Fakultät für Architektur
Institut Entwerfen und Bautechnik
Fachgebiet Tragkonstruktionen
Leitung: Prof. Dipl.-Ing. Matthias Pfeifer

Simulations of the structural behavior of historical constructions

Reinforced Concrete

The Concrete

Concrete is a artificially produced stone

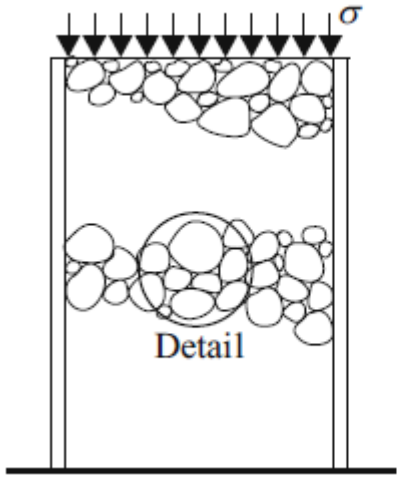
- supplement (gravel, sand)
- cement as binder
- water

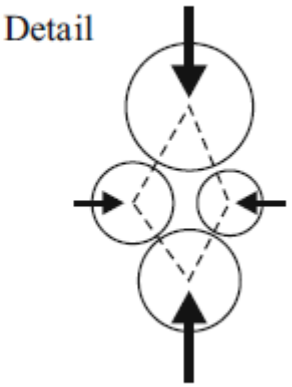
Reinforced Concrete

The Concrete

Shown is a tube filled with gravel

- horizontal deflection forces be here through the tube recorded



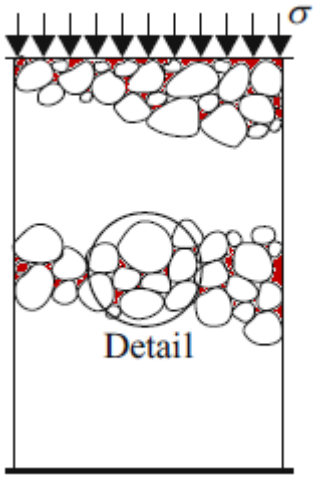


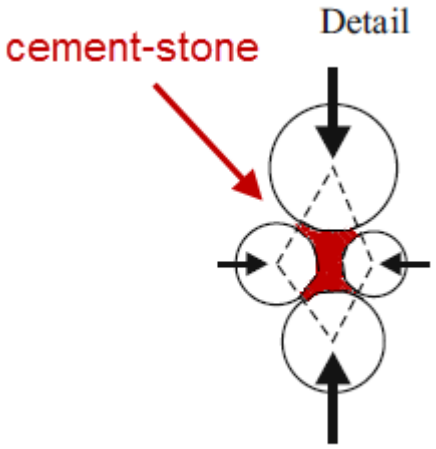
Reinforced Concrete

The Concrete

Shown is a concrete body

- horizontal deflection forces be absorbed by the cement

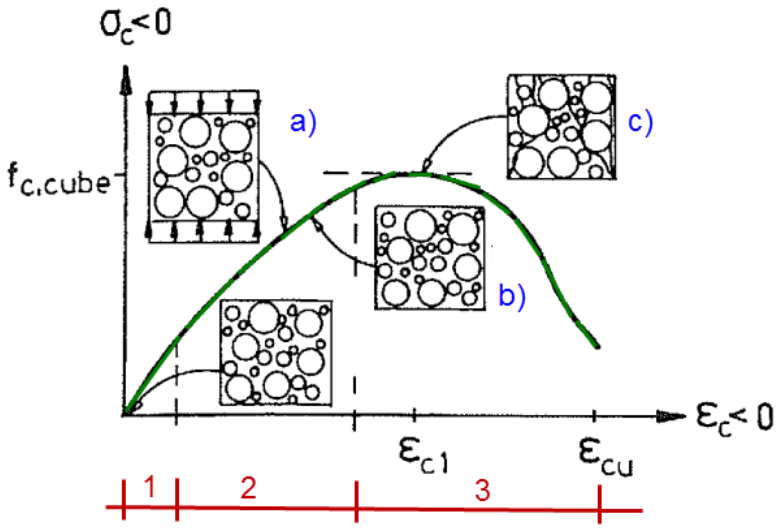




Reinforced Concrete

The Concrete

Stress-strain diagram / uniaxial pressure stress



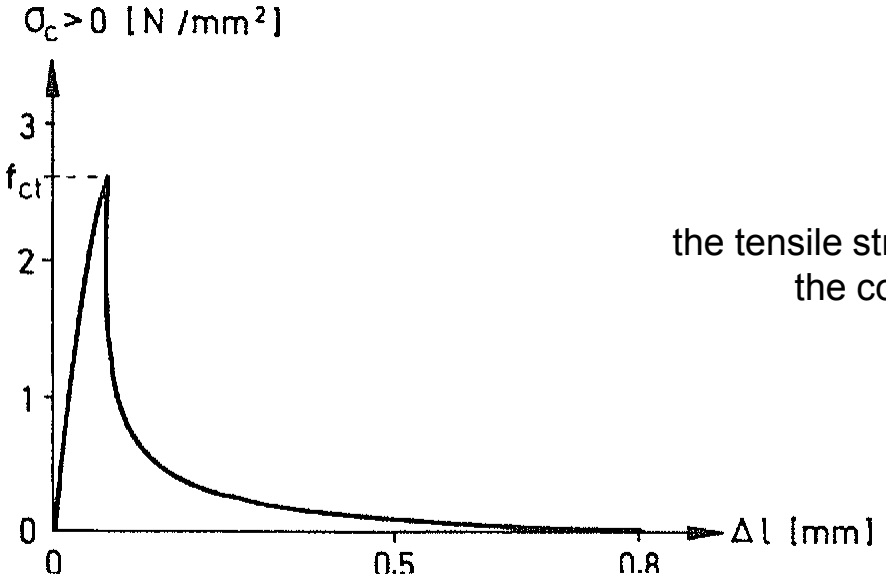
1) nearly linear elastic behavior
2) non linear behavior
3) local behavior

a) the micro-cracks grow
b) association of micro-cracks
c) maximum load, formation of fracture surfaces

