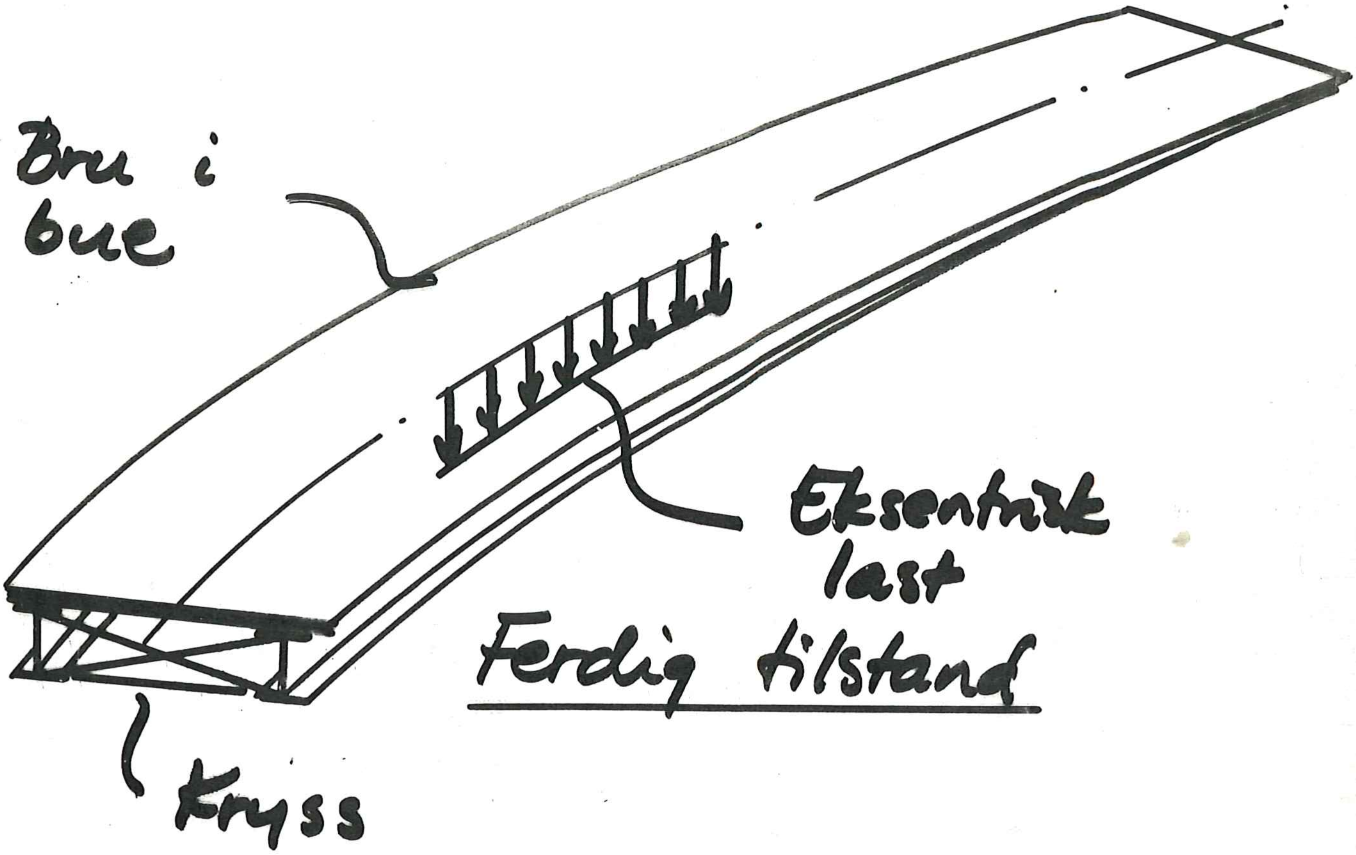
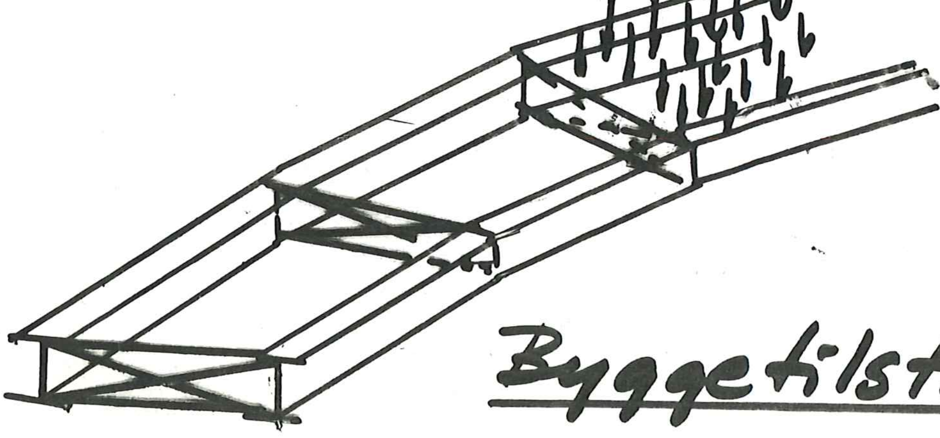
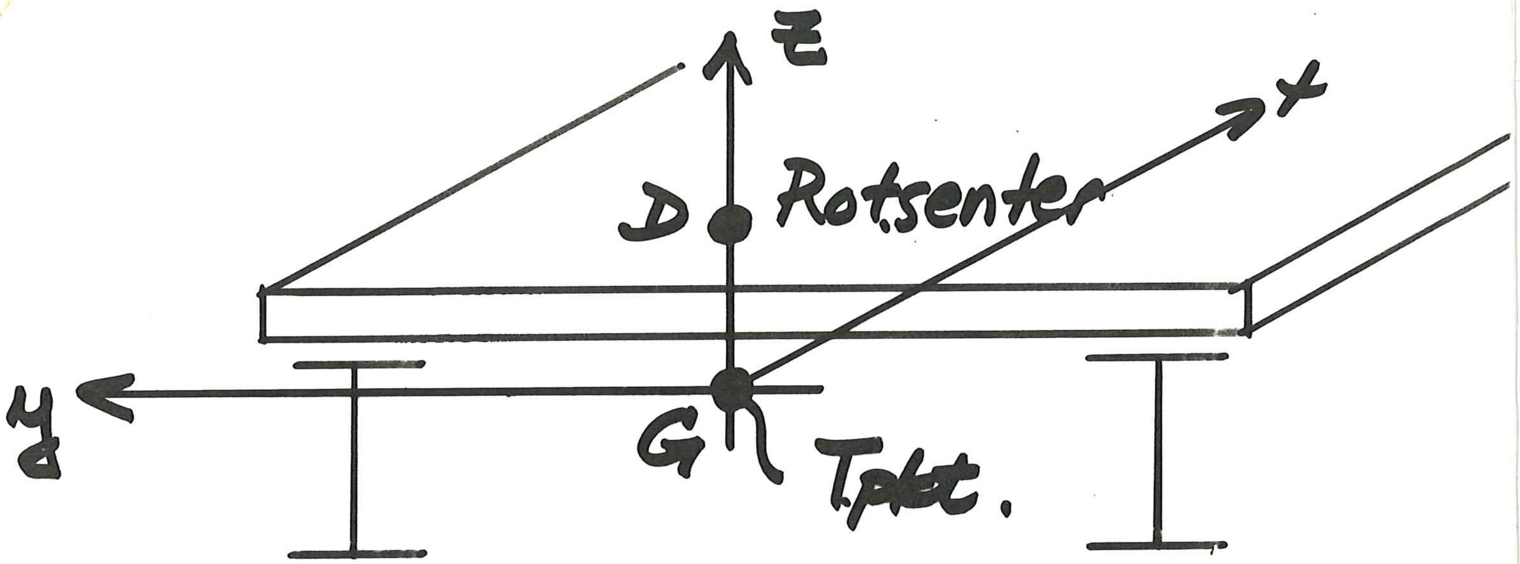
SAMVIRKE - BRU - PROGRAM



Ferdig tilstand



Byggetilstand



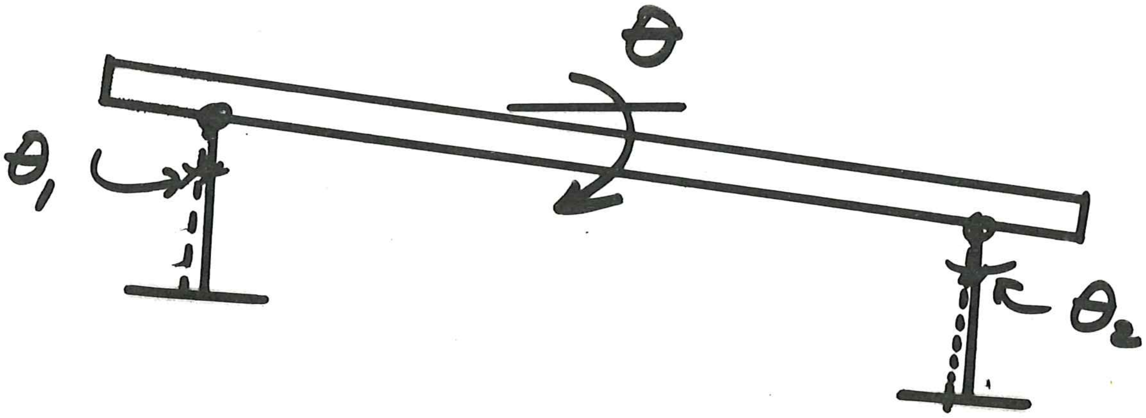
x = langs brua.

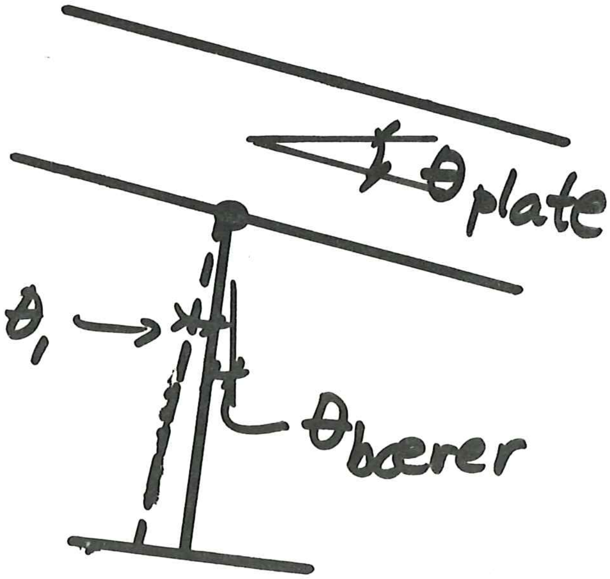
y, z = hovedakser gj. tpkt.

