FORMLER

Momentteoremet

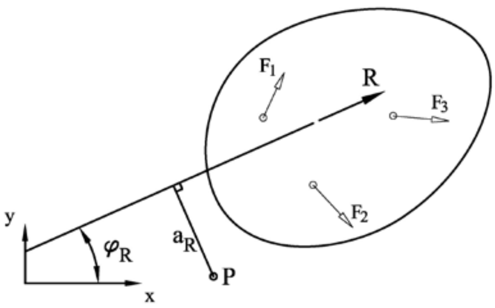
Resultantens moment om et vilkårlig punkt P er lik summen av enkeltkreftenes momenter om P, dvs.
$R \cdot a_R = \Sigma(F_i \cdot a_i)$

Resultanten

$$R_x = \Sigma F_{ix} \qquad R_y = \Sigma F_{iy} \qquad R = \sqrt{R_x^2 + R_y^2}$$

$$\varphi_R = \tan^{-1}\left(\frac{R_y}{R_x}\right)$$

$$a_R = \frac{\Sigma M_p}{R}$$



Likevektslikninger

Alt. 1
$\Sigma F_x = 0$, for enhver akseretn.
$\Sigma F_y = 0$, for enhver akseretn.
$\Sigma M_p = 0$, for ethvert momentpkt.

Alt. 2
$\Sigma F_x = 0$ (evt. $\Sigma F_y = 0$)
$\Sigma M_A = 0$, $\Sigma M_B = 0$
AB ikke parallell med y (evt. x)

Alt. 3
$\Sigma M_A = 0$, $\Sigma M_B = 0$, $\Sigma M_C = 0$
ABC ikke på linje

Statisk bestemthet

Generelt: $3e = r$ e= antall elementer
r = antall ukjente reaksjonskrefter

Fagverk: $s + o = 2k$ s = antall staver
o = antall opplagerkrefter
k = antall knutepunkt

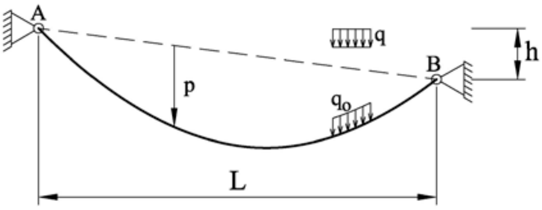
Arealsenter

$$\bar{x} = \frac{1}{A}\int_A x\,dA = \frac{\Sigma A_i x_i}{\Sigma A_i}$$

Tyngdepunktssetningen

$$\bar{x} = \frac{\Sigma G_i x_i}{\Sigma G_i}$$

Kabler



p= pilhøyde
p_o = pilhøyde midt mellom opphengspunktene
q_o = egentyngden per meter kabel

Kabellengde: $$s = L + \frac{h^2}{2L} + \frac{8p_o^2}{3L}$$

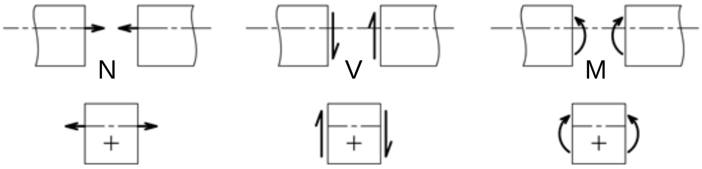
Lastintensitet i horisontalretning: $$q = q_o \frac{s}{L}$$

Snittkrefter

Sammenheng mellom lastintensitet, skjærkraft og bøyemoment

$$\frac{dV}{dx} = -q, \qquad \frac{dM}{dx} = V$$

Fortegnsregler:



Materialegenskaper

	Stål	Aluminium
Egenvekt, ρ	7,85t/m^3	2,7t/m^3
E-modul, E	206 000MPa	70 000MPa
Temperaturutvidelseskoeff., α	11·10^{-6} m/m°C	23,8·10^{-6} m/m°C

Fasthetslære, grunnleggende

Aksialspenninger: $\sigma_A = \dfrac{F}{A}$ Tøyning: $\varepsilon = \dfrac{\Delta L}{L}$

Termisk tøyning: $\varepsilon_T = \alpha \cdot \Delta T$ Hookes lov: $\sigma = E\varepsilon$

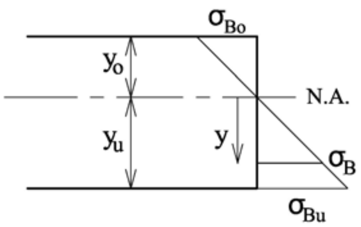
Forlengelse av aksialbelastet stav: $\Delta L = \dfrac{FL}{EA}$

