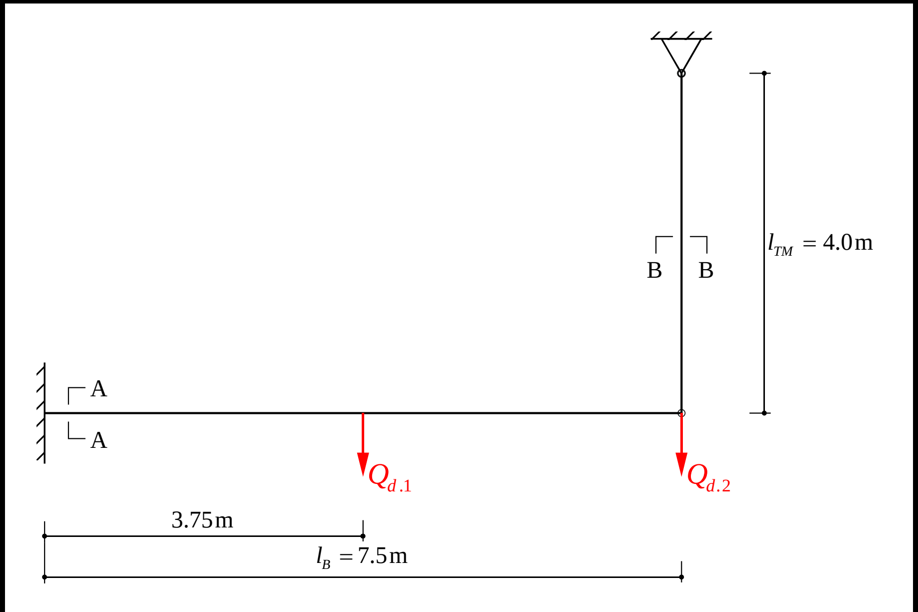
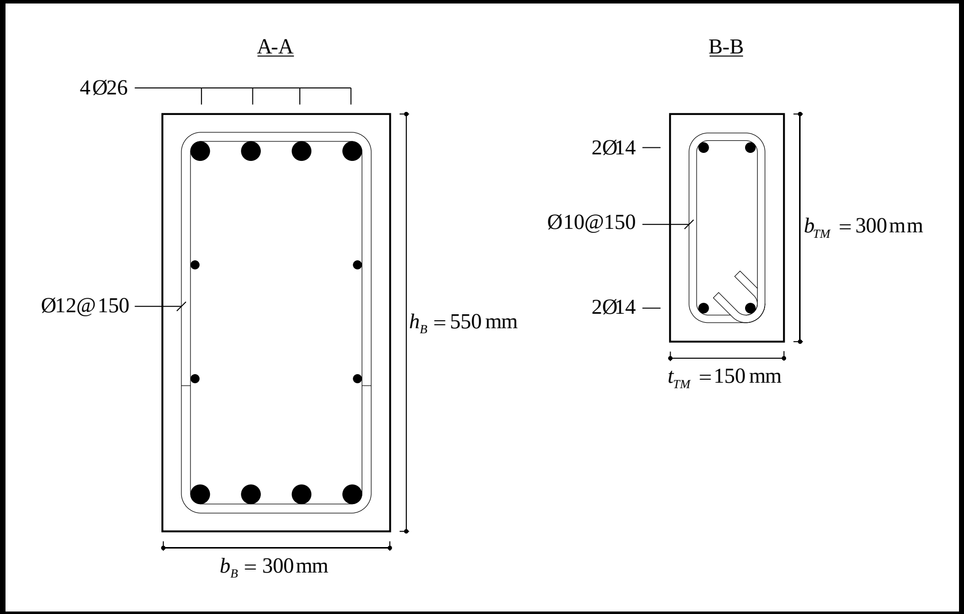
Advanced Structural Concrete

Introduction of Exercise 2

Introduction Ex 2

Deformation demand and deformation capacity





Load scenario 1: $Q_{d.1} = 300\,\mathrm{kN},\ Q_{d.2} = 0\,\mathrm{kN}$

Load scenario 2: $Q_{d.1} = 0\,\mathrm{kN},\ Q_{d.2} = 300\,\mathrm{kN}$

Fully cracked structure: EI^{II}, EA^{II}

Task: Verify bearing capacity of the structure considering the deformation demand and the deformation capacity

