



POSTAL BOOK PACKAGE 2024

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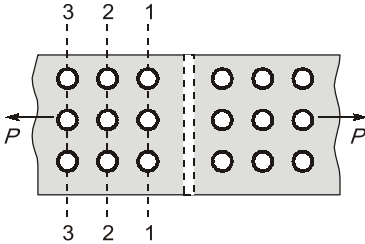
CIVIL ENGINEERING

Objective Practice Sets

Design of Steel Structures

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Riveted, Bolted and Pinned Connections

- Q.1** The yield stress of mild steel of normally rolled structural steel is about (in N/mm^2):
 (a) 240 to 260 (b) 330 to 360
 (c) 420 (d) 550
- Q.2** Minimum pitch for riveted connections should **not** be less than
 (a) 1.5 times the hole diameter
 (b) 2.5 times the hole diameter
 (c) 1.5 times the nominal diameter of rivet
 (d) 2.5 times the nominal diameter of rivet
- Q.3** If same number of bolts has been used in the joints, then which of the following patterns will yield highest efficiency?
 (a) Chain (b) Staggered
 (c) Diamond (d) Staggered diamond
- Q.4** For reversal of stress, the most suited bolt is
 (a) black (b) turned
 (c) friction grip (d) ordinary
- Q.5** High strength bolts are designed on the basis of
 (a) friction (b) tension
 (c) compression (d) shear
- Q.6** Two steel plates each of 10 mm thickness are connected by double cover butt joint by bolts as shown in figure. If the bolt diameter is 20 mm and steel is of grade Fe 410, then which one of the following section is the most critical section for the main plate?

 (a) Section 1-1
 (b) Section 2-2
- (c) Section 3-3
 (d) Both section 1-1 and section 3-3
- Q.7** When the axis of load lies in the plane of rivet group, then the rivets are subjected to
 (a) only shear stresses
 (b) only tensile stresses
 (c) only compressive stresses
 (d) torsional moment
- Q.8** Which of the following types of riveted joint is free from bending stresses?
 (a) Lap joint
 (b) Butt joint with single cover plate
 (c) Butt joint with double cover plates
 (d) None of the above
- Q.9** As compared to field rivets, the shop rivets are,
 (a) stronger (b) weaker
 (c) equally strong (d) any of the above
- Q.10** By providing sufficient edge distance, which of the following failures of riveted joint can be avoided?
 (a) Tension failure of plate.
 (b) Shear failure of rivet.
 (c) Shear failure of the plate.
 (d) Crushing failure of rivet.
- Q.11** Which of the following statement is correct?
 (a) Material cost of a rivet is higher than that of a bolt.
 (b) Tensile strength of a bolt is lesser than that of a rivet.
 (c) Bolts are used as temporary fastenings whereas rivets are used as permanent fastenings.
 (d) Riveting is less noisy than bolting
- Q.12** Minimum pitch of the rivets shall not be less than
 (a) $1.5d$ (b) $2.0d$
 (c) $2.5d$ (d) $3.0d$

Q.13 As per **IS : 800**, the rivets subjected to combined tensile and shear stresses are proportioned such that

(a) $\left(\frac{f_s}{p_s}\right)^2 + \left(\frac{f_t}{p_t}\right)^2 \leq 1.4$

(b) $\left(\frac{f_s}{p_s}\right) + \left(\frac{f_t}{p_t}\right) \leq 1.4$

(c) $\left(\frac{f_s}{p_s}\right)^2 + \left(\frac{f_t}{p_t}\right)^2 \leq 1.4$

(d) $\left(\frac{f_s}{p_s}\right)^2 + \left(\frac{f_t}{p_t}\right)^2 \geq 1.4$

where f_s and f_t are respectively actual shear and tensile stresses in a rivet and p_s and p_t are respectively permissible shear and tensile stresses in the rivet.

Q.14 The greater gauge of long rivets should not exceed

- (a) $2d$ (b) $4d$
(c) $6d$ (d) $8d$

Q.15 What is the maximum permissible longitudinal pitch in staggered riveted compression joints?

