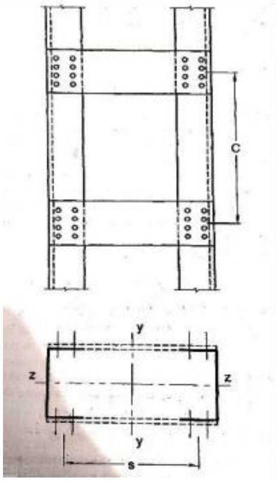
DESIGN OF STEEL AND RCC STRUCTURES (5012,rev21)

THEORY QUESTIONS

MODULE I

- Sketch the battened columns (3marks)



- Explain the step-by-step procedure for the design of a compression member (7marks)

Design of compression member

1) Find the factored load (1.5xworking load)
2) Assume a suitable value of design compressive stress (f_{cd}) to determine the area of cross section
3) Calculate the effective sectional area required

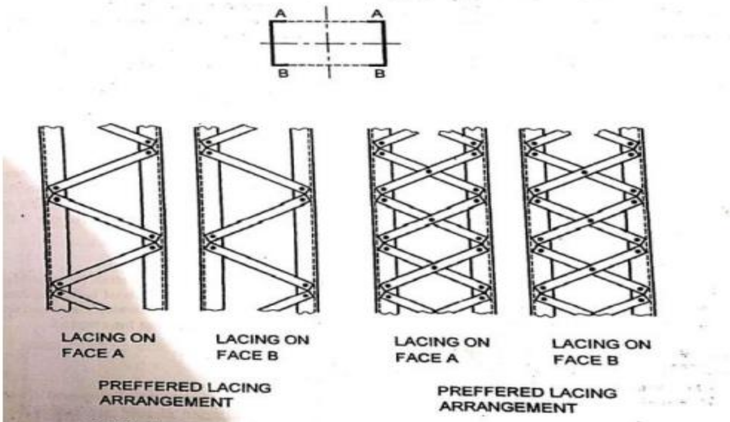
$$A_e = \frac{P_d}{f_{cd}}$$

4) Select a section having gross area greater than the calculated area
5) Calculate slenderness ratio ($\frac{KL}{r}$)
4) Find the value of design compressive stress(f_{cd})
5) Calculate the load carrying capacity of the selected section

$$P_d = A_e f_{cd}$$

6) If it is greater than factored load the design is safe, otherwise redesign the section by considering another section of area greater than required area

- Sketch the single and double lacing system



10A Single Laced System

10B Double Laced System

- Write down the step-by-step procedure in designing a tension member including equations

Design steps – Tension Member

1. Determination of factored load

   Factored load = 1.5 x working load

2. Identifying the required section

   Area required $= \dfrac{Factored\ load}{\frac{fy}{\gamma mo}}$

3. Provide an area of section which is more than required area
4. Determine the number of bolts or the welding required and arrange (connection design)
5. Check for the of the tensile strength of member

   i) Gross section yielding

   $$T_{dg} = A_g \frac{f_y}{\gamma_{mo}}$$

   ii) Rupture of net section

   $$T_{dn} = \frac{0.9 A_{nc} f_u}{\gamma_{ml}} + \frac{\beta A_{go} f_y}{\gamma_{mo}}$$

Lower of the two should be greater than the factored load, otherwise redesign the member by considering another section having area greater than the required area

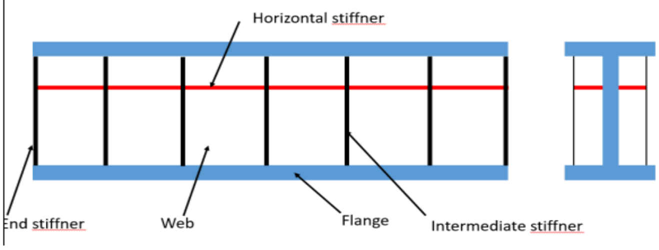
MODULE II

- Write any three types of steel trusses (3marks)

1. King post truss
2. Queen post truss
3. Howe truss
4. Fink truss
5. Fan truss
6. North light truss or saw tooth truss
7. Belgian truss

- Draw the suitable cross section of a plate girder and marks the parts associated with (7marks)

Plate girder



- Write any three functions of a plate girder

It carries heavy loads on relatively long spans
It can resist lateral movements
It can resist shear
It can resist bending moment

- Define laterally supported beams

Laterally supported beam – A beam in which compression flange is laterally supported by flooring, then it is known as laterally supported beam. It is mainly subjected to bending and shear.

