Budapest University of Technology and Economics

Department of Mechanics, Materials and Structures

English courses

Reinforced Concrete Structures

Code: BMEEPSTK601

Lecture no. 11:

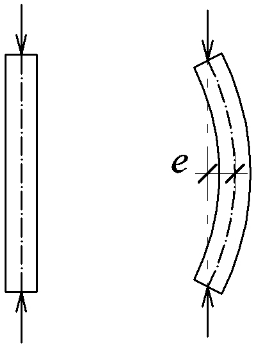
REINFORCED CONCRETE SECTIONS SUBJECTED TO AXIAL AND ECCENTRIC COMPRESSION

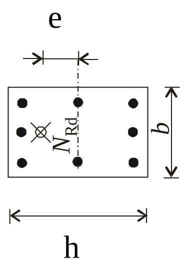
Content:

Introduction

Introduction

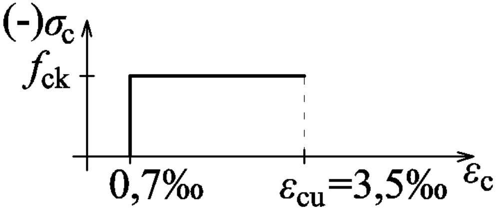
The Eurocode 2 does not distinguish axial and eccentric compression, because due to imperfection, the theoretically axial compression force does always have some eccentricity.

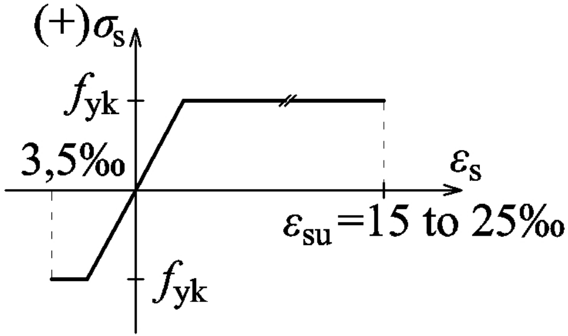




1. Suppositions

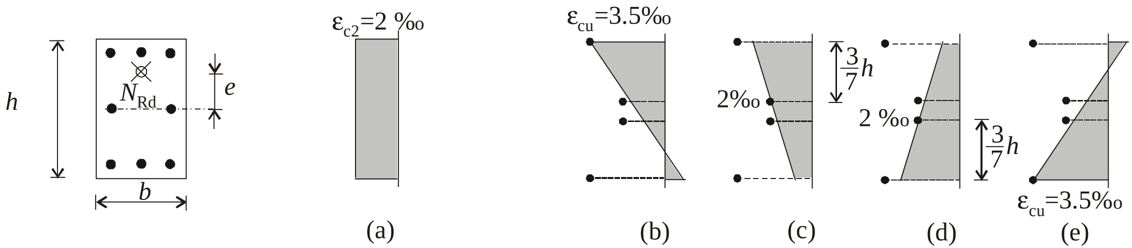
-plane sections remain plane
-bound connectionbetween concrete and steel is perfect
-the mechanical behavior of concrete and steel can be modelled by the idealized σ-ε relationships indicated below:





2. Failure modes

Failure modes of the rc. section subjected to axial or eccentric compression can be given by the ε-diagrams given below



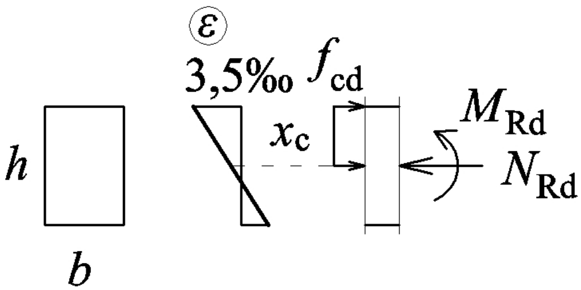
The deformation of the steel at rupture of the concrete extreme fibre is

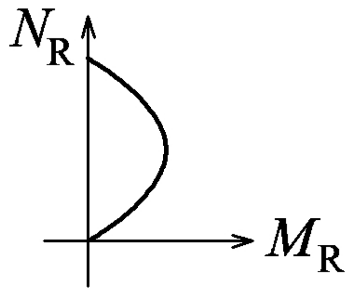
$\varepsilon_s \prec \varepsilon_{s1} = \frac{f_{yd}}{E_s}$, that is steel is in the elastic state: $\sigma_s = \frac{560}{\xi_c} - 700$ (N/mm^2)

For practical design the use of M_R-N_R capacity curves is recommended!

