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CMRIT — CMR INSTITUTE OF TECHNOLOGY, BENGALURU. ACCREDITED WITH A+ GRADE BY NAAC

Solution and Scheme of evaluation Internal Assessment Test 1– April 2022

Sub:	Design of steel structures				Sub Code:	18CV61	Branch:	Civil
Date:	9/05/2022	Duration:	90 min's	Max Marks: 50	Sem / Sec:	6		OBE

Answer any TWO FULL Questions
Note: Use of IS 800:2007 is permitted and assume missing data.

		MARKS	CO	RBT
1 (a)	Explain difference between working stress design and limit state design of steel structures. Working stress method (WSM) old method Based on linear elastic theory This method is based on assumption that structural material behaves in a linear elastic manner and adequate safety can be ensured by restricting the working load(service load) on the structure. The stresses caused by Characteristic loads are checked against the permissible stresses (allowable) stresses Permissible stress =yield stress/factor of safety Working stress <= permissible stress **Limit state of serviceability** A Civil Engineering Designer has to ensure that the structures and facilities he designs are (i) fit for their purpose (ii) safe and (iii) economical and durable. Thus safety is one of the paramount responsibilities of the designer. However, it is difficult to assess at the design stage how safe a proposed design will actually be. There is, in fact, a great deal of uncertainty about the many factors, which influence both safety and economy. The uncertainties affecting the safety of a structure are due to Uncertainty about loading Uncertainty about material strength and Uncertainty about structural dimensions and behaviour. These uncertainties together make it impossible for a designer to guarantee that a structure will be absolutely safe. All that the designer can ensure is that the risk of failure is extremely small, despite the uncertainties. Limit State of Serviceability will be associated with the discomfort faced by the user while using the structure that is one is excess deflection or deformation of the structure. Suppose if we are residing in a tall building towards the top floor then due to cyclone or due to earthquake the building may vibrate considerably. But if Limit State of Strength is considered in design the structure will not collapse. Repairable damage or crack generated due to fatigue, corrosion and durability also should be kept in mind. These are the some parameters which are associated with the Limit State Serviceability.	[04] [04]	CO1	L2
(b)	Design a bolted connection for lap joint of plate thickness of 10mm and 12mm to carry a service load of 100kN. Use M16 4.6 grade bolt. Give the details with neat sketch. a) Lap joint Strength of bolt in single shear: (assume fully threaded bolt) $V_{dsb} = \frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb})/\gamma_{mb}$	[17]	CO1	L4

$= \frac{400}{\sqrt{3}}(1 * 0.78 * pi * 20 * 20/4 + 0)$ /1.25= 56.58kN

Bolts in Bearing = V_{dpb} = (2.5K_b d t f_u)/ γ_{mb}

K_b *is least of* $e/3d_o$, $p/3d_o$- 0.25 , fub/fu , 1 from the IS 800:2007 pg no 75

Assumed e=40mm, p= 50mm, d_o= 20+2=22mm

40/ 3*22= 0.60

50/3*22-0.25= 0.50

400/410= 0.97

1

V_{dpb} = (2.5*0.50*20*12*410)/ 1.25 = 98.40kN

Therefore, the strength of bolt in lap joint is 56.58kN

2 (a) Explain the various modes of failure of bolted connection with neat sketch. [08] CO1 L2

