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ESE 2021

UPSC ENGINEERING SERVICES EXAMINATION

Preliminary Examination

Civil Engineering

Topicwise **Objective** Solved Questions

Volume-I

Topicwise Presentation

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ESE-2021 : Preliminary Examination

Civil Engineering : Volume-I

Topicwise Objective Solved Questions : (1995-2020)

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Director's Message

Engineering is one of the most chosen graduating field. Taking engineering is usually a matter of interest but this eventually develops into "purpose of being an engineer" when you choose engineering services as a carrier option.

Train goes in tunnel we don't panic but sit still and trust the engineer, even we don't doubt on signalling system, we don't think twice crossing over a bridge reducing our travel time; every engineer has a purpose in his department which when coupled with his unique talent provides service to mankind.



B. Singh (Ex. IES)

I believe *"the educator must realize in the potential power of his pupil and he must employ all his art, in seeking to bring his pupil to experience this power"*. To support dreams of every engineer and to make efficient use of capabilities of aspirant, MADE EASY team has put sincere efforts in compiling all the previous years' ESE-Pre questions with accurate and detailed explanation. The objective of this book is to facilitate every aspirant in ESE preparation and so, questions are segregated chapterwise and topicwise to enable the student to do topicwise preparation and strengthen the concept as and when they are read.

I would like to acknowledge efforts of entire MADE EASY team who worked hard to solve previous years' papers with accuracy and I hope this book will stand up to the expectations of aspirants and my desire to serve student fraternity by providing best study material and quality guidance will get accomplished.

B. Singh (Ex. IES)
CMD, MADE EASY Group

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UNIT

IV

Design of Steel Structures

Syllabus

Principles of Working Stress methods, Design of tension and compression members, Design of beams and beam column connections, built-up sections, Girders, Industrial roofs, Principles of Ultimate load design.

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1

Structural Fasteners

1.1 Consider the following statements:

Aluminium is being increasingly used for structural purposes because

1. its modulus of elasticity is double that of steel
2. its coefficient of thermal expansion is half that of steel
3. it requires less maintenance
4. the strength to unit weight ratio of aluminium is high

Which of these statements are correct?

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

[ESE : 1995]

1.2 A steel plate is 30 cm wide and 10 mm thick. A rivet of nominal diameter 18 mm is driven. The net sectional area of the plate is

- (a) 18.00 cm² (b) 28.20 cm²
(c) 28.05 cm² (d) 32.42 cm²

[ESE : 1995]

1.3 Which one of the following is the most important consideration in the design of a riveted joint between structural members when the centroid of the rivets does not coincide with the axis of the load?

- (a) Direct shear force in each rivet is proportional to its radial distance from its centroid and the resultant force in each rivet should not exceed its rivet value.
- (b) Shear force caused in each rivet due to eccentricity of the load is proportional to its radial distance from its centroid and the direct shear force in each rivet should be limited to half the rivet value.
- (c) The shear force caused in each rivet due to eccentricity of the load is proportional to the radial distance of the rivet from the centroid of the rivet group and the maximum resultant force in any rivet should not exceed the rivet value.

(d) The shear force caused in the rivet due to eccentricity of load as well as direct shear force caused in the rivet should not exceed rivet value individually.

[ESE : 1995]

1.4 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

[ESE : 1995]

1.5 A circular plate 100 mm diameter is welded to another plate by means of 6 mm fillet weld. If the permissible shearing stress in the weld equals 10 kg/mm², then the greatest twisting moment that can be resisted by the weld will be

- (a) 424π kg-m (b) 300π kg-m
(c) 212π kg-m (d) 60π kg-m

[ESE : 1996]

1.6 A mild steel flat subjected to tensile force of 84 tonnes is connected to a gusset plate using rivets. If the forces required to shear a single rivet, to crush the rivet and to tear the plate per pitch length are 5000 kg, 8000 kg and 6000 kg respectively, then the number of rivets required is

- (a) 12 (b) 14
(c) 16 (d) 17

[ESE : 1996]

1.7 In a fillet weld the weakest section is the

- (a) smaller side of the fillet
(b) throat of the fillet
(c) side perpendicular to force
(d) side parallel to force

[ESE : 1996]

1.8 Which one of the following methods of design is not suitable for structures subjected to impact and fatigue?

- (a) Simple design
- (b) Semi-rigid design
- (c) Rigid design
- (d) Plastic design

[ESE : 1996]

1.9 Assertion (A) : In structural bearing type joints, each connection is assumed to transmit its proportional share of the applied load.

