$\vec{r} = \vec{R} + \vec{U}(\vec{R})$

$\vec{U}(\vec{R}) = \vec{u}(\vec{r})$

Predavanje 5. maj 2021

$\vec{U}(\vec{R}) - \vec{U}(\vec{r}) = \vec{U}(\vec{R}) - \vec{U}(\vec{R} + \vec{U}(\vec{R})) \doteq -\mathrm{Grad}\,\vec{U}\;\vec{U}(\vec{R})$

$\vec{U}(\vec{R}) \approx \vec{U}(\vec{r}) = \vec{u}(\vec{r})$

Majhna deformacija $\vec{U}(\vec{R}) \approx \vec{U}(\vec{r}) = \vec{u}(\vec{r})$.

$$\boxed{\varepsilon_2(\vec{n}) = 2\vec{n} \cdot \underline{\underline{E}}\vec{n}} \qquad \varepsilon_2 \doteq 2\varepsilon_1 \Rightarrow \varepsilon_1 = \vec{n} \cdot \underline{\underline{E}}\vec{n} \doteq \vec{n} \cdot \underline{\underline{\varepsilon}}\vec{n}$$

$$\underline{\underline{\varepsilon}} = \frac{1}{2}\left(\mathrm{Grad}\,\vec{U} + (\mathrm{Grad}\,\vec{U})^T\right)$$

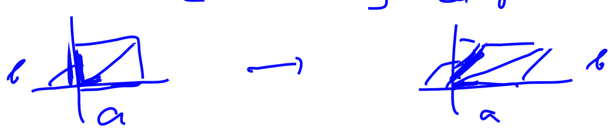
$$= \frac{1}{2}\left(\mathrm{grad}\,\vec{u} + (\mathrm{grad}\,\vec{u})^T\right)$$

Osnovni načini deformacij:

- enoosna;
- enakomerni razteg ali skrčitev, $\underline{\underline{\epsilon}} = \epsilon \underline{\underline{I}}$; $= \varepsilon \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ $\quad 3\varepsilon$
- strižna deformacija, sl $\underline{\underline{\epsilon}} = 0$;
- ravninska deformacija; $u_1 = u_1(X, Y)$, $u_2 = u_2(X, Y)$, $u_3 = 0$. $\longrightarrow \underline{\underline{\varepsilon}} = \begin{bmatrix} \varepsilon_{11} & \varepsilon_{12} \\ \varepsilon_{12} & \varepsilon_{22} \end{bmatrix}$

$$\underline{\underline{\varepsilon}} = \begin{bmatrix} \varepsilon_{11} & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}$$

$$\underline{\underline{\varepsilon}} = \begin{bmatrix} 0 & \frac{1}{2}\gamma & 0 \\ \frac{1}{2}\gamma & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad \text{za } \gamma > 0$$



$$b \longrightarrow \sqrt{b^2 + (\gamma a)^2} = b\sqrt{1 + \left(\frac{\gamma a}{b}\right)^2} \doteq b\left(1 + \left(\frac{\gamma a}{b}\right)^2\right)$$

$$\sqrt{1+x} \doteq 1 + \frac{1}{2}x \qquad \frac{\gamma a}{b} << 1$$

$f(x+h) \doteq f(x) + f'(x) \cdot h$

$x = 1; \quad h = x$

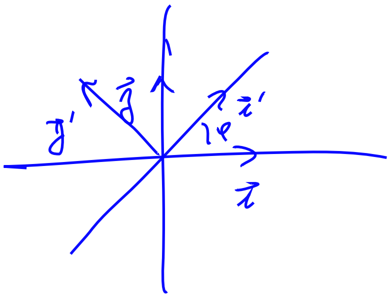
$t_n = \sigma = \vec{n}\cdot \underline{\underline{t}}\,\vec{n}$

$\varepsilon(\vec{n}) = \vec{n}\cdot \underline{\underline{\varepsilon}}\,\vec{n}$

$\vec{n} = \vec{e}_1 \; ; \quad \varepsilon(\vec{e}_1) = \varepsilon_{11}$

Ravninska deformacija

Odvisnost komponente deformacijskega tenzorja od koordinatnega sistema, anlogija z napetostnim tenzorjem.



$$\underline{\underline{\varepsilon}} = \begin{bmatrix} \varepsilon_x & \frac{1}{2}\gamma_{xy} \\ \frac{1}{2}\gamma_{xy} & \varepsilon_y \end{bmatrix}$$

