Constitutive Model for Bituminous Stabilized Materials and Modelling of Cold Recycled Pavement Layers

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INTRODUCTION

Cold recycling techniques are becoming more and more popular everywhere in the world, as it is well proven that bituminous stabilized mixtures (BSM) are sustainable both from an environmental and economical point of view [1,2,3]. There have been limited studies focusing on mechanical properties of those mixtures and on their performance with respect to the service lives of pavement structures with in-place recycled layers. For this reason.

Objective:

- Design of a constitutive model for different types of BSMs and on the modeling of flexible pavement structures with BSMs as base layers.

Research Process:

- 3D Elasto-Plastic model was created using ABAQUS software in order to calibrate and validate the constitutive mechanical properties of the different cold mixtures,
- The outputs obtained were then used in a multilayer axisymmetric 2D model for traffic simulation. The modelled structures were subjected to a cyclic loading of 0.1 second with 0.9 second of rest period. The load applied on the structures has been calibrated in order to have a comparable effect to the real tire pressure experienced by the structures under traffic.
- Rutting evolution curves until a failure threshold value of 20 mm rut depth have been developed and the results have clearly shown how the BSM as a base layer can provide superior or comparable performance in terms of rutting as compared to granular virgin material.

LABORATORY SPECIMENS and TESTS

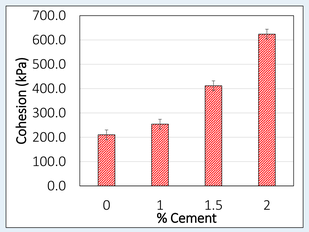
Specimens were prepared in the laboratory using 93% of RAP (Reclaimed Asphalt Pavement), Mineral Filler, Cement and Foamed Bitumen.

1) Mixing.

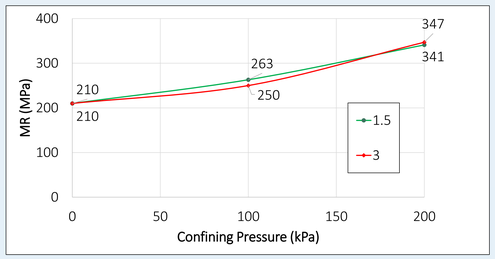
2) Compaction.

3) Final specimens: 150 mm diameter and 300 mm height.

After 28 days curing at room temperature, Triaxial tests at different confining pressures and Resilient Modulus tests were performed to have information on the plastic and elastic properties of different bituminous stabilized mixtures.



1) Cohesion results from Triaxial tests (Mohr-Coulomb criterion)



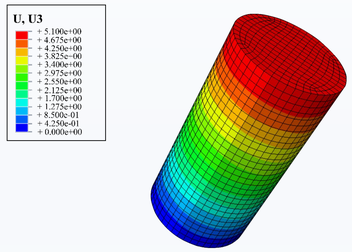
2) Resilient Modulus results from mixtures with 1.5 and 3% Cement

FINITE ELEMENT MODELS

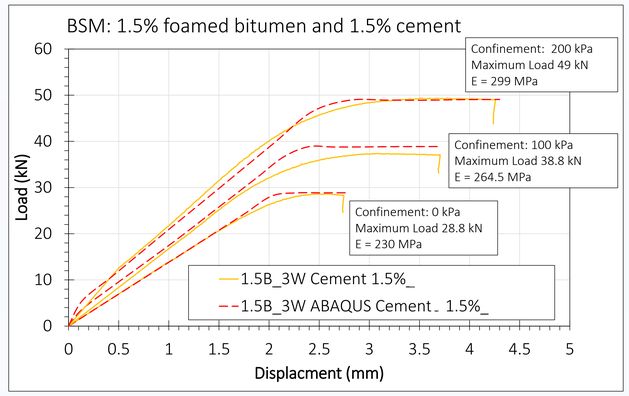
Laboratory test 3D Model

Computational mechanics approach: Inverse analysis to get the local properties of the material

- Calibration of the inputs (global properties obtained from laboratory results) to simulate force-displacement triaxial test curves with no confining pressure applied
- Validation of the model applying different confining pressures (100 kPa, 200 kPa) to verify model ability to predict material behavior under different conditions.

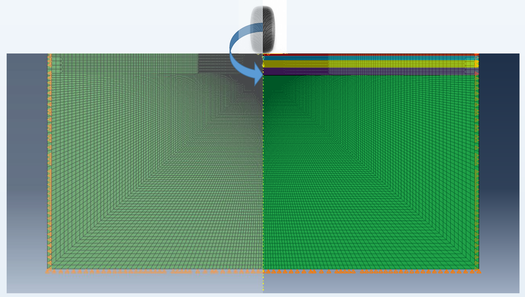


Material Properties:
Confining Pressure: 0,100,200 kPa
Young's Modulus: 230 MPa
Poisson's Ratio: 0.4
Friction angle: 31 °
Cohesion: 450 kPa



Multilayer Axisymmetric Pavement 2D Model

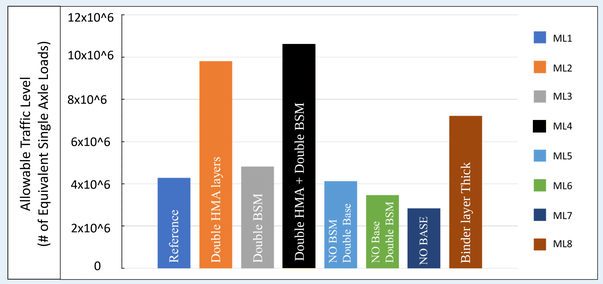
Elastic and Plastic properties calibrated with the previous model were used as input in a multilayer system to predict rutting accumulation on pavement surface.



Layer properties:

	E (MPa)	ν	Cohesion (kPa)	ϕ °
HMA	2000	0.35	N/A	N/A
BINDER	2500	0.35	N/A	N/A
BSM	270	0.4	450	31
BASE	150	0.4	75	40
SOIL	70	0.45	50	15

RESULTS and CONCLUSIONS



- Different pavement structures (with and without BSM as base layer) were compared in terms of traffic loading applications before reaching 20 mm rut depth.
- Structures with BSM showed very good performance, in some cases superior to traditional crushed aggregates base layers.

References: 1)Jenkins, K. J., Twagira, M.E., Kelfkens, R.W. & Mulusa W.K. "New laboratory testing procedures for mix design and classification of bitumen-stabilised materials." Road Materials and Pavement Design 13.4 (2012): 618-641. 2)Tebaldi, Gabriele, et al. "Cold recycling of reclaimed asphalt pavements." Testing and Characterization of Sustainable Innovative Bituminous Materials and Systems. 239-296. Springer, Cham (2018). 3) Dave, E. V. "Cold recycling of asphalt concrete: review of North American state of practice." RILEM TC-SIB: TG-6, Liverpool (2011).