Budapest University of Technology and Economics

Department of Mechanics and Structures
English courses
Reinforced Concrete Structures
Code: BMETKEPB603

Lecture no. 1:

Introduction, concrete and steel, reinforced concrete (r.c.)

Introduction, ways of communication

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Practical teachers: Bernát Csuka and Dr György Visnovitz

Topics schedule and requirements and lectures will be available on the home page of the Department: www.szt.bme.hu
To get to informations of the subject, choose: English, Download, English courses, Reinforced Concrete

Weekly reception hours will be commumicated on the home page and at the entrance of the Department (K242)

Use of Reinforced Concrete Design Aids is indispensable on the practical lessons, it is available in the copying room of the Department.
Recommended text books are listed on the topics schedule.

1st lecture:

Introduction, concrete and steel, reinforced concrete (r.c.)

Content:

1. Brief history of (r.)c. construction
2. Co-action of concrete and steel in r.c.
3. Characteristics and basic mechanical behaviour of concrete and steel
4. Co-action of concrete and steel in reinforced concrete
5. Requirements to be satisfied by design
6. Method of design

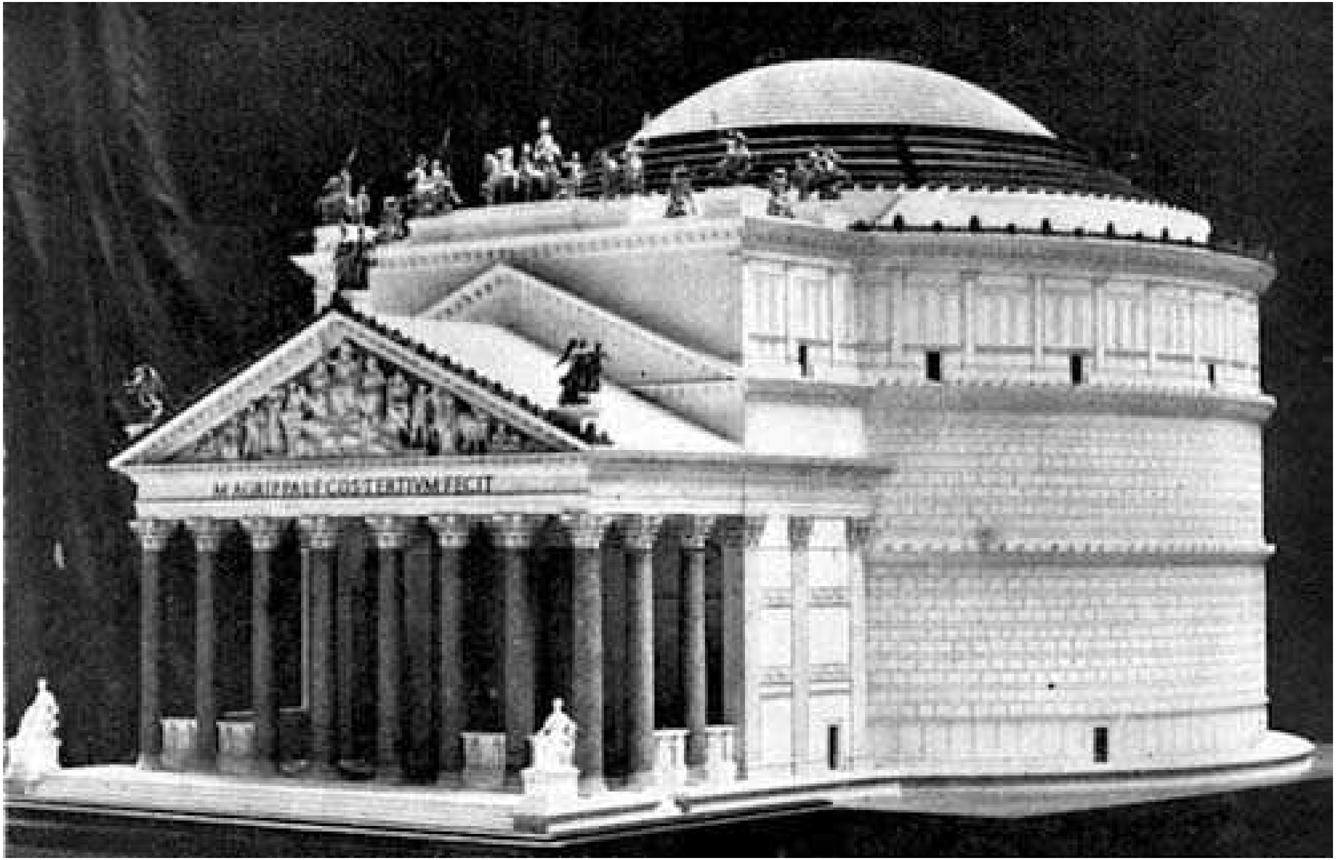
1. Brief history of (r.)c. construction

Roman times: ground stone + good quality mortar with hydraulic bound was used for the constuction of the 43 m diameter dome of the Pantheon in Rome 200 BC.

