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Civil Engineering

(Previous Year Questions With Detailed Solutions)

Volume - I

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Address : Office No. 6, 'A' Wing, 3rd Floor, Vega Center Building, Shankar Sheth Road,
Near Income Tax Building, Above Airtel Office, Swargate, Pune - 411042.

Mobile : 7277555151

E-mail : iit.academy.pune@gmail.com, iitianspublication@gmail.com

Website : www.iitiansacademy.com

Previous Year Question Paper

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GPSC Gujarat Public Service Commission

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BPSC Bihar Public Service Commission

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CIVIL ENGINEERING
Volume - I

1. Building Construction & Materials

Syllabus

Properties of wet and hardened concrete, tests on concrete, factors affecting strength of concrete, water-cement ratio, aggregate-cement ratio, mix design, additives, design of form work, types of formwork. Stones, bricks, cements, lime, mortar, timber, plastic, concrete, steel, paints and varnishes. Principles of building planning and design, integrated approach, building byelaws, building services such as vertical transportation, water supply sanitation, thermal ventilation, lighting, acoustics, fire protection, electrical fittings. Foundations, stones, brick and block masonry, steel and reinforced cement concrete structures, floors, doors and windows, roofs, finishing works, water proofing.

Content		Page No.

1 Stones

MPSC

1. Black cotton soil is a product of decomposition of
(1) Granite (2) Marble
(3) Basalt (4) Sandstone
[MPSC : 2012]

2. Laterite is used in
(1) Carving and ornametal works.
(2) Fire resistance works.
(3) Electrical switch boards.
(4) Heavy engineering works.
[MPSC : 2012]

3. What is the temperature range in the low temperature tempering process?
(1) 150°C to 200°C (2) 200°C to 250°C
(3) 100°C to 150°C (4) 250°C to 300°C
[MPSC : 2013]

4. The stone whose crushing strength is maximum is
(1) Granite (2) Chalk
(3) Slate (4) Marble
[MPSC : 2015]

5. What is the minimum crushing strength of granite used in India ?
(1) 200 N/mm^2 (2) 50 N/mm^2
(3) 100 N/mm^2 (4) 250 N/mm^2
[MPSC : 2017]

6. Hardness of the stones can be tested by
(1) Impact strength (2) Abrasion strength
(3) Mohr's scale (4) Crushing strength
[MPSC : 2018]

7. _____ are provided as a protective coatings to walls at its top to prevent seepage of water.
(1) Corabels (2) Cornice
(3) Copings (4) Floating
[MPSC : 2019]

8. Specific gravity of building stones should be more than
(1) 2.7 (2) 2.9
(3) 3.0 (4) 2.5
[MPSC : 2020]

GPSC

1. Spalling hammer is used for
(1) Driving wooden headed chiesel
(2) Carving of stones
(3) Rough dressing of stones
(4) Breaking small projection of stones
[GPSC : 2017]

2. Correct match of Column I (types of rocks) with Column II (method of formation) and Column III (example of rock) is

Column I	Column II	Column III
P. Igneous	L. Deposition of layers in water bodies followed by intense pressure	X. Marble
Q. Metamorphic	M. Volcanic action followed by cooling of lava	Y. Granite
R. Sedimentary	N. Formed from other rock types due to heat or pressure or both	Z. Dolomite

(1) PMX, QLY, RNZ (2) PNY, QMZ, RLX
(3) PMY, QNX, RLZ (4) PLZ, QNY, RMX
[GPSC : 2018]

3. Correct match of Column I (chemical classification of rocks) with Column II (main mineral/s contained in the rock) is

Column I	Column II
A. Siliceous rocks	i. Carbonate of lime
B. Argillaceous rocks	ii. Sand, quartz
C. Calcareous rocks	iii. Clay minerals

(1) A-ii, B-iii, C-i (2) A-iii, B-i, C-ii
(3) A-i, B-iii, C-ii (4) A-ii, B-i, C-iii

[GPSC : 2018]

4. Correct match of Column I (types of stones) with Column II (types of work for which they are used) is

Column I	**Column II**
A. Marble	i. damp-proofing, flooring, roofing, etc.
B. Slate	ii. Fire resistant masonry
C. Limestone	iii. Ornamental work, flooring etc.
D. Compact sandstone	iv. raw material for cement

(1) A-iv, B-i, C-ii, D-iii
(2) A-i, B-iv, C-ii, D-iii
(3) A-iii, B-i, C-iv, D-ii
(4) A-ii, B-i, C-iv, D-iii

[GPSC : 2018]

5. A simple field test carried out to determine deterioration of stones when immersed in water is known as

(1) Absorption test (2) Mohr's hardness test
(3) Toughness test (4) Smiths test

[GPSC : 2018]

6. The machine used to determine hardness of stone is called

(1) Dorry's testing machine
(2) Deval testing machine
(3) Brinell hardness testing machine
(4) Rockwell hardness test machine

[GPSC : 2018]

7. Which of the following stone is recommended for road metal work?

(1) Sandstone (2) Quartzite
(3) Slate (4) Marble

[GPSC : 2018]

8. Which of the following is a not an intrusive igneous rock?

(1) Granite (2) Gabbro
(3) Diorite (4) Basalt

[GPSC : 2018]

9. Which of the following is a significant constituent of sedimentary rock?

(1) Magnetite (2) Hematite
(3) Calcite (4) Halite

[GPSC : 2018]

10. Most of the stones possess the specific gravity in the range of

(1) 1.0 to 1.5 (2) 1.5 to 2.0
(3) 2.4 to 2.8 (4) 3.0 to 4.0

[GPSC : 2018]

11. In stone masonry, some stones at regular intervals are placed right across the wall, such stones are known as ....

(1) Through stone (2) Corbel
(3) Quoins (4) Spalls

[GPSC : 2019]

