1C3 Design of bridges

Jakub Dolejš

Tomáš Rotter

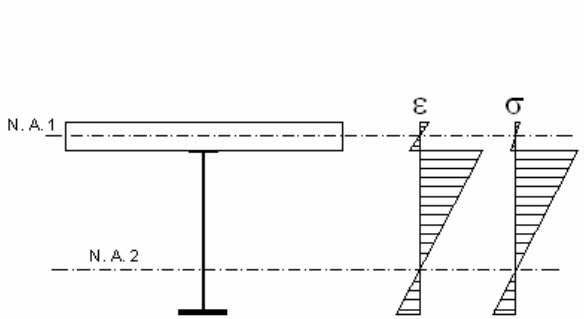
List of lectures

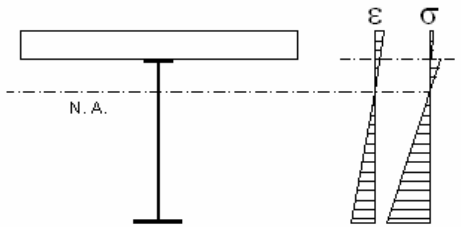
1. History and types of steel bridges
2. Fundamental terms
3. Basis of design
4. Bearings, expansion joint, bridge accessories
5. Bridge deck
6. Plate girder steel bridges 1
7. Plate girder steel bridges 2
8. Plate girder steel bridges 3
9. Composite steel-concrete bridges 1
10. Composite steel-concrete bridges 2
11. Truss girder bridges
12. Pedestrian footbridges
13. Examples of bridge structures

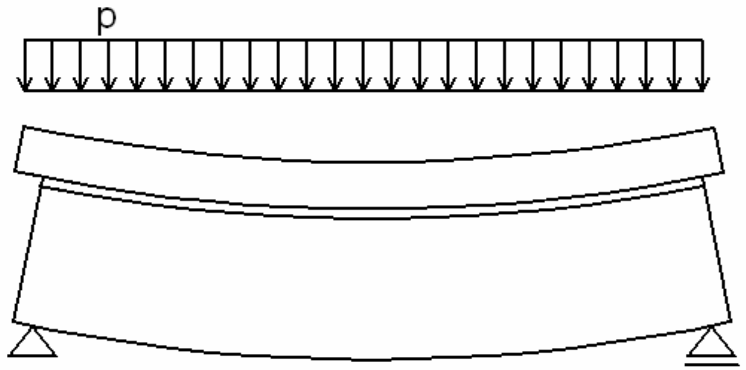
Objectives of the lecture 9

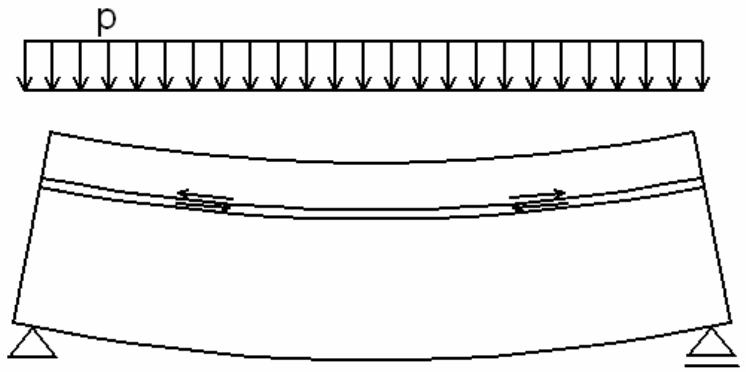
- basic principles
- global analysis
- ultimate limit states
- serviceability limit states
- examples