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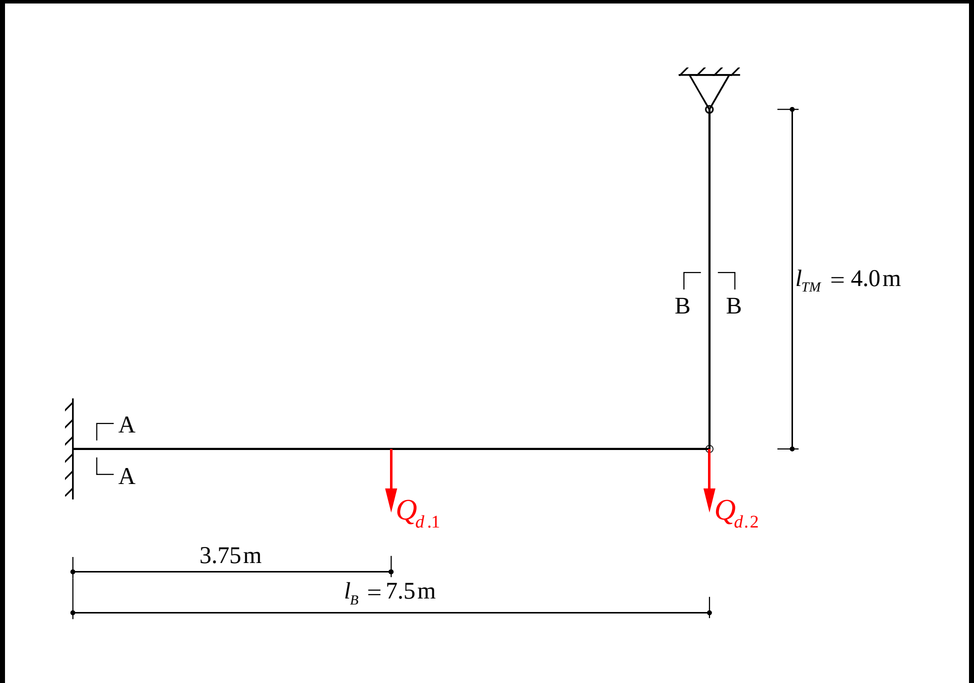
Deformation demand and deformation capacity



Load scenario 1: $Q_{d.1} = 300\,\text{kN},\ Q_{d.2} = 0\,\text{kN}$

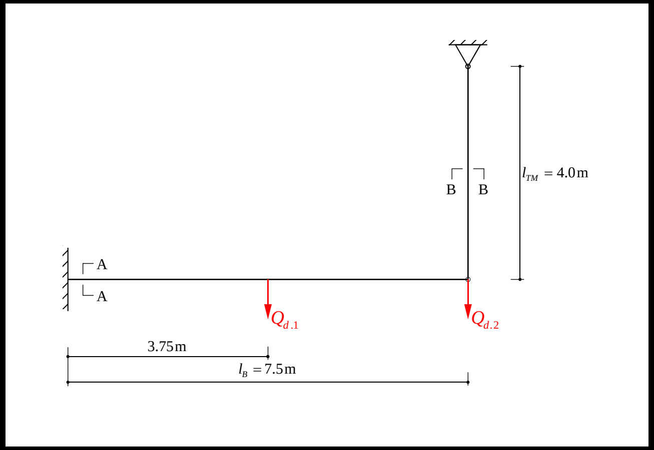
Load scenario 2: $Q_{d.1} = 0\,\text{kN},\ Q_{d.2} = 300\,\text{kN}$

1. Determine section forces and compare with resistance of structure. Redistribution of forces necessary?
2. Deformation demand
3. Deformation capacity
4. Deformation demand vs. deformation capacity

Introduction Ex 2

Determine section forces and compare with resistance of structure. Redistribution of forces necessary?