- (a) 500 mm (b) 400 mm
(c) 300 mm (d) 100 mm

Q.16 Match **List-I** (Failure mode) with **List-II** (Reason) and select the correct answer using the codes given below the lists:

List-I

- A. Shear failure of plates
B. Bearing failure of plates
C. Tearing failure of plates
D. Splitting failure of plates

List-II

1. Insufficient edge distance
2. Strength of plate is less than that of the rivets

Codes:

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

Q.17 20 mm diameter rivets are used to connect 10 mm thick plates. The permissible stresses for rivets in shear and bearing are 80 MPa and 250 MPa

respectively. The difference of rivet value in single shear and double shear is

- (a) 27.6 kN (b) 24.7 kN
(c) 32.5 kN (d) 34.2 kN

Q.18 According to IS specifications, the maximum pitch of rivets in compression is

- (a) lesser of 200 mm and $12t$
(b) lesser of 200 mm and $16t$
(c) lesser of 300 mm and $32t$
(d) lesser of 300 mm and $24t$

where t is thickness of thinnest outside plate or angle.

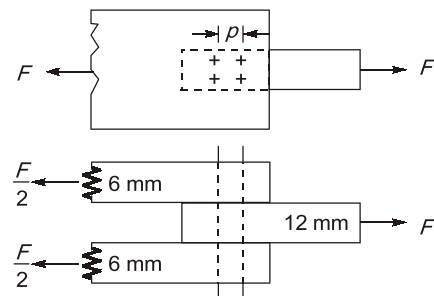
Q.19 What is the ratio of the yield stress in power driven shop rivets relative to the permissible bearing stress of mild steel?

- (a) 1.0 (b) 0.8
(c) 0.6 (d) 0.4

Q.20 A bolt designated as Hex bolt $M 16 \times 70$ NL will have

- (a) diameter of 16 mm
(b) diameter of 70 mm
(c) length of 16 mm
(d) cross-sectional area of $16 \times 70 \text{ cm}^2$

Q.21 Consider the riveted joint shown in figure. The maximum permissible value of ' p ' (rivet diameter 20 mm) is



- (a) 50 mm (b) 60 mm
(c) 72 mm (d) 96 mm

Q.22 The minimum thickness of a steel plate, which is directly exposed to weather and is not accessible for cleaning and repainting, should be

- (a) 4.5 mm (b) 6 mm
(c) 8 mm (d) 10 mm

Q.23 Two 10 mm thick plates are connected by lap joint to transmit a factored load of 100 kN using black bolts of 12 mm diameter and grade 4.6. The

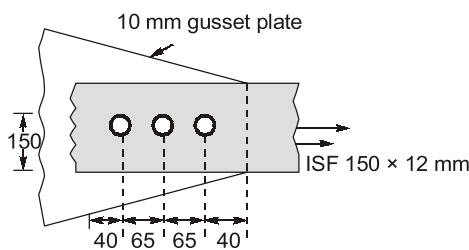
minimum number of bolts required for safe design would be (given $f_u = 410$ MPa)

- (a) 3 (b) 4
(c) 5 (d) 6

Q.24 If diameter of a bolt is 22 mm, then maximum number of bolt (s) that can be accommodated in one row in 150 mm wide plate is (are)

- (a) 1 (b) 2
(c) 3 (d) 4

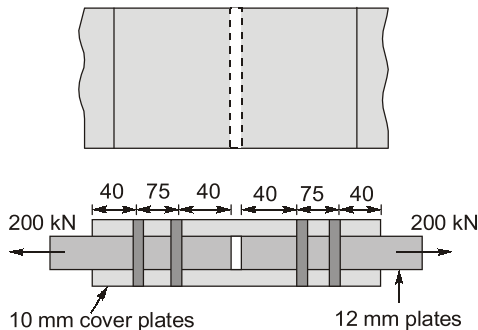
Q.25 For the connection as shown in the figure, the bolt value will be



(Take diameter of bolt as 20 mm and grade 4.6)

- (a) 35.7 kN (b) 70.2 kN
(c) 135.7 kN (d) 109.3 kN

Q.26 The total number of 24 mm diameter bearing-type bolts required for the double-bolted double-cover butt joint for the figure shown below will be (bolt is of grade 4.6)



- (a) 1 (b) 2
(c) 3 (d) 4

Q.27 If the thickness of plate to be connected by a rivet is 15 mm, then suitable size as per Unwin's formula will be

- (a) 15 mm (b) 16.5 mm
(c) 22 mm (d) 24 mm

Q.28 For field rivets, the permissible stresses are reduced by what percentage?

