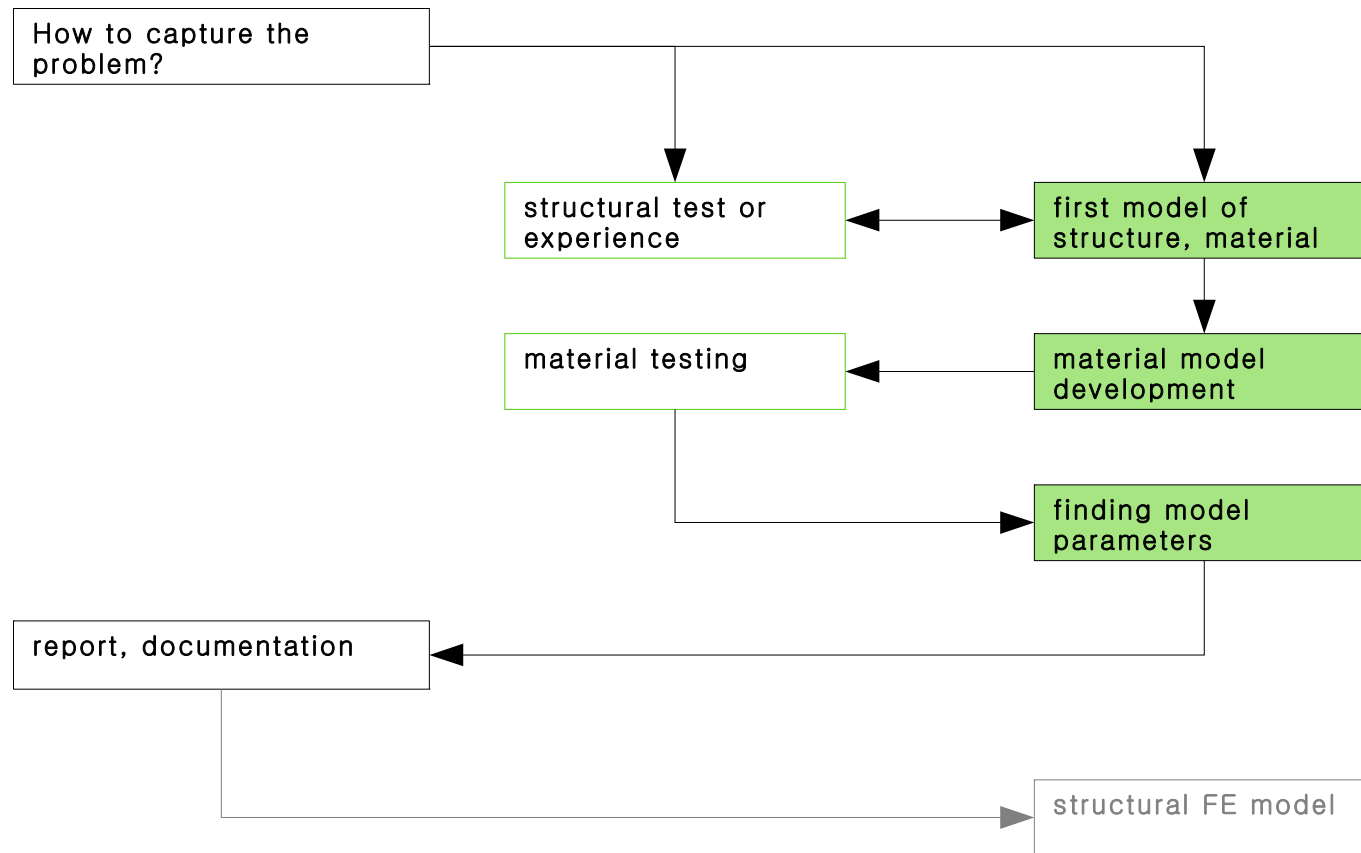


Material modeling using Zebulon

An approach to material modeling



Some material models available in Zebulon/Zmat

•Elasticity

- linear elastic
- linear viscoelastic
- hyperelastic
- hyperviscoelastic
- ...

•Yield criteria

- mises
- tresca
- hill
- cast iron
- linear drucker prager
- various porous criteria

•Fracture mechanics

- K, J
- linear, nonlinear

•Flow rules

- norton
- hyperbolic
- gsell
- sellars_tegart
- ...

•Hardening

- linear isotropic
- nonlinear isotropic
- linear kinematic
- nonlinear kinematic
- ...

•Damage

- anisotropic
- anisotropic, scalar
- elastic
- ...