Load scenario 1: $Q_{d.1} = 300\,\text{kN},\; Q_{d.2} = 0\,\text{kN}$



M

N

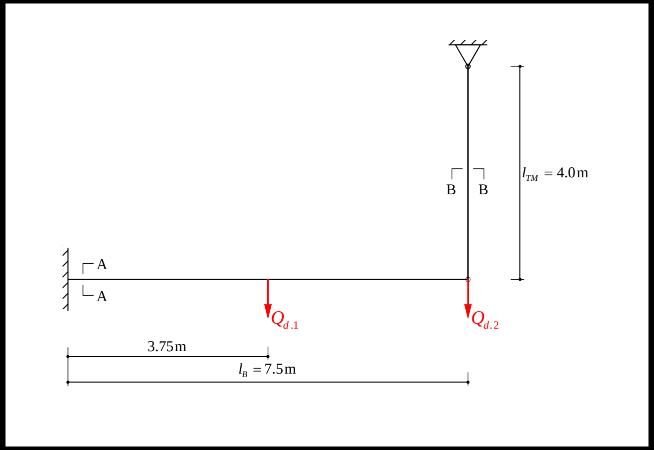
Static systems

+

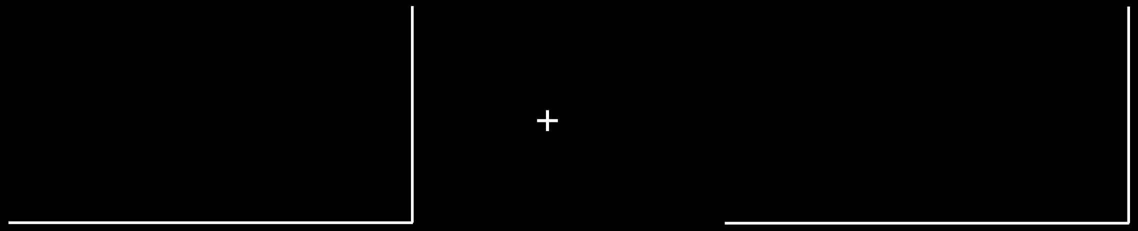
Introduction Ex 2

Deformation demand

Load scenario 1: $Q_{d.1} = 300\,\text{kN},\ Q_{d.2} = 0\,\text{kN}$



Static systems



Introduction Ex 2

Deformation capacity

Rotation capacity:

- Limitation of the plastic rotation by the reinforcing steel (rupture of the reinforcement):

$$\Theta_{pus} = L_{pl} \cdot \left(\frac{\varepsilon_{smu}}{d-x} - \frac{\varepsilon_{smy}}{d-x} \right)$$

Curvature at onset of yielding

Curvature at rupture of the reinforcement

- Limitation of the plastic rotation by the concrete (compressive failure):

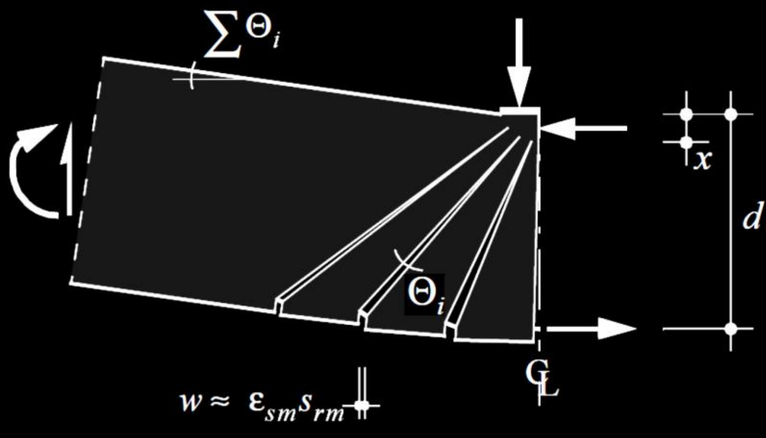
$$\Theta_{puc} = L_{pl} \left(\frac{\varepsilon_{c2d}}{x} - \frac{\varepsilon_{smy}}{d-x} \right)$$

Curvature at onset of yielding

Curvature at concrete crushing

Rotation per crack: $\Theta_i \approx \frac{\varepsilon_{sm} s_{rm}}{d-x}$

Plastic hinge rotation = sum of the plastic rotations of all cracks from the onset of yielding