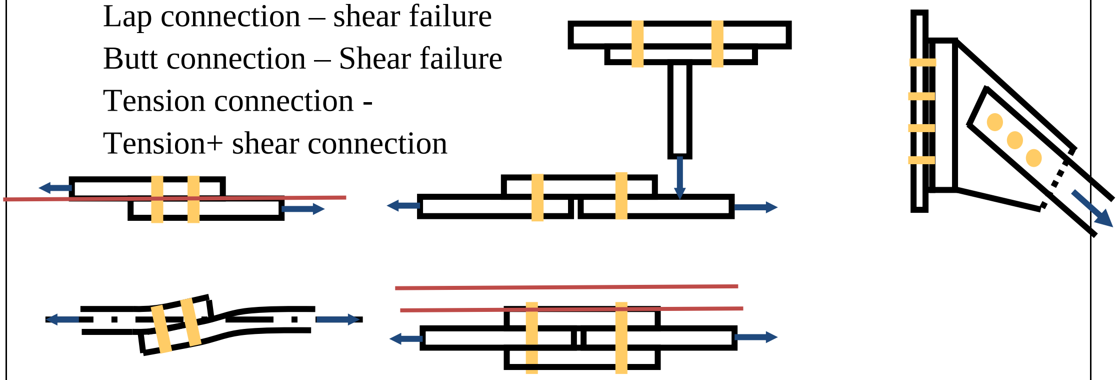
Classification based on type of force in the bolt

Lap connection – shear failure

Butt connection – Shear failure

Tension connection -

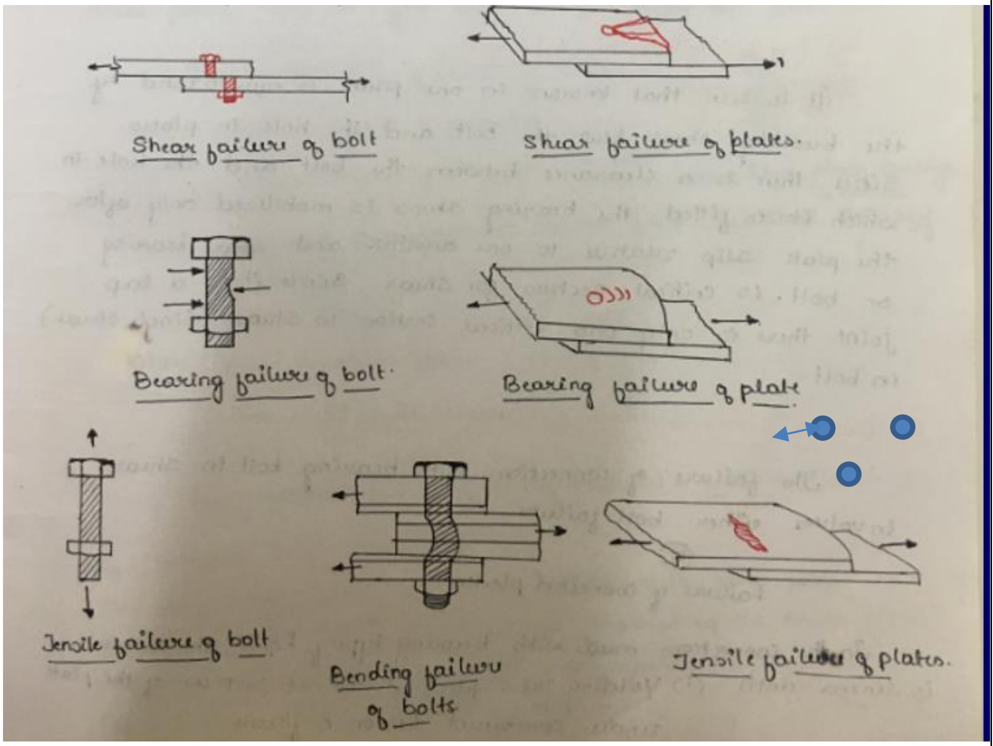
Tension+ shear connection



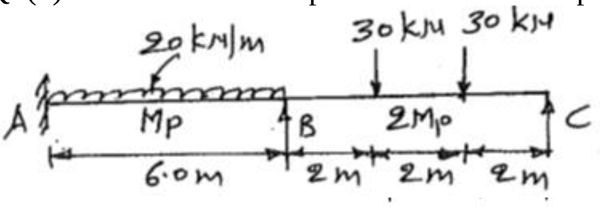
a) Lap Connection b) Butt Connection

Behaviour of bolted joints:

1. Shear failure of bolt
2. Shear failure of plate
3. Bearing failure of bolt
4. Bearing failure of plate
5. Tensile failure of bolt
6. Tensile failure of plate