Reason (R) : Applied load passes through the centroid of the connector group.

- (a) both A and R are true and R is the correct explanation of A
- (b) both A and R are true but R is not a correct explanation of A
- (c) A is true but R is false
- (d) A is false but R is true

[ESE : 1996]

1.10 Upper yield point in the stress-strain curve in structural steel can be avoided by

- (a) cold working
- (b) hot working
- (c) quenching
- (d) galvanizing

[ESE : 1997]

1.11 In the design of framed connections, the rivets or bolts connecting the web of the beam with connecting angles are subject to

- (a) single shearing and bearing on the web
- (b) double shearing and bearing on the web
- (c) double shearing and no bearing on the web
- (d) no shearing but only bearing on the web

[ESE : 1997]

1.12 The effective length of the fillet weld is

- (a) Total length $-2 \times$ throat size
- (b) Total length $-2 \times$ weld size
- (c) $0.7 \times$ total length
- (d) Total length $-(\text{weld size}/\sqrt{2})$

[ESE : 1997]

1.13 Consider the following statements:

1. To insert a 28 mm nominal diameter rivet, 29.5 mm rivet hole is made.
2. Provision is made to allow temperature expansion of the bolt.

Which of these statements are correct?

- (a) Both 1 and 2
- (b) 1 only
- (c) 2 only
- (d) Neither 1 nor 2

[ESE : 1997]

1.14 In a diamond riveting, for a plate of width 'b' and rivet diameter 'd', the efficiency of the joint is given by

- (a) $\frac{(b-d)}{b}$
- (b) $\frac{(b-2d)}{b}$
- (c) $\frac{(b-d)}{d}$
- (d) $\frac{(b-2d)}{d}$

[ESE : 1997]

1.15 For two plates of equal thickness, full strength of fillet weld can be ensured if its maximum size, for square edge, is limited to

- (a) 1.5 mm less than the thickness
- (b) 75% of the thickness
- (c) 80% of the thickness
- (d) thickness of the plate

[ESE : 1998]

1.16 In a double-riveted double-covered butt joint, the strength of the joint per pitch length in shearing the rivets is n times the shear strength of one rivet in single shear, where 'n' is equal to

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

[ESE : 1998]

1.17 A welded fillet joint of length L can be subjected to a maximum load of (f_s -fillet size and p_{ss} = permissible shear stress).

- (a) $\frac{(f_s \times L \times p_{ss})}{3}$
- (b) $f_s \times L \times p_{ss}$
- (c) $(0.7)(f_s \times L \times p_{ss})$
- (d) $2(f_s \times L \times p_{ss})$

[ESE : 1998]

1.18 Match **List-I** (Use) with **List-II** (Type of weld) and select the correct answer using the codes given below the lists:

List-I

- A. Structural members
- B. Joining two surfaces
- C. A hole is made in one of
- D. Pressure is applied

List-II

1. Slot weld subject to direct tension or compression
2. Seam weld approximately at right angles to each other

3. Fillet weld the components and welding is done around the periphery of the hole
4. Plug weld continuously
5. Butt weld

Codes:

	A	B	C	D
(a)	5	4	1	3
(b)	4	3	2	1
(c)	5	3	1	2
(d)	4	5	3	2

[ESE : 1999]

1.19 A welding detail is shown in figure-I

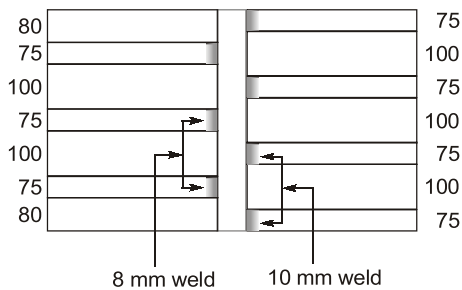


Figure-I

The welding notation for the figure is

- (a) $\frac{80}{75} \frac{75}{100} \frac{100}{75}$
- (b) $\frac{75}{80} \frac{100}{75} \frac{100}{100}$
- (c) $\frac{100}{80} \frac{75}{100} \frac{75}{80}$
- (d) $\frac{80}{100} \frac{100}{75} \frac{75}{100}$

[ESE : 1999]