L_{pl} Plastic hinge length, region in which the chord reinforcement yields

ε_{smu} Mean steel elongation when reaching $\sigma_{sr} = f_t$

ε_{smy} Mean steel elongation when reaching $\sigma_{sr} = f_s$

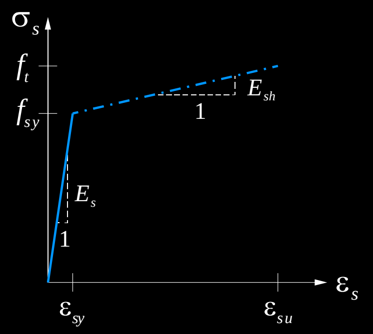
TCM

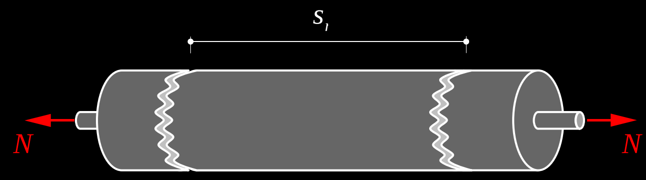
Introduction Ex 2

Deformation capacity

Rotation capacity:

$$\rho_{eff} = \frac{1}{\frac{M_r(d-x)E_s}{f_{ct}EI^{II}} + 1 - n}$$





① Elastic reinforcement over entire crack element:

$$\varepsilon_m = \frac{\sigma_{sr}}{E_s} - \frac{\tau_{b0}s_r}{E_s\varnothing} = \frac{\sigma_{sr}}{E_s} - \lambda\frac{f_{ctm}(1-\rho)}{2E_s\rho}$$

$$\sigma_{sr} \leq f_{sy}$$

② Reinforcement yields near cracks, elastic between cracks:

$$\varepsilon_m = \frac{(\sigma_{sr} - f_{sy})^2\varnothing}{4E_{sh}\tau_{b1}s_r}\left(1 - \frac{E_{sh}\tau_{b0}}{E_s\tau_{b1}}\right) + \frac{(\sigma_{sr} - f_{sy})}{E_s}\frac{\tau_{b0}}{\tau_{b1}} + \left(\varepsilon_{sy} - \frac{\tau_{b0}s_r}{E_s\varnothing}\right)$$

$$f_{sy} \leq \sigma_{sr} \leq \left(f_{sy} + \frac{2\tau_{b1}s_r}{\varnothing}\right)$$

③ Reinforcement yields over entire crack element:

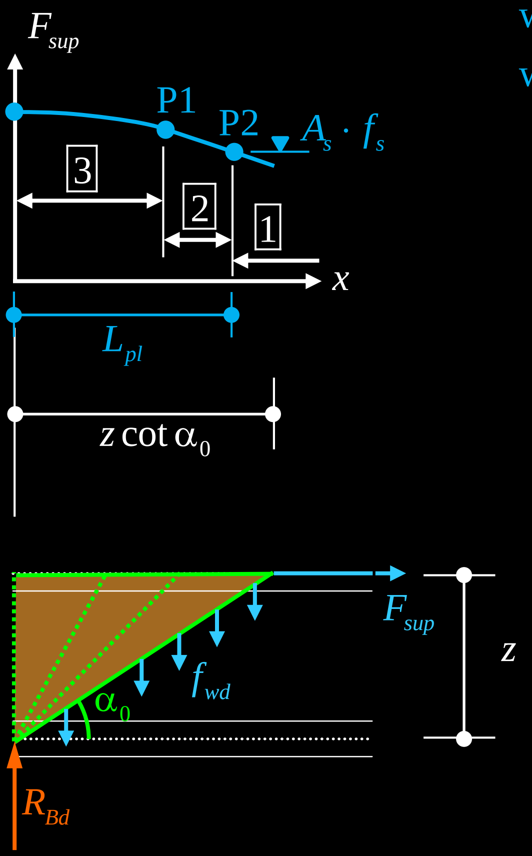
$$\varepsilon_m = \varepsilon_{sy} + \frac{(\sigma_{sr} - f_{sy})}{E_{sh}} - \frac{\tau_{b1}s_r}{E_{sh}\varnothing}$$

$$\left(f_{sy} + \frac{2\tau_{b1}s_r}{\varnothing}\right) \leq \sigma_{sr} \leq f_{su}$$

