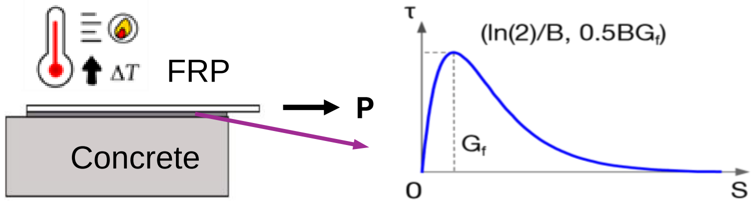
Bond behavior of CFRP-to-concrete interface subjected to loading and elevated temperature

Analytical solution



First stage

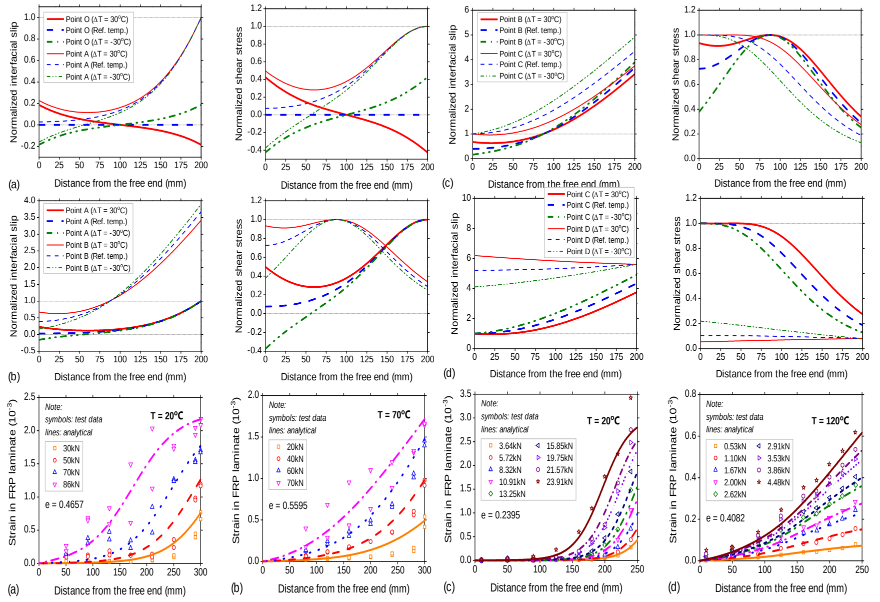
$$\tau=\begin{cases}2BG_f\left\{\dfrac{2(D+1)}{n_1e^{-AB\sqrt{D+1}x}-n_2De^{AB\sqrt{D+1}x}+2}-\left[\dfrac{2(D+1)}{n_1e^{-AB\sqrt{D+1}x}-n_2De^{AB\sqrt{D+1}x}+2}\right]^2\right\} & (x\le x_0)\\ -2BG_f\left\{\dfrac{2(D+1)}{n_3e^{AB\sqrt{D+1}x}-n_4De^{-AB\sqrt{D+1}x}+2}-\left[\dfrac{2(D+1)}{n_3e^{AB\sqrt{D+1}x}-n_4De^{-AB\sqrt{D+1}x}+2}\right]^2\right\} & (x>x_0)\end{cases}$$

Second stage

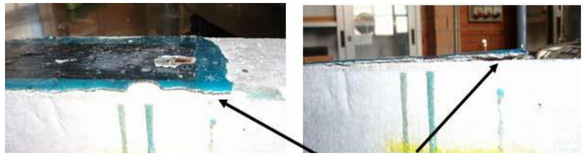
$$\tau=2BG_f\left\{\frac{2(D+1)}{\left(n_1e^{-AB\sqrt{D+1}x}-n_2De^{AB\sqrt{D+1}x}+2\right)}-\left[\frac{2(D+1)}{\left(n_1e^{-AB\sqrt{D+1}x}-n_2De^{AB\sqrt{D+1}x}+2\right)}\right]^2\right\}$$

