23CE503:STRUCTURAL ENGINEERING - I (RCC)

Topic: Unit- 1 Intoduction To RCC & Working Stress Method - Beams

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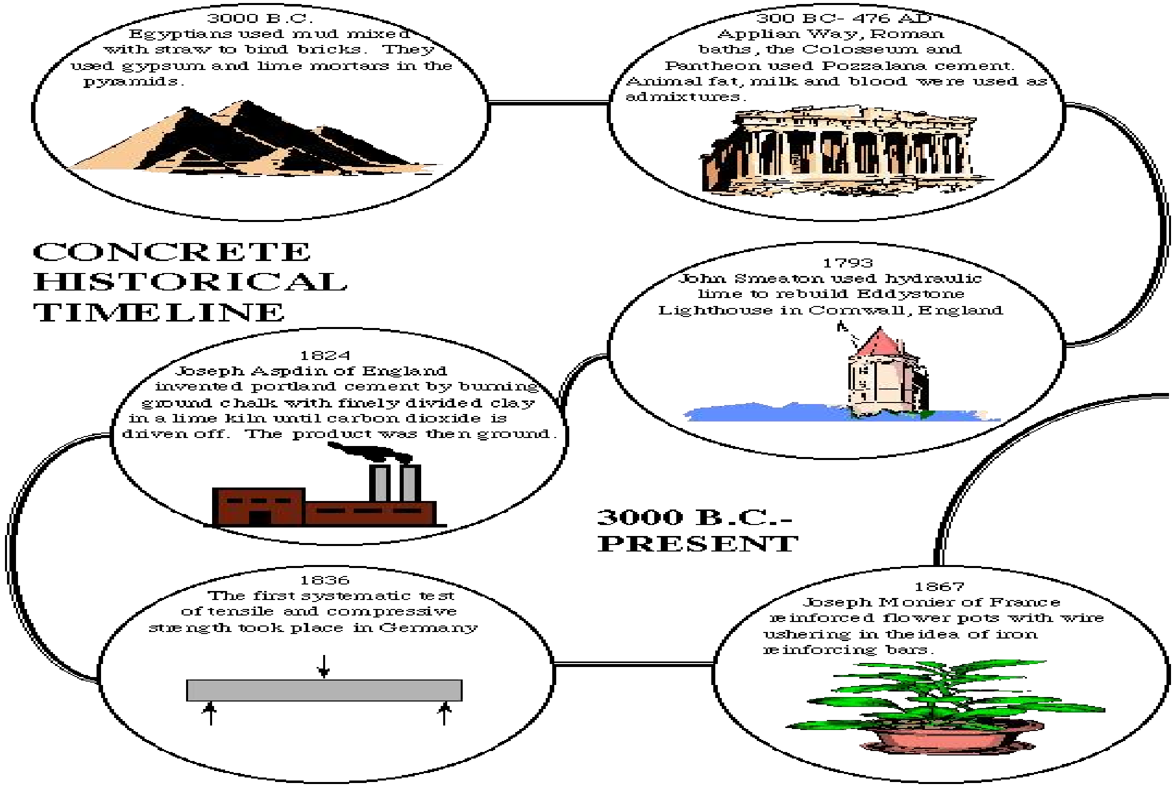
CONTENTS