12. The compound which is responsible for early strength of concrete is

(1) C_3S (2) C_2S
(3) C_3A (4) C_4AF

[GPSC : 2019]

13. Smith's test is performed on stones to assess its______.

(1) Hardness
(2) Specific gravity
(3) Soluble and clayey matter
(4) Insoluble matter

[GPSC : 2019]

14. In stone masonry, the stones are placed in position such that the natural bedding plane is

(1) Normal to the direction of pressure they carry
(2) Parallel to the direction of pressure they carry

(3) At 45° to the direction of pressure they carry
(4) At 60° to the direction of pressure they carry
[GPSC : 2019]

15. A good building stone should have a wearing resistance less than
(1) 1.5% (2) 3%
(3) 5% (4) 7%
[GPSC : 2019]

16. Stratification can be seen widely in which of the following rocks?
(1) Igneous rocks
(2) Metamorphic rocks
(3) Sedimentary rocks
(4) Fossil rocks
[GPSC : 2019]

17. Metamorphic rocks are the rocks which are formed
(1) When molten lava (magma) cools and turns to solid rock
(2) When heat and pressure are applied on the rocks
(3) When small pieces of rocks are pressed together over a period of time
(4) Due to the gradual erosion of the earth surface.
[GPSC : 2019]

18. Mafic rocks are a part of
(1) Igneous rocks (2) Sedimentary rocks
(3) Metamorphic rocks (4) Fossil rocks
[GPSC : 2019]

19. The magnitude of an earthquake is based on what aspect of the seismic wave?
(1) Amplitude (2) Frequency
(3) Time period (4) Intensity
[GPSC : 2019]

20. On mohr's scale, a scratch with the aid of a finger nail indicates a hardness in the range of
(1) 0 - 1 (2) 1 - 2
(3) 2 - 3 (4) 3 - 4
[GPSC : 2019]

WBPSC

1. An artificial stone made from pieces of marble and cement and used for floors, facing of walls etc, is known as
(1) Mosaic (2) Terrazzo
(3) Marble (4) Teracotta
[WBPSC : 2012]

2. Granite contains primarily
(1) Quartz
(2) Quartz and feldspar
(3) Mica
(4) Quartz and mica
[WBPSC : 2012]

3. Sandstone is a
a. Sedimentary rock
b. Aqueous rock
c. Siliceous rock
The correct answer is
(1) only a (2) both a and b
(3) both a and c (4) all of the above
[WBPSC : 2016]

4. Crushing strength of good building stone should be more than
(1) 50 MPa (2) 100 MPa
(3) 150 MPa (4) 200 MPa
[WBPSC : 2016]

TNPSC

1. The rock generally used for roofing is
(1) Granite (2) Basalt
(3) Slate (4) Pumice
[TNPSC : 2008]

2. The hardest rock is
(1) Marble (2) Diamond
(3) Talc (4) Quartz
[TNPSC : 2008]

3. The stone masonry of finely dressed stones laid in cement of lime is :

Answers 1. Stones

MPSC	**1.** (3)	**2.** (1)	**3.** (1)	**4.** (1)	**5.** (3)	**6.** (3)	**7.** (3)	**8.** (1)		
GPSC	**1.** (3)	**2.** (3)	**3.** (1)	**4.** (3)	**5.** (4)	**6.** (3, 4)	**7.** (2)	**8.** (4)	**9.** (3)	**10.** (3)
	11. (1)	**12.** (1)	**13.** (3)	**14.** (1)	**15.** (2)	**16.** (3)	**17.** (2)	**18.** (1)	**19.** (1)	**20.** (3)
WBPSC	**1.** (1)	**2.** (2)	**3.** (4)	**4.** (2)						
TNPSC	**1.** (3)	**2.** (2)	**3.** (4)	**4.** (2)	**5.** (4)	**6.** (3)	**7.** (4)	**8.** (4)	**9.** (1)	
RPSC	**1.** (4)	**2.** (2)	**3.** (3)	**4.** (3)						
KPSC	**1.** (1)	**2.** (3)								
Kerala	**1.** (1)									
APPSC	**1.** (2)									

Explanations 1. Stones

MPSC

1. Ans : 3

Black soil is a sedimentary type of soil that is found in place of its origin, i.e. it is not transmitted from its original place. It is formed by the wear and tear of the specific rock. The moderate climatic condition and volcanic erupted igneous or basalt rock as a parent rock is required for the formation of black soil.

Then, due to the weathering or breaking of the igneous rock and cooling and solidification of the lava, the black soil is formed. Since, it is formed from lava it is also known as lava soil.

2. Ans : 1

Different types of works and Recommended types of stones

1) For Heavy engineering work such as bridge, piers, abutments, break waters, docks, light houses, retaining wall etc - Granite.
2) For Building facing the sea - Granite and fine grained sandstone.
3) Building in industrial area - Granite and compact sandstone.
4) Arches - Fine grained sandstone.
5) Building face work, carved works and ornamental work - Fine Grained granite, Marble, closed grain sandstone, laterite.
6) Fire resisting structure - Compact Sandstone.
7) Road metal and aggregate for concrete - Granite, Basalt, Quartzite.
8) Railway Ballast - Coarse grained sandstone, Quartzite.
9) Electrical Switch Board - Slate, marble.
10) Damp Proofing, flooring, roofing etc - Slate.

3. Ans : 1

- Tempering is a common method to improve the ductility and impact toughness of steels. It is widely applied for ultra high-strength martensitic steels due to the limited toughness properties of quenched medium- and high-carbon steels.
- Low-temperature tempering in the temperature range of 150-200^{o}C is applied to ultra high-strength carbon steels with a medium carbon content, as it usually provides a significant improvement of impact toughness without drastically decreasing hardness and tensile strength. Generally, the tempering temperature

affects the mechanical properties more than the tempering time when tempering temperature are 500°C or less.