$\varepsilon_{12} = \frac{1}{2}\gamma_{xy} \qquad \varepsilon'_{12} = \frac{1}{2}\gamma'_{xy}$

V koordinatnem sistemu z osema $\vec{\imath}\,' = \cos\varphi\vec{\imath} + \sin\varphi\vec{\jmath}$ in $\vec{\jmath}\,' = -\sin\varphi\vec{\imath} + \cos\varphi\vec{\jmath}$ je

$$\epsilon'_{11} = \frac{1}{2}(\epsilon_{11} + \epsilon_{22}) + \frac{1}{2}(\epsilon_{11} - \epsilon_{22})\cos 2\varphi + \epsilon_{12}\sin 2\varphi,$$
$$\epsilon'_{22} = \frac{1}{2}(\epsilon_{11} + \epsilon_{22}) - \frac{1}{2}(\epsilon_{11} - \epsilon_{22})\cos 2\varphi - \epsilon_{12}\sin 2\varphi,$$
$$\epsilon'_{12} = -\frac{1}{2}(\epsilon_{11} - \epsilon_{22})\sin 2\varphi + \epsilon_{12}\cos 2\varphi.$$

$$\gamma'_{xy} = -(\varepsilon_x - \varepsilon_y)\sin 2\varphi + \gamma_{xy}\cos 2\varphi$$

Osna deformacija v smeri $\vec{n} = \cos\varphi\vec{\imath} + \sin\varphi\vec{\jmath}$ je

$$\epsilon_1(\vec{n}) = \vec{n}\cdot\underline{\underline{\epsilon}}\,\vec{n} = \epsilon_1(\varphi) = \frac{1}{2}(\epsilon_x + \epsilon_y) + \frac{1}{2}(\epsilon_x - \epsilon_y)\cos 2\varphi + \frac{1}{2}\gamma_{xy}\sin 2\varphi.$$

Ekstremalne lastnosti deformacijskega tenzorja

Smeri ekstremalne osne deformacije sta

$$\varphi_1^{\mathrm{a}} = \frac{1}{2}\arctan\frac{2\epsilon_{xy}}{\epsilon_x - \epsilon_y}, \quad \varphi_2^{\mathrm{a}} = \varphi_1^{\mathrm{a}} + \frac{\pi}{2}.$$

$$\varepsilon_{ext} = \frac{1}{2}\left(\varepsilon_{11} + \varepsilon_{22} \pm \sqrt{\left(\frac{1}{2}(\varepsilon_{11} - \varepsilon_{22})\right)^2 + \varepsilon_{12}^2}\right) =$$

$$= \frac{1}{2}\left(\varepsilon_{11} + \varepsilon_{22} \pm \sqrt{(\varepsilon_{11} - \varepsilon_{22})^2 + \underbrace{4\varepsilon_{12}^2}_{\gamma_{xy}^2}}\right) \qquad \varepsilon_{12} = \frac{1}{2}\gamma_{xy}$$

Ekstremalna osna deformacija je

$$\epsilon_1^{\max,\min} = \frac{1}{2}\left(\epsilon_x + \epsilon_y \pm \sqrt{(\epsilon_x - \epsilon_y)^2 + \gamma_{xy}^2}\right).$$

$\vec{m} \perp \vec{n}$ $\qquad$ $\vec{m} \cdot \underline{\underline{\varepsilon}}\,\vec{n} = \vec{n} \cdot \underline{\underline{\varepsilon}}\,\vec{m}$

Mera strižne deformacije v ravnini med seboj pravokotnih enotskih vektorjev $\vec{m}$ in $\vec{n}$ je $\gamma(\vec{m},\vec{n}) = 2\vec{m} \cdot \underline{\underline{\epsilon}}\,\vec{n}$.

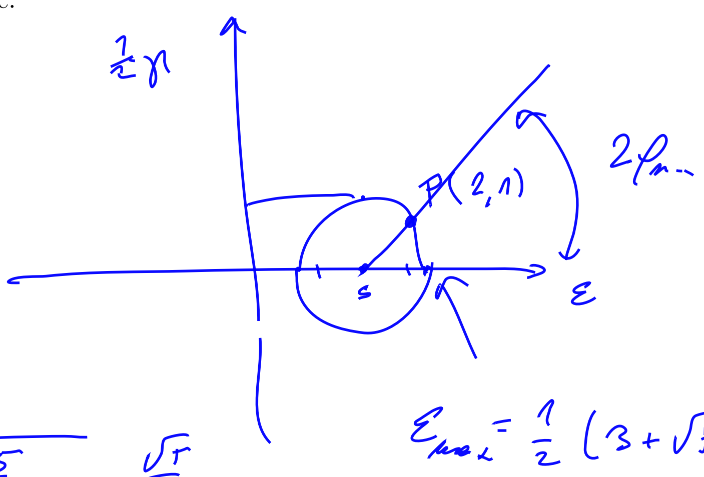
Smeri ekstremalne osne deformacije oklepajo s smerema ekstremalne strižne deformacije kot $\pi/4$.

