STEEL STRUCTURES TEST I

Number of Questions: 25 **Time: 60 min.**

Directions for questions 1 to 25: Select the correct alternative from the given choices.

1. How are the most commonly produced and used structural elements in frames, floor beams, with high moment of inertia about X-axis, are designated?
(A) ISWB – section
(B) ISLB – section
(C) ISMB – section
(D) ISHB – section

2. Match Group – A with Group – B and select the correct answers

	Group – A		Group – B
P.	Used when two plates are placed one below the other.	1.	Fillet weld
Q.	Pressure applied continuously	2.	Plug weld
R.	Member subjected to direct axial loads	3.	Slot weld
S.	Joining two surfaces in two different planes.	4.	Seam weld
		5.	Butt weld

Codes:

	P	Q	R	S
(A)	4	5	3	2
(B)	4	3	2	1
(C)	5	4	1	2
(D)	3	4	5	3

3. For economical spacing of roof truss, if t, p, r are the cost of truss, purlin and roof coverings respectively, then
(A) $t = p + r$
(B) $t = 2p + r$
(C) $t = p + 3r$
(D) $t = p + 2r$

4. Gantry girders are usually designed
(A) formultistorey buildings
(B) using channel sections only
(C) as laterally supported beams
(D) as laterally unsupported beams

5. Bearing stiffners in a plate girder is used wherever there is concentrated load to
(A) increase shear resistance
(B) prevent excessive deflection
(C) prevent buckling of web
(D) to transfer the load from compression flange to the tension flange

6. Which of the bolted connections have maximum efficiency?
(A) Zig – Zag (B) Diamond
(C) Chain (D) Both A and B

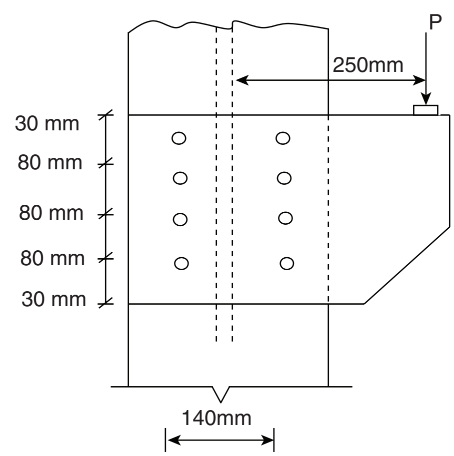
7. _______ beams are used for large spans and light loads
(A) ISLB
(B) Tubular beams
(C) Castellated beams
(D) ISWB

8. A steel c/s has less capacity to resist torsion, when
(A) Shear center is above center of gravity
(B) Shear center is below center of gravity
(C) Shear center coincides with Center of gravity
(D) Not related with their locations

9. The design normal strength of a fillet weld is
(A) f_u (B) $\dfrac{f_y}{\sqrt{3}}$
(C) f_y (D) $\dfrac{f_u}{\sqrt{3}\,\gamma_{mw}}$

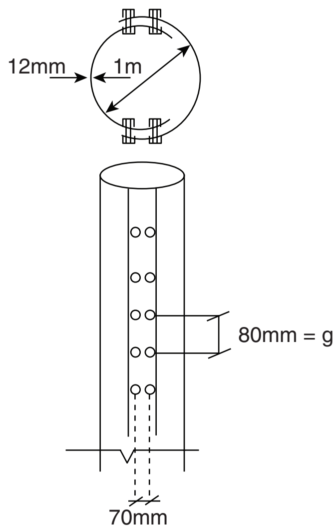
10. Maximum pitch for a tension member whose thickness is "t" is
(A) 12t or 200 mm
(B) 16t or 200 mm
(C) Least of a and b
(D) Only 200 mm

11. Determine the safe load P that can be carried by the joint shown in figure below. The bolts used are 20 mm diameter of grade 4.6. The thickness of flange of I-section is 9 mm and that of bracket plate is 10 mm



(A) 93.68 kN
(B) 89.49 kN
(C) 65.68 kN
(D) 72.92 kN

12. Boiler plates of t = 15 mm thickness are lap jointed with bolts 18 Φ of 4.6 Grade. If the diameter of boiler is 1m determine maximum pressure that can be allowed in boiler.



