2 CHAPTER
Riveted, Bolted and Pinned Connections

Q.1 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

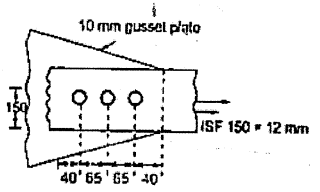
Q.2 If diameter of a bolt is 22 mm, then maximum number of bolt (s) that can be accommodated in one row in 150 mm wide plate is (are)
(a) 1 (b) 2
(c) 3 (d) 4

Q.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

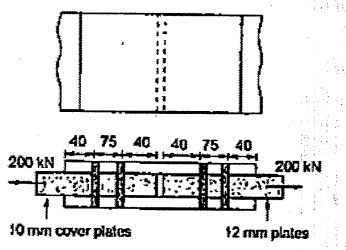
Q.5 High strength bolts are designed on the basis of
(a) friction (b) tension
(c) compression (d) shear

Q.6 For the connection as shown in the figure, the bolt value will be



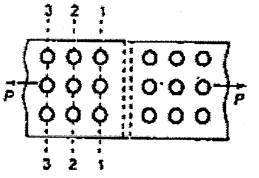
(Take diameter of bolt as 20 mm and grade 4.6)
(a) 35.7 kN (b) 70.2 kN
(c) 135.7 kN (d) 109.3 kN

Q.7 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.8 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.9 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.10 Which of the following types of revetted 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.11 The difference between gross diameter and nominal diameter for the rivets upto 25 mm diameter is
(a) 1 mm (b) 1.5 mm
(c) 2 mm (d) 2.5 mm

Q.12 As compared to field rivets, the shop rivets are,
(a) stronger (b) weaker
(c) equally strong (d) any of the above

Q.13 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.14 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.15 For field rivets, the permissible stresses are reduced by what percentage?
(a) 10% (b) 15%
(c) 25% (d) $33\frac{1}{3}\%$

Q.16 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.17 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.18 A 16 mm thick plate is joined by double cover butt joint using a 10 mm thick cover plate. The steel has a permissible tensile strength of 150 MPa. What is the efficiency of joint per pitch of 9 cm if 20 mm diameter power driven shop rivets are used?
(a) 72.61% (b) 21.63%
(c) 16.44% (d) 33.62%

Q.19 Minimum pitch of the rivets shall not be less than
(a) $1.5d$ (b) $2.0d$
(c) $2.5d$ (d) $3.0d$

Q.20 Efficiency of a riveted joint, having the minimum pitch is
(a) 40% (b) 50%
(c) 60% (d) 70%

Q.21 As per IS : 800, the rivets subjected to combined tensile and shear stresses are proportioned such that
(a) $\left(\frac{f_s}{p_s}\right)^{\frac{1}{2}}+\left(\frac{f_t}{p_t}\right)^{\frac{1}{2}} \le 1.4$
(b) $\left(\frac{f_s}{p_s}\right)+\left(\frac{f_t}{p_t}\right) \le 1.4$
(c) $\left(\frac{f_s}{p_s}\right)^{2}+\left(\frac{f_t}{p_t}\right)^{2} \le 1.4$
(d) $\left(\frac{f_s}{p_s}\right)^{2}+\left(\frac{f_t}{p_t}\right)^{2} \ge 1.4$

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.22 For rivets in tension with countersunk heads, the tensile value shall be
(a) reduced by 25%
(b) reduced by 33.3%
(c) increased by 25%
(d) increased by 33.3%

Q.23 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.24 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.25 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) $\eta = \frac{b+d}{b}$

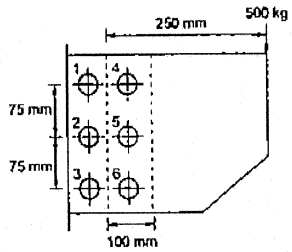
Q.26 Match List-I (Type of stress) with List-II (Allowable value of stress) and select the correct answer using the codes given below the lists:
(f_y = minimum yield stress of steel)

List-I	List-II
A. Axial tension	1. $0.75 f_y$
B. Bending tension	2. $0.66 f_y$
C. Maximum shear stress	3. $0.60 f_y$
D. Bearing stress	4. $0.40 f_y$

Codes:

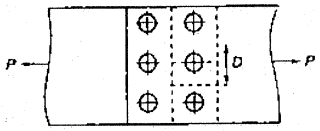
	A	B	C	D
(a)	2	3	1	4
(b)	3	2	4	1
(c)	2	3	4	1
(d)	3	2	1	4

Q.27 The rivets in an eccentrically loaded riveted joint are shown in figure below.