Reinforced Concrete

The Concrete

Stress-strain diagram / uniaxial tensile stress

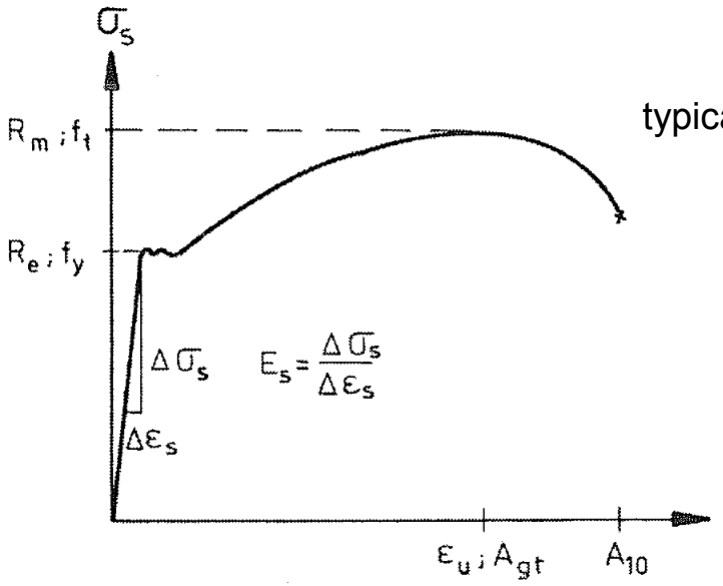


the tensile strength is only about 10% of the compressive strength

Reinforced Concrete

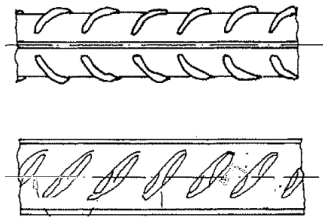
The Steel

Stress-strain diagram / uniaxial tensile stress



typical stress-strain line for hot rolled structural steel

typical round structural steel



Reinforced Concrete

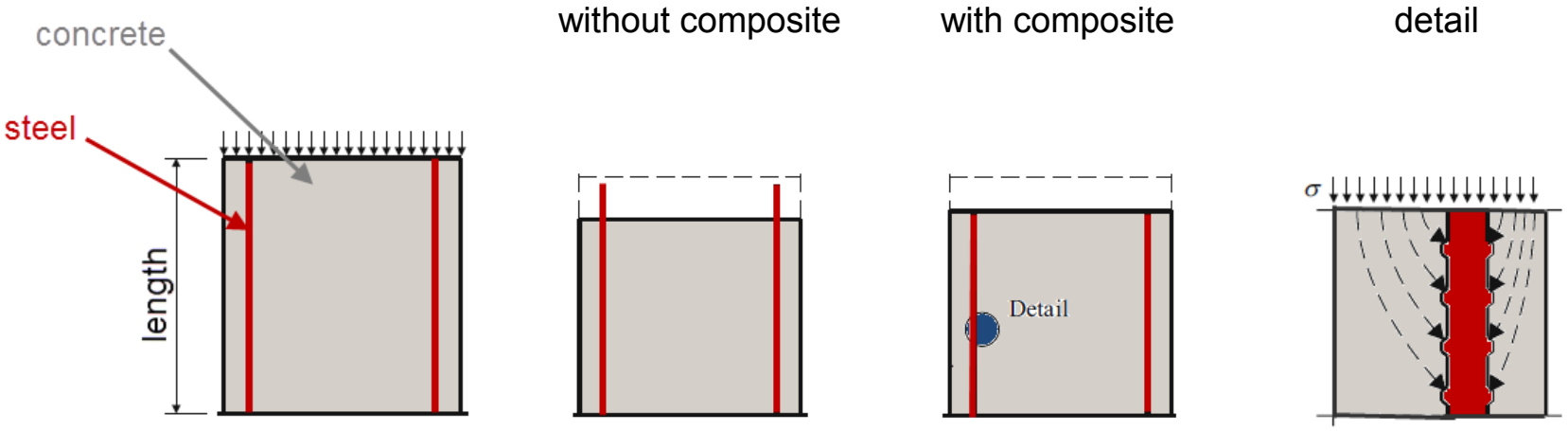
Task Distribution Concrete / Steel

Because of to the high compressive strength and low tensile strength of the concrete, in the design theory of reinforced concrete construction

- the pressure loads being take over by the concrete
- the tensile loads being take over by the steel

Reinforced Concrete

The composite behavior



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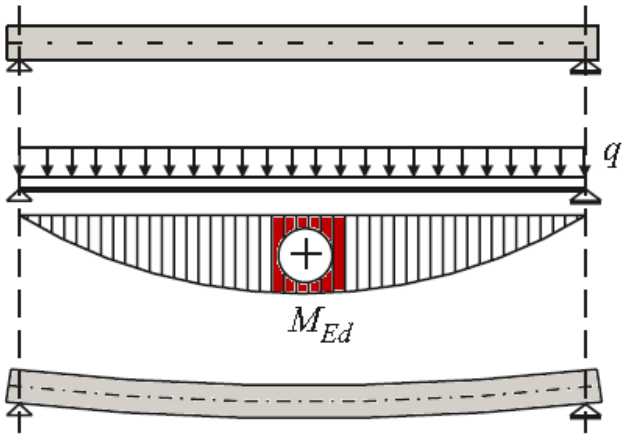
Bending design in reinforced concrete