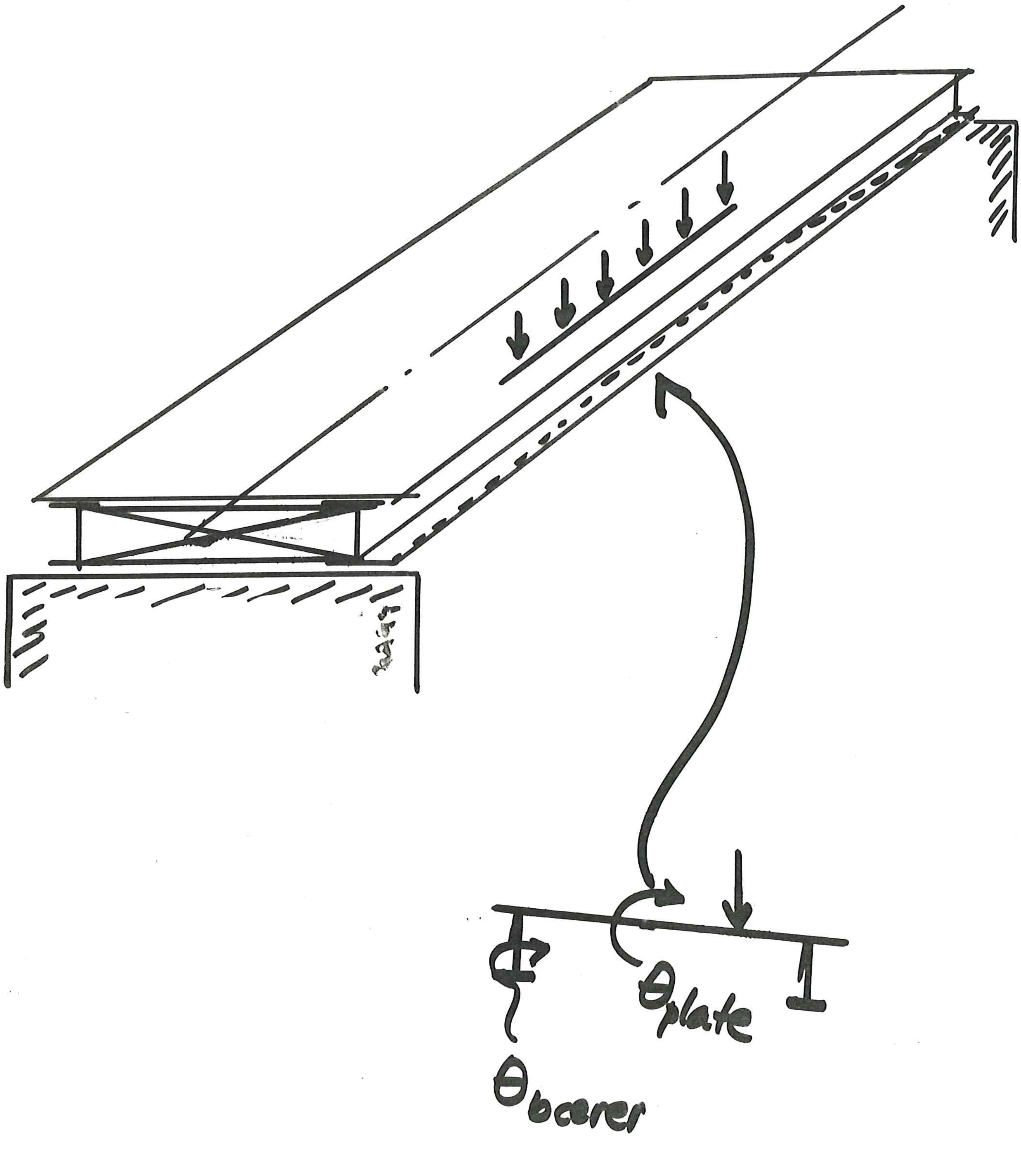
$\int y \, dA = \int z \, dA = 0$

$\int yz \, dA = 0$

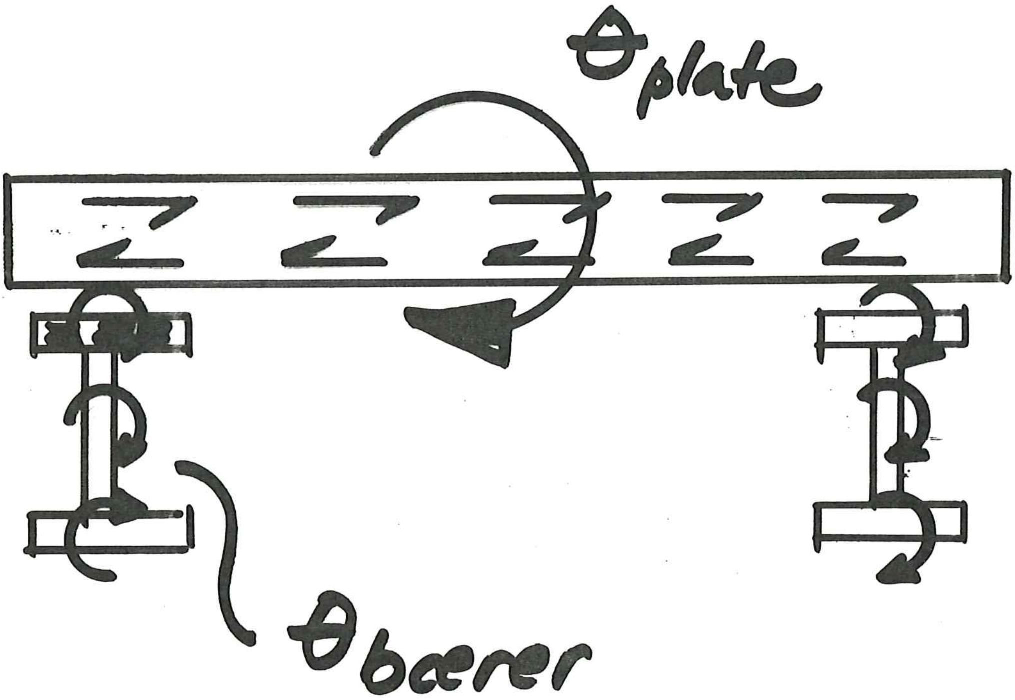

Udeformert


θ
θ1
θ2


θplate
θ1
θbærer


θ_{plate}
θ_{bearer}

St. Venant - torsjon

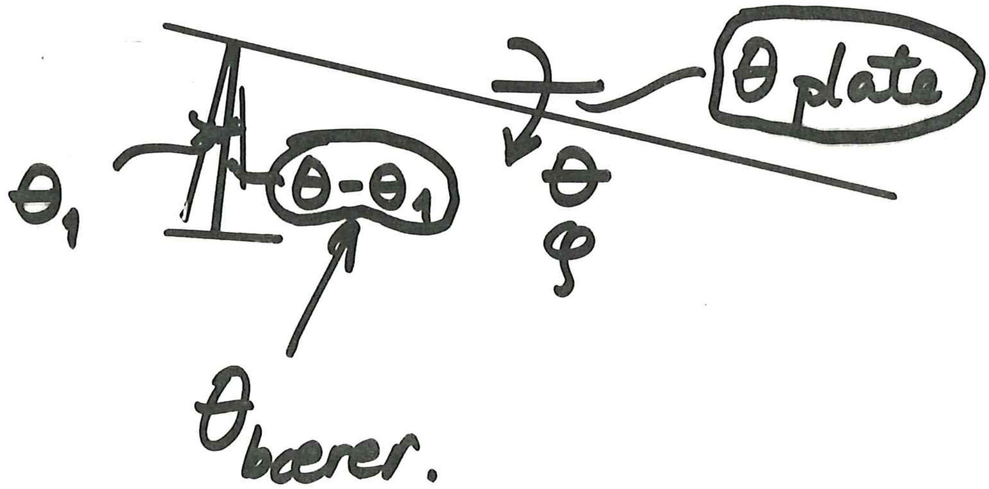


$$\varphi_{,x} = \frac{M_x}{GI_t}$$

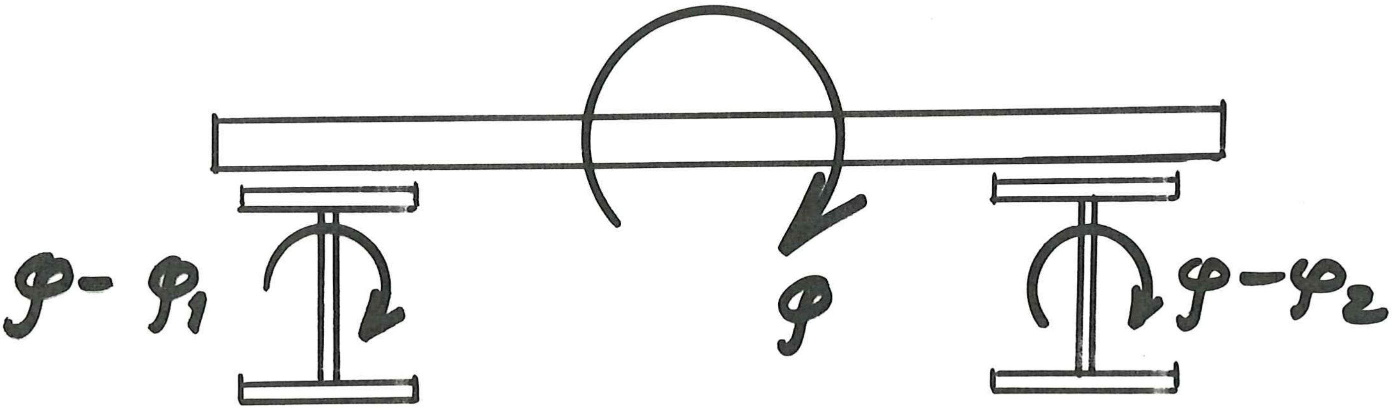
$$GI_t = \frac{1}{3} \sum G_i \, b_i \, t_i^{\,3}$$

Må modifiseres!

$$M_x = (GI_t)_{plate} \cdot \theta_{plate} + \sum_{bærere} GI_t \cdot \theta_{bærer}$$



Hvelvning



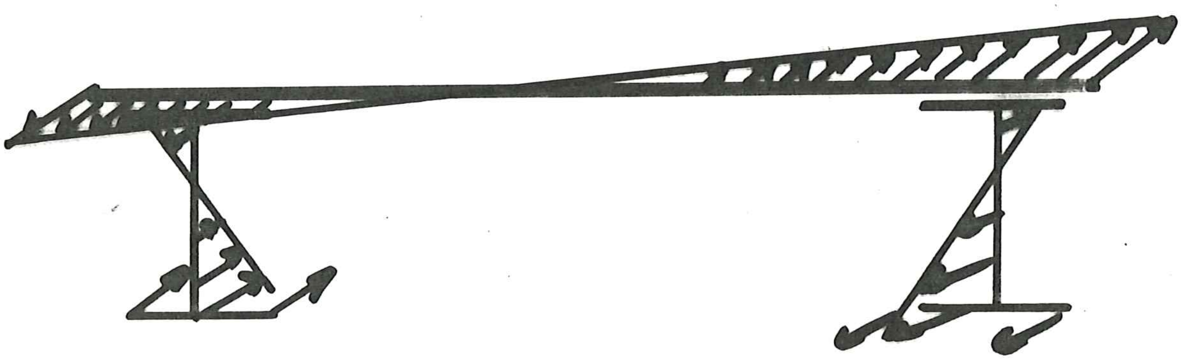
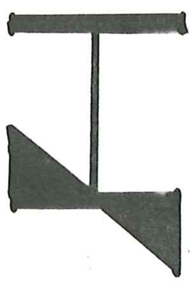


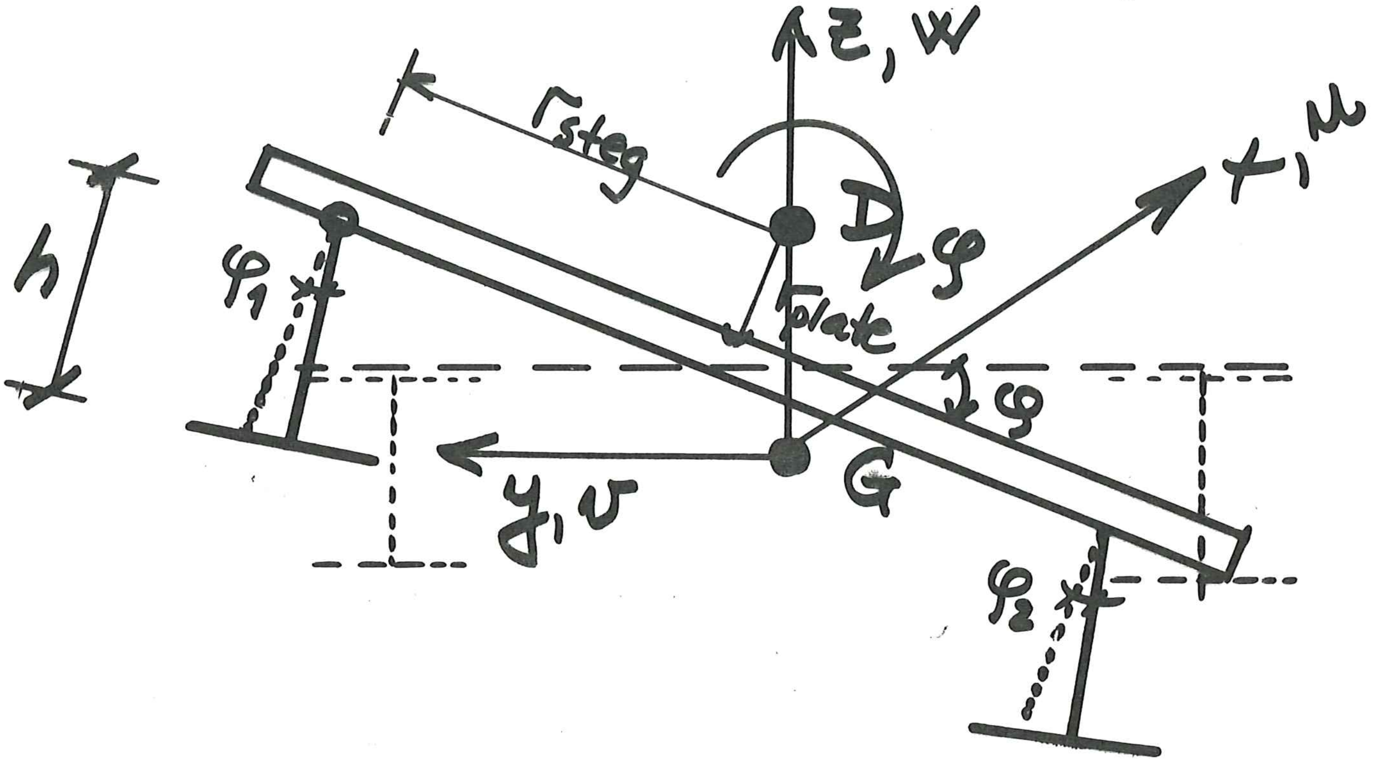
Plate: $\sigma_x = -E\omega\varphi_{,xx}$