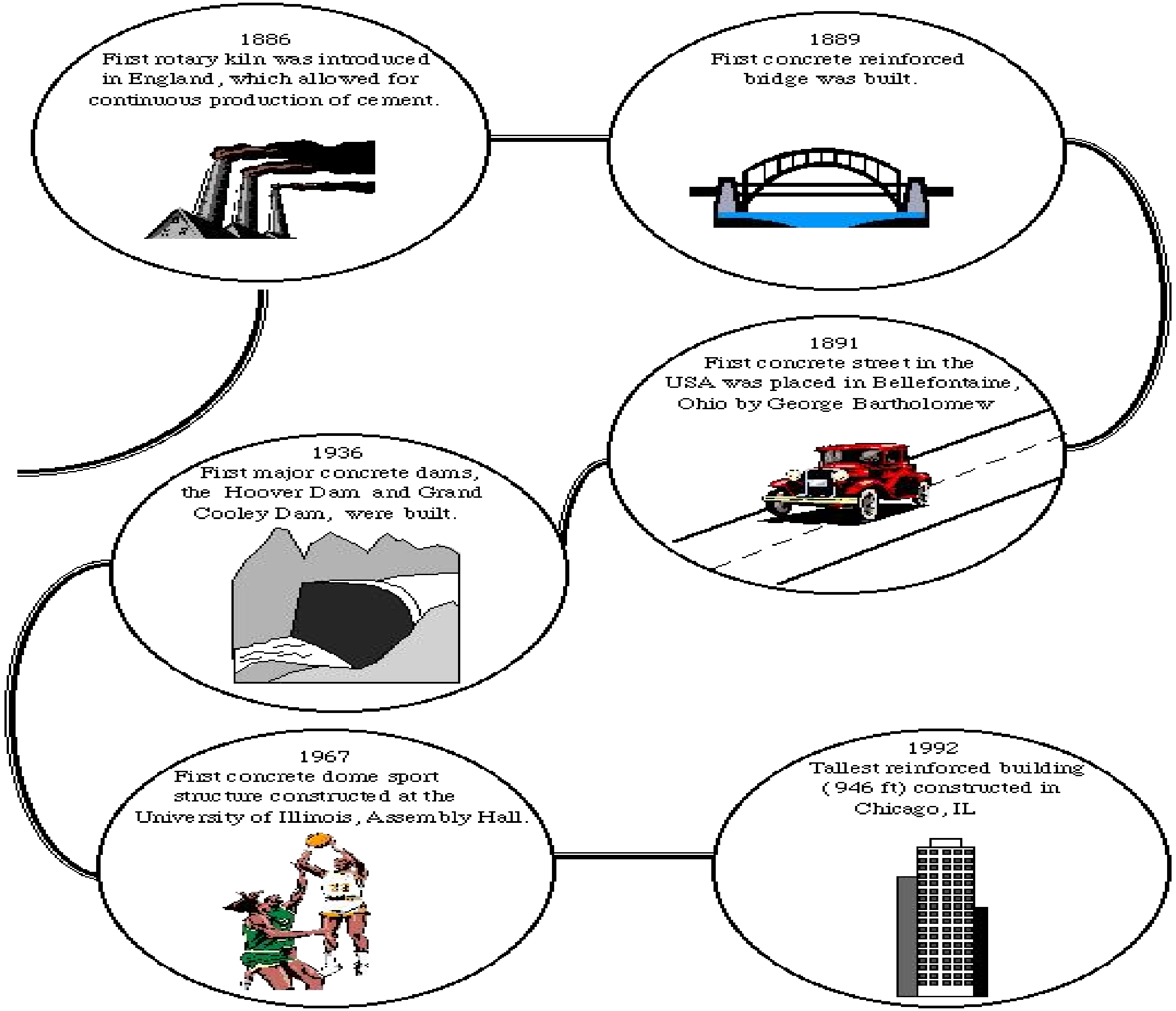
UNIT-I

- Concrete is everywhere!!

  Roads, sidewalks, houses, bridges, skyscrapers, pipes, dams, canals, missile silos, and nuclear waste containment



The word concrete comes from the Latin word "concrete us" (meaning compact or condensed),


1886
First rotary kiln was introduced in England, which allowed for continuous production of cement.
1889
First concrete reinforced bridge was built.
1891
First concrete street in the USA was placed in Bellefontaine, Ohio by George Bartholomew
1936
First major concrete dams, the Hoover Dam and Grand Cooley Dam, were built.
1967
First concrete dome sport structure constructed at the University of Illinois, Assembly Hall.
1992
Tallest reinforced building (946 ft) constructed in Chicago, IL

- When was concrete first made?
  - **500 BC**
- What is the purpose of cement in concrete?
  - **It acts as a primary binder to join the aggregate into a solid mass.**
- What role does water play in producing concrete? **Water is required for the cement to hydrate and solidify.**
- Why does concrete harden?
  - **The chemical process called cement hydration produces crystals that interlock and bind together.**

- Why does concrete set (harden) slowly? **It takes time for the hydrated cement crystals to form**
- Is concrete stronger in compression, tension, or the same in either?
  - **It is stronger in compression.**
- How long can concrete last (in years)?
  - **50,000**

- Concrete is strong in Compression but weak in tension, thus adding reinforcement increases the strength in tension
- Concrete is reinforced to give it extra tensile strength; without reinforcement, many concrete buildings would not have been possible.

Concrete Reinforcing

- **Concrete - No Useful Tensile Strength**
- **Reinforcing Steel- Tensile Strength**
  - Similar Coefficient of thermal expansion
  - Chemical Compatibility
  - Adhesion Of Concrete To Steel

- **Theory of Steel Location**

    •“Place reinforcing steel where the concrete is in tension”

Unit-I

- Reinforced concrete can encompass many types of structures and components, including slabs,beams,columns,foundations,frames
- and more.
- Reinforced concrete can be classified as precast or cast-in-situ

UNIT-I

What is concrete? & RCC ?