Basic principles



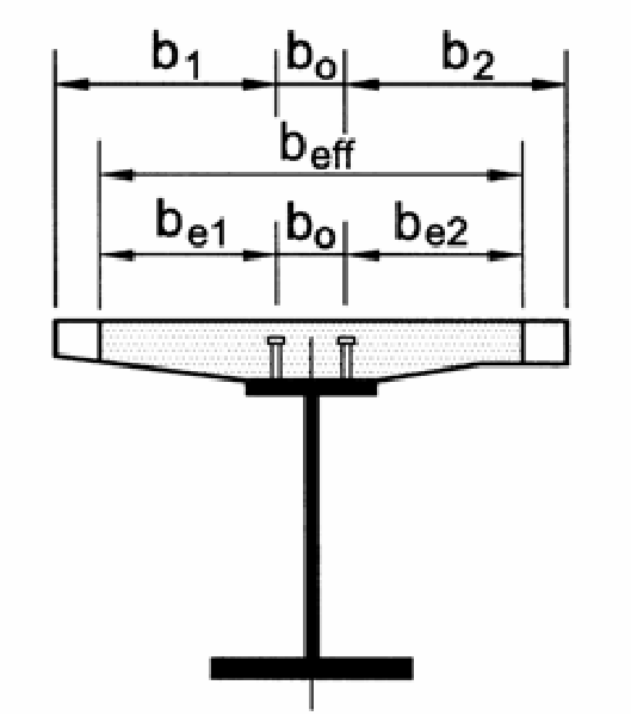






Global analysis

Effective width of concrete deck

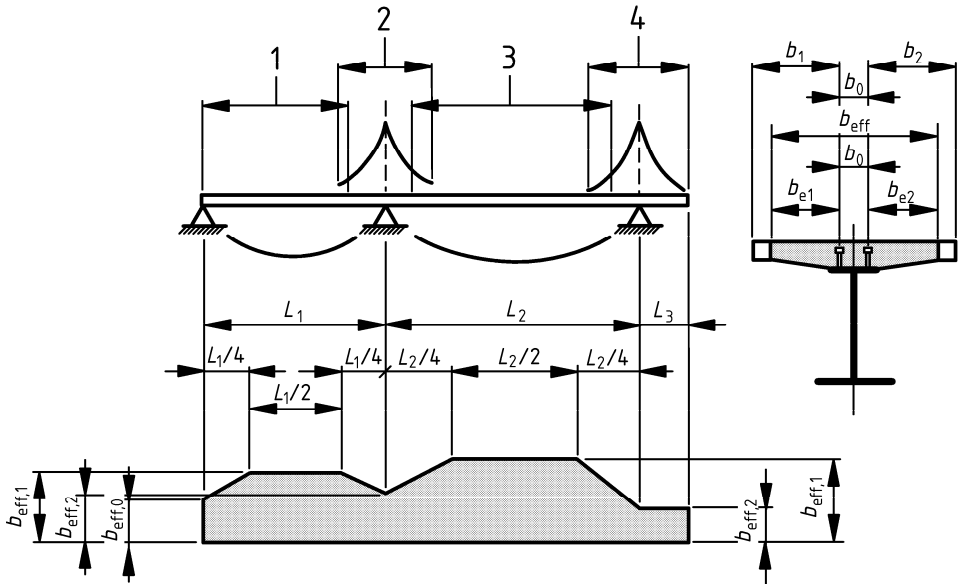


$$B_{eff} = \min\left[(b_1 + b_0 + b_2); (b_{e1} + b_0 + b_{e2})\right]$$

$$b_{e1} = L/8$$