Dimensioning for the maximum stress M_{Ed}



undeformed beam

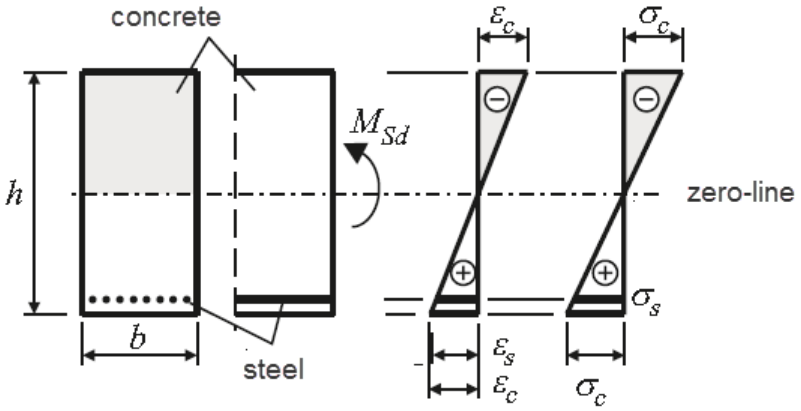
moment diagram a result of q

deformed beam
Top compressive, below tensile stresses

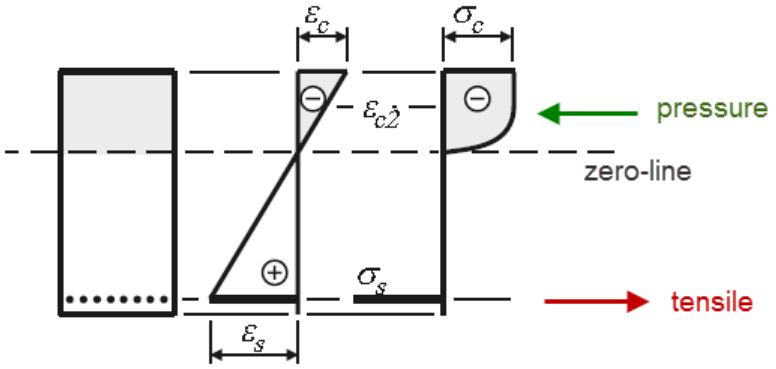
Reinforced Concrete

Bending design in reinforced concrete

Stress condition in reinforced concrete



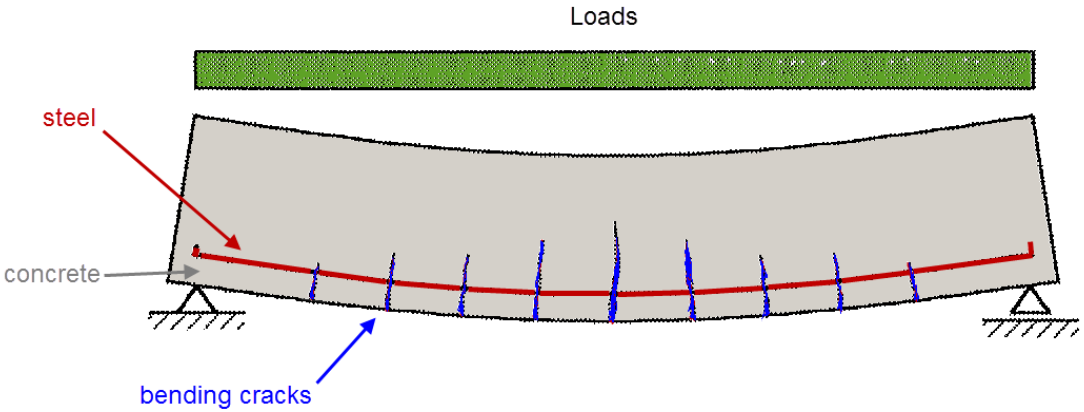
