UPPSC

Uttar Pradesh Public Service Commission

Assistant Engineer Examination

Previous Years Solved Papers

Civil Engineering

Objective Paper-I | **General Studies**

Objective Paper-II | **General Hindi**

2 Model Test Papers also included

2020

MADE EASY

MADE EASY Publications

www.madeeasypublications.org

MADE EASY Publications

Corporate Office: 44-A/4, Kalu Sarai (Near Hauz Khas Metro Station), New Delhi-110016
E-mail: infomep@madeeasy.in
Contact: 011-45124612, 0-9958995830, 8860378007
Visit us at: www.madeeasypublications.org

UPPSC-Assistant Engineer Examination : Civil Engineering

First Edition: 2015
Reprint: 2017
Second Edition: 2020

Preface

B. Singh (Ex. IES)

UPPSC Assistant Engineer Examination has been always preferred by Engineers due to job stability and opportunity to work in home sate. UPPSC Combined State Engineering Services examination is conducted time to time but not every year. MADE EASY team has made deep study of previous exam papers and observed that a good percentage of questions are of repetitive in nature, therefore previous year's papers are advisable to solve before a candidate takes the exam. This book is also useful for MP State Engineering Services, UPSC Engineering Services and other Competitive exams for Engineering graduates.

The current edition of this book contains complete solutions to all questions with accuracy. I have true desire to serve student community by providing good source of study and quality guidance. I hope this book will be proved an important tool to succeed in UPPSC and other competitive exams. Any suggestions from the readers for improvement of this book are most welcome.

With Best Wishes

B. Singh

CMD, MADE EASY

UPPSC : Exam Pattern

Combined State Engineering Service Examination 2019
Assistant Engineer examination

Paper I : Objective **Maximum Time : 2½ Hours • Maximum Marks : 375** Each question carries 3 marks. There is a penalty of –1 mark for every wrong attempted answer	
General Hindi	25 Questions
Technical Paper I	100 Questions
Total	**125 Questions** (375 Marks)

Paper II : Objective **Maximum Time : 2½ Hours • Maximum Marks : 375** Each question carries 3 marks. There is a penalty of –1 mark for every wrong attempted answer	
General Studies	25 Questions
Technical Paper II	100 Questions
Total	**125 Questions** (375 Marks)

Contents

Civil Engineering

Section-A :

Objective Paper-I

1. Structural Analysis 1-38
2. Design of Concrete Structure 39-59
3. Design of Steel Structure 60-78
4. Fluid Mechanics 79-100
5. Irrigation Engineering 101-108
6. Soil Mechanics 109-139

Actual Paper held in 2011 (Objective-I) 140-149

Model Test-I (Obj. Paper-I) 150-167

Model Test-II (Obj. Paper-I) 168-185

Section-B :

Objective Paper-II

1. Building Materials 187-191
2. Building Construction 192-196
3. Construction Management & Planning 197-200
4. Engineering Hydrology 201-210
5. Irrigation Engineering 211-231
6. Transportation Engineering 232-252
7. Environmental Engineering 253-269
8. Surveying 270-289

Actual Paper held in 2011 (Objective-II) 290-297

Model Test-I (Obj. Paper-I) 298-312

Model Test-II (Obj. Paper-I) 313-327

Section-C :

General Hindi

1. 2011 Solved Paper Hindi 329-341
2. 2008 Solved Paper Hindi 342-352
3. 2007 Solved Paper Hindi 353-363
4. 2007 (II) Solved Paper Hindi 364-372
5. 2004 Solved Paper Hindi 373-381

Model Test -I 382-388

Model Test -II 389-395

Section-D :

General Studies

1. General Science 397-308
2. General Studies 409-419
3. Geography 420-433
4. Polity 434-443
5. Economy 444-447
6. G.K. Current & Miscellaneous 448--457

Actual Paper held in 2011 (GS) 458-465

Model Test -I 466-474

Model Test -II 475-483

Technical & Non-technical Paper-2013

[Exam Held in 2016]

1. Civil Engineering Paper-I (Obj) ..... 484 - 500
2. Civil Engineering Paper-II (Obj) ..... 501 - 512
3. General Hindi ..... 513 - 521
4. General Studies ..... 522 - 534

UPPSC

Combined State Engineering
Services Examination

Previous Year Solved Papers

Section-A

Objective : Paper-I

Civil Engineering

3 Design of Steel Structures

2003

Q.1 In a simply supported beam of span L each end is restrained against torsion, compression flange being unrestrained. According to IS: 800, the effective length of the compression flange will be equal to

(a) L (b) $0.85L$
(c) $0.75L$ (d) $0.70L$

Q.2 In the case of a tension member consisting of two angles back to back on the same side of gusset plate, what is k equal to? (Area of connected leg = A_1, Area of outstanding leg = A_2)

(a) $\frac{3A_1}{3A_1 + A_2}$ (b) $\frac{3A_1}{A_1 + 3A_2}$

(c) $\frac{5A_1}{A_1 + 5A_2}$ (d) $\frac{5A_1}{5A_1 + A_2}$

Q.3 As per Indian Standards rolled steel I-sections are classified into

(a) four series (b) five series
(c) six series (d) seven series

Q.4 A simply supported beam of span L supports a concentrated load W at its midspan. If the cross-section of the beam is an I-section, then the length of elastic-plastic zone of the plastic hinge will be

(a) $L/8$ (b) $L/4$
(c) $L/2$ (d) $3L/4$

Q.5 A ductile structure is defined as one for which the plastic deformation before fracture

(a) is smaller than the elastic deformation
(b) vanishes
(c) is equal to the elastic deformation
(d) is much larger than the elastic deformation

Q.6 The strength at which steel fails under repeated application of load is known as

(a) impact strength (b) tensile strength
(c) yield strength (d) fatigue strength

Q.7 The thickness of web for unstiffened plate girder with clear distance 'd' between the flanges shall not be less than

(a) $d/200$ (b) $d/85$
(c) $d/100$ (d) $d/160$

Q.8 The ratio of elastic modulus to plastic modulus for a rectangular section of steel is

(a) 1.5 (b) 0.66
(c) 1.70 (d) 0.25

Q.9 The effective length of the fillet weld is

(a) Total length – 2 × throat size
(b) Total length – 2 × weld size
(c) 0.7 × total length
(d) Total length $-\left(\frac{\text{Weld size}}{\sqrt{2}}\right)$

Q.10 For an I-beam, shape factor is 1.12. The factor of safety in bending is 1.5. If the allowable stress is increased by 20% for wind and earthquake loads, then the load factor is

(a) 1.10 (b) 1.25
(c) 1.35 (d) 1.40

Q.11 Four vertical columns of the same material, height and weight have the same end conditions. The buckling load will be the largest for a column having the cross-section of

(a) solid square (b) thin hollow circle
(c) solid circle (d) H-section

Q.12 Yield line theory results in

(a) elastic solution
(b) lower bound solution

(c) upper bound solution
(d) unique solution

Q.13 The effective length of a structural steel compression member of length L effectively held in position and restrained against rotation at one end but neither held in position nor restrained against rotation at the other end, is
(a) L (b) $1.2L$
(c) $1.5L$ (d) $2.0L$

Q.14 Which of the following sections should be preferably be used at a place where torsion occurs?
(a) Angle section (b) Box section
(c) Channel section (d) I-section