Which rivets will be stressed to maximum?
(a) 1 and 4 (b) 1 and 3
(c) 3 and 6 (d) 4 and 6

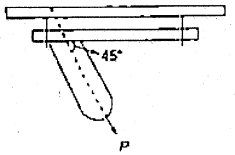
Q.28 To ascertain the strength of a double cover butt joint as shown in figure, the riveted joint is checked for



(a) tearing the plate
(b) double shearing of the rivets
(c) bearing of the rivets
(d) All of the above

Q.29 The greater gauge of long rivets should not exceed
(a) $2d$ (b) $4d$
(c) $6d$ (d) $8d$

Q.30 Four bolts share the load P as shown in the figure below. The shear strength of bolt is 30 kN and tension strength of bolt is 40 kN.



Which one of the following is the value of P?
(a) 96 kN (b) 105 kN
(c) 117 kN (d) 134 kN

Q.31 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.32 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.33 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.34 When the axis of load lies in the plane of rivet group, then the most heavily loaded rivet will be the one which
(a) is at the CG of the rivet group
(b) is at the minimum distance from CG of the rivet group
(c) gives the maximum angle between the two forces F_a and F_m
(d) gives the minimum angle between the two forces F_a and F_m

where, F_a is the load shared by each rivet due to axial load and F_m is the shearing load due to moment in any rivet

Q.35 For bolts upto 25 mm diameter, the difference between gross diameter and nominal diameter is
(a) 0 mm (b) 1.5 mm
(c) 2 mm (d) 1 mm

Q.36 According to IS specifications, the maximum pitch of rivets in compression is
(a) lesser of 200 mm and 12 t
(b) lesser of 200 mm and 16 t
(c) lesser of 300 mm and 32 t
(d) lesser of 300 mm and 24 t
where t is thickness of thinnest outside plate or angle.

Q.37 A member of a roof truss consists of two angle sections 80 × 50 × 6 mm placed back-to-back on both sides of a 8 mm thick gusset plate. It carries a direct load of 71 kN. What is the number of power driven field rivets required for the joint? Assume diameter of rivets as 16 mm.
(a) 3 rivets (b) 4 rivets
(c) 2 rivets (d) none of these

Q.38 The type of stress induced in the foundation bolts fixing a column to its footing is
(a) pure compression (b) bearing
(c) pure tension (d) bending

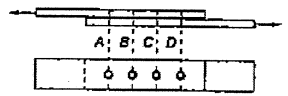
Q.39 When the effect of wind or earthquake load is considered in the design of rivets and bolts for steel structures, by what percentage the permissible stresses may be exceeded?
(a) 15% (b) 25%
(c) 33.33% (d) 50%

Q.40 A 6 mm thick mild steel plate is connected to 8 mm thick plate by 16 mm diameter shop rivets. What is the number of rivets required to carry 60 kN load?
(a) 2 (b) 3
(c) 4 (d) 6

Q.41 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

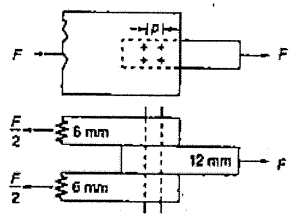
Q.42 A bolt designated as Hex bolt M 16 x 70 NL will have
(a) diameter of 16 mm
(b) diameter of 70 mm
(c) length of 16 mm
(d) cross-sectional area of 16 x 70 cm²

Q.43 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.44 Consider the riveted joint shown in figure. The maximum permissible value of 'p' (rivet diameter 20 mm) is

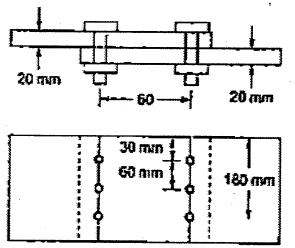


(a) 50 mm (b) 60 mm
(c) 72 mm (d) 96 mm

Q.45 In which of the following case we avoid bolted connection?
(a) Connection subjected to fire
(b) Connection subjected to frequent earthquake load
(c) Connection subjected to snow load
(d) Connection subjected to corrosion problem