uncracked state
(Condition I)

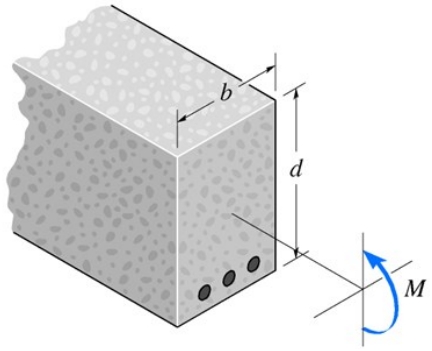


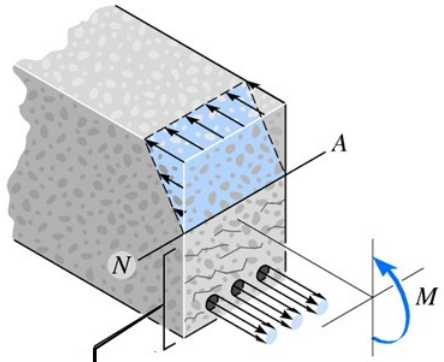
cracked state
(Condition II)

Reinforced Concrete

Beam with deflection



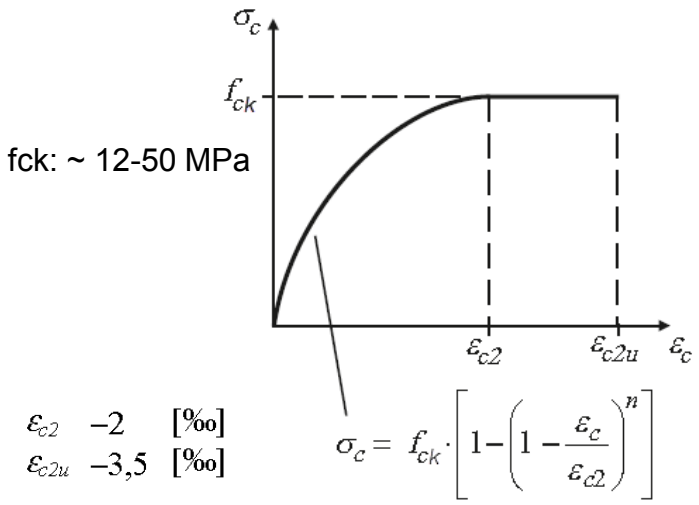




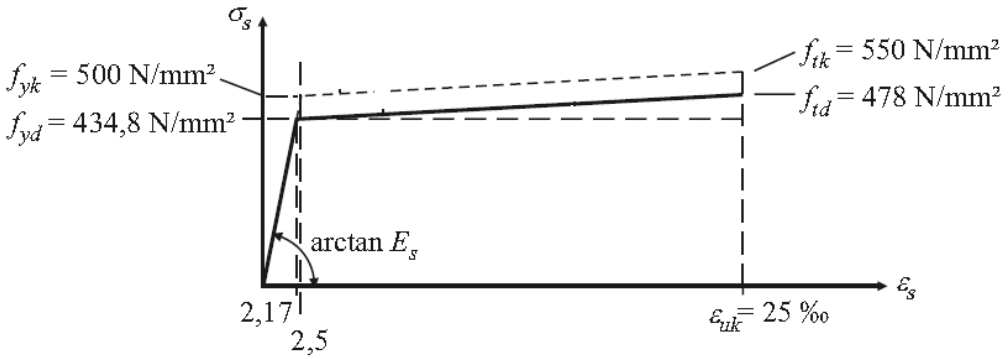
Assumption: due to cracks concrete is not load bearing in this area

