Nilachal Polytechnic

Bhubaneswar

Sem. : 4TH Subject : [redacted]

Branch: Civil Engineering

Name of the Faculty : Dipika Samal

Text Book to be followed by Student / Faculty

Book- : **A.K. Jain (ALL)**

Chapter-2 : Philosophy of Limit state method (LSM)

1.Learning Objectives

Student will learn –

i) Define the limit states,
ii) Identify and differentiate the different limit states,
iii) State if the structures are to be designed following all the limit states,
iv) Explain the concept of separate partial safety factors for loads and material strengths depending on the limit state being considered,
v) Justify the "size effect" of concrete in its strength,

2. Essential Questions (Fundamental Question)

i) Differentiate between limit states of collapse and limit states of serviceability.

ii) Define characteristics strength of material.

iii) Define moment of resistance.

iv) Explain liveload and dead loads.

v) What is limit state design?

3. Hours Required

Theory	**1hr**
Problems	**nill**
Question & Answer Theory	**1hr**
Total	**2hr**

4. Question for Teaching / Assignment / Self Practice

Question sets	02 Marks	05 Marks	10Marks
Teaching	03	01	nill
Assignment	01	01	nill
Self Practice	01	01	nill
Total	**05**	**03**	

Lesson Description

- This chapter discusses limit-state design of offshore_structures. The concept of limit-state design is introduced to allow an assessment that considers limit states such as ultimate, fatigue, serviceability, and accidental.
- The structure will need to be checked for all groups of limit states to ensure sufficient safety margins between the maximum likely loads and minimum resistance of the structure.
- Extreme care is required in the finite element analysis to ensure that the correct load and resistance factors have been applied, particularly when several models are being used and the results are linearly superimposed.
- This chapter discusses ultimate-limit-state design as it relates to ductility and brittle fracture avoidance, plated structures, shell structures, etc. Fatigue-limit-state design is also discussed in this chapter.
- Several levels of fatigue analysis may be performed including fatigue screening, detailed analysis, reanalysis of welding improvements, and reanalysis of design improvements.

Enclosed :

1. **Course Material.**

CHAPTER -2

SAFETY AND SERVICEABILITY REQUIREMENTS

- In the method of design based on limit state concept, the structure shall be designed to 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 it will not reach a limit state.

- 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.
- 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 the 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.

Limit State of Collapse

The limit state of collapse of the structure or part of the structure could be assessed from rupture of one or more critical sections and from buckling due to elastic or plastic instability (including the effects of sway where appropriate) or overturning. The resistance to bending, shear, torsion and axial loads at every section shall not be less than the appropriate value at that section produced by the probable most un favourable combination of loads on the structure using the appropriate partial safety factors.

Limit State Design

- For ensuring the design objectives, the design should be based on characteristic values for material strengths and applied loads (actions), which take into account the probability of variations in the material strengths and in the loads to be supported.
- The characteristic values should be based on statistical data, if available. Where such data is not available, they should be based on experience.
- The design values are derived from the characteristic values through the use of partial safety factors, both for material strengths and for loads.

- In the absence of special considerations, these factors should have the values given in this section according to the material, the type of load and the limit state being considered. The reliability of design is ensured by requiring that Design Action Design Strength.

Limit States of Serviceability

To satisfy the limit state of serviceability the deflection and cracking in the structure shall not be excessive. This limit state corresponds to deflection and cracking.

Deflection

The deflection of a structure or part shall not adversely affect the appearance or efficiency of the structure or finishes or partitions.

Cracking

- Cracking of concrete should not adversely affect the appearance or durability of the structure; the acceptable limits of cracking would vary with the type of structure and environment.
- The actual width of cracks will vary between the wide limits and predictions of absolute maximum width are not possible.
- The surface width of cracks should not exceed 0.3mm.

- In members where cracking in the tensile zone is harmful either because they are exposed to the effects of the weather or continuously exposed to moisture or in contact soil or ground water, an upper limit of 0.2 mm is suggested for the maximum width of cracks.

CHARACTERISTIC AND DESIGN VALUES AND PARTIAL SAFETY FACTORS

1. Characteristic Strength of Materials

Characteristic strength means that value of the strength of the material below which not more than 5 percent of the test results are expected to fall and is denoted by f. The characteristic strength of concrete ($f$ck) is as per the mix of concrete. The characteristic strength of steel (fy) is the minimum stress or 0.2 percent of proof stress.