Q.15 Two ISMC 400 channels placed back to back at a spacing of 250 mm carry an axial load of 1600 kN. The lacing system should be designed to resist a transverse shear equal to :
(a) 40 kN (b) 80 kN
(c) 100 kN (d) 160 kN

Q.16 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 cm^2 (b) 28.20 cm^2
(c) 28.05 cm^2 (d) 32.42 cm^2

2004

Q.17 The property by which a metal resists impact load is called
(a) Ductility (b) Toughness
(c) Elasticity (d) Malleability

Q.18 Load factor is defined as
(a) $\frac{\text{ultimate load}}{\text{yield load}}$ (b) $\frac{\text{yield load}}{\text{working load}}$
(c) $\frac{\text{ultimate load}}{\text{working load}}$ (d) none of these

Q.19 Which of the following section will have largest shape factor?
(a) Rectangle
(b) I-section
(c) Solid circular section
(d) Diamond section

Q.20 As per IS : 800, the maximum bending moment for design of a continuous purlin can be taken as
(a) $\frac{WL}{6}$ (b) $\frac{WL}{8}$
(c) $\frac{WL}{10}$ (d) $\frac{WL}{12}$
Where symbols have their usual meaning.

Q.21 The slenderness ratio of lacing bar should not exceed
(a) 100 (b) 120
(c) 145 (d) 180

Q.22 Lacing bars in a steel column should be designed to resist
(a) bending moment due to 2.5% of the column load
(b) shear force due to 2.5% of the column load
(c) 2.5% of the column load
(d) both (a) and (b)

Q.23 The maximum slenderness ratio of a steel column, the design of which is governed by wind or seismic force is
(a) 150 (b) 180
(c) 250 (d) 350

Q.24 The effective length of a fillet weld should not be less than
(a) two times the weld size
(b) four times the weld size
(c) six times the weld size
(d) eight times the weld size

Q.25 The cross section of the weld throat is the
(a) minimum dimension
(b) average dimension
(c) maximum dimension
(d) none of these

Q.26 Bolts are most suitable to carry
(a) shear force
(b) bending moment
(c) axial tension
(d) shear force and bending moment

Q.27 Efficiency of a rivetted joint having the minimum pitch as per IS : 800 is
(a) 40% (b) 50%
(c) 60% (d) 70%

Q.28 Minimum pitch of the rivets shall not be less than
(a) 1.5 d (b) 2.0 d
(c) 2.5 d (d) 3.0 d

Q.29 As per IS : 800 the maximum deflection in a beam should not exceed
(a) $\frac{L}{180}$ (b) $\frac{L}{250}$
(c) $\frac{L}{325}$ (d) $\frac{L}{360}$
where, L = span of beam

Q.30 If the rivet diameter is 30 cm, the diameter of the rivet hole shall be
(a) 31 mm (b) 31.5 mm
(c) 32 mm (d) 32.5 mm

Q.31 If the thickness of plate to be connected by a rivet is 16 mm, the suitable size of rivet will be
(a) 16 mm (b) 20 mm
(c) 24 mm (d) 27 mm

Q.32 The maximum stress that can be applied to a material for an infinite number of cycles of repeated stress without causing failure is called
(a) elastic limit (b) proportional limit
(c) ultimate strength (d) endurance limit

Q.33 A body is subjected to a stress of 3 N/mm^2 in compression and a tensile stress of 5 N/mm^2 both acting perpendicular to each other. The maximum shear stress in the body will be
(a) 2 N/mm^2 (b) 3 N/mm^2
(c) 4 N/mm^2 (d) 5 N/mm^2

2007 (I)

Q.34 Two ISMC 400 channels placed back to back at a spacing of 250 mm carry an axial load of 1600 kN. The lacing system should be designed to resist a transverse shear equal to :
(a) 40 kN (b) 80 kN
(c) 100 kN (d) 160 kN

Q.35 Horizontal stiffeners in the plate girders are used to
(a) Increase the bending strength of the web
(b) Increase the shear capacity of the web
(c) Prevent local buckling of flange
(d) Prevent local buckling of web

Q.36 In a roof truss, the member which supports the purlins is known as :
(a) main strut (b) main tie
(c) sag tie (d) principal rafter

Q.37 If the diameter of a rivet is more than 25 mm. The diameter of rivet hole as compared to nominal diameter of rivet will be:
(a) more by 1.5 mm (b) more by 2.0 mm
(c) more by 2.5 mm (d) equal

Q.38 As per IS : 800 - 1984, if the diameter of rivets is 18 mm, then the minimum width of lacing plate should be:
(a) 50 mm (b) 55 mm
(c) 60 mm (d) 65 mm

Q.39 As per IS : 800 - 1984, the allowable bending compressive stress in rolled I-beams and channels when compressive flange is continuously laterally supported should be:
(a) 165 N/mm^2 (b) 175 N/mm^2
(c) 185 N/mm^2 (d) 200 N/mm^2

Q.40 As per IS : 800 - 1984, an angle section purlin is designed for a bending moment equal to:
(a) $\frac{wl^2}{9}$ (b) $\frac{wl^2}{10}$
(c) $\frac{wl^2}{12}$ (d) none of the above
Where, w = load per meter;
l = span of purlin

Q.41 Design of structure should not consider snow load when roof is steeper than :
(a) 60° (b) 45°
(c) 30° (d) 15°

Q.42 If the vertical plane of load coincides with the vertical centroidal axis of the section, the torsion is not developed in the following section:
(a) an angle section (b) a T - section
(c) an I-section (d) a channel section

Q.43 As per IS : 800, the minimum number of rivets used for attaching the lug angle to the gusset or other supporting member is :

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

Q.44 The ratio of plastic moment capacity to yield moment capacity of a MS beam section is taken as about:
(a) 0.85 (b) 1.15
(c) 1.50 (d) 1.70

2007 (II)

Q.45 The modulus of elasticity of rolled structural mild steel is about
(a) 2×10^5 MPa (b) 2×10^6 MPa
(c) 2×10^7 MPa (d) 2×10^8 MPa

Q.46 The slenderness ratio of lacing bars should not exceed
(a) 100 (b) 120
(c) 145 (d) 180

Q.47 The property by which a metal resists impact load is called
(a) Ductility (b) Toughness
(c) Elasticity (d) Malleability

Q.48 If the rivet diameter is 30 mm, the diameter of rivet hole shall be
(a) 31 mm (b) 31.5 mm
(c) 32 mm (d) 32.5 mm

Q.49 A body is subjected to a stress of 3 N/mm^2 in compression and a tensile stress of 5 N/mm^2 both acting perpendicular to each other. The maximum shear stress in the body will be
(a) 2 N/mm^2 (b) 3 N/mm^2
(c) 4 N/mm^2 (d) 5 N/mm^2

Q.50 The minimum pitch of the rivet shall not be less than
(a) d (b) 1.5 d
(c) 2.0 d (d) 2.5 d

Q.51 In a plate girder design, the web contribution to the compression flange area is
(a) A_w (b) $\frac{A_w}{8}$
(c) $\frac{A_w}{6}$ (d) $\frac{A_w}{50}$
A_w is the area of web plate

Q.52 Welded connections are preferred to riveted connections because
(a) they are economical
(b) of the ease of connection
(c) the loss of member strength is smaller
(d) they reduce the secondary strength