3. The M_R-N_R capacity diagram of concrete sections

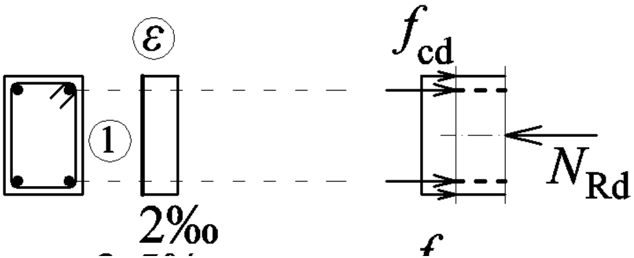
For concrete sections the M_R-N_R capacity curve has the character indicated below. Because of zero tensile strength of the concrete, at N_R=0, the capacity moment M_R=0.





4. The M_R-N_R capacity diagram of reinforced concrete sections

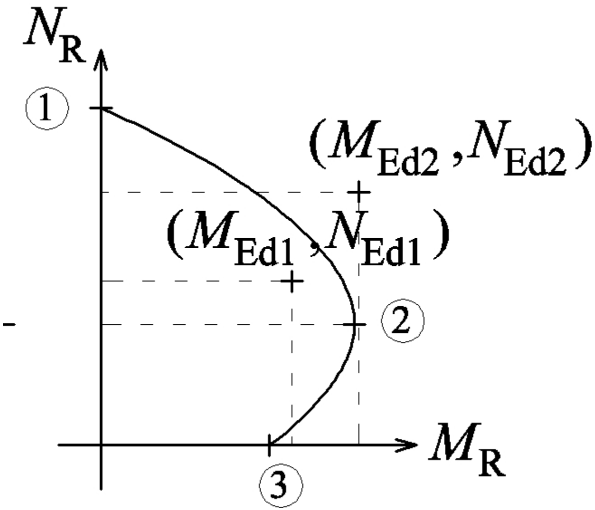
Point 1: axial compression



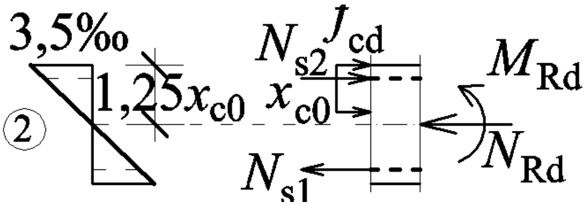
$$N_{Rd} = A_c f_{cd} + A_s f_{yd} = N'_u$$

