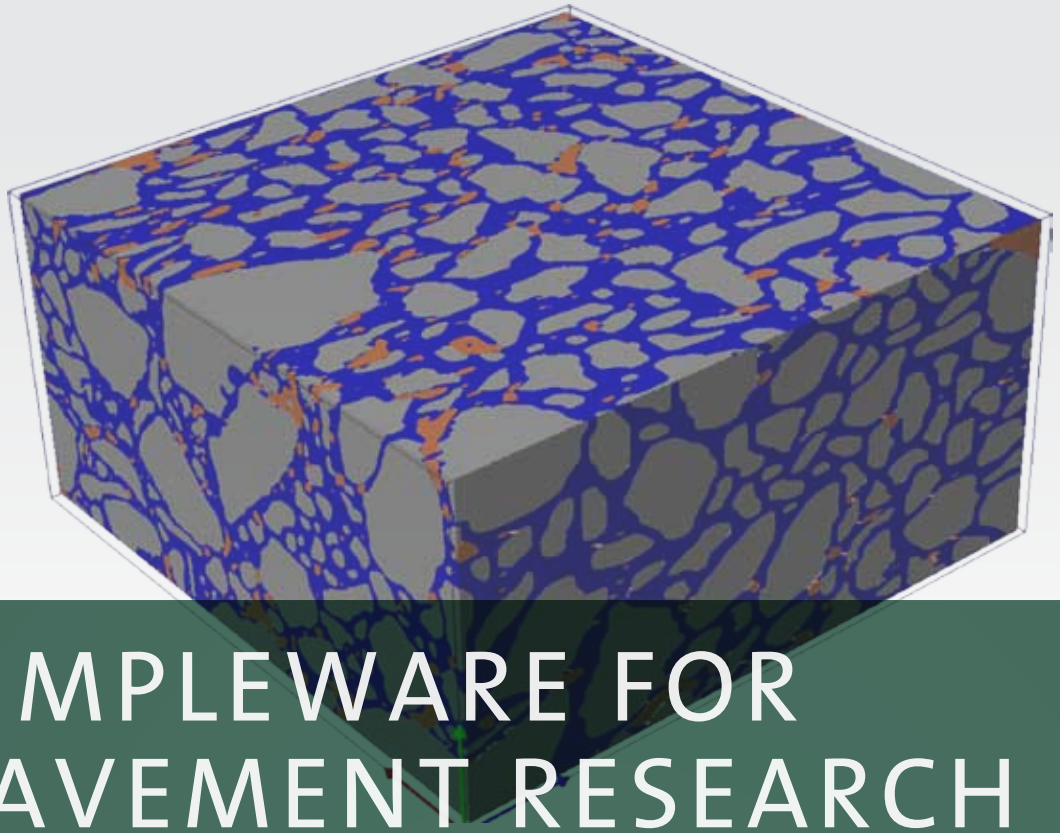


simpleware
3D image visualisation, analysis and model generation

SIMPLEWARE FOR PAVEMENT RESEARCH

Case Study

Shear Modulus Simulation of Asphalt Mixtures

Asphalt concrete mixtures used for pavements and roads are susceptible to deformation and rutting over time. By characterising asphalt mixtures through finite element modelling and non-destructive evaluation, researchers can reduce costs compared to physical testing.

Simpleware software was used to develop 2D and 3D micromechanical finite element models for predicting the shear modulus of two asphalt mixture types. X-ray Computed Tomography (CT) scans were processed in Simpleware ScanIP and meshed in additional module +FE to produce 2D and 3D computational models suitable for simulating a shear frequency sweep at constant height (FSCH) test in Abaqus.

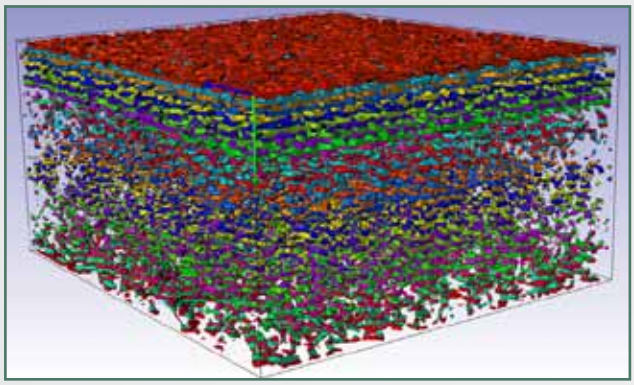
Characteristics

» 2D and 3D micromechanical FE models from X-ray CT images
» Segmentation using automated thresholding in Simpleware ScanIP
» Generation of robust multipart meshes with perfectly bonded interfaces
» Shear modulus predictions in Abaqus
» Validation of models against experimental results