Reinforced Concrete

Bending design in reinforced concrete



Parabolic-rectangle diagram for concrete compression zone



bilinear ideal elastic-plastic stress-strain distribution

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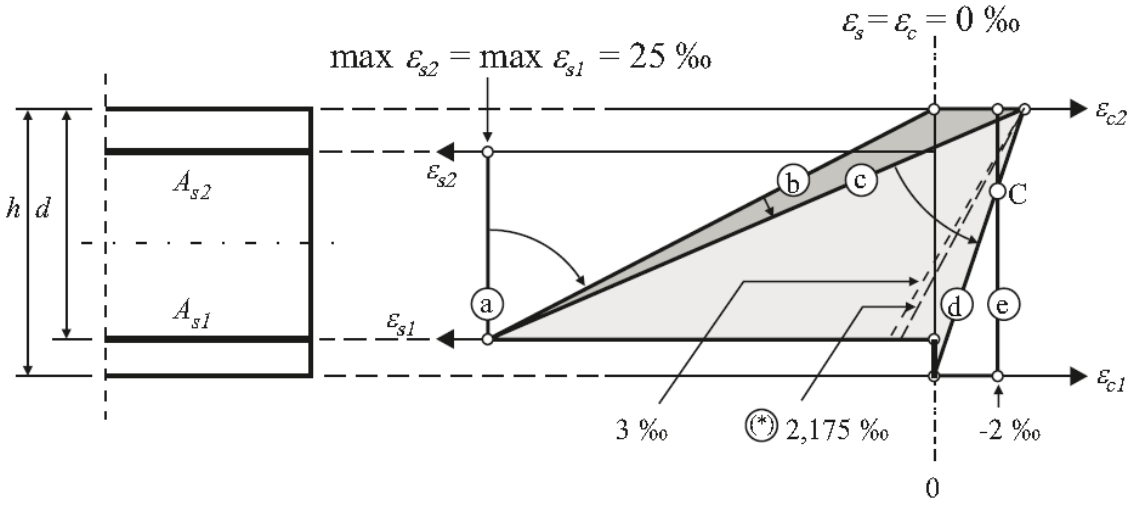
Bending design in reinforced concrete

Possible strain distributions



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Bending design in reinforced concrete

ω-method for the design

C 12/15 … C 50/60						
μ_{Eds}	ω_1	$\xi = x/d$	$\zeta = z/d$	ε_{c2}	ε_{s1}	σ_{s1}
[–]	[–]	[–]	[–]	[‰]	[‰]	[N/mm²]
0,01	0,0101	0,030	0,990	–0,77	25,00	434,8
0,02	0,0203	0,044	0,985	–1,15	25,00	434,8
…	…	…	…	…	…	…
0,36	0,4768	0,589	0,755	–3,50	2,44	434,8
0,371	0,4994	0,617	0,743	–3,50	2,175	434,8

$$\mu_{Eds} = \frac{M_{Eds}}{b \cdot d^2 \cdot f_{cd}} \qquad A_{s1} = \omega_1 \cdot b \cdot d \cdot \frac{f_{cd}}{\sigma_{s1}} + \frac{N_{Ed}}{\sigma_{s1}}$$

mode Frontier

Objective in the application of mode Frontier

- Analyses for gaining knowledge about the structural responses that arise due to different parameter changes
- Structural responses to this e.g. be
    - Deformations
    - Stresses
    - Strain conditions
    - Crack widths in concrete section
    - …

mode Frontier / Ansys

Structural model

- Structure as a finite element model in ANSYS
- Concrete is modeled as a solid
- Steel is modeled as a beam element
- Implementation of Multiplas to model the material behavior