- Mixture of gravel, crushed rock, or other aggregates held together held together in a rocklike mass with a paste of cement and water
- Admixtures are added to change the physical and chemical characteristics of concrete such as … …
- Concrete is poor in tensile strength.
- Steel reinforcement is added to provide the tensile strength, but steel is poor in compressive strength itself.
- Reinforced Cement Concrete is combination of concrete and steel.
- In RCC, the compressive strength is provided by the concrete and tensile strength is provided by steel/

Advantages of Reinforced Cement Concrete

- RCC has considerable compressive strength as compared to other material.
- Great resistance to fire and water
- RCC structures are rigid
- Has long service life
- Has low maintenance cost
- Versatile construction material can be used for all structural components like footings, columns, beams and slabs etc.
- Can be molded to the desired form and shape
- Use locally available material in most of the areas.

Disadvantages of Reinforced Cement Concrete

- Without sufficient tensile reinforcement, RCC is poor in tensile strength.
- Forms are essential for the concrete works. Formwork constitute a big part of the concrete cost
- For long span structures, the RCC sections may become very heavy as compared to steel members
- The quality control and mix proportioning has dominant effect on the properties of concrete.
- The shrinkage of concrete due to drying and temperature effects.
- Creep effect: the Deformation under long term sustained loading

Types of Portland Cement

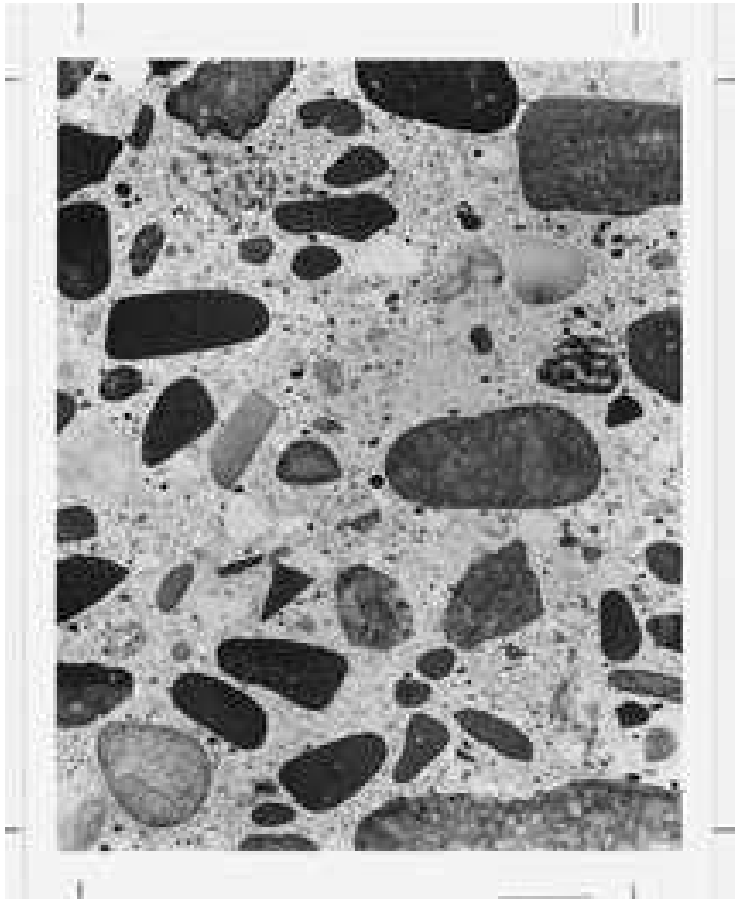
- Type I Cement: Commonly used all purpose cement.
- Type II cement: Modified type I cement having lower heat of hydration and can withstand exposure to sulfate
- Type III cement: High early strength concrete which can produce the compressive strength twice the type I cement in 24 hours.
- Type IV cement: Low heat cement can dissipate cement slowly and used for mass concrete.
- Type V cement: Used for concretes exposed to high concentrations of sulfate

Admixtures:

- Admixtures are used to change the properties of concrete.
  - They are to concrete as beauty aids are to populace.
- Air entraining Agent: ASTM C260 and C618
  - To improve the freeze and Thaw resistance of concrete.
  - Add bubbles into the concrete-foam concrete
  - On freezing the water enters the bubbles.
- Accelerators: High early strength
- Retarders:
  - To decelerate the setting and thereby the temperatures of concrete. Used for mass concrete.
- Superplsticisers of High Range Water Reducers (HRWR):
  - Reduce water content, increase workability and strength.