(A) 0.12 N/mm^2
(B) 0.26 N/mm^2
(C) 0.38 N/mm^2
(D) 0.45 N/mm^2

13. Match List – I of types of sections of beams with List – II the cases for which beams are designed.

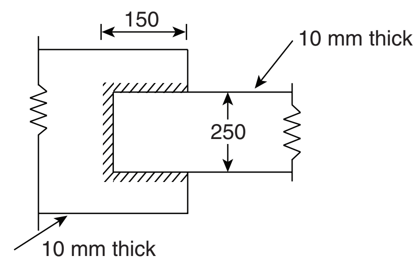
	List – I		**List – II**
P.	Plastic section	1.	Elastic design
Q.	Compact section	2.	Indeterminate frames
R.	Semi-compact section	3.	Plate Girdes
S.	Slender section	4.	Simply supported beams

Codes:

	P	Q	R	S
(A)	2	4	1	3
(B)	4	2	3	1
(C)	3	1	2	4
(D)	1	3	4	2

14. Statement I: In long columns the axial buckling stress remains below the proportional limit and they buckle elastically.
Statement II: The failure loads for such columns are proportional to the flexural rigidity (EI) of the column and independent of the strength of steel.
(A) Both I and II are true and II is correct explanation of I
(B) Both I and II are true and II is not correct explanation of I
(C) I is true and II is false
(D) Both I and II are false

15. Determine the block shear strength of the welded tension member shown in figure. Plates are of Fe 410 grade
P.S.F for yielding = 1.1
P.S.F for ultimate stress = 1.25

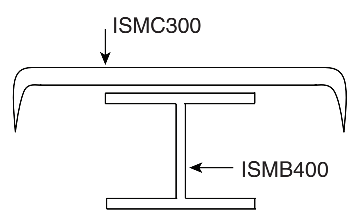


(A) 1543 kN (B) 1728 kN
(C) 1648 kN (D) 1483 kN

16. Determine the flenural design strength of the following welded members. The girders are simply supported and have continuous lateral support. Consider that only flanges resist BM.
Flanges: 250 × 12mm
Web: 1200 × 8mm
Span: 12m
(A) 1652.72 kN (B) 826.36 kN
(C) 727.19 kN (D) 1454.38 kN

17. A built up section is composed of an I section ISMB 400 and C section ISMC 300 connected on top of I section as shown in figure. The minimum radius of gyration of built up section in cm is ____

ISMB 400	**ISMC 300**
I_{zz} = 20458.4 cm^4	I_{zz} = 6362.6 cm^4
I_{yy} = 422.1 cm^4	I_{yy} = 310.8 cm^4
A = 78.46 cm^2	C_{yy} = 2.36 cm
	t_w = 7.6 cm
	A = 45.64 cm^2



(A) 10.6 cm (B) 13.5 cm
(C) 12.1 cm (D) 14.7 cm

18. Match List – I with List – II and select the correct answer using the codes given below the lists:

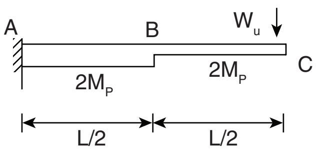
	List – I (Methods of Analysis)		**List – II (Conditions satisfied)**
a.	Exact Plastic Analysis	1.	Equilibrium, sufficient plastic hindges and non-violation of plastic moment capacity.
b.	Mechanism method of plastic analysis	2.	Equilibrium and non-violation of plastic moment capacity

c.	Equilibrium method of plastic analysis	3.	Equilibrium, continuity and non-violation of plastic moment capacity
		4.	Equilibrium and sufficient plastic hindges.

Codes:

	a	b	c
(A)	3	1	2
(B)	1	2	4
(C)	3	4	2
(D)	1	4	2

19. Find out the collapse load for the following cantilever beam in figure below



(A) 0.75 Mp/L (B) Mp/L
(C) 2 Mp/L (D) 1.5 Mp/L

20. Two framing angles ISA 150 × 150 × 10 mm are used to make beam to column connection. One angle is placed on either side of the web of the beam as in figure. 3 bolts of 16 mm diameter of 4.6 Grades are used to connect the angle legs to the beam web. Determine the reaction that can be transferred through the joint. Given pitch $P = 65$ mm and end distance $e = 40$ mm