Ekstremalna strižna deformacija je

$$\gamma_{\text{ext}} = \pm(\epsilon_1^{\max} - \epsilon_1^{\min}).$$

V koordinatnem sistemu z osema v smereh ekstremalnih osnih deformacij je strižna komponenta pripadajočega deformacijskega tenzorja enaka nič.

$$\underline{\underline{\varepsilon}} = \varepsilon_0 \begin{bmatrix} 2 & 1 \\ 1 & 1 \end{bmatrix}$$



$S = \frac{1}{2} 3 \cdot \varepsilon_0$

$R = \sqrt{\left(\frac{1}{2}(1)\right)^2 + 1^2} = \sqrt{\frac{5}{4}} = \frac{\sqrt{5}}{2}$

$\varepsilon_{max} = \frac{1}{2}(3+\sqrt{5})$

$\varepsilon_{min} = \frac{1}{2}(3-\sqrt{5})$

$\frac{1}{2}\gamma_{max} = \frac{\sqrt{5}}{2}$

$$\sigma = E\varepsilon \qquad \varepsilon = \frac{1}{E}\sigma$$

$$t_{ij} = \sum_{k,l=1}^{3} C_{ijkl}\, \varepsilon_{kl}$$

$$t_{ij} = t_{ji} \qquad C_{ijkl} \qquad \varepsilon_{kl} = \varepsilon_{lk}$$

Posplošeni Hookov zakon

C_{ijkl} so komponente elastičnega tenzorja $\underline{\underline{C}}$

$C_{ijkl} = C_{jikl} = C_{jilk}$ 36

Velja $\boxed{C_{ijkl} = C_{klij}}$ $\{6\,7\} = 21$

Linearna zveza med napetostjo in deformacijo, elastični tenzor, podajnostni tenzor. Zapis zveze med $\underline{\underline{t}}$ in $\underline{\underline{\epsilon}}$, Voigtov zapis z elastično matriko reda 6×6.

$$\varepsilon_{ij} = \sum_{i,j=1}^{3} S_{ijkl}\, t_{kl}$$

S_{ijkl} so komponente podajnostnega tenzorja $\underline{\underline{S}}$

$$\boxed{\underline{\underline{S}} = \underline{\underline{C}}^{-1}}$$

$$\underline{\underline{t}} \to \begin{bmatrix} t_{11} \\ t_{22} \\ t_{33} \\ t_{23} \\ t_{13} \\ t_{12} \end{bmatrix} \qquad \begin{bmatrix} t_{11} & t_{12} & t_{13} \\ & t_{22} & t_{23} \\ & & t_{33} \end{bmatrix}$$

$$\underline{\underline{e}} \to \begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ 2\varepsilon_{23} \\ 2\varepsilon_{13} \\ 2\varepsilon_{12} \end{bmatrix} = \begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \\ \gamma_{yz} \\ \gamma_{zx} \\ \gamma_{xy} \end{bmatrix}$$

Voigtov zapis

$$\begin{bmatrix} t_{11} \\ t_{22} \\ t_{33} \\ t_{23} \\ t_{13} \\ t_{12} \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} & C_{16} \\ & C_{22} & C_{23} & C_{24} & C_{25} & C_{26} \\ & & - & - & - & \\ & & & - & - & - \\ & & & & C_{55} & C_{56} \\ & & & & & C_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ 2\varepsilon_{23} \\ 2\varepsilon_{13} \\ 2\varepsilon_{12} \end{bmatrix}$$

Simetrije elastičnega tenzorja

1. anizotropija (21);
2. monoklinična (13);
3. ortotropična (9);
4. kubična (3);
5. tranzverzalna izotropija (5); $C_{66} = \frac{1}{2}(C_{11} - C_{12})$ oziroma $S_{66} = 2(S_{11} - S_{12})$.
6. izotropija (2);