1.20 A structural member carrying a pull of 700 kN is connected to a gusset plate using rivets. If the

pulls required to shear the rivet, to crush the rivet and to tear the plate per pitch length are respectively 60 kN, 35 kN and 70 kN, then the number of rivets required will be

- (a) 22 (b) 20
(c) 18 (d) 12

[ESE : 1999]

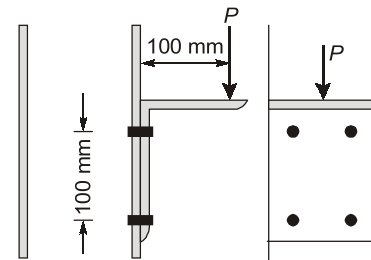
1.21 **Assertion (A)** : When a mild steel bar is tested in tension, the stress drops down from upper yield point to lower yield point without elongation.

Reason (R) : The boundaries of grains of mild steel are composed of brittle material.

- (a) both A and R are true and R is the correct explanation of A
(b) both A and R are true but R is not a correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE : 2000]

1.22 Each bolt shown in the given figure is capable of resisting a shear force of 20 kN and tension of 15 kN. The interaction equation between the forces is



- (a) $\frac{P}{40} + \frac{P}{30} = 1.4$ (b) $\frac{P}{80} + \frac{P}{15} = 1.4$
(c) $\frac{P}{80} + \frac{P}{30} = 1.4$ (d) $\frac{P}{40} + \frac{P}{15} = 1.4$

[ESE : 2000]

1.23 Consider the following statements regarding pin connections:

1. Moment at pin connection is zero.
2. Only one pin is used in a connection.
3. Secondary stresses do not occur.
4. They are rigid.

Which of these are the advantages of pin connections?

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

[ESE : 2000]

1.33 A plate used for connecting two or more structural members intersecting each other is termed as

- (a) Template (b) Base plate
(c) Gusset plate (d) Shoe plate

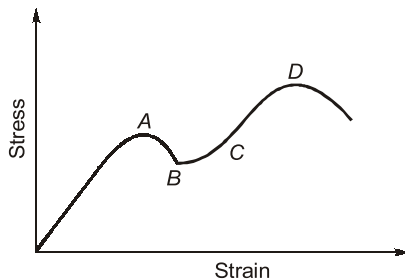
[ESE : 2003]

1.34 In a riveted joint, failure will occur due to which one of the following?

- (a) Shear failure of rivet
(b) Bearing failure of rivet
(c) Tearing failure of plate
(d) Minimum load value of shearing, bearing or tearing failure

[ESE : 2003]

1.35 The stress strain diagram for mild steel subjected to tensile load is given below. Now consider the following statements:



- The diagram represents average stress strain diagram.
- The diagram represents actual stress strain diagram.
- A represents upper yield point.
- B represents lower yield point.

Which of these statements are correct?

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

[ESE : 2004]

1.36 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%

[ESE : 2004]

1.37 A 6 mm thick mild steel plate is connected to an 8 mm thick plate by 16 mm diameter shop rivets. What is the number of rivets required to carry an 80 kN load?

- (a) 2 (b) 3
(c) 4 (d) 6

[ESE : 2004]

1.38 Consider the following statements:

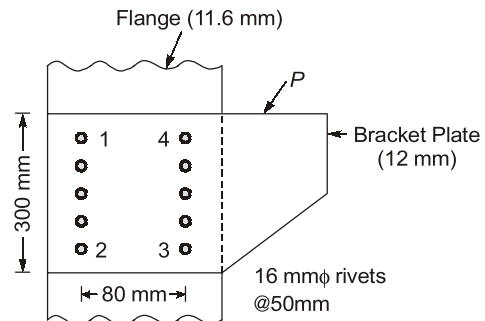
- The gross area of a rivet is taken as the cross-sectional area of the rivet hole.
- The distance between the centres of the rivets should not be less than 2.5 times the gross diameter of the rivet.
- In no case shall fewer than two bolts or rivets be used for attaching the lug angle to the gusset.

Which of these statements are correct?

