Tampereen teknillinen korkeakoulu
Materiaalitekniikan osasto

2802020 Materiaalien mekaaninen käyttäytyminen
2802021 Mechanical behavior of materials

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Examination 08.04.2002

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**Vastaa korkeintaan viiteen kysymykseen !**
**Answer only in five questions of your choice!!**

1. Selosta vetokokeen suorittaminen: koejärjestelyt, mittaukset, tulosten käsittely ja määritettävät parametrit.
   Explain the conduction of a tensile test: experimental set-ups, measurements, data handling and determined parameters.

2. Anisotrooppinen lineaarinen elastisuus
   Anisotropic linear elasticity.

3. Esitä kaksi esimerkkiä dislokaatioiden leikkauksista. Mitä tapahtuu ja mitä seurauksia leikkauksesta on.
   Give two examples of the intersection of dislocations. What happens and what kind of consequences the intersection has.

4. Miten metallien myötölujuus riippuu lämpötilasta ja myötönopeudesta. Selitä myös miksi !!
   How the yield strength of metals depends on the temperature and strain rate. Explain also why !!

5. Partikkelilujittaminen.
   Particle strengthening.

6. Tärkeimmät virumislujuuteen vaikuttavat tekijät.
   The most important factors affecting the creep strength.

7. Selitä **TARKASTI** seuraavat väsymiseen liittyvät käsitteet:
   a) jännitysamplitudi
   b) keskijännitys
   c) jännityssuhde R
   d) terävä väsymisraja
   e) Minerin sääntö

   Explain the following terms related to fatigue:
   a) stress amplitude
   b) mean stress
   c) stress ratio R
   d) (sharp) fatigue limit
   e) Miner's rule

$\sigma_T = \frac{F}{A_i} = \frac{F}{A_0} \cdot \frac{A_0}{A_i} = \sigma_E \left( \frac{A_0}{A_i} \right) = \sigma_E (1 + \varepsilon_E)$ $\sigma_T = K(\varepsilon_T)^n$ $\tau = \frac{32 M_t r}{\pi D^4}$ $\varepsilon_2 = \varepsilon_3 = -\nu \varepsilon_1$

$\frac{\Delta V}{V} = \varepsilon_1 (1 - 2\upsilon)$ $\sigma_y = m \cdot \tau_{crss}$ $\tau_B \cong \frac{Gb}{L - 2r}$ $\frac{\Delta V}{V} = \frac{3\sigma}{E}(1 - 2\upsilon) = \frac{\sigma}{K}$

$K = -\Omega_0 \left( \frac{\partial \sigma}{\partial \Omega} \right)_{\Omega_0} = +\Omega_0 \left( \frac{\partial^2 U}{\partial \Omega^2} \right)_{\Omega_0}$ $\tau = \tau_{max} \cdot \sin\left( \frac{2\pi x}{b} \right)$ $\tau_{max} \approx \frac{G}{30}$ $\tau_f = G \cdot \exp\left( \frac{-2\pi w}{b} \right)$

$\tau = \frac{Gb}{2\pi r}$ $U_s \approx Gb^2$ $\sigma_x = \frac{-Gb}{2\pi(1-\nu) r} \sin\theta (2 + \cos\theta)$ $\sigma_y = \frac{Gb}{2\pi(1-\nu) r} \sin\theta \cos 2\theta$

$\tau_{xy} = \tau_{xy} = \frac{Gb}{2\pi(1-\nu) r} \cos\theta \cos 2\theta$ $\sigma_z = \frac{-Gb\nu \sin\theta}{\pi(1-\nu) r}$ $v_D = \left( \frac{\tau}{\tau_0} \right)^p$ $F_s = \frac{Gb^2}{2\pi r}$

$F = \tau b$ $\frac{a}{2}[\bar{1}01] \rightarrow \frac{a}{6}[\bar{2}11] + \frac{a}{6}[\bar{1}\bar{1}2]$ $\tau = \frac{Gb}{r}$ $\tau_{rss} = \frac{F \cdot \cos\lambda}{A_s} = \frac{F}{A_0} \cos\phi \cos\lambda = \frac{\sigma}{m}$

