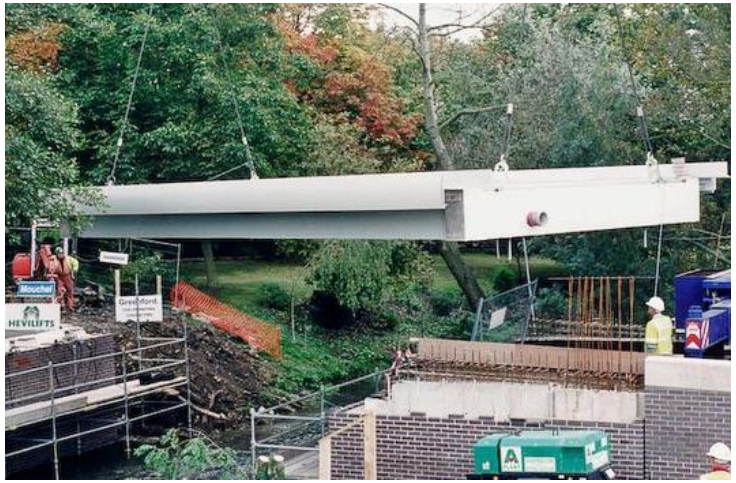
Tyre Load Fatigue of Cellular FRP Bridge Decks