Bjelke: $\sigma_x = -E\omega\varphi_{,xx} + E\bar{\omega}\varphi_{1,xx}$



Bare bidrag underflens

Ligninger for hvelvning

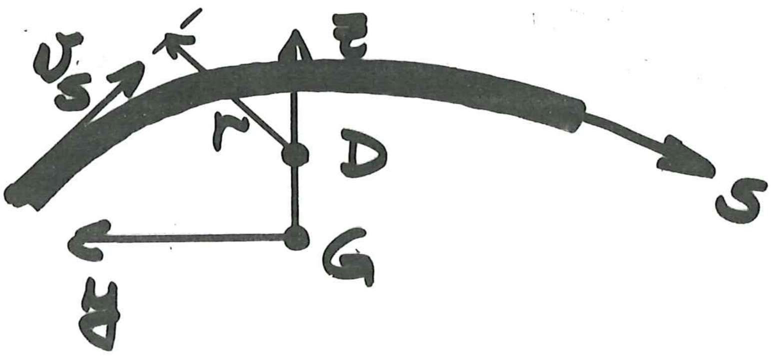


Forskyvning langs flate:

$$\underline{v_s = \varphi \cdot r}$$

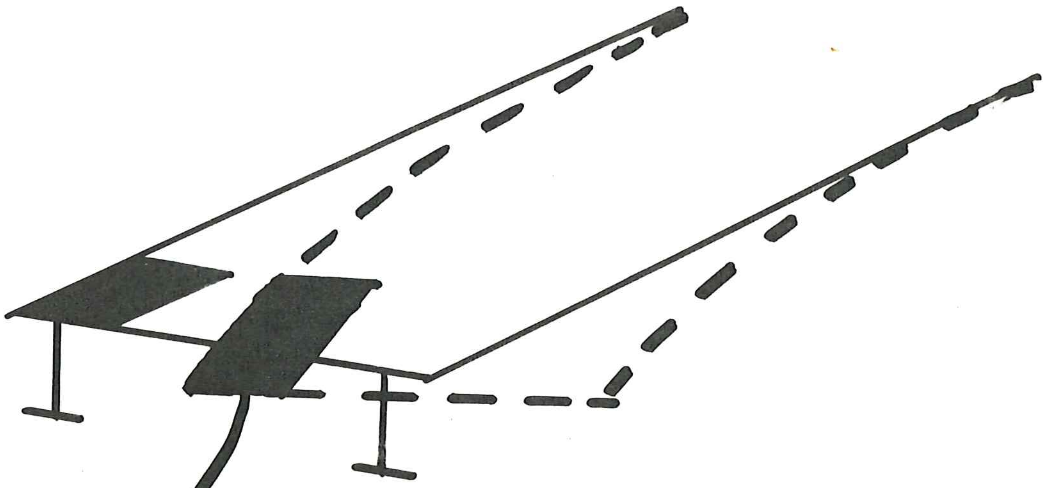
Korreksjon for underflens:

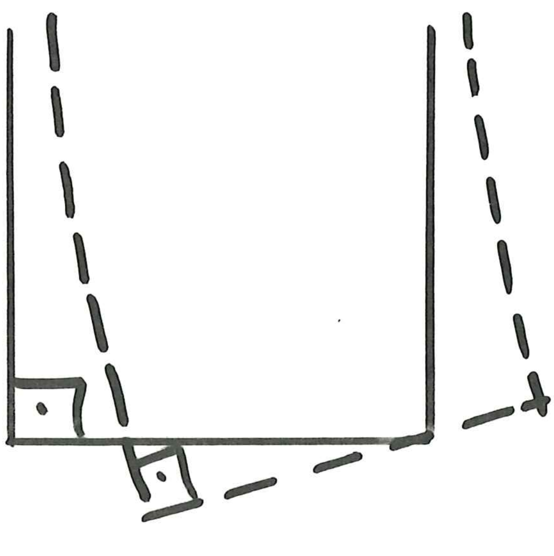
$$\underline{\bar{v}_s = \varphi \cdot r - \varphi_1 \cdot h}$$



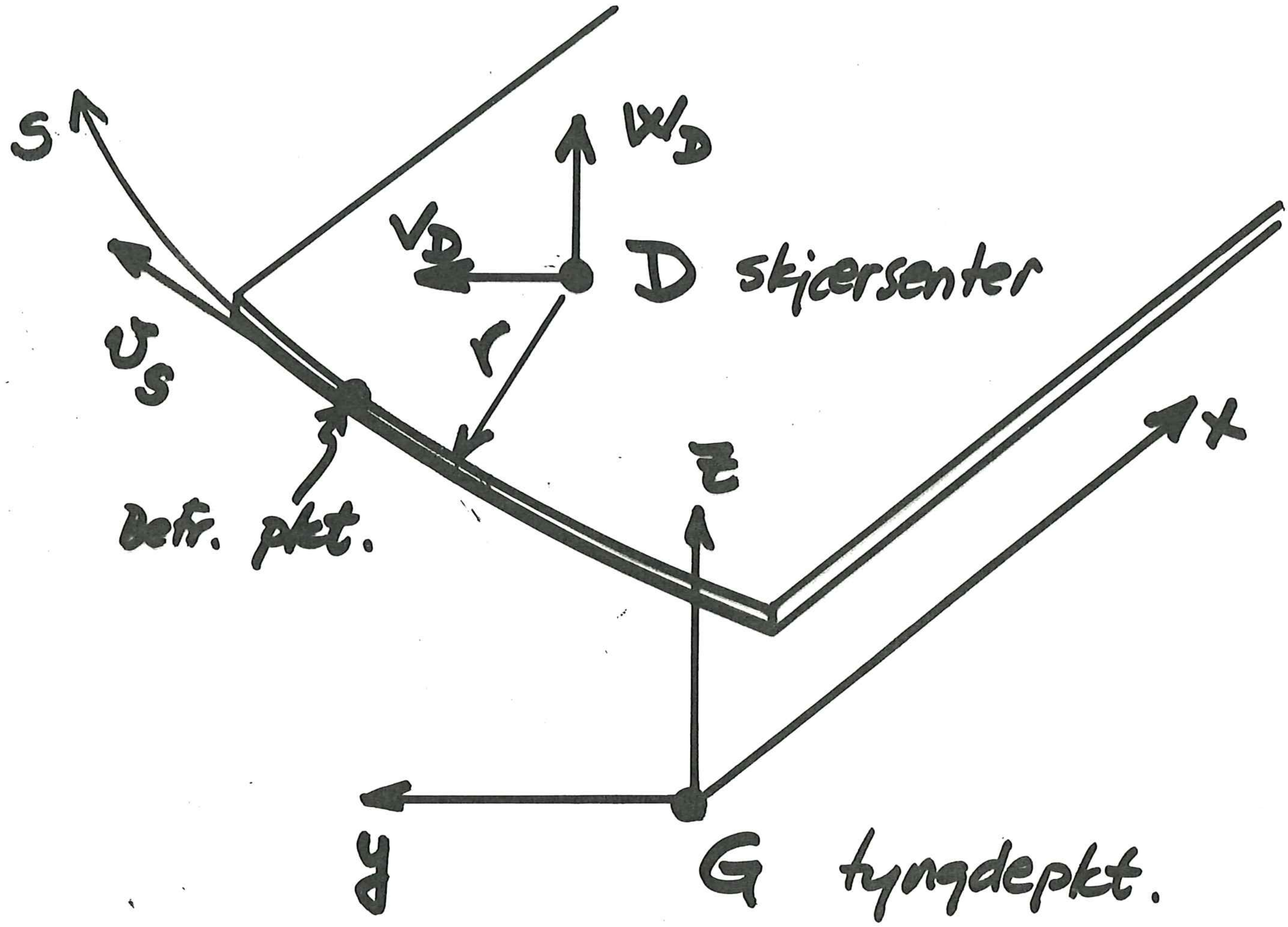
Vlasov teori :

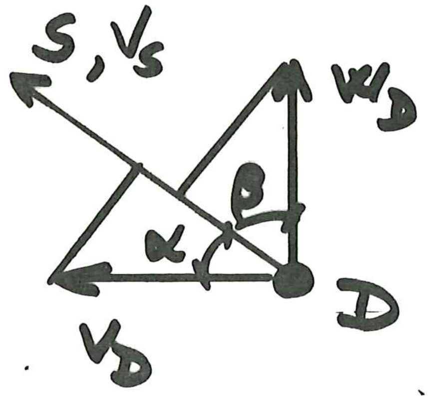
$$\boxed{\gamma_{xs} = \frac{\partial u}{\partial s} + \frac{\partial v_s}{\partial x} = 0}$$



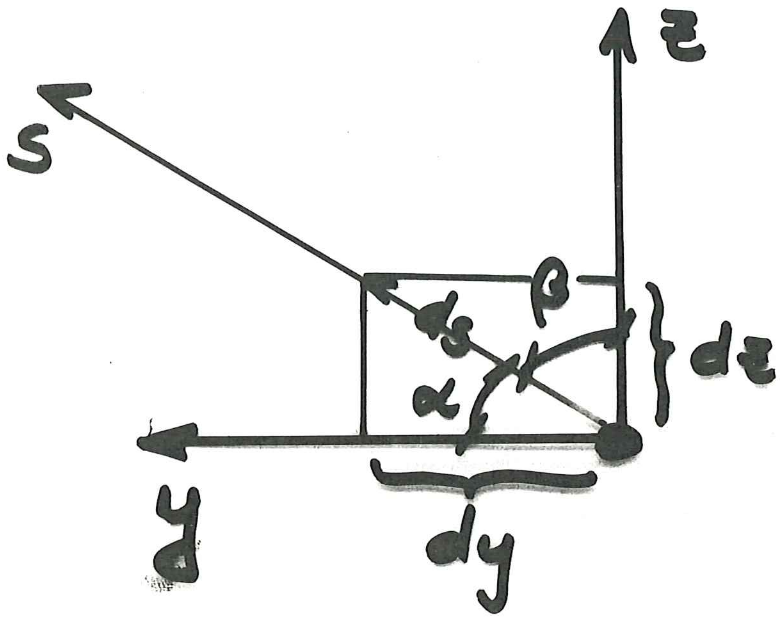


Komplett forskyvning:





$$\boxed{v_s = \varphi \cdot r + v_D \cdot \cos\alpha + w_D \cdot \cos\beta}$$



$$\cos\alpha = \frac{\partial y}{\partial s} \quad ; \quad \cos\beta = \frac{\partial z}{\partial s}$$

$$\boxed{v_s = \varphi \cdot r + v_D \cdot \frac{\partial y}{\partial s} + w_D \cdot \frac{\partial z}{\partial s}}$$

Vlasov:

$$\frac{\partial u}{\partial s} = -\frac{\partial v_s}{\partial x}$$

$$= -\frac{\partial \varphi}{\partial x} \cdot r - \frac{\partial v_D}{\partial x} \cdot \frac{\partial y}{\partial s} - \frac{\partial w_D}{\partial x} \cdot \frac{\partial z}{\partial s}$$

Konst. tverrsn. over element.