$\sigma_T = K'(\dot{\varepsilon})^m$ $\tau = \tau_0 + \alpha G b (\rho)^{1/2}$ $\tau \approx \frac{Gb}{L'} \cos\frac{\phi_c}{2}$ $\tau^* = (\tau_{app} - \tau_0) \left( \frac{d}{4r} \right)^{1/2}$

$\tau = \tau_0 + \alpha G b \sqrt{\rho}$ $\sigma_a = \sigma_{fat} \left( 1 - \frac{\sigma_{mean}}{T.S.} \right)$ $\sigma_{th} = \left( \frac{\gamma E}{a_0} \right)^{1/2}$

$\tau_{app} = \tau_0 + 2\tau^* r^{1/2} d^{-1/2} = \tau_0 + k'_y d^{-1/2}$ $\sigma_y = \sigma_0 + k_y d^{-1/2}$ $\varepsilon = \frac{\sigma}{E}$ $\gamma = \frac{\tau}{G}$ $\sigma_T = F/A_i$

$\sigma_T = \frac{F}{A_i} = \frac{F}{A_0} \cdot \frac{A_0}{A_i} = \sigma_E \left( \frac{A_0}{A_i} \right) = \sigma_E (1 + \varepsilon_E)$ $\sigma_T = \sigma_E (1 + \varepsilon_E)$ $\varepsilon_T = \ln(1 + \varepsilon_E)$

$\dot{\varepsilon}_{II} = A \sigma^{m'} \exp(-Q_c / RT)$ $\dot{\varepsilon}_{dg} = \dot{\varepsilon}_0 \exp\left( -\frac{U_0}{kT} \right) \left[ \exp\left( \frac{\delta U}{kT} \right) - 1 \right]$ $\sigma_F = \frac{K_c}{(\pi c)^{1/2}}$ $\frac{dc}{dN} \approx A(\Delta K)^m$

$N_v(\text{veto}) \approx \exp\left( -\frac{Q_f}{kT} \right) \exp\left( \frac{\sigma\Omega}{kT} \right)$ $U_{el} \approx \frac{\sigma^2}{2E} \pi c^2$ $\sigma_F = \left( \frac{E G_c}{\pi c} \right)^{1/2}$ $\sigma_F = \left( \frac{2\gamma E}{\pi c} \right)^{1/2}$

$N_v(\text{puristus}) \approx \exp\left( -\frac{Q_f}{kT} \right) \exp\left( -\frac{\sigma\Omega}{kT} \right)$ $\dot{\varepsilon}_{NH} = A_{NH} \left( \frac{D_L}{d^2} \right) \left( \frac{\sigma\Omega}{kT} \right)$ $\dot{\varepsilon}_C = A_C \left( \frac{D_{GB}\delta'}{d^3} \right) \left( \frac{\sigma\Omega}{kT} \right)$

$\dot{\varepsilon}_i = A_i D_i \left( \frac{\sigma}{G} \right)^{m''} \left( \frac{\sigma\Omega}{kT} \right) \left( \frac{b}{d} \right)^{n'}$ $\sigma_{th} = \frac{\lambda E}{2\pi a_0} \cong \frac{E}{2\pi} \cong \frac{E}{10}$ $\Delta K \sim \Delta\sigma (c)^{1/2}$

$\sigma_{max} \approx 2\sigma \left( \frac{c}{\rho} \right)^{1/2}$ $\sigma_F = \left( \frac{\gamma E \rho}{4 a_0 c} \right)^{1/2}$ $\sigma_F = \left( \frac{2\gamma E \rho}{3\pi a_0 c} \right)^{1/2}$ $\frac{d}{dc} \left[ 4c\gamma - \frac{\pi\sigma^2 c^2}{E} \right]_{\sigma = \sigma_F} = 0$

$\frac{1}{2}\Delta\varepsilon_{el} = \frac{\sigma'_f}{E} (2N_f)^{-b}$ $\frac{1}{2}\Delta\varepsilon_{pl} = \varepsilon'_f (2N_f)^{-c}$ $\sum \frac{n_i}{N_{fi}} = 1$

$\frac{1}{2}\Delta\varepsilon = \frac{1}{2}\Delta\varepsilon_{el} + \frac{1}{2}\Delta\varepsilon_{pl} = \frac{\sigma'_f}{E} (2N_f)^{-b} + \varepsilon'_f (2N_f)^{-c}$