$\vec{e}_1, \vec{e}_2, \vec{e}_3$ | $\vec{e}_1{}', \vec{e}_2{}', \vec{e}_3{}'$

$\vec{e}_1{}' = \vec{e}_1; \quad \vec{e}_2{}' = \vec{e}_2; \quad \vec{e}_3{}' = -\vec{e}_3$

$$\boxed{C_{ij}' = C_{ij}}$$

$t_{ij}' = \vec{e}_i{}' \cdot \underline{\underline{t}}\, \vec{e}_j{}'$

$t_{11}' = t_{11}; \quad t_{22}' = t_{22}, \quad t_{33}' = \vec{e}_3{}' \cdot \underline{\underline{t}}\, \vec{e}_3{}' = (-\vec{e}_3) \cdot \underline{\underline{t}}\, (-\vec{e}_3) = t_{33}$

$t_{12}' = t_{12}; \quad t_{13}' = \vec{e}_1{}' \cdot \underline{\underline{t}}\, \vec{e}_3{}' = \vec{e}_1 \cdot \underline{\underline{t}}(-\vec{e}_3) = -t_{13}; \quad t_{23}' = -t_{23}$

$\varepsilon_{ij}' = \vec{e}_i \cdot \underline{\underline{\varepsilon}}\, \vec{e}_j \Rightarrow \varepsilon_{13}' = -\varepsilon_{13}; \quad \varepsilon_{23}' = -\varepsilon_{23}$

$t_{11} = C_{11}\varepsilon_{11} + C_{12}\varepsilon_{22} + C_{13}\varepsilon_{33} + C_{14} 2\varepsilon_{23} + C_{15} 2\varepsilon_{13} + C_{16} 2\varepsilon_{12}$

$t_{11}' = C_{11}'\varepsilon_{11}' + C_{12}'\varepsilon_{22}' + C_{13}'\varepsilon_{33}' + C_{14}' 2\varepsilon_{23}' + C_{15}' 2\varepsilon_{13}' + C_{16}' 2\varepsilon_{12}'$

$t_{11} = C_{11}\varepsilon_{11} + C_{12}\varepsilon_{22} + C_{13}\varepsilon_{33} - C_{14} 2\varepsilon_{23} - C_{15} 2\varepsilon_{13} + C_{16} 2\varepsilon_{12}$

$0 = 4C_{14}\varepsilon_{23} + 4C_{15}\varepsilon_{13} \Rightarrow C_{14} = C_{15} = 0$

$C_{24} = C_{25} = 0$

$C_{34} = C_{35} = 0$

$C_{64} = C_{65} = 0$

$\rightarrow \quad t_{23} = C_{41}\varepsilon_{11} + C_{42}\varepsilon_{22} + C_{43}\varepsilon_{33} + C_{44}2\varepsilon_{23} + C_{45}2\varepsilon_{13} + C_{46}2\varepsilon_{12}$

$t'_{23} = C_{41}\varepsilon_{11} + C_{42}\varepsilon_{22} + C_{43}\varepsilon_{33} + C_{44}2\varepsilon'_{23} + C_{45}2\varepsilon'_{13} + C_{46}2\varepsilon_{12}$

$\rightarrow \quad -t_{23} = C_{41}\varepsilon_{11} + C_{42}\varepsilon_{22} + C_{43}\varepsilon_{33} - C_{44}2\varepsilon_{23} - C_{45}2\varepsilon_{13} + C_{46}2\varepsilon_{12}$

$0 = 2C_{41}\varepsilon_{11} + 2C_{42}\varepsilon_{22} + 2C_{43}\varepsilon_{33} + 4C_{46}\varepsilon_{12}$

$C_{14} = C_{41} = 0 \qquad C_{42} = 0 \;(= C_{24}), \qquad C_{43} = 0 \;(= C_{34}), \qquad C_{46} = 0$

$\boxed{C_{46} = 0}$

$$\left.\begin{aligned} t_{13} &= \dots \\ t'_{13} &= \dots \end{aligned}\right\} \Rightarrow \boxed{C_{56} = 0}$$