Q.53 Which of the following sections should be preferably be used at a place where torsion occurs?
(a) Angle section (b) Box section
(c) Channel section (d) I section

Q.54 Intermediate vertical stiffeners are provided in plate girder to
(a) Transfer concentrated load
(b) Eliminate web buckling
(c) Eliminate excessive deflection
(d) Transfer distributed load

Q.55 Design bond stress in limit state design method for deformed bars conforming to IS :1786 and M-20 concrete is
(a) 1.2 N/mm^2 (b) 1.40 N/mm^2
(c) 1.92 N/mm^2 (d) 1.90 N/mm^2

Q.56 If the vertical plane of load coincides with the vertical centroid axis of the section, the section in which the torsion does nos. develop, is the following section.
(a) I-section (b) T section
(c) Angle section (d) Channel section

Q.57 For heavy vibratory loads in industrial building, the roof trusses are provided with
(a) diagonal bracing in the lower chord member
(b) diagonal bracing in the upper chord member
(c) transverse bracing
(d) knee bracing

Q.58 As per I.S. code, modular ratio of an RCC section is calculated from
(a) σ_{st} (b) σ_{cbc}
(c) σ_{cbc} and σ_{st} (d) None of the above

Q.59 As per IS : 800, the effective length of a compression member effectively held in position and restrained against rotation at both ends is
(a) 0.65 L (b) 0.80 L
(c) 1.00 L (d) 1.50 L
L is the length of compression member

Q.60 The size of the fillet weld is indicated by
(a) side of the triangle of the fillet
(b) throat of the fillet
(c) length of the weld
(d) size of the plate

Q.61 In a beam that carries axial load also, the effect of deflection may be ignored, when the axial load is
(a) compressive
(b) tensile
(c) concentrated
(d) uniformly distributed

Q.62 The ratio of elastic modulus to plastic modulus for a rectangular section of steel is
(a) 1.5 (b) 0.66
(c) 1.70 (d) 0.25

2008

Q.63 The junction between flange and web of an I-section is called
(a) Lap Joint (b) Butt Joint
(c) Fillet Joint (d) Shear Joint

Q.64 The strength at which steel fails under repeated application of load is known as
(a) impact strength (b) tensile strength
(c) yield strength (d) fatigue strength

Q.65 A steel plate is 300 mm wide and 100 mm thick. It has one rivet of nominal diameter 18 mm. The net sectional area of the plate is
(a) 1800 mm^2 (b) 2805 mm^2
(c) 2820 mm^2 (d) 3242 mm^2

Q.66 The effective length of a column is the length between the points of
(a) supports
(b) maximum bending moments
(c) zero bending moments
(d) zero shear force

Q.67 Four vertical columns of the same material, height and weight have the same end conditions. The buckling load will be the largest for a column having the cross-section of
(a) solid square (b) thin hollow circle
(c) solid circle (d) H-section

Q.68 If the angle between fusion faces of a fillet weld is 60° to 90°, the effective throat thickness as per Bureau of Indian Standards is equal to
(a) $\frac{1}{\sqrt{2}}$ size of weld (b) $\frac{1}{\sqrt{3}}$ size of weld
(c) $\sqrt{2}$ size of weld (d) $\sqrt{3}$ size of weld

Q.69 In case of I-section steel beam,
(a) shear capacity of flange is neglected
(b) shear capacity of web is neglected
(c) shear capacity of both flange and web is neglected
(d) none of the above

Q.70 Vertical web stiffeners are used in plate girder to
(a) avoid buckling of girder
(b) improve the aesthetic of girder
(c) increase the moment capacity of girder
(d) none of the above

Q.71 The weakest plane in a fillet weld is
(a) a side parallel to the force
(b) a side normal to the force
(c) along the throat
(d) normal to the throat

Q.72 Effective length of steel column effectively held at both ends in position but not restrained in directions is x-times its length between two ends, where x is equal to
(a) 0.65 (b) 0.85
(c) 0.95 (d) 1.00

2011

Q.73 Which one of the following methods of design is not suitable for structure subjected to impact and fatigue?
(a) Simple design (b) Semi-rigid design
(c) Rigid design (d) Plastic design

Q.74 The probability based assessment of safety is ensured by
1. Plastic Analysis
2. Statistical Method
3. Reliability Approach

Which are the correct of the above?
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3

Q.75 Consider the following statements:
1. If a lug angle is required for making connection in an angle section tension member, effective area of member will be the gross area of bolt holes.
2. In a double angle tension member with angles of opposite sides of a gusset plate, the net area provided will be same as for double angles on the same sides of gusset plate.

(a) Only (1) is correct
(b) Only (2) is correct
(c) Both (1) and (2) are correct
(d) Neither (1) nor (2) is correct

Q.76 On which connection, load is not eccentric?
(a) Lap joint
(b) Single cover butt joint
(c) Double cover butt joint
(d) None of these

Q.77 When wind or seismic forces are considered for structural design, allowable stress in material are generally increased by
(a) 20% (b) 25%
(c) $33\frac{1}{3}\%$ (d) 50%

Q.78 Horizontal web stiffener are used in plate girders, if depth to thickness of web ratio is larger than
(a) 100 (b) 180
(c) 200 (d) 300

Q.79 The main advantage of a steel member is that it
(a) has high strength
(b) is gas and water tight
(c) has long service life
(d) all of these

Q.80 As per Indian Standards rolled steel I-sections are classified into
(a) four series (b) five series
(c) six series (d) seven series

Q.81 In a plate girder bridge, if the thickness of web is less than $d/200$, where d is the unsupported depth web, the web plate should be provided with
(a) vertical stiffener
(b) horizontal stiffener
(c) end stiffener
(d) both vertical and horizontal stiffener

Q.82 When an equal single angle is used as tension member, the contribution of outstanding leg towards effective area is
(a) same as that of connected leg
(b) less than that of connected leg by a factor
(c) two times that of connected leg
(d) one and half times the connected leg

■■■■

Answers | Design of Steel Structures

1.	(a)	15.	(a)	29.	(c)	43.	(d)	57.	(a)	71.	(c)
2.	(d)	16.	(c)	30.	(c)	44.	(c)	58.	(b)	72.	(d)
3.	(b)	17.	(b)	31.	(c)	45.	(a)	59.	(a)	73.	(d)
4.	(a)	18.	(c)	32.	(d)	46.	(c)	60.	(a)	74.	(b)
5.	(d)	19.	(d)	33.	(c)	47.	(b)	61.	(b)	75.	(b)
6.	(d)	20.	(c)	34.	(a)	48.	(c	62.	(b)	76.	(c)
7.	(b)	21.	(c)	35.	(a)	49.	(c)	63.	(d)	77.	(c)
8.	(b)	22.	(b)	36.	(d)	50.	(d)	64.	(d)	78.	(d)
9.	(b)	23.	(c)	37.	(b)	51.	(c)	65.	(b)	79.	(d)
10.	(d)	24.	(b)	38.	(b)	52.	(c)	66.	(c)	80.	(b)
11.	(b)	25.	(a)	39.	(a)	53.	(b)	67.	(b)	81.	(d)
12.	(c)	26.	(a)	40.	(b)	54.	(b)	68.	(a)	82.	(b)
13.	(d)	27.	(c)	41.	(a)	55.	(b)	69.	(a)		
14.	(b)	28.	(c)	42.	(d)	56.	(c)	70.	(a)		

