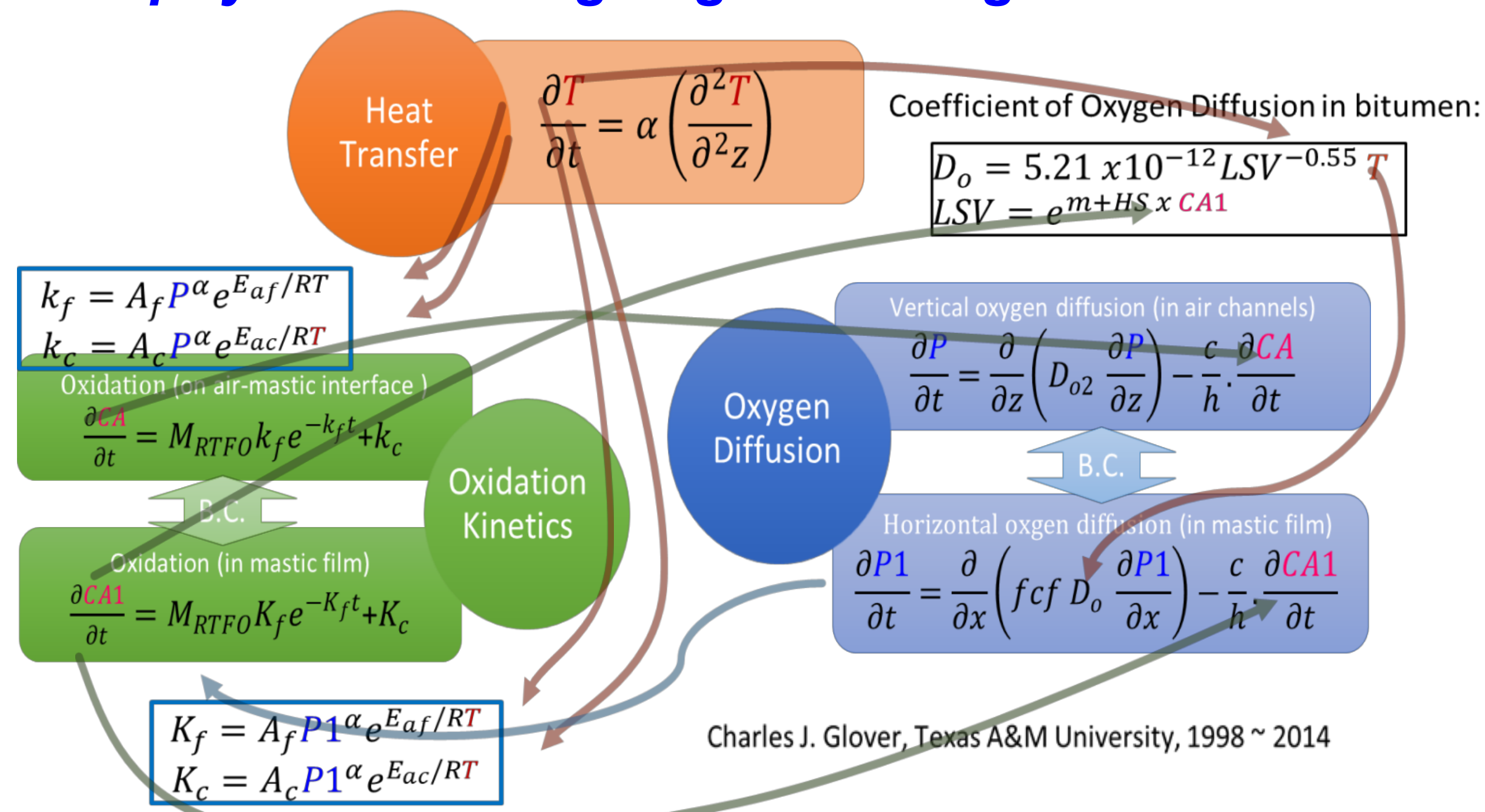


I. OBJECTIVE

To investigate the pavement mechanical responses considering the long-term field ageing via a finite element (FE) modelling approach.