Global analysis

Multispan bridge – effective width



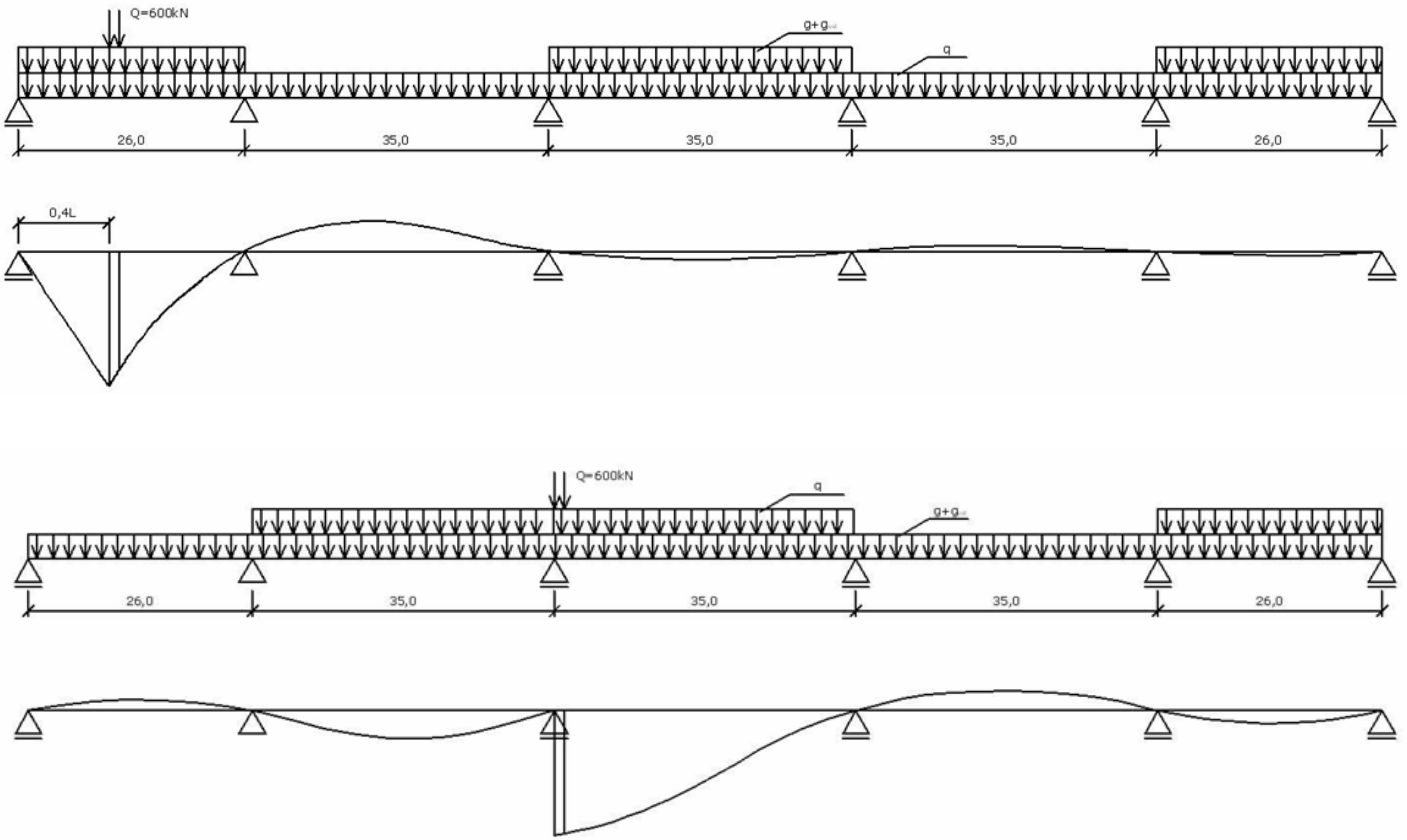
1 $L_e = 0{,}85\ L_1$ for $b_{eff,1}$
2 $L_e = 0{,}25\ (L_1 + L_2)$ for $b_{eff,2}$
3 $L_e = 0{,}70\ L_2$ for $b_{eff,1}$
4 $L_e = 2L_3$ for $b_{eff,2}$