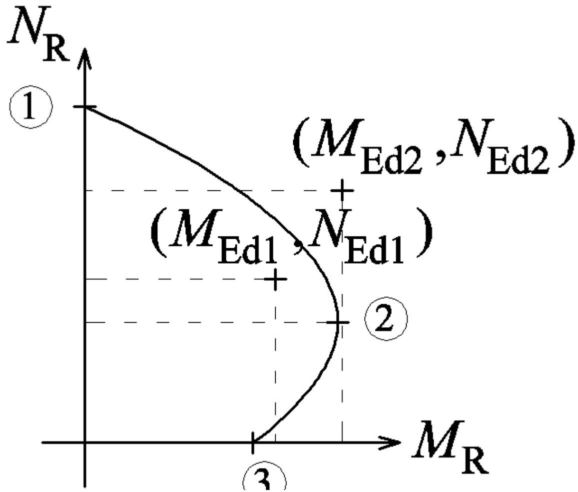
$$\mathrm{M}_{\mathrm{Rd}} = 0$$

-



Point 2: eccentric compression $(x_c=x_{co})$



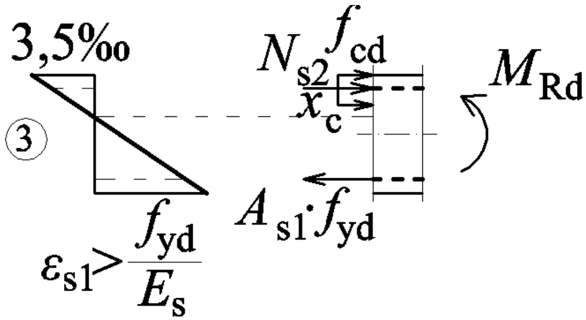


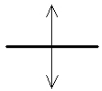
$$N_{Rd} = bx_{co}f_{cd} = N_{bal}$$

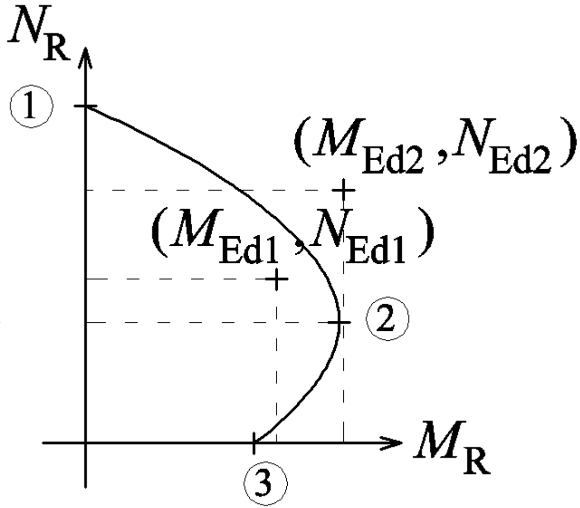
$$M_{Rd} = N_{bal}\left(\frac{h}{2} - \frac{x_{co}}{2}\right) + A_{s1}f_{yd}z_s =$$

$$= \Delta M_R + M_s = M_{Rd,max}$$

Point 3: flexure



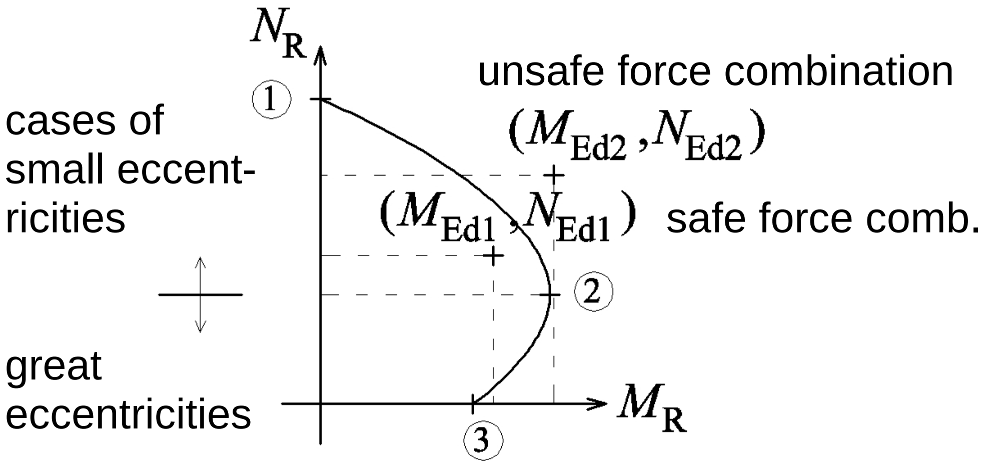




$N_{Rd}=0$

$$M_{Rd} \approx A_{s1} f_{yd} z_s = M_s$$

5. Safe and unsafe applied force combinations



6. Applied force combinations to be investigated

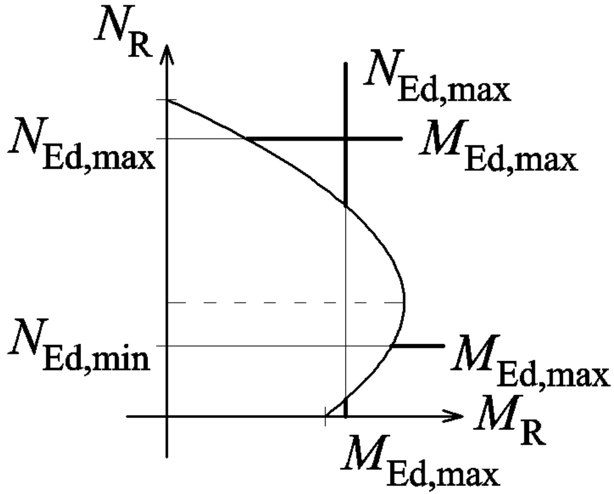
Any of the below force combinations can be dangerous, should be investigated:

1. $(M_{Ed,max}, N_{Ed,min}(M_{Ed,max}))$

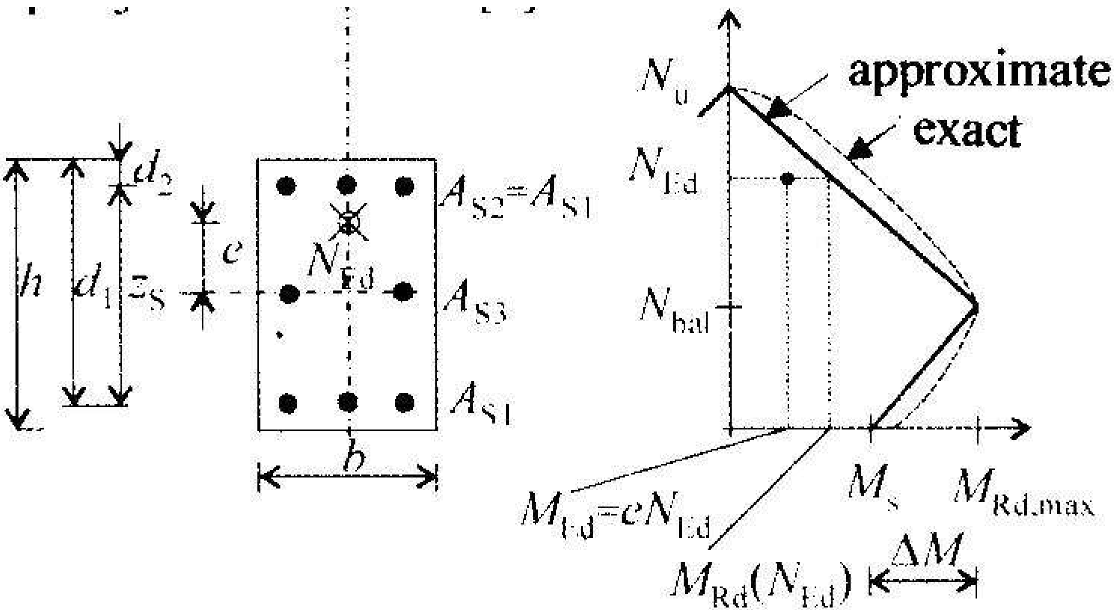
2. $(M_{Ed,max}, N_{Ed,max}(M_{Ed,max}))$

3. $(N_{Ed,max}, M_{Ed,max}(N_{Ed,max}))$

4. $(N_{Ed,min}, M_{Ed,max}(N_{Ed,min}))$

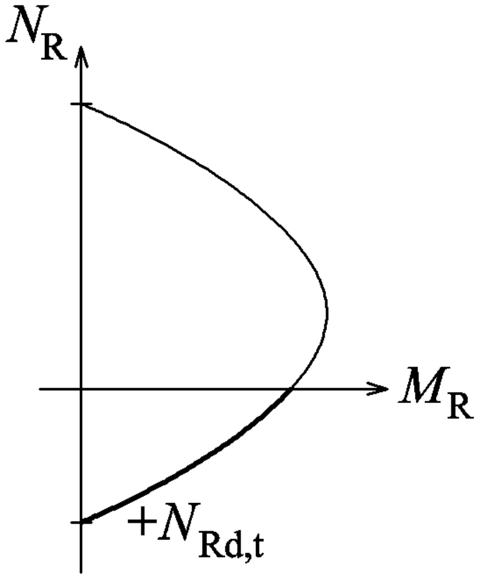


7. Linearization of the M_R-N_R capacity diagram



8. Axial and eccentric tension

Part of the capacity diagram below the M_R axis show capacity of the rc section in eccentric and axial tension



For axial tension:

$$N_{Rd,t} = (A_{s1} + A_{s2}) f_{yd}$$

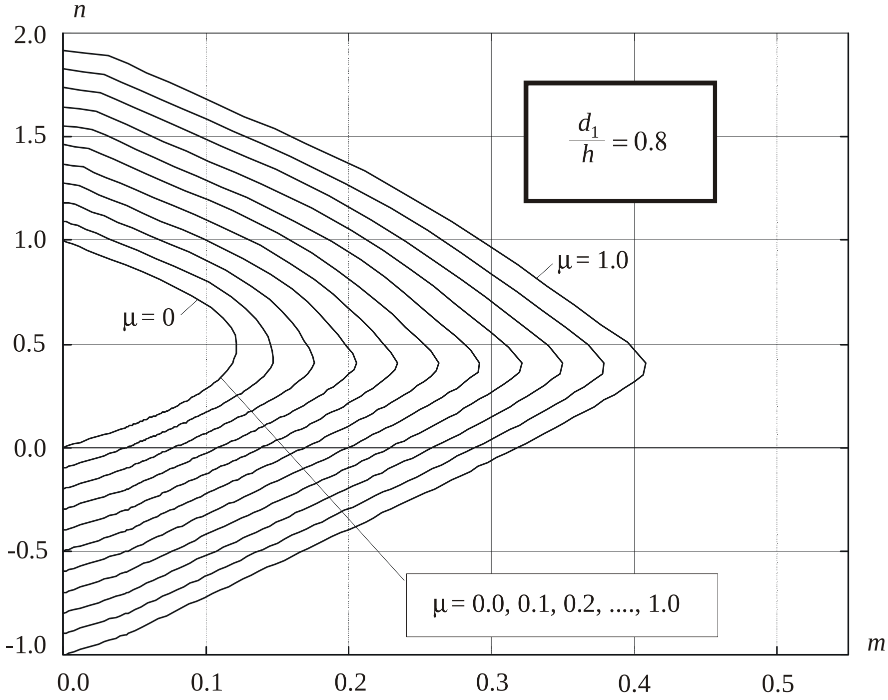
9. Use of a series of dimensionless capacity diagrams