Third stage

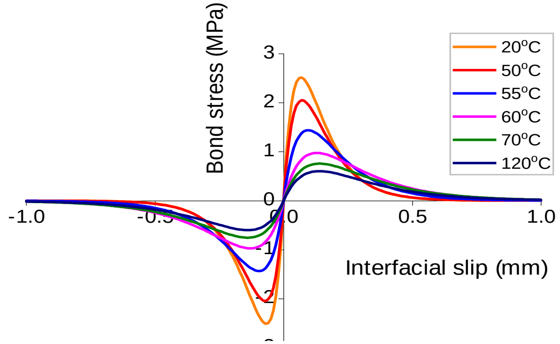
$$\tau=2BG_f\left\{\frac{2(D+1)}{\left(n_1e^{-AB\sqrt{D+1}x}-n_2De^{AB\sqrt{D+1}x}+2\right)}-\left[\frac{2(D+1)}{\left(n_1e^{-AB\sqrt{D+1}x}-n_2De^{AB\sqrt{D+1}x}+2\right)}\right]^2\right\}$$



Temperature-dependent bond-slip model



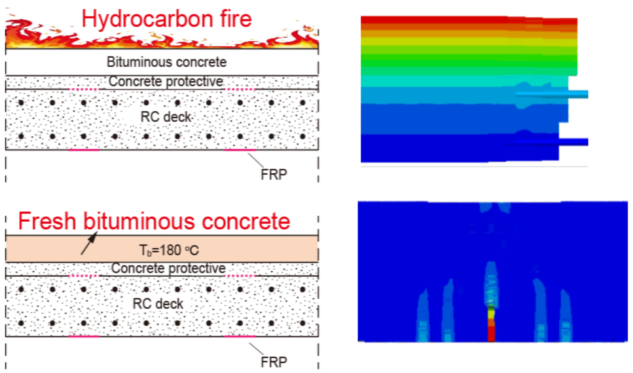
High temperature-induced bond degradation

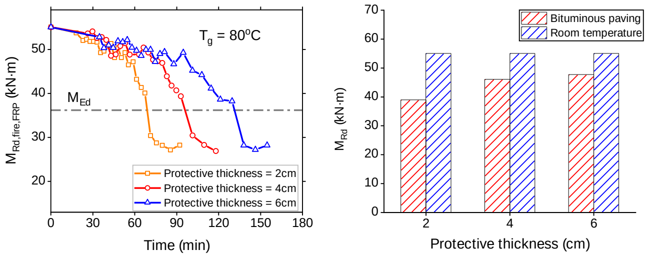


$$\frac{G_{f,T}}{G_{f0}}=\left(\frac{1-a_1}{2}\right)\tanh\left[-a_2\left(\frac{T}{T_g}-a_3\right)\right]+\left(\frac{1+a_1}{2}\right)$$