4. Ans : 1

Crushig strength for different rocks in N/mm² are as fllows :

1) Trap - 300 to 350.
2) Basalt - 153 to 189.
3) Granite - 104 to 140.
4) Slate - 70 to 210.
5) Marble - 72 to 75.
6) Sandstone - 65 to 70.
7) Limestone - 55 to 60.
8) Laterite - 1.8 to 3.2.

5. Ans : 3

Crushing strength of granite lies in range of 104 to 140 N/mm².

6. Ans : 3

Following are the test performed on stones in order to check different properties :

1) Durability Test :

A) Smith test - to check durability and earthy matter in stones.
B) Brards test - to check frost resistance.
C) Acid test - To check weather resistance.
D) Crystallisation Test.

2) Strength Test :

A) Compressive Strength Test.
B) Transverse strength test.
C) Tensile Strength test.
D) Shear Strength test.
E) Abrasion Strength test.

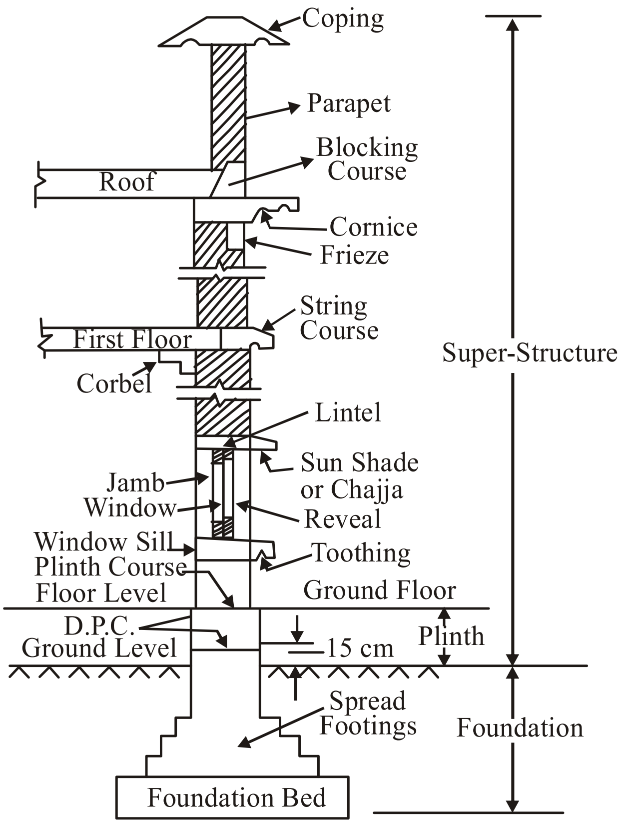
3) Water Absorbtion test.

4) Hardness test :

Performed by scratching a stone on each other with known values of hardness as per mohr's scale.

5) Toughness (Impact) test.

7. Ans : 3



Copings are provide as a protective coatings to wall at its top to prevent seepage of water

8. Ans : 1

A good building stone should have following properties :

1) Specific gravity should be more than 2.7.
2) Percentage of water absorbtion by weight of stone should be less than 5%.
3) Crushing strength should be more than 100 N/mm².
4) Coefficient of hardness should be greater than 17.
5) Toughness index should not be less than 13.
6) The percentage of wear in the attrition test should not be more than 3.

GPSC

1. Ans : 3

Spalling hammer is a heavy axle like hammer with chisel edge, used for breaking and rough-dressing stone.

2. Ans : 3

Igneous Rocks :

Form when molten rock (magma or lava) cools and solidifies. Ex. Granite, basalt etc.

Sedimentary Rocks :

Originate when particles settle out of water or air, or by precipitation of minerals from water. They accumulate in layers. Ex. Shale, chalk, sandstone, Dolomite etc.

Metamorphic Rocks :

Result when existing rocks are changed by heat, pressure, or reactive fluids, such as hot, mineral-laden water. Ex. Slate, gnesis, marble.

3. Ans : 1

Rocks are classified into three types based on their chemical composition and they are as follows

1) Argillaceous Rocks :

The rocks in which clay content is predominant are called argillaceous rocks. These rocks are soft in nature and with the presence of water they can be crumbled easily. Ex. Shale, slate, laterite, etc.

2) Calcareous Rocks :

The rocks in which calcium carbonate is the major ingredient are known as calcareous rocks. These are generally hard but their durability is dependent on surrounding constituents which may react with calcium and affect the durability of rock. Marble, limestone, dolomite, etc.

3) Siliceous Rocks :

The rocks which contain silica in predominant amount are called as siliceous rocks. Presence of a large amount of free silica makes them harder and durable. It also provides strong resistance to weathering. Granite, Sand, quartzite, etc.

4. Ans : 3

Different types of works and Recommended types of stones

1) For Heavy engineering work such as bridge, piers, abutments, break waters, docks, light houses, retaining wall etc - Granite.
2) For Building facing the sea - Granite and fine grained sandstone.
3) Building in industrial area - Granite and compact sandstone.
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5) Building face work, carved works and ornamental work - Fine Grained granite, Marble, closed grain sandstone, laterite.
6) Fire resisting structure - Compact Sandstone.
7) Road metal and aggregate for concrete - Granite, Basalt, Quartzite.
8) Railway Ballast - Coarse grained sandstone, Quartzite.
9) Electrical Switch Board - Slate, marble.
10) Damp Proofing, flooring, roofing etc - Slate.

5. Ans : 4

Smiths Test :

Break off the freshly quarried stone chippings to about the size of a rupee coin and put them in a glass of clean water, one-third full. If the water becomes slightly cloudy, the stone is good and durable. If water becomes dirty, it indicates that the stone contains too much of earthy and mineral matter.

6. Ans : 3 & 4

1) Dorrys Testing machine :

The machine is used to determine the resistance of aggregate to wear by abrasion.