Concrete

- Rocklike Material
- Ingredients
  - Portland Cement
  - Course Aggregate
  - Fine Aggregate
  - Water
  - Admixtures (optional)



Testing of concrete

- Following are the various test performed on concrete
- 1..Test on
- I. workability II. Slump

IV.Flow table test
V.Vee bee consistometer method
2.Test on compressive 4.strength Test on
flexural
3.strenght Test on modulus of
elasticity
4.Test on fresh concrete
5.Test cement content of hardened concrete

Properties of Aggregates

- compressive strength: Should be higher than concrete strength of 40-120 MPa

- Voids: Represent the amount of air space between the aggregate particles - Course aggregates contain 30- 50% of voids and fine aggregate 35-40%

- Moisture content represents the amount of water in aggregates: absorbed and surface moisture - Course
- aggregates contain very little absorbed water while fine aggregates contain 3-5% of absorbed water and
- 4-5% surface moisture

Properties of Water

- **Any drinkable water can be used for concrete making - Water containing more than 2000 ppm of dissolved salts should be tested for its effect on concrete**

-Chloride ions not more than 1000 ppm - Sulphate ions not more than 3000 ppm

- Bicarbonate ions not more than 400 ppm

- The water should satisfy the requirements of **Section 5.4**
- of **IS:456 - 2000**.
- "Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete and steel".

Loads

- Dead loads:
  - - Constant magnitude mostly remain in one position
    - - Frames, walls, beams, ceiling, stairways etc.

Reinforced concrete—12 in.	150 psf	2 × 12 @ 16-in. double wood floor	7 psf
Acoustical ceiling tile	1 psf	Linoleum or asphalt tile	1 psf
Suspended ceiling	2 psf	Hardwood flooring ($\frac{7}{8}$-in.)	4 psf
Plaster on concrete	5 psf	1-in. cement on stone-concrete fill	32 psf
Asphalt shingles	2 psf	Movable steel partitions	4 psf
3-ply ready roofing	1 psf	Wood studs w/$\frac{1}{2}$-in. gypsum	8 psf
Mechanical duct allowance	4 psf	Clay brick wythes—4 in.	39 psf

- Live loads: Loads changing magnitude and positions
  - – Traffic loads for bridges ,impact loads due to vibration, people loads
    - etc.

Lobbies of assembly areas	100 psf	Classrooms in schools	40 psf
Dance hall and ballrooms	100 psf	Upper-floor corridors in schools	80 psf
Library reading rooms	60 psf	Stairs and exitways	100 psf
Library stack rooms	150 psf	Heavy storage warehouse	250 psf
Light manufacturing	125 psf	Retail stores—first floor	100 psf
Offices in office buildings	50 psf	Retail stores—upper floors	75 psf
Residential dwelling areas	40 psf	Walkways and elevated platforms	60 psf

LOADS

- Environmental loads: Due to environment in which the building is placed.
  - Snow and ice loads:
  - Rain loads
  - Wind
  - Seismic or earthquake loads
- To select the appropriate level of design load, the combinations of these loads are made as per guidelines given by various codes.
  - For Railway bridges: American Railway Engineering Association (AREA)
  - For highway bridges: AASHTO
  - For buildings International Building Code (IBC)/ACI Code

Stiffness of Concrete

- The stiffness of concrete is required to estimate the deflection of members. The stiffness is given by the modulus of elasticity.
- For a non-linear stress (*fc*) versus strain (*εc*) behaviour of concrete the modulus can be initial, tangential or secant modulus.
- The modulus of elasticity for short term loading (neglecting the effect of creep) is given by the following equation.

$$E_c = 5000\sqrt{f_{ck}}$$

Durability of Concrete

- The durability of concrete is of vital importance regarding the life cycle cost of a structure. The life cycle cost includes not only the initial cost of the materials and labour, but also the cost of maintenance and repair.

  - Some special types of high performance concrete are as follows.
    1) High strength concrete
    - 2) High workability concrete
    - 3) Self-compacting concrete
    - 4) Reactive powder concrete
    - 5) High volume fly ash concrete
    - 6) Fibre reinforced concrete

DIFFERENT METHODS OF DESIGN OF CONCRETE

1. Working Stress Method
2. Limit State Method
3. Ultimate Load Method
4. Probabilistic Method of Design

LIMIT STATE METHOD OF DESIGN

- The object of the design based on the limit state concept is to achieve an acceptable probability, that a structure will not become unsuitable in it's lifetime for the use for which it is intended,
  - i.e. It will not reach a limit state

- A structure with appropriate degree of reliability should be able to withstand safely.