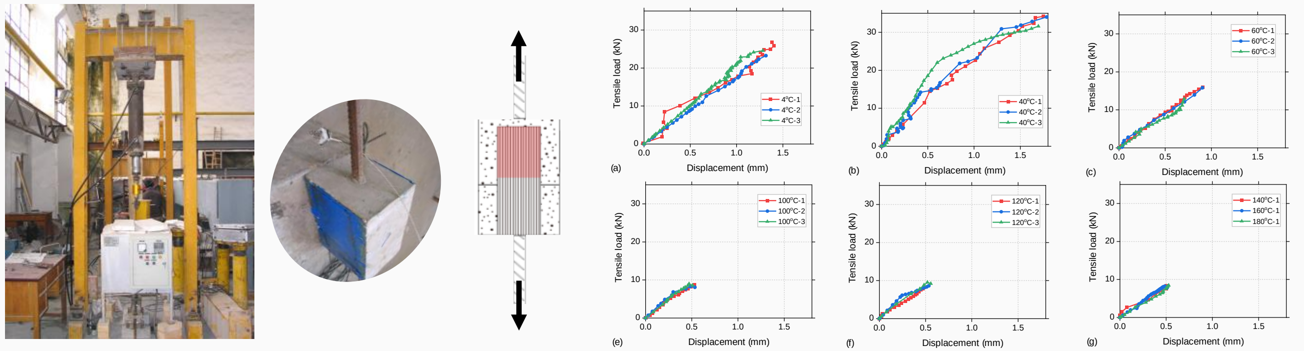
$a_1=0.489,\ a_2=3.282,\ a_3=0.958$

Finite element simulation





Experimental study



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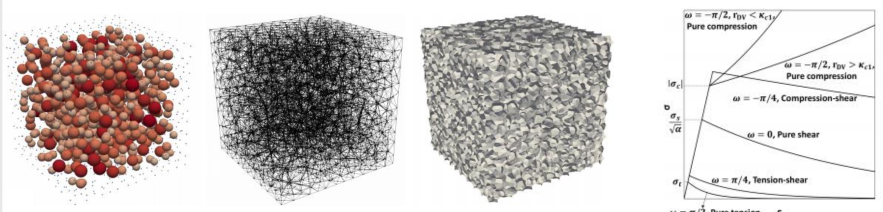
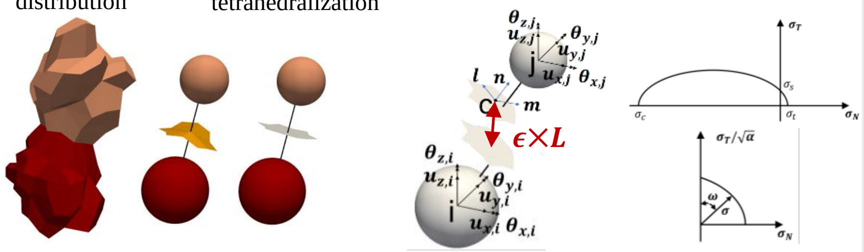
Lattice discrete particle model (LDPM)



Aggregate distribution — Delauney tetrahedralization — LDPM tessellation — Constitutive law



Two aggregates sharing (projected) contact areas — Nodal degrees of freedom and facet strain of a lattice element — Stress boundary

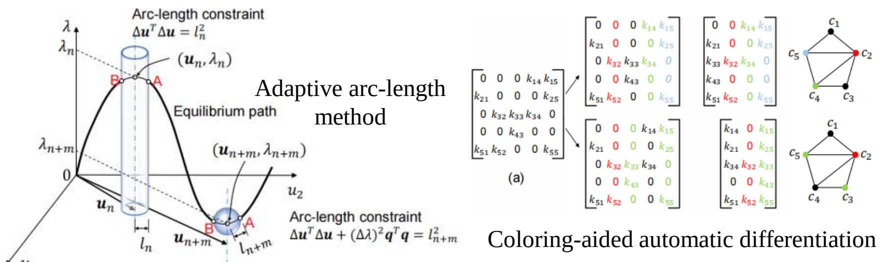
A displacement jump is transformed into facet strains by dividing by the lattice element length:

$$\epsilon_{Nk} = \mathbf{n}_k^T [\![\mathbf{u}_{Ck}]\!]/l_e = \mathbf{B}_N^{jk}\mathbf{Q}_j - \mathbf{B}_N^{ik}\mathbf{Q}_i$$

$$\epsilon_{Lk} = \mathbf{l}_k^T [\![\mathbf{u}_{Ck}]\!]/l_e = \mathbf{B}_L^{jk}\mathbf{Q}_j - \mathbf{B}_L^{ik}\mathbf{Q}_i$$

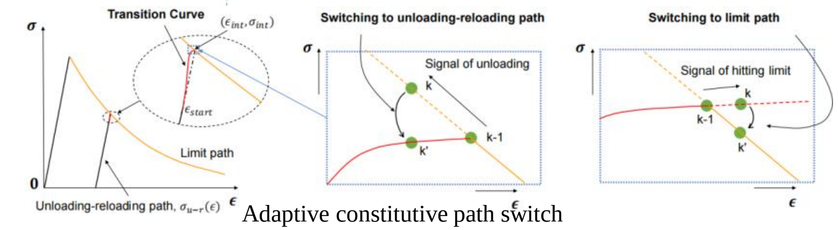
$$\epsilon_{Mk} = \mathbf{m}_k^T [\![\mathbf{u}_{Ck}]\!]/l_e = \mathbf{B}_M^{jk}\mathbf{Q}_j - \mathbf{B}_M^{ik}\mathbf{Q}_i$$