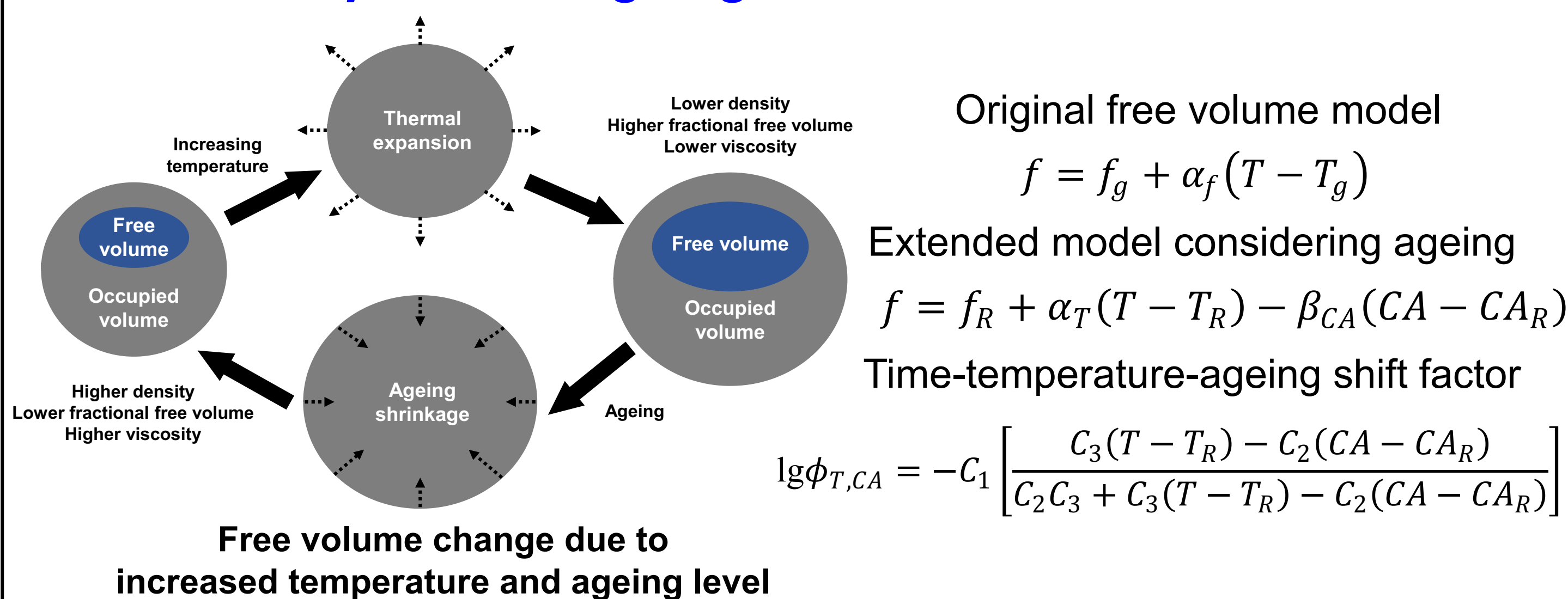
II. METHODOLOGIES

i. Multiphysics Field Ageing Modelling



Circular dependency of pavement field ageing

ii. Time-Temperature-Ageing Shift Model



iii. Coupled Field Ageing-Viscoelastic Modelling

Viscoelastic-ageing constitutive model

$$\sigma_{ij} = K_{\infty} \varepsilon_{kk}^{ve} \delta_{ij} + 2G_{\infty} e_{ij}^{ve} + \sum_{m=1}^M [K_m (\varepsilon_{kk}^{ve} - \varepsilon_{kk}^{m-vi}) \delta_{ij} + 2G_m (e_{ij}^{ve} - e_{ij}^{m-vi})]$$