Explanations | Design of Steel Structures

1. (a)

Type of member	End Condition of Bracing	Effective length l
Simply supported beams	Restrained against torsion (i) unrestrained against lateral bending (ii) partially restrained against lateral bending (iii) fully restrained against lateral bending	 L 0.85 L 0.7 L
All Members	Effective lateral bracing at intervals along the length	Distance between intersections of bracings with member

2. (d)

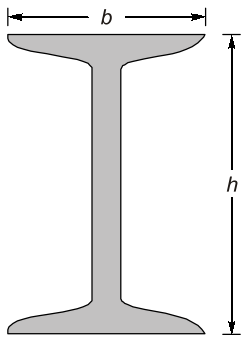
For single angle,

$$k = \frac{3A_1}{3A_1 + A_2}$$

For angles connected back-to-back on the same side of the gusset plate,

$$k = \frac{5A_1}{5A_1 + A_2}$$

3. (b)



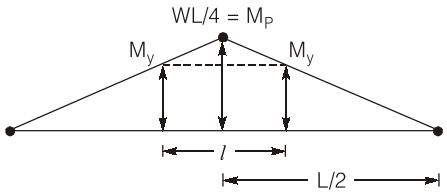
I – section

As per Indian Standards rolled steel I-section are classified into five series:

1. Indian Standard Junior Beam (ISJB)
2. Indian Standard Light Beam (ISLB)
3. Indian Standard Medium Weight Beam (ISMB)
4. Indian Standard Wide Flange Beam (ISWB)
5. Indian Standard Column Section (ISSC)

4. (a)

For I-section shape factor $\frac{M_P}{M_y} = 1.1$ to 1.2



From the bending moment diagram

$$\frac{\frac{WL}{4}}{L/2} = \frac{M_y}{\left(\frac{L}{2} - \frac{l}{2}\right)}$$

$$\frac{W}{2}\left[\frac{L}{2} - \frac{l}{2}\right] = M_y$$

Taking $M_P = \frac{WL}{4}$

and $M_y = \frac{M_P}{1.1}$

$l = 0.09\,L = L/11$

Taking $M_y = \frac{M_P}{1.2}$

$l = L/6$

So l varies between $\frac{L}{6}$ to $\frac{L}{11}$

Therefore $\frac{L}{8}$ is suitable choice

6. (d)

Due to cyclic or reverse cyclic loading if total accumulated strain energy exceed the toughness, then fracture failure occur and the strength corresponding to fatigue is known as fatigue strength.

The strength of material against impact loading is known as impact strength (toughness).

The maximum resistance offered by material against tension is known as tensile strength. Whereas yield strength is stress corresponding to yield point.

Hence option (d) is correct.

7. (b)

As per **IS 800 :1984** Clause **6.7.3.1 (a)**, the thickness of the web plate for unstiffened web is the greater of $\frac{d\sqrt{\tau_{va,\,cal}}}{816}$ and $\frac{d\sqrt{f_y}}{1344}$ but not less than $\frac{d}{85}$ where $\tau_{va,cal}$ is calculated average stress in the web due to shear force.

8. (b)

Ratio of $\frac{M_y}{M_p}$ = ?

$$R = \frac{M_y}{M_p} = \frac{1}{\left(M_p / M_y\right)}$$

Since $\frac{M_p}{M_y}$ = Shape factor and for rectangular section SF = 1.5

So, $R = \frac{1}{3/2} = \frac{2}{3} = 0.66$

Hence option (b) is correct.

9. (b)

Effective length is the length of the fillet weld for which the specified size and throat thickness of weld exist. It 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. End returns are made equal to twice the size of the weld to relieve the latter from high stress concentrations at their ends.

10. (d)

Factor of safety = $\frac{\text{Yield stress}}{\text{Allowable stress}}$

With increase in allowable stress, the factor of safety will reduce to $\frac{1.5}{1.2} = 1.25$.

$\therefore$ Load Factor = FOS × shape factor

$= 1.25 \times 1.12 = 1.40$

11. (b)

Euler's bulking load,

$$P = \frac{\pi^2 EI}{L_{eff}}$$

$$P \propto I$$

Since weight is same, then area cross-section of all cross-section will be same.

For same area, the moment of inertia of hollow circle is more than remaining sections.

Hence the buckling load will be largest for a column having thin hollow cross-section.

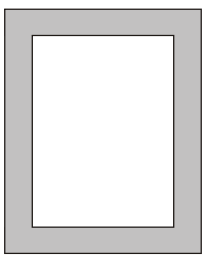
12. (c)

The yield line theory is the ultimate load theory. Both the virtual work method as well as equilibrium method give the upper bound solution, i.e. the computed collapse load on the basis of an assumed yield line pattern is bound to be larger than the actual collapse load.

13. (d)

Degree of restraint	Effective length
(i) Effectively held in position and restrained against rotation at one end, an the other end restrained against rotation but not held in position.	1.2L
(ii) Effectively held in position and restrained against rotation at one end, and the other end is partially restrained against rotation but not held in position.	1.5L
(iii) Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position.	2.0L
(iv) Effectively held in position and restrained against rotation at one end but neither held in position nor restrained against rotation at the other end.	2.0L

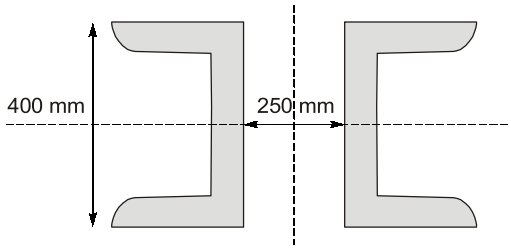
14. (b)



Hollow rectangular box section

The box section are preferred where torsion occurs. The box sections are very strong in resisting torsion.

15. (a)



Lacing are designed to resist transverse shear equal to 2.5% of total axial force on the column taken into account.

$$\therefore \quad V = \frac{2.5}{100} \times P$$

Here $P = 1600$ kN;

$$V = \frac{2.5}{100} \times 1600$$

$$V = 40 \text{ kN}$$

16. (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

$= (30 - 1.95) \times 1.0 = 28.05 \text{ cm}^2$

17. (b)

Ductility: Ductility of a metal is that property due to which a metal sheet can be drawn into a wire of thin section.

Example: Mild steel, Aluminium, Gold, Silver etc.

Toughness: Toughness is the resistance to the impact loading against fructure. If a metal is tough then it has ability to store large strain energy before fracture.

Elasticity: It is that property of material by which the original dimensions can be recovered after unloading.

Malleability: It is that property of metal due to which a piece of metal can be converted into a thin sheet.

Hence option (b) is correct.

18. (c)

$$\text{Load factor} = \frac{\text{Collapse load (ultimate load)}}{\text{Working load}}$$

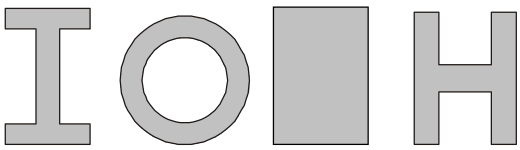
$$\text{Also, Load factor} = \frac{W_C}{W_W} = \frac{M_p}{M} = \frac{f_y z_p}{f z}$$

$$\text{Load factor} = \left(\frac{f_y}{f}\right) \times \left(\frac{z_p}{z}\right)$$

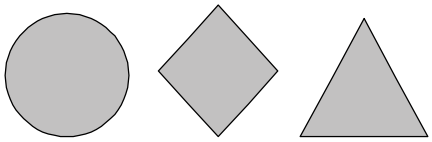
$$\text{Load factor} = (\text{FOS}) \cdot \text{Shape factor}$$

Hence option (c) is correct.