2) The Devals Abrasion Testing Machine :

This test is used to determine the aggregate abrasion value of coarse aggregates as described in IS: 2386 (Part 4).

3) Brindle Hardness testing machine :

These machines measure the hardness of a material by pressing a chromium-steel or tungsten-carbide ball against the smooth material surface under standard test conditions. The hardness is expressed in HBW, where the ball indenter is made of tungsten carbide.

4) Rockwell hardness test method :

This method consists of indenting the test material with a diamond cone or hardened steel ball indenter. The indenter is forced into the test material under a minor preliminary load and the permanent effect is studied to know the hardness of the sample material.

7. Ans : 2

From the mentioned rocks in option Quartzite is best suited for Road metal work and aggregate for concrete.

8. Ans : 4

Igneous rock may be classified into two category

1) Extrusive Rock :

When molten mass called magma is forced up as volcanic eruptions and spreads over the surface of earth where it solidifies are known as effusive rocks. Ex. basalt and trap.

2) Intrusive Rock :

If the magma solidifies below the earth's surface itself, the solid crystalline rock is termed as deep-seated plutonic rock. Ex. granite, syenite, diorite and gabbro.

If the magma solidifies at a relatively shallow depth, the resultant rock possesses a finely grained crystalline structure and is termed as hypabyssal. Ex. Dolerite.

9. Ans : 3

The principle constituents of igneous rocks are quartz, mica and felspar and that of sedimentary rocks are calcite and dolomite.

10. Ans : 3

Most of stone possess specific gravity in the range of 2.3 to 2.8.

11. Ans : 1

- Trough stone / tie stone / perpend stone is a stone that extends through an entire wall's width right across the wall, from the outer to the inner wall
- Corbel is a structural piece of stone used to support (or appear to support) a ceiling, beam, shelf, or the roof overhang itself.
- Quoins are large rectangular blocks of masonry or brick that are built into the corners of a wall.

Spalls are chips or stone pieces used for backing up or filling the interstices in stone masonry.

12. Ans : 1

- Tricalcium silicate promotes cement to hydrate quickly and makes more strength at early stages.
- Dicalcium silicate strengthens the concrete from 7 days to 1 year.
- Tricalcium aluminate has a small contribution to the strength of first 24 hours but they have a high heat of hydration.
- Tetra Calcium Alumino Ferrate is comparatively inactive.

13. Ans : 3

Smiths Test :

Break off the freshly quarried stone chippings to about the size of a rupee coin and put them in a glass of clean water, one-third full. If the water becomes slightly cloudy, the stone is good and durable. If water becomes dirty, it indicates that the stone contains too much of earthy and mineral matter.

14. Ans : 1

In stone masonry, stones (stratified rocks) are so placed that the direction of pressure to the plane of bedding is right angles.

15. Ans : 2

A percentage wear of less than 3% indicates a good quality stone. A percentage wear of 3% indicates a tolerable stone and greater than 3% indicates a Not satisfactory stone.

16. Ans : 3

Sedimentary Rocks originate when particles settle out of water or air, or by precipitation of minerals from water. They accumulate in layers and forms stratified rocks.

17. Ans : 2

Metamorphic rock result when existing rocks (either igneous or sedimentary) are changed by heat, pressure, or reactive fluids, such as hot, mineral-laden water. Ex. Slate, gnesis, marble.

4 Slope & Deflection

MPSC

1. The slope of cantilever beam having span 'L', at the free end due to concentrared load 'P' applied at free end is

(1) PL^2/EI (2) $PL^2/2EI$

(3) $PL^3/3EI$ (4) $PL^3/2EI$

[MPSC : 2011]

2. The .... at any section in a given beam is equal to .... at corresponding section in conjiugate beam.

(1) Slope, Shear force

(2) Deflection, shear force

(3) Slope, bending moment

(4) Slope, deflection

[MPSC : 2012]

3. A simply supported beam subjected to uniformly varying load of intensity W at left end (A) reduces to zero at right end (B). Then slope at end B is

(1) $\frac{5WL^3}{360EI}$ (2) $\frac{9EL^3}{360EI}$

(3) $\frac{3EL^3}{360EI}$ (4) $\frac{7EL^3}{360EI}$

[MPSC : 2012]

4. A beam fixed at one end and free at the other end is subjected to U.D.L of intensity 'w' over the entire span 'L' Then the deflection at free end will be

(1) $WL^4/8\ EI$ (2) $WL^3/3\ EI$

(3) $WL^2/8\ EI$ (4) $WL^4/3EI$

[MPSC : 2012]

5. A beam of span 'L' is simply supported at ends A and B carries a point load at 'C' at a distance 'a' from A and 'b' from B.

If a<b then the maximum deflection will occur:

(1) At C

(2) Between A and C

(3) Between B and C

(4) Any where along the span

[MPSC : 2012]

6. What does moment area method find ?

(1) Bending moment of beam

(2) Deflection of beam

(3) Moment of Inertia

(4) Reactions of beam

[MPSC : 2012]

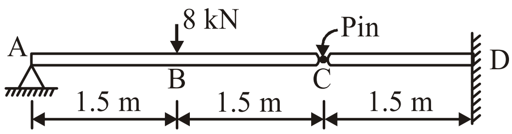
7. Maximum deflection of a cantilever due to pure moment 'M' at its free end , is :

(1) $\frac{ML^2}{3\ EI}$ (2) $\frac{ML^2}{4\ EI}$

(3) $\frac{ML^2}{2\ EI}$ (4) $\frac{ML^2}{6\ EI}$

[MPSC : 2016]

8. The beam AC simply supported at A and at C is pinned to a cantilever beam CD as shown in figure. Both beams have identical flexural rigidities EI. The vertical load of 8 kN acts at point B. The deflection of point B is :