- (a) 1 and 2 (b) 1 and 3
(c) 2 and 3 (d) 1, 2 and 3

[ESE : 2004]

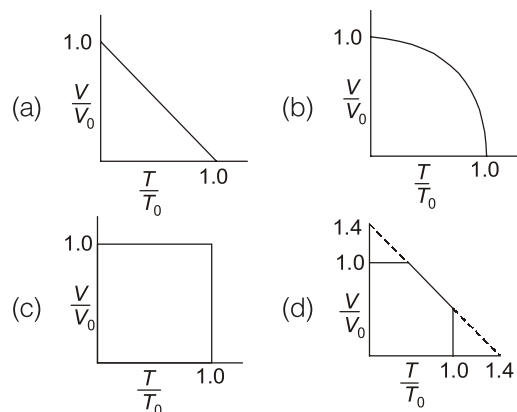
1.39 Which one of the following is the most critical rivet in the joint shown in the figure given below?



- (a) No. 1 (b) No. 2
(c) No. 3 (d) No. 4

[ESE : 2005]

1.40 A bolt is subjected to shear force V and tension T . The capacity of the bolt in resisting shear and tension respectively are V_0 and T_0 . Which one of the following diagrams represents interaction relations?



[ESE : 2006]

1.50 Consider the following statements :

1. When wind load is the primary load, no increase in the allowable stresses is provided for in members or fasteners.
2. Due to wind load acting along with dead and live loads, increase in allowable stress upto 33.33% can be provided for.
3. Due to wind load acting along with dead load, increase in allowable stress of 25% in foundation bolts can be provided for.

Which of these statements is/are correct?

- (a) 1, 2 and 3 (b) 1 only
(c) 2 and 3 (d) 3 only

[ESE : 2009]

1.51 A bolt designated as Hex bolt M 16 × 70 NL will have

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

[ESE : 2010]

1.52 The maximum longitudinal pitch allowed in bolted joints of tension members is

- (a) 16 times the diameter of the bolt
(b) 32 times the diameter of the bolt
(c) 16 times the thickness of the plate
(d) 32 times the thickness of the plate

[ESE : 2010]

1.53 A structural member carrying a pull of 700 kN is connected to a gusset plate using rivets of 20 mm diameter. If the pull required for shearing the rivets, to crush the rivets and to tear the plate per pitch length are 60 kN, 35 kN and 70 kN respectively, then the number of rivets required is

- (a) 12 (b) 18
(c) 20 (d) 22

[ESE : 2010]

1.54 The effective length of the fillet weld is

- (a) Total length – 2 × throat size
(b) Total length – 2 × weld size
(c) $0.7 \times$ total length

(d) Total length – $\left(\frac{\text{Weld size}}{\sqrt{2}}\right)$

[ESE : 2011]

1.55 When the distance between centers of two adjacent rivets connecting the members subjected to either compression or tension exceeds the maximum pitch, then the additional rivets which are not subjected to the calculated stresses are known as

- (a) Packing rivets
(b) Long-grip rivets
(c) Tacking rivets
(d) Auxiliary rivets

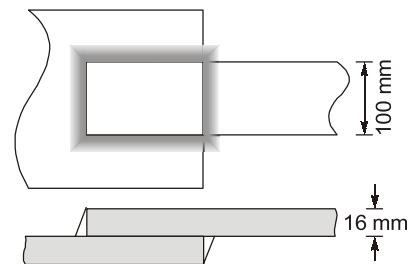
[ESE : 2011]

1.56 The maximum longitudinal pitch in bolted joints, subjected to tensile forces, wherein t = thickness of the plate and D = diameter of bolt, is

- (a) $32D$ (b) $16D$
(c) $32t$ (d) $16t$

[ESE : 2011]

1.57 A tie bar $100 \text{ mm} \times 16 \text{ mm}$ thick is to be welded to another plate as shown in figure using 8 mm fillet welds. If the tensile stress in plates is 150 N/mm^2 and shear stress in weld is 110.0 N/mm^2 , the minimum overlap required will be



- (a) 50 mm (b) 75 mm
(c) 100 mm (d) 150 mm

[ESE : 2011]

1.58 For two plates of equal thickness, full strength of square-edged fillet weld can be ensured if its maximum size is limited to

- (a) 1.5 mm less than the plate thickness
(b) 67% of the plate thickness
(c) 80% of the plate thickness
(d) Thickness of the plate

[ESE : 2011]

1.59 When the effect of wind or earthquake load is taken into account in the design of a riveted connection, the permissible stresses in rivets may be exceeded by

- (a) 16.66% (b) 33.33%
 (c) 25% (d) 30%

[ESE : 2012]

