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AN AUTONOMOUS INSTITUTION

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COIMBATORE

DEPARTMENT OF CIVIL ENGINEERING

19CET302-DESIGN OF RC STRUCTURAL ELEMENTS

III YEAR / V SEMESTER

Unit 1 : INTRODUCTION

Methods of RCC design



Methods of RCC design



A reinforced concrete structure should be designed to satisfy the following criteria-

- Adequate safety, in items stiffness and durability
- Reasonable economy.

The following design methods are used for the design of RCC Structures.

- a) The working stress method (WSM)
- b) The ultimate load method (ULM)
- c) The limit state method (LSM)



Working Stress Method (WSM)

- This method is based on linear elastic theory or the classical elastic theory. This method ensured adequate safety by suitably restricting the stress in the materials (i.e. concrete and steel) induced by the expected working loads on the structures.
- The assumption of linear elastic behaviour considered justifiable since the specified permissible stresses are kept well below the ultimate strength of the material.
- The ratio of yield stress of the steel reinforcement or the cube strength of the concrete to the corresponding permissible or working stress is usually called factor of safety.
- The WSM uses a factor of safety of about 3 with respect to the cube strength of concrete and a factor of safety of about 1.8 with respect to the yield strength of steel.



Ultimate load method (ULM)

- The method is based on the ultimate strength of reinforced concrete at ultimate load is obtained by enhancing the service load by some factor called as load factor for giving a desired margin of safety .Hence the method is also referred to as the load factor method or the ultimate strength method.
- In the ULM, stress condition at the state of in pending collapse of the structure is analysed, thus using, the non-linear stress – strain curves of concrete and steel.
- The safely measure in the design is obtained by the use of proper load factor.
- The satisfactory strength performance at ultimate loads does not guarantee satisfactory strength performance at ultimate loads does not guarantee satisfactory serviceability performance at normal service loads.



Advantages of ULM : Following are the advantages of ULM :

1. Different load factors for different types of loads can be used.
2. Reserve strength in the plastic stage is being utilized by this method.
3. Load factors used in this method gives sufficient margin of safety.

Disadvantages of ULM :

Following are the disadvantages of ULM :

1. It ensures safety at ultimate loads but does not satisfy the serviceability requirements at service (working) loads.
2. There is increase in deflection and crack width due to use of high strength reinforcing steel and concrete.
3. It does not take into account the effect of creep and shrinkage.



Limit state method (LSM)

- Limit states are the acceptable limits for the safety and serviceability requirements of the structure before failure occurs.
- The design of structures by this method will thus ensure that they will not reach limit states and will not become unfit for the use for which they are intended.
- It is worth mentioning that structures will not just fail or collapse by violating (exceeding) the limit states. Failure, therefore, implies that clearly defined limit states of structural usefulness has been exceeded.



1. Working Stress Method (WSM) gives satisfactory performance of the structure at working loads but it becomes unrealistic at ultimate state of collapse. On the other hand, Ultimate Load Method (ULM) provides realistic assessment of safety, it does not guarantee the satisfactory serviceability at working loads.
2. The best suitable method is that which not only takes into account the ultimate strength but also the serviceability and durability requirement.
3. In this method, the structure shall be designed to withstand safely all loads which are expected to act on it throughout its life span.
4. It shall also satisfy the serviceability requirements such as prevention of excessive deflection, cracking and vibrations.
5. This method of design is based upon safety at ultimate loads and serviceability requirements.
6. The —Limit State|| may be defined as the acceptable limit for the safety and serviceability requirements.



7. In LSM, design values are obtained by multiplying working loads with partial factor of safety and the design strength of materials is obtained by dividing characteristic strengths (ultimate strength) with partial FOS.