- (a) 10% (b) 15%
(c) 25% (d) $33\frac{1}{3}\%$

Q.29 In which of the following cases a structural is fastener over designed?

1. When design is based on Unwin's formula
2. Long sustained loading leading to creep.
3. When reversal of stresses takes place.
4. In fatigue loadings.

Select the correct answer using the codes given below

- (a) 1, 3 and 4 (b) 2 and 4
(c) 3 and 4 (d) none of these

Q.30 Efficiency of a riveted joint, having the minimum pitch is

- (a) 40% (b) 50%
(c) 60% (d) 70%

Q.31 The common assumption that all rivets share equally a non-eccentric load is valid at a load

- (a) below the working load
(b) equal to the working load
(c) above the working load
(d) equal to the failure load

Q.32 If 'A' is the area of cross-section of a bar, the gauge length for the measurement of ductility will be

- (a) $5.65 \times A^{1/2}$ (b) $5.65 \times A$
(c) $6.56 \times A^{1/2}$ (d) $6.56 \times A$

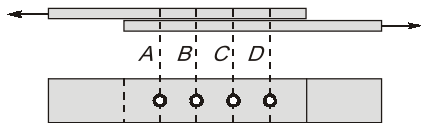
Q.33 If d and b are rivet diameter and width of plate, the efficiency (η) of the riveted joint, is given by

- (a) $\eta = \frac{p}{d-b}$ (b) $\eta = \frac{d}{b+d}$
(c) $\eta = \frac{b-d}{b}$ (d) $\eta = \frac{b+d}{b}$

Q.34 When the effect of wind or earthquake load is considered in the design of rivets and bolts for steel structures, by what percentage the permissible stresses may be exceeded?

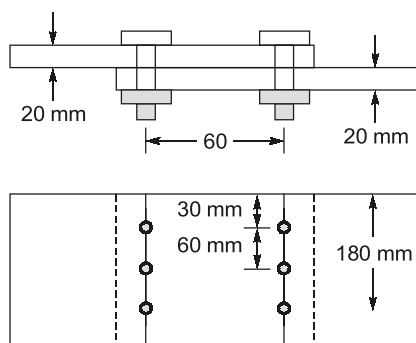
- (a) 15% (b) 25%
(c) 33.33% (d) 50%

Q.35 Which one of the following statements regarding the riveted joint as shown in the given figure is correct?



- (a) In elastic theory all rivets carry equal forces
- (b) In plastic theory all rivets carry equal forces
- (c) Both in elastic and plastic theories all rivets carry equal forces
- (d) In plastic theory the outer rivets A and D carry greater proportion of load

Q.36 The strength of plate joint shown in below figure:



Given M 20 bolts of grade 4.6 and Fe410 (E250) plates are used.

- For M 20 bolts of grade 4.6
 $d = 20 \text{ mm}$, $d_0 = 22 \text{ mm}$, $f_{ub} = 400 \text{ MPa}$,
 $\gamma_{mb} = 1.25$
 - For Fe410 plates.
 $f_u = 410 \text{ MPa}$, $\gamma_{mn} = 1.25$
- (a) 473.056 kN (b) 573.056 kN
(c) 673.056 kN (d) 773.056 kN

Q.37 Which of the following factors are considered correct regarding pin connections?

- (i) Pin connections are rigid.
 - (ii) Secondary stresses do not occur.
 - (iii) Moment pin connection is zero.
 - (iv) Only one pin is used in the connection.
- (a) (i), (ii), (iii) only (b) (ii), (iii), (iv) only
(c) (i), (iii), (iv) only (d) All of the above

Q.38 The strength of a 20 mm diameter bolt of grade 4.6 for double cover butt joint, each cover plate being 8 mm thick. The main plates to be jointed are 12 mm thick.

Assume $A_{nb} = 245 \text{ mm}^2$, $f_{ub} = 400$,
 $\gamma_{mb} = 1.25$, $K_b = 0.50$.

