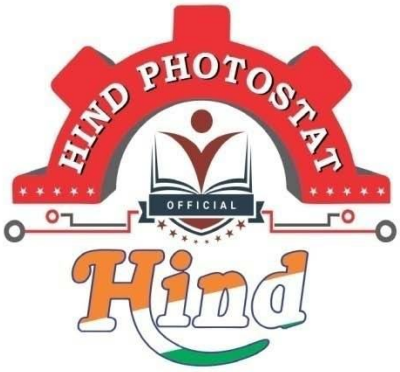

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UNACADEMY

CIVIL ENGINEERING

STEEL STRUCTURE ANALYSIS

BY- JASPAL SIR

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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Lesson 1 13 Oct.

#General Design Consideration.

- Design of steel structure consists of design of steel members and their connections so that applied load can be resisted and transferred safely & economically.
- Design of steel structure is based on following theories.

A) Working stress design method / Elastic method.
B) Ultimate load method / Plastic method.
C) Limit state method.

Note:→ The basic difference b/w 3 design method is the manner in which safety is considered in designing

A) WORKING STRESS DESIGN METHOD. (WSM)

- In this method, designing is based on elastic theory.
- Here structures are analysed elastically for worst combination of working loads & the members are proportioned such that allowable or permissible stresses are never exceeded.
- Here permissible stress, is defined as ratio of yield stress to FOS (factor of safety). and this FOS is found on the basis of experience.

i.e. Working stress ≤ permissible stress.

$$\leq \frac{\text{yield stress}}{\text{FOS}}$$

- This theory possess certain inherent drawbacks such as:→

a) as in this case, linear elastic behaviour is assumed, reserved strength of material (strength beyond elastic limit) is not utilised, resulting

in uneconomical design.

b) The assumption that working stress would be kept less than permissible stress is not possible due to.
   (i) stress concentration (Bolt, weld)
   (ii) residual stress
   (iii) other secondary effects. (Temperature change ⇒ thermal stress)
   (or sinking of support).

c) It assumes, all the loads to act simultaneously with same degree of uncertainity.

B) Ultimate load method / Plastic method.

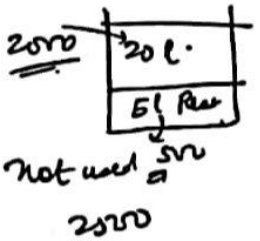
- In this method, the designing is based on ultimate strength.
- This method of design is based on failure condition rather than working load conditions.
- Here failure implies collapse or excessive large deformation.
- When sufficient plastic hinges are formed in the structure at maximum stressed point, a mechanism is developed, that causes failure of the structure.

Note: ⇒ When a system of load is applied to an elastic body, it deforms & shows resistance against it, this body is termed as STRUCTURE, but if no resistance is set up against deformation, then it is termed as MECHANISM.

- In this method, service loads are multiplied by the load factor & cross-section of the members are selected on the basis of collapse strength.

i.e. | load factor × working load ≤ ultimate load or collapse load

- Since, in this method, reserved strength of material (steel) is used, it results in smaller sized section w.r.t. those designed using working stress design method.
- However it does not consider serviceability conditions (deflection, vibrations, fatigue)
- Here FOS, is not considered on material strength.
- Also, all the loads are considered to be acting simultaneously with same load factor in this case.



= 15l + 5l + 20l
↓
1500
= 2000 Rs

date after which our structure cannot perform its function.

C) Limit State Method.

- All the drawback of WSM, and ultimate load method are overcome in this case.
- In this method, partial safety factors for loading & material strength is applied (which is based on acceptable probability of failure)
- These partial FOS accounts for possible overload, and under strength of material.

Factored load = characteristic load × γ_f

Factored strength = $\frac{\text{characteristic strength}}{\gamma_m}$

γ_f = partial safety factor for load

γ_m = partial safety factor for material strength

Note:→ All the characteristic values are the values that are not expected to be exceeded with more than 5% probability during the life of the structure

Lesson 2. 14 Oct.

— Partial FOS on load (γ_f) accounts for the following.

a) Possibility of load exceeding characteristic load.

b) Possibility of inaccurate assessment of load.

c) Uncertainity in the assessment of effect of load.

d) Uncertainity in the assessment of limit state being considered.

— Partial FOS on material strength (γ_m) accounts for the following.

a) Possibility of strength falling below characteristic strength.

b) Reduction in the member size.

c) Reduction in the strength due to fabrication and tolerance.

d) Uncertainties in the calculation of strength of the member.

Note:→ Here limit states are the states beyond which the structure no longer satisfies the performance requirements.

- These limit are classified as follows :→

A) Limit state of collapse / strength.

B) Limit state of serviceability.

- Limit state of collapse / strength includes

a) loss of equilibrium of structure as a whole or any of its part or components.

b) loss of stability of the structure (including the effect of sway & overturning) on any of its part or structure or as a whole.

c) Failure by excessive deformation, rupture of structure or any of its parts.

d) Fracture due to fatigue.

e) Brittle failure

Note:⇒ For brittle failure to occur, a combination of tensile stress, low temperature, thick material & rapid change of stress

⇒ Limit state of serviceability includes

a) It includes deformation and deflection which may adversly affect the appearance of use of structure.

b) vibration in the structure or any of its component. causing discomfort to the occupants. and limits the functioning of structure.

c) Corrosion and durability.

d) Fire resistance.

e) Ponding of structure (accumulation of water)

f) Repairable damage due to fatigue.