- All loads, that are reliable to act on it throughout it's life and it should also satisfy the subs ability requirements, such as limitations on deflection and cracking.

- It should also be able to maintain the required structural integrity, during and after accident, suchas fires, explosion & local failure.

  •i.e. limit sate must be consider in design to ensure an adequate degree of safety and serviceability

- The most important of these limit states, which must be examine in design are as follows

- Limit state of collapse

  - Flexure
  - Compression
  - Shear
  - Torsion

•This state corresponds to the maximum load carrying capacity.

Assumptions in Limit State Design Method

1. Plane section normal to the axis remains plane even after bending. i.e. strain at any point on the cross section is directly proportional to the distance from the N.A.
2. Maximum strain in concrete at the outer most compression fibre is taken as 0.0035 in bending.
3. The tensile strength of the concrete is ignored.
4. The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoidal, parabola or any other shape.
5. The stresses in the reinforcement are derived from representative stress – strain curve for the type of steel used.
6. The maximum strain in tension reinforcement in the section at failure shall not be less than
   - fy /(Es*1.15) + 0.002

Types of Sections

- **Balanced Sections**
- Section in which, tension steel also reaches yield strain simultaneously as the concrete reaches the failure strain in bending
- **Under Reinforced Section**
  - Section in which, tension steel also reaches yield strain at loads lower then the load at which concrete reaches the failure strain in bending
- **Over Reinforced Section**
- Section in which, tension steel also reaches yield strain at loads higher then the load at which concrete reaches the failure strain in bending

TYPES OF REINFORCED CONCRETE BEAMS

b) Singly reinforced beam

c) Doubly reinforced beam

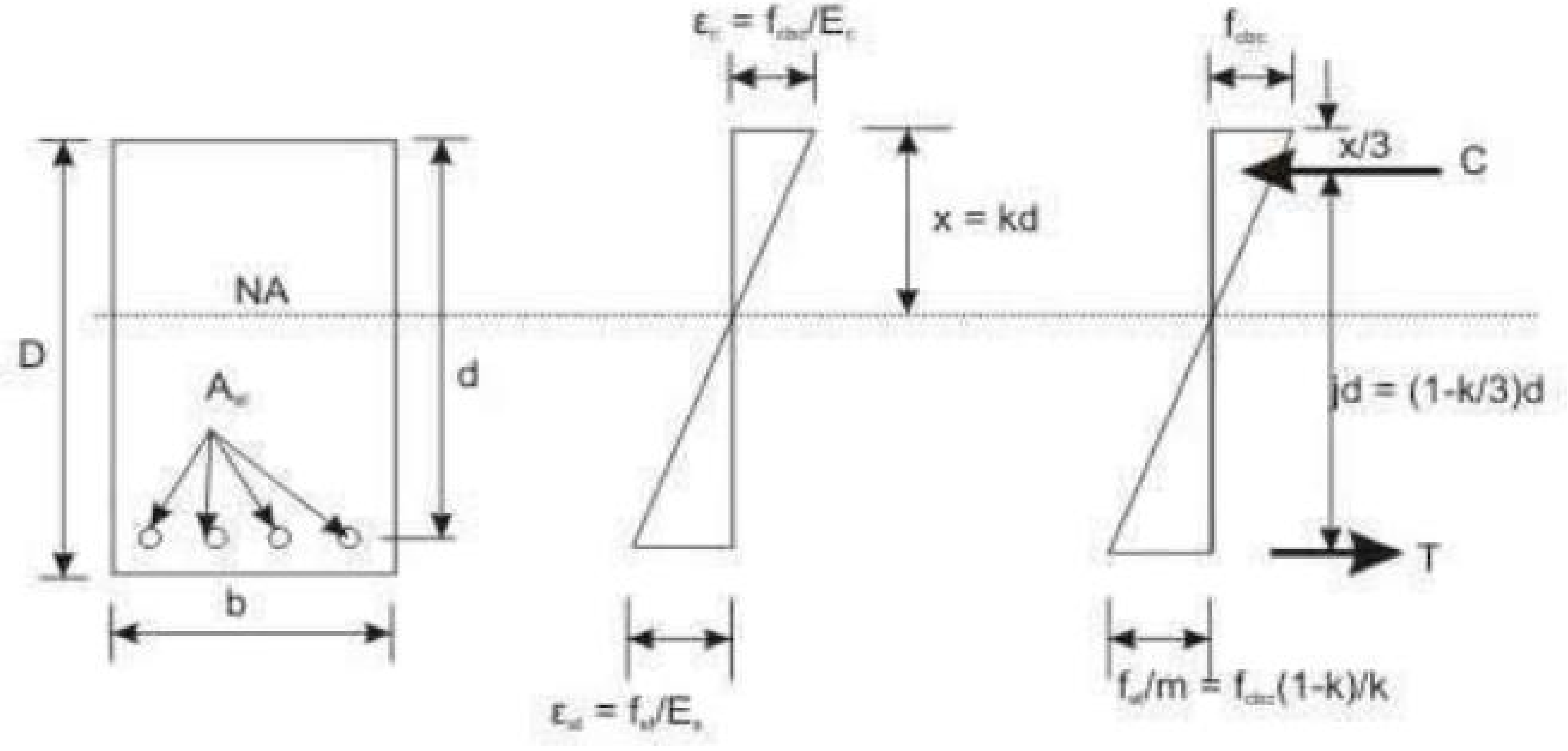
d) Singly or Doubly reinforced flanged beams