- (a) 90.52 kN (b) 86 kN
(c) 80.52 kN (d) 96 kN

Directions : Each of the next items consists of two statements, one labelled as 'Statement (I)' and the other as 'Statement (II)'. Examine these two statements carefully and select the answers to these items using the codes given below:

Codes:

- (a) Both Statement (I) and Statement (II) are individually true; and Statement (II) is the correct explanation of Statement (I)
- (b) Both Statement (I) and Statement (II) are individually true; but Statement (II) is NOT the correct explanation of Statement (I)
- (c) Statement (I) is true; but Statement (II) is false
- (d) Statement (I) is false; but Statement (II) is true

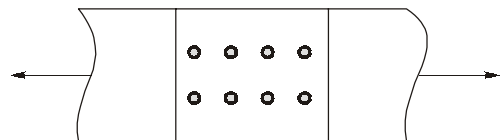
Q.39 Statement (I): Deflection of a beam with bolted connections is greater than that of a beam with riveted connections.

Statement (II): Bolted connections allow greater slip between components than riveted connections.

Q.40 Statement (I) : In structural bearing type joints, each connection is assumed to transmit its proportional share of the applied load.

Statement (II) : Applied load passes through the centroid of the connector group.

Q.41 Statement (I) : In a bolted joint, all similarly placed bolts share the load equally.



Statement (II) : Bolts are placed in holes having slightly larger diameters.

Q.42 Statement (I): For large load, HSFG bolts behave as normal bearing type bolts.

Statement (II): HSFG bolts behave as slip resistant bolt upto a load which overcomes the frictional resistance provided by the pre-load of the bolt.

Q.43 Consider the following statements regarding connections:

- 1. Riveted connections have inherent inefficiency compared to bolted connections.
- 2. Welded connections are susceptible to failure by cracking under repeated cyclic loads.

Answers Riveted, Bolted and Pinned Connections

- | | | | | | | | | | |
|------------|---------|------------|------------|------------------|------------|---------|------------|---------|------------|
| 1. (a) | 2. (b) | 3. (c) | 4. (c) | 5. (a) | 6. (c) | 7. (a) | 8. (c) | 9. (a) | 10. (c) |
| 11. (c) | 12. (c) | 13. (b) | 14. (d) | 15. (c) | 16. (c) | 17. (b) | 18. (a) | 19. (b) | 20. (a) |
| 21. (d) | 22. (c) | 23. (c) | 24. (b) | 25. (b) | 26. (b) | 27. (c) | 28. (c) | 29. (c) | 30. (c) |
| 31. (c) | 32. (a) | 33. (c) | 34. (b) | 35. (c) | 36. (c) | 37. (a) | 38. (a) | 39. (a) | 40. (a) |
| 41. (b) | 42. (a) | 43. (d) | 44. 363.64 | | 45. 94.03 | | 46. 2800 | | 47. 19 |
| 48. (d) | 49. (c) | 50. (c) | 51. (d) | 52. (d) | 53. (d) | 54. (b) | 55. 109.56 | | 56. (c, d) |
| 57. (c, d) | | 58. (b, d) | | 59. (a, b, c, d) | 60. (a, d) | | 61. (a, d) | | |
| 62. (a, d) | | 63. (a, d) | | 64. (b, c) | 65. (c, d) | | | | |

Explanations Riveted, Bolted and Pinned Connections

- | | |
|--|--|
| <p>1. (a)
Yield stress ≈ 250 MPa
Ultimate stress ≈ 410 MPa</p> <p>2. (b)
According to clause 10.2.2 of IS 800-2007, the minimum pitch for riveted connections should not be less than 2.5 times the hole diameter.</p> <p>3. (c)
For the same number of bolt used in joint hen diamond pattern will yield highest efficiency.</p> <p>6. (c)
For the given diagram/joint connections section 3-3 is the most critical section for the main plate and section 1-1 in the most critical section for the cover plates.</p> <p>9. (a)
Shop rivets are stronger than the field rivets.</p> <p>10. (c)
By provide proper edge distance, we can prevent shear failure, splitting failure and bearing failure of plates.</p> <p>11. (c)
Bolts are temporary fasteners as they can be tightened as can be loose with the help of nut bolt combination but there is not such scope is case of rivets.
Material cost of bolted connection is higher than riveted connection.</p> | <p>12. (c)
Minimum pitch of rivets shall not be less than 2.5 times the nominal diameter of rivet.</p> <p>14. (d)
Grater gauge of long rivet $\nless 8d$
where d = diameter of rivet</p> <p>17. (b)
Rivet value in single shear</p> $= \text{Min. of } \begin{cases} \frac{\pi}{4} d^2 \times \tau_{vf} \\ \sigma_b \times d \times t \end{cases}$ $= \text{Min of } \begin{cases} \frac{\pi}{4} \times \frac{21.5^2 \times 80}{1000} = 29.04 \text{ kN} \\ \frac{250 \times 21.5 \times 10}{1000} = 53.75 \text{ kN} \end{cases}$ <p>= 29.04 kN
Rivet value in double shear</p> $= \text{Min. of } \begin{cases} 2 \times \frac{\pi}{4} d^2 \times \tau_{vf} \\ \sigma_b \times d \times t \end{cases}$ $= \text{Min. of } \begin{cases} 58.08 \text{ kN} \\ 53.75 \text{ kN} \end{cases}$ <p>= 53.75 kN
Difference = $53.75 - 29.04 = 24.7$ kN</p> <p>19. (b)
$\frac{\text{yield stress of power driven shop rivets}}{\text{permissible bearing stress of mild steel}} = 0.8$</p> |
|--|--|