Static solution

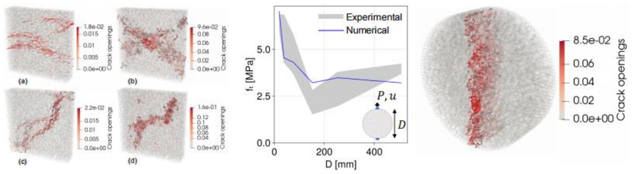


Adaptive arc-length method

Coloring-aided automatic differentiation

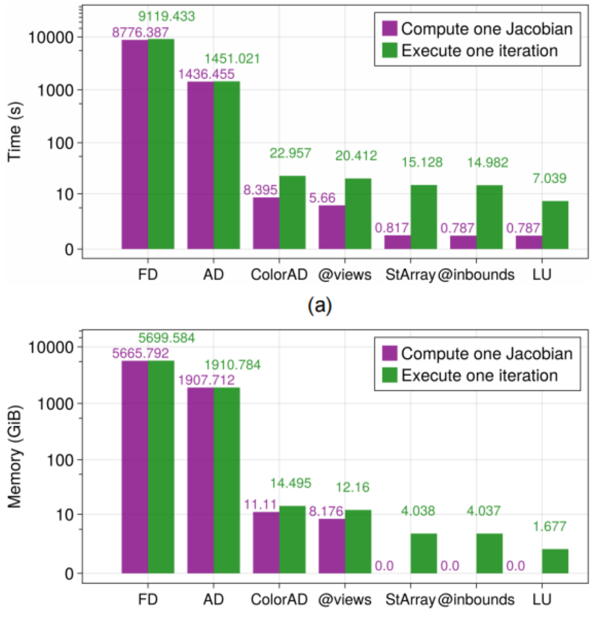


Adaptive constitutive path switch



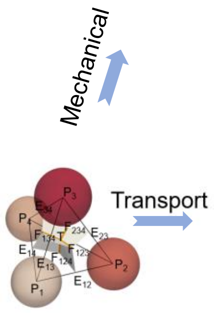
Calibration and validation

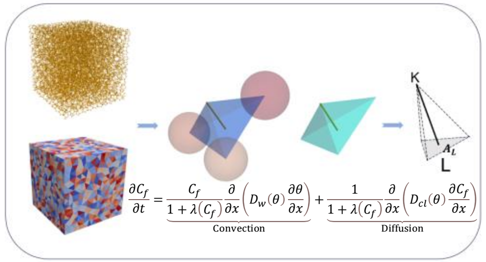
Computational efficiency

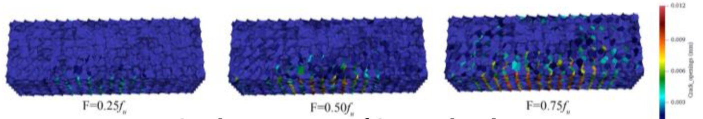


Computational efficiency improvement

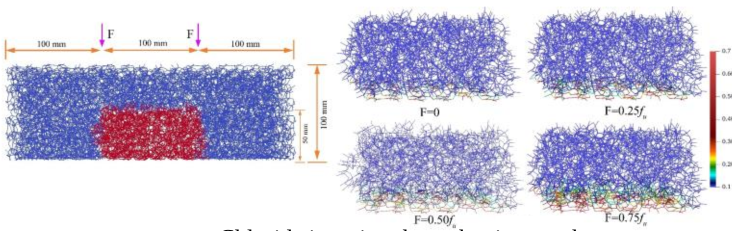
Coupled mechanical and mass transport LDPM