It was forgotten in medieval times
1796: romen cement was fi
separate use of concrete and iron till beginning of XIXth century
1824: Aspdin (England) portlan cement
1848, France: Lambot: r.c. ship body
1850, USA: a lawyer named Hyatt submitted a patent for r.c. beams, using links and longitudinal bars
1867, France, Monnier: flower pots, tubes, patent for slabs, stairs
1870: Hennebique (France): r.c. floor constructions
1887: Koenen designed r.c. beams
Rr.c. structural systems, smaller bridges at the end of XIXth century

Beginning of the XXth century: Mörsch (Germany) elaborated the complete theory, used truss model for shear design (will be shown later)
Elaboration of national standards at 1st decade of XXth century: Switzerland (1903), Hungary (1909)
1920-ies: Freyssinet (France) introduced the prestressing technology
Became the most important structural meterial from the 1930-ies.
1951, Menyhard (Hungary): first use of plasticity theory in national standard
Developments in the 20th century in:

-concrete technology
-steel products (high strength steel)
-prefabrication
-monolithic construction with industrialized methods
-thin wall r.c. constr., shells
-mass production of prestressed r.c. members .
-design theory (use of probability principles, limit state design theory)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2. Co-action of concrete and steel in r.c.

Advantages

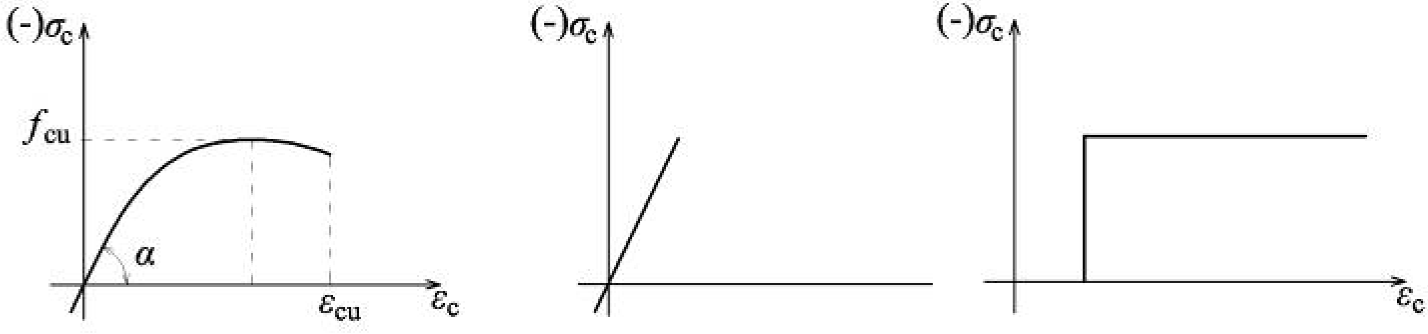
- same coefficient of thermal axpansion (α_t= 1E-5 1/°C)
- concrete prevents buckling of slender steel bars
- concrete improves fire-resistance
- concrete protects steel from corrosion

3. Characteristics and basic mechanical behaviour of concrete and steel

-Concrete:

composition: cement (cca 300kg)+ aggregate(cca 1,2m^3) + water(cca 150 l) ≈ 1 m^3 fresh concrete

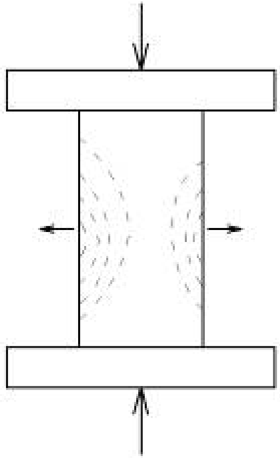
σ–ε relationships of concrete:

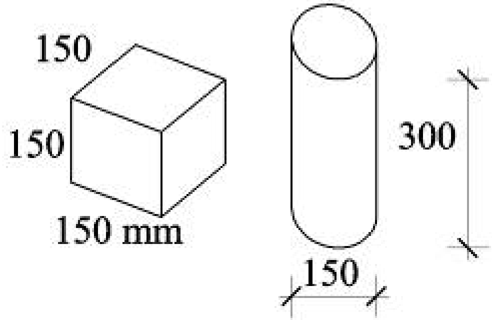


uncracked and cracked state   polastic state

uniaxial tension and compression test -   idealizad diagrams

Compression tests of concrete specimens
failure of concrete by crushing





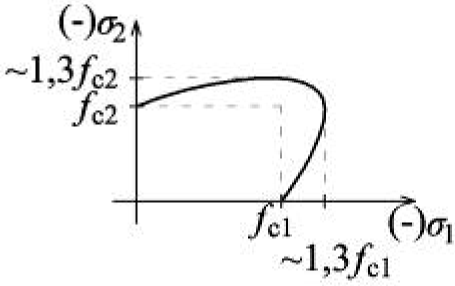
cube strength and cylinder strength

characteristic strength (f_{ck}) and design strength (f_{cd}), safety factor:

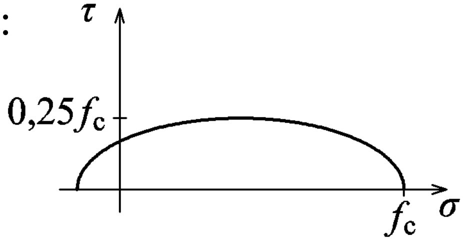
$f_{cd} = f_{ck}/\gamma_C \qquad \gamma_C = 1{,}5$

compressive strength ≈ 10x tensile strength

strength under biaxial loading



shear strength:



Concrete grades, *designation of concrete*: C16/20-XC0-32-F2

C: concrete 16: cylinder compr. Strength (N=mm^2) 20: cube strengt
32: max.diam. of aggregate F2: stands for consistency (moderately plastic)

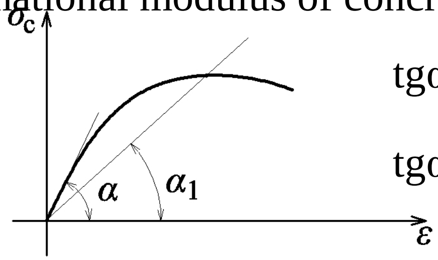
placing of fresh concrete (danger of desintegration, importance of vibration)

curing of fresh concrete (keep wet during the first week!)

linear coeff. of thermal expansion: α_t =1E-5

modulus of elasticity and deformational modulus of concrete

$$E_c = \frac{E_{co}}{1+\varphi_{cr}}$$

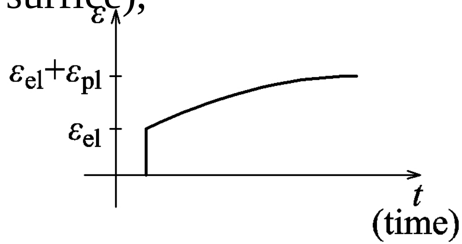


$tg\alpha = E_{co}$

$tg\alpha_1 = E_c$

creep of concrete: long term deformation under constant compression stress (moving of water towards the surfice),

creep coefficient $\varphi_{cr} = \frac{\varepsilon_{pl}}{\varepsilon_{el}} \approx 1{,}5$ to $2{,}5$



depends from: concrete grade, age, stress level, effective thickness, rel. humidity of the air, duration of loading *shrinkage of concrete*: loss of volume of the concrete due to drying, independent from stresses

consequences of shrinkage: compression in steel bars, shrinkage cracks the more reinforcement, the greater danger of cracking)

final deformation due to shrinkage:

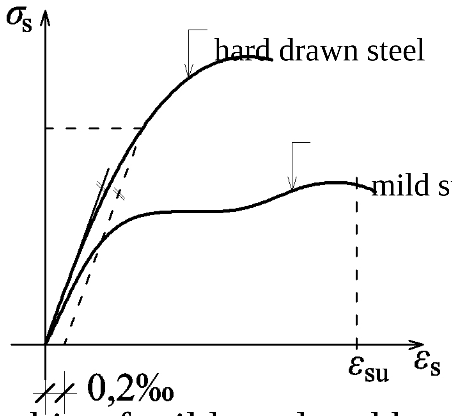
depends from: age of concrete, rel. hum. of the air, effective thickness

Reinforcing steel

mechanical behaviour

Nodulus of elasticity:

$E_s = tg\alpha$



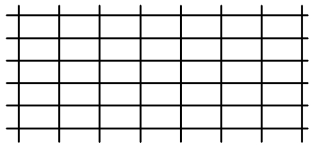
σ–ε relationship of mild steel and hard drawn steel

Types of reinforcing steel: mild steel (hot rolled steel)
hard drawn steel, high strength steel