$$\begin{cases} \eta_m^k(T, CA) = \phi_{T,CA} \eta_m^k(T_R, CA_R) = \phi_{T,CA} K_m(T_R, CA_R) \tau_m(T_R, CA_R) \\ \eta_m^g(T, CA) = \phi_{T,CA} \eta_m^g(T_R, CA_R) = \phi_{T,CA} G_m(T_R, CA_R) \tau_m(T_R, CA_R) \end{cases}$$

$$\begin{cases} (\phi_{T,CA} \tau_m) \varepsilon_{kk}^{m-vi} + \varepsilon_{kk}^{m-vi} - \varepsilon_{kk}^{ve} = 0 \\ (\phi_{T,CA} \tau_m) e_{ij}^{m-vi} + e_{ij}^{m-vi} - e_{ij}^{ve} = 0 \end{cases}$$

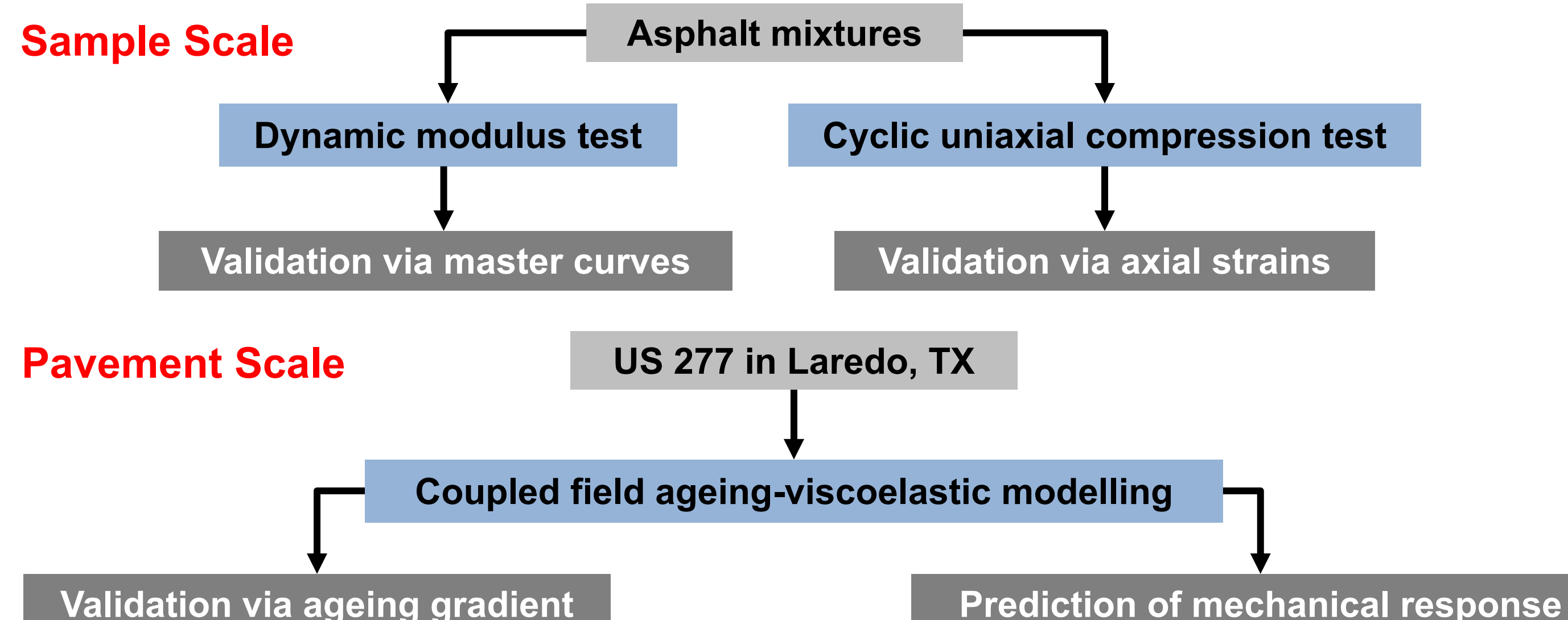
Weak form formulations in FE modelling

$$\begin{cases} (\phi_{T,CA} \times \tau_m \times (u1m) + (u1m) - \text{solid.eevol}) \times \text{test}(u1m) \\ (\phi_{T,CA} \times \tau_m \times (u2m_{ij}) + (u2m_{ij}) - \text{solid.eeldev}_{ij}) \times \text{test}(u2m_{ij}) \end{cases}$$