Aksialforskyvning:

$$\boxed{u(x,s) = u_0(x) - \varphi_{,x} \cdot \int_s r\,ds - v_{D,x} \cdot y - w_{D,x} \cdot z}$$

$u_0(x)$ = int. konstant

Innfør hvelvningsparameteren

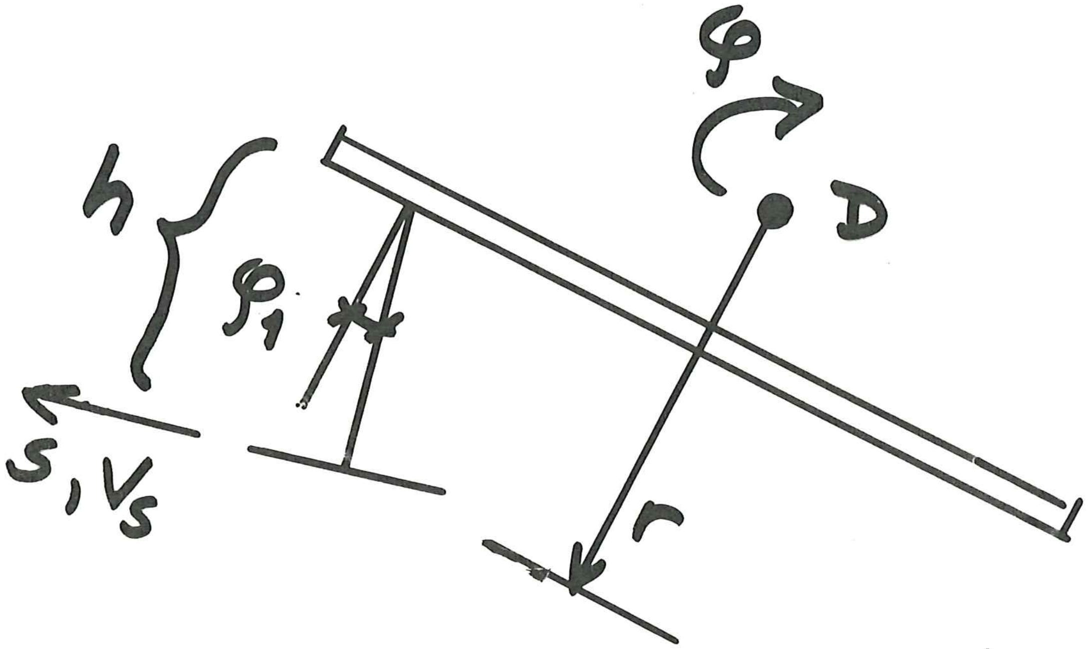
$$\omega = \int_s r\,ds$$

Gir

$$\boxed{u(x,s) = u_0(x) - \varphi_{,x} \cdot \omega - v_{D,x} \cdot y - w_{D,x} \cdot z}$$

$$\boxed{\varphi_{,x} \equiv \frac{d\varphi}{dx} = \frac{\partial \varphi}{\partial x}}$$

Underflens :



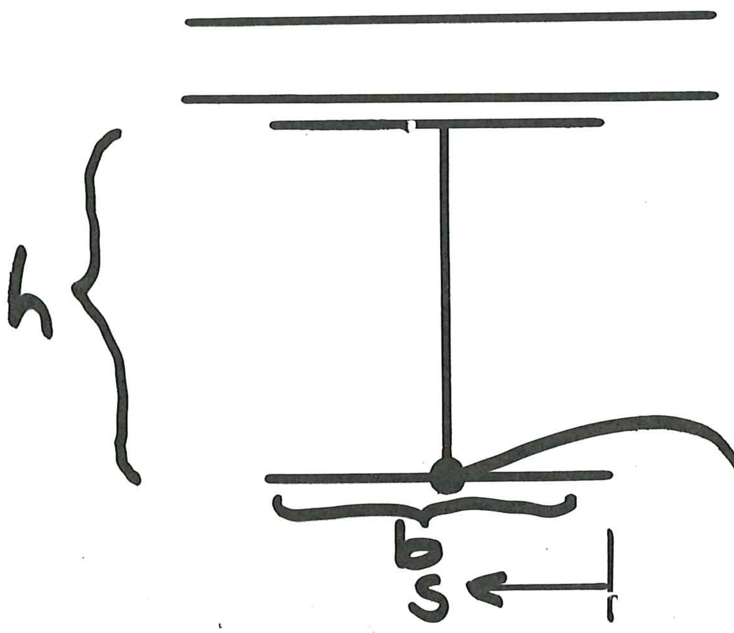
$$V_s = \varphi \cdot r - \underline{\underline{\varphi_1 \cdot h}} + V_D \cdot \frac{\partial y}{\partial s} + W_D \cdot \frac{\partial z}{\partial s}$$

Gir

$$u(x,s) = u_0(x) - \varphi_{,x} \cdot \omega + \underline{\underline{\varphi_{1,x} \cdot \bar{\omega}}}$$

$$- V_{D,x} \cdot y - W_{D,x} \cdot z$$

$$\boxed{\bar{\omega} = \int h \, ds = h \cdot s + C}$$

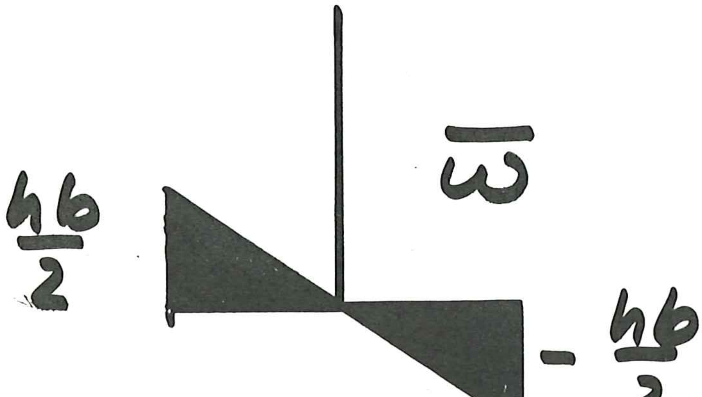


$$\overline{\omega} = h \cdot s + C$$

kontinuitet i u gir $\overline{\omega} = 0$ her

Dvs.

$$h \cdot \frac{b}{2} + C = 0 \quad \therefore \quad \underline{C = -\frac{hb}{2}}$$



Rent moment-bidrag i underflens.

Virtuelt arbeid:

$$\int_V \underbrace{\sigma_x \cdot \delta\varepsilon_x \, dV}_{\substack{\text{Hvelvning} \\ \text{Aksialdef.} \\ \text{Bøyning}}} + \int_V \underbrace{\tau \cdot \delta\gamma \, dV}_{\text{St. Venant}}$$

$$= \int_{S_\sigma} \underbrace{(t_x \cdot \delta u + t_y \cdot \delta v + t_z \cdot \delta w)\, dS}_{\text{Ytre laster}}$$

$$\boxed{\text{Må finne uttrykk for } \varepsilon_x \text{ og } \sigma_x.}$$

Tøyning:

$$\varepsilon_x = u_{,x} =$$

$$u_{0,x} - \varphi_{,xx} \cdot \omega + \underbrace{\varphi_{1,xx} \cdot \bar{\omega}}_{\text{For underflens}}$$

$$- v_{D,xx} \cdot y - w_{D,xx} \cdot z$$

Virtuell:

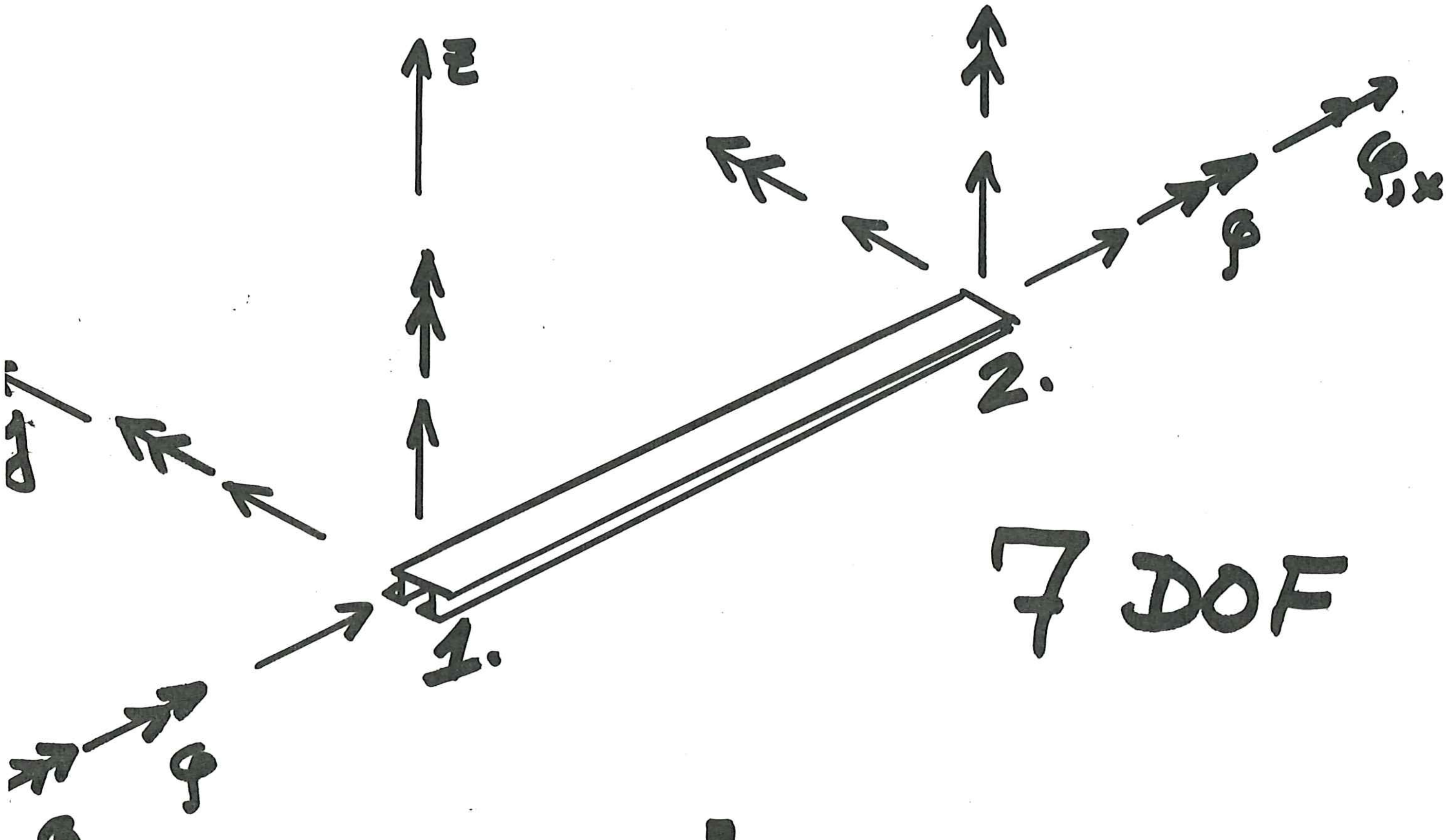
$$\boxed{\begin{aligned} \delta\varepsilon_x = {} & \delta u_{0,x} - \omega \cdot \delta\varphi_{,xx} - \bar{\omega} \cdot \delta\varphi_{1,xx} \\ & - y \cdot \delta v_{D,xx} - z \cdot \delta w_{D,xx} \end{aligned}}$$

Spenning:

$$\sigma_x = E \cdot \varepsilon_x$$

$$= E\left(u_{0,x} - \omega \varphi_{1,xx} + \bar{\omega} \varphi_{1,xx} - y \cdot v_{D,xx} - z \cdot w_{D,xx}\right)$$