$$\mu = \frac{A_s f_{yd}}{bhf_{cd}}$$

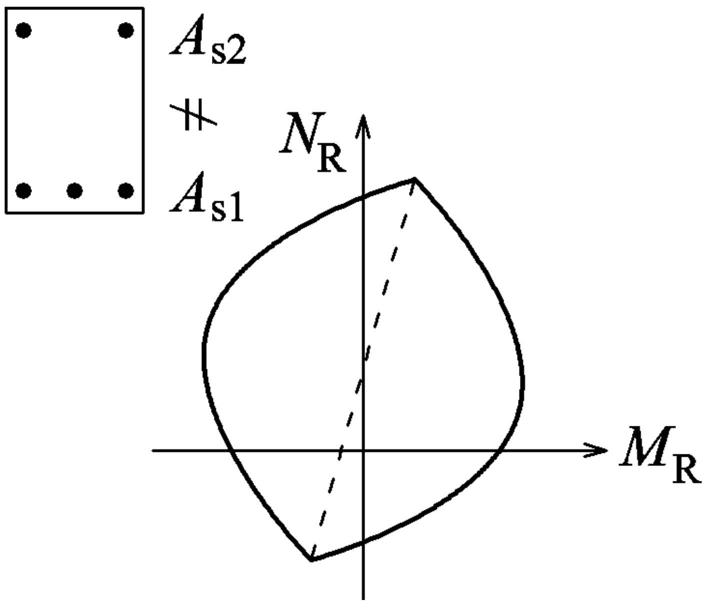
$$m = \frac{M_{Ed}}{bh^2 f_{cd}}$$

$$n = \frac{N_{Ed}}{bhf_{cd}}$$

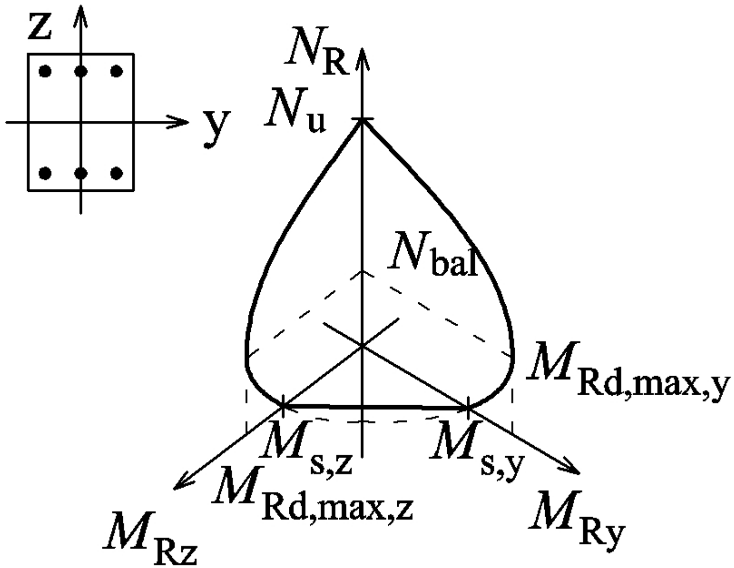
$$A_s = \sum A_{si} = 2A_{s1}$$



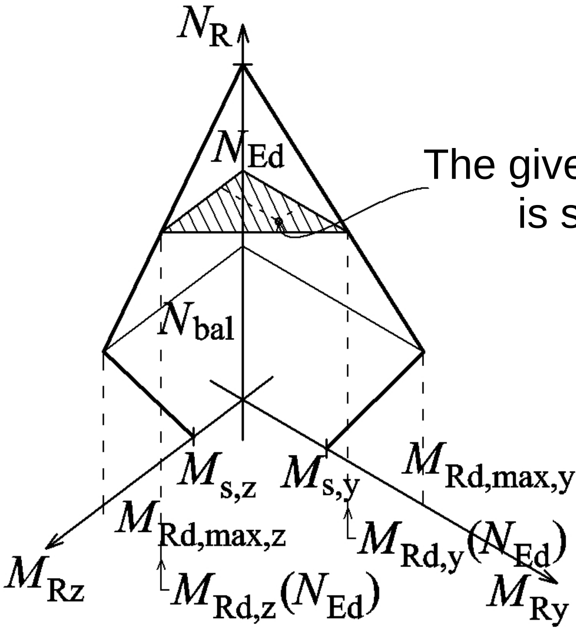
10. M_R-N_R capacity diagram of nonsymmetric reinforced concrete sections



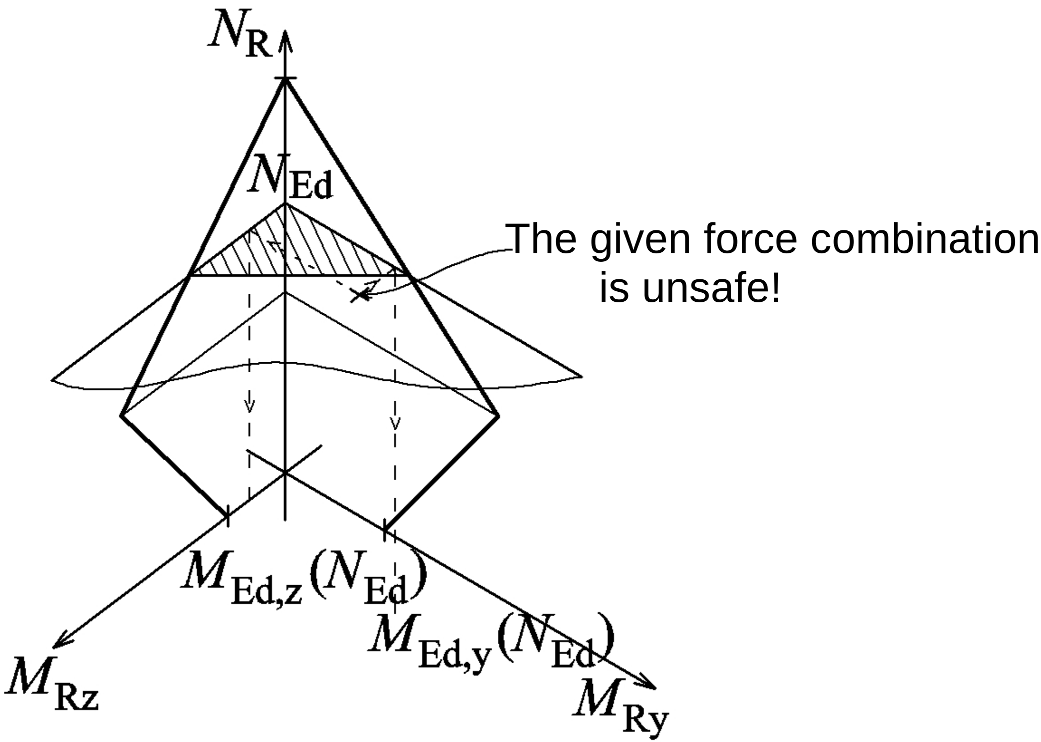
11. The (M_{Rz}, M_{Ry}, N_R) capacity body



12. Check of rc. sections subjected to compression with double eccentricity



The given force combination is safe!


