Spring 4-12-2016

Multiscale Research Toward Resilient Civil Infrastructure

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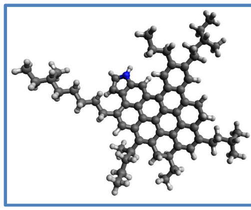
Background and Motivation

Infrastructure materials are generally composite in nature and consist of different phases. Despite their widespread use, the mechanisms behind their behavior are often not fully understood.

The aim of this research is to develop the capability to predict the performance of infrastructure based on its components, thus eliminating the need for costly experimental tests.

Such an objective requires thorough understanding of material properties at various length-scales and investigation of the linkage between each scale. This approach can lead to more optimized designs, sustainable performance and maximized public benefit.



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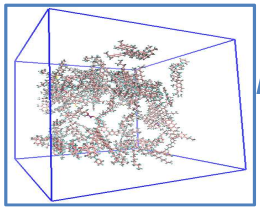

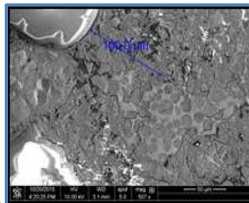

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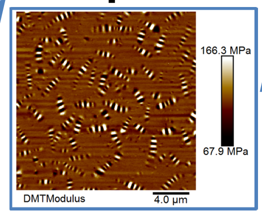

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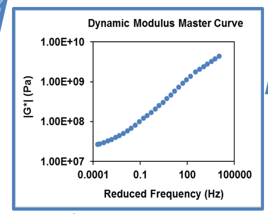

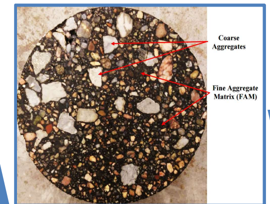

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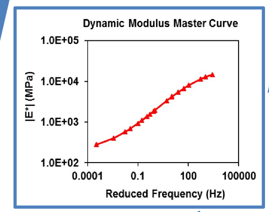

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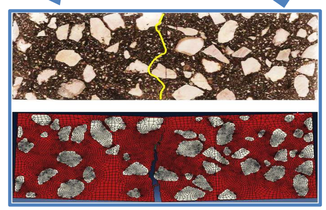

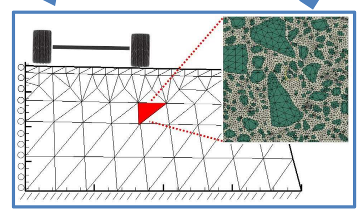

Research Method

Asphalt concrete which is a widely used material in infrastructure exhibits complex behavior. It is a mixture of coarse particles surrounded by matrix phase containing fine particles and asphalt binder. In order to investigate the effects of different components on mixture performance, experimental and numerical studies at different length-scales were conducted.

Scanning Electron Microscopy (SEM)

Dynamic Shear Rheometer (DSR)

Atomic Force Microscopy (AFM)

Nanoindentation

Universal Testing Machine (UTM)

Results and Conclusions

- The effect of additives and aging on the molecular composition of binder and its mechanical properties was investigated.
- AFM results revealed different phases and their elastic properties, which were comparably higher than the micro scale properties while nanoindentation indicated existence of a weak Interfacial Transition Zone (ITZ).
- Mechanical properties of mixtures such as viscoelastic response and fatigue fracture were characterized using different test methods such as Time Sweep, Semi-Circular Bending and Dynamic Modulus tests. The FEM models were then validated using experimental results.
- Computational simulations can become a powerful tool to predict overall mechanical behavior of mixtures with only components' properties required as inputs.

Acknowledgement

The authors would like to thank NSF, FHWA, NDOR for their financial support and providing us with the necessary materials.
The authors would also like to thank T. You, S. Amelian, G. Nsengiyumva, H. Alnazi and D. Nguyen for their valuable contributions.

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