20. (a)

Hex bolt M16 × 70NL means

Bolt of diameter 16 mm and length of 70 mm.

21. (d)

Maximum permissible value of pitch in rivet connection is 4.5D where D = Diameter of rivet.

So $4.5 \times (20 + 1.5) = 96.75 = 96$

22. (c)

S.No	Section	Directly exposed to weather	Accessible for cleaning & painting	Minimum thickness t(mm)
1.	Steel	yes	No	6
2.	Steel	no	no	8
3.	Steel	no	yes	4

23. (c)

For grade 4.6 bolts,

$$f_{ub} = 392.4 \text{ MPa}$$

$$\rho_{mb} = 1.25$$

Net tensile stress area of 12 mm diameter bolt,

$$A_{nb} = 113 \text{ mm}^2$$

Strength of bolt in single shear,

$$\begin{aligned} V_{nb} &= \frac{V_{nsb}}{\gamma_{mb}} = \frac{A_{nb} F_{ub}}{\sqrt{3} \gamma_{mb}} \\ &= \frac{113 \times 392.4}{\sqrt{3} \times 1.25} \\ &= 20.48 \text{ kN} \end{aligned}$$

Strength of bolt is bearing,

$$\begin{aligned} V_{pb} &= \frac{V_{npb}}{\gamma_{mb}} = \frac{2.5dt f_u}{\gamma_{mb}} \\ &= \frac{2.5 \times 12 \times 10 \times 410}{1.25} \\ &= 98.4 \text{ kN} \end{aligned}$$

Bolt value = minimum of V_{nb} and V_{pb}

$$= 20.48 \text{ kN}$$

$$\therefore \text{Number of bolts} = \frac{100}{20.48} = 4.88 \approx 5 \text{ bolts.}$$

24. (b)

Minimum edge distance,

$$e = 1.7 \times \text{hole dia.}$$

$$= 1.7 \times 22 = 37.4 \text{ mm}$$

Then, number of bolts n ,

$$150 = 2e + (nd_o) + g$$

where, g is the gauge distance.

$$\therefore 150 = 2 \times 37.4 + (n \times 22) + 22 \text{ (let } g = d_o)$$

$$n = 2.4 \approx 2$$

27. (c)

Diameter of rivet as per Unwin's formula is given

$$\text{as, } d = 6.05\sqrt{t} \text{ mm}$$

where, t = thickness of plate in mm.

$$\begin{aligned} \therefore d &= 6.05\sqrt{15} \\ &= 23.43 \text{ mm} \end{aligned}$$

Adopt 22 mm as unwind formula gives diameter on higher side.

28. (c)

For field rivets, stress are reduced by 25%.

30. (c)

Given rivet in having minimum pitch so its is 2.5D

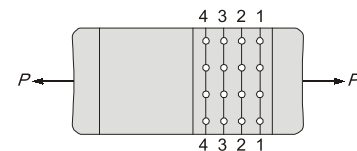
Now effectively

$$= \frac{f_t \times (2.5D - D)}{f_t \times 2.5D} = \frac{1.5D}{2.5D} = 0.6 = 60\%$$

33. (c)

Efficiency of riveted joint,

$$\eta = \frac{\text{Strength of riveted joint}}{\text{Strength of solid plate}} \times 100$$

The section 1 - 1 is most critical and the strength of joint at section 1 - 1 is $(b - d)t\sigma_{at}$ The strength of solid plate is $b \cdot t\sigma_{at}$

$$\text{So, } \eta = \frac{b - d}{b} \times 100$$

35. (c)

The rivets are assumed to resist the load equally in the elastic theory. Actually the outer rivets carry more load compared to rivets in the middle rows. When the load is increased, the more highly stressed rivets start yielding earlier and there is redistribution of load among rivets. The failure will

occur when all rivets have yielded and the strength of the group of rivets is equal to the strength of one rivet multiplied by the number of rivets.