ELEMENTMETODEN



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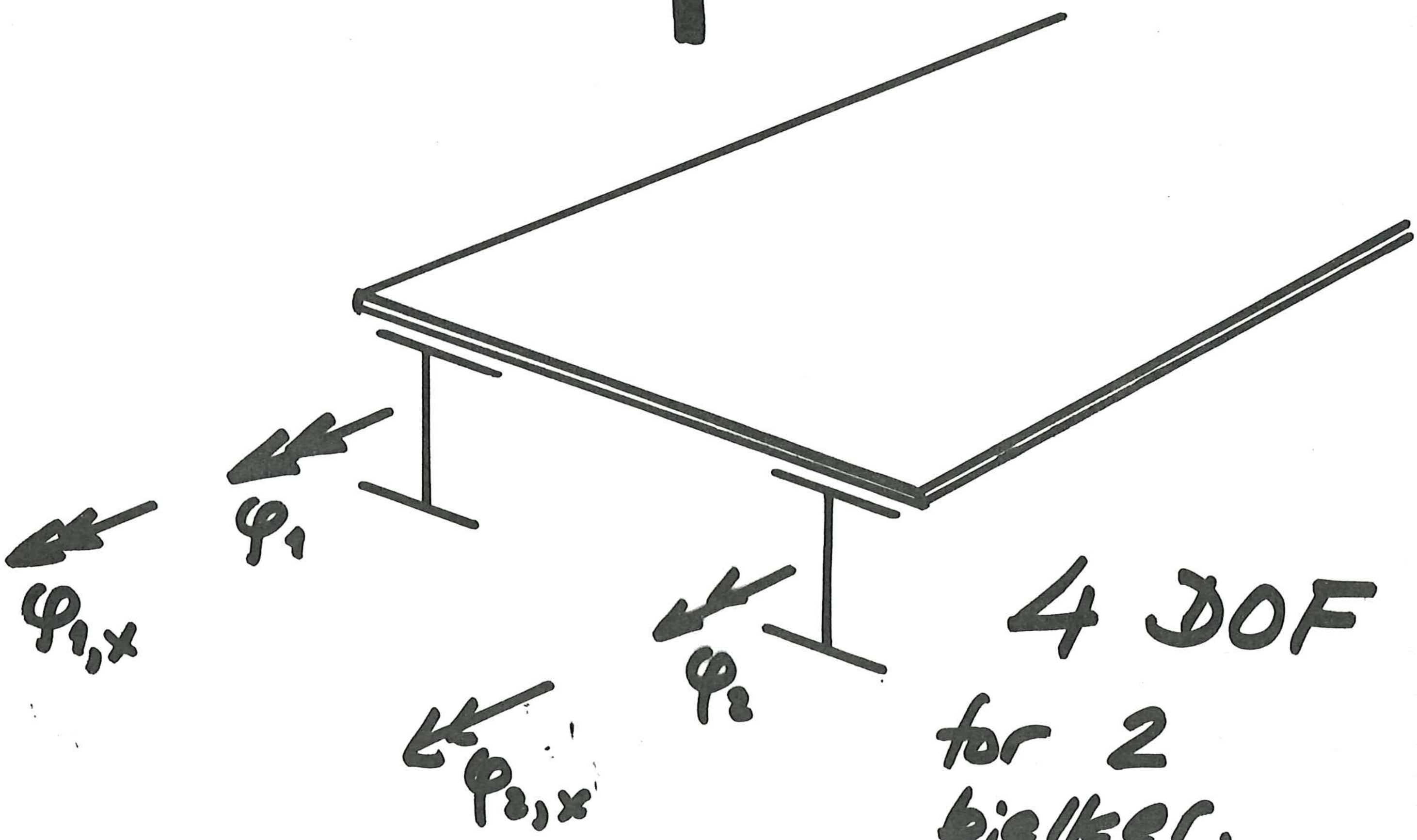

Interpolasjon:

$$\varphi(x) = \mathbb{N}_\varphi^T \boldsymbol{\varphi} = \mathbb{N}_\varphi^T \left\{ \begin{matrix} \begin{pmatrix} \varphi \\ \varphi_{,x} \end{pmatrix}_1 \\ \hline \begin{pmatrix} \varphi \\ \varphi_{,x} \end{pmatrix}_2 \end{matrix} \right\}$$

$$\varphi_1(x) = \mathbb{N}_{\varphi_1}^T \boldsymbol{\varphi}_1 = \mathbb{N}_{\varphi_1}^T \left\{ \begin{matrix} \begin{pmatrix} \varphi_1 \\ \varphi_{1,x} \end{pmatrix}_1 \\ \begin{pmatrix} \varphi_1 \\ \varphi_{1,x} \end{pmatrix}_2 \end{matrix} \right\}$$

$$u(x) = \mathbb{N}_u^T \mathbf{u} = \mathbb{N}_u^T \left\{ \begin{matrix} u_1 \\ u_2 \end{matrix} \right\}$$

$$v(x) = \mathbb{N}_v^T \mathbf{v} = \mathbb{N}_v^T \left\{ \begin{matrix} \begin{pmatrix} v \\ \theta_z \end{pmatrix}_1 \\ \hline \begin{pmatrix} v \\ \theta_z \end{pmatrix}_2 \end{matrix} \right\}$$

$$w(x) = \mathbb{N}_w^T \mathbf{w} = \mathbb{N}_w^T \left\{ \begin{matrix} \begin{pmatrix} w \\ \theta_y \end{pmatrix}_1 \\ \begin{pmatrix} w \\ \theta_y \end{pmatrix}_2 \end{matrix} \right\}$$

Virtuelt arbeid fra hvelvning + aksial + bøyning

$$\int_V \sigma_x \cdot \delta\varepsilon_x \, dV =$$

Aksial Bøyn. om z

$$EA \int_L u_{,x} \cdot \delta u_{,x} \, dx + EI_z \int_L v_{,xx} \cdot \delta v_{,xx} \, dx$$

Bøyn. om y

$$+ EI_y \int_L w_{,xx} \cdot \delta w_{,xx} \, dx$$

$$+ EI_\omega \int_L \varphi_{,xx} \cdot \delta\varphi_{,xx} \, dx \Big\} \quad \begin{array}{l} k_{\varphi\varphi} \\ \text{Hvelvning} \\ \text{når tv.snitt} \\ \text{beholder form} \end{array}$$

$$+ EI_{\overline{\omega}} \int_L \varphi_{1,xx} \cdot \delta\varphi_{1,xx} \, dx \Big\} \quad \begin{array}{l} k_{\varphi_1\varphi_1} \\ \text{Hvelvning-} \\ \text{stivhet} \\ \text{koplet til} \end{array}$$

Forts. ⟶

φ_1

$$\left.\begin{array}{l} -EI_{\omega\bar{\omega}} \int_L \varphi_{,xx} \cdot \delta\varphi_{1,xx}\, dx \\ \boxed{\text{Kobling } \varphi \leftrightarrow \varphi_1} \\ -EI_{\omega\bar{\omega}} \int_L \varphi_{1,xx} \cdot \delta\varphi_{,xx}\, dx \end{array}\right\} \text{Sym. } (1)$$

$$\left.\begin{array}{l} -EI_{\bar{\omega}y} \int_L V_{,xx} \cdot \delta\varphi_{1,xx}\, dx \\ \boxed{\text{Kobling } \varphi_1 \leftrightarrow V} \\ -EI_{\bar{\omega}y} \int_L \varphi_{1,xx} \cdot \delta V_{,xx}\, dx \end{array}\right\} \text{Sym. } (2)$$

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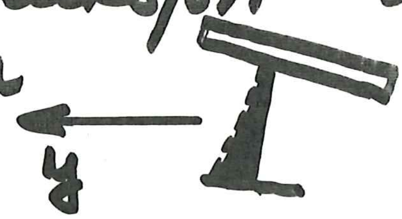
(1): • Reduksjon av torsjonsstivh.
• fra

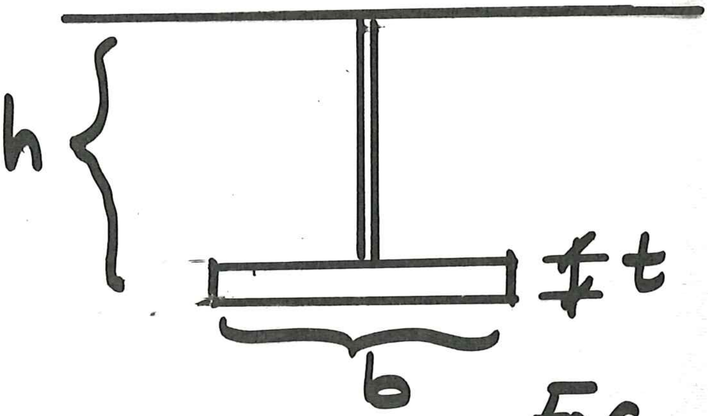


(2): Reduksjon av y-stivhet fra samme.

Tverrsnittskonstanter:

$$I_z = \int_A y^2 \, dA \quad ; \quad I_y = \int_A z^2 \, dA$$

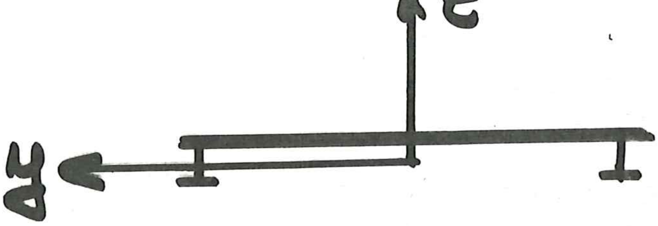
$$I_\omega = \int_A \omega^2 \, dA$$



$$I_{\bar{\omega}} = \int_{A_{Flens}} \bar{\omega}^2 \, dA = \frac{h^2 b^3 t}{12}$$

For hver u.flens

$$I_{\omega\bar{\omega}} = \int_{A_{Flens}} \omega \cdot \bar{\omega} \, dA$$



$$I_{\bar{\omega}y} = \int_{A_{Flens}} \omega \cdot y \, dA \underset{\text{stor bredde}}{\simeq} 0$$

Sub - stivhetsmatriser :

Hvelvning + aksial + bøyning

$$\mathbb{k}_{uu} = EA \int_L \mathbb{N}_{u,x} \, \mathbb{N}_{u,x}^T \, dx \quad (2 \cdot 2)$$

$$\mathbb{k}_{vv} = EI_z \int_L \mathbb{N}_{v,xx} \, \mathbb{N}_{v,xx}^T \, dx \quad (4 \cdot 4)$$

$$\mathbb{k}_{ww} = EI_y \int_L \mathbb{N}_{w,xx} \, \mathbb{N}_{w,xx}^T \, dx \quad (4 \cdot 4)$$

$$\mathbb{k}_{\varphi\varphi} = EI_\omega \int_L \mathbb{N}_{\varphi,xx} \, \mathbb{N}_{\varphi,xx}^T \, dx \quad (4 \cdot 4)$$

$$\mathbb{k}_{\varphi_1\varphi_1} = EI_{\bar{\omega}} \int_L \mathbb{N}_{\varphi_1,xx} \, \mathbb{N}_{\varphi_1,xx} \, dx \quad (4 \cdot 4)$$

Koblings-matriser:

Hvelvning + bøyning

$$\mathbb{k}_{\varphi\varphi_1} = \Theta E I_{\omega\bar{\omega}} \int_L \mathbb{N}_{\varphi,xx}\, \mathbb{N}_{\varphi_1,xx}^T \, dx$$

$\boxed{\text{Symmetri}}$

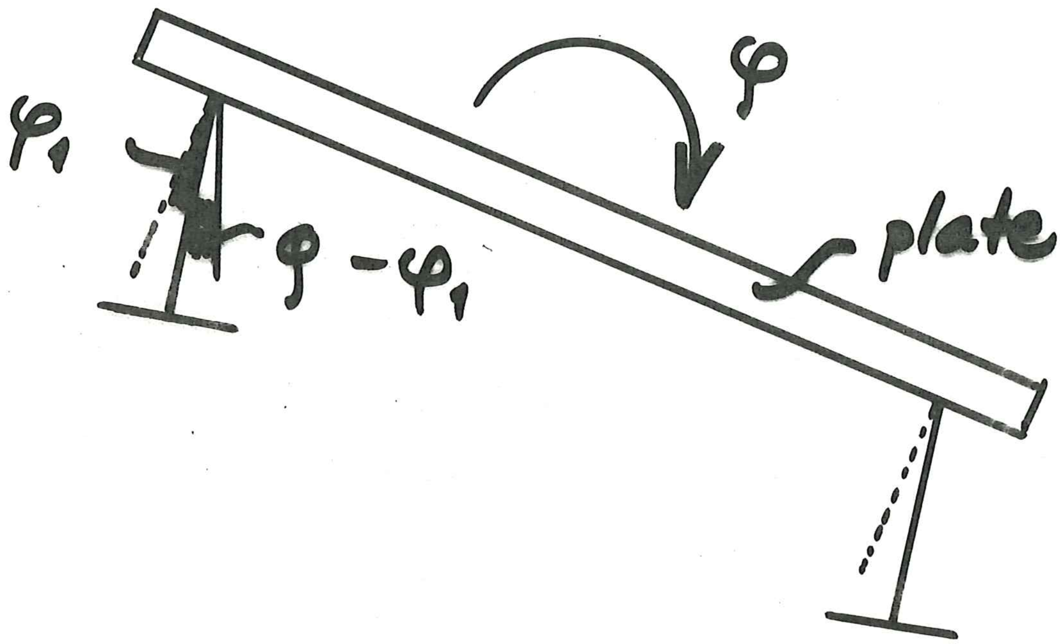
$$\mathbb{k}_{\varphi_1,\varphi} = \Theta E I_{\omega\bar{\omega}} \int_L \mathbb{N}_{\varphi_1,xx}\, \mathbb{N}_{\varphi,xx}^T \, dx$$

$$\mathbb{k}_{v\varphi_1} = \Theta E I_{\bar{\omega}y} \int_L \mathbb{N}_{v,xx}\, \mathbb{N}_{\varphi_1,xx}^T \, dx$$