- 1.60** A mild steel flat subjected to a tensile force of 840 kN is connected to a gusset plate using rivets. If the permissible forces required per pitch length (i) to shear a single rivet, (ii) to crush the rivet and (iii) to tear the plate are 50 kN, 80 kN and 60 kN respectively, then the number of rivets required is
- (a) 12 (b) 14
 (c) 16 (d) 17

[ESE : 2012]

- 1.61** The effective throat thickness of a fillet weld depends upon
- (a) angle between fusion faces
 (b) length of weld
 (c) permissible shear stress
 (d) type of weld

[ESE : 2012]

- 1.62** When the load line coincides with the centroid of the rivet group, the rivets are subjected to
- (a) shear only
 (b) tension only
 (c) bending only
 (d) shear as well as tension

[ESE : 2012]

- 1.63** Which of the following statements is/are correct?
1. A steel structure designer can guarantee the safety of the structure.
 2. Working stress method of design of steel structures offers a safer and economical structure.
 3. Strength and serviceability of a structure cannot be predicted on account of several unforeseen factors
- (a) 1, 2 and 3 (b) 3 only
 (c) 2 only (d) 1 only

[ESE : 2013]

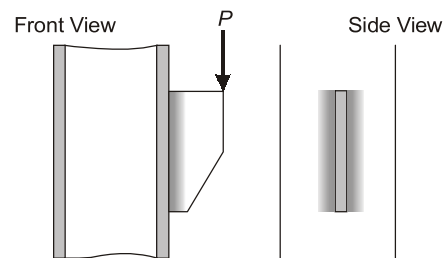
- 1.64** An angle ISA 50 × 50 × 6 is connected to a gusset plate 5 mm thick, with 16 mm bolts. What is the bearing strength of the bolt when the hole diameter is 16 mm and the allowable bearing stress is 250 MPa?
- (a) 8 kN (b) 20 kN
 (c) 22.5 kN (d) 24 kN

[ESE : 2014]

- 1.65** The effective length of a fillet weld is taken as the actual length
- (a) plus twice the size of the weld
 (b) minus twice the size of the weld
 (c) plus the size of the weld
 (d) minus the size of the weld

[ESE : 2014]

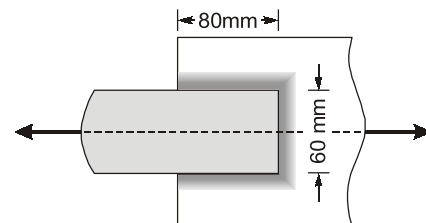
- 1.66** For the welded joint shown in the figure, the direct vertical shear stress on the weld is 40 MPa and the bending stress is 120 MPa. For what strength should the weld be designed?



- (a) 80 MPa (b) 120 MPa
 (c) 132 MPa (d) 160 MPa

[ESE : 2015]

- 1.67** A fillet-welded joint is shown in the figure. The size of the weld is 8 mm. Safe stress in the weld is 110 N/mm². What is the safe force (to the nearest magnitude) to which the weld can be subjected?



- (a) 125 kN (b) 130 kN
 (c) 140 kN (d) 135 kN

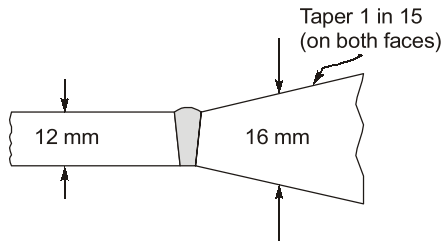
[ESE : 2015]

- 1.68** A circular shaft of diameter 120 mm is welded to a rigid plate by a fillet weld of size 6 mm. If a torque of 8 kNm is applied to the shaft, what is the maximum stress in the weld (to the nearest unit)?
- (a) 84 N/mm² (b) 87 N/mm²
 (c) 90 N/mm² (d) 95 N/mm²

[ESE : 2015]

- 1.69** Two plates of dimensions 150 mm × 16 mm and 150 mm × 12 mm at their welding edges are

joined by butt welding as shown in the figure. What is the maximum tension that this single V-butt weld joint can transmit? The permissible tensile stress in the plates is 150 MPa.



- (a) 168.75 kN (b) 270 kN
(c) 218 kN (d) 1350 kN

[ESE : 2015]

1.70 What is the maximum number of 20 mm diameter bolts that can be accommodated in a single row on a 140 mm wide flat strip used as one of the structural elements involved in the process?

