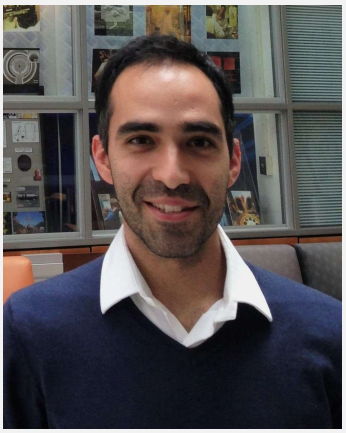
CERIS : Civil Engineering Research and Innovation for Sustainability

Development of an accelerated asphalt concrete aging method and utilization of nano-modifiers to improve durability of asphalt concrete



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Summary

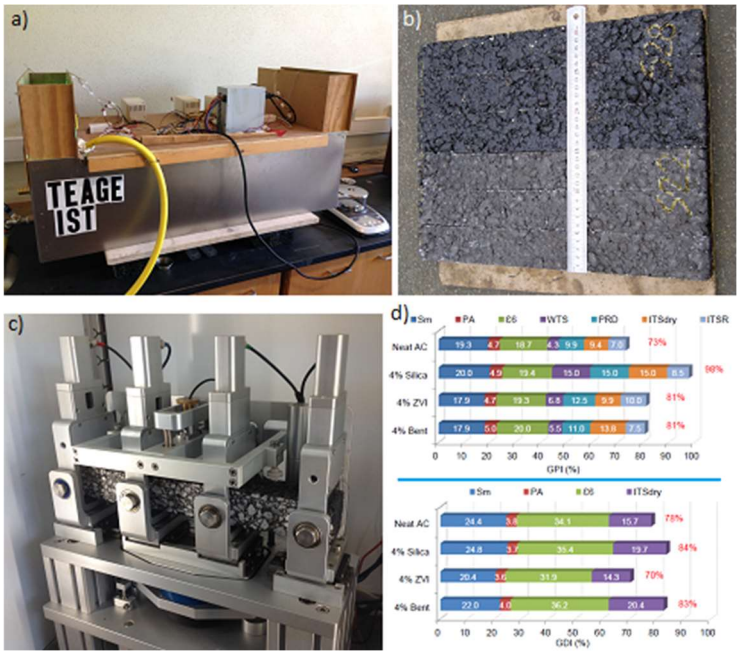
The modification of asphalt binders with nanomaterials can lead to improvements in the asphalt mixtures' mechanical performance. However, there is some uncertainty on the effect of each type of nanomaterial on the properties of the asphalt mixture and studies involving asphalt mixtures with nanomodified binders are limited, and particularly scarce concerning stiff binders. This thesis evaluates the effects of nanomaterials modification in the asphalt concrete mechanical performance and durability. Three types of nanomaterials – nanosilica, zero-valent iron and nanoclay bentonite – were used to modify a conventional 35/50 penetration class asphalt binder. The correspondent nanomodified asphalt mixtures were tested for affinity aggregate-binder, permanent deformation, stiffness, fatigue resistance, water sensitivity and retained Marshall stability.

To evaluate the effect of the nanomodifications in the aging process, a new ageing method was developed, the TEcnico Accelerated aGEing (TEAGE), intended to simulate aging due to environmental conditions at the desired service location. The TEAGE method was used to simulate 7-year Lisbon environmental conditions, and revealed great potential for a representative accelerated ageing simulation in laboratory. The method successfully induced an aging gradient through the depth of the specimens, as observed in field-aged in-service pavements. The results showed that the nanomodifications led to improvements on the asphalt mixtures mechanical performance. The modification with nanosilica achieved higher stiffness modulus, lower phase angle, and lower permanent deformation. The modification with nanoclay bentonite exhibited lower phase angle and longer fatigue life. The modification with zero-valent iron presented better water sensitivity.

Considering the results of the aged mixtures, the modification with zero-valent iron did not perform well when aged, however, nanosilica and nanoclay bentonite modifications gave several contributions to aging resistance, particularly, in fatigue resistance.

Keywords

Asphalt mixtures, nanomaterials, mechanical performance, ageing.



a) TEAGE – equipment for accelerated ageing of asphalt mixtures in the laboratory; b) example of fresh (top) and aged (bottom) asphalt mixture; c) fatigue resistance test on the four-point bending equipment; d) global performance index and global durability index of the neat and nanomodified asphalt mixtures.