- Explain different classes of cross sections

IS 800:2007, clause 3.7.2, page 17

Class 1 (Plastic)

Cross sections which can develop plastic hinges and have the rotation capacity required for failure of the structure by formation of plastic mechanism

Class 2 (Compact)

Cross sections which can develop plastic moment of resistance but have inadequate plastic hinge rotation capacity for formation of plastic mechanism due to local buckling

Class 3 (Semi-compact)

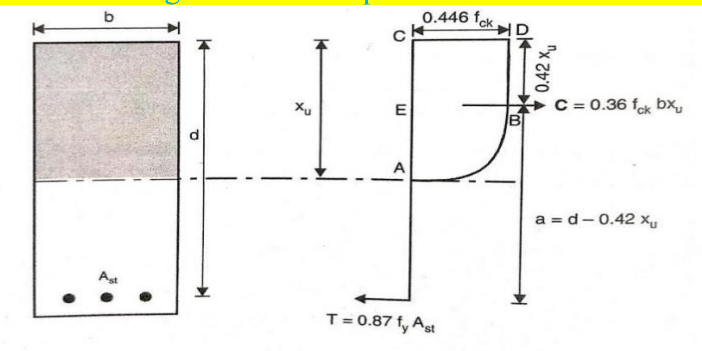
Cross sections in which the extreme fibre in compression can reach yield stress, but cannot develop the plastic moment of resistance due to local buckling

Class 4 (Slender)

Cross sections in which the elements buckle locally even before reaching yield stress

MODULE III

1. Sketch the design stress block parameters (3marks)



2. Explain the concept of balanced, under reinforced and over reinforced section (7marks)

Balanced section Sections - In which tension steel reaches yield strain (0.87fy/1.15Es+0.002) and concrete reaches failure strain (0.0035) simultaneously are called balanced sections.

• Xu/d = Xumax/d

• Actual neutral axis same as critical neutral axis

Under reinforced section- In this case the steel fails first by reaching its yield strain, although in concrete the ultimate strain has not reached. Steel is ductile material and it gives sufficient warning before failure.

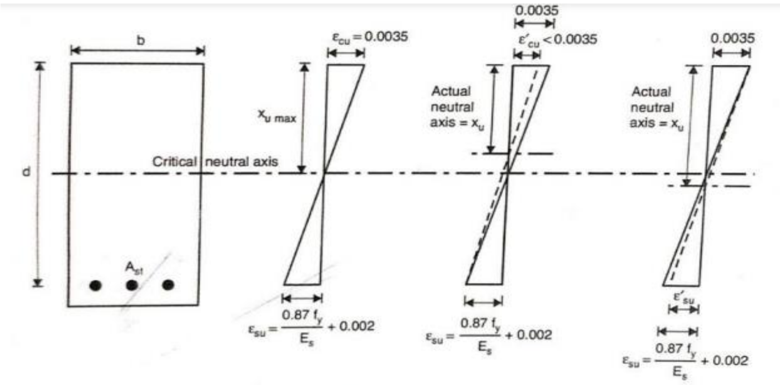
• Xu/d < Xumax/d

• Actual neutral axis above critical neutral axis

Over reinforced section -The over reinforced section is that in which strain in concrete reaches its ultimate value earlier than steel. This means that over reinforced sections fail by crushing failure of concrete. Therefore, code IS456:2000 recommends that such sections should be redesigned