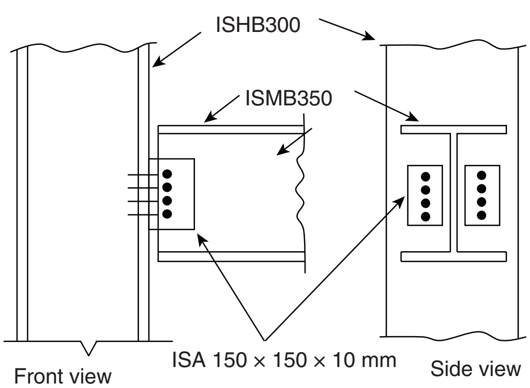
Column ISHB 300 @ 618.03 N/m

$t_f = 10.6$ mm

Beam section ISMB 350 @ 514.04 N/m

$t_w = 8.1$ mm

Grade of steel is Fe 410

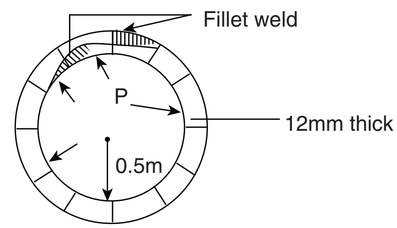


(A) 198.36 kN (B) 174.14 kN
(C) 200.68 kN (D) 183.42 kN

21. A circular plate, 200 mm in diameter is welded to another plate by means of 6 mm fillet weld. Calculate the ultimate twisting moment capacity that can be resisted by the weld use steel grade Fe 410 and shop welding

(A) 49.97 kNm (B) 36.31 kNm
(C) 57.68 kNm (D) 61.31 kNm

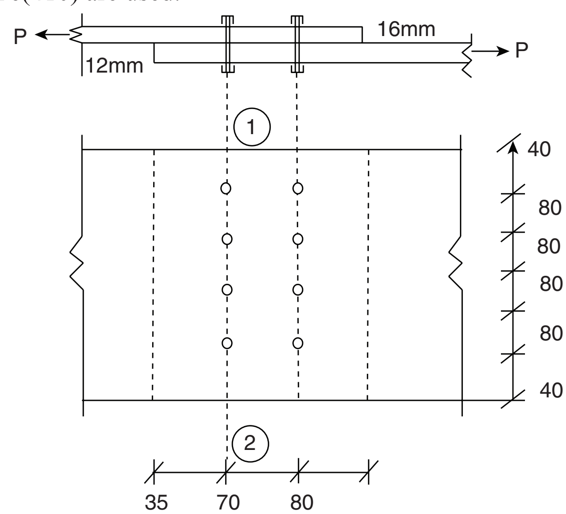
22. A circular penstock of mild steel of grade Fe 410, 1.0 m diameter is fabricated in works shop with 12 mm thick plates. The plates are secured by 8 mm size fillet weld provided on inside and outside of lapped ends as shown in figure. Determine safe internal pressure than can be allowed in the penstock. (in N/mm^2)



(A) 3.55 (B) 7.01
(C) 4.24 (D) 2.36

Common Data for Questions 23 and 24:

23. Find the design strength of Lap joint between 2 plates shown in figure Bolts 20 Φ, 4.6 Grade plates *E* 250 Fe(410) are used.



(A) 271 kN (B) 362 kN
(C) 308 kN (D) 420 kN

24. Find the efficiency for the bolted connection in problem no 23.

(A) 82% (B) 50%
(C) 32% (D) 41%

25. Match List – I (of different types of structural beams) List – II (functions of the beams)

	List–I		List–II
a.	Girder	1.	Provided in buildings to support roofs.
b.	Purlins	2.	These carry roof loads in trusses
c.	Joists	3.	Supports a number of joists
d.	Spandrels	4.	Carry part of floor that of the exterior wall.

Codes:

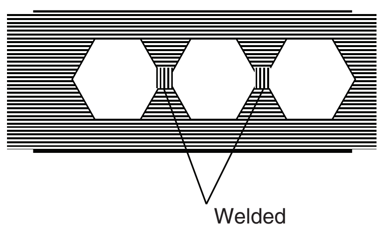
	a	b	c	d
(A)	1	2	3	4
(B)	2	1	4	3
(C)	3	2	1	4
(D)	2	3	4	1

Answer Keys

1. C	**2.** D	**3.** B	**4.** D	**5.** C	**6.** B	**7.** C	**8.** C	**9.** D	**10.** B
11. D	**12.** B	**13.** A	**14.** A	**15.** C	**16.** B	**17.** D	**18.** D	**19.** C	**20.** A
21. A	**22.** C	**23.** B	**24.** D	**25.** C					