Matthew Poulton

Wendel Sebastian

FRP Bridge Decks in the UK

West Mill Bridge

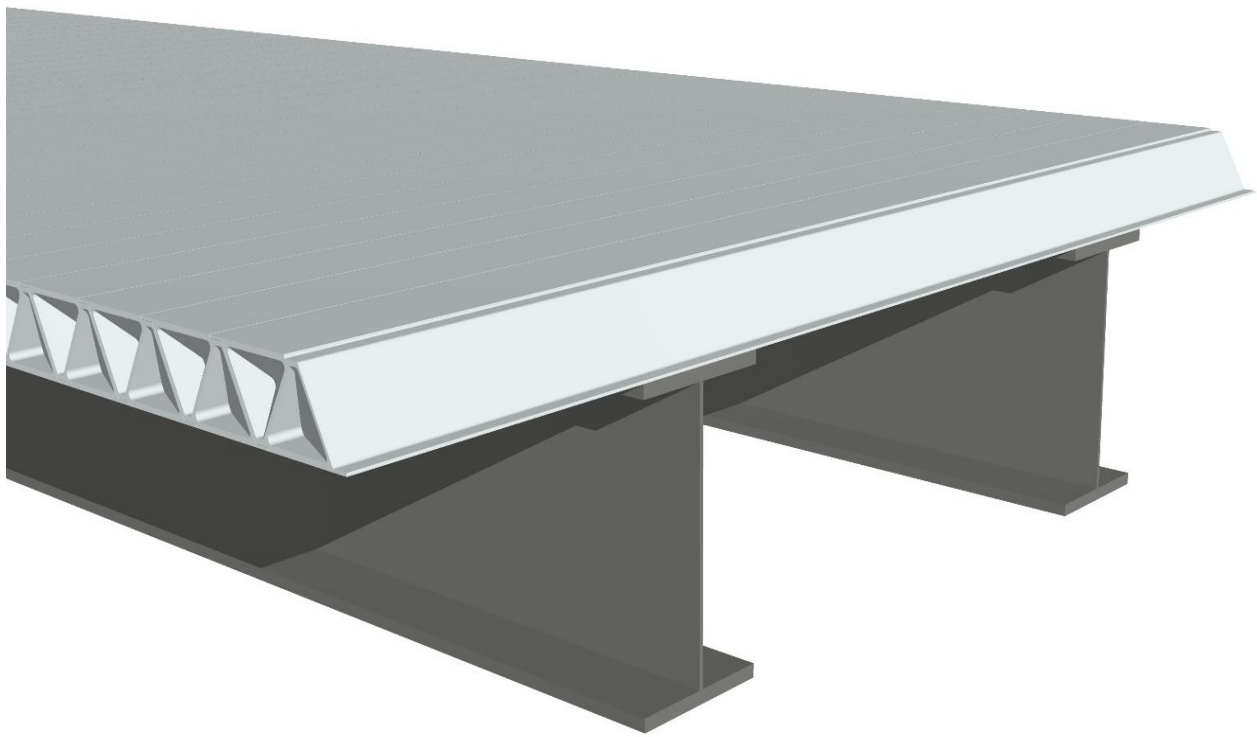


Mount Pleasant Bridge

Church Lane Bridge

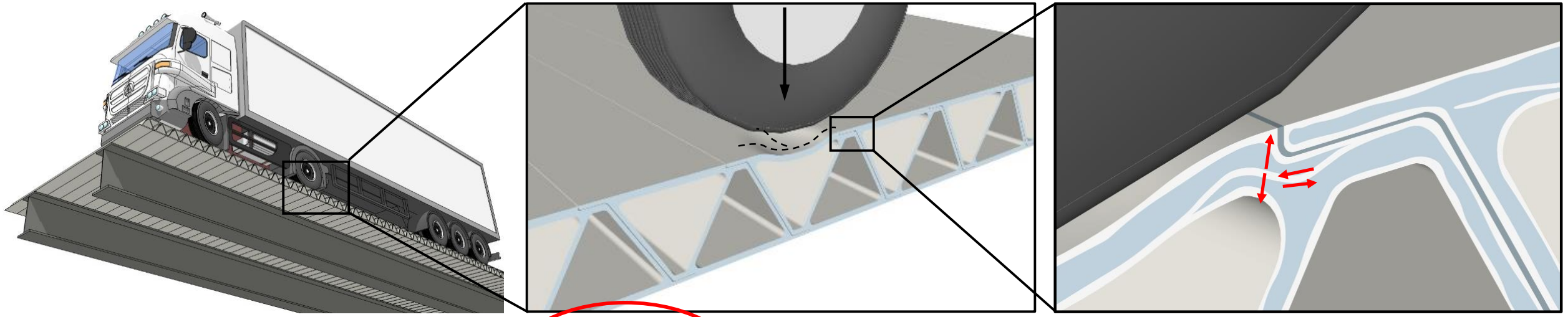
Pultruded-Cellular FRP Decks

Fiberline ASSET Deck



Local Behaviour

Global Level → Local Level → Material Level



Longitudinal bending of deck between girders

Deck acts as top chord of girder

Tyre imposes non-uniform contact pressure

Bi-axial curvature of top flange

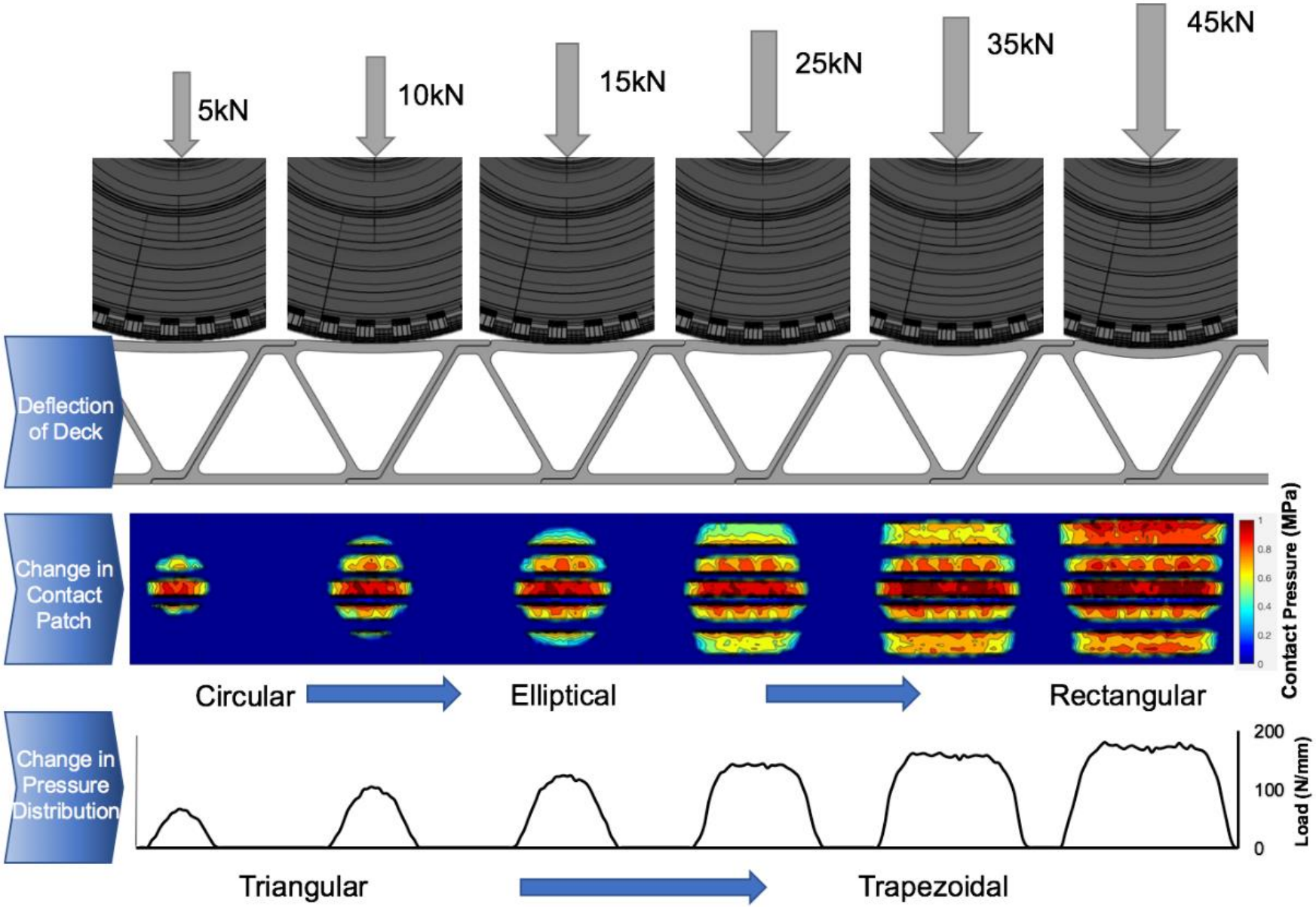
Fibre waviness, resin rich areas, macro-cracks