$\boxed{\text{Symmetri}}$

$$\mathbb{k}_{\varphi_1,v} = \Theta E I_{\bar{\omega}y} \int_L \mathbb{N}_{\varphi_1,xx}\, \mathbb{N}_{v,xx}^T \, dx$$

Virtuelt arbeid fra St. Venant



$$\int_V \tau \cdot \delta\gamma \, dV \longrightarrow \int M_x \cdot \delta\varphi_{,x} \, dx$$

$$= \int_A GI_t \int_L \varphi_{,x} \cdot \delta\varphi_{,x} \, dx \, dA$$

$$\boxed{\begin{aligned} &= (GI_t)_{plate} \cdot \int_L \varphi_{,x} \cdot \delta\varphi_{,x} \, dx \\ &+ \sum (GI_t)_I \cdot \int_L (\varphi_{,x} - \varphi_{1,x}) \cdot (\delta\varphi_{,x} - \delta\varphi_{1,x}) \, dx \end{aligned}}$$

Stivhetsmatriser fra St. Venant

Diagonal submatriser:

$$\mathbb{k}_{\varphi\varphi} = (GI_t)_{hele} \cdot \int_L \mathbb{N}_{\varphi,xx} \mathbb{N}_{\varphi,xx}^T \, dx$$

$$\mathbb{k}_{\varphi_1\varphi_1} = \sum_I (GI_t)_I \cdot \int_L \mathbb{N}_{\varphi 1,xx} \mathbb{N}_{\varphi 1,xx}^T \, dx$$

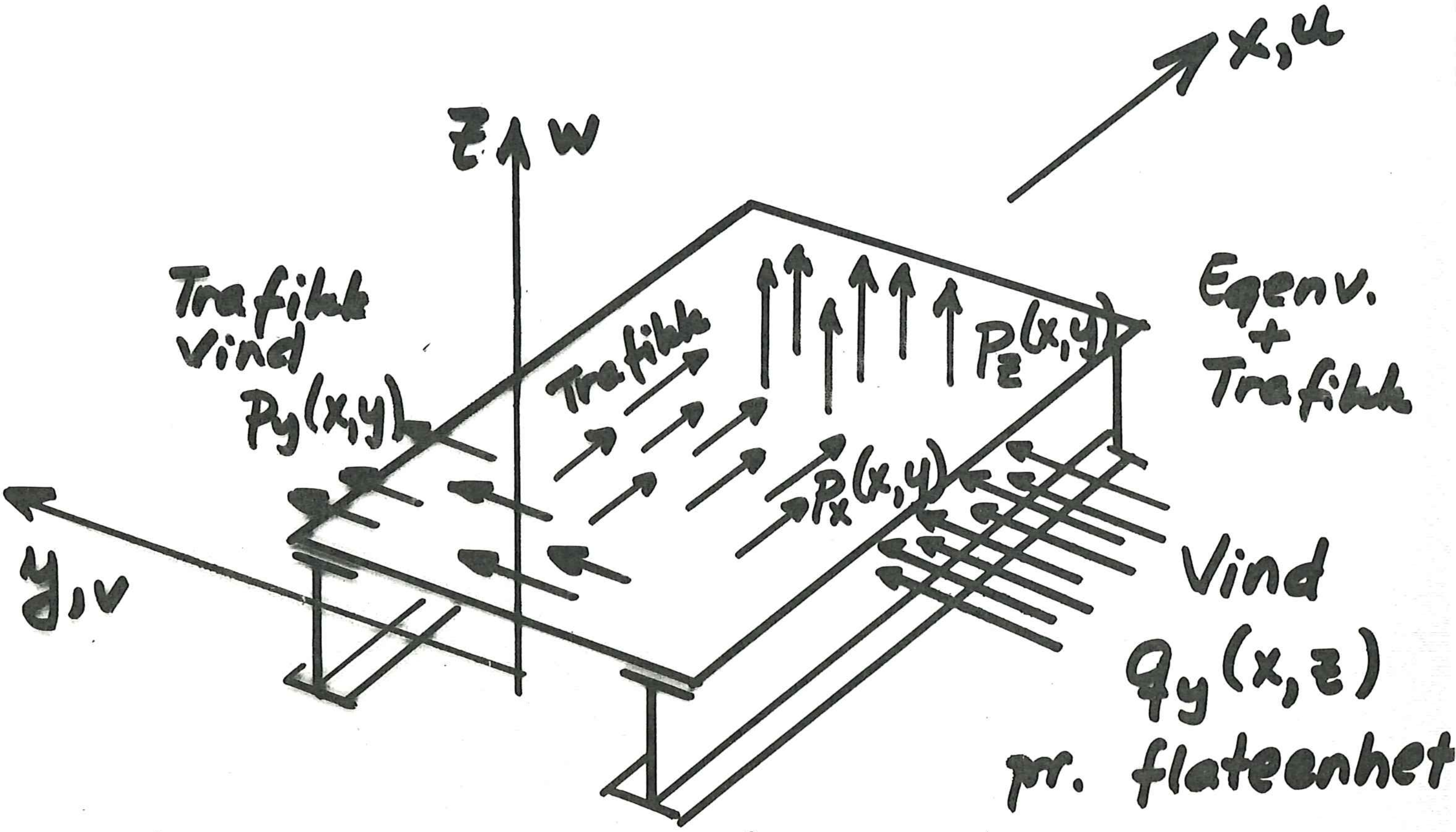
Kryss submatriser:

$$\mathbb{k}_{\varphi\varphi_1} = \div \sum_I (GI_t)_I \cdot \int_L \mathbb{N}_{\varphi,xx} \mathbb{N}_{\varphi 1,xx}^T \, dx$$

$\boxed{\text{Symmetri}}$

$$\mathbb{k}_{\varphi_1\varphi} = \div \sum_I (GI_t)_I \cdot \int_L \mathbb{N}_{\varphi 1,xx} \mathbb{N}_{\varphi,xx}^T \, dx$$

Ytre Laster



Last pr. arealenhet

Virtuelt arbeid fra ytre laster:

$$\int_{S_e} (p_x \cdot \delta u + p_y \cdot \delta v + p_z \cdot \delta w + q_y \cdot \delta v)\, dS$$

Aksiallast p_x

$$u(x,y) = u_0(x) - \varphi_{,x} \cdot \omega - v_{D,x} \cdot y_p - w_{D,x} \cdot z_p$$

$$u(x,y) = \mathbb{N}_u^T(x)\,\mathbb{u} - \omega\,\mathbb{N}_{\varphi,x}^T\,\boldsymbol{\varphi} - y_p\,\mathbb{N}_{v,x}^T\,\mathbb{v} - z_p\,\mathbb{N}_{w,x}^T\,\mathbb{w}$$

$$\delta u(x,y) = \mathbb{N}_u^T\,\delta\mathbb{u} - \omega\,\mathbb{N}_{\varphi,x}^T\,\delta\boldsymbol{\varphi} - y_p\,\mathbb{N}_{v,x}^T\,\delta\mathbb{v} - z_p\,\mathbb{N}_{w,x}^T\,\delta\mathbb{w}$$

$$\int_{A_{pl}} p_x \, \delta u \, dA = \int \delta u^T p_x \, dA$$

$$= \delta \mathbf{u}^T \underbrace{\iint_{A_{pl}} \mathbf{N}_u(x) \cdot p_x(x,y)\, dA}_{} \quad \mathbf{S}_u$$

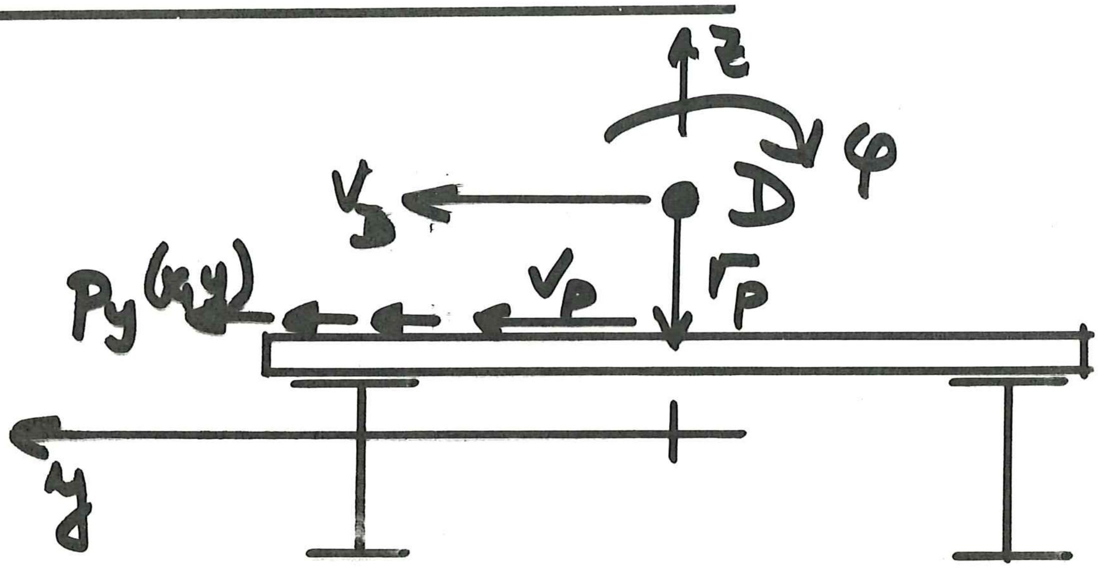
$$- \delta \mathbf{v}^T \underbrace{\iint_{A_{pl}} y_p \cdot \mathbf{N}_{v,x} \cdot p_x(x,y)\, dA}_{} \quad \mathbf{S}_v$$

$$- \delta \mathbf{w}^T \underbrace{\iint_{A_{pl}} z_p \cdot \mathbf{N}_{w,x} \cdot p_x(x,y)\, dA}_{} \quad \mathbf{S}_w$$

$$- \delta \boldsymbol{\varphi}^T \underbrace{\iint_{A_{pl}} \omega \cdot \mathbf{N}_{\varphi,x} \cdot p_x(x,y)\, dA}_{} \quad \mathbf{S}_\varphi$$

Også på plass for bimom. dvs. $\varphi_{,x}$ -plass.