(1) $\frac{2.25}{EI}$ (2) $\frac{4.5}{EI}$

(3) $\frac{6.75}{EI}$ (4) $\frac{8}{EI}$

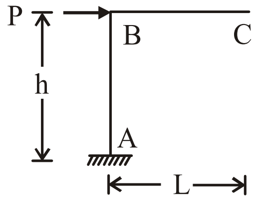
[MPSC : 2016]

9. "The partial derivative of the total internal energy in a beam, with respect to the load applied at any point is equal to the deflection at that point." This is the statement of

(1) Moment area theorem
(2) Castigliano's second theorem
(3) Conjugate beam theorem
(4) Muller – Breslau's influence theorem

[MPSC : 2018]

10. A rigid cantilever frame ABC is loaded and supported as shown in the figure below.
The horizontal displacement of point C is

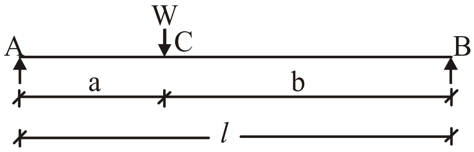


(1) $\frac{2Ph^3}{3EI}$ (2) $\frac{Ph^2(2h+L)}{2EI}$

(3) $\frac{Ph^3}{3EI}$ (4) $\frac{Ph^2(h+L)}{3EI}$

[MPSC : 2018]

11. A simply supported beam of length …carries a point load 'W' at point 'C' as shown in the figure. The maximum deflection lies at



(1) Point A
(2) Point B
(3) Point C
(4) Between points B and C

[MPSC : 2018]

12. Deflection of the free end of cantilever having point load at the mid span is

(1) $\frac{Wl^3}{3EI}$ (2) $\frac{5Wl^3}{24EI}$

(3) $\frac{5Wl^3}{48EI}$ (4) $\frac{Wl^3}{48EI}$

[MPSC : 2018]

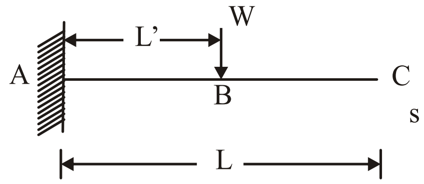
13. Maximum deflection of a simply supported beam with the total uniformly distributed load 'W' is :

(1) $\frac{Wl^3}{384EI}$ (2) $\frac{5}{384}\frac{Wl^3}{EI}$

(3) $\frac{Wl^3}{48EI}$ (4) $\frac{5}{48}\frac{Wl^3}{EI}$

[MPSC : 2019]

14. Which of the following is true in the following figure?



(1) Deflection at C = deflection at B + θ_B(L – L')

(2) Deflection at C = $\frac{L}{L'}$ × deflection at B

(3) Deflection at C = deflection at B + θ_B(L – L')

(4) Both (1) and (3)

[MPSC : 2019]

15. Maximum deflection for a simply supported beam subjected to udl 'W' throughout span 'I' is :

(1) $\frac{Wl^3}{48EI}$ (2) $\frac{Wl^4}{48EI}$

(3) $\frac{5}{384}\frac{Wl^3}{EI}$ (4) $\frac{5}{384}\frac{Wl^4}{EI}$

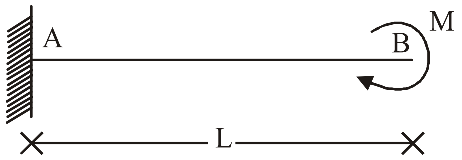
[MPSC : 2019]

16. The deflection at the free end of a cantilever of rectangular cross-section due to certain loading is 0.8 cm. If the depth of the section is doubled keeping the width same, then the deflection at the free end due to the same loading will be :

(1) 0.1 cm
(2) 0.4 cm
(3) 0.8 cm
(4) 1.6 cm

[MPSC : 2019]

17. A cantilever beam AB of span 'L' is subjected to a moment 'M' at the free end as shown in figure. What is the slope and deflection at free end B ?
Consider same c/s and material. (i.e, EI is same)



(1) $\frac{ML}{EI}, \frac{ML^2}{2EI}$ (2) $\frac{M}{LEI}, \frac{ML^2}{EI}$

(3) $\frac{2ML}{EI}, \frac{2ML^2}{EI}$ (4) $\frac{ML}{EI}, \frac{2ML^2}{EI}$

[MPSC : 2019]

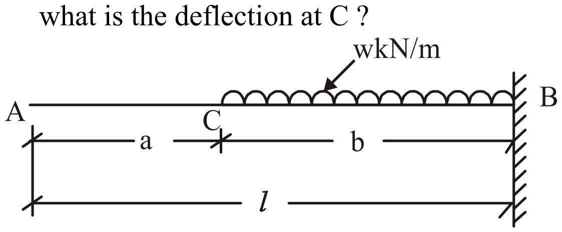
18. A simply supported beam of span l is carrying point load W at mid span. What is the deflection at centre of beam ?

(1) $\frac{Wl^2}{48EI}$ (2) $\frac{Wl^3}{48EI}$

(3) $\frac{5}{348}\frac{Wl^3}{EI}$ (4) $\frac{11}{120}\frac{Wl^3}{EI}$

[MPSC : 2020]

19. A cantilever beam AB of length 'l' and subjected to a U.D.L. of intensity 'w'kN/m over a length 'b' is shown in the figure. If EI is constant, then what is the deflection at C ?