$$b_{eff} = b_0 + \sum \beta_i b_{ei}$$

$$\beta_i = (0{,}55 + 0{,}025 L_e / b_{ei}) \leq 1{,}0$$

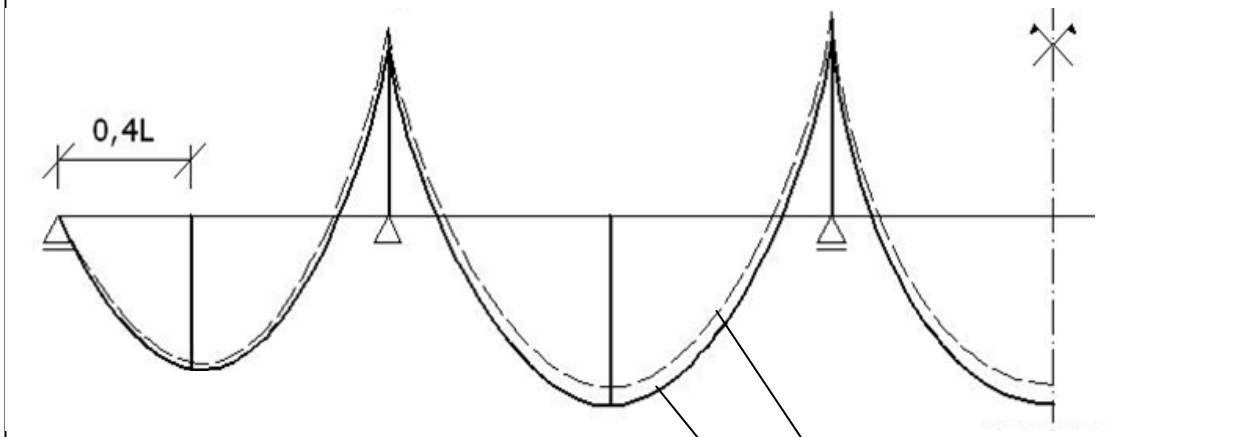
Global analysis

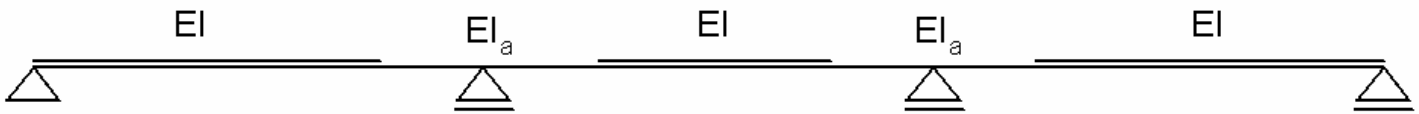
Multispan bridge – influence lines (example)