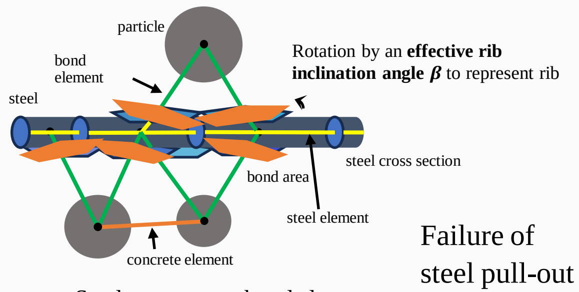


Cracking patterns of 3-point bending

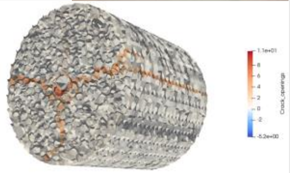


Chloride invasion through microcracks

LDPM for reinforced concrete



Steel-to-concrete bond element



Failure of steel pull-out

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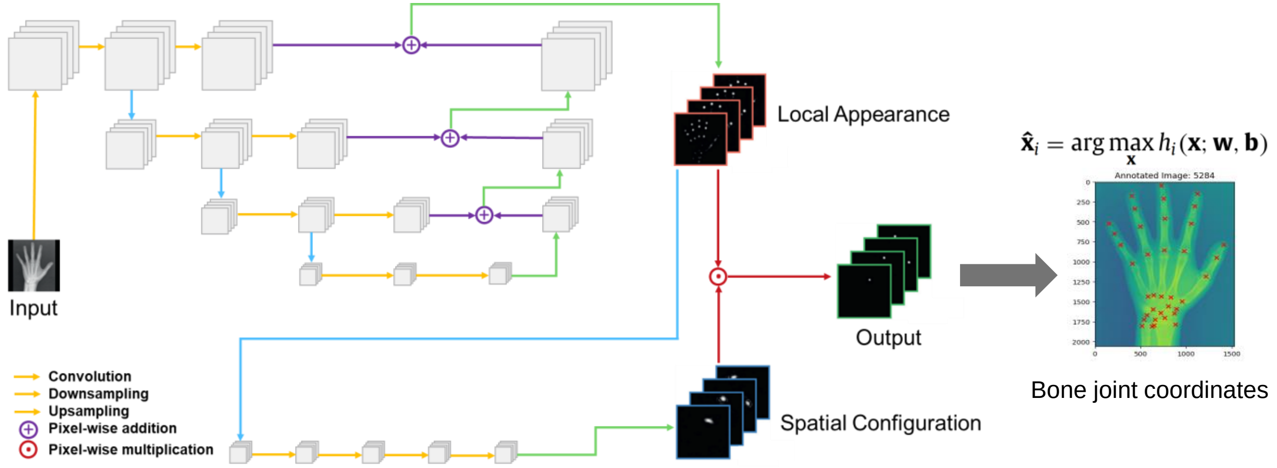
SpatialConfiguration-Net



Dataset (https://ipilab.usc.edu/research/baaweb/)

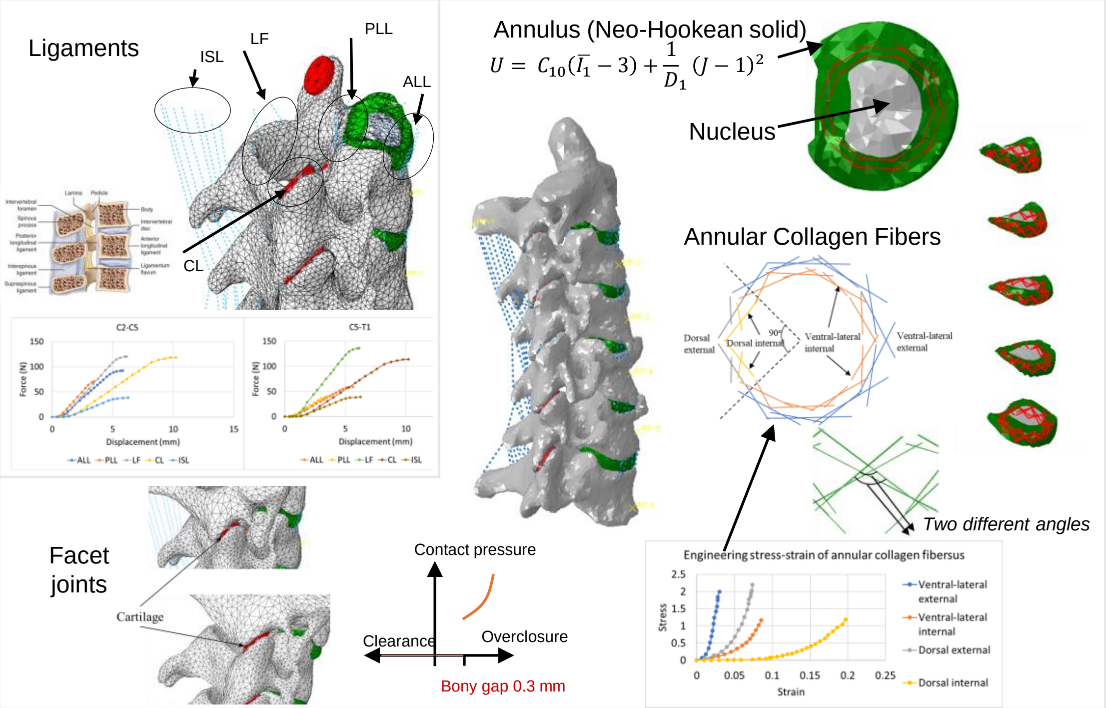
Manual annotation of landmarks (Payer et al. 2019)

