	SRI VIDYA COLLEGE OF ENGINEERING & TECHNOLOGY **VIRUDHUNAGAR**	

CE6505 DESIGN OF REINFORCED CONCRETE ELEMENTS

UNIT – I

METHODS OF DESIGN OF CONCRETE STRUCTURES

QUESTIONS & ANSWERS

PART – A

1. **What is Ultimate Limit State (ULS)**

ULS in concerned with the maximum load – carrying capacity of thestructure within the limits of strength of the materials used.

2. **What is characteristic load?**

Generally, load on any structural members cannot be determined accurately. For most structures, it is uneconomical to design using anticipated maximum load.Therefore, in normal design practice, the load to be used is based on thecharacteristic load. Characteristic load is defined as the minimum load thatstatistically will not exceed during the design life of the structure.

3. **State the 3 types of load.**

a) Dead load b) Imposed loadc) Wind load

4. **State four objectives of the design of reinforced concrete structure.**

Properly designed reinforced concrete structures should:

- Have acceptable probability of performing satisfactorily during their intended life,
- Sustain all loads with limited deformations during construction and use,
- Be durable,
- Adequately resist the effects of misuse and fire.

5. **How to fulfill the three objectives of the design of reinforced concrete structures?**

The three objectives can be fulfilled by:

(i) Understanding the strength and deformation characteristics of concrete and steel,

(ii) Following the clearly defined standards for materials, production, workmanship and maintenance, and use of structures in service,

(iii) Adopting measures needed for durability.

6. **What are the three methods of design of reinforced concrete structural elements?**

The three methods are:

- Limit state method,
- Working stress method,
- Method based on experimental approach

7. **How to estimate the design loads in (i) limit state method, and (ii) working stress method?**

(i) In limit state method,

Design loads = Characteristic loads multiplied by the partial safety factor for loads

(ii) In working stress method,

Design loads = Characteristic loads.

UNIT 1
METHODS OF DESIGN OF CONCRETE STRUCTURES

1. Explain the limit state philosophy as detailed in the current IS code. (NOV-DEC 2012)

- ✓ The Answer is in Page No.67 of IS 456:2000.

- ✓ In the method of design based on limit state concept, the structure shall be designed withstand safely all loads liable to act on it throughout its life;
- ✓ it shall also satisfy the serviceability requirements, such as limitations on deflection and cracking.

- ✓ The acceptable limit for the safety and serviceability requirements before failure occurs is called a 'limit state'.

- ✓ The aim of design is to achieve acceptable probabilities that the structure will not become unfit for the use for which it is intended, that is, that it will not reach a limit state.

- ✓ 351.1 All relevant limit states shall be considered in design to ensure an adequate degree of safety and serviceability. In general, the structure shall be designed on the basis of the most critical limit state and shall be checked for other limit states.
- ✓ 35.1.2 For ensuring the above objective, the design should be based on characteristic values for material strengths and applied loads, which take into account the variations in material strengths and in the loads to be supported.

- ✓ The characteristic values should be based on statistical data if available; where such data are not available they should be based on experience. The 'design values' are derived from the characteristic values through the use of partial safety factors, one for material strengths and the other for loads.

- ✓ In the absence of special considerations these factors should have the values given in 36 according to the material, the type of loading and the limit state being considered.

2. Design a R.C beam to carry a load of 6 kN/m inclusive of its own weight on an effect span of 6m keep the breath to be 2/3 rd of the effective depth .The permissible stressed in the concrete and steel are not to exceed 5N/mm^2 and 140 N/mm^2.take m=18. (NOV- DEC 2012).

Step 1: Design constants.

Modular ratio, m =18.
A Coefficient n $\sigma_{bc}.m/(\sigma_{bc}.m + \sigma st)$ 0.39
Lever arm Coefficient, j=1-(n/3) = 0.87
Moment of resistance Coefficient Q $\sigma_{bc}/2$. n. j 0.84

Step 2: Moment on the beam.