Bøyespenningsformelen

$$\sigma_B = \frac{M}{I_x} y$$

$$\sigma_{Bo} = \frac{M}{W_{xo}} \quad hvor \quad W_{xo} = \frac{I_x}{y_o}$$

$$\sigma_{Bu} = \frac{M}{W_{xu}} \quad hvor \quad W_{xu} = \frac{I_x}{y_u}$$



Arealmoment

Annet arealmoment

$I_x = \int y^2 dA$, om x-aksen

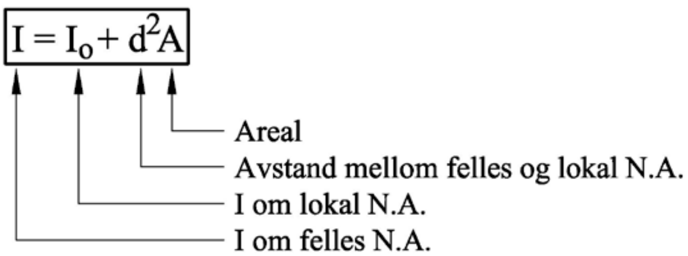
$I_y = \int x^2 dA$, om y-aksen

Arealmoment

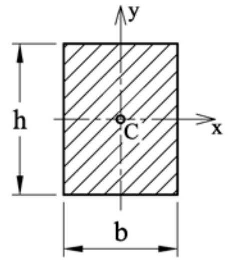
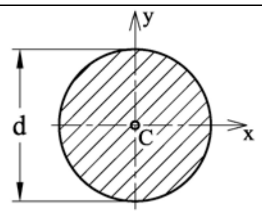
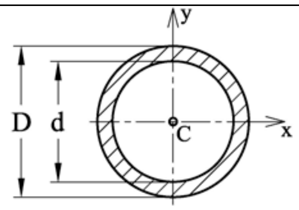
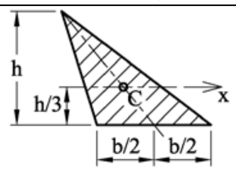
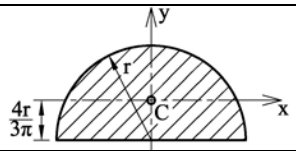
$S_x = \int y dA = \Sigma y_i A_i$

$S_y = \int x dA = \Sigma x_i A_i$

Steiners formel:

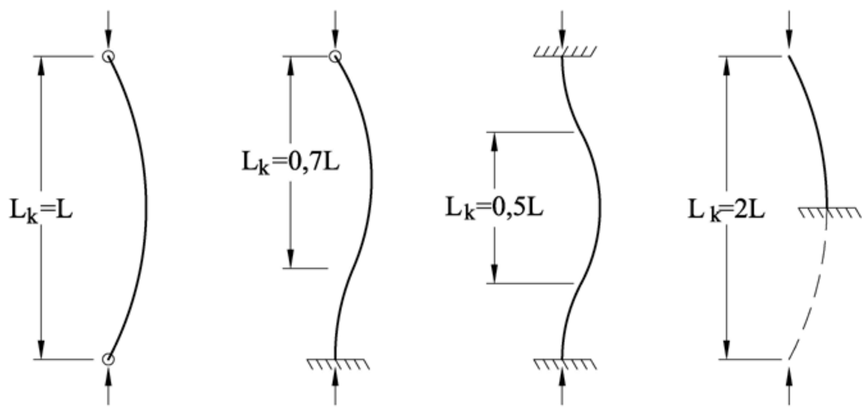


Tverrsnittsegenskaper

Snittflate	Annet arealmoment	Motstandsmoment	Polart arealmoment
	$I_x = \dfrac{bh^3}{12}$ $I_y = \dfrac{hb^3}{12}$	$W_x = \dfrac{bh^2}{6}$ $W_y = \dfrac{hb^2}{6}$	$I_P = \dfrac{bh}{12}(h^2 + b^2)$
	$I_x = I_y = \dfrac{\pi d^4}{64}$	$W_x = W_y = \dfrac{\pi d^3}{32}$	$I_P = \dfrac{\pi d^4}{32}$
	$I_x = I_y = \dfrac{\pi}{64}(D^4 - d^4)$	$W_x = W_y = \dfrac{\pi}{32} \cdot \dfrac{D^4 - d^4}{D}$	$I_P = \dfrac{\pi}{32}(D^4 - d^4)$
	$I_x = \dfrac{bh^3}{36}$		
	$I_x = 0{,}12 r^4$ $I_y = \dfrac{\pi}{8} r^4$		

Knekking

Knekklengde:



Elastisk knekking (Eulerlast): $F_k = \dfrac{\pi^2 E I_0}{L_k^2}$ *alternativt* $\sigma_k = \dfrac{\pi^2 E}{\lambda}$

Treghetsradius: $i = \sqrt{\dfrac{I_0}{A}}$ Slankhet: $\lambda = \dfrac{L_k}{i}$

Tetmajers formler for plastisk knekning:

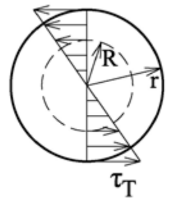
St37: $\sigma_k = 310 - 1{,}14\lambda \quad for \quad \lambda \in < 10{,}105 >$

St50/St60: $\sigma_k = 335 - 0{,}62\lambda \quad for \quad \lambda \in < 10{,}89 >$

