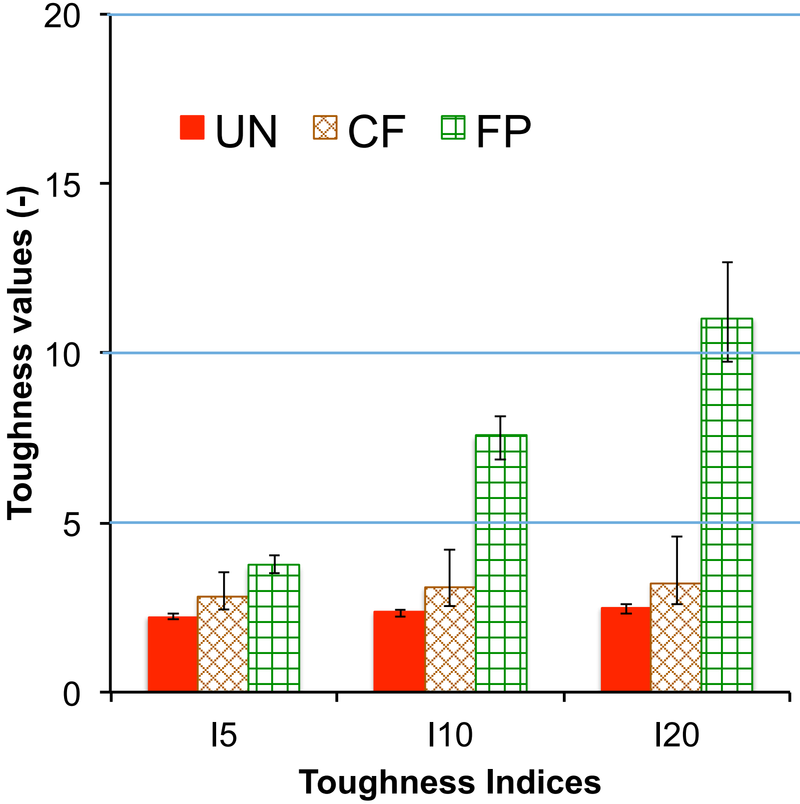
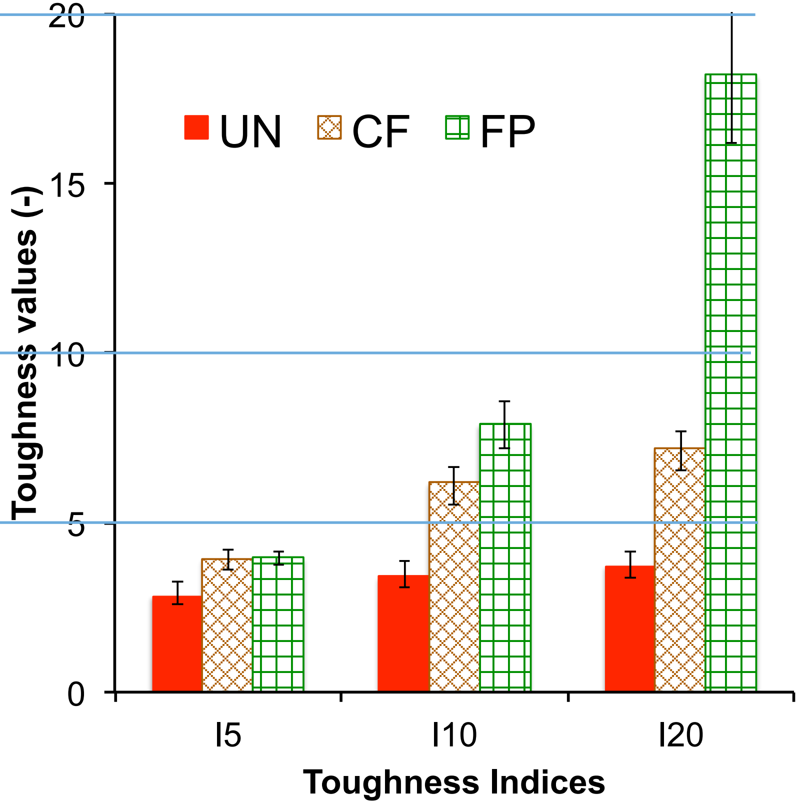
Energy-based dimensionless indices

- **UniAN**



- **UniBO**



Conclusions

- Grid-reinforcement did not affect first-crack load and deflection (pre-cracking behavior)
- Post cracking behavior was similar with different test geometries and conditions (temperature, loading rate)
- Pre & Post cracking behavior was similar to that of fiber-reinforced concrete (FRC)
- Energy-based dimensionless were effective in characterizing flexural toughness
- The grid effect is more evident at higher limiting deflections (I20)