In LSM, structures are designed for limit state of collapse and are checked for limit state of serviceability.

Note:→ In IS 800 : 2007, design criteria are largely based on LSM; however it still retains the WSM (design by), but it accounts for reserved strength also, beside elastic strength.

Partial safety factor for material strength (γ_m)

Description	Partial safety factors for material (γ_m)	
a) Resistance governed by yielding	1.1	
b) Resistance of member to buckling	1.1	
c) Resistance governed by ultimate stress	1.25	
d) Resistance of connections	shop fabrication	field fabrication
(i) Bolted connection, friction type (γ_{mf})	1.25	1.25
(ii) Bolted connection, bearing type (γ_{mb})	1.25	1.25
(iii) Riveted connection (γ_{mr})	1.25	1.25
(iv) Welded connection (γ_{mw})	1.25	1.5

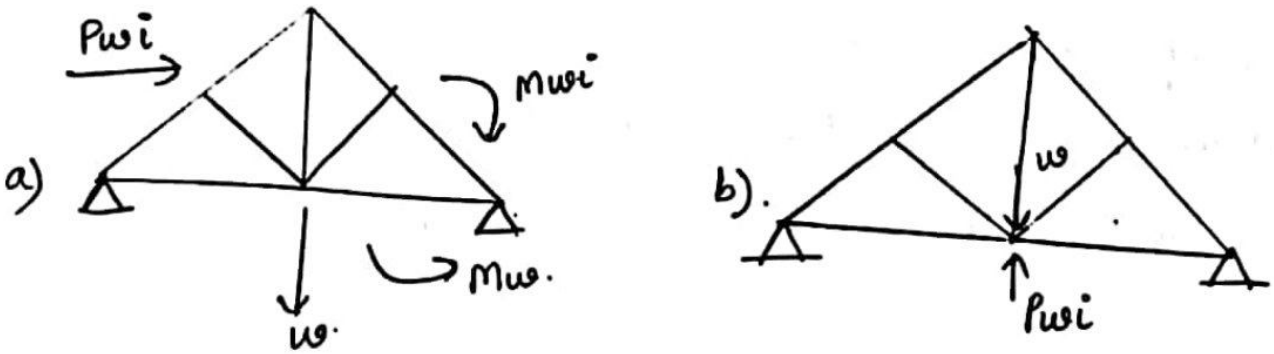
Partial safety factor for load (γ_f)

Combination	Limit state of collapse.				
	DL	LL		EL/WL	AL
		leading LL	accompanying LL		
a) DL + LL + CL	1.5	1.5	1.05	—	—
b) DL + LL + CL + WL/EL	1.2	1.2	1.05 → EL	0.6 → EL	—
	1.2 → WL	1.2 → WL	0.53 → WL	1.2 → WL	
c) DL + WL/EL	1.5	—	—	1.5	—
	(0.9)*	—	—		
d) DL + ER	1.2	1.2	—	—	—
	(0.9)*				
e) DL + LL + AL	1	0.35	0.35	—	1.0

Combination	Limit state of serviceability.				
	DL	LL.		EL/WL	AL
		leading LL	accompanying LL		
a) DL + LL + CL	1	1	1	—	—
b) DL + LL + CL + WL/EL	1	0·8	0·8	0·8	
c) DL + WL/EL.	1	—	—	1	—
d) DL + ER	—	—	—	—	—
e) DL + LL + AL.	—	—	—	—	—

Note 1: γ_f for DL = 0·9* is to be considered when it contributes to the stability against overturning or causes stress reduction.

For eg. → a) overturning of roof truss caused by wind
& → b) wind uplift in roof truss



Here DL = dead load
LL = live load
CL = crane load
EL = earthquake load
WL = wind load.
ER = erection load.
AL = accidental load (such as those due to blast)
SL = snow load. (Type of LL)

ER = erection load

such as due to storage or positioning of construction, erection of equipment, provision of temporary bracings etc.

Note 2: → When action of different live load is simultaneous the leading live loads are one which causes higher load effects in the member / section and all the remaining live loads are classified as accompanying live loads.

Note 3: → Wind load & earthquake load are not considered to act simultaneously.

Q The load on a floor beam of a commercial building are as follows.

Roof load

Dead load = $12 KN/m^2$.

live load = $9 KN/m^2$.

Roof finish = $4 KN/m^2$.

Determine the design load for

a) limit state of strength b) limit state of serviceability.

DL + LL = 12 + 9 = 21.

a) for limit state of strength

(DL + LL) × 1.5

DL = 12 + 4 = 16

LL = 9.

factored = 1.5(16 + 9)

= 37.5 KN/m^2

b) (DL + LL) × 1

⇒ 16 + 9

= 25 KN/m^2