Q.46 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.47 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 mm, d_0 = 22 mm, f_{ub} = 400 MPa, γ_{mb} = 1.25
- For Fe410 plates
  f_u = 410 MPa, γ_{mo} = 1.25

(a) 473.056 kN (b) 573.056 kN
(c) 673.056 kN (d) 773.056 kN

Q.48 A boiler shell is made up of 14 mm thick Fe415 plates. If the joint is double bolted lap joint with M16 bolts of grade 4.6 at distance of 50 mm. The design strength of plate per pitch width is:
(a) 132.50 kN (b) 152.50 kN
(c) 112.20 kN (d) 172.20 kN

Q.49 For a plate having lap joint (having 6 bolts), the number of shear planes at thread n_n = 1 per bolt, number of shear planes at shank, n_s = 0 per bolt. Assuming d = 20 mm, f_{ub} = 400 MPa, γ_{mb} = 1.25, the design strength in shear as per limit state method;
(a) 184.36 kN (b) 271.586 kN
(c) 284.36 kN (d) 212.586 kN

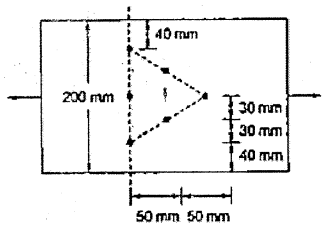
Q.50 A 18 mm thick plate is joined to a 16 mm plate by 200 mm long (effective) single V butt weld. The strength of the joint is
(Assume Fe410 and ship welds are used)

(a) 378 kN (b) 218 kN
(c) 428 kN (d) 328 kN

Q.51 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.52 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 $A_{nb} = 245\ mm^2$, $f_{ub} = 400$, $\gamma_{mb} = 1.25$, $K_b = 0.50$.
(a) 90.52 kN (b) 86 kN
(c) 80.52 kN (d) 96 kN

Q.53 A plate (200 × 10 mm) with holes as shown below, if yield and the ultimate strength of steel used are 250 MPa and 420 MPa and 20 mm diameter bolts are used



The efficiency of the plate with holes is:
(a) 88% (b) 84%
(c) 93% (d) 96%

■■■■

Answers Revetted, Bolted and Pinned Connections

1. (c)	2. (b)	3. (c)	4. (c)	5. (a)	6. (b)	7. (b)	8. (c)	9. (a)	10. (c)
11. (b)	12. (a)	13. (c)	14. (c)	15. (c)	16. (c)	17. (c)	18. (d)	19. (c)	20. (c)
21. (b)	22. (b)	23. (d)	24. (a)	25. (c)	26. (b)	27. (d)	28. (d)	29. (d)	30. (d)
31. (c)	32. (c)	33. (b)	34. (d)	35. (a)	36. (a)	37. (c)	38. (c)	39. (b)	40. (c)
41. (b)	42. (a)	43. (c)	44. (d)	45. (b)	46. (c)	47. (c)	48. (a)	49. (b)	50. (a)
51. (a)	52. (a)	53. (c)							

Explanations Revetted, Bolted and Pinned Connections

1. (c)
For grade 4.6 bolts,
$f_{ub} = 392.4$ MPa
$\gamma_{mb} = 1.25$
Net tensile stress area of 12 mm diameter bolt,
$A_{nb} = 113\ mm^2$
Strength of bolt in single shear,

$$V_{nb} = \frac{V_{nsb}}{\gamma_{mb}} = \frac{A_{nb} f_{ub}}{\sqrt{3}\gamma_{mb}}$$

$$= \frac{113 \times 392.4}{\sqrt{3} \times 1.25} = 20.48 \text{ kN}$$

Strength of bolt is bearing,

$$V_{pb} = \frac{V_{pbb}}{\gamma_{mb}} = \frac{2.5dtf_u}{\gamma_{mb}}$$

$$= \frac{2.5 \times 12 \times 10 \times 410}{1.25}$$

$$= 98.4 \text{ kN}$$

Bolt value = minimum of V_{nb} and V_{pb}
= 20.48 kN

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

2. (b)
Minimum edge distance,
$e = 1.7 \times$ hole dia.
$= 1.7 \times 22 = 37.4$ mm
Then, number of bolts n,
$150 = 2e + (nd_o) + g$
where, g is the gauge distance.
∴ $150 = 2 \times 37.4 + (n \times 22) + 22$ (let $g = d_o$)
$n = 2.4 \approx 2$