• Xu/d > Xumax/d

• Actual neutral axis below critical neutral axis



(a) (b) Balanced section (c) Under-reinforced section (d) Over-reinforced section

3. Write down the steps involved in the designing of a two-way slab (7marks)

1. Check whether one way or two-way slab
2. Assume an $\frac{l}{d}$ ratio & calculate depth
3. Calculation of effective span (l_{eff})
4. Calculation of load – Add dead load , live load and finishes
5. Find maximum bending moment in both spans

   $M_x = \alpha_x w {l_x}^2$

   $M_y = \alpha_y w {l_x}^2$
6. Check whether section is over reinforced or under reinforced
7. Determination of area of steel
8. Torsional reinforcement at corners
9. Check for shear
10. Check for deflection
11. Check for development length

4. Explain the concept of limit state method of design (3marks)

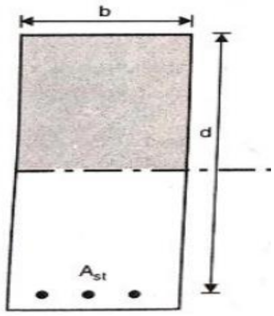
Limit state is defined as the acceptable limit of safety and serviceability requirements before failure. The aim of this method is that the structure should be able to withstand safely all the load that are liable to act on it throughout its life and it should also satisfy the serviceability requirements of limiting deflection and cracking. The most important limit states which are considered in design are as follows

A) Limit state of collapse

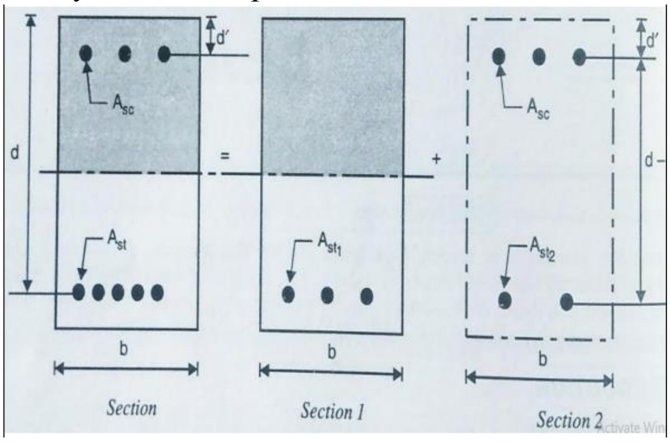
B) Limit state of serviceability

5. Explain the concept of singly reinforced and doubly reinforced beam sections (7marks)

Singly reinforced beam - The beam that is longitudinally reinforced only in tension zone, it is known as singly reinforced beam. In such beams the tension is carried by the reinforcement while the compression is carried by the concrete.



Doubly reinforced beam - The beam that is reinforced with steel in the tension and compression zone is known as doubly reinforced beam. This type of beam is provided mainly when the depth of the beam is restricted.



6. Concept of development length

   IS 456:2000 Page No.42, Clause 26.2.1
7. Anchorage value

   IS 456:2000 Page No.43, Clause 26.2.2.1 & 26.2.2.2
8. Minimum tension reinforcement

   IS 456:2000 Page No.46, Clause 26.5.1.1
9. Minimum shear reinforcement

   IS 456:2000 Page No.48, Clause 26.5.1.6
10. Write the codal provision regarding the span to effective depth ratios of beam and slab

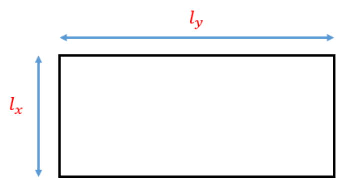
    IS 456:2000 Page No.37, Clause 23.2.1

11. Differentiate one way slab and two-way slab

ONE WAY & TWO WAY

- They are classified on the basis of $\frac{l_y}{l_x}$ ratio
- If $\frac{l_y}{l_x} > 2$ → One way slab