Torsjon

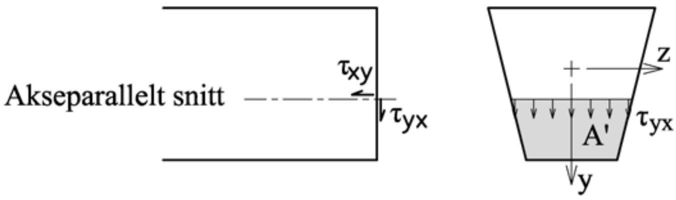
Torsjonsskjærspenning i sirkulærsylindrisk tverrsnitt

$$\tau_T = \frac{M_T}{I_P} R \quad hvor \quad I_P = \int R^2 dA$$



Bøyeindusert skjærspenning

$$\tau_{yx} = \tau_{xy} = \frac{V}{Ib} S' \quad hvor \quad S' = \int_{A'} y dA = \Sigma y_i A_i$$



<u>Rektangulært tverrsnitt</u>	<u>Sirkulært tverrsnitt</u>	<u>Tynnvegget rør</u>
$\tau_{\max} = 1{,}5 \frac{V}{A}$	$\tau_{\max} = 1{,}33 \frac{V}{A}$	$\tau_{\max} = 2{,}0 \frac{V}{A}$

Sikkerhetsfaktor

$$\text{n} = \frac{\text{konstruksjonens teoretiske kapasitet}}{\text{konstruksjonens største (tillatte) påkjenning}}$$

Dimensjoneringskriterium for flytning (von Mises)

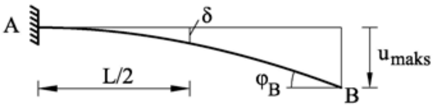
Jevnføringsspenning: $\sigma_j < \frac{R_e}{n}$, hvor R_e = Flytegrense

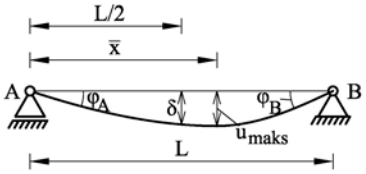
Kun normalspenning: $\sigma_j = \sigma_x$

En-akset spenningstilstand: $\sigma_j = \sqrt{\sigma_x^2 + 3\tau_{yx}^2}$

Plan spenningstilstand: $\sigma_j = \sqrt{\sigma_x^2 + \sigma_y^2 - \sigma_x \sigma_y + 3\tau_{yx}^2}$

Deformasjon av enkle bjelker





EI = konstant

δ = utbøyning på midten

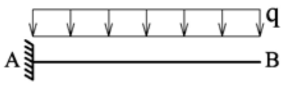
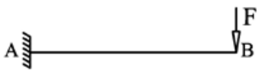
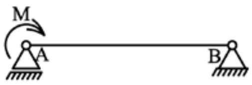
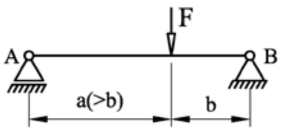
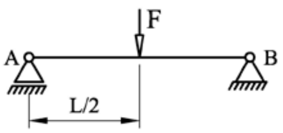
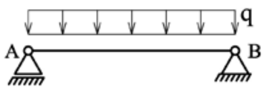
u_{maks} = maksimal utbøyning

u_{last} = utbøyning under punktlast

$\overline{x}$ = avstand fra A til punkt med maksimal utbøyning

φ_A = tangenthelning ved A

φ_B = tangenthelning ved B

1		$u_{maks} = \frac{qL^4}{8EI},\ \varphi_B = \frac{qL^3}{6EI},\ \delta = \frac{17}{384}\frac{qL^4}{EI}$
2		$u_{maks} = \frac{FL^3}{3EI},\ \varphi_B = \frac{FL^2}{2EI},\ \delta = \frac{5}{48}\frac{FL^3}{EI}$
3		$u_{maks} = \frac{ML^2}{2EI},\ \varphi_B = \frac{ML}{EI}$
4		$u_{maks} = \frac{ML^2}{9\sqrt{3}EI},\ \overline{x} = (1-\frac{\sqrt{3}}{3})L,\ \varphi_A = \frac{ML}{3EI},\ \varphi_B = \frac{ML}{6EI},\ \delta = \frac{ML^2}{16EI}$
5		$u_{maks} = \frac{Fb(L^2-b^2)^{\frac{3}{2}}}{9\sqrt{3}LEI},\ \overline{x} = \sqrt{\frac{L^2-b^2}{3}},\ u_{last} = \frac{Fa^2b^2}{3LEI}$ $\varphi_A = \frac{F\cdot ab(a+2b)}{6LEI},\ \varphi_B = \frac{F\cdot ab(b+2a)}{6LEI},\ \delta = \frac{Fb(3L^2-4b^2)}{48EI}$
6		$\delta = u_{maks} = \frac{FL^3}{48EI}, \varphi_A = \varphi_B = \frac{FL^2}{16EI}$
7		$\delta = u_{maks} = \frac{5}{384}\frac{qL^4}{EI},\ \varphi_A = \varphi_B = \frac{qL^3}{24EI}$