Example – J2 Plasticity model of Ti6Al4V

Viscoplastic potential

$$\Omega = \frac{K}{n+1} \left\langle \frac{J(\underline{\sigma} - \underline{X}) - R - R_0}{K} \right\rangle^{n+1}$$

$$J(\underline{\sigma} - \underline{X}) = \left[\frac{3}{2} (\sigma'_{ij} - X'_{ij})(\sigma'_{ij} - X'_{ij}) \right]^{1/2}$$

Viscoplastic flow rate

$$\dot{\underline{\epsilon}}_p = \frac{3}{2} \left\langle \frac{J(\underline{\sigma} - \underline{X}) - R - R_0}{K} \right\rangle^n \frac{\underline{\sigma}' - \underline{X}'}{J(\underline{\sigma} - \underline{X})}$$

Nonlinear kinematic hardening

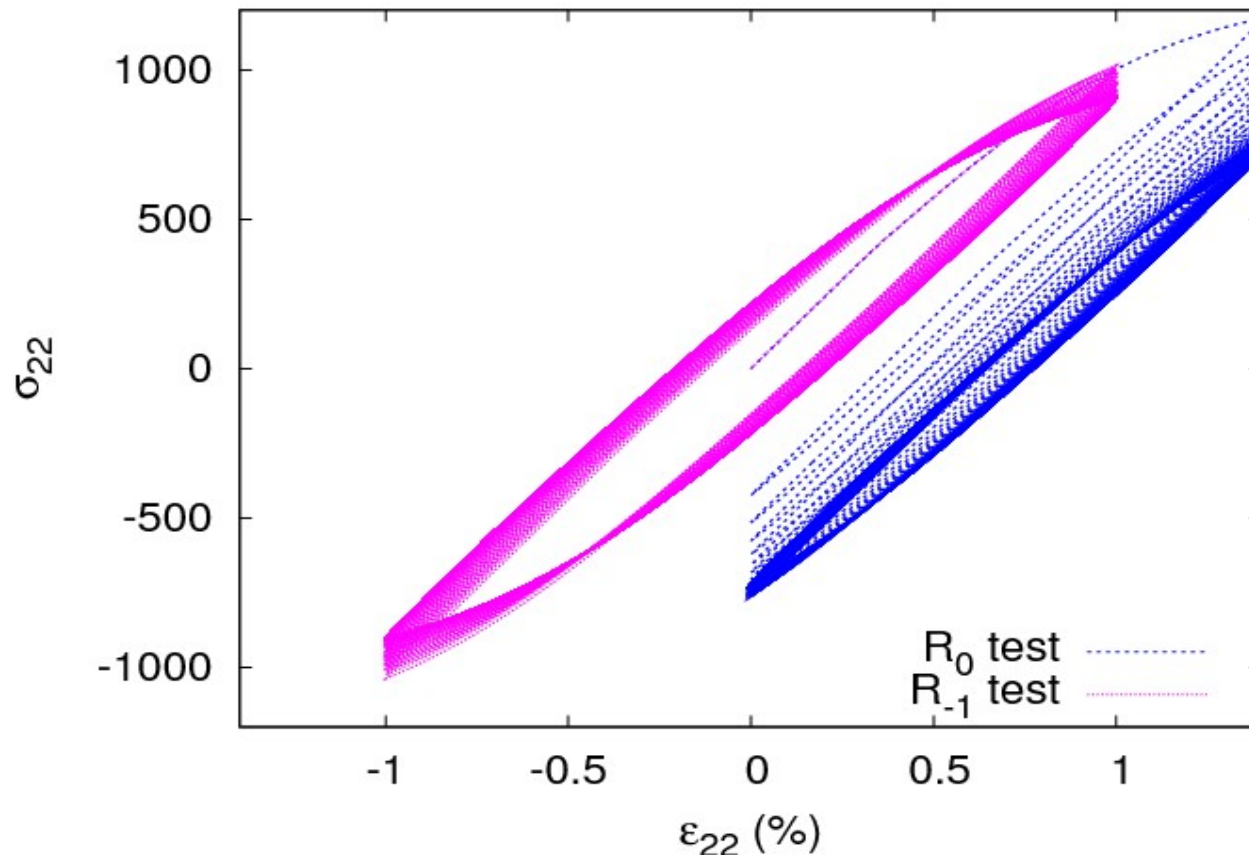
$$\underline{X} = \sum_k \underline{X}_k$$

$$\dot{\underline{X}}_k = \frac{2}{3} C_k \dot{\underline{\epsilon}}_p - D_k \underline{X}_k \dot{p}$$

Nonlinear isotropic hardening

$$\dot{R} = b(Q - R)\dot{p} ; \quad \dot{p} = \left| \frac{2}{3} \dot{\epsilon}_{pij} \dot{\epsilon}_{pij} \right|$$

Example – J2 Plasticity model of Ti6Al4V



Model parameters

Q	b	K	n	R_0	C_1	D_1	C_2	D_2	C_3	D_3
-240	9	251	7.41	300	105000	300	250000	1000	750000	3000



Why to use Zebulon/Zmat for material modeling

- extensive library of material models
- strictly object oriented c++ code
 - models of elasticity, flow, plasticity can be combined in an almost arbitrary manner
 - fast, cost efficient development of new material models
- efficient optimisation tools (Zopt) for material parameter identification
- Zebulon / Zmat material models can be used as plugins
 - with Abaqus, Ansys, LS-Dyna, SAMCEF, MSC-Marc, Cosmos