$M = (w.l^2)/8 = (6x6^2)/8 = 27kNm$
$M = Q_b d^2$
$d^2 = M/Q_b = (27x106)/ (0.84x2/3xd)$ d = 245mm.

Step 3: Balanced Moment.

$Q_b d^2 = 0.84x245x3652 = 27.41kNm. > M.$
It can be designed as singly reinforced section

Step 4: Area of steel.

$A_{st} = M_{bal} / (\sigma st.j.d)$ 616.72mm²
Use 20mm dia bars ast π/4 (202) = 314.15mm²
No. of bars = A_{st}/a_{st} = 616.72/314.15 = 1.96 say 2nos.
Provide 2#20mm dia bars at the tension side.

3. Design a doubly reinforced beam of section 240X500mm to carry a bending moment of 80kNm.Assume clear cover at top a bottom as 30mm and take m=18.adopt working stress method. (NOV-DEC 2010).

*Assume the permissible stresses in the concrete and steel are not to exceed 5N/mm² and 140 N/mm².

Step 1: Design constants

Modular ratio, m =18.
A Coefficient n σbc.m/(σbc.m + σst) 0.39
Lever arm Coefficient, j=1-(n/3) = 0.87

Moment of resistance Coefficient Q σbc/2. n. j 0.84

Step 2: Moment on the beam.	M = 80kNm M = Qbd² D = 500mm, b = 240mm, d = 500-30mm = 470mm
Step 3: Balanced Moment.	M_{bal} = Qbd² = 0.84x240x4702 = 44.53kNm. < M. It can be designed as doubly reinforced section.
Step 4: Area of Tension steel.	Ast = Ast1 + Ast2 Ast1 = Mbal / (σst.j.d) (44.53x106)/(140x0.87x470) = 777.87mm² Use 20mm dia bars ast π/4 (202) = 314.15mm2 No. of bars = Ast/ast = 777.87/314.15 = 2.47 say 3nos. Ast2 = (M-Mbal) / (σst.(d-d1)) = (80x106-44.53x106)/(140x(470-30)) = 575.8mm² Use 20mm dia bars ast π/4 (202) = 314.15mm² No. of bars = Ast/ast = 575.8/314.15 = 1.8 say 2nos
Step 5: Area of Compression steel:	Asc = (M-Mbal) / (σsc.(d-d1)) = (80x106-44.53x106)/(51.8x(470-30)) =1580.65 mm² Use 20mm dia bars ast π/4 (202) = 314.15mm² No. of bars = Ast/ast = 1580.65/314.15 = 5.5 say 6nos. Provide 6#20mm dia bars as compression reinforcement

4. Determine the moment of resistance of a singly reinforced beam 160X300mm effective section, if the stress in steel and concrete are not to exceed 140N/mm2 and 5N/mm².effectve span of the beam is 5m and the beam carries 4 nos of 16mm dia bars. Take m=18.find also the minimum load the bam can carry. Use WSD method. (NOV-DEC 2009)

Step 1: Actual NA.	 b xa2/2 = m.Ast.(d- xa) 160. xa2/2 = 18 X 804.24(300 –xa) Xa = 159.42mm
Step 2: Critical NA.	xc σbc.d/(σst/.m + σcbc) 117.39mm < Xa 159.42mm it is Over reinforced Section.
Step 3: Moment of Resistance	M (b. xa/2 .σcbc)(d- xa/3) = (160x159.42/2x5)(300-159.42/3)

= 15.74kNm

Step 4: Safe load.

M = (w.l2)/8
W = (8 x 15.74)/52
= 5.03 kN/m

5. Differentiate between working stress method and limit state method. (APRIL MAY 2012)

- In the limit state method of analysis, the principles of both elastic as well as plastic theories used and hence suitable for concrete structures.
- The structure designed by limit state method is safe and serviceable under design loads and at the same time it is ensured that the structure does not collapse even under the worst possible loading conditions.
- The process of stress redistribution, moment redistribution etc., are considered in the analysis and more realistic factor of safety values are used in the design.
- Hence the design by limit state method is found to be more economical.
- The overall sizes of flexural members (depth requirements) arrived by limit state method are less and hence they provide better appearance to the structure.
- Because of the modified assumptions regarding the maximum compressive strains in concrete and steel, the design of compressive reinforcement for double reinforced beams and eccentrically loaded columns by limit state method gives realistic valued which is not so in other methods.