SINGLYREINFORCED BEAM:

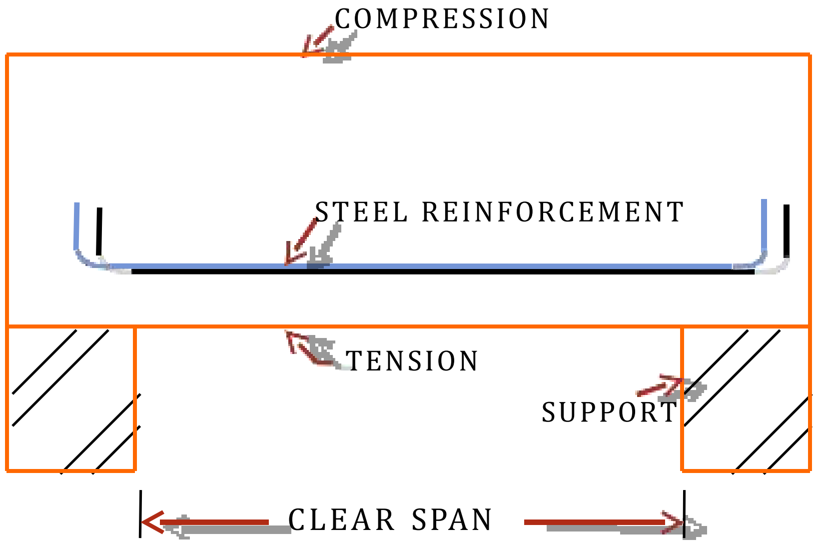
- In singly reinforced simply supported beams or slabs reinforcing steel bars are placed near the bottom of the beam or slabs where they are most effective in resisting the tensile stresses.

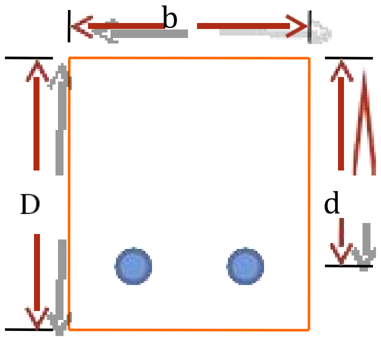
Singly Reinforced Rectangular section-WSM

