Mechanical behavior of mixtures containing crumb rubber added by dry process

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CONTEXT AND OBJECTIVES

Reducing the environmental impact of road works

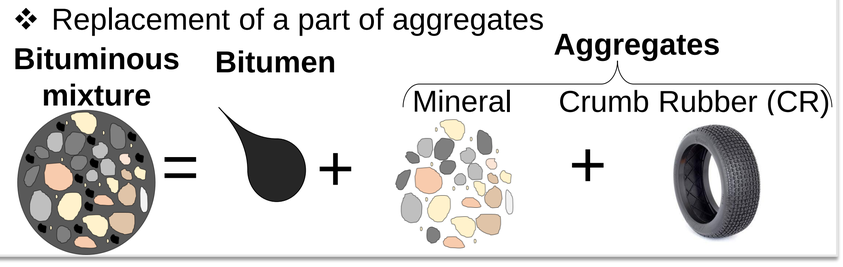
- ❖Reduction of energy consumption
- ❖Reduction of emissions
- ❖Preservation of natural resources through the use of recycled materials

Waste tires

≈ **550 000** tons of new tires put on the market
&
≈ **350 000** tons of used tires collected by Aliapur

Dry process

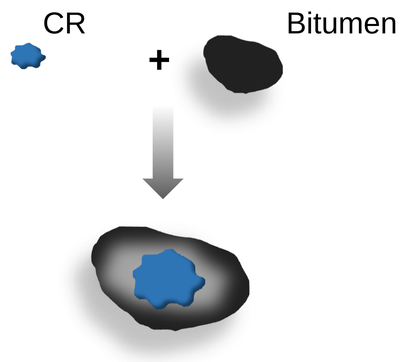
❖ Replacement of a part of aggregates



Objectives: Design & characterisation of thermomechanical behaviour Bituminous mixtures considering dry process

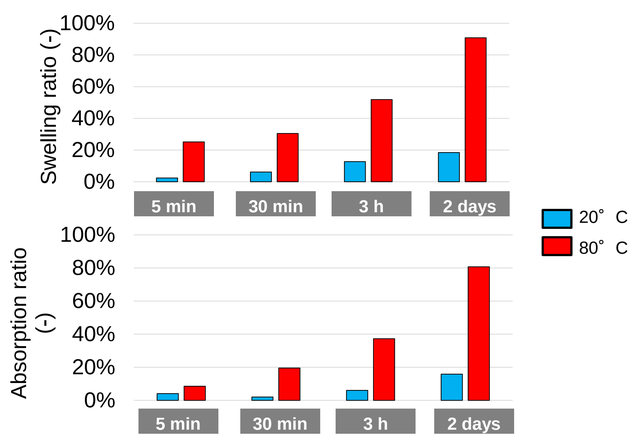
MIXTURES DESIGN AND TESTED MATERIALS

CR/bitumen interactions



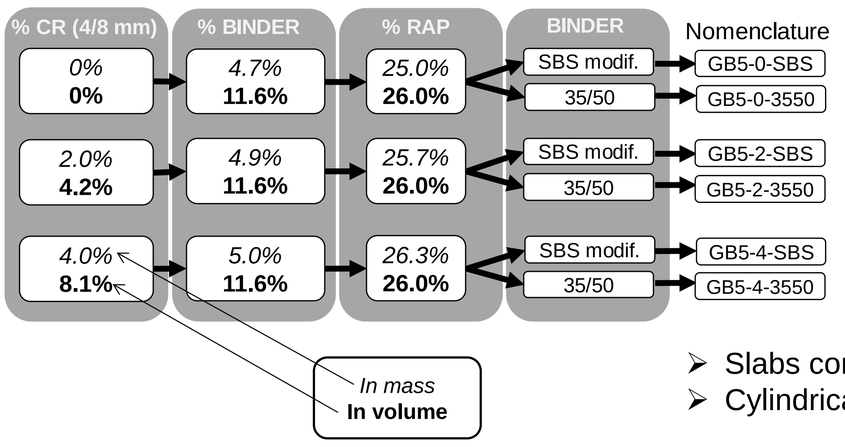
➢ Absorption of bitumen light fractions and swelling

