Deformation behaviour of bitumen and bituminous mixes

Overview

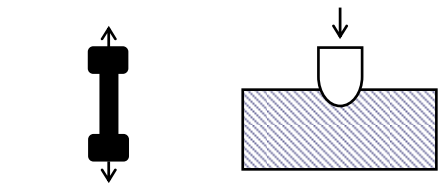
•The permanent deformation or Rutting of asphalt pavements due to heavy vehicles is a considerable problem to pavement industry.

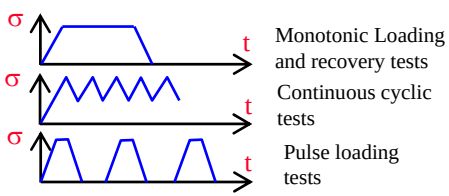
•Asphalt is a complex composite material with three phases: bitumen, aggregate and air voids.

•The development of a reliable and easy to implement model to predict rutting during road design stages requires an understanding of the influence of the mix components and their interactions.

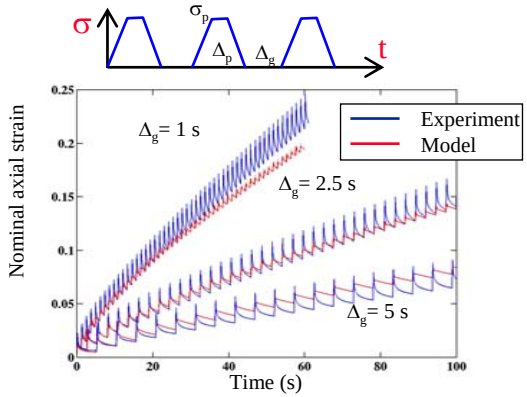
Bitumen behaviour

An experimental and theoretical study was conducted in order to understand the deformation behaviour of pure bitumen. Tests under various loading conditions: monotonic, cyclic and pulse loading at different temperatures and loading rates were performed for uniaxial tension and spherical indentation.





• A phenomenological model for the deformation behaviour of pure bitumen has been developed with good agreement with experimental results (see below). The model works with six parameters that can be easily obtained from four uniaxial monotonic tensile or indentation tests. This model is able to predict any of the complicated loading conditions studied.



Pulse loading behaviour on 50 pen bitumen. T=10ºC, Δp=0.2 s and σ_p=0.32 MPa.

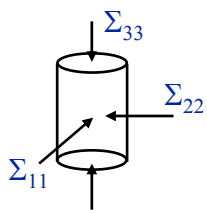
Mix behaviour

Asphalt is under triaxial state of stresses under a passing wheel load. Therefore it is necessary to understand the triaxial behaviour of the material to generate a constitutive model.

An experimental and theoretical study of deformation behaviour of asphalt mixes under uniaxial and triaxial stresses at various loading conditions similar to pure bitumen were conducted in order to establish a constitutive micro-mechanical model.

The effect of volume fraction of aggregate and its shape was studied for different mixes under various loading conditions.

Effect of confining pressure

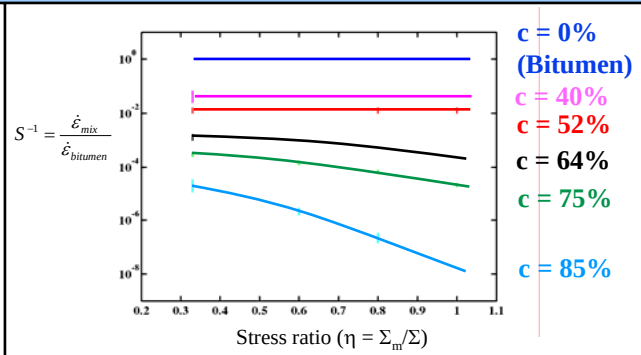


$\Sigma_m = \Sigma_{kk}/3$

$\Sigma = \Sigma_{33}-\Sigma_{11}$

$\eta = \Sigma_m/\Sigma$

The effect of stress ratio, η (Hydrostatic stress / Deviatoric stress) is important in the fully dense mixes (c >64%), decreasing the mix strain rate as η increases. For lower c the deformation behaviour is not affected by stress ratio (see below).



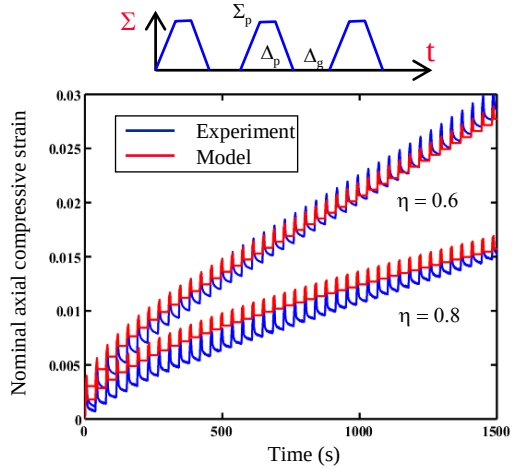
Effect of stress ratio on deformation behaviour of mixes with varying volume fractions of round aggregate (c).

Mix modelling

From the experimental observations, two models to predict the deformation behaviour of bituminous mixes are proposed:

•Continuum phenomenological model, similar to the model for pure bitumen.

•Micro-mechanical model, which requires the properties of bitumen, volume fraction of components and dilation of the mix.



Triaxial pulse loading behaviour on 75% c mix. T=20ºC, Δp=8 s, Δg=30 s and Σ_p=0.32 MPa.

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