Introduction Ex 2

Deformation capacity

Rotation capacity:



with P1: $\sigma_{smin} = f_s$

with P2: $\sigma_{sr} = f_s$

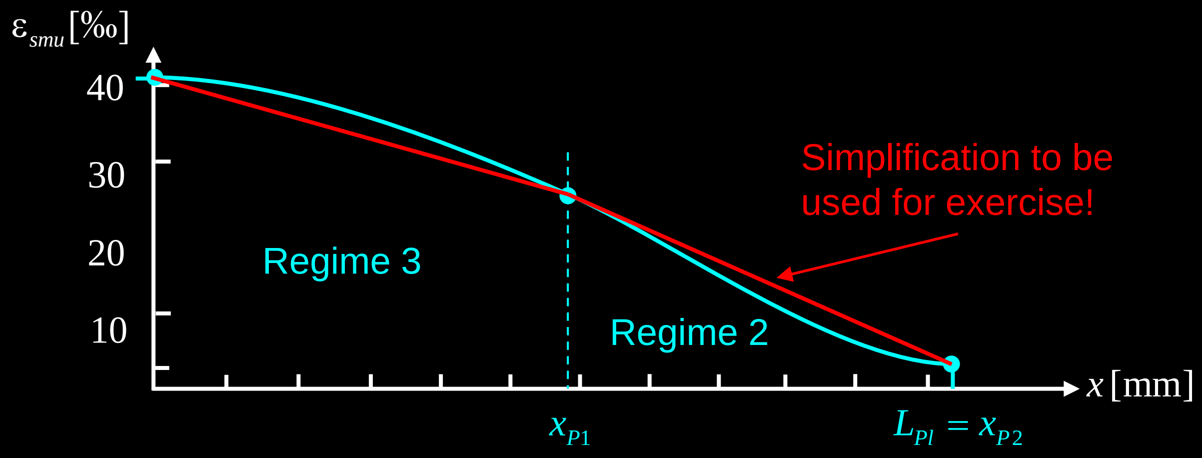
3 fully yielded

2 partially yielded

1 elastic

$$x_{P2} = \sqrt{\frac{2A_s\left(f_t - f_s\right)z}{f_{wd}}}$$

$$x_{P1} = \sqrt{\frac{2A_s\left(f_t - f_s - \frac{2\tau_{b1}s_r}{\varnothing}\right)z}{f_{wd}}}$$



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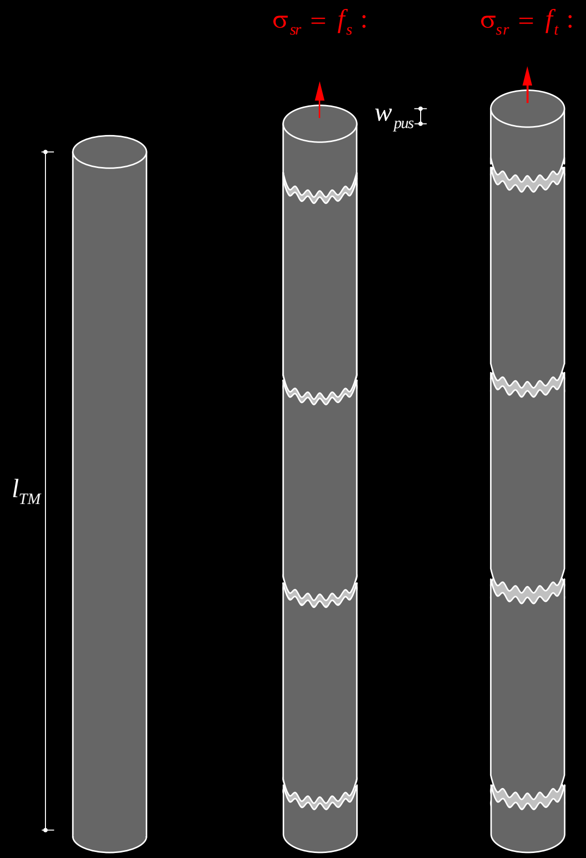
Deformation capacity

Tension member:



$$w_{pus} = \left(\varepsilon_{sm}\left(\sigma_{sr} = f_t\right) - \varepsilon_{sm}\left(\sigma_{sr} = f_s\right)\right) \cdot l_{TM}$$

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Organisation

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