Thanks to:
UCDAVIS
UNIVERSITY OF CALIFORNIA

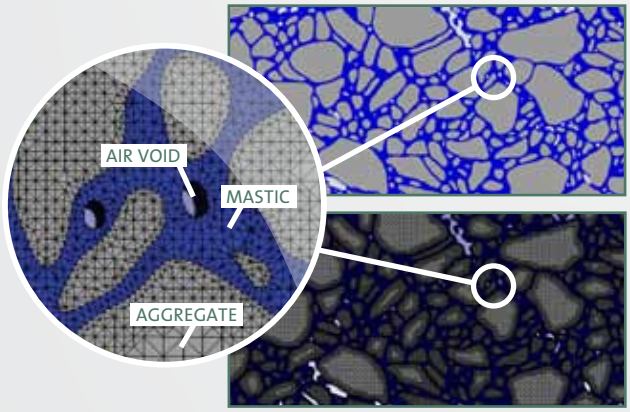
IMAGE PROCESSING IN SIMPLEWARE SCANIP

X-ray computed tomography images were obtained from pavement samples using a medical CT scanner, providing a resolution of 0.24 mm in XY, and 1mm in Z. Samples with two design thicknesses were then imported into Simpleware ScanIP. Automatic thresholding tools were used to segment image data into air void, mastic and aggregate subdomains based on measured intensity groups. The total volume of the asphalt mixture sample was calculated, and the upper limit of the air void intensity range determined by trial and error to match the measured air void contents. Colour mapping was also employed to clearly visualise the boundaries between each subdomain. The mask for the air void domain was excluded from the final material structure due to its lack of stiffness.



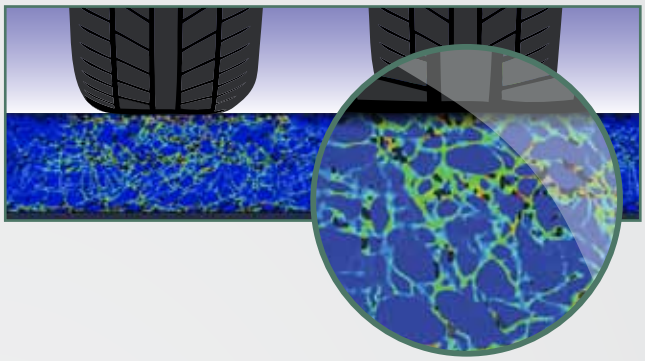
MESHING IN SIMPLEWARE +FE

Simpleware module +FE was used to convert segmented data into a robust mesh suitable for Finite Element Analysis (FEA). Aggregate and mastic domains were slightly smoothed prior to export to improve mesh realism while preserving element quality and volume. High quality tetrahedral meshes with perfectly bonded boundaries were created for aggregate and mastic domains while preserving an empty air void domain. 2D and 3D FE meshes were then exported to Abaqus for further analyses.



SIMULATION IN ABAQUS

Micromechanical viscoelastic FE simulations were carried out on meshed 2D and 3D samples using lab measured shear modulus values and virtual transverse strain gauges. Tests were run to predict the global viscoelastic behaviour of the asphalt mixtures under the same loading frequencies and temperatures. The simulations indicated higher levels of strain at the mastic phase compared to the aggregate phase of the asphalt samples, and a high degree of near-surface shear strain. The tests also demonstrated that 2D models always under-predicted laboratory tests, while the 3D numerical models were closer to physical results.



CONCLUSION

This case study highlights the effectiveness of finite element models developed in Simpleware software for predicting the shear modulus of asphalt mixture types taken from X-ray CT data. 3D micromechanical FE models were used to predict the shear modulus of asphalt concrete mixes at high testing temperatures with a precise degree of accuracy across a wide range of loading frequencies.

REFERENCES

1. Coleri, E., Harvey, J.T., 2013. A fully heterogeneous viscoelastic finite element model for full-scale accelerated pavement testing. *Construction and Building Materials*, 43, 14-30.

2. Coleri, E., Harvey, J.T., Yang, K., Boone, J.M., 2012. Development of a micromechanical finite element model from computed tomography images for shear modulus simulation of asphalt mixtures. *Construction and Building Materials*, 30, 783-793.