- Stress strain curve in working stress Design



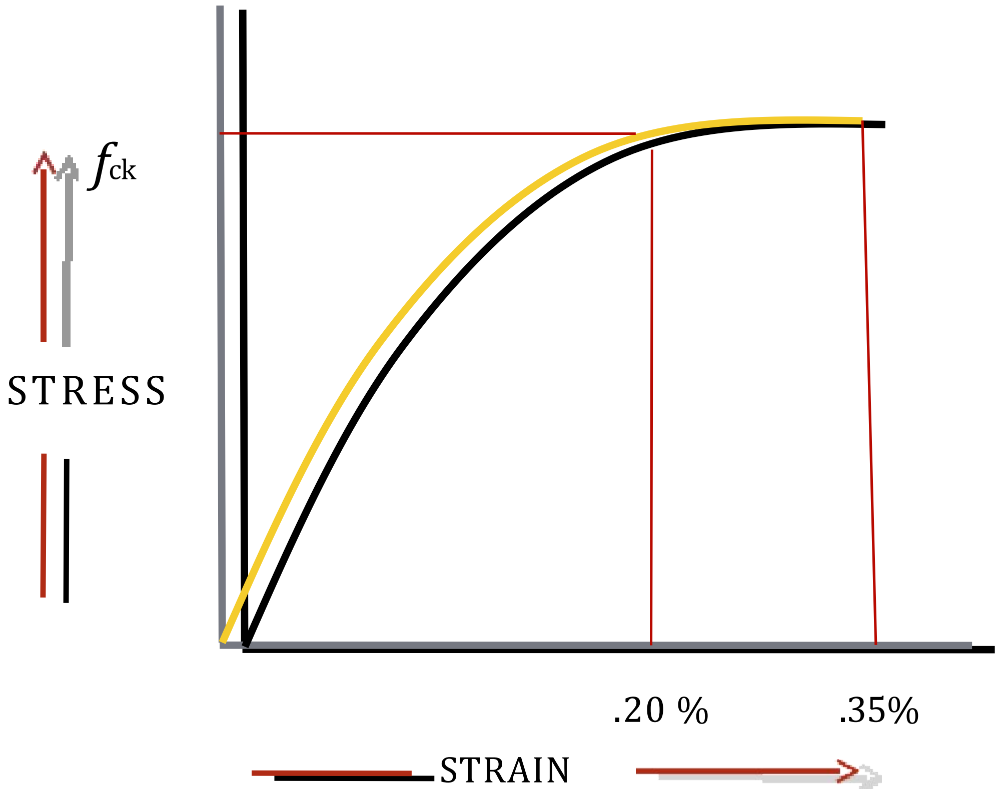
Reinforcement in simply supported beam



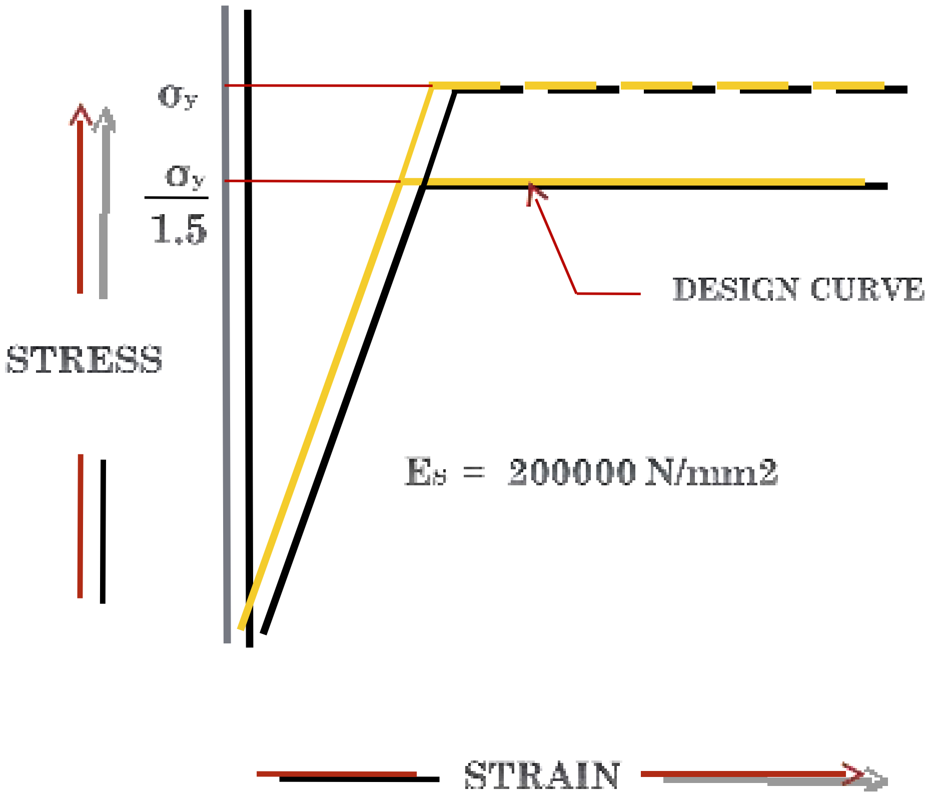


SECTION A - A

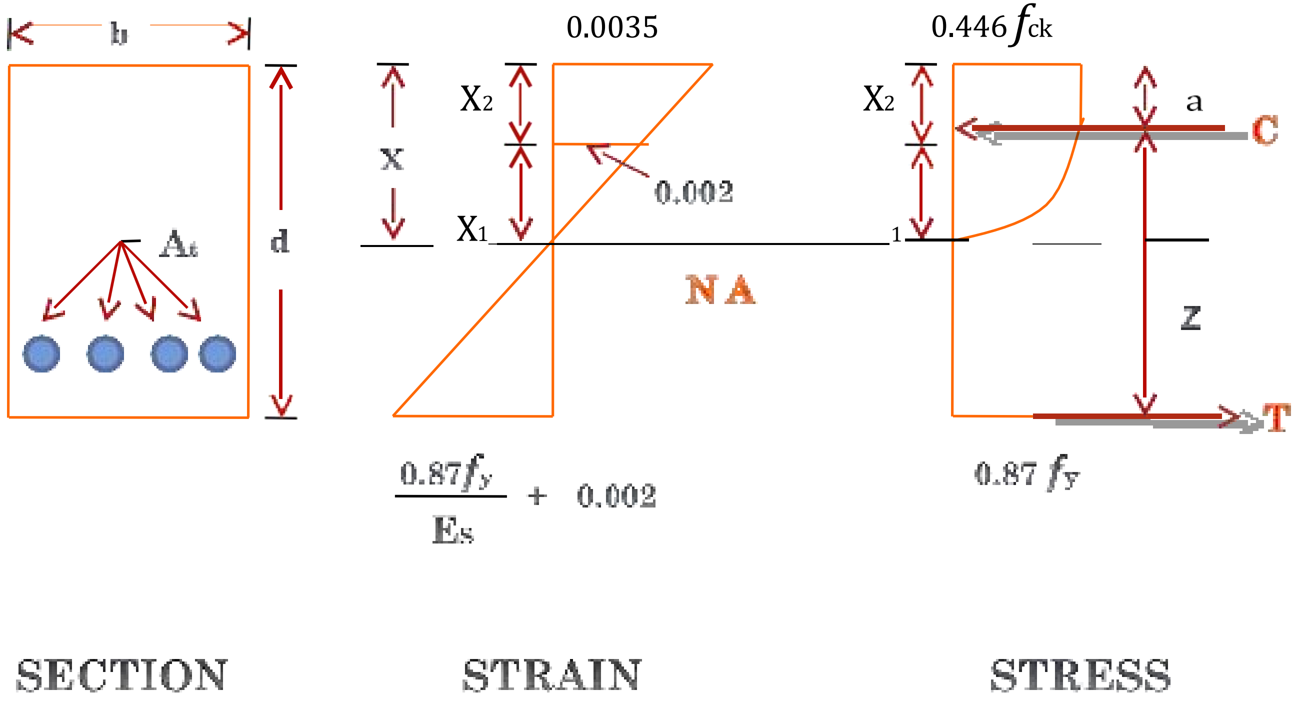
STRESS – STRAIN CURVE FOR CONCRETE



STRESS – STARIN CURVE FOR STEEL



STRESS BLOCK PARAMETERS



- x = Depth of Neutral axis
- b = breadth of section
- d = effective depth of section

- The depth of neutral axis can be obtained by considering the equilibrium of the normal forces, that is,

- Resultant force of compression = average stress X area

$$= 0.36\, f_{ck}\, bx$$

- Resultant force of tension = $0.87\, f_y\, A_t$
- Force of compression should be equal to force of tension,

$$0.36\, f_{ck}\, bx = 0.87\, f_y\, A_t$$

$$x = \frac{0.87\, f_y\, At}{0.36\, f_{ck}\, b}$$

Where A_t = area of tension steel

- The distance between the lines of action of two forces C & T is called the lever arm and is denoted by z.
- Lever arm $z = d - 0.42\,x$
- $$z = d - 0.42\left(\frac{0.87\,f_y\,A_t}{0.36\,f_{ck}\,b}\right)$$
- $$z = d - \frac{f_y\,A_t}{f_{ck}\,b}$$

MAXIMUM DEPTH OF NEUTRAL AXIS

f_y N/mm2	x_m
250	0.53 d
415	0.48 d
500	0.46 d

LIMITING MOMENT OF RESISTANCE VALUES, N MM

Grade of concrete	Grade of steel		
	Fe 250 steel	Fe 450 steel	Fe 500 steel
General	0.148 f_{ck} bd	0.138 f_{ck} *bd*	*0.133* f_{ck} *bd*
M20	2.96 bd	2.76 bd	2.66 bd
M25	3.70 bd	3.45 bd	3.33 bd
M30	4.44 bd	4.14 bd	3.99 bd

Thank You..