mode Frontier / Ansys

Possible Parameters

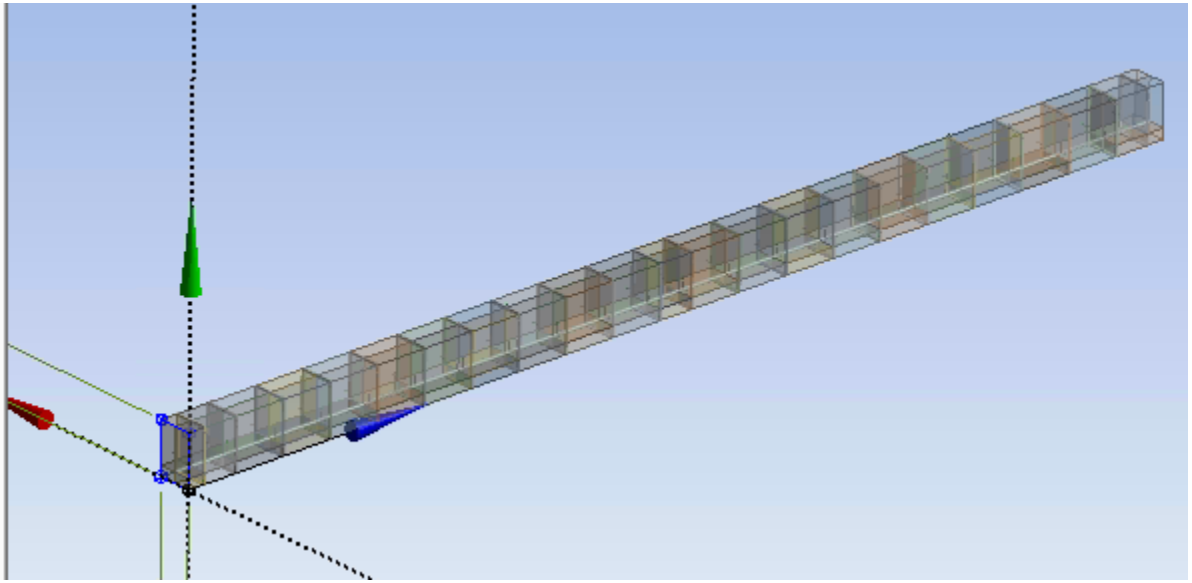
- Concrete strength class
- Influence of the tensile strength of the concrete
- Influence of the stress-strain relationship
- Bond behavior
- Amount of steel
- Number of bars
- Boundary conditions
- ….

Ansys Model

Reinforced Concrete Beams

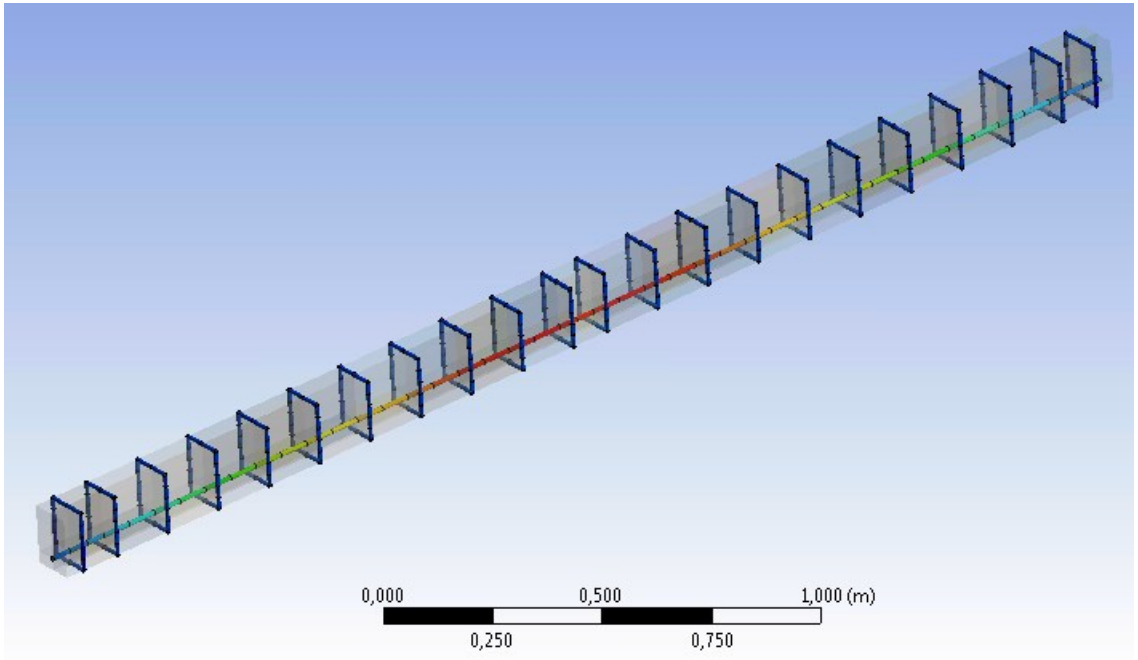
Detailansicht

Details von Sketch1	
Skizze	Sketch1
Skizzensichtbarkeit	Skizze ein...
Zwangsbedingungen anzeigen?	Nein
Abmessungen: 2	
D H1	0,1 m
D V2	0,15 m
Kanten: 4	
Linie	Ln7
Linie	Ln8
Linie	Ln9
Linie	Ln10