Global analysis

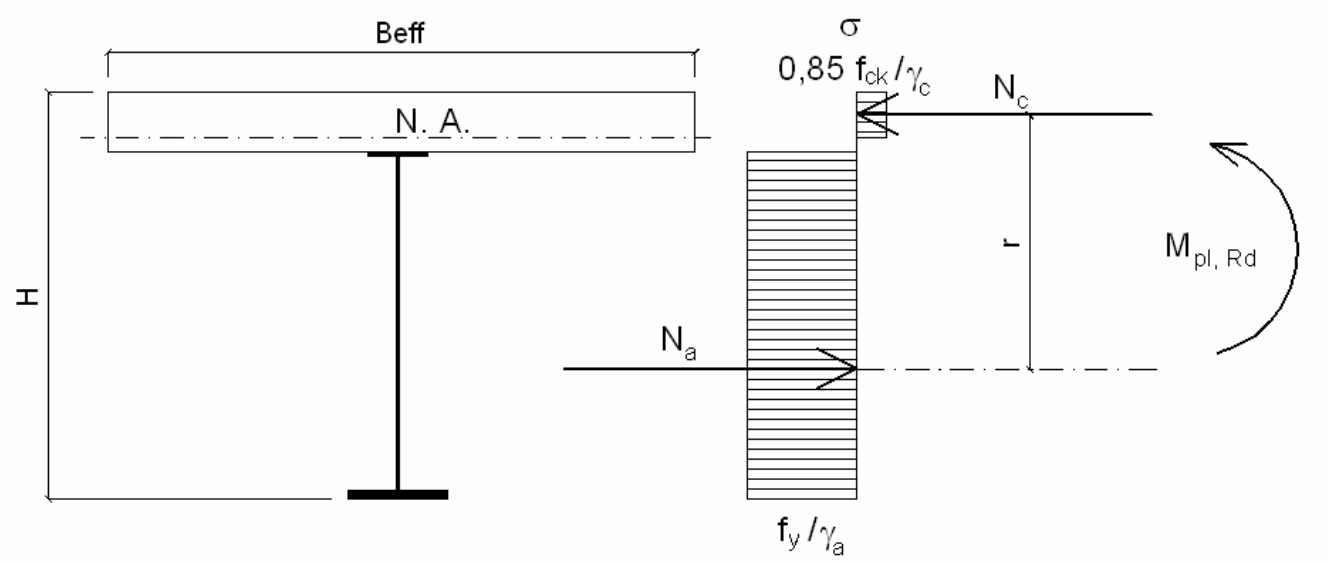
Redistribution of moments





ULS

1. Neutral axis in concrete, positive moment



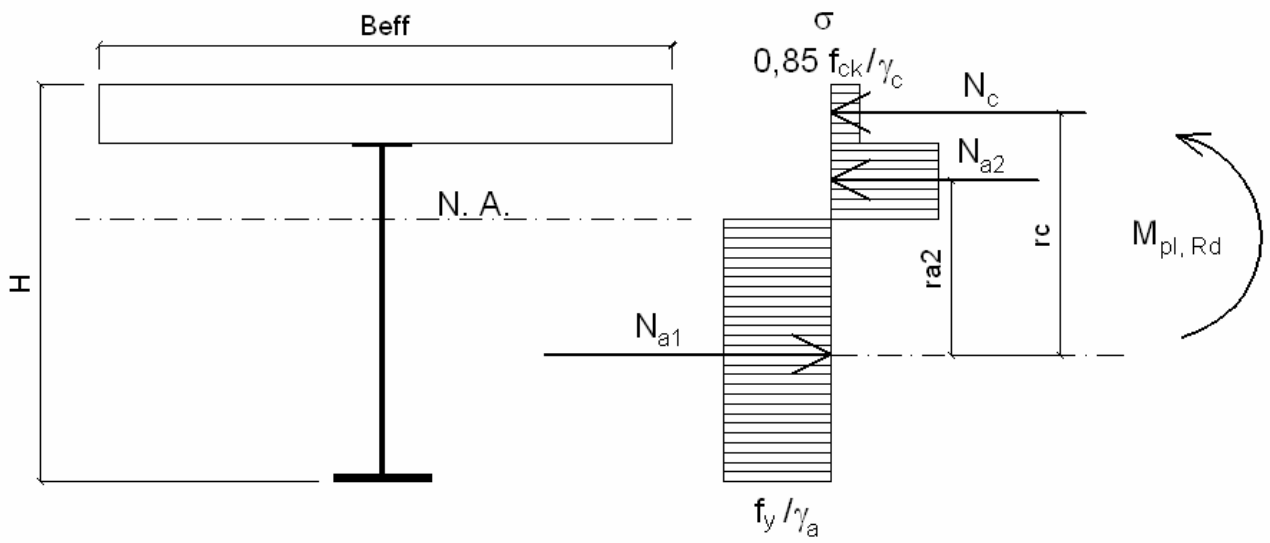
$$N_{c,f} = N_{pl,a}$$

$$0{,}85 \,.\, B_{eff} \,.\, x \,.\, f_{c,k} \,/\, \gamma_c = A_a \,.\, f_y \,/\, \gamma_a$$