Hints and Explanations

7. Castellated Beams



Choice (C)

11. For Fe 410 Grade of steel $f_u = 410$ MPa
For 4.6 Grade bolts $f_{ub} = 400$ MPa
Partial safety factor for the material of bolt $\gamma_{mb} = 1.25$

Net Area $A_{nb} = 0.78 \times \frac{\pi}{4} \times 20^2 = 245$ mm^2

Diameter $d = 20$ mm $\Rightarrow d_o = 22$ mm
Pitch $P = 80$ mm
Edge distance $(e) = 30$ mm
Strength of bolt in single shear

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} \times \left[\frac{A_{nb}}{\gamma_{mb}}\right] = \frac{400}{\sqrt{3}} \times \frac{245}{1.25} \times 10^{-3}$$

$= 45.26$ kN

Strength of bolt in bearing $V_{dbb} = 2.5\, K_b dt \frac{f_u}{\gamma_{mb}}$

$$K_b = \frac{e}{3d_o} = \frac{30}{3 \times 22} = 0.454$$

$$= \frac{P}{3d_o} - 0.25 = \frac{80}{3 \times 22} - 0.25 = 0.96.$$

$$= \frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975 \;\; = 1$$

$\therefore$ $K_b = 0.454$

$V_{dpb} = 2.5 \times 0.454 \times 20 \times 9 \times \frac{410}{1.25} \times 10^{-3} = 67$ kN

$\therefore$ Strength of bolt $V_{sd} = 45.26$ kN
No. of bolts $n = 8$

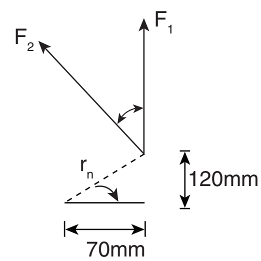
Direct shear force in each bolt $F_1 = \frac{P_1}{h} = \frac{P_1}{8}$

Force due to torque in bolt $F_2 = \frac{P.e_o\, r_n}{\Sigma r^2}$

$r_n = \sqrt{(40+80)^2 + 70^2} = 138.92$mm
$\Sigma r^2 = 4\,[(40 + 80)^2 + 70^2 + 40^2 + 70^2] = 103200$ mm

$$F_2 = \frac{P_1 \times 250 \times 138.92}{103200} = 0.3365 P_1$$

$$\cos\theta = \frac{70}{\sqrt{120^2 + 70^2}} = 0.5038$$



Resulted force

$$R = \sqrt{F_1^2 + F_2^2 + 2F_1 F_2 \cos\theta}$$

$$= \sqrt{\left(\frac{P_1}{8}\right)^2 + (0.3365P_1)^2 + \left(2 \times \frac{P_1}{8} \times 0.3365P_1 \times 0.5038\right)}$$

$R = 0.4138\, P_1$
Resulted force $\leq$ Strength of bolt
$0.4138P_1 \leq 45.26$
$P_1 \leq 109.38$ kN
Service load

$$P = \frac{P_1}{\text{load factor}} = \frac{109.38}{1.5}$$

$= 72.92$ kN Choice (D)

12. $d = 18$mm
$d_o = 20$mm
$A_{sb} = 254$mm^2
$A_{nb} = 198$mm^2
Considering width of plate $g = 80$mm
Strength of Bolt:

Shear $V_{dsb} = \frac{1}{1.25}\left[\frac{400}{\sqrt{3}}(198)\right] = 36.58$ kN

$2 \times$ Bolt value $= 73.16$ kN

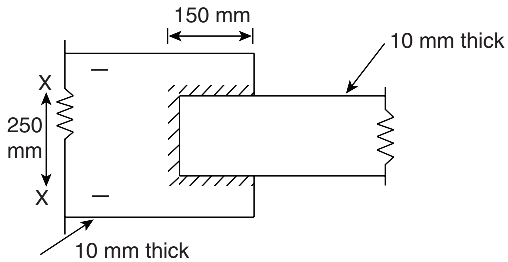
Stress in the plate/area $= \frac{73.16 \times 10^3}{70 \times 80} = 13.06$ N/mm^2

Hoop stress $= \frac{Pd}{2t} = \frac{P \times 1.5 \times 10^3}{2 \times 15}$

$$13.06 = \frac{P \times 1.5 \times 10^3}{2 \times 15}$$

$P = 0.26$ N/mm^2 Choice (B)

15.