8. To make sure that the above objectives are satisfied, the design should be based upon characteristic values for material strengths and applied loads, taking into accounts the variation in the material strength and loading



COMPARISON BETWEEN WORKING STRESS METHOD (WSM) AND LIMIT STATE METHOD (LSM)



S.NO	WSM	LSM
1	It is based on the behavior of structure under service load (working loads).	The structure shall be designed on the basis of most critical limit state and checked for other limit states.
2	This method is assumed to be deterministic because all loads, stresses and factor of safety are known.	This method is non-deterministic because loads and stresses are predicted based upon experience and field datas.
3	Safety against ultimate loads is not known.	It satisfies all the limit states of collapse and serviceability.
4	Structures are proportioned to develop stresses upto a fraction of the ultimate stress of concrete and yield stress of steel by applying FOS.	In this method, the design values are obtained by applying partial safety factors
5	WSM leads to comparatively larger sections of structural members with higher quantities of steel reinforcement.	LSM results in lesser quantities of steel reinforcement as compare to WSM



DIFFERENT TYPES OF LIMIT STATES

Limit state is a state of impending failure beyond which a structure ceases to perform satisfactorily in terms of safety and serviceability.

Different types of limit states which are to be considered in design are :

- (a) Limit State of Collapse (or Ultimate Limit State).
- (b) Limit State of Serviceability
- (c) Other Limit States.

(a) Limit State of Collapse

1. Limit State of Collapse (or failure) depends upon ultimate strength.
2. Limit State of Collapse have been introduced from safety requirements.
3. Limit State of Collapse occur when the structure as a whole or part of the structure collapses under following conditions :
 - (i) Limit State of Collapse in Flexure.
 - (ii) Limit State of Collapse in Compression.
 - (iii) Limit State of Collapse in Shear.
 - (iv) Limit State of Collapse in Torsion.
 - (v) Limit State of Collapse in Bond.



(b) Limit State of Serviceability

1. The limit state of serviceability relates to the performance and behaviour of structure at service loads (working loads).
2. This limit state is introduced to prevent objectionable deflection and cracking.
3. Generally, design is based upon limit state of collapse at ultimate loads and serviceability (in excessive cracking and deflection) at working loads.
The two important limit state of serviceability are :

(i) Limit State of Deflection (ii) Limit State of Cracking

(c) Other Limit States (As per IS : 456 – 2000, Clause 35–4): Structures designed for unusual or special functions shall comply with any relevant additional limit state considered appropriate to that stretches such as limit states of vibrations, impact resistance, durability, fire resistance etc.



LIMIT STATE OF COLLAPSE

- LIMIT STATE OF COLLAPSE FLEXURE -As per IS .- 456 - 2000, Clause 38
- LIMIT STATE OF COLLAPSE Compression-As per IS .- 456 - 2000, Clause 39
- LIMIT STATE OF COLLAPSE Shear- As per IS .- 456 - 2000, Clause 40

LIMIT STATE OF SERVICEABILITY

- LIMIT STATE OF SERVICEABILITY:DEFLECTION As per IS .- 456 - 2000, Clause 42
- LIMIT STATE OF SERVICEABILITY:CRACKING As per IS .- 456 - 2000, Clause 43



3 GATE CE 1997
MCQ (Single Correct Answer) +1 -0.3



The permissible tensile stress in concrete made of M 25 concrete is

A 3.5 N/mm²

B 60 N/mm²

C 2.5 N/mm²

Correct Answer

D None of the above

1 GATE CE 2014 Set 2
MCQ (Single Correct Answer) +1 -0.3



The target mean strength f_{cm} for concrete mix design obtained from the characteristic strength (f_{ck}) and standard deviation σ , as defined in IS:456-2000, is

A $f_{ck} + 1.35\sigma$

B $f_{ck} + 1.45\sigma$

C $f_{ck} + 1.55\sigma$

D $f_{ck} + 1.65\sigma$

Correct Answer



3 GATE CE 2013
MCQ (Single Correct Answer) +1 -0.3



Maximum possible value of compaction factor for fresh (green) concrete is

A 0.5

B 1.0

Correct Answer

C 1.5

D 2.0

1 GATE CE 1995
MCQ (Single Correct Answer) +1 -0.3



Workability of concrete is influenced most by its

A Water-cement ratio

B Aggregate-cement ratio

C Cement content

D Water content

Correct Answer

Explanation



2 GATE CE 1994

MCQ (Single Correct Answer) +1 -0.3



Grading of aggregate in a concrete mix is necessary to achieve

A Adequate workability

B Higher density

C Reduction in Voids

Correct Answer

D Better durability



THANK YOU