Introduction, concrete and steel, reinforced concrete (r.c.)
Introduction, ways of communication

Lecturer: Dr András Draskóczy
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 communicated 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
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 construction of the 43 m diameter dome of the Pantheon in Rome 200 BC.

It was forgotten in medieval times
1796: roman 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 material 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)
2. Co-action of concrete and steel in r.c.

Advantages

same coefficient of thermal expansion ($\alpha_t = 1E-5 \ 1/°C$)
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 1,2m³) + water (cca 150 l) \( \approx 1 \text{ m}^3 \) fresh concrete

\( \sigma - \varepsilon \) relationships of concrete:

uniaxial tension and compression test - idealized diagrams

uncracked and cracked state - polastic state
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:
\[
f_{cd} = f_{ck} / \gamma_C \quad \gamma_C = 1.5
\]
compressive strength \(\approx 10\times\) 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 strength
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: \( \alpha_t = 1 \times 10^{-5} \)

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 surface),

creep coefficient \( \varphi_{cr} = \frac{\varepsilon_{pl}}{\varepsilon_{el}} \approx 1.5 \text{ to } 2.5 \)

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:
\[ E_s = \tan \alpha \]

\( \sigma - \varepsilon \) 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/mm²)
        concrete  rupture strength (N/mm²)

Design strength:  \[ f_{yd} = \frac{f_{yk}}{\gamma_s} \]
        \[ \gamma_s = 1.15 \] safety factor

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

Diameters:  \( \phi 6, 8, 10, 12, \ldots, 40 \)  cages

        ladders
Jointing of bars by pressed sleeves

by resistance spot-welding:

by arc-welding with tie:


surface pattern of bars: smooth and deformed bars

twisted ribs: 
arrow ribs:
bound stresses, bound coefficients smooth surface: $\alpha_b = 1$
deformed surface: $\alpha_b = 2$

$$= \phi \frac{\pi}{4} f_{yd} = \varphi \pi \alpha_b f_{ct,d} l_b \quad \rightarrow \quad l_b = \frac{f_{yd} d}{4 \alpha_b f_{ct,d}}$$

The necessity of bound:

overlap connection of bars

The necessity of bound:

slip

pull-out test: determination of the anchorage length ($l_b$)
Reduction of the anchorage length by application of 90 degree bent and of hoop:
5. Requirements to be satisfied by design

- loadbearing capacity
  equilibrium between internal forces provoked 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
- technological, functional, aesthetical requirements
- economy in complex meaning (of design, construction, use and demolition)
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)