$A_{vg} = A_{vn} = 2(150 \times 10) = 3000 \text{ mm}^2$
$A_{tg} = A_{tn} = 2(250 \times 10) = 5000 \text{ mm}^2$

$$T_{db1} = \frac{A_{vg}\, f_y}{\sqrt{3}\gamma_{mo}} + \frac{0.9 A_{tn}\, f_u}{\gamma_{ml}}$$

$$= \left[\frac{3000 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 5000 \times 410}{1.25}\right] \times 10^{-3}$$

$= 1869.65$ kN

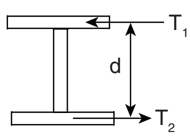
$$T_{db2} = \frac{0.9\, A_{vn}\, f_u}{\sqrt{3}\,\gamma_{ml}} + \frac{A_{tg}\, f_y}{\gamma_{mo}}$$

$$= \left[\frac{0.9 \times 3000 \times 410}{\sqrt{3} \times 1.25} + \frac{5000 \times 250}{1.1}\right] \times 10^{-3}$$

$= 1647.66$ kN

$\therefore$ Block shear strength = 1648 kN Choice (C)

16. $M_d = A_f \times \dfrac{f_y}{\gamma_{mo}} \times d$



$$M_d = (250 \times 12) \times \frac{250}{1.1} \times (1212)$$

$= 826.36 \times 10^6$ Nmm
$= 826.36$ kNm Choice (B)

17. $I_{zz} = I_{zz(I)} + I_{zz(C)}$
$= 26821 \text{cm}^4$

$$\text{Centroid} = \frac{A_1 C_{yy} + A_2 (7.6 + 20)}{A_1 + A_2}$$

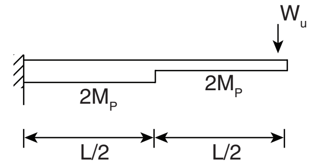
$$= \frac{(45.64 \times 2.36) + (78.46 \times (7.6 + 20))}{45.64 + 78.46}$$

$= 18.32$ cm

$I_{yy} = [422.1 + 78.46 \times (18.32 - 20)^2 + 310.8 + 45.64 \times (18.32 - 2.36)^2] = 12579 \text{ cm}^4$

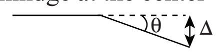
$$r_{\min} = \sqrt{\frac{I_{yy}}{A}} = \sqrt{\frac{12579}{(45.64 + 78.46)}} = 14.7\text{cm}$$ Choice (D)

19.



There is a change of forming one plastic hindge

Case (i): Plastic hindge at the center where c/s changes



Internal work done

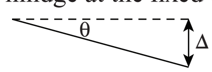
$$= W_u \times \Delta = W_u \times \frac{L}{2}\,\theta$$

External work done $= M_p\,\theta$

$$M_p\,\theta = W_u \times \frac{L}{2}\,\theta$$

Collapse Load $W_u = \dfrac{2M_p}{L}$

Case (ii): Plastic hindge at the fixed end



Internal work done $= W_u \Delta = W_u \times L\,\theta$
External work done $= 2\,M_P\,\theta$
$W_u L\,\theta = 2\,M_P\,\theta$

$$W_u = \frac{2M_P}{L}$$ Choice (C)

20. For *Fe* 410 grade of steel $f_u = 410$ MPa
For 4.6 Grade bolts $f_{ub} = 400$ MPa
$d = 16$mm $d_o = 18$mm
$\gamma_{mb} = \gamma_{ml} = 1.25$
Bolts connecting both angle legs to web of beam are in double shear,

$$V_{dsb} = \frac{f_{ub}}{\gamma_{mb}}\left(\frac{n_n\, A_{nb} + n_s\, A_{sb}}{\sqrt{3}}\right)$$

$$A_{sb} = \frac{\Pi}{4} \times 16^2 = 201.06\,\text{mm}^2$$

$A_{nb} = 0.78 \times A_{sb} = 156.83 \text{ mm}^2$

$$V_{dsb} = \frac{400}{1.25 \times \sqrt{3}}(201.06 + 156.83) \times 10^{-3} = 66.12 \text{ kN}$$