19. (d)



S.F. = 1.2 S.F. = 1.27 S.F. = 1.5 S.F. = 1.5



S.F. = 1.7 S.F. = 2.0 S.F. = 2.34

Hence diamond section have largest shape factor, which is equals to 2.34.

20. (c)

As per **IS 800 : 1984**, the maximum bending moment in the purlin,

$$M = \frac{wL^2}{10} \text{ or } \frac{WL}{10}$$

where, w = Uniformly distributed load on purling per unit length including wind load.

W = Total load on purling including wind load.

Hence option (c) is correct.

21. (c)

The slenderness ratio of lacing bar should not be greater than 145.

$$\lambda \not> 145$$

Hence option (c) is correct.

22. (b)

Lacing bars are designed to resist transverse shear equals to 2.5% of total axial force on the member column taken into account.

$$\therefore \qquad V = \frac{2.5}{100} \times P$$

Hence option (b) is correct.

23. (c)

As per IS: 800 - 1984, the slenderness ratio for compression members should be:

1. Subjected to dead load and live load = 180.
2. Member subjected to compression due to *EQ* and wind force = 250.
3. For compression flange of beam = 300.
4. For ties or bracing member of truss = 300.

Hence option (c) is correct.

24. (b)

Minimum length of weld required to be effective in load transfer is 4*s*. If minimum length of weld is 4*s* then it will be 100% effective.

where s = Size of weld.

Hence option (b) is correct.

25. (a)

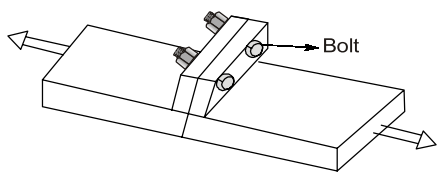
Throat is the weakest section of weld which has minimum dimension.

Hence option (a) is correct.

26. (a)

A bolt can be loaded in

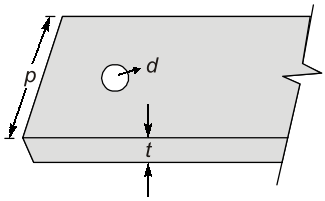
(i) Tension
(ii) Shear
(iii) Shear and tension both



A bolt primarily designed to withstand tensile loading. Hence ideally the bolt should only be loaded in tension.

Hence option (c) is correct.

27. (c)



where p = minimum pitch = $2.5d$

Assuming joint fails in tearing, strength of joint

$$= (p-d)t\,\sigma_{at}$$

Strength of plate without hole reduction

$$= pt.\sigma_{at}.$$

$$\therefore \quad \eta = \frac{(p-d)t\,\sigma_{at}}{pt\,\sigma_{at}} \times 100$$

$$\Rightarrow \quad \eta = \frac{(2.5d-d)t\,\sigma_{at}}{2.5dt\,\sigma_{at}} \times 100$$

$$\Rightarrow \quad \eta = \frac{1.5dt\,\sigma_{at}}{2.5dt\,\sigma_{at}} \times 100$$

$$\Rightarrow \quad \eta = \frac{1.5}{2.5} \times 100 = 60\%$$

Hence option (c) is correct.

28. (c)

Minimum pitch:

Minimum pitch = 2.5 times the nominal dia of rivet = 2.5 d

Nominal dia = dia of shank (d)

Maximum pitch:

(a) $16t$ or 200 mm (which ever is less) — For tension member.

(b) $12t$ or 200 mm (which ever is less) — For compression member.

(c) $32t$ or 300 mm (which ever is less) — For tack rivet.

Hence minimum pitch for rivet is 2.5 d

Hence option (c) is correct.

29. (c)

As per **IS 800 : 1984**

The max permissible deflection in working stress method (WSM) is $\frac{\text{Span}}{325}$.

Hence option (c) is correct.

30. (c)

Diameter of rivet hole

d' = Nominal dia (d) +1.5 mm For $d \le 25$ mm

d' = Nominal dia (d) +2.0 mm For $d > 25$ mm

The dia of hole is also called gross dia of rivet.

Here,

Rivet dia (d) =Nominal dia = 30 mm > 25 mm

gross dia, d' =30 + 2

$\therefore \quad d' = 32$ mm

Hence option (c) is correct.

31. (c)

The diameter of rivet suitable to the thickness of member is given by 'Unwin's Formula'.

$$d = 6.05\sqrt{t_{min}}$$

where,

t_{min} = thickness of thinner member being jointed.

Here, $t_{min} = 16$ mm

$$\therefore \quad d = 6.05\sqrt{16} \simeq 24\text{ mm}$$

Hence option (c) is correct.

32. (d)

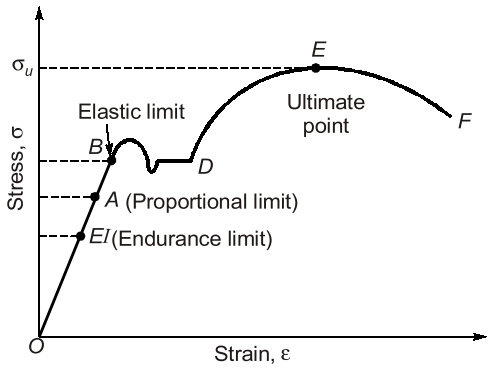
Elastic limit: Elastic limit is the point upto which material remain elastic. After removal of load original dimensions can be recovered upto elastic limit.

Proportional limit: The point upto which hook's law is valid i.e. stress is directly proportional to strain. Upto proportional limit stress strain curve is straight line.

Ultimate strength: Ultimate strength is the maximum stress that can be induced in material.

Endurance limit: It is that stress level below which a material has high probability of no failure even at infinite number of load cycles. Endurance limit is lower than proportional limit.

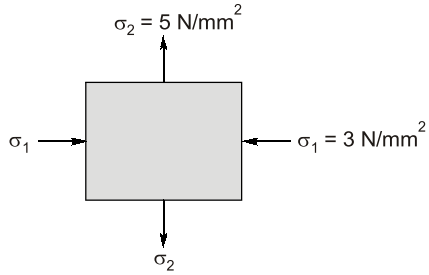
For mild steel endurance limit: 186 N/mm^2.



33. (c)

Given $\sigma_1 = -3\ N/mm^2$

$\sigma_2 = 5\ N/mm^2$



Maximum shear stress,

$$\sigma_{max} = \left|\frac{\sigma_1 - \sigma_2}{2}\right|$$

$$\sigma_{max} = \left|\frac{-3-5}{2}\right| = 4\ N/mm^2$$

Hence option (c) is correct.

34. (a)

[Refer Solution No. 15]

35. (a)

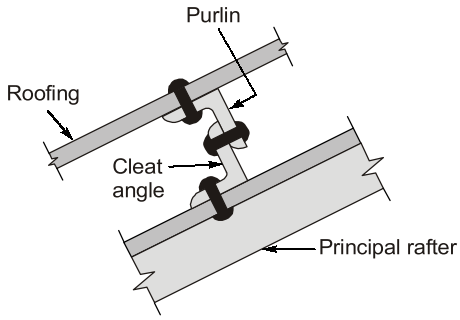
Use of Stiffeners:

(a) **Horizontal stiffeners:** Horizontal stiffeners primarily safe guard against buckling due to bending compression. It increase the bending strength of the web.