2. Characteristic Loads

Characteristic load means that value of load which has a 95 percent probability of not being exceeded during the life of the structure. Since data are not available to express loads in statistical terms, for the purpose of this standard, dead loads given in IS 875 (Part I), imposed loads given in IS 875 (Part 2), wind loads given in IS 875 (Part 3), snow load as given in IS 875 (Part **4)** and seismic forces given in IS 1893-2002(part-I) shall be assumed as the characteristic loads.
When assessing the strength of a structure or structural member for the limit state of collapse, the values of partial safety factor, should be taken as 1.5 for concrete and 1.15 for steel.

LIMIT STATE OF COLLAPSE: FLEXURE

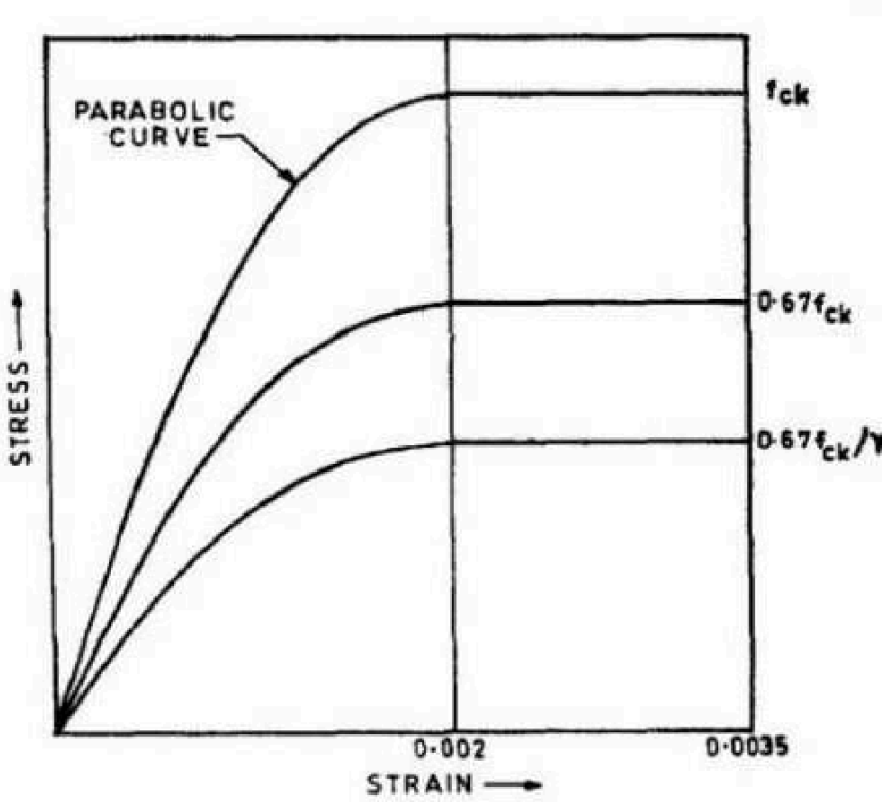
Assumptions for Limit State of Collapse (Flexure):

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.

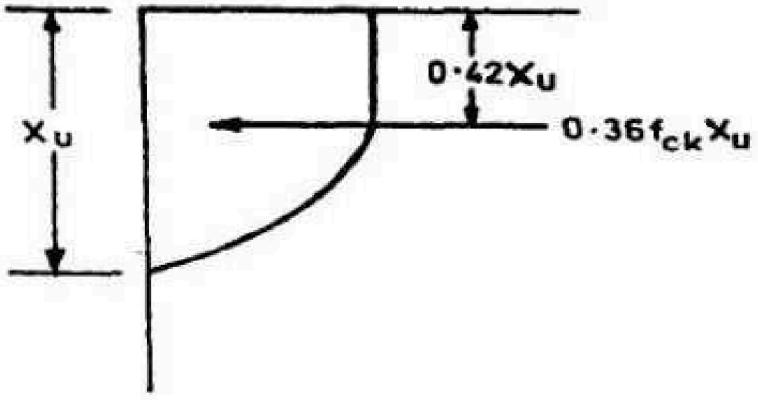
2) Maximum strain in concrete at the outer most compression fibre is taken as 0.0035 in bending.

3) The relationship between the compressive stress distribution in concrete and the strain in concrete may be assumed to be rectangle, trapezoid, parabola or any other

shape which results in prediction of strength in substantial agreement with the results of test. An acceptable stress strain curve is as shown below.