High normal and tangential stresses at fibre-resin interface

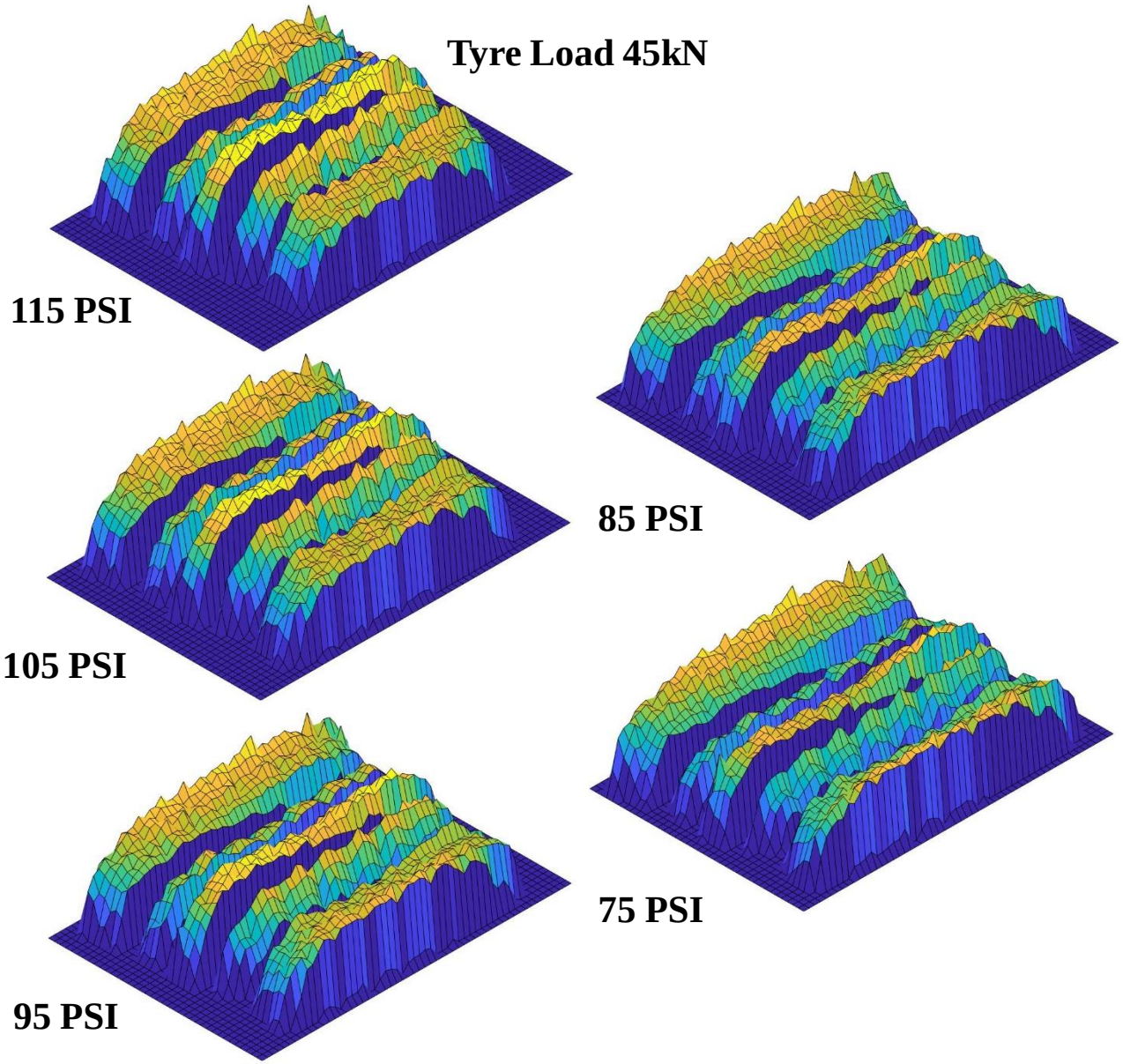
Tyre-Deck Interaction

Pressure Sensor Mat

