MATERIAALIYHTÄLÖT

Kimmoteoria:

$$\begin{cases} \sigma_x = E_{11}\varepsilon_x + E_{12}\varepsilon_y + E_{13}\varepsilon_z + E_{14}\gamma_{xy} + E_{15}\gamma_{yz} + E_{16}\gamma_{xz} \\ \sigma_y = E_{21}\varepsilon_x + E_{22}\varepsilon_y + E_{23}\varepsilon_z + E_{24}\gamma_{xy} + E_{25}\gamma_{yz} + E_{26}\gamma_{xz} \\ \sigma_z = E_{31}\varepsilon_x + E_{32}\varepsilon_y + E_{33}\varepsilon_z + E_{34}\gamma_{xy} + E_{35}\gamma_{yz} + E_{36}\gamma_{xz} \\ \tau_{xy} = E_{41}\varepsilon_x + E_{42}\varepsilon_y + E_{43}\varepsilon_z + E_{44}\gamma_{xy} + E_{45}\gamma_{yz} + E_{46}\gamma_{xz} \\ \tau_{yz} = E_{51}\varepsilon_x + E_{52}\varepsilon_y + E_{53}\varepsilon_z + E_{54}\gamma_{xy} + E_{55}\gamma_{yz} + E_{56}\gamma_{xz} \\ \tau_{xz} = E_{61}\varepsilon_x + E_{62}\varepsilon_y + E_{63}\varepsilon_z + E_{64}\gamma_{xy} + E_{65}\gamma_{yz} + E_{66}\gamma_{xz} \end{cases}$$

Lineaarisesti kimmoinen ja isotrooppinen materiaali:

Yleistetty Hooken laki

$$\sigma_x = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_x + \nu(\varepsilon_y + \varepsilon_z)\right] \qquad \tau_{xy} = G\gamma_{xy}$$

$$\sigma_y = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_y + \nu(\varepsilon_x + \varepsilon_z)\right] \qquad \tau_{xz} = G\gamma_{xz}$$

$$\sigma_z = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_z + \nu(\varepsilon_x + \varepsilon_y)\right] \qquad \tau_{yz} = G\gamma_{yz}$$

$$\varepsilon_x = \frac{1}{E}\left[\sigma_x - \nu(\sigma_y + \sigma_z)\right] \qquad \gamma_{xy} = \tau_{xy}/G$$

$$\varepsilon_y = \frac{1}{E}\left[\sigma_y - \nu(\sigma_x + \sigma_z)\right] \qquad \gamma_{xz} = \tau_{xz}/G$$

$$\varepsilon_z = \frac{1}{E}\left[\sigma_z - \nu(\sigma_x + \sigma_y)\right] \qquad \gamma_{yz} = \tau_{yz}/G$$

Suhteellinen tilavuuden muutos

$$e = \Delta V / V_0 = \varepsilon_x + \varepsilon_y + \varepsilon_z = \frac{1-2\nu}{E}(\sigma_x + \sigma_y + \sigma_z)$$

Puristusmoduuli

$$K = -\frac{p}{e} = \frac{E}{3(1-2\nu)}$$

TASOJÄNNITYSTILA

$$\sigma_z = \tau_{xz} = \tau_{yz} = 0$$

Materiaaliyhtälöt:

$$\varepsilon_x = \frac{1}{E}(\sigma_x - \nu\sigma_y) \qquad \gamma_{xy} = \tau_{xy}/G$$
$$\varepsilon_y = \frac{1}{E}(\sigma_y - \nu\sigma_x) \qquad \gamma_{xz} = 0$$
$$\varepsilon_z = -\frac{\nu}{E}(\sigma_x + \sigma_y) \qquad \gamma_{yz} = 0$$

$$\sigma_x = \frac{E}{1-\nu^2}(\varepsilon_x + \nu\varepsilon_y) \qquad \sigma_y = \frac{E}{1-\nu^2}(\varepsilon_y + \nu\varepsilon_x)$$
$$\tau_{xy} = G\gamma_{xy} \qquad \sigma_z = \tau_{xz} = \tau_{yz} = 0$$

TASOMUODONMUUTOSTILA

$$\varepsilon_z = \gamma_{xz} = \gamma_{yz} = 0$$

Materiaaliyhtälöt:

$$\sigma_x = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_x + \nu\varepsilon_y\right] \qquad \tau_{xy} = G\gamma_{xy}$$
$$\sigma_y = \frac{E}{(1+\nu)(1-2\nu)}\left[(1-\nu)\varepsilon_y + \nu\varepsilon_x\right] \qquad \tau_{xz} = 0$$
$$\sigma_z = \frac{E}{(1+\nu)(1-2\nu)}(\varepsilon_x + \varepsilon_y) \qquad \tau_{yz} = 0$$

$$\varepsilon_x = \frac{1+\nu}{E}\left[(1-\nu)\sigma_x - \nu\sigma_y\right] \qquad \varepsilon_y = \frac{1+\nu}{E}\left[(1-\nu)\sigma_y - \nu\sigma_x\right]$$
$$\gamma_{xy} = \tau_{xy}/G \qquad \varepsilon_z = \gamma_{xz} = \gamma_{yz} = 0$$