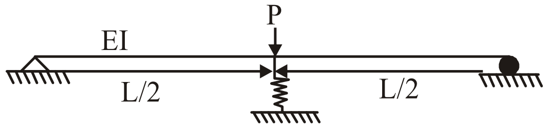
(1) $\frac{w.a.b^3}{6EI}$ (2) $\frac{w.b^3}{6EI}$

(3) $\frac{w.a.b^3}{8EI}$ (4) $\frac{w.b^4}{8EI}$

[MPSC : 2020]

GPSC

1. A simply supported beam of span length L and flexure stiffness EI has another spring support at the centre span of stiffness K as shown in figure. The central deflection of the beam due to a central concentrated load of P would be



(1) $[PL^3/48EI]+[P/K]$
(2) $PL^3/[48EI+KL^3]$
(3) $[PL^3/48EI][P/K]$
(4) $[PL^3/48EI]+K$

[GPSC : 2017]

2. Moment area method is best suitable for finding
(1) Slope and deflection of cantilever beam
(2) Slope and deflection of continuous beam
(3) Deflection of simply supported beam
(4) Slope of fixed beam

[GPSC : 2018]

3. In moment area method the slope of real beam at a section is represented by
(1) Bending moment of M/EI diagram
(2) Shear force of M/EI diagram
(3) Total area of M/EI diagram
(4) Area of Shear Force Diagram of real beam

[GPSC : 2018]

4. A fixed or clamped support in real beam becomes .... in conjugate beam.
(1) Free (2) Remains fixed
(3) Hinge (4) Roller

[GPSC : 2018]

5. A cantilever AB is subjected to a concentrated load at the free end. The slope and deflection at the free end are $WL^2/2$ EI and $WL^3/3$ EI . If the same load is applied at mid-span point, the deflection at the free end will be
(1) 5 $WL^3/384$ EI (2) 5 $WL^3/48$ EI
(3) $WL^3/6$ EI (4) $WL^3/16$ EI

[GPSC : 2018]

Answers	6. Torsion

MPSC	**1.** (2) **2.** (2) **3.** (1) **4.** (4) **5.** (3) **6.** (3) **7.** (3) **8.** (3) **9.** (1) **10.** (4) **11.** (3) **12.** (4)
GPSC	**1.** (3) **2.** (4) **3.** (3) **4.** (2) **5.** (1) **6.** (2) **7.** (1) **8.** (1) **9.** (4) **10.** (4) **11.** (2) **12.** (1) **13.** (4) **14.** (1)
BPSC	**1.** (2) **2.** (3) **3.** (3)
WBPSC	**1.** (3)
TNPSC	**1.** (4) **2.** (3) **3.** (2) **4.** (2) **5.** (3) **6.** (1)
KPSC	**1.** (1) **2.** (2) **3.** (1)
UKPSC	**1.** (2)
OPSC	**1.** (2)
Kerala	**1.** (3) **2.** (2) **3.** (2) **4.** (2)

Explanations	6. Torsion

MPSC

1. Ans : 2

8.49×10^4 N/mm^2

Given, A solid circular shaft of

D = 100 mm, L = 30 mm

T = 25 kNm, θ = 0.09 rad

Modulus of rigidity = G = ?

We know, Torsional formula.

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

From this, $\frac{T}{J} = \frac{G\theta}{L}$; $G = \frac{TL}{J\theta}$

$$\therefore\ G = \frac{25\times10^6\times3\times10^3\times32}{\pi\times(100)^4\times0.09}$$

$$G = 8.49\times10^4\ N/mm^2$$

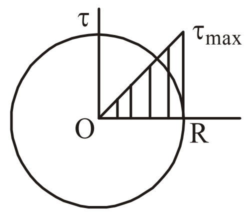
2. Ans : 2

- When a shaft is made to transmit power, a pure twisting couple or torque acts about its polar axis.
- Shear stresses are set up perpendicular to the radius at all transverse section.
- As a result, complementory shear stresses are developed on the longitudinal planer which cause a distortion of filaments.

By Torsion Formula,

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{l}$$

This shows for given shaft, shear stress is proportional to radius its variation is as shown.



For a given shaft of 200 mm radius T = 300 N.m. shear stress of centre is "zero".

3. Ans : 1

Circular shaft diometer = D

Torsional moment = T

Shear stress developed = τ = ?

We have, $\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{l}$

$$\therefore \frac{T}{J} = \frac{\tau}{R} \quad \text{\_\_\_\_(1)}$$

Where, J = Polar moment of inertia

$= I_x + I_y$

for solid shaft, $J = \frac{\pi D^4}{32}$

$\therefore$ from eqn (1),

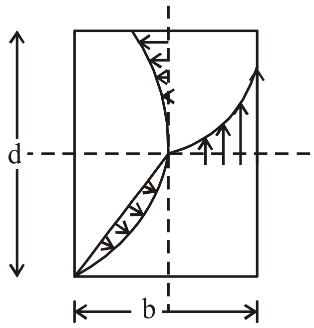
$$\tau = \frac{T}{J} \times R = \frac{T}{J} \times \frac{D}{2}$$

$$= \frac{T}{\pi D^4 / 32} \times \frac{D}{2}$$

$$\tau = \frac{16T}{\pi D^3}$$

4. Ans : 4

- Non-circular sections are torsionally weak as shear stress distribution is non-symmetrical about the centre, such section when subjeced to torque get warped & their plane section before twisting doesn't remain plane anymore.
- For rectangular shaft maximum shear stress is developed on the middle surface of longer side, though maximum distance from the centre is at corners, stress at corner is zero.



The maximum stress is given by,

$$\tau_{max} = \frac{T}{\alpha\, bd^2}$$

5. Ans : 3

$$\left(\frac{16T}{\pi f_s}\right)^{1/3}$$

Solid shaft subjected to torque T

Maximum shear stress = f_s,

By torsion formula

$$\frac{T}{J} = \frac{f_s}{R}$$

$$J = \frac{\pi}{32} D^4 \text{ and } R = \frac{D}{2}$$

$$\therefore \frac{J}{R} = \frac{T}{f_s}; \frac{\pi / 32 D^4}{D/2} = \frac{T}{f_s}$$

$$D^3 = \frac{16T}{\pi f_s}$$

Therefore, diameter = D = $\left(\frac{16T}{\pi f_s}\right)^{1/3}$

6. Ans : 3

Magnitude of shear stress inducced in a shaft due to applied torque varies from zero at centre to maximum at circumference.