Non-Uniform Tyre Contact Pressure Distribution



Influence of Inflation Pressure



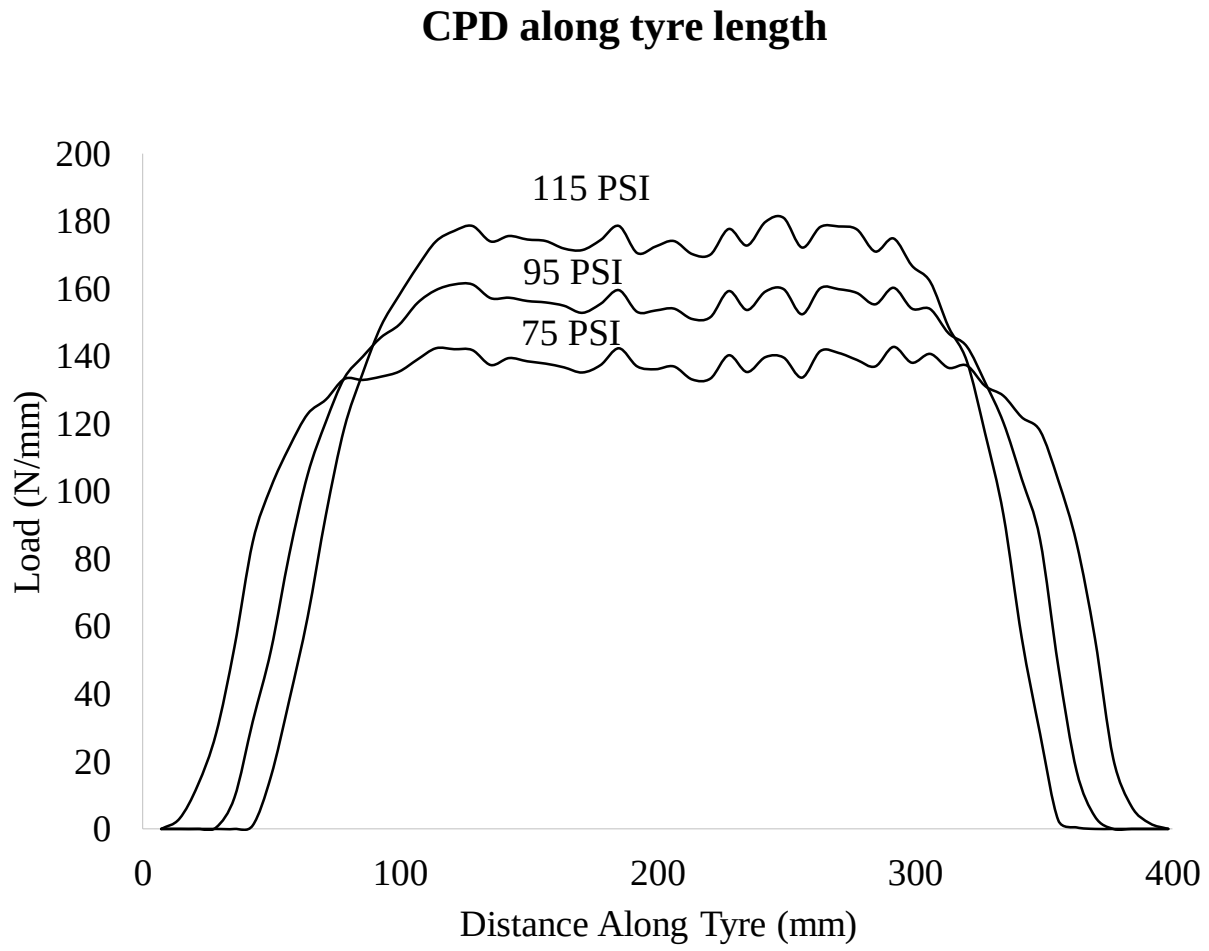


Plate-Pad CPD