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- ❖ The overall sizes of flexural members (depth requirements) arrived by limit state method are less and hence they provide better appearance to the structure.

- ❖ Because of the modified assumptions regarding the maximum compressive strains in concrete and steel, the design of compressive reinforcement for double reinforced beams and eccentrically loaded columns by limit state method gives realistic valued which is not so in other methods.

7. Explain the following terms:

a. Characteristic strength and characteristic loads.

b. Partial safety factors.

c. Balanced section and under reinforced section.

a.)The Answer is in Page No.67 of IS 456:2000.

b.)The Answer is in Page No.68 of IS 456:2000.

c.) When the maximum stress in steel and concrete simultaneously reach their allowable values, the section is said to be balanced section. in this section the actual neutral axis depth is equal to the critical neutral axis. When the percentage of steel in the section is less than that required for a balanced section. In this section the actual neutral axis depth is equal to the critical neutral axis.

8. Design an interior panel of RC slab 3mX6m size, supported by wall of 300mm thick. Live load on the slab is 2.5kN/m².the slab carries 100mm thick lime concrete (density 19kN/m²).Use M15 concrete and Fe 415 steel. (NOV-DEC 2009)

Step 1: Type of Slab.

ly/lx = 6/3 = 2 = 2.it has to be designed as two way slab.

Step 2: Effective depth calculation.

For Economic consideration adopt shorter span to design the slab.

d = span/(basic value x modification factor)

= 3000/(20x0.95) = 270mm D = 270 + 20 + 10/2

= 295mm

Step 3: Effective Span.

For shorter span:

Le = clear span + effective depth

= 3000 + 270 = 3.27m (or)

Le = c/c distance b/w supports = 3000 + 2(230/2)

=3.23m

Adopt effective span = 3.23m least value.

For longer span:

Le = clear span + effective depth
= 6000 + 270 = 6.27m (or)
Le = c/c distance b/w supports = 6000 + 2(230/2)
= 6.23m Adopt effective span
= 6.23m least value.

Step 4: Load calculation

Live load = 2.5kN/m²
Dead load = 1x1x0.27x25
= 6.75kN/m²
Dead load = 1x1x0.1x19
= 1.9kN/m²
Floor Finish = 1kN/m²
Total load = 12.15kN/m²
Factored load = 12.15 x 1.5 = 18.225kN/m²

Step 5: Moment calculation

. Mx αx . w . lx= 0.103x18.225x3.23
= 9.49kNm
My αy . w . lx = 0.048 x18.225x3.23
= 4.425kNm

Step 6: Check for effective depth..

M = Qbd²
d^2 = M/Qb
= 9.49/2.76x1
= 149.39mm say 150mm.
For design consideration adopt d = 150mm

Step 7: Area of Steel.

For longer span:

Mu = 0.87 fy Ast d (1- (fy ast)/(fck b d)) 4.425x106
=0.87x415xAstx150(1-(415 Ast)/(20x1000x150)) Ast = 180mm²
Use 10mm dia bars Spacing
S = ast/Astx1000
= (78.53/300)1000
= 261mm
Say 260mmc/c.

Provide 10mm dia @260mm c/c.

For shorter span:

Mu = 0.87 fy Ast d (1- (fy ast)/(fck b d))9.49x10^6
=087x415xAstx150(1-(415 Ast)/(20x1000x150)) Ast = 200mm²

Use 10mm dia bars Spacing ,
S = ast/Astx1000 = (78.53/300)1000 = 281mm
Say 300mmc/c.
Provide 10mm dia @300mm c/c.