36. (c)

Thickness of thinner plate, $t = 20$ mm

Width of plate $b = 180$ mm

There is no staggering, $P_{sl} = 0$

Number of bolts in weakest section = 3

Net area at weakest section,

$$\begin{aligned} A_u &= [b - nd_o + 0]t \\ &= [180 - 3 \times 22] \times 20 \\ &= 2280 \text{ mm}^2 \end{aligned}$$

Design strength of plates in the joint

$$\begin{aligned} &= \frac{0.9f_u A_n}{\gamma_{m1}} = \frac{0.9 \times 410 \times 2280}{1.25} \\ &= 673056 \text{ N} = 673.056 \text{ kN} \end{aligned}$$

37. (a)

Secondary stresses do not occur in pin connections. Not only one pin is used in the connection.

38. (a)

$$t = 12 \text{ mm}$$

Strength of bolt in double shear = V_{sb}

$$= \frac{2A_{nb}f_{ub}}{\sqrt{3}\gamma_{mb}} = \frac{2 \times 245 \times 400}{\sqrt{3} \times 1.25 \times 1000}$$

$$\Rightarrow V_{sb} = 90.52 \text{ kN}$$

Strength bolt in bearing;

$$\begin{aligned} V_{pb} &= 2.5K_b dt \frac{f_u}{\gamma_{mb}} \\ &= \frac{2.5 \times 0.5 \times 20 \times 12 \times 400}{1.25 \times 1000} = 96.0 \text{ kN} \end{aligned}$$

The strength of bolt will be minimum of the strength in shear and bearing is 90.52 kN.

39. (a)

Greater slip between components is provided by bolted connections than by riveted connections. HSFG bolts designed as slip critical connections are used in order to overcome such slip.

41. (b)

Both the statements are correct but not related to each other.

42. (a)

Once slip occurs, HSFG bolts behave as normal bearing type bolts. Thus after slip, the load is resisted by both frictional resistance and the bearing, and before slip, HSFG bolt is slip resistant bolt.

43. (d)

Riveted connections are gradually replaced by bolted connections due to low strength of rivets, higher installation costs and the inherent inefficiency of the connection.

Connections account for more than half the cost of structural steel work and so their design and detailing are of primary importance for the economy of the structure.

44. 363.64 (360 to 366)

Gross yielding strength,

$$\begin{aligned} T_{dg} &= \frac{f_y \times A_g}{\gamma_{m0}} \\ &= \frac{250 \times (200 \times 8)}{1.1 \times 1000} \text{ kN} = 363.64 \text{ kN} \end{aligned}$$

45. 94.03 (93 to 95)

$$P_s = 2 \times \frac{\pi}{4} d^2 \times f_s \quad [\text{due to double shear}]$$

where, d = nominal diameter of bolt = 18 mm

$$f_s = \frac{f_{ub}}{\sqrt{3} \times 1.25}$$

$$P_s = 2 \times \frac{\pi}{4} \times (18)^2 \times \frac{400}{\sqrt{3} \times 1.25} = 94.03 \text{ kN}$$

$$P_b = 2.5k_b dt \times \frac{f_u}{\gamma_{m0}}$$

Here f_u = Ultimate strength of plate material (tensile).

$$\Rightarrow P_b = 2.5 \times 0.5 \times (18 \times 16) \times \frac{410}{1.25} = 118.08 \text{ kN}$$

Hence, bolt value is minimum of P_s and P_b , i.e. 94.03 kN.

46. (2800)

Net sectional area of the plate is given by

$$\begin{aligned} A_{\text{net}} &= (B - nd_o) \times t \\ &= [300 - 1 \times (18 + 2)] \times 10 \\ &= 2800 \text{ mm}^2 \end{aligned}$$