Explanation is as of question (2)

7. Ans : 3

Solid circular shaft is subjected to

Torque = T & bending moment = M, simultaneous.

We know,

Maximum bending stress $= \sigma = \frac{32M}{\pi D^3}$

Maximum shear stress $= \tau = \frac{16T}{\pi D^3}$

Therefore,

The ratio of maximum bending stress and maximum torsional shearing stress can be given as,

$$\frac{\sigma}{\tau} = \frac{32M / \pi D^3}{16T / \pi D^3}$$

$$= \frac{2M}{T}$$

8. Ans : 3

Please Refer (MPSC) Q. No. 7.

9. Ans : 1

- When a solid shaft of diameter 'D' carries twisting moment that develops maximum shear stress (τ_o)

We know,

$$\tau_D = \frac{16T}{\pi b^3} = \tau$$

Now shaft is replaced by a hollow one of outside diameter 'D' and inside diameter 'D/2',

Therefore,

$$\frac{T}{J} = \frac{\tau_D}{R}$$

$$J = \frac{\pi}{32}\left(D^4 - \left(\frac{D}{2}\right)^4\right) \text{ and } R = \frac{D}{2}$$

$$\therefore \quad \tau_D = \frac{T}{J} \times R$$

$$= \frac{T}{\frac{\pi}{32}\left(D^4 - \frac{D^4}{16}\right)} \times \frac{D}{2}$$

$$\tau_o = \frac{32 \times 16 \times T}{\pi\ 15D^4} \times \frac{D}{2} = \frac{256T}{15D^3}$$

$$\therefore \quad \frac{\tau_o}{\tau_D} = \frac{256T / 15D^3\pi}{16T / \pi D^3}$$

$$\tau_o = \frac{16}{15} \times \tau_o$$

$$\tau_o = 1.067\ \tau_D$$

10. Ans : 4

Shaft is subjected to Torque "T", where

G = Shear modulus & J = Polor moment of Inertia

L = Length of shaft.

let, "U" be the strain energy stored in solid shaft due to torque "T".

We know, $U = \frac{1}{2} T\theta$

and $\theta = \frac{TL}{GJ}$ ....By torsion formula

$$\therefore \quad U = \frac{1}{2} \times T \times \frac{TL}{GJ}$$

$$U = \frac{T^2L}{2GJ}$$

11. Ans : 3

Torsion equation given,

$$\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$$

Where,

J = Polar moment of Inertia and

$\frac{J}{R} = Z_p$ = Polar section modulus of shaft such that, strength of shaft which is a measure of resisting twisting action capacity is given by,

$T = Zp \times \tau$

For a shaft to be strongest its polar section modulus should be maximum.

Generally, hollow circular shafts are more stronger than solid circular shafts.

Torsional rigidity is the product of modulus of rigidity (G) and polar moment of Inertia (J).

$T_R = GJ$

12. Ans : 4

Strength of shaft is the ability of a shaft to resist the action of twisting moment.

$T = \tau \times Z_p$ ____(1)

Where,

τ = Permissible shear stress

Z_p = Polar section modulus of shaft

$Z_p = \frac{\pi D^3}{16}$ .....for soild circular shaft ____(2)

$= \frac{\pi\left(D^4 - d^4\right)}{16D}$ .....for hollow shaft.

Diameter of shaft A = D = 50 mm
Diameter of shaft B = D^1 = 50 mm
From equation (1),

$$\frac{\text{Strength of shaft B}}{\text{Strength of shaft A}} = \frac{\tau \times (Z_p)_B}{\tau \times (Z_p)_A} = \frac{(Z_p)_B}{(Z_p)_A}$$

Therefore, from eqation (2)

$$(Z_p)_B = \frac{\pi(100)^3}{16} \; \& \; (Z_p)_A = \frac{\pi(50)^3}{16}$$

$$\therefore \frac{(Z_p)_B}{(Z_p)_A} = \frac{(100)^3}{(50)^3} = \left(\frac{100}{50}\right)^3 = (2)^3 = 8$$

Strength of shaft 'B' is '8' times that of 'A'.

GPSC

1. Ans : 3

$\pi(D^4 - d^4)/32D$

Explanation :

Hollow circular section of
External diameter = D
Internal diameter = d

We know, section modulus (Z) of a section is given as,

$$Z = \frac{I}{y_{max}}$$

Where,
I = moment of inertia off neutral axis.
y_m = distance of extreme fibre from N.A. for given shaft (hollow),

$$I = \frac{\pi}{64}\left(D^4 - d^4\right) \text{ and } y_{max} = \frac{D}{2}$$

$\therefore$ Section modulus

$$= Z = \frac{\frac{\pi}{64}\left(D^4 - d^4\right)}{D/2} = \frac{\pi\left(D^4 - d^4\right)}{32D}$$

2. Ans : 4

Shafts are of same material, $G_1 = G_2$
Shafts are of same length, $L_1 = L_2$
Shafts subjected to torque, T
We know,

Strain energy in torsion, $U = \frac{T^2L}{2GJ}$

So for some G, L and T above equation reduces to $U \, \alpha \, \frac{1}{J}$ where, $J = \frac{\pi}{32}D_2^4$

$\therefore$ Here, $J_1 = \frac{\pi}{32}d_1^4$ and $J_2 = \frac{\pi}{32}d_2^4$

Therefore, the ratio of strain energy V_1/V_2

$$= \frac{J_2}{J_1} = \frac{\frac{\pi}{32}.d_2^4}{\frac{\pi}{32}.d_1^4} = \left[\frac{d_2}{d_1}\right]^4$$

3. Ans : 3

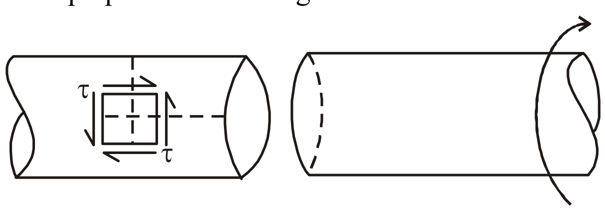
Pure shear stress :

- Due to pure twisting moment shear stresses are developed in two mutually perpendicular planes:

a) In the plane of cross-section in circum ferential direction.

b) Normal to the plane of cross-section in longitudinal direction.