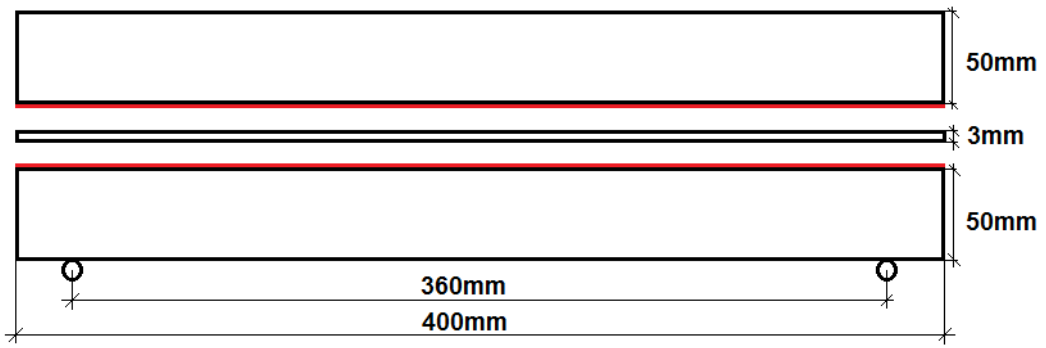
Future work (1)

- Evaluate temperature and deformation rate effects (time-temperature superposition)
- Review first crack definition
- Back-analysis of previous 3PB tests and generalization of results
- Evaluate other deflection-based toughness indices

Future work (2)

Original contribution by Dr. Shangtong Yang, University of Strathclyde Glasgow, UK

- Extended finite element simulation
  - Three-phase model – asphalt concrete, geogrid and interfaces;
  - Cracks/damaged modeled in both concrete and interfaces.

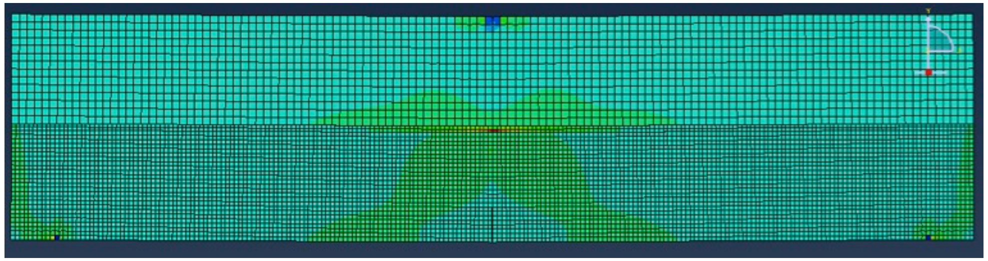


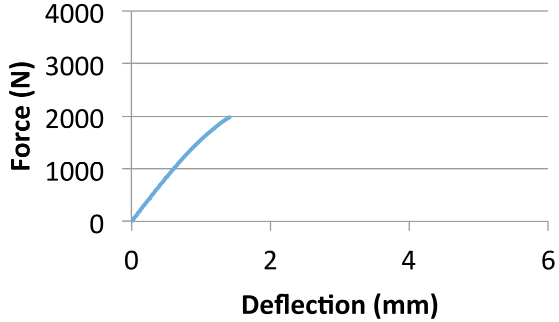
- Asphalt Concrete—quasi-brittle material;
- Glass Fiber Reinforced Polymer geogrid (FP) — elastic material;
- Red line (---) — interface: cohesive crack model.

Future work (2)

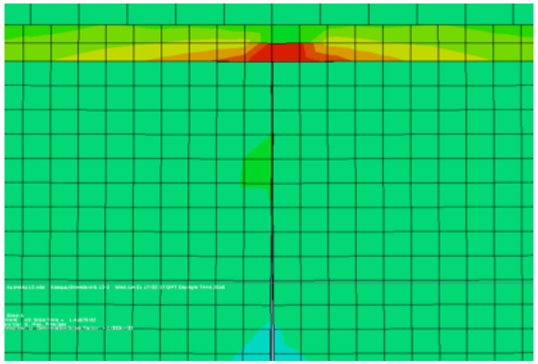
Original contribution by Dr. Shangtong Yang, University of Strathclyde Glasgow, UK

- Extended finite element simulation – Preliminary results
  - Stress distribution, load deflection curve





  - Crack propagation



June 7-9, 2016 – Nantes, FRANCE
8th RILEM International Conference on Mechanisms of Cracking and Debonding in Pavements

Thank you!