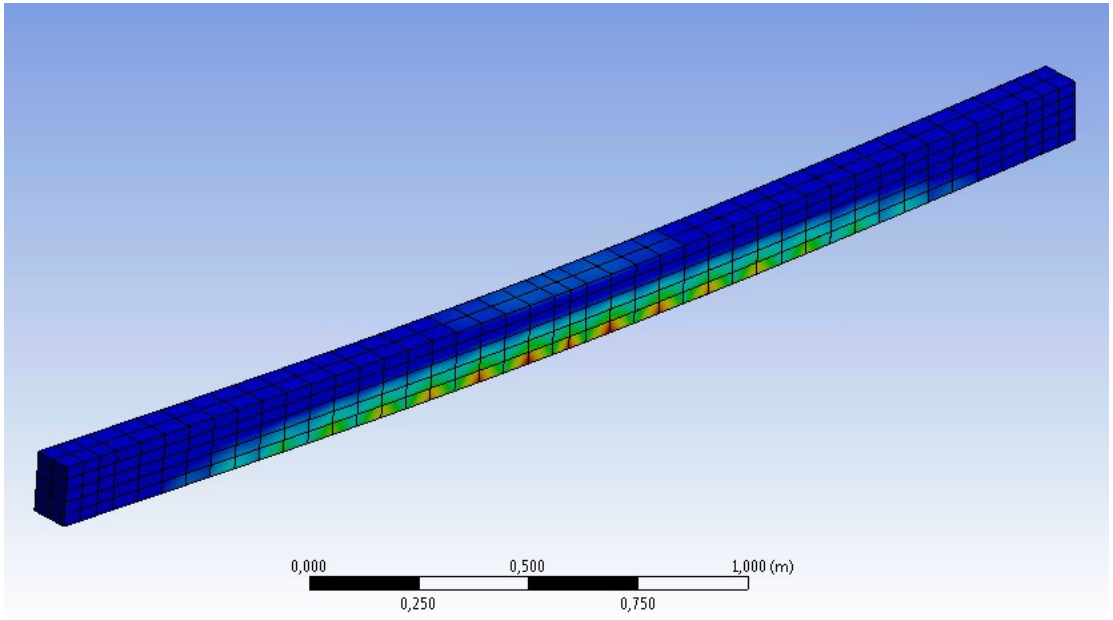
Ansys Model

Axial Force



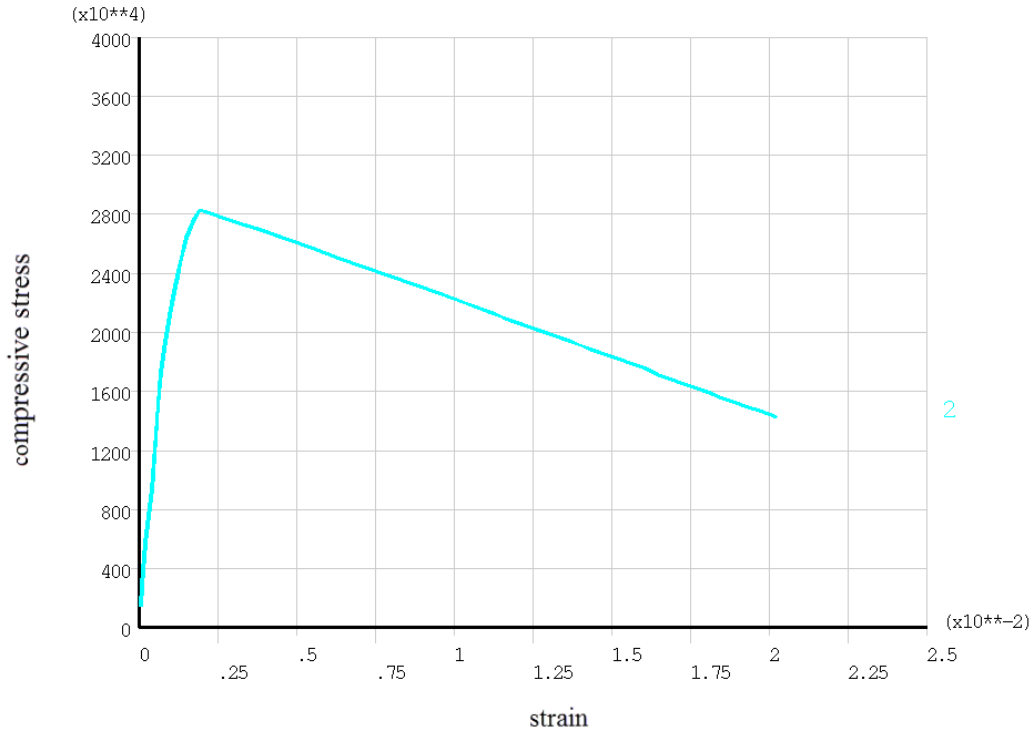
Ansys Model

Plastic Deformation



multiplas

stress-strain-diagram for concrete body




```
/prep7
mat=1

Rd=ARG1          !Standardmäßig: 28*1e6 (fcm)

!
Elastizitaetskonstanten-----------------------------------------
-------
Ec=9500*Rd**(1/3)*1e4   !Tangentenmodul
ex,mat,Ec
nuxy,mat,0.0

!
Dichte-----------------------------------------------------------
-------
dens,mat,2.5*1e3

!Festigkeitswerte --
Betonmodell------------------------------------------
LAW=2

Ru=1.2*Rd
Rz=0.1*Rd
delt=0.25
delc=1.00
!Spannungs-
Dehnungslinie----------------------------------------------------
Oi=0.33
```

Datei	
Dateiname	
Dateistatus	Datei wurde nicht gefunden
Definition	
Unterdrückt	Nein
Schrittauswahlmodus	Erste
Ziel	Mechanical APDL
Argumente eingeben	