Laterallast p_y



$$v_P = v_D + \varphi \cdot r_P$$

$$= \mathbb{N}_v^T \mathbb{v} + r_P \mathbb{N}_\varphi^T \boldsymbol{\varphi}$$

$$\delta v_P = \mathbb{N}_v^T \delta \mathbb{v} + r_P \mathbb{N}_\varphi^T \delta \boldsymbol{\varphi}$$

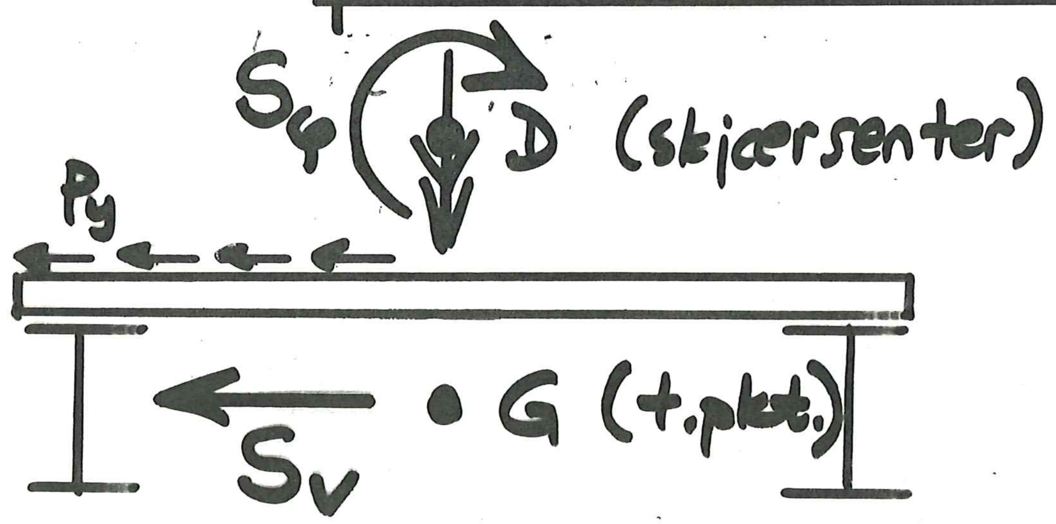
$$= \delta \mathbb{v}^T \mathbb{N}_v + \delta \boldsymbol{\varphi}^T r_P \mathbb{N}_\varphi$$

$$\int_{A_{pl}} p_y \, \delta v_p \, dA$$

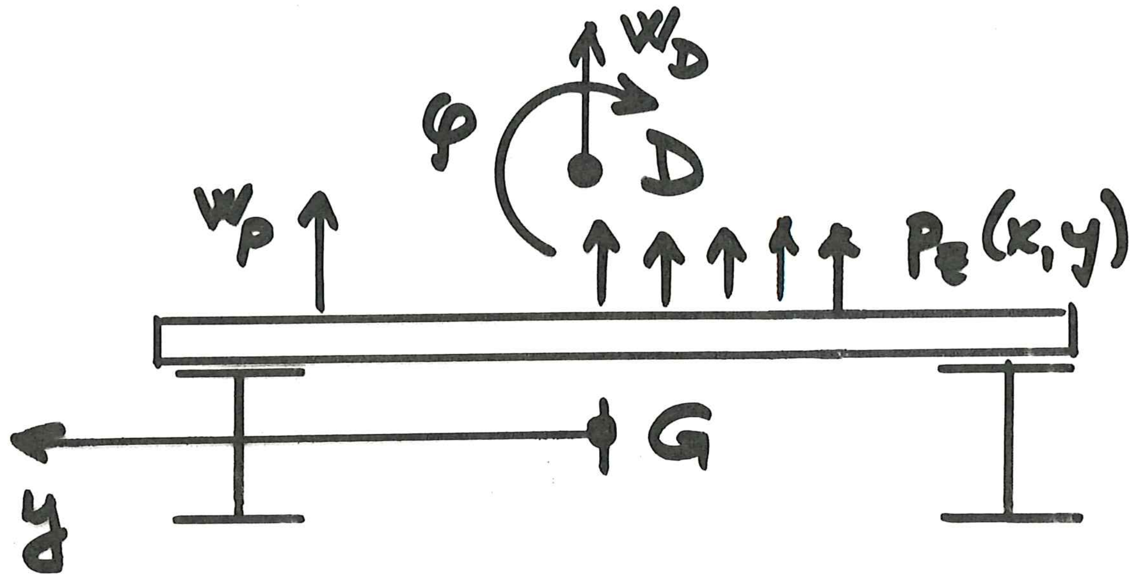
$$= \delta \mathbb{V}^T \iint_{A_{pl}} \mathbb{N}_v(x) \cdot p_y(x,y) \, dA \qquad \mathbb{S}_v$$

$$+ \delta \boldsymbol{\varphi}^T \iint_{A_{pl}} \overbrace{r_p}^{z_D - z_p} \mathbb{N}_\varphi(x) \cdot p_y(x,y) \, dA \qquad \mathbb{S}_\varphi$$

På plass for torsj. mom.
og bimoment



Vertikallast p_z



$$w_P = w_D + \varphi \cdot y$$

$$= \mathbb{N}_w^T \mathbb{w} + y \cdot \mathbb{N}_\varphi^T \boldsymbol{\varphi}$$

$$\delta w_P = \mathbb{N}_w^T \delta \mathbb{w} + y\, \mathbb{N}_\varphi^T \delta \boldsymbol{\varphi}$$

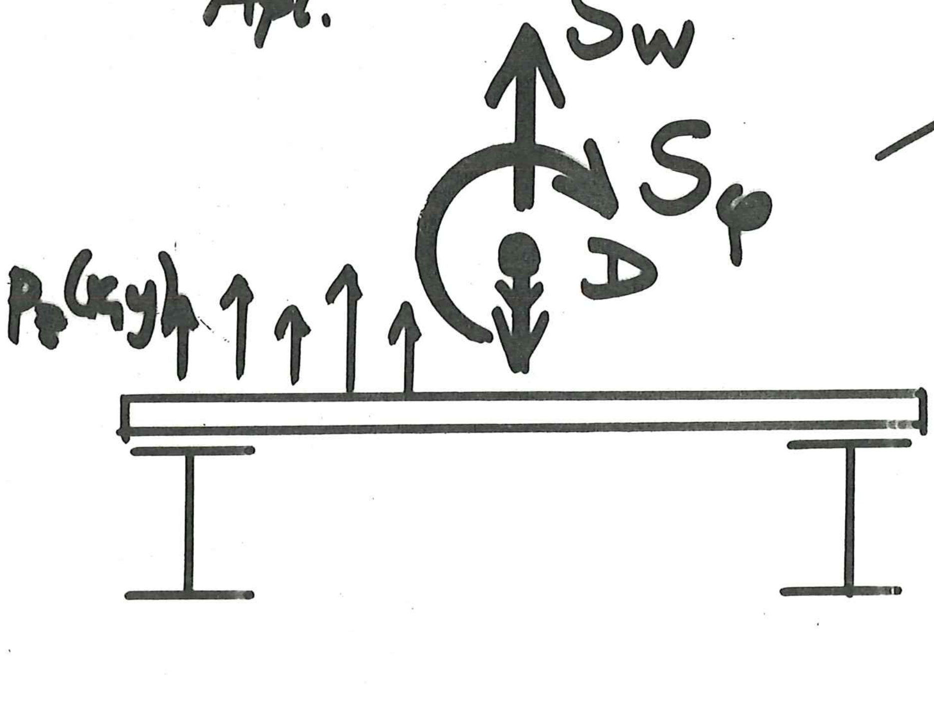
$$= \delta \mathbb{w}^T \mathbb{N}_w + y\, \delta \boldsymbol{\varphi}^T \mathbb{N}_\varphi$$

$$\int_{A_{plate}} p_z \cdot \delta w \, dA =$$

$$\delta \boldsymbol{w}^T \iint_{A_{pl}} \underline{\boldsymbol{N}_w(x) \cdot p_z(x,y)\, dA} \quad \boldsymbol{S}_w$$

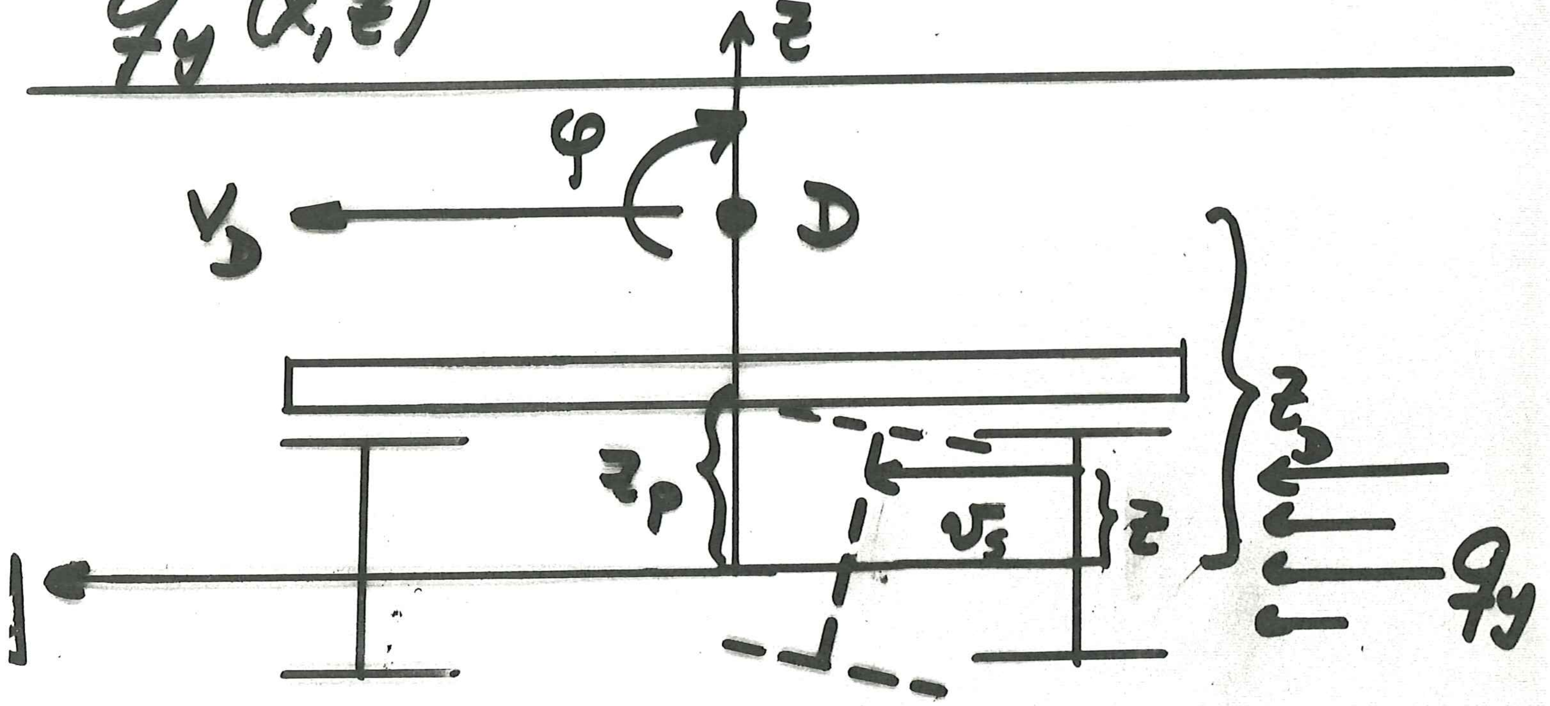
$$+\, \delta \boldsymbol{\Phi}^T \iint_{A_{pl.}} \underline{y\, \boldsymbol{N}_\varphi(x) \cdot p_z(x,y)\, dA} \quad \boldsymbol{S}_{\Phi}$$

<u>På M_x og B.</u>



Vindlast på bærer

$q_y(x,z)$



$$v_s(z) = v_D + \varphi \cdot (z_D - z)$$

$$- \varphi_1 \cdot (z_p - z)$$

$$= \mathbb{N}_v^T(x)\, \mathbb{V} + (z_D - z)\, \mathbb{N}_\varphi^T \Phi$$

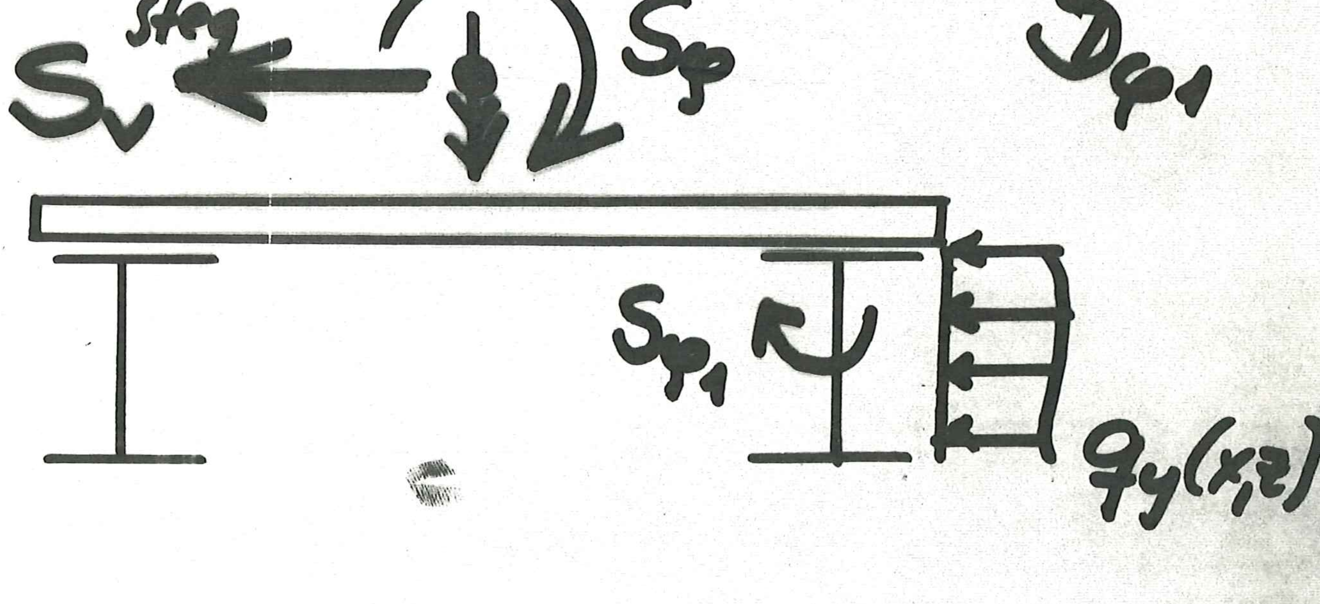
$$- (z_p - z)\, \mathbb{N}_{\varphi_1}^T \Phi_1$$

$$\int_{A_{steg}} q_y \cdot \delta v \, dA =$$

$$\delta \mathbb{v}^T \int_{x}\int_{z\ \mathrm{steg}} \mathbb{N}_v(x) \cdot q_y(x,z)\, dz\, dx \qquad \mathbb{S}_v$$

$$+\ \delta \boldsymbol{\varphi}^T \iint_{\mathrm{steg}} \mathbb{N}_\varphi(x) \cdot (z_D - z) \cdot q_y(x,z)\, dz\, dx \qquad \mathbb{S}_\varphi$$

$$+\ \delta \boldsymbol{\varphi}_1^T \iint_{\mathrm{steg}} \mathbb{N}_{\varphi_1}(x) \cdot (z_P - z) \cdot q_y(x,z)\, dz\, dx \qquad \mathbb{S}_{\varphi 1}$$