(b) **Vertical stiffeners:** Vertical stiffeners is primarily supposed to resist shear buckling but little as bending buckling.

36. (d)

In roof truss principle rafter supports the purlins.



Hence option (d) is correct.

37. (b)

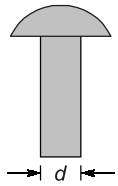
Diameter of Rivet Hole:

d' = Nominal dia (d) + 1.5 mm For $d \le 25$ mm

d' = Nominal dia (d) + 2.0 mm For $d > 25$ mm

The dia of hole is also called gross dia of rivet.

where d = dia of shank



38. (b)

As per **IS 800 : 1984**, the minimum width of lacing plate.

Nominal dia of Rivet (mm)	Minimum width (mm) [generally three times the nominal dia.]
22	65
20	60
18	55
16	50

Hence for 18 mm dia rivet, the minimum width of lacing plate should be 55 mm.

39. (a)

As per **IS 800 : 1984**, the allowable bending compressive stress in rolled-I beams and channels when compressive flange is continuously laterally supported should be $165\ N/mm^2$.

40. (b)

[Refer Solution No. 20]

41. (a)

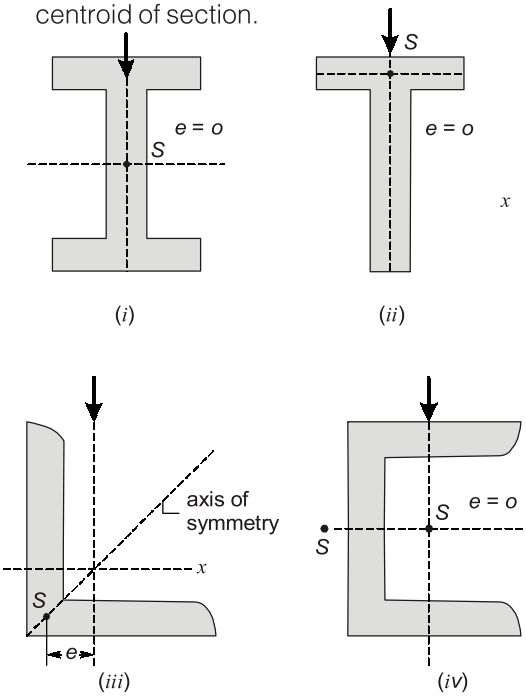
Snow load should not be considered in the design of structure when roof is steeper than 50°.

Here most suitable option is (a).

42. (d)

The shear centre (S) is that point which the resultant shear force acts so that the member is subjected to simple bending and free from torsion. If mean lateral load acting through the shear centre will produce bending without torsion.

Shear centre (S) always lies on the axis of symmetry if exists. When area is symmetrical about both axes then shear centre is same as centroid of section.



Note: For sections consisting of two narrow intersecting rectangles, the shear centre (s) lies at the junction as in (iii)

Hence option (d) is correct.

43. (d)

As per **IS 800 : 1984**, the minimum number of rivet used to connect the lug angle should be two (2).

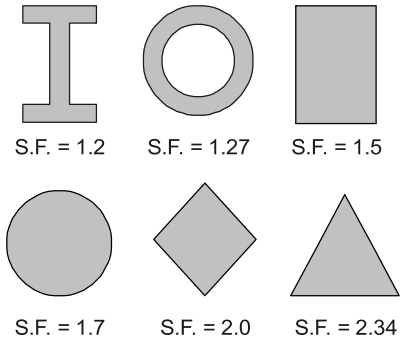
Hence option (d) is correct.

44. (c)

The ratio of plastic moment capacity to yield moment capacity is known as shear factor.

$$\text{S.F} = \frac{M_p}{M_y} = \frac{Z_p}{Z_y}$$

Shape factor depends upon cross-sectional area.



If we consider beam section as rectangular. Then SF = 1.5.

So correct option is (c).

45. (a)

The modulus of elasticity for steel,

$$E_S = 2 \times 10^5 \text{ N/mm}^2$$

or $$E_S = 2 \times 10^5 \text{ MPa}$$

46. (c)

The slenderness ratio of lacing bar should not be greater than 145.

$$\lambda \not> 145$$

47. (b)

[Refer Solution No. 17]

48. (c)

Diameter of rivet hole

d' = Nominal dia (d) +1.5 mm For $d \le 25$ mm

d' = Nominal dia (d) +2.0 mm For $d > 25$ mm

The dia of hole is also called gross dia of rivet.

Here

Rivet dia (d) = Nominal dia

= 30 mm > 25 mm

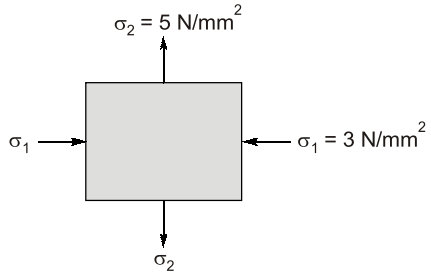
gross dia, d' =30 + 2

$\therefore$ d' = 32 mm

Hence option (c) is correct.

49. (c)

Given, $\sigma_1 = -3\ N/mm^2, \sigma_2 = 5\ N/mm^2$



Maximum shear stress,

$$\sigma_{max} = \left|\frac{\sigma_1 - \sigma_2}{2}\right|$$

$$\sigma_{max} = \left|\frac{-3-5}{2}\right| = 4\ N/mm^2$$

Hence option (c) is correct.

50. (d)

[Refer Solution No. 28]

51. (c)

In plate girder,

Effective flange area = $A_f + \frac{A_w}{6}$

Where, A_f = Area of flange plate

$\frac{A_w}{6}$ = Web contribution to compression flange area.

Hence option (c) is correct.

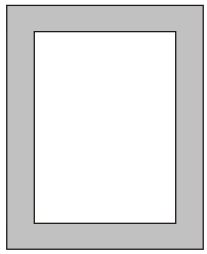
52. (c)

Advantages of welded joint over riveted joint:

1. As no holes are required for welding, so the loss of member strength is smaller.
2. Welded joints are economical as less labour and material are required at joint.
3. The welded connection look better than the usually bulky riveted joints.
4. The speed of fabrication is higher with the welding process.
5. The welding process requires less working space than the riveting process.
6. No noise is produced in the welding process as the riveting process.

Hence option (c) is correct.

53. (b)



Hollow rectangular box section

The box section are preferred where torsion occurs. The box sections are very strong in resisting torsion.

54. (b)

The element provided to stiffen the web against buckling are called intermediate stiffeners. Intermediate stiffeners of two types:

(a) **Vertical stiffener:** Vertical stiffener is mainly supposed to resist shear buckling but little as bending buckling.

(b) **Horizontal stiffeners:** Horizontal stiffeners primarily safeguard against buckling due to bending compression.

Hence option (b) is correct.

55. (c)

For M20, $\tau_{bd} = 1.2$

For deformed bar above value of τ_{bd} is increased by 60%.

$\therefore \quad (\tau_{bd})_{design} = \tau_{bd} \times 1.6$

$= 1.2 \times 1.6 = 1.92$

Hence option (c) is correct.