6. (b)
Strength of bolt in single shear

$$= \frac{A_{nb} f_{ub}}{\sqrt{3}\gamma_{mb}}$$

$$= \frac{\pi/4 \times 22^2 \times 400}{\sqrt{3} \times 1.25}$$

$$= 70.23 \text{ kN}$$

Strength of bolt in bearing $F_{pb} = 2.5\frac{k_b d t f_u}{\gamma_{mb}}$

where, k_b is minimum of,

$$\frac{e}{3d_0} = \frac{40}{3 \times 22} = 0.606$$

$$\frac{p}{3d_0} - 0.25 = 0.735$$

$$\frac{f_{ub}}{f_u} \approx 1$$

Thus, $k_b = 0.606$

∴ $$T_{pb} = \frac{2.5 \times 0.606 \times 22 \times 10 \times 410}{1.25}$$

$$= 109.322 \text{ kN}$$

Thus bolt value will be minimum of above two values, i.e., 70.23 kN.

7. (b)

$$\text{Number of bolts} = \frac{\text{Applied pull}}{\text{Bolt value}}$$

In double cover butt joint, bolts are in double shearing strength of bolt in double shear

$$= \frac{2 \times \frac{\pi}{4} \times d_0^2 \times f_{ub}}{\sqrt{3}\gamma_{mb}}$$

$$= \frac{2 \times \frac{\pi \times 26^2}{4} \times 400}{\sqrt{3} \times 1.25} \text{N}$$

$$= 196.18 \text{ kN}$$

Strength of bolts in bearing

$$T_{pb} = \frac{2.5 K_b d t f_u}{\gamma_{mb}}$$

K_b = Minimum of (i) $\frac{e}{3d_o}$

$$= \frac{40}{78} = 0.51$$

(ii) $\frac{p}{3d_o} - 0.25 = \frac{75}{78} - 0.25 = 0.71$

(iii) $\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.97$

(iv) $K_b = 0.51$

Hence, $$T_{pb} = \frac{2.5 \times 0.51 \times 24 \times 10 \times 410}{1.25}$$

$$= 106.4 \text{ kN}$$

Therefore, number of bolts = $\frac{200}{106.4} = 1.99 \approx 2$

11. (b)
If gross diameter and nominal diameter are d' and d respectively then,
$d' = d + 1.5$ mm (for $d \le 25$ mm)
$= d + 2$ mm (for $d > 25$ mm)

13. (c)
Diameter of rivet as per Unwin's formula is given as, $d = 6.05\sqrt{t}$ mm
where, t = thickness of plate in mm.
∴ $d = 6.05\sqrt{15}$
$= 23.43$ mm
Adopt 22 mm as unwind formula gives diameter on higher side.

14. (c)
By provind proper edge distance, we can prevent shear failure, spliting failure and bearing failure of plates.

18. (d)

Gross dia of rivet = 20 + 1.5 = 21.5 mm

Strength of plate per pitch,

$= 150 \times (90 - 21.5) \times 16$

$= 164400\ N$

Strength of rivet in bearing,

$= 300 \times 21.5 \times 16 = 103200\ N$

Strength of rivet in double shear,

$= 2 \times \tau_{vf} \times \frac{\pi}{4} \times d^2$

$= 2 \times 100 \times \frac{\pi}{4} \times 21.5^2$

$= 72610\ N$

$\therefore$ Strength of joint per pitch,

= minimum of above three

$= 72610\ N$

Strength of plate per pitch,

$= 150 \times 90 \times 16 = 216000\ N$

$\therefore$ Efficiency of joint $= \frac{72610}{216000} \times 100 = 33.62\%$

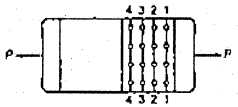
19. (c)

Minimum pitch of rivets shall not be less than 2.5 times the nominal diameter of rivet.