$$M_{pl,Rd} = N_a \,.\, r = N_c \,.\, r$$

ULS

2. Neutral axis in steel, positive moment



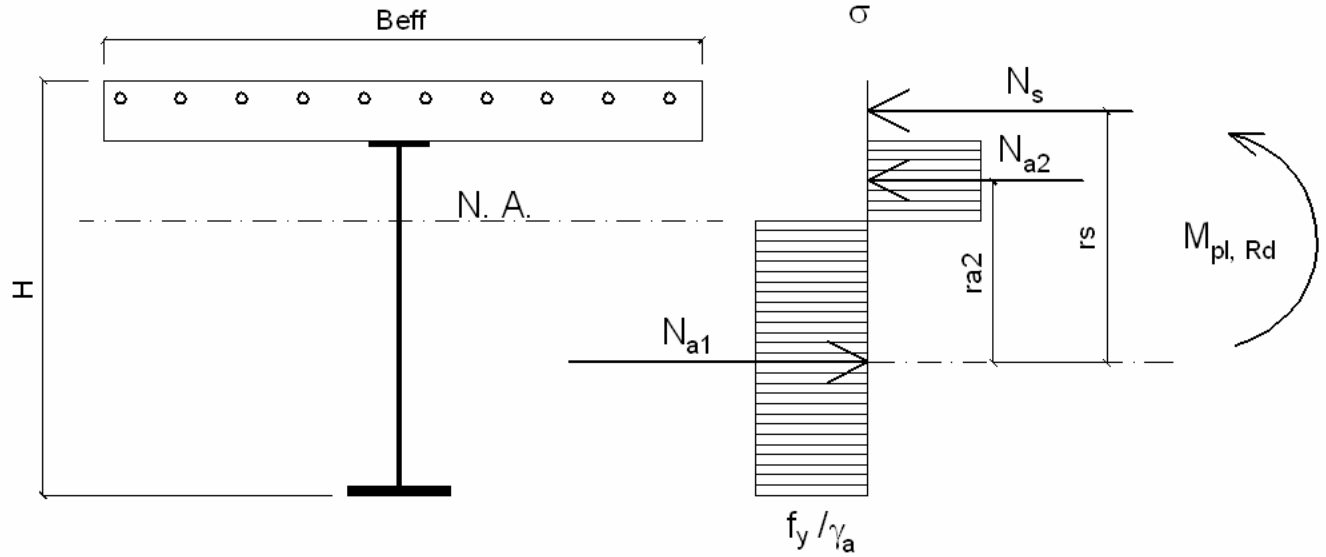
$$N_c + N_{a2} = N_{a1}$$

$$0{,}85 \,.\, A_c \,.\, f_{c,k} \,/\, \gamma_c + A_{a2} \,.\, f_y \,/\, \gamma_a = A_{a1} \,.\, f_y \,/\, \gamma_a$$