56. (a)

[Refer Solution No. 42]

57. (a)

Diagonal bracing in the lower chord member is used only when heavy vibration loads are anticipated in the industrial buildings.

Whereas the diagonal bracing in the upper chord member reduces the unsupported length of the diagonal and make them more effective in compression.

A transverse bracing is used to reduce the end moments of the columns.

A knee bracing are intended to supplement the lateral resistance of post frame when loaded by lateral wind forces.

Hence option (a) is correct.

58. (b)

As per **IS 456 : 2000**

The modular ratio of concrete is given by the formula

$$m = \frac{280}{3\sigma_{cbc}}$$

where σ_{cbc} = Permissible stress in bending compression

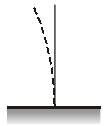
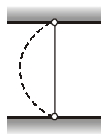
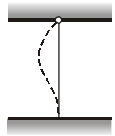
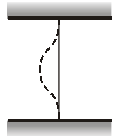
Hence $m \alpha \frac{1}{\sigma_{cbc}}$

Hence option (b) is correct.

59. (a)

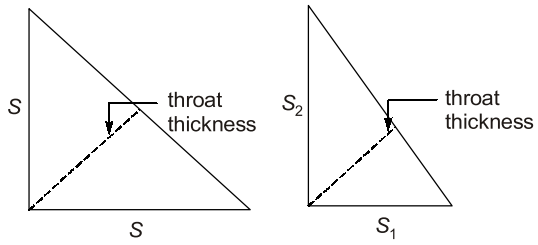
As per **IS 800 : 1984**

Effective length of compression members.

Boundary Condition				Schematic Representation	Effective Length
At one end		At the other end			
Translation	Rotation	Translation	Rotation		
(1)	(2)	(3)	(4)	(5)	(6)
Restrained	Restrained	Free	Free		2.0L
Free	Restrained	Free	Restrained		
Restrained	Free	Restrained	Free		1.0L
Restrained	Restrained	Free	Restrained		1.2L
Restrained	Restrained	Restrained	Free		0.8L
Restrained	Restrained	Restrained	Restrained		0.65L

Note: L is the unsupported length of the compression member.

60. (a)

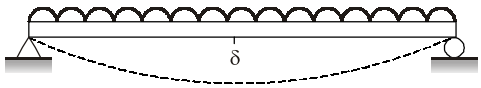


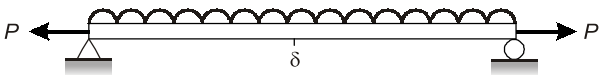
Where S = Size of weld

Hence option (a) is correct.

61. (b)

Axially tensile load counter balance the deflection caused by transverse loading on the beam. Hence in this case effect of deflection may be ignored.





Hence option (b) is correct.

62. (b)

Ratio of $\frac{M_y}{M_p}$ = ?

$$R = \frac{M_y}{M_p} = \frac{1}{\left(M_p / M_y\right)}$$

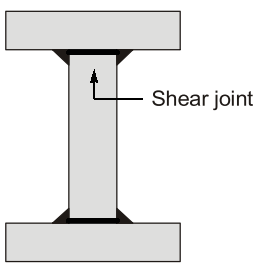
Since $\frac{M_p}{M_y}$ = Shape and for rectangular section

SF = 1.5

$$R = \frac{1}{1.5} = 0.66$$

Hence option (b) is correct.

63. (d)



64. (d)

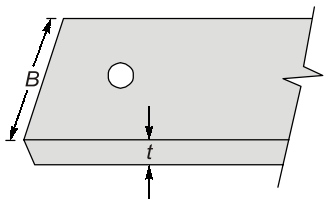
Due to cyclic or reverse cyclic loading if total accumulated strain energy exceed the toughness, then fracture failure occur and the strength corresponding to fatigue is known as fatigue strength.

The strength of material against impact loading is known as impact strength (toughness).

The maximum resistance offered by material against tension is known as tensile strength. Whereas yield strength is stress corresponding to yield point.

Hence option (d) is correct.

65. (b)



Given, B = 300 mm

t = 100 mm

d = 18 mm

Gross dia of rivetd'

= 18 + 1.5 = 19.5 mm

Net sectional are in tension

$= (B - d') \times t$

$= (300 - 19.5) \times 100$

$= 28050\ \text{mm}^2$

Hence no option is correct.

If thickness of plate is taken as 10 mm.

Then net sectional area

$= (B - d') \times t$

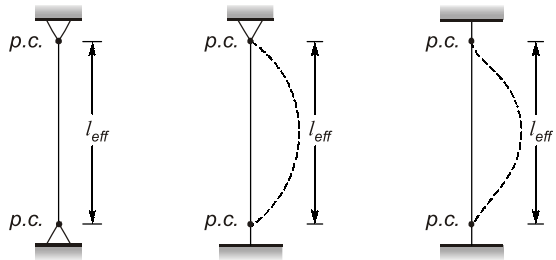
$= (300 - 19.5) \times 10$

$= 2805\ \text{mm}^2$

Hence most close option is (b).

66. (c)

The effective length of a column is the length between the two point of contraflexure (point of zero bending moment)



Hence option (c) is correct.

67. (b)

Euler's bulking load,

$$P = \frac{\pi^2 EI}{L_{eff}}$$

$$P \propto I$$

Since weight is same, then area cross-section of all cross-section will be same.

For same area, the moment of inertia of hollow circle is more than remaining sections.

Hence the buckling load will be largest for a column having thin hollow cross-section.

68. (a)

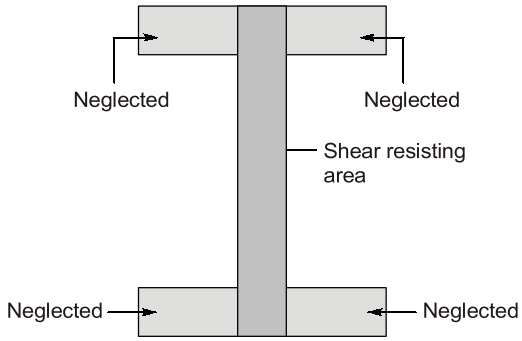
As per Indian standard:

Angle	Throat thickness
60°–90°	$\frac{1}{\sqrt{2}}$ or 0.7
91°–100°	0.65
101°–106°	0.6
107°–113°	0.55

Hence option (a) correct.

69. (a)

In case of I-section, shear capacity of flange is neglected.



Hence option (a) is correct.

70. (a)

Use of Stiffeners

(a) **Vertical stiffeners:** Vertical stiffeners is mainly supposed to resist shear buckling but little as bending buckling.

(b) **Horizontal stiffeners:** Horizontal stiffeners primary safeguard against buckling due to bending compression.

Hence option (a) is correct.

71. (c)

Throat is the weakest section of the fillet weld.

72. (d)

[Refer Table of Sol. No. 59]

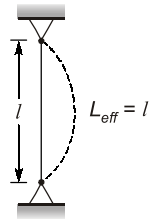
For given question,

$$\therefore \quad l_{eff} = xl$$

$$l = xl$$

$$\therefore \quad x = 1$$

Hence option (d) is correct.



73. (d)

The connection, weather 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 moment at the connections. Semi-rigid connections resist the bending moment in between the flexible and rigid connections. Plastic 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.

Hence option (d) is correct.