(b) Analyse the continuous beam ABC subjected to working loads shown in Fig Q4(b) and determine the plastic moment. Adopt a load factor of 1.85 [17] CO1 L4



Solution:

Step 1: Degree of indeterminacy:

Degree of indeterminacy = 5 – 3 = 2

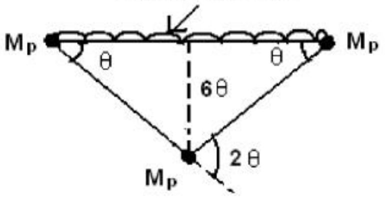
No. of possible plastic hinges = 5

No. of independent mechanisms = 5 – 2 = 3

hinges at A, B, and under concentrated loads and under udl.

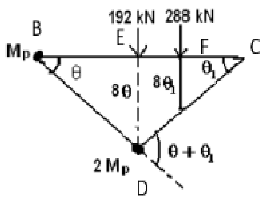
Step 2: Mechanism (1):

5 x 3.2 = 16 kN/m



$$EWD = 16 \times \frac{1}{2} \times 12 \times 6\theta$$
$$= 576\,\theta$$
$$IWD = M_p\theta + M_p(2\theta) + M_p\theta$$
$$= 4M_p\theta$$
$$IWD = EWD$$
$$4M_p\theta = 576\,\theta$$
$$M_p = 144 \text{ kNm}$$

Step 3: Mechanism (2):



From Δ DBE, tan θ =ED/BE
ED=BE tan θ = 8θ
From Δ DCE, tan θ1 =ED/EC
ED=EC tan θ1= 16θ1
Equating both ED,

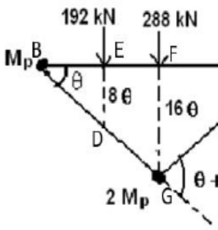
$$8\,\theta = 16\,\theta_1$$
$$\theta_1 = \frac{\theta}{2}$$
$$\theta + \theta_1 = \theta + \frac{\theta}{2} = \frac{3\theta}{2}$$

60x3.2=192

8θ1=8 x θ/2

$$EWD = (192 \times 8\theta) + (288 \times 4\theta) = 2688\,\theta$$
$$IWD = M_p\theta + 2M_p(\theta + \theta_1) = 4M_p\theta$$
$$IWD = EWD$$
$$4M_p\theta = 2688\,\theta$$
$$M_p = 672 \text{ kNm}$$

Step 4: Mechanism (3): In Span BC , under 288 kN.



Δ EBD, $\tan\theta = \frac{ED}{BE} \Rightarrow ED = BE.(\tan\theta)$ $\boxed{ED = 8\theta}$ —(1)

Δ BFG, $\tan\theta = \frac{FG}{BF} \Rightarrow FG = BF.\tan\theta$ $\boxed{FG = 16\times\theta}$ —(2)

Δ FCG, $\tan\theta_1 = \frac{FG}{FC} \Rightarrow FG = FC \times \tan\theta_1$ $\boxed{FG = 8\times\theta_1}$ —(3)

Equating (2) and (3)

$16\theta = 8\theta_1$

$\theta_1 = \frac{16\theta}{8} = 2\theta \rightarrow \boxed{\theta_1 = 2\theta}$

External work done $= 192 \times ED + 288 \times FG$

$= 192 \times 8\theta + 288 \times 8\theta_1$

$= 192 \times 8\theta + 288 \times 8 \times (2\theta)$

$= 6144\,\theta$ —(4)

Internal work done $= M_p\theta + 2M_p(\theta + \theta_1)$

$= M_p\theta + 2M_p(\theta + 2\theta)$

$= M_p\theta + 2M_p \times 3\theta$

$= 7M_p\theta$ —(5)

EWD = IWD

$6144\theta = 7M_p\theta$

$M_p = 877.71$ kNm

$\therefore$ Plastic moment of beam section (Max) = 877.71 kNm