$$M_{pl,Rd} = N_c \,.\, r_c + N_{a2} \,.\, r_{a2}$$

ULS

3. Neutral axis in steel, negative moment



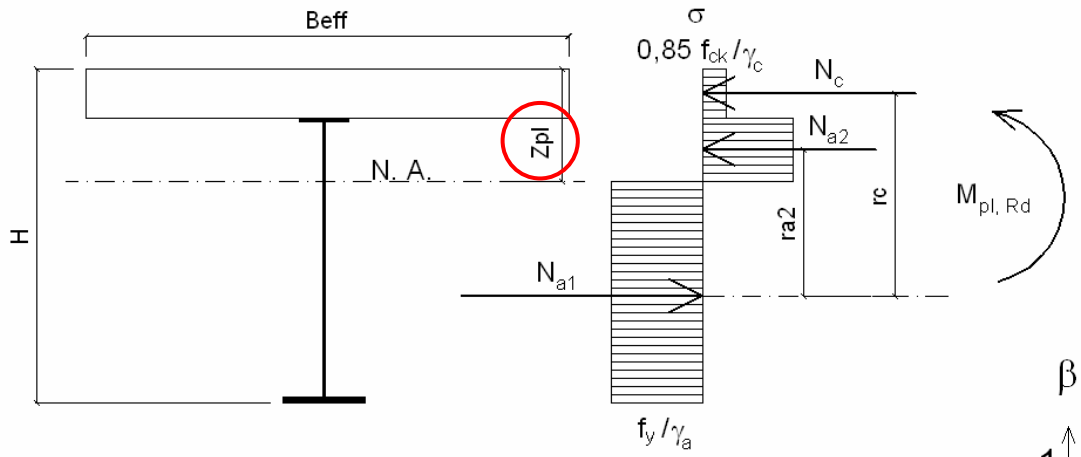
$$N_s + N_{a2} = N_{a1}$$

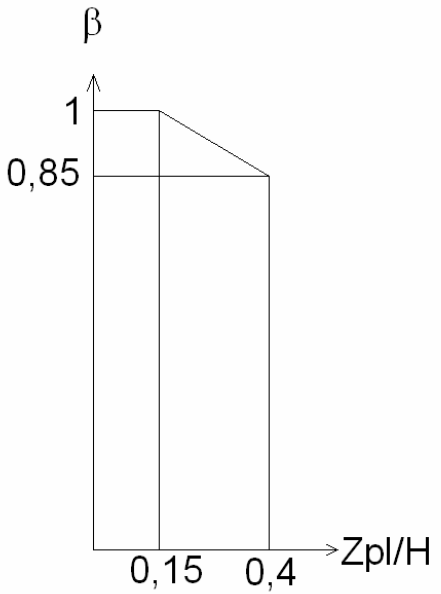
$$A_s \cdot f_s / \gamma_s + A_{a2} \cdot f_y / \gamma_a = A_{a1} \cdot f_y / \gamma_a$$