- (a) 4 (b) 3
(c) 2 (d) 5

[ESE : 2015]

1.71 What is the nearest magnitude of strength of a 6 mm fillet weld of 100 mm length made between two flats each 10 mm thick? The allowable shear stress on the weld is 110 MPa.

- (a) 23 kN (b) 33 kN
(c) 46 kN (d) 66 kN

[ESE : 2015]

1.72 Consider the following statements:

- When analyzing by the Ultimate Load Method, the eccentrically loaded fastener group rotates about an instantaneous centre.
- The rivet which is the farthest from the centre of gravity of the rivet group and may also be the nearest to the applied load line is the most 'critical' one.
- The deformation at each rivet is not proportional to its distance from the centre of rotation.

Which of the above statements are correct?

- (a) 1 and 3 only (b) 2 and 3 only
(c) 1 and 2 only (d) 1, 2 and 3

[ESE : 2015]

1.73 Which of the following statements are correct in respect of welded connections?

- Strength of Butt weld is equal to the strength of components joined.
 - Fillet welds carry the loads computed based on the tensile strength characteristic of fusion material.
 - For effective transmission of load by fillet weld, the fusion faces shall subtend an angle between 60° and 120° .
- (a) 1, 2 and 3 (b) 1 and 2 only
(c) 2 and 3 only (d) 1 and 3 only

[ESE : 2015]

1.74 The block shear failure of a bolted joint in tension occurs because of

- Use of high shear strength bolts
 - Use of plates with higher bearing strength
- (a) 1 only (b) 2 only
(c) Both 1 and 2 (d) Neither 1 nor 2

[ESE : 2016]

1.75 The design strength of a tension member is governed by

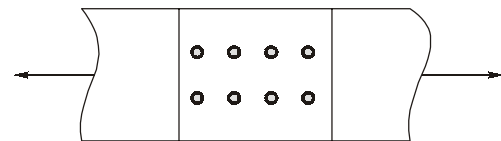
- Rupture at a critical section
- Yielding of gross area
- Block shear of end region

Select the correct answer using the codes given below:

- (a) 1 only (b) 2 only
(c) 3 only (d) 1, 2 and 3

[ESE : 2017]

1.76 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.

- (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

[ESE : 2018]



Answers		Structural Fasteners															
1.1	(d)	1.2	(c)	1.3	(c)	1.4	(d)	1.5	(c)	1.6	(d)	1.7	(b)	1.8	(d)	1.9	(a)
1.10	(a)	1.11	(b)	1.12	(b)	1.13	(d)	1.14	(a)	1.15	(a)	1.16	(d)	1.17	(c)	1.18	(c)
1.19	(a)	1.20	(b)	1.21	(a)	1.22	(c)	1.23	(c)	1.24	(b)	1.25	(b)	1.26	(a)	1.27	(b)
1.28	(c)	1.29	(a)	1.30	(c)	1.31	(a)	1.32	(d)	1.33	(c)	1.34	(d)	1.35	(b)	1.36	(b)
1.37	(c)	1.38	(b)	1.39	(c)	1.40	(d)	1.41	(c)	1.42	(a)	1.43	(b)	1.44	(d)	1.45	(a)
1.46	(c)	1.47	(a)	1.48	(c)	1.49	(c)	1.50	(c)	1.51	(a)	1.52	(c)	1.53	(c)	1.54	(b)
1.55	(c)	1.56	(d)	1.57	(c)	1.58	(a)	1.59	(c)	1.60	(d)	1.61	(a)	1.62	(a)	1.63	(b)
1.64	(b)	1.65	(b)	1.66	(c)	1.67	(d)	1.68	(a)	1.69	(a)	1.70	(c)	1.71	(c)	1.72	(c)
1.73	(d)	1.74	(c)	1.75	(d)	1.76	(b)										

Explanations Structural Fasteners

1.1 (d)

Aluminium has greater strength to unit weight ratio compared to steel therefore they are being increasingly used for structural purposes.

The modulus of elasticity of aluminium is about one third that of steel while its coefficient of thermal expansion is double that of steel.

1.2 (c)

For a rivet with nominal diameter less than or equal to 25 mm, the hole diameter is taken 1.5 mm more than nominal diameter. For nominal diameter more than 25 mm, the hole diameter is 2 mm more than the nominal diameter. The rivet is heated uniformly from temperature 550°C to 1000°C and after placing it in the hole in the heated condition, its head is pressed on the rivet. Thus it fills the hole completely. However it can be cold driven also.