25. (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 $b \cdot t\sigma_{at}$

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

33. (b)

Rivet value in single shear = Min. of $\begin{cases} \frac{\pi}{4} d^2 \times \tau_{vf} \\ \sigma_b \times d \times t \end{cases}$

$= \text{Min of} \begin{cases} \frac{\pi}{4} \times \frac{21.5^2 \times 80}{1000} = 29.04\ kN \\ \frac{250 \times 21.5 \times 10}{1000} = 53.75\ kN \end{cases}$

$= 29.04$ kN

Rivet value in double shear

$= \text{Min. of} \begin{cases} 2 \times \frac{\pi}{4} d^2 \times \tau_{vf} \\ \sigma_b \times d \times t \end{cases}$

$= \text{Min. of} \begin{cases} 58.08\ kN \\ 53.75\ kN \end{cases}$

$= 53.75$ kN

Difference = 53.75 – 29.04 = 24.7 kN

37. (c)

For power driven field rivets,

$\tau_{vf} = 90$ MPa

$\sigma_{bf} = 270$ MPa

Gross diameter of rivets,

$= 16 + 1.5 = 17.5$ mm

Strength of rivets on 8 mm gusset,

$= \sigma_{bf} \times d \times t$

$= \frac{270 \times 17.5 \times 8}{1000} = 37.8$ kN

Strength of rivets in double shear,

$= 2 \times \tau_{vf} \times \frac{\pi \times d^2}{4}$

$= \frac{2 \times 90}{1000} \times \frac{\pi}{4} \times 17.5^2$

$= 43.3$ kN

Rivet value = 37.8 kN

$\therefore$ Number of rivets required,

$= \frac{71}{37.8} = 1.88 \approx 2$ rivets

40. (c)

For shop rivets, permissible stresses are

In shearing, $\tau_s = 100$ MPa

In bearing, $\sigma_b = 300$ MPa

The gross diameter of hole (D)

$= 16 + 1.5 = 17.5$ mm

Strength of rivets in bearing $= Dt\sigma_b$

$= 17.5 \times 6 \times 300 = 31.5$ kN

Strength of rivets in single shear

$= \frac{\pi D^2}{4} \times \tau_s$

$= \frac{\pi}{4} \times (17.5)^2 \times 100$

$= 24.05$ kN

$\therefore$ Rivet value = 24.05 kN

Hence, number of rivets required

$= \frac{80}{24.05} = 3.33 \approx 4$ nos.

43. (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.

45. (b)

Because bolted joints are susceptible to vibration as in case of earthquake.

46. (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

47. (c)

Thickness of thinner plate, $t = 20$ mm

Width of plate $b = 180$ mm

There is no staggering, $P_s = 0$

Number of bolts in weakest section = 3

Net area at weakest section,

$A_n = [b - nd_0 + 0]t$

$= [180 - 3 \times 22] \times 20$

$= 2280\ mm^2$

Design strength of plates in the joint

$= \frac{0.9 f_u A_n}{Y_{m1}} = \frac{0.9 \times 410 \times 2280}{1.25}$

$= 673056\ N = 673.056$ kN

46. (a)

Pitch = 50 mm

Diameter of bolts

$= d = 16$ mm

Diameter of bolt hole,

$= d_0 = 18$ mm

$t = 14$ mm

$b - p = 50$ mm,

$f_u = 410$ Mpa

Number of bolts in double bolted joint per 50 mm width, $n = 1$

$\therefore \quad A_n = (50 - 1 \times 18) \times 14 = 448\ mm^2$

$\therefore$ Design strength of plate per 50 mm width

$T_{dn} = \frac{0.9 \times 410 \times 448}{1.25} = 132.50$ kN

49. (b)

Total $n_n = 1 \times 6 = 6$ and total $n_s = 0$

$A_{nb} = 0.78 \times \frac{\pi}{4} d^2 = 0.78 \times \frac{\pi}{4} (20)^2$

$= 245\ mm^2$

Assuming no reduction factor,

Nominal shear strength,

$V_{nsb} = \frac{f_{ub}}{\sqrt{3}} (n_n A_{nb} + n_s A_{sb})$

$= \frac{400}{\sqrt{3}} (6 \times 245 + 0) = 339.482$ kN

$\therefore$ Design strength in shear

$= \frac{V_{nsb}}{Y_{mb}} = \frac{339.482}{1.25} = 271.586$ kN

50. (a)

Since penetration is not complete, effective throat thickness,

$t = \frac{5}{8} t$

$\Rightarrow \quad t = \frac{5}{8} \times 16 = 10$ mm