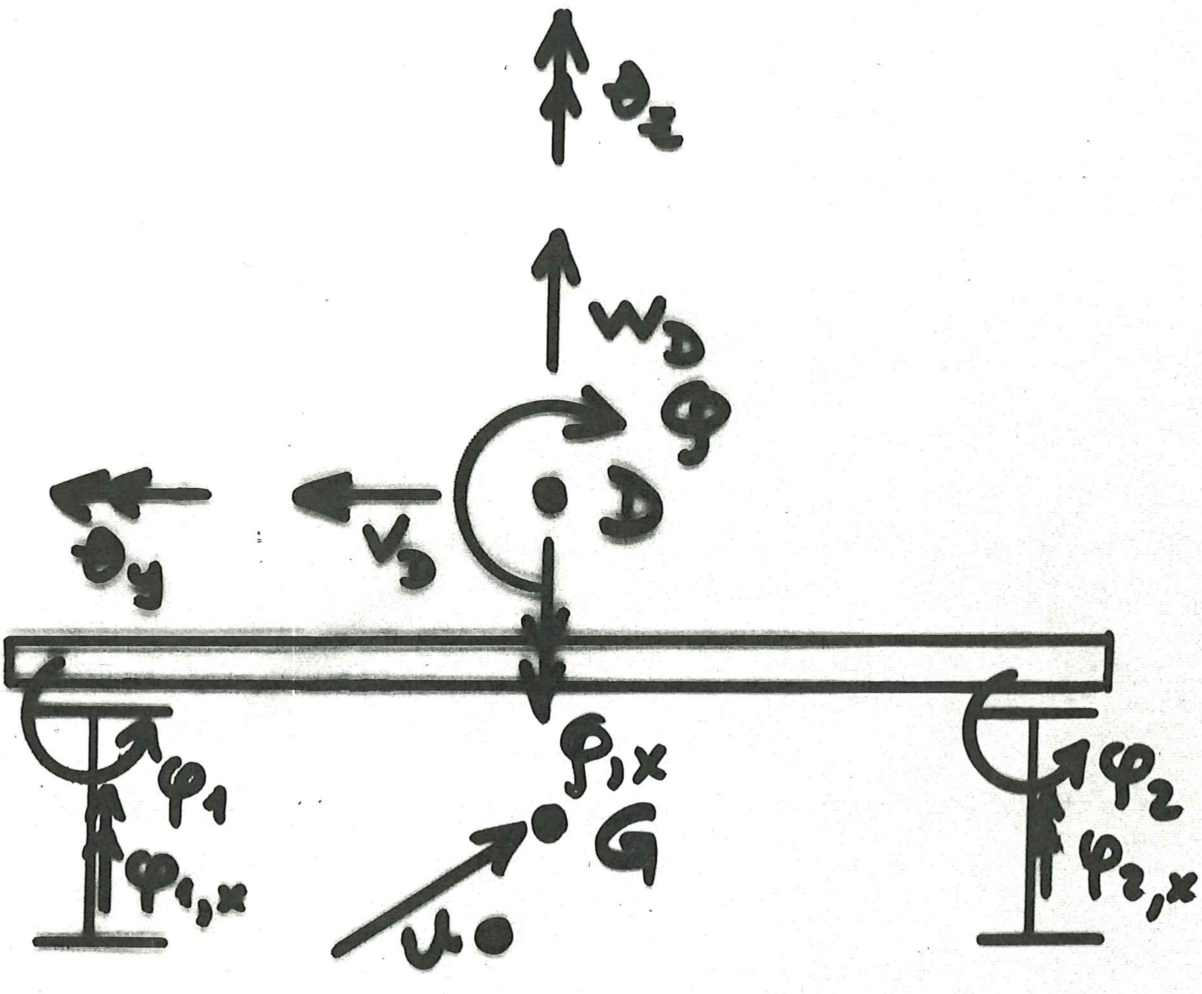


$$
\begin{bmatrix} \underline{S}_u \\ \underline{S}_v \\ \underline{S}_w \\ \underline{S}_\varphi \\ \underline{S}_{\varphi_1} \\ \underline{S}_{\varphi_2} \end{bmatrix}
=
\begin{array}{cccccc}
u & v & w & \varphi & \varphi_1 & \varphi_2 \\
\end{array}
$$

$$
\begin{bmatrix}
K_{uu} & & & & & \\
 & K_{vv} & & & K_{v\varphi_1} & K_{v\varphi_2} \\
 & & K_{ww} & & & \\
 & & & K_{\varphi\varphi} & K_{\varphi\varphi_1} & K_{\varphi\varphi_2} \\
 & K_{\varphi_1 v} & & K_{\varphi_1\varphi} & K_{\varphi_1\varphi_1} & \\
 & K_{\varphi_2 v} & & K_{\varphi_2\varphi} & & K_{\varphi_2\varphi_2}
\end{bmatrix}
\begin{bmatrix} \underline{u} \\ \underline{v} \\ \underline{w} \\ \underline{\varphi} \\ \underline{\varphi}_1 \\ \underline{\varphi}_2 \end{bmatrix}
\begin{array}{l} \}2 \\ \}4 \\ \}4 \\ \}4 \\ \}4 \\ \}4 \end{array}
\quad (22 \cdot 22)
$$

Element - sub - matriser

Parameter



11 DOF pr. node

22 DOF pr. element

Temperaturlast:

$$\sigma_x = E(\varepsilon_x - \alpha T)$$

$$\varepsilon_x = u_{0,x} - \omega\,\varphi_{,xx} + \underbrace{\bar{\omega}\,\varphi_{1,xx}}_{\text{Flens}} - y \cdot v_{D,xx} - z \cdot w_{D,xx}$$

som før

Virtuell:

$$\delta\varepsilon_x = \delta u^T \mathbb{N}_{u,x} - \delta\varphi^T \mathbb{N}_{\varphi,xx} \cdot \omega$$

$$+ \delta\varphi_1^T \mathbb{N}_{\varphi_1,xx} \cdot \bar{\omega}$$

$$- \delta v^T \mathbb{N}_{v,xx} \cdot y - \delta w^T \mathbb{N}_{w,xx} \cdot z$$

$\int \sigma_x \cdot \delta \varepsilon_x \, dV$

gir som tidligere stivheter

+ fra temperatur:

$$- \delta u^T \int_L \int_A N_{u,x} \cdot E\alpha T \, dA \, dx$$

$$+ \delta \varphi^T \int_L \int_A N_{\varphi,x} \cdot \omega E\alpha T \, dA \, dx$$

$$- \delta \varphi_1^T \int_L \int_{A_{\text{Flens}}} N_{\varphi_1,x} \cdot \bar{\omega} E\alpha T \, dA \, dx$$

$$+ \delta v^T \int_L \int_A N_{v,xx} \cdot y \cdot E\alpha T \, dA \, dx$$

$$+ \delta w^T \int_L \int_A N_{w,xx} \cdot z \cdot E\alpha T \, dA \, dx$$

Temperatur-laster:

$$\mathcal{S}_u = \int_L \int_A \mathbb{N}_{u,x} \cdot E\alpha T \, dA \, dx$$

$$\mathcal{S}_v = -\int_L \int_A \mathbb{N}_{v,xx} \cdot y \cdot E\alpha T \, dA \, dx$$

$$\mathcal{S}_w = -\int_L \int_A \mathbb{N}_{w,xx} \cdot z \cdot E\alpha T \, dA \, dx$$

$$\mathcal{S}_\varphi = -\int_L \int_A \mathbb{N}_{\varphi,xx} \cdot \omega \cdot E\alpha T \, dA \, dx$$

$$\mathcal{S}_{\varphi_1} = \int_L \int_{\substack{A \\ \text{Flens}}} \mathbb{N}_{\varphi_1,xx} \cdot \overline{\omega} \cdot E\alpha T \, dA \, dx$$

Svinn i betong:

Analogt temperatur

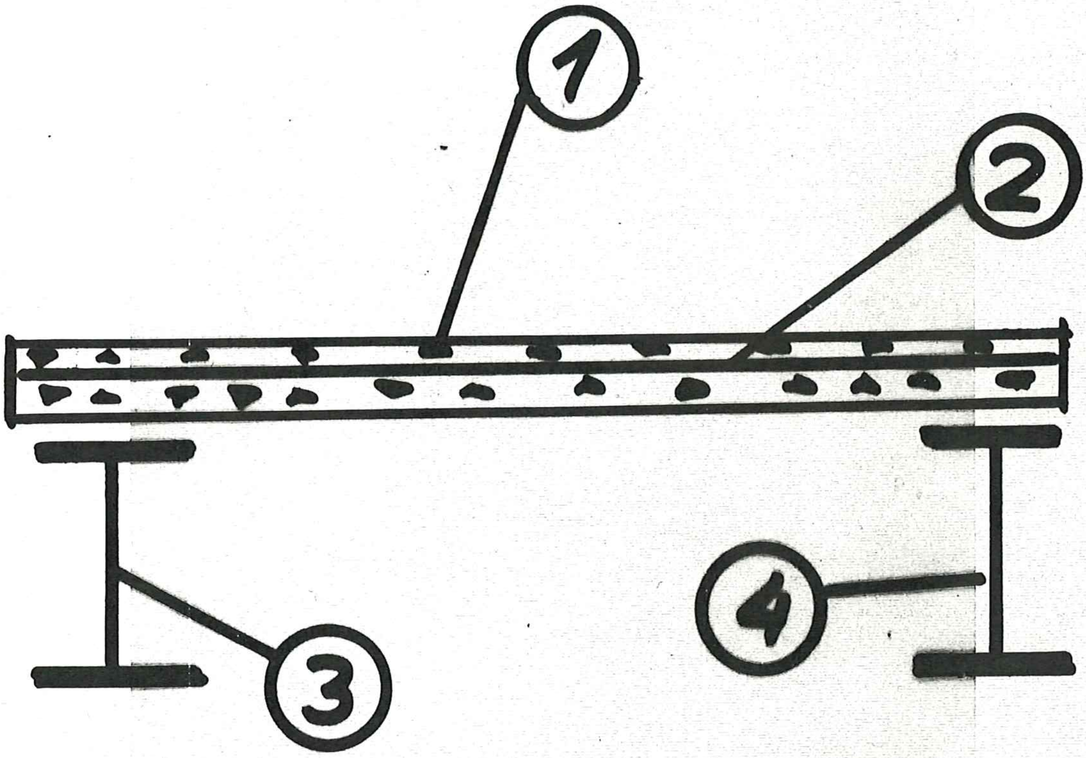
$$\boxed{\alpha T \rightarrow \varepsilon_s}$$

Kryp i betong:

$$\boxed{E = \frac{E_c}{1+\varphi}}$$

Benyttes for langtids last.

Tverrsnittsdeler:



(1) Betongplate

(2) Langsgående arm.

(3) Stålbjelke

(4) Stålbjelke