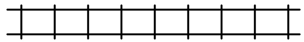
Designation of steel products: B38.24 yield limit (N/mm^2)
concrete rupture strength (N/mm^2)

Design strength: $f_{yd} = f_{yk}/\gamma_s$ $\gamma_s = 1{,}15$ safety factor

Products: 12 m long staight bars, rolls up to 8 mm diameter
Spot-welded mashes (fabrics)

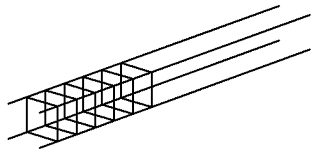


ladders

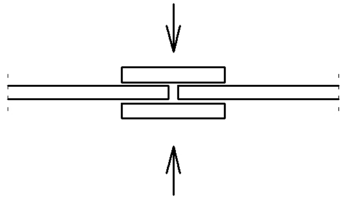


Diameters: ϕ6, 8, 10, 12, …., 40

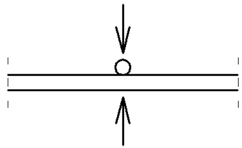
cages



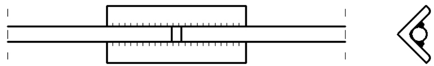
Jointing of bars by pressed sleeves



by resistance spot-welding:

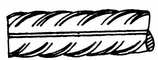


by arc-welding with tie:



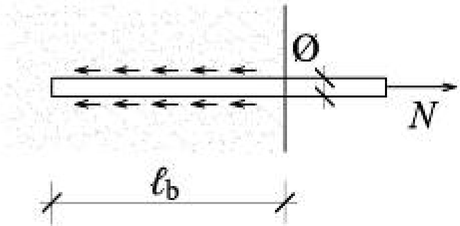
4. Co-action of concrete and steel in reinforced concrete

surfice pattern of bars: smooth and deformed bars

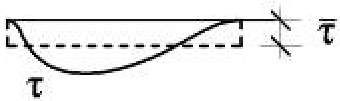
twisted ribs:  arrow ribs: 

bound stresses, bound coefficients smooth surfice: α_b=1

deformed surfice: α_b=2

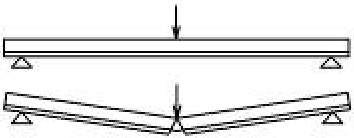


$$= \phi^2 \pi \frac{1}{4} f_{yd} = \varphi \pi \alpha_b f_{ctd} l_b \rightarrow l_b = \frac{f_{yd} d}{4 \alpha_b f_{ct,d}}$$

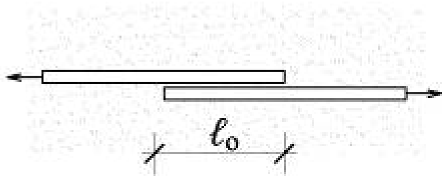


$\bar{\tau} = \alpha_b f_{ct,d}$

The necessity of bound:



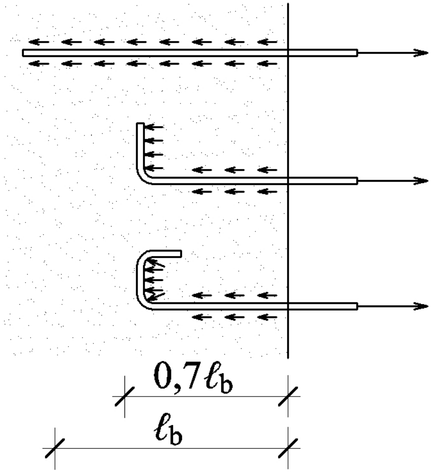
slip



overlappiong connection of bars

pull-out test: determination of the anchorage length (l_b)

Reduction of the anchorage length by applikation of 90 degree bent and of hoop:



5. Requirements to be satisfied by design

-loadbearing capacity

eqiulibrium between internal forces provoced by loads and effects and resistance forces of cross-sections

loss of stability (buckling, overturning, sliding)

-rigidity

-crack control (aesthetics, functionality, corrosion)

-durability (fatigue failure)

-fire-resistance

-tchnological, functional, aesthetical requirements

-economy in complex meaning (of design, construction, use and demolishment)

6. Method of design

design data
- actions, loads
- subsoil conditions
- choice of adequate technology

preliminary project
- importance of cooperation between architect and structural engineer

building permission project
- static model and calculations
- choice of structural material
- investigation of variants
- economical evaluation

working drawings (execution project, detailed drawings)
- consultations with the constructor
- part of the documentation: drawings, lists of bars
technical description

bill of quantities
list of works
technological project (in special cases)