$21 - 8 = 17$

$$C = \begin{bmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & C_{16} \\ & C_{22} & C_{23} & 0 & 0 & C_{26} \\ & & C_{33} & 0 & 0 & C_{36} \\ & & & C_{44} & C_{45} & 0 \\ & & & & C_{55} & 0 \\ C_{16} & C_{26} & C_{36} & 0 & 0 & C_{66} \end{bmatrix}$$

ortotropična simetrija

$$C = \begin{bmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & 0 \\ & C_{22} & C_{23} & 0 & 0 & 0 \\ & & C_{33} & 0 & 0 & 0 \\ & & & C_{44} & 0 & 0 \\ & & & & C_{55} & 0 \\ & & & & & C_{66} \end{bmatrix}$$

$6 + 3 = 9$

kubična simetrija

$$C = \begin{bmatrix} C_{11} & C_{12} & C_{12} & 0 & 0 & 0 \\ & C_{11} & C_{12} & 0 & 0 & 0 \\ & & C_{11} & 0 & 0 & 0 \\ & & & C_{44} & 0 & 0 \\ & & & & C_{44} & 0 \\ & & & & & C_{44} \end{bmatrix}$$

3

transverzalna simetrija
invarijantna za rotacije
oko osi $\vec{e}_3$

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} & & & \\ & C_{11} & C_{13} & & & \\ & & C_{33} & & & \\ & & & C_{44} & & \\ & & & & C_{44} & \\ & & & & & C_{66} \end{bmatrix}$$

5

$C_{66} = \frac{1}{2}(C_{11} - C_{12})$

Izotropični material

$$S_{66} = 2(S_{11} - S_{12})$$

$$\begin{bmatrix} C_{11} & C_{12} & C_{12} \\ & C_{11} & C_{12} \\ & & C_{11} \\ & & & C_{44} \end{bmatrix}$$

$$C_{44} = \frac{1}{2}(C_{11} - C_{12})$$

Podajnostni tenzor, zapis zveze med $\underline{\epsilon}$ in $\underline{t}$ za ortotropičen material

$$\underline{\underline{S}} = \begin{bmatrix} 1/E_1 & -\nu_{12}/E_2 & -\nu_{13}/E_3 & 0 & 0 & 0 \\ -\nu_{21}/E_1 & 1/E_2 & -\nu_{23}/E_3 & 0 & 0 & 0 \\ -\nu_{31}/E_1 & -\nu_{32}/E_2 & 1/E_3 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1/\mu_{23} & 0 & 0 \\ 0 & 0 & 0 & 0 & 1/\mu_{13} & 0 \\ 0 & 0 & 0 & 0 & 0 & 1/\mu_{12} \end{bmatrix}$$

E_i Youngovi moduli, ν_{ij} Poissonovi količniki, strižni moduli $\mu_{ij} = G_{ij}$.

$$S_{11} = \frac{1}{E_1} \qquad S_{12} = -\frac{\nu_{12}}{E_2}, \qquad S_{13} = -\frac{\nu_{13}}{E_3} \qquad S_{44} = \frac{1}{\mu_{23}}$$

$$S_{21} = -\frac{\nu_{21}}{E_1}$$

$$S_{12} = S_{21} \Rightarrow \frac{\nu_{12}}{E_2} = \frac{\nu_{21}}{E_1} \qquad \nu_{21} = \frac{E_1}{E_2}\nu_{12}$$

$$\underline{t} = \begin{bmatrix} t_{11} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \qquad \begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ 2\varepsilon_{23} \\ 2\varepsilon_{13} \\ 2\varepsilon_{12} \end{bmatrix} = S \begin{bmatrix} t_{11} \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \Rightarrow$$

$$\varepsilon_{11} = \frac{1}{E_1} t_{11}$$

$$\varepsilon_{22} = -\frac{\nu_{21}}{E_1} t_{11} \Rightarrow \varepsilon_{22} = -\nu_{21}\varepsilon_{11}$$

$$\varepsilon_{33} = -\frac{\nu_{31}}{E_1} t_{11} \Rightarrow \varepsilon_{33} = -\nu_{31}\varepsilon_{11}$$

$$\underline{t} = \begin{bmatrix} 0 \\ t_{22} \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \Rightarrow \varepsilon_{22} = \frac{1}{E_2} t_{22} \qquad \varepsilon_{13} = \varepsilon_{23} = \varepsilon_{12} = 0$$

$$\nu_{21} = -\frac{\varepsilon_{22}}{\varepsilon_{11}}$$

$$2\varepsilon_{12} = \frac{1}{\mu_{12}} t_{12} \qquad t_{12} = 2\mu_{12}\varepsilon_{12}$$