74. (b)

The probability based assessment of safety is ensured by statistical method and reliability approach.

Hence option (b) is correct.

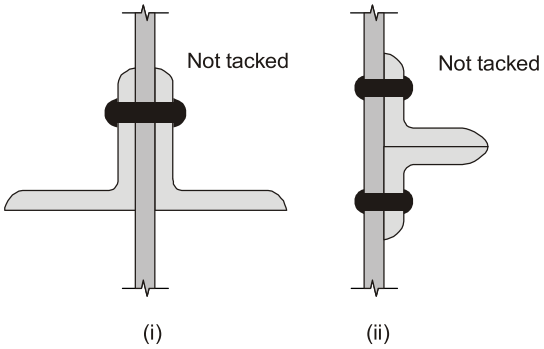
75. (b)

Lug angle is small piece of angle used to connect the single angle member to the gusset plate. The purpose of lug angle is to reduce the length of connection to gusset plate and to reduce the shear leg effect. Hence the effective area of member will be gross area minus area of rivet hole.

Hence statement (1) is wrong.

In below case (i) and (ii) two angle behave individually hence net area would be twice the

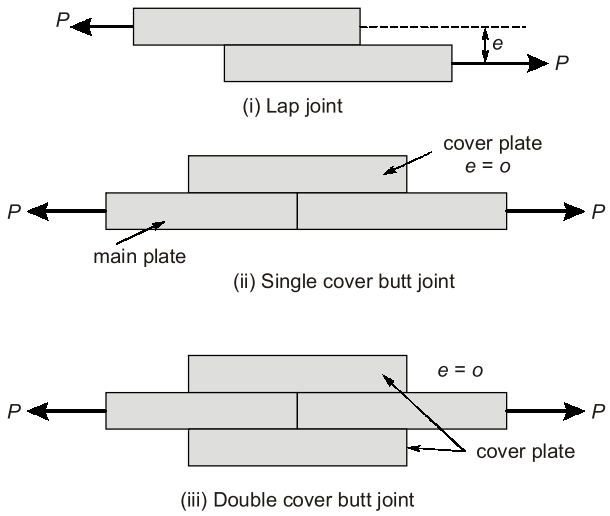
area corresponding to single angle connected to a gusset plate.



So statement (2) is correct.

Thus option (b) is correct.

76. (c)



Single and double cover butt joint both have eccentricity zero but lap joint has an eccentricity. As compare to single cover butt joint double cover butt joint is more efficient.

Thus the most suitable option is (c).

77. (c)

As per IS 800: 1984, when wind or earthquake (seismic forces) are considered for structural design, allowable stress in material are increased by $33\frac{1}{3}\%$.

Whereas for structural fasteners (bolt, rivet and weld), allowable stress are increased by 25%.

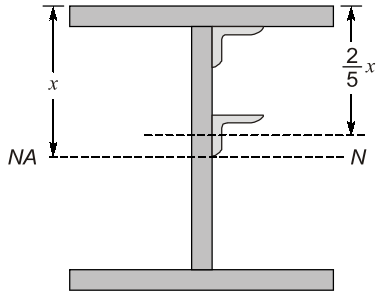
Hence option (c) is correct.

78. (d)

Design criteria for stiffeners:

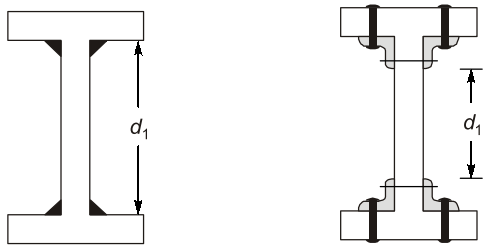
1. $\frac{d_1}{t_w} < 85$ No stiffener required (No horizontal and vertical)
2. $85 < \frac{d_2}{t_w} \le 200$ Only vertical stiffeners
3. $200 < \frac{d_2}{t_w} \le 250$ Apart from vertical stiffeners

   one horizontal stiffener is provided at a distance from compression flange equal to $2/5^{th}$ of the distance of compression flange from NA



4. If $\frac{d_2}{d_w}$ One horizontal is provided.
5. If $\frac{d_1}{t_w} > 400$ Section must be redesign.

For symmetrical section, $d_1 = d_2$



Hence option (d) is correct.

79. (d)

Steel has following advantages as structural member:

1. Steel members have high strength per unit weight. Therefore, a steel member of a small section which has little self weights able to resist heavy loads.
2. Properly maintained steel structures has a long life as it is gas and water tight.

3. The properties of steel mostly do not changes with time. This make steel the most suitable material for structure.
4. Steel being a ductile material, doesn't fail suddenly, but gives visible evidence of impending failure by large deflection.
5. Steel has the high scrap value.

Hence option (d) is correct.

80. (b)

[Refer Solution No. 3]

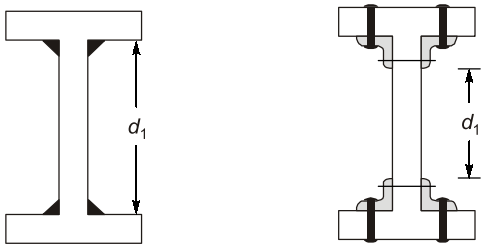
81. (d)

Design criteria for stiffeners:

1. $\frac{d_1}{t_w} < 85$ No stiffener required (No horizontal and vertical)
2. $85 < \frac{d_2}{t_w} \le 200$ Only vertical stiffeners
3. $200 < \frac{d_2}{t_w} \le 250$ Apart from vertical stiffeners

   one horizontal stiffener is provided at a distance from compression flange equal to $2/5^{th}$ of the distance of compression flange from NA
4. If $\frac{d_2}{d_w}$ One horizontal is provided
5. If $\frac{d_1}{t_w} > 400$ Section must be redesign.

For symmetrical section, $d_1 = d_2$



Hence option (d) is correct.

From point (2),

$$200 < \frac{d_2}{t_w} \le 250$$

$$200 < \frac{d_2}{t_w}$$

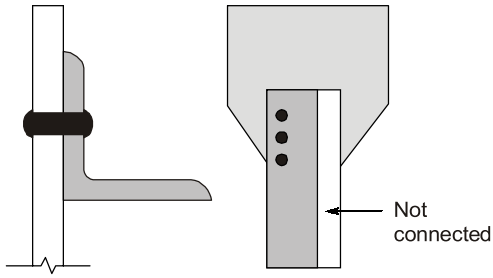
$$\therefore \quad t_w < \frac{d_2}{200}$$

[Vertical stiffeners along with one horizontal stiffener are provided]

Hence option (d) is correct.

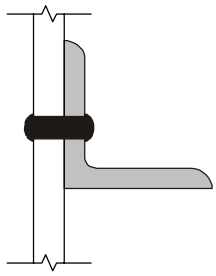
82. (b)

The nonuniform straining of web due to tension is called shear leg.



The shear leg reduces the effectiveness of the tension member (e.g., Angle section) component that is no directly connected to gusset plate. For angle section the unconnected leg is known as outstand leg.

Hence the contribution of outstanding leg in resisting tension is less than the connected leg by a factor which is known as k (reduction factor) e.g.



Here reduction factor, k

$$k = \frac{3A_1}{3A_1 + A_2}$$

where, A_1 = area of connected leg

A_2 = area of outstanding leg

Hence option (b) is correct.

■■■