Solid-like generalised Maxwell model

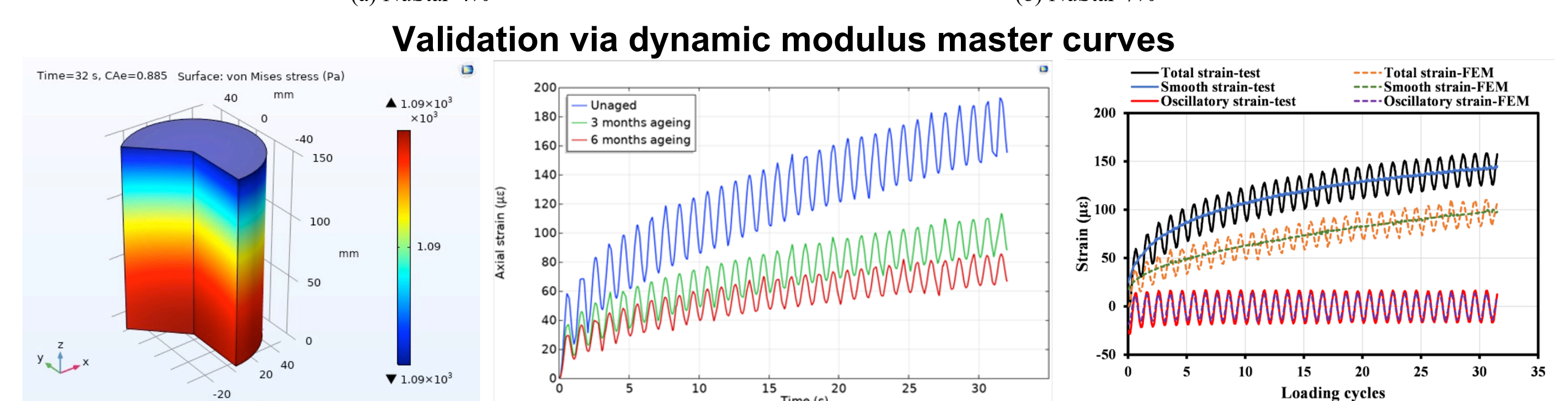
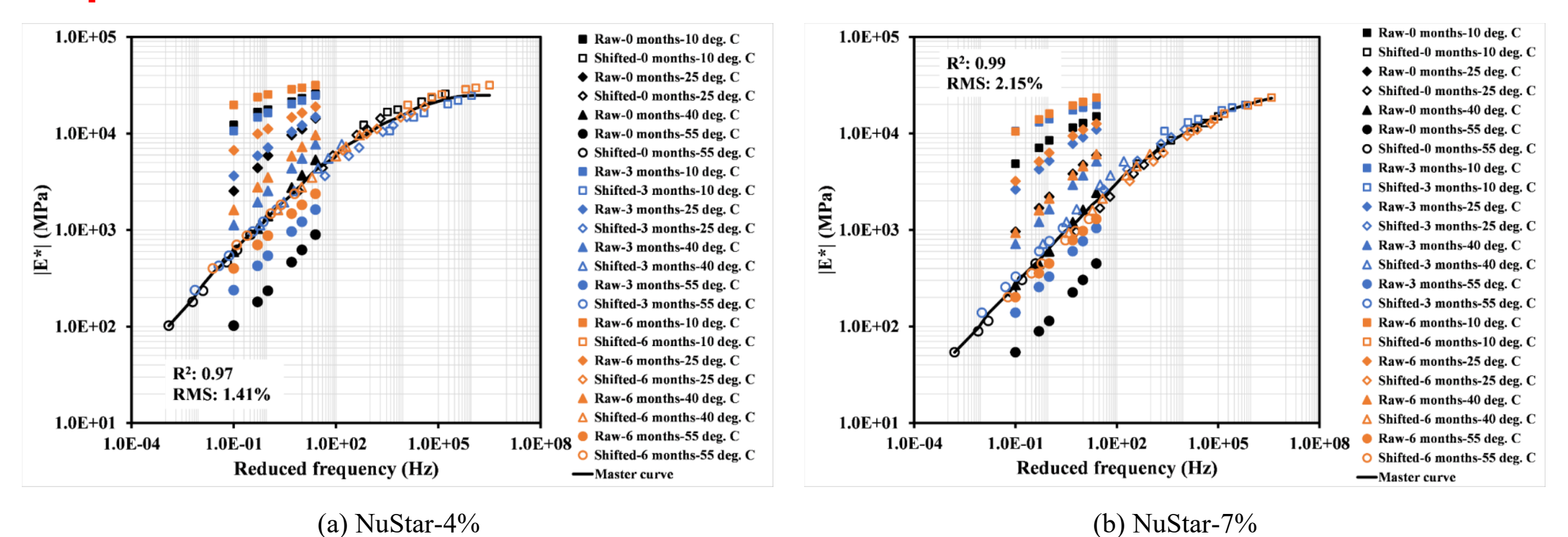
$$\text{solid.Sil}_{ij} = \sum_{m=1}^M [K_m (\text{solid.eevol} - u1m) + 2G_m (\text{solid.eeldev}_{ij} - u2m_{ij})]$$