Experimental evaluation of swelling and absorption in aromatic oil



Production of mixtures and specimens

6 different GB5® mixtures:



Specimens production

➢ Slabs compacted using a LPC-type wheel compactor
➢ Cylindrical specimens are cored from slabs

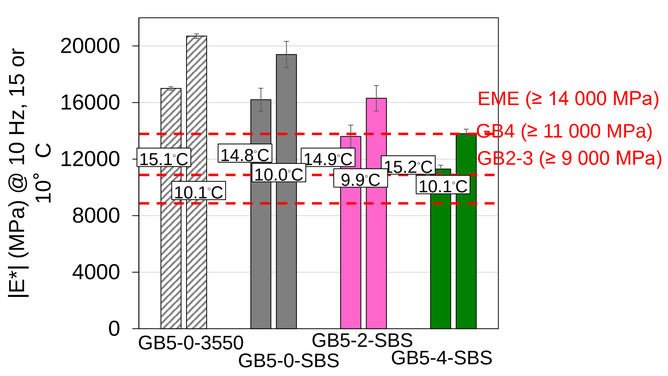
LABORATORY INVESTIGATION

Standard tests

Standard tests at Eiffage lab

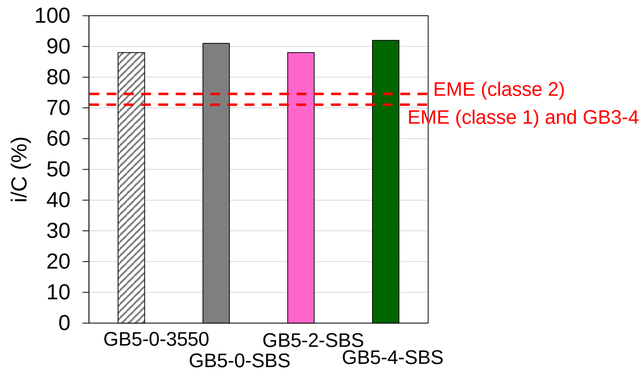
Standard complex modulus NF EN 12697-26

➢ Tension/compression (T/C)
➢ Axial strain amplitude ≈30 µm/m



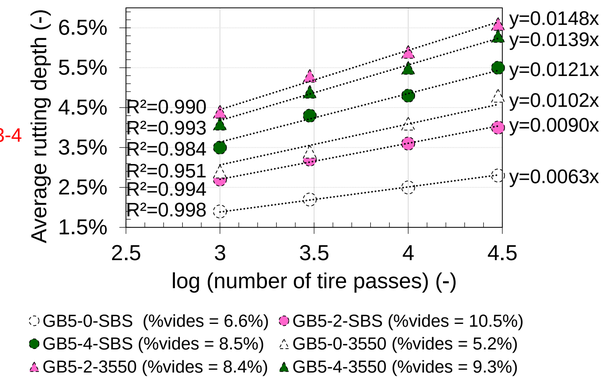
Water sensitivity NF EN 12697-12

➢ Compression tests (DURIEZ)