$$M_{pl,Rd} = N_s \cdot r_s + N_{a2} \cdot r_{a2}$$

ULS

Reduction of moment resistance



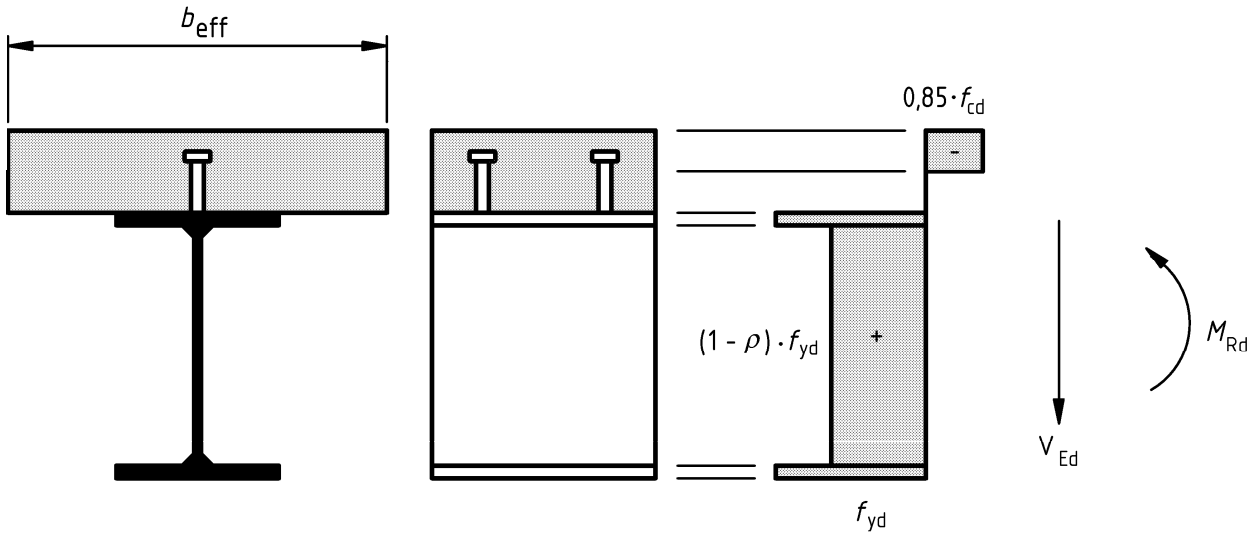


$$M_{pl,Rd} = \beta \left(N_c \,.\, r_c + N_{a2} \,.\, r_{a2} \right)$$

ULS

Moment resistance reduction due to vertical shear

$$\rho = \left(2V_{Ed}/V_{Rd} - 1\right)^2$$



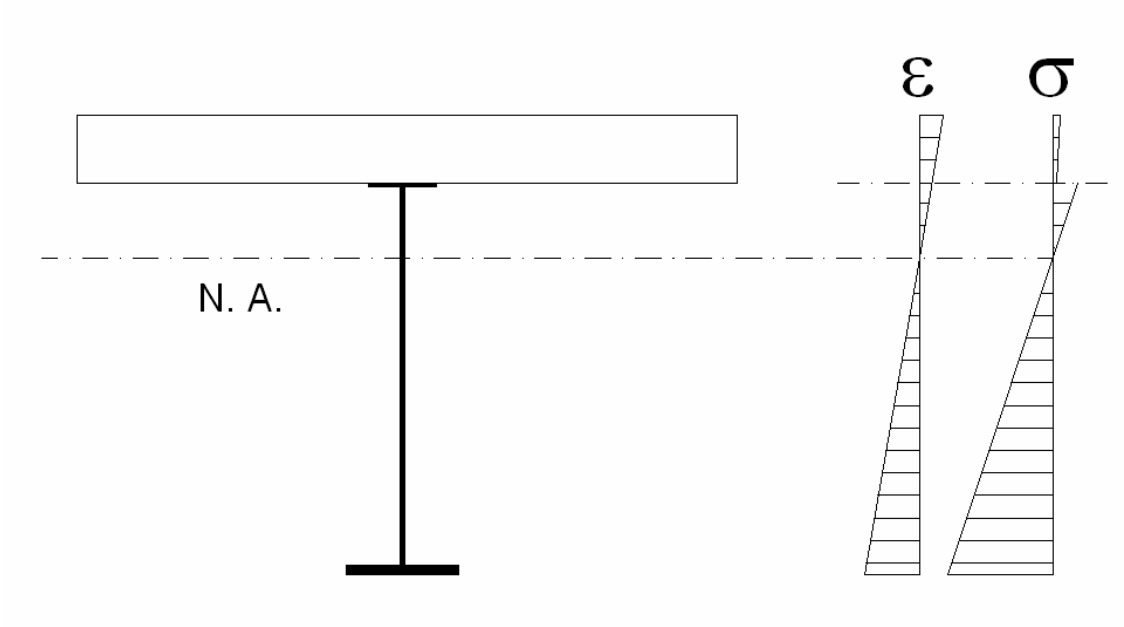
Serviceability limit states

Deflection

Stress

(Web breathing)

Visual impression



Serviceability limit states

Elastic analysis:

- concrete relaxation
- short / long term loads
- effect of shrinkage

$$n_L = n_0 \left(1 + \psi_L \varphi_t\right)$$

$$n_0 = E_a / E_{cm}$$

Serviceability limit states

Brandýsek: 3 spans, 2 x 5 beams

Serviceability limit states

Mosty u Jablunkova

Serviceability limit states

Ostrov

Serviceability limit states

Děčín

Thank you
for your kind attention

Notes to users of the lecture

- This session is a basic information about actions on bridges and requires about 60 min lecturing.
- The use of relevant standards of national standard institutions are strongly recommended.
- Keywords for the lecture:

  composite bridge, shear connection, steel, concrete, road bridge, footbridge, railway bridge, Eurocodes.