Precomputed Data Augmentation

Evaluation metrics

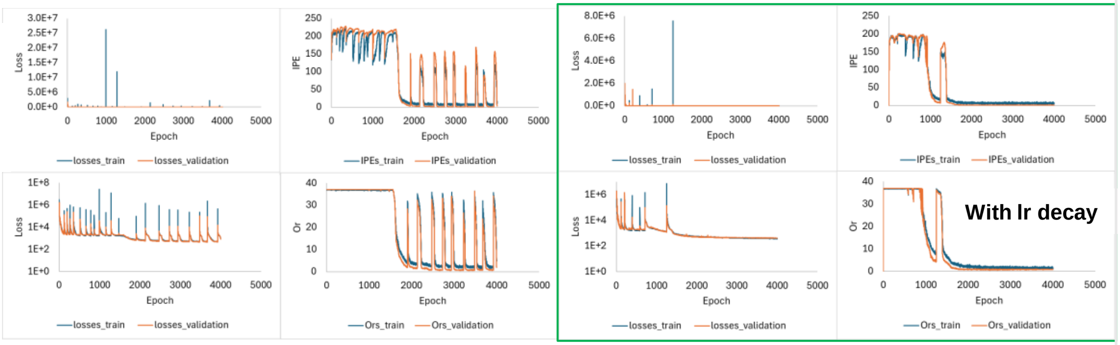
1. Euclidean distances of specifically predicted and target landmarks
2. Number of outliers with a given radius

FEM spine modeling

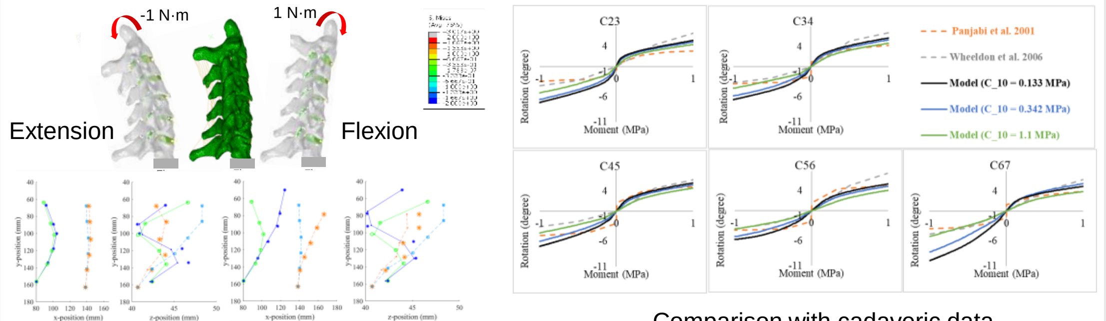


Train and validation

Adam optimization
lr = 0.0001
beta1 = 0.5
beta2 = 0.999



Calibration and validation

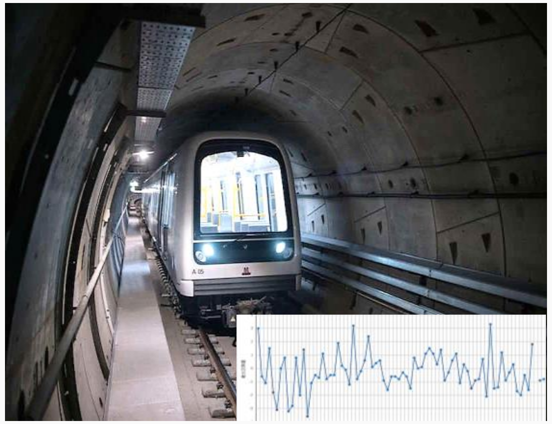


Comparison with in vivo data

Comparison with cadaveric data

Deformation Characteristics of Hangzhou Soft Soil under Cyclic Loading (2017)