STRESS-STRAIN CURVE FOR CONCRETE



STRESS BLOCK PARAMETERS

For design purposes, the compressive strength of concrete in the structure shall be assumed to be 0.67 times the characteristic strength. The partial safety factor ■ *m* = 1.5 shall be applied in addition to this.

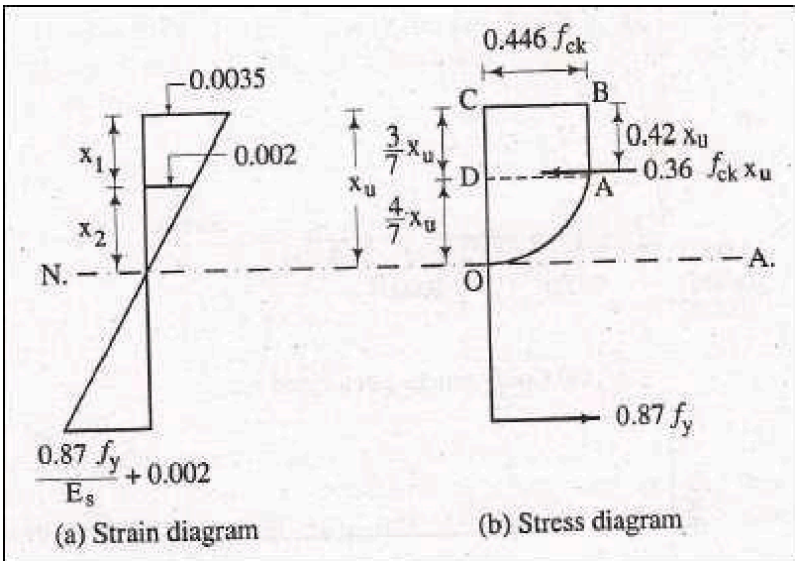
NOTE - For the above stress-strain curve the design stress block parameters are as follows: Area of stress block = 0.36.fck.xu

Depth of centre of compressive force = 0.42xu from the extreme fibre in compression

Where

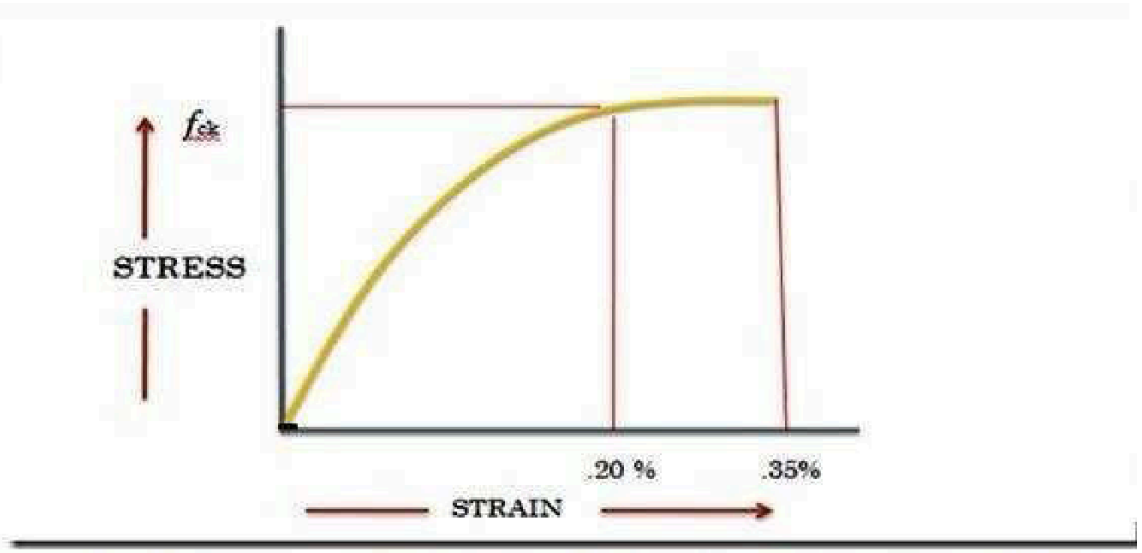
fck = characteristic compressive strength of concrete,

and xu = depth of neutral axis.



4) the tensile strength of the concrete is ignored.

5) the stresses in the reinforcement are derived from representative stress – strain curve for the type of steel used.



STRESS — STARIN CURVE FOR STEEL

6) the maximum strain in tension reinforcement in the section at failure shall not be less tha

$$\frac{f_y}{1.15\,E_s} + 0.002 = \frac{0.87 f_y}{E_s} + 0.002$$

Faculty **HOD** **Principal**