Diameter of rivet hole = 18 + 1.5 = 19.5 mm

The net cross-sectional area of plate
 = (30 - 1.95) × 1.0 = 28.05 cm²

1.3 (c)

For eccentric riveted connection,
 Direct shear force,

$$R_p = \frac{P}{N}$$

P → Load with eccentricity e

N → Number of rivets

Shear force due to eccentricity,

$$R_m = \frac{Per}{\sum r^2}$$

r → radial distance of rivet from centroid.

$$\text{Resultant } \vec{R} = \vec{R}_p + \vec{R}_m$$

The magnitude of resultant should be less than rivet value.

1.5 (c)

The strength of weld (F)

$$= 0.707 \times 10 \times 6 = 42.42 \text{ kg/mm}$$

Length of the weld, $l = \pi d = 100\pi$ mm

$$\begin{aligned} \text{Twisting moment} &= Fl \times \frac{d}{2} \\ &= 42.42 \times 100\pi \times 50 \\ &= 212\ 100\pi \text{ kg-mm} \\ &= 212.1\pi \text{ kg-m} \end{aligned}$$

1.6 (d)

Rivet value is minimum of 5000 kg, 8000 kg and 6000 kg.

∴ Rivet value = 5000 kg

$$\text{Number of rivets} = \frac{84 \times 1000}{5000} = 16.8 \approx 17$$

1.7 (b)

Throat being the minimum section will carry maximum stress. Thus, it is weakest.

1.8 (d)

The connection, whether riveted, bolted or welded, can be designed as flexible, semi-rigid or rigid connections. Flexible connections are also known as simple connections. These connections are assumed to resist shear only. Rigid connections, also known as moment connections, can resist both shear and bending moments at the connections. Semi-rigid connections resist the bending moment in between the flexible and rigid connections.

Plastic or ultimate design considers complete mobilization of strength of material. This method does not take into consideration the effect of impact, fatigue, creep and shrinkage. The serviceability requirements of avoidance of excessive deflection and cracking are not considered.

1.10 (a)

Plastic deformation of metals below the recrystallization temperature is known as cold working. In this process steel is loaded above elastic limit to have some plastic strain which in turn omits upper yield point later.

1.12 (b)

The effective length of fillet weld is taken equal to its overall length minus twice the weld size. The deduction is made to allow for craters to be formed at the ends of the welded length. The effective length of a fillet should not be less than 4 times the weld size.

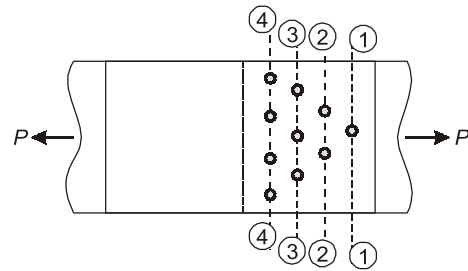
1.13 (d)

For rivets with diameter ≤ 25 mm
Diameter of the hole = $(d + 1.5)$ mm
For rivets with diameter ≥ 25 mm
Diameter of the hole = $(d + 2)$ mm
For 28 mm diameter, diameter of hole = $(28 + 2)$ mm = 30 mm
This provision is provided for ease of alignment of bolt.

1.14 (a)

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. The strength of joint at section 1 – 1 is $(b - d) t \sigma_{at}$.

The strength of solid plate is $b t \sigma_{at}$.

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

1.15 (a)

The maximum size of a fillet weld is obtained by subtracting 1.5 mm from the thickness of the thinner member to be jointed. This specification limits the size of the fillet weld so that total strength may be developed without overstressing the adjacent metal.

1.16 (d)

Strength of one rivet in single shear

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

Strength of double riveted double cover butt joint per pitch length = P_d

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

But $P_d = nP_s$ (given)

$$\Rightarrow P_d = 4P_s$$

1.17 (c)

The strength fillet weld = $0.7 (fs \times pss)$ per unit length. So maximum load is strength of fillet weld \times joint length (L).

1.18 (c)

In butt welds, the effective thickness is generally less than the plates connected so the joint has less than 100% efficiency. They are stronger than fillet welds and used most frequently. They are used when the members to be jointed are lined up. It is usually designed for direct tension or compression. Fillet welds are provided when two members to be jointed are in different planes. If a sufficient length of fillet weld cannot be provided, the connection can be strengthened