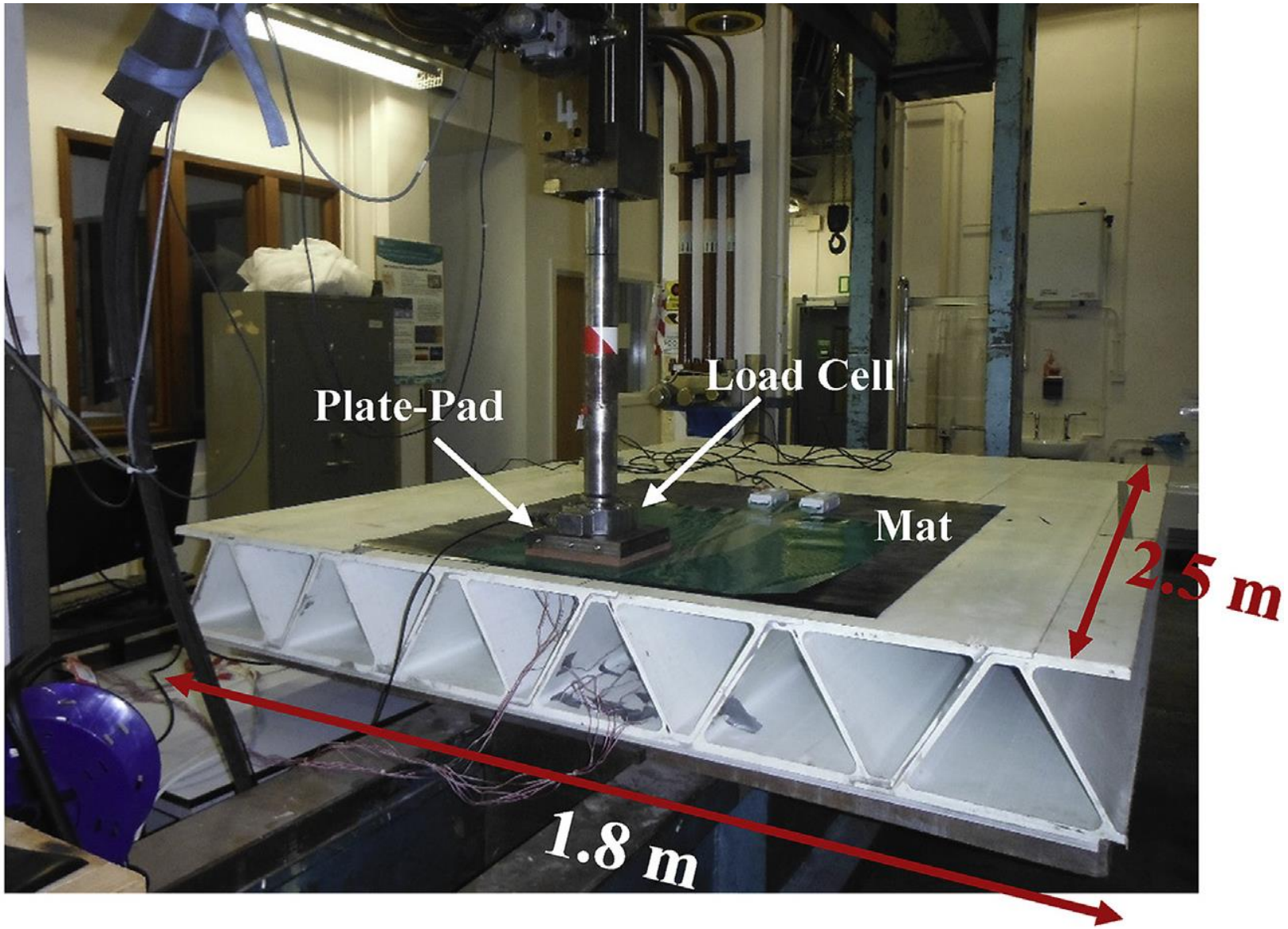
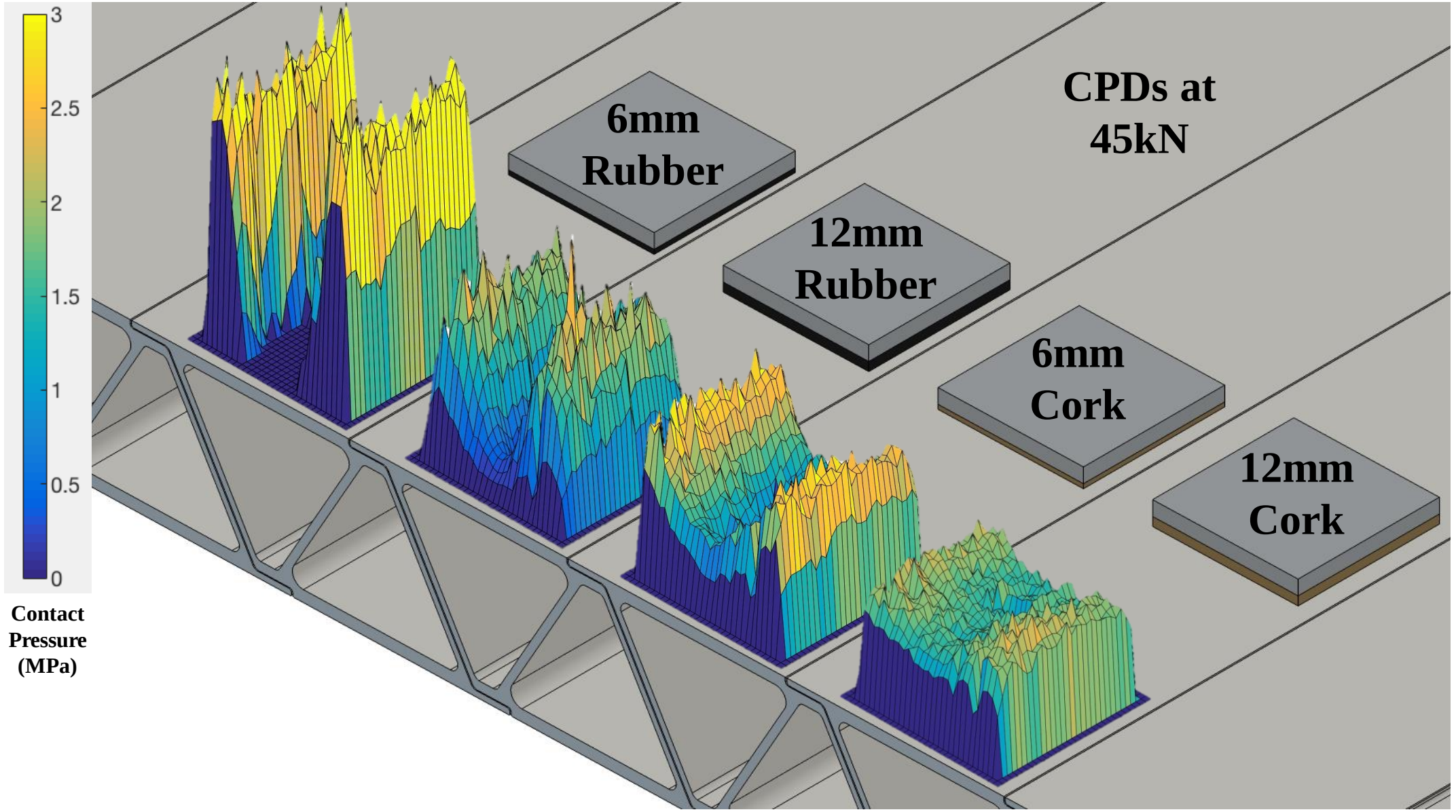
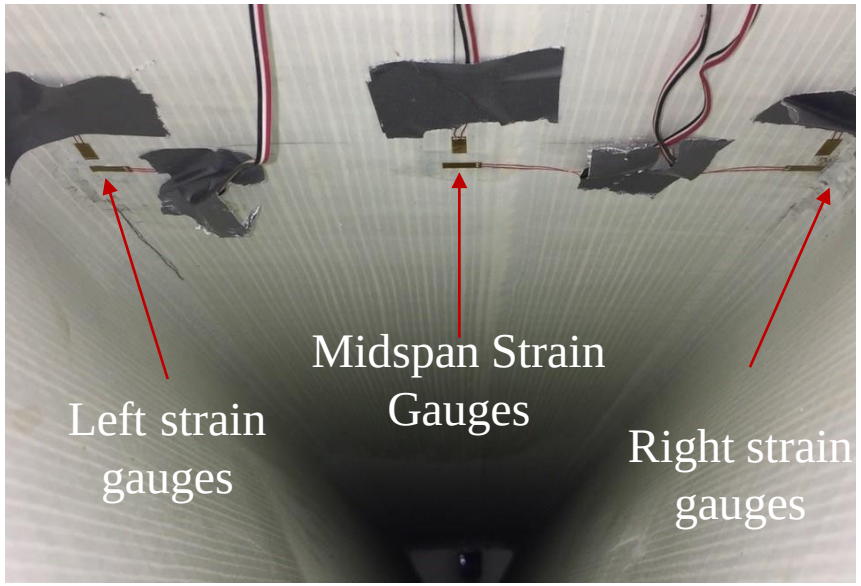
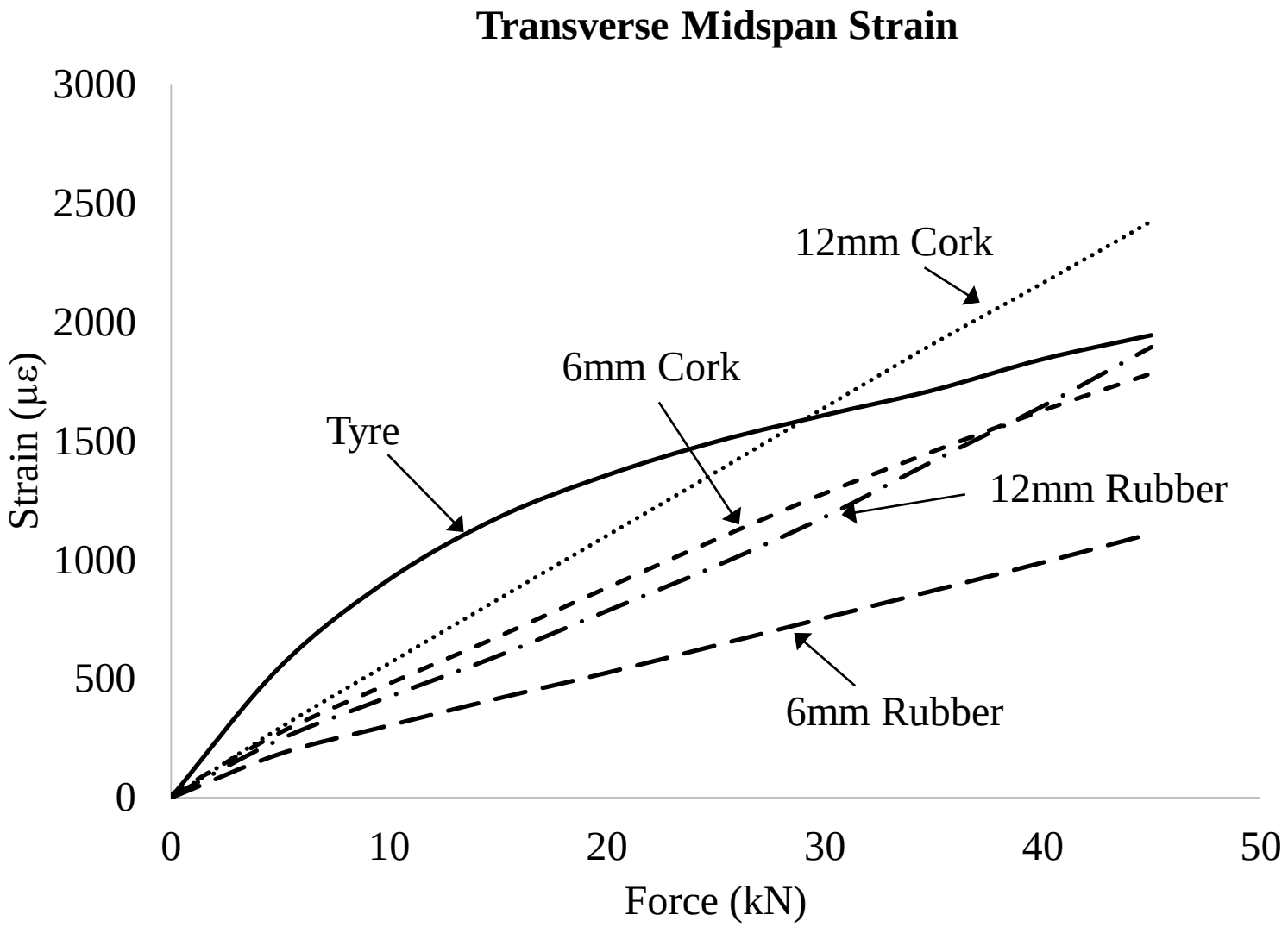