N_R
N_{Ed}
The given force combination
is unsafe!
$M_{Ed,z}(N_{Ed})$
$M_{Ed,y}(N_{Ed})$
M_{Rz}
M_{Ry}

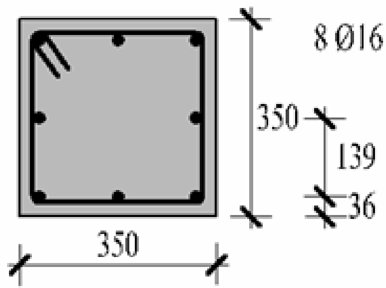
13. Numerical example

The column section given below is subjected to an eccentric compression force N_{Ed}= 1620 kN, e= 27,7 mm.
Check the section by determining the simplified (linearized) M_R-N_R capacity diagram of it!

Materials: concrete: C20/25-32/KK steel: B60.50
Concrete cover 20 mm link diameter: ϕ_k = 8 mm

$f_{cd} = \frac{20}{1,5} = 13,3$ N/mm^2 $f_{yd} = \frac{500}{1,15} = 435$ N/mm^2

$\xi_{co} = 0,49$



Solution:

d = 350 - 20 - 8 - 8 = 314 mm

$N_u' = bhf_{cd} + A_s \cdot 435 = (350^2 \cdot 13{,}3 + 1608 \cdot 435) \cdot 10^{-3} =$

$= 1633 + 700{,}3 = 2333{,}3$ kN

$N_{bal} = b\xi_{co}df_{cd} = 350 \cdot 0{,}49 \cdot 314 \cdot 13{,}3 \cdot 10^{-3} = 716{,}2$ kN

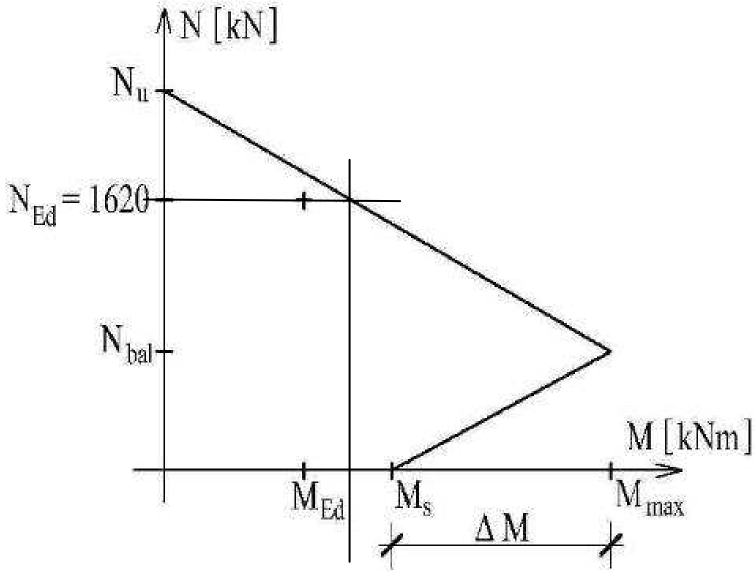
$$\Delta M = N_{bal}\left(\frac{h}{2} - \frac{\xi_{co}d}{2}\right) = 716{,}2 \cdot \left(\frac{350}{2} - \frac{0{,}49 \cdot 314}{2}\right) \cdot 10^{-3} = 70{,}2 \text{ kNm}$$

$M_s = A_{s1}f_{yd}z_s = 603 \cdot 435 \cdot 278 \cdot 10^{-6} = 72{,}9$ kNm

$M_{Rd,max} = M_s + \Delta M = 143{,}1$ kNm

$M_{Ed} = N_{Ed}e = 1620 \cdot 0{,}0277 = 44{,}87$ kNm

The point (M_{Ed}, N_{Ed}) is inside the diagram: the cross-section is safe!



Numerically:

$M_{Rd}(N_{Ed})$

$$M_{Rd}(N_{Ed}) = M_{Rd,\max} \frac{N'_u - N_{Ed}}{N'_u - N_{bal}} = 143{,}1 \cdot \frac{2333{,}3 - 1620}{2333{,}3 - 716{,}2} = 63{,}12\,kNm >$$

$> M_{Ed}$=44,87 kNm   OK, safe!