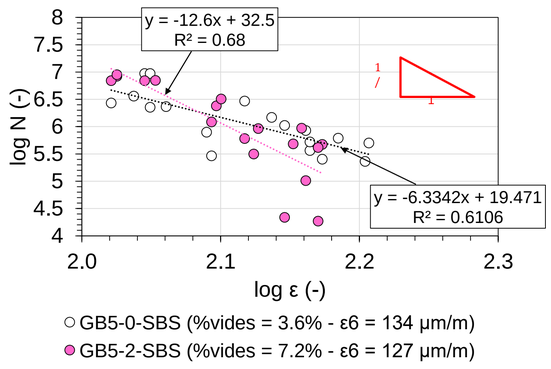
Rutting NF EN 12697-22

➢ French rolling wheel device @ 50°C



2-point bending fatigue NF EN 12697-24

➢ On trapezoidal specimens @ 10 °C, 25 Hz



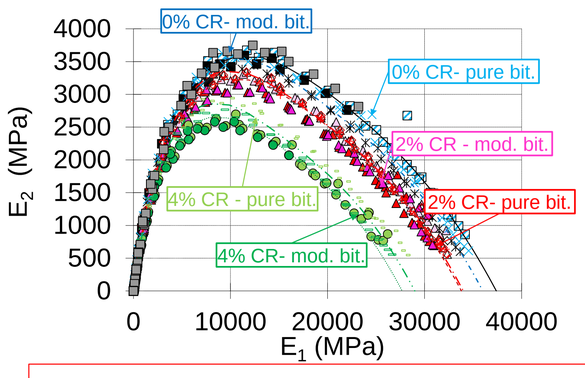
→ Bituminous mixtures with 4% CR conform to the GB3 requirements
→ Bituminous mixtures with 2% CR conform to the GB4 requirements
→ Bituminous mixtures with CR conform to the EME requirements except for the stiffness

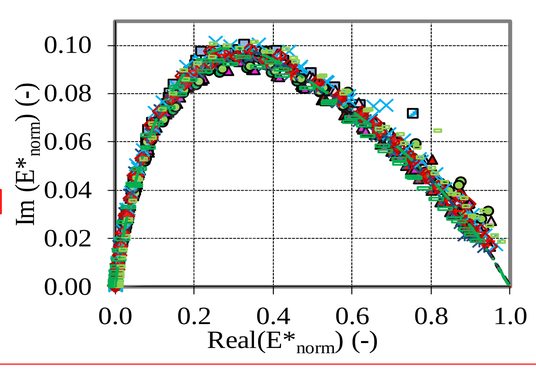
Advanced tests and modeling

Advanced tests at ENTPE

Complex modulus test

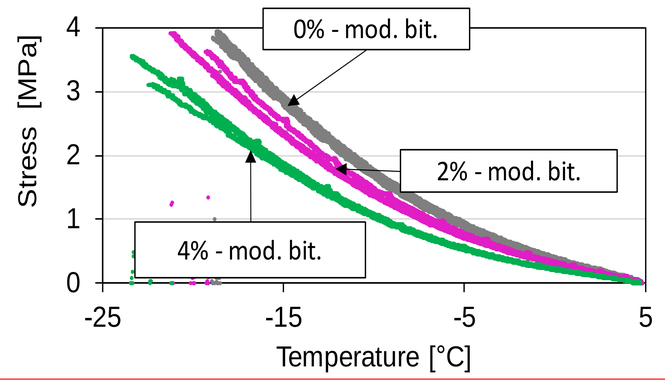
➢ T/C
➢ Axial strain amplitude : 50 µm/m
➢ 9 temperatures from -25 ºC to 50 ºC and 8 frequencies from 0.003 Hz to 10 Hz





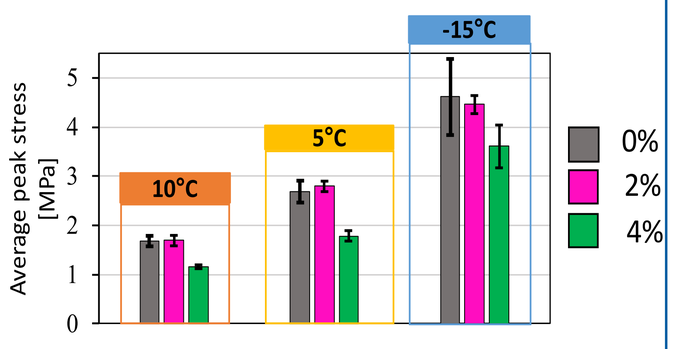
Thermal Stress Restrained Specimen Test (TSRST)

➢ T_i = 5ºC
➢ ε_{axial} = 0
➢ Temperature rate : -10ºC/h



Direct Tensile Strength Test (DTST)

➢ Axial strain rate : 3.2 10^{-4}/min



Main output

E* → Reduced stiffness with the addition of CR but normalized curves are all overlapping
→ Sucessful modeling with 2S2P1D model

DTST → No difference of peak stresses observed when 0% and 2% CR are added → Conservation of mechanical properties for % CR < 4%

TSRST → ↘ of cracking temperature and thermal stress with the addition of CR
→ ↗ low-temperature cracking resistance with the addition of rubber