Plate-Pad CPD

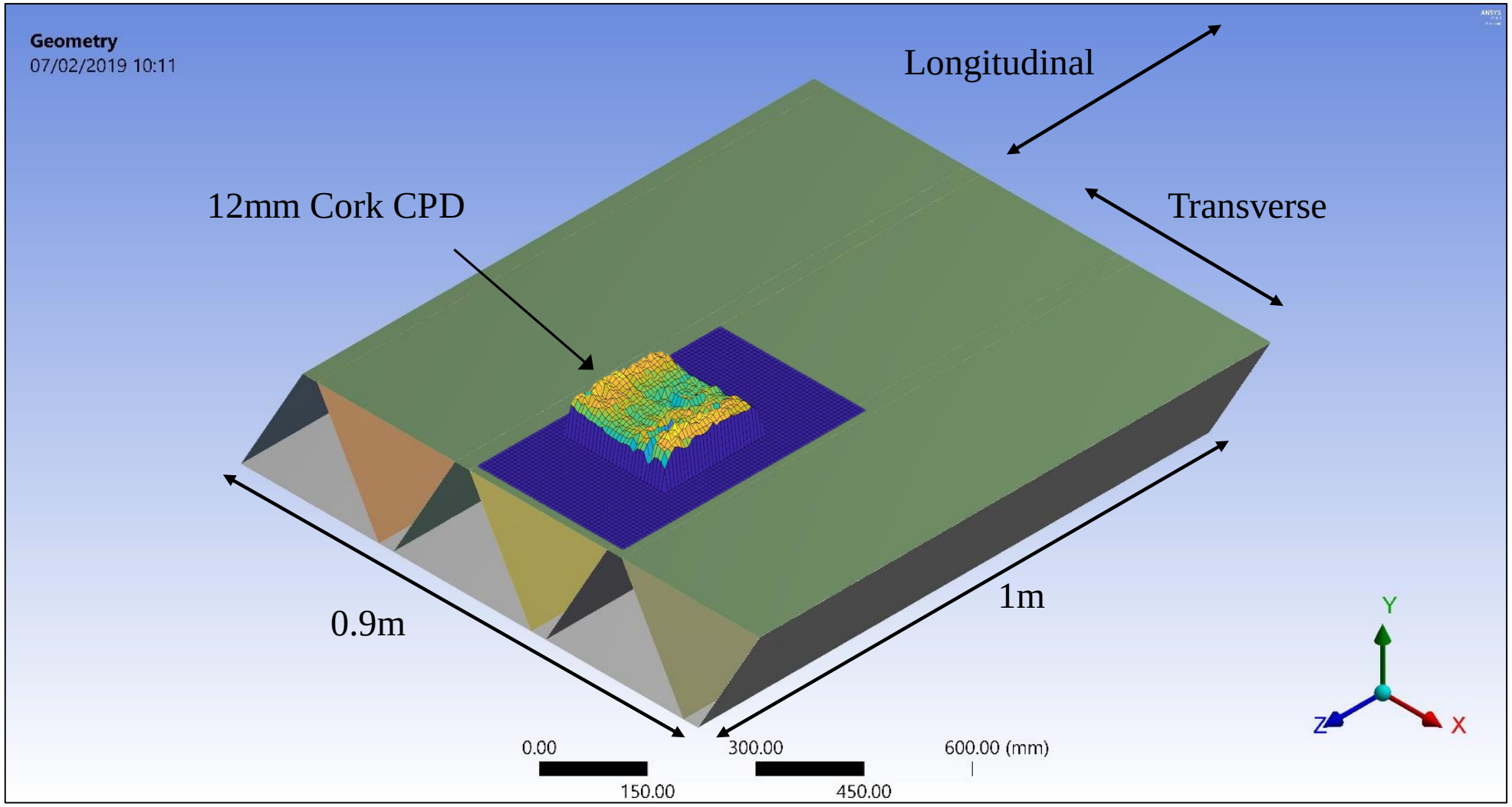


Local Strains

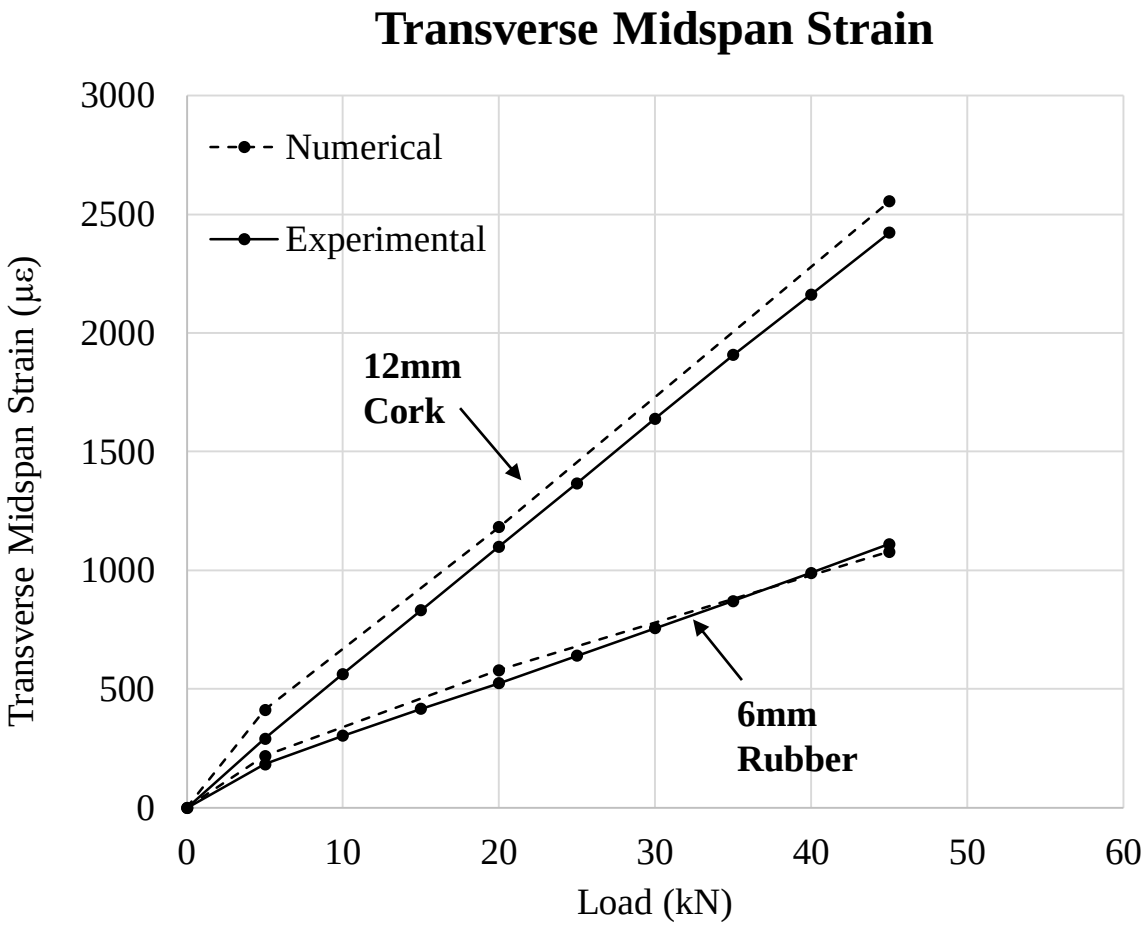


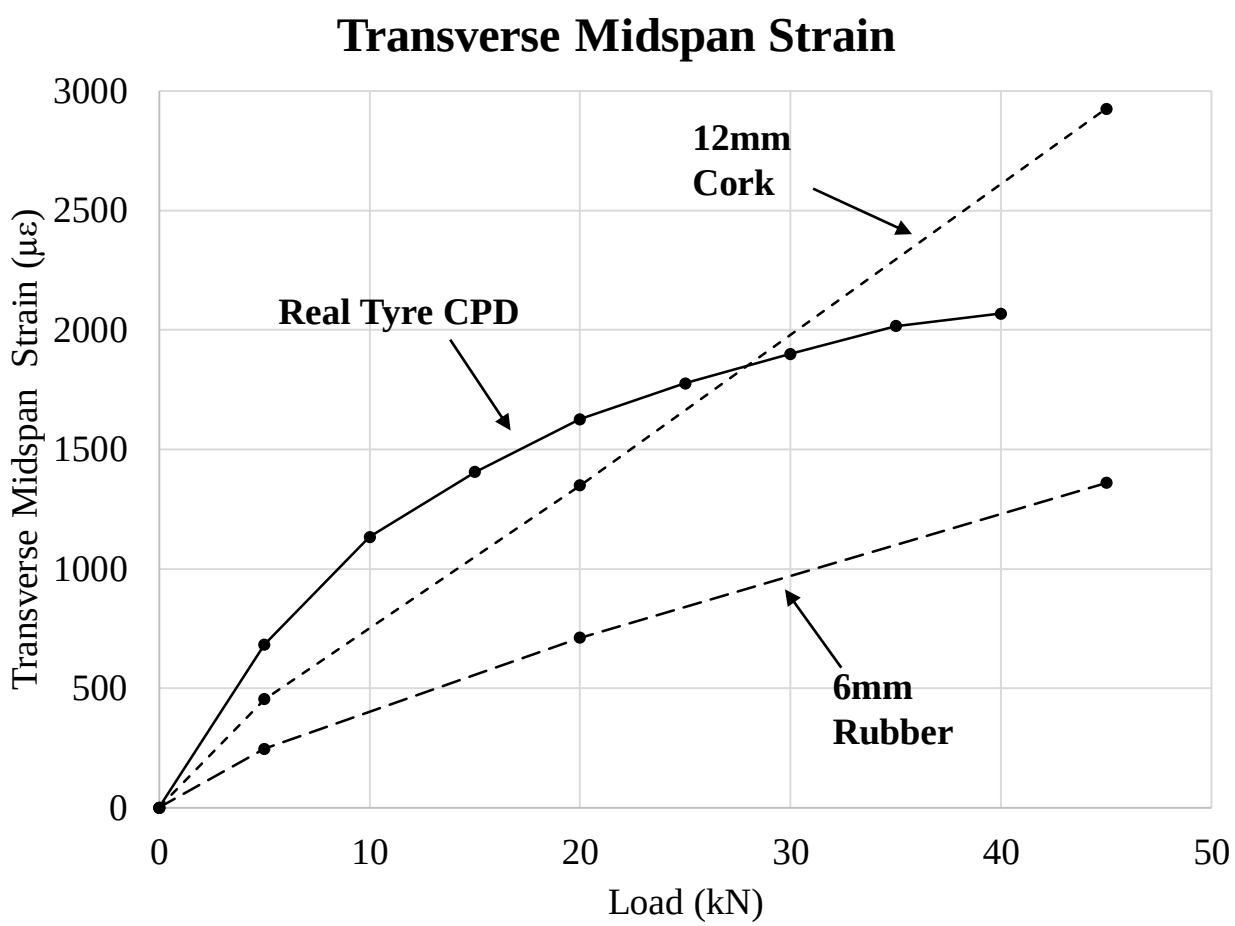


Numerical Model



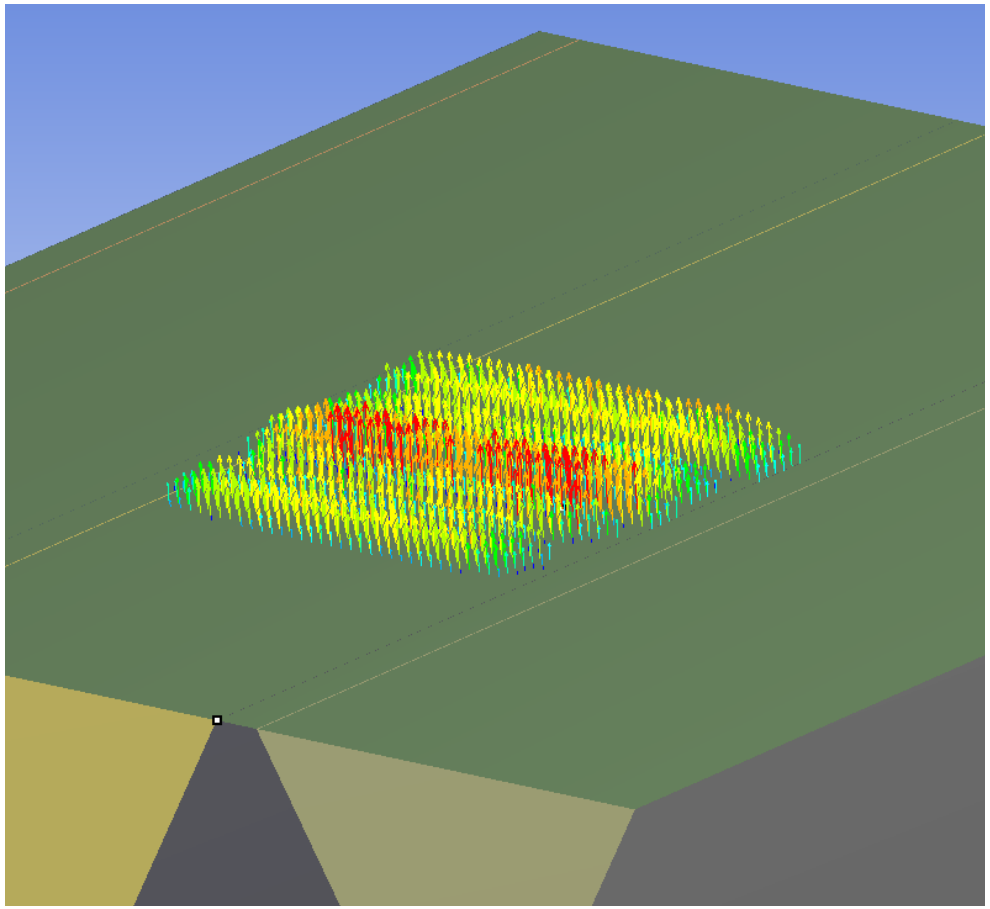
Experimental vs Numerical Strains



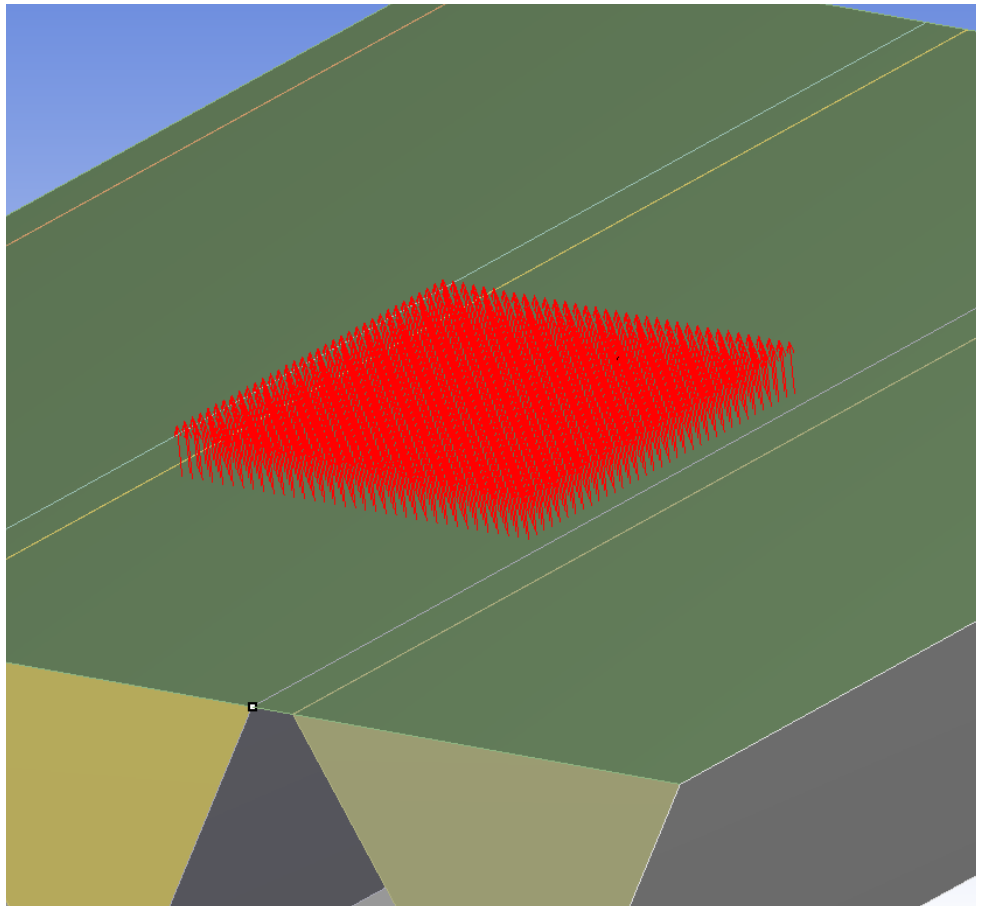


Experimental vs Numerical Strains

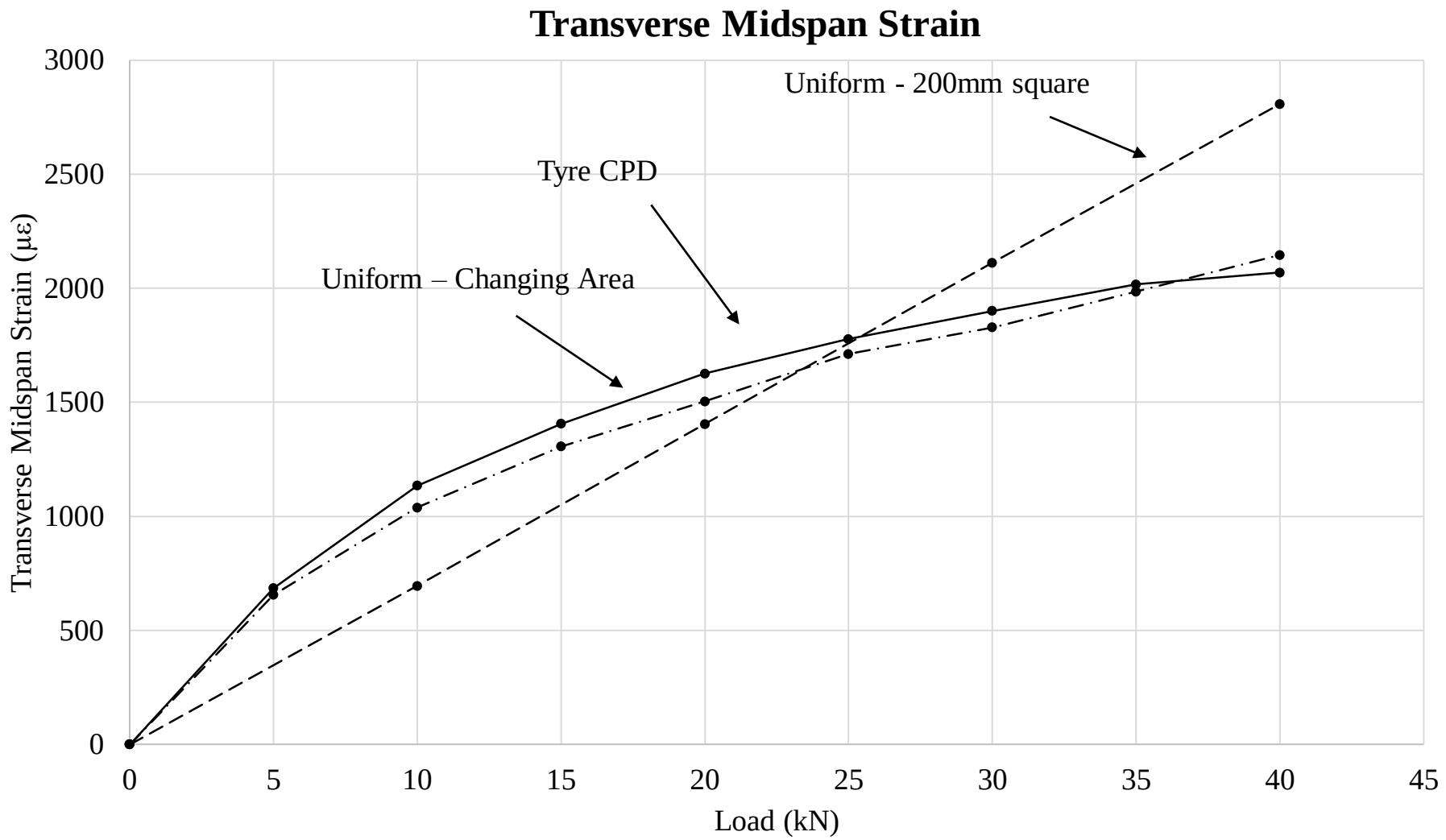
Tyre CPD



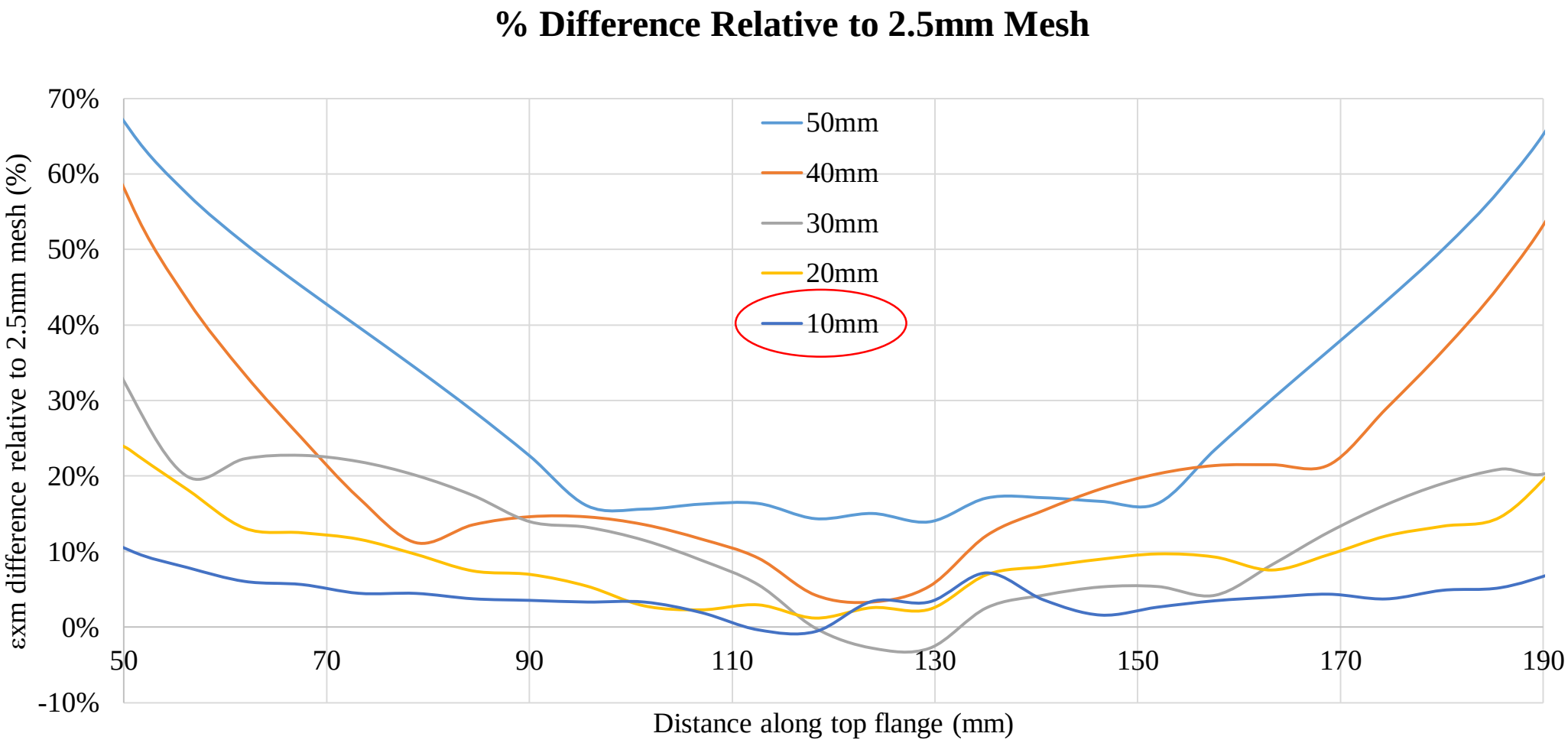
Uniform – Changing Area



Uniform-Square with Changing Area



Mesh Sensitivity



Conclusions

- The tyre CPD is highly non-uniform, dependent on load, inflation pressure and tyre construction.
- A steel plate-pad does not produce a uniform CPD when applied to an FRP deck.
- The changing tyre CPD produced a non-linear load strain response, whereas the plate-pad produced a linear response.
- The measured CPD from a pressure sensor mat can be directly imported into an FE model of the deck.
- A uniform-square CPD with equal contact area to the real tyre at each load can reasonably replicate the local strains at midspan.

Future Work

- CPD measurement of various tyre constructions at different loads and inflation pressures.
- Application of measured CPD to full 3D FE model of ASSET deck.
- Classification of fibre waviness and other defects to be included in FE model.
- Quasi-static and fatigue testing of web-flange-junction of pultruded GFRP decking systems.
- Application of acoustic emission and digital image correlation to assessment of local effects.

Thank you