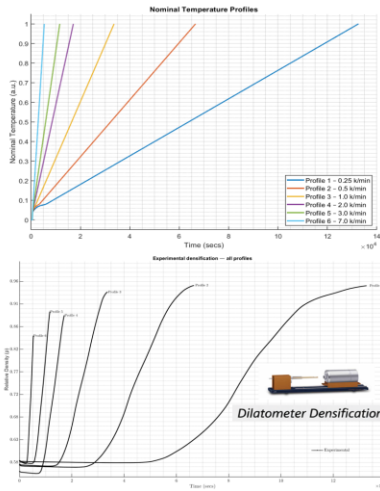
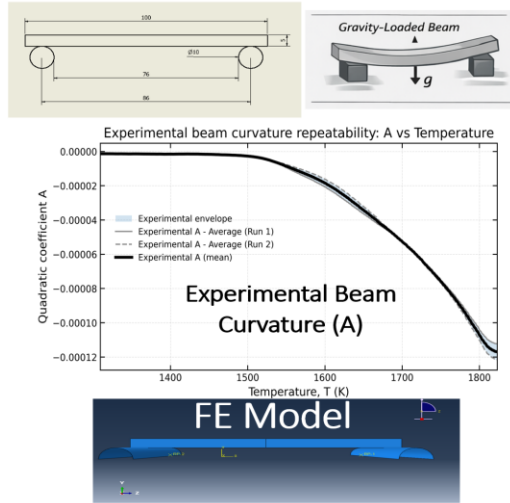


1. Experiments

Material Data



Part Data



2. Olevsky Constitutive Law

Data Points: 322000

Equation 1

$$\dot{\epsilon}_e = \frac{\sigma_e}{2G_p} \quad \dot{\epsilon}_v = \frac{\sigma_m - \sigma_s}{3K_p}$$

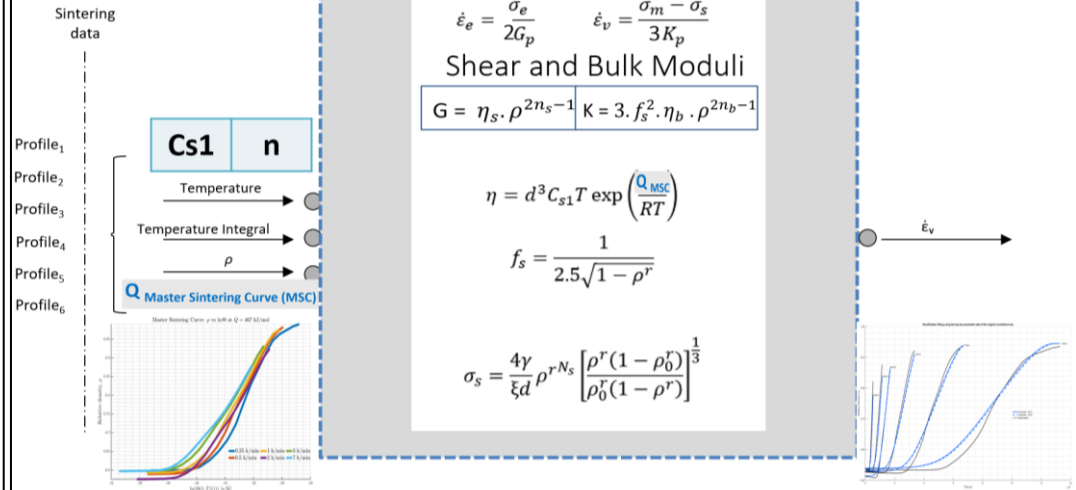
Shear and Bulk Moduli

$$G = \eta_s \cdot \rho^{2n_s - 1} \quad K = 3 \cdot f_s^2 \cdot \eta_b \cdot \rho^{2n_b - 1}$$

$$\eta = d^3 C_{s1} T \exp\left(\frac{Q_{MSC}}{RT}\right)$$

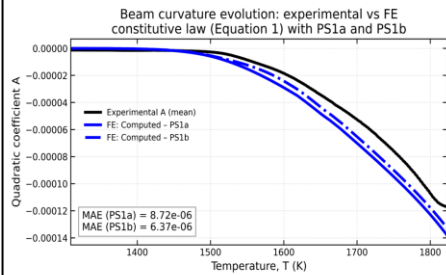
$$f_s = \frac{1}{2.5\sqrt{1 - \rho^r}}$$

$$\sigma_s = \frac{4\gamma}{\xi d} \rho^{rN_s} \left[\frac{\rho^r(1 - \rho_0^r)}{\rho_0^r(1 - \rho^r)} \right]^{\frac{1}{3}}$$

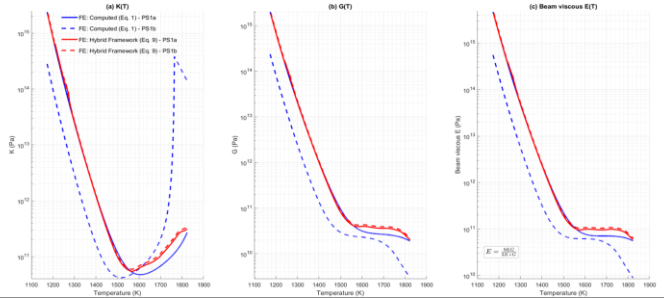
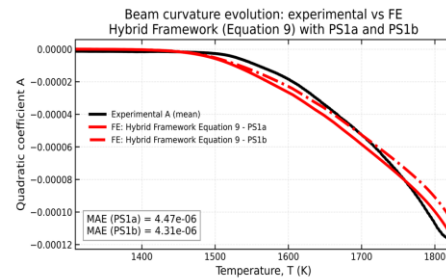


4. Beam Curvature (A) Validation

Original constitutive law



Hybrid Framework



3. Hybrid Framework

$$\dot{\epsilon}_{ij} = \frac{1}{G} S_{ij} + \frac{1}{K} p \delta_{ij} - \dot{\epsilon}_v^{ANN} \delta_{ij} - \text{Equation 9}$$

Total Sintering Strain rate

$$\dot{\epsilon}_{ij} = \frac{S_{ij}}{2G} + \frac{\sigma_m}{3K} - \text{ANN Predicted } \dot{\epsilon}_v^{ANN} \text{ (Free Sintering)}$$

Deviatoric: $\frac{S_{ij}}{2G}$

Mean $\sigma_m = \text{Gravity}$: $\frac{\sigma_m}{3K}$

ANN Predicted $\dot{\epsilon}_v^{ANN}$ (Free Sintering)

Data Points: 15k per profile