Strength of bolt in bearing,

$$V_{dpb} = 2.5\, K_b \frac{dt\, f_u}{\gamma_{mb}}$$

$$K_b = \frac{e}{3d_o} = \frac{40}{3 \times 18} = 0.74$$

$$= \frac{P}{3d_o} - 0.25 = \frac{65}{3 \times 18} - 0.25 = 0.95$$

$$= \frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975 = 1$$

$\therefore\quad K_b = 0.74$

$$V_{dpb} = 2.5 \times 0.74 \times 16 \times 8.1 \times \frac{410}{1.25} \times 10^{-3}$$

$$= 78.64 \text{ kN}$$

$\therefore$ Strength of one bolt = 66.12 kN

As 3 bolts are provided, maximum end reaction that can be transferred

$= 3 \times 66.12 = 198.36$ kN Choice (A)

21. Diameter $D = 200$ mm

Fe 410 Grade $\therefore f_u = 410$ MPa

Shop weld: $\gamma_{mw} = 1.25$

Ultimate twisting moment capacity

$T_u = P_{dw} \times r$

$$= L_w \times t_t \times \frac{f_u}{\sqrt{3}\times\gamma_{mw}} \times \frac{200}{2}$$

$$= (\pi \times 200) \times (0.7 \times 6) \times \frac{410}{\sqrt{3}\times 1.25} \times \frac{200}{2}$$

$= 49.97 \times 10^6$ Nmm = 49.97 kNm Choice (A)

22. Fe 410 $f_u = 410$ MPa

Size of weld $S = 8$ mm

Throat thickness = $KS = 0.7 \times 8 = 5.6$ mm

$\gamma_{mw} = 1.25$

Let internal pressure = p

Hoop force/mm length $F_h = \dfrac{pd}{2}$

Design strength of fillet weld/mm length

$$P_w = t_t \times \frac{f_u}{\sqrt{3}\times r_{mw}} \times 2 = 5.6 \times \frac{410}{\sqrt{3}\times 1.25} \times 2$$

$P_w = 2120.95$ N

For safe conditions

Hoop force/mm length = Strength of weld/mm length

$$2120.95 = \frac{pd}{2} = \frac{p\times 1000}{2}$$

$p = 4.24$ N/mm^2 Choice (C)

23.

Bolt	Plate
$d = 20$ mm	$t_1 = 12$ mm
$d_o = 22$ mm	$t_2 = 16$ mm
$A_{sb} = \frac{\pi}{4} \times 20^2 = 314$ mm^2	$f_u = 410$ MPa
$A_{nb} = 0.78A_{sb} = 245$ mm^2	$f_y = 250$ MPa
$f_{ub} = 400$ MPa	$\gamma_{mb} = 1.25$
$f_{yb} = 0.6 \times 400 = 240$MPa	

Single shear $n_n = 1$ $n_s = 0$

Shear strength

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}} \frac{[\text{nn Anb} + \text{ns Asb}]}{\gamma_{mb}}$$

$$= \frac{400}{\sqrt{3}\times 1.25}[245 \times 1] = 45.27 \text{ KN}$$

Bearing strength

$$V_{dpb} = \frac{1}{\gamma_{mb}} [2.5\, K_b d t f_u]$$

$$K_b = \frac{e}{3d_o} = \frac{35}{3\times 22} = 0.53$$

$$= \frac{p}{3d_o} - 0.25 = \frac{70}{3\times 22} - 0.25 = 0.81$$

$$= \frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975 = 1$$

$K_b = 0.53$

$$V_{dpb} = \frac{1}{1.25}[2.5 \times 0.53 \times 20 \times 12 \times 410]$$

$= 104.3$ kN

Plate yield of gross c/s:

$$T_{dg} = \frac{A_g\, f_y}{\gamma_{mo}} = \frac{(320\times 12)\times 250}{1.1}$$

$= 872.7$ kN

Tearing/Rupture:

$$T_{dh} = \frac{0.9\, A_n\, f_u}{\gamma_{ml}}$$

$A_n = (320 - 4 \times 22) \times 12 = 2784$ mm^2

$$T_{dh} = \frac{0.9\times 2784\times 410}{1.25} = 821.8 \text{ kN}$$

Joint Strength:

Strength of bolt in shear = $45.2 \times 8 = 362$ kN

Strength of bolt in bearing = $104 \times 8 = 832$.kN

Yielding = 872 kN

Rupture = 821 kN

Strength of Joint = 362 kN Choice (B)

24. Efficiency $\eta = \dfrac{\text{strength of Joint}}{\text{yield strength}} \times 100$

$$= \frac{362}{872} \times 100 = 41\%$$ Choice (D)