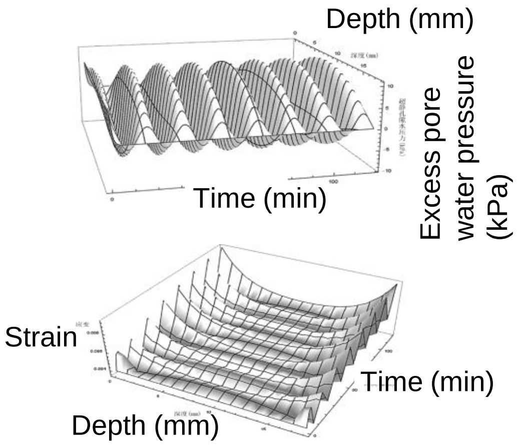
Engineering problem



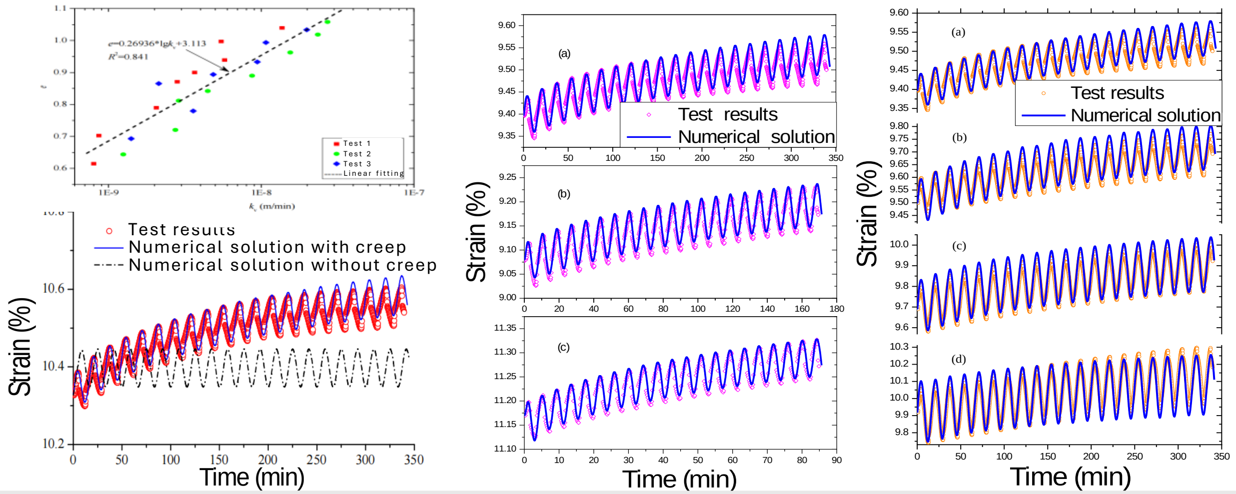
Experiments

Elastic visco-plastic consolidation model and solution

$$
\begin{cases}
\dfrac{k_{vo}}{\gamma_w}\left(\dfrac{\sigma_o'}{\sigma_z'}\right)^{\frac{c_c}{c_k}}\left[\dfrac{\partial^2 u}{\partial z^2}+\dfrac{c_c}{c_k}\left(\dfrac{1}{\sigma_z'}\right)\left(\dfrac{\partial u}{\partial z}\right)^2\right]=-\dfrac{\partial \varepsilon_z}{\partial t}\\
\dot{\varepsilon}_z=\dfrac{\kappa}{V}\dfrac{\dot{\sigma}_z'}{\sigma_z'}+\dfrac{\psi}{Vt_0}exp\left[-\left(\varepsilon_z-\varepsilon_{z0}^{ep}\right)\dfrac{V}{\psi}\right]\left(\dfrac{\sigma_z'}{\sigma_{z0}'}\right)^{\frac{\lambda}{\psi}}\\
u(0,t)=0\\
u(H,t)=0\\
u(z,0)=Initial\ excess\ pore\ water\ pressure\\
\varepsilon_z(z,0)=Initial\ strain
\end{cases}
$$



Calibration and Validation



Calcusettlement v2.0