  $\frac{l_y}{l_x} \leq 2$ → Two way slab



Where l_y= Length of longer span

l_x= Length of shorter span

ONE WAY SLAB

- RCC slabs supported on two opposite sides or on all 4 sides with $\frac{l_y}{l_x}>2$
- Slab spans in one direction as bending takes place only along shorter span
- Main reinforcement are provided along shorter direction
- Distribution steels are provided along longer span direction (2^0 reinforcement)
- Distribution steels is provided to prevent additional stresses developed due to temperature and shrinkage variation
- Slabs are designed as beams of unit width

TWO WAY SLAB

- RCC slabs supported on all 4 sides with $\frac{l_y}{l_x} \leq 2$
- Slab spans in two direction as bending takes place in two direction
- Main reinforcement is provided in both direction

MODULE IV

- Write down the values of effective length of columns for various end conditions in terms of unsupported length

  IS 456:2000 Page No 94 table 28

- Differentiate long column and short column

  Short column - The column is considered as short when the slenderness ratio of column that is ratio of effective length to its least lateral dimension is less than or equal to 12. Such columns generally fail by crushing

  Long column - If the slenderness ratio of the column is greater than 12, it is called as long or slender columns. Long columns generally fail by buckling

- Write the codal provision regarding the spacing of ties provided in columns

  IS 456:2000 Page No 49 Clause 26.5.3.2 section c-1

- Write the codal provision regarding the diameter of ties provided in columns

  IS 456:2000 Page No 49 Clause 26.5.3.2 section c-2

- List types of footing

Foundations

1. Shallow foundation
    a) Spread footing
    b) Wall/strip footing
    c) Combined footing
    d) Cantilever/strap footing
    e) Mat/raft footing
2. Deep foundation
    a) Pile foundation
    b) Well foundation
    c) Pier foundation

- Write the steps in designing an isolated column footing

Design steps – Isolated column footing

1. Determination of size of footing

   Area of footing $= \frac{Load}{SBC\ of\ soil}$

Total load = Load transferred from column + weight of footing

Usually, weight of footing is taken as 10% of load from column

$$Area = \frac{1.1W}{SBC}$$

assume suitable ratio to length and breadth and find L&B (If rectangular)

2. Calculation of depth based on bending compression
3. Calculation of depth based on one way shear
4. Check for two-way shear
5. Determination of area of steel

- Write the codal provision regarding the provision of longitudinal reinforcement in columns

  IS 456:2000 Page No 49 Clause 26.5.3.1 points a, c, d & g

  - Minimum % of longitudinal reinforcements =0.8% gross c/s
  - Maximum % of longitudinal reinforcements =6 % gross c/s
  - Minimum diameter of longitudinal reinforcement =12mm
  - Maximum spacing of longitudinal bars =300mm
  - Minimum clear cover to the main reinforcement =40mm
  - The minimum number of longitudinal bars for

    circular columns=6

    rectangular columns =4

- Define Isolated footing

  Isolated footing

  Footings which are provided under single columns are called Isolated footing. These are usually square or rectangular and rarely circular. They are ideally provided when loads are small and soil is not very poor.

- Explain the types of footing

  Footing is the Portion of foundation which ultimately delivers the load to the soil. Different types of foundations are provided depending upon the type of structure, distribution of loads, type and capacity of subsoil. Following are the some of the common types of foundations

  I. Shallow foundation (depth<=width)
     1. Spread footing–transmits load of walls/columns
        a) Isolated footing (columns)
        b) Continuous footing (walls)
     2. Wall/Strip footing
     3. Combined footing – spread footing which supports two or more columns
     4. Cantilever/Strap footing – spread footing of two columns connected by strap beam
     5. Mat/raft footing – Footing that covers entire area beneath a structure and support all the columns and walls

  II. Deep foundation (depth>width)
     1. Pile foundation – when loads are heavy and soil has poor bearing capacity
     2. Well, /Caisson foundation – for bridges
     3. Pier foundation