P ARG1	28000000,
ARG2	
ARG3	

```
cmsel,,Beton
emodif,all,type,1
emodif,all,mat,1
```

```
multiPlas   einax. Druckversuch, law = 9, mlaw = 0, Temp = 20  C
```

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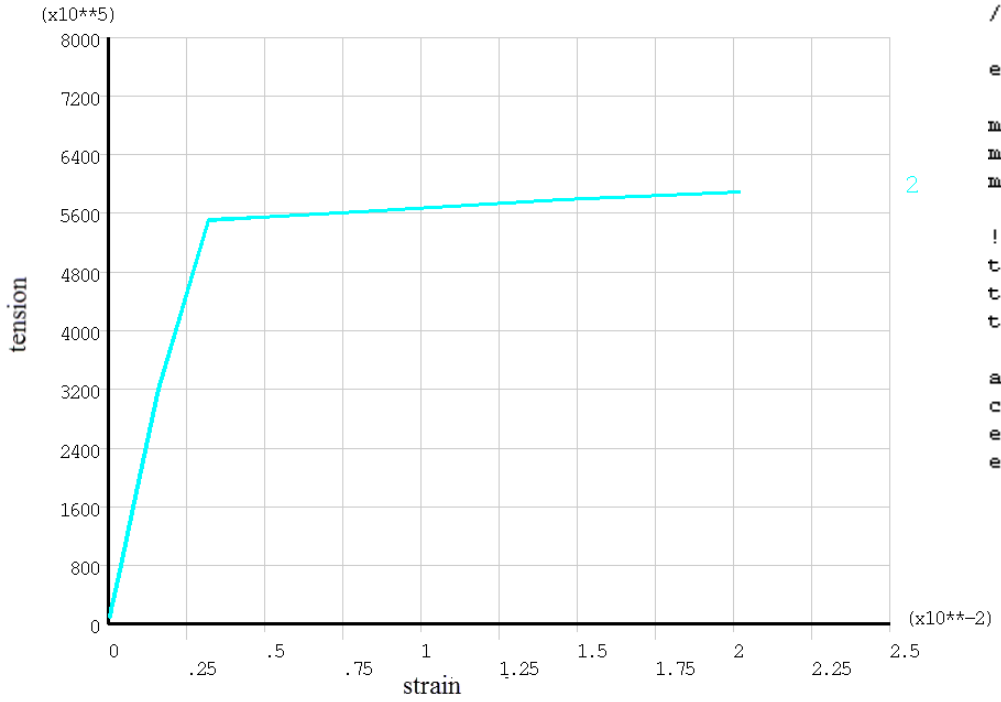
stress-strain-diagram for steel




```
/prep7

et,2,beam188

mp,EX,2,2E11
mp,nuxy,2,0.30
mp,dens,2,7820

!Festigkeitswerte -- Bewehrung ----------------------
tb,BKIN,2
tbtemp,0
tbdata,1,550E6,2E9,,,, !fysk[N/m²],Etan[N/m²]

allsel,
cmsel,,Bewehrung
emodif,all,type,2
emodif,all,mat,2
```

Research

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more topics

- Identification of relevant parameters to be optimized for structural responses in reinforced concrete
- Identification of efficient approaches for repair of reinforced concrete structures
- Development of concrete repair and upgrading concepts