iv. Experiments and Numerical Modelling

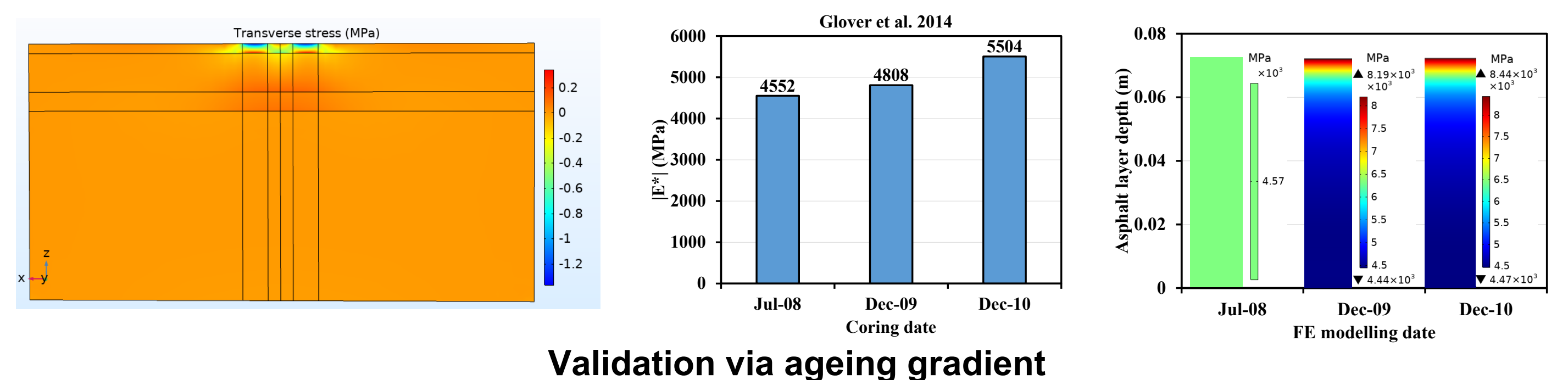


III. MODEL VALIDATION RESULTS

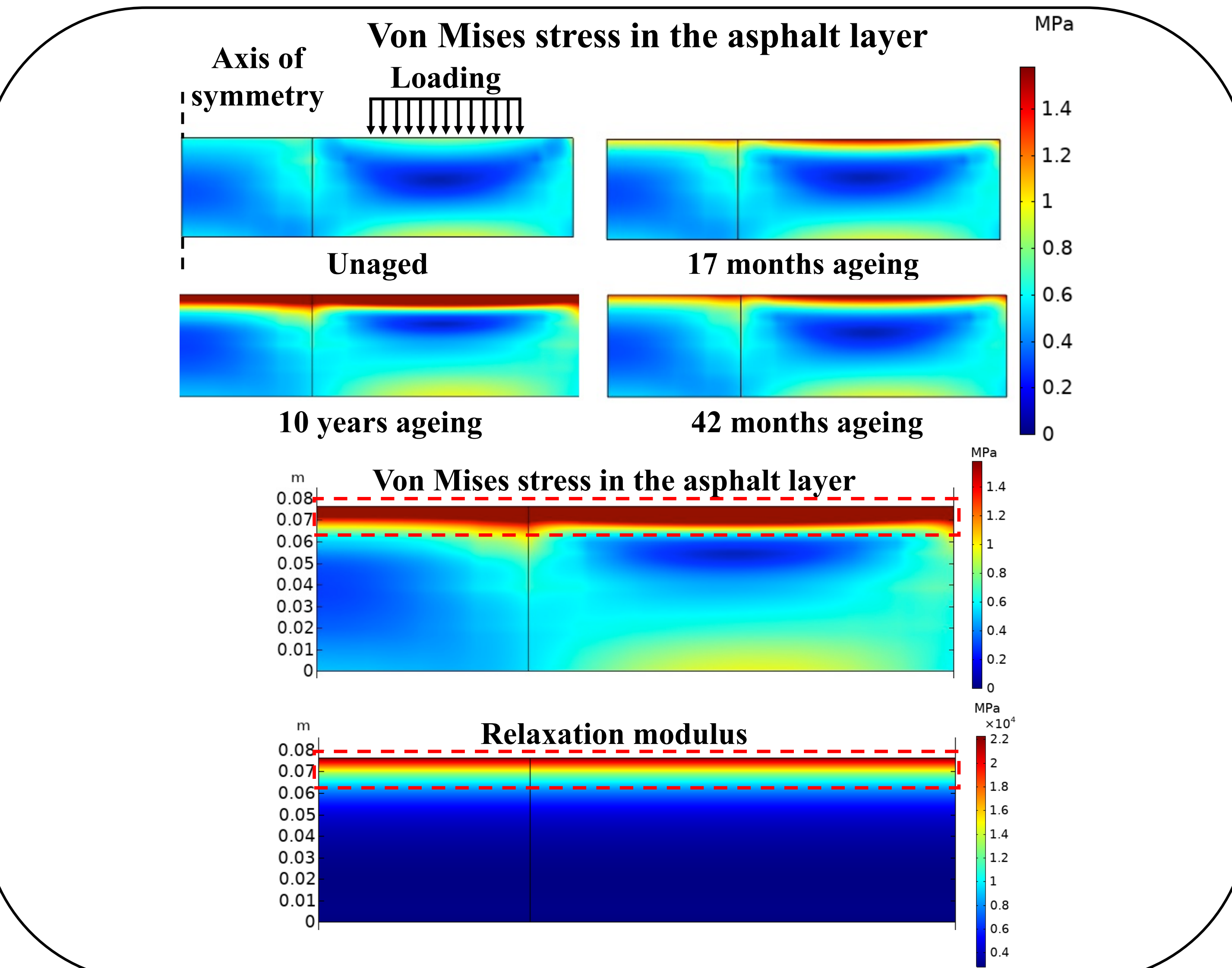
Sample Scale



Pavement Scale



IV. MODEL PREDICTION RESULTS



V. CONCLUSIONS

- The time-temperature-ageing shift model provides an efficient approach to couple field ageing and mechanical analyses for the FE modelling of asphalt pavements.
- The proposed coupled field ageing-viscoelastic FE model can predict the field ageing gradients and obtain the mechanical responses of the aged asphalt pavements.
- The field ageing gradient leads to the change of the high stress regions in the pavements, from the bottom of asphalt layer towards its surface.
- The high stress region's position is related to the pavement depth with the higher ageing gradient.