Izotropija

$$E = E_1 = E_2 = E_3 \; ; \quad \nu_{12} = \nu_{13} = \nu_{23} = \nu$$

$$\mu_{23} = \mu_{13} = \mu_{12} = \mu = G$$

$$\frac{1}{G} = 2\left(\frac{1}{E} + \frac{\nu}{E}\right) = \frac{2(1+\nu)}{E} \Rightarrow G = \frac{E}{2(1+\nu)}$$

$$\begin{bmatrix} \frac{1}{E} & -\frac{\nu}{E} & -\frac{\nu}{E} & \dots \end{bmatrix} \qquad \underline{\varepsilon} = \underline{S}\,\underline{t}$$

$$S = \begin{bmatrix} \frac{1}{E} & -\frac{\nu}{E} & & & & \\ & \frac{1}{E} & & & & \\ & & \ddots & & & \\ & & & \frac{1}{G} & & \\ & & & & \ddots & \\ & & & & & \frac{1}{G} \end{bmatrix}$$

$$\varepsilon_{11} = \underbrace{\frac{1}{E} t_{11} - \frac{\nu}{E} t_{22} - \frac{\nu}{E} t_{33}}{} = \frac{1+\nu}{E} t_{11} - \frac{\nu}{E}(t_{11} + t_{22} + t_{33})$$

$$\varepsilon_{22} = \frac{1+\nu}{E} t_{22} - \frac{\nu}{E}(t_{11} + t_{22} + t_{33})$$

$$\varepsilon_{33} = \frac{1+\nu}{E} t_{33} - \frac{\nu}{E}(t_{11} + t_{22} + t_{33})$$

Hookov zakon za izotropičen material

$$\epsilon_{ij} = \frac{1+\nu}{E} t_{ij} - \frac{\nu}{E}(t_{11} + t_{22} + t_{33})\delta_{ij}$$

oziroma

$$\underline{\underline{\epsilon}} = \frac{1+\nu}{E}\underline{\underline{t}} - \frac{\nu}{E}(\mathrm{sl}\,\underline{\underline{t}})\underline{\underline{I}}.$$

$$\delta_{ij} = \begin{cases} 1 & i = j \\ 0 & i \neq j \end{cases}$$

$i = j = 1, 2, 3$

$$2\varepsilon_{12} = \frac{1}{G} t_{12} \Rightarrow \varepsilon_{12} = \frac{1}{2G} t_{12} = \frac{2(1+\nu)}{2E} t_{12} = \frac{1+\nu}{E} t_{12}$$

$i = 1,\ j = 2$

Zveza $G = \frac{E}{2(1+\nu)}$. ✓

$$\underline{\underline{t}} = 2\mu\, \underline{\underline{e}} + \lambda(\mathrm{sl}\,\underline{\underline{e}})\underline{\underline{I}}$$

$$\mathrm{sl}\,\underline{\underline{t}} = 2\mu\, \mathrm{sl}\,\underline{\underline{e}} + \lambda(\mathrm{sl}\,\underline{\underline{e}})\,3 = (2\mu + 3\lambda)\,\mathrm{sl}\,\underline{\underline{e}}$$

$$\underline{\underline{e}} = \frac{1}{2\mu}\left(\underline{\underline{t}} - \lambda\,\mathrm{sl}\,\underline{\underline{e}}\,\underline{\underline{I}}\right) = \frac{1}{2\mu}\underline{\underline{t}} - \frac{\lambda}{2\mu(2\mu + 3\lambda)}\,\mathrm{sl}\,\underline{\underline{t}}\,\underline{\underline{I}}$$

Lamejeva koeficienta $\mu = G$, $\lambda = \frac{\nu E}{(1-2\nu)(1+\nu)}$,

$$\underline{\underline{t}} = 2\mu\underline{\underline{\epsilon}} + \lambda(\mathrm{sl}\,\underline{\underline{\epsilon}})\underline{\underline{I}}.$$

$$\nu = \frac{\lambda}{2(\lambda + \mu)}, \qquad E = \frac{\mu(3\lambda + 2\mu)}{\lambda + \mu}.$$

λ, μ

Lamejeva koeficienta

$$\frac{1}{2\mu} = \frac{1+\nu}{E} \Rightarrow \mu = \frac{E}{2(1+\nu)}$$

Enakomerna kompresija, kompresijski modul $\kappa = \frac{E}{3(1-2\nu)}$.

Nestisljivi material $\nu = \frac{1}{2}$, vrednosti Poissonovega količnika $\nu \in (-1, \frac{1}{2}]$.