- The shear stress produced by torque vary from zero at centre of cross-section maximum at surface in circumferential direction.
- An element on the surface is subjected to pure shear stresses.
- As ductile material are weak in shear, Hence ductile materials fail due to principle shear stress and ductile failure plane in torsion will be perpendicular to longitudinal axis.



4. Ans : 2

Given,
Max. shear stress = τ_{max} = 5 N/mm^2
Diameter of shaft = D = 40 mm

Twisting moment = T = ?

We have,

$$\frac{T}{J}=\frac{\tau}{R}$$

$$T=\frac{\tau}{R}\times\frac{\pi D^4}{32}$$

$$=\frac{2\times 5}{40}\times\frac{\pi\times(40)^4}{32}$$

$$=\frac{5\times 40^3}{16}\times\pi$$

T = 62.80 N.m.

5. Ans : 1

Shaft is of diameter = D and subjected to moment M and torque T,

Equivalent bending moment is the moment which produces some maximum normal stress as produced by combined effect of bending & twisting

If M_e = equivalent bending moment,

σ = maximum normal stress produced

$$\sigma=\frac{32M_e}{\pi D^3}$$

$$\therefore\ \frac{16}{\pi D^3}\left[M+\sqrt{M^2+T^2}\right]=\frac{32M_e}{\pi D^3}$$

$$M_e=\frac{1}{2}\left[M+\sqrt{M^2+T^2}\right]$$

6. Ans : 2

Torsional stiffness (K) :

- It is the torque required to produce unit angle of twist in the direction of twist.

$$K=\frac{GJ}{L}$$

So, Higher is the value of J = Polar moment of inertia higher will be torsional stiffness.

- Therefore, section in increasing order of their torsional stiffness,

L - Section < open ring section < closed ring < circular disc section.

7. Ans : 1

Torsional failure surface of ductile material occurs at transverse plane.

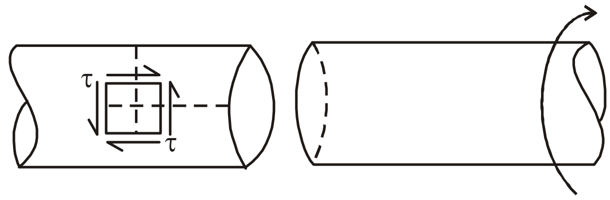
Pure shear stress :

- Due to pure twisting moment shear stresses are developed in two mutually perpendicular planes:

a) In the plane of cross-section in circum ferential direction.

b) Normal to the plane of cross-section in longitudinal direction.

- The shear stress produced by torque vary from zero at centre of cross-section maximum at surface in circumferential direction.
- An element on the surface is subjected to pure shear stresses.
- As ductile material are weak in shear, Hence ductile materials fail due to principle shear stress and ductile failure plane in torsion will be perpendicular to longitudinal axis.

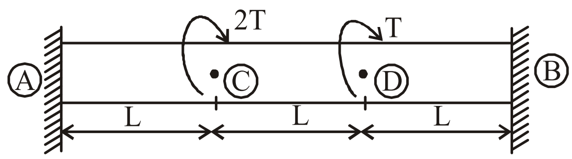


8. Ans : 1

For the shafts having square cross-section the maximum shear stress occurs at a point on the edge to the cross section that is closest to the centre axis of the shaft.

- For rectangular shaft maximum shear stress is developed on the middle surface of longer side, though maximum distance from the centre is at corners, stress at corner is zero.

9. Ans : 4



Considering effect of torque '2T' @ C only, support reaction of A,

$$T_{A_1}=2T\times\frac{2L}{3L}=\frac{4T}{3}$$

3. Theory of Structures/Structural Analysis

Syllabus

Theory of structures : Analysis of beams, frames and trusses, slope deflection method, moment distribution method.

Structural analysis : Analysis of arches and suspension cables, influence lines, stiffness and flexibility matrix methods.

Content		Page No.

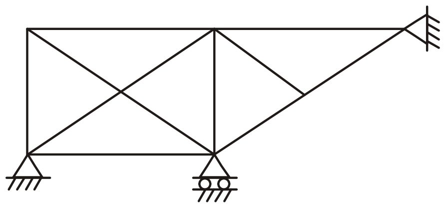
1 Static & Kinematic Indeterminacy

MPSC

1. A continuous beam ABCDE has four simple supports A,B,C and D. DE is overhang. Hinge 'F' is provided along span BC. The degree of static indeterminacy is
(1) 4 (2) 1
(3) 2 (4) 3
[MPSC : 2011]

2. Maximum number of unknown forces that can be determined in concurrent force system under equilibrium is
(1) Zero (2) 2
(3) 3 (4) 6
[MPSC : 2012]

3. The degree of static indeterminacy in the frame shown in fig. is :



(1) 1 (2) 2
(3) 3 (4) Zero
[MPSC : 2013]

4. Match **List - I** (Type of structure) with **List - II** (statical indeterminacy) and select the correct answer using the codes given below.
Where m = no. of members
J = no. of joints
R = no. of reactions

List- 1		List – 2
A. Rigid jointed plane frame	**1.**	(m + r) - 3j
B. Pin jointed space frame	**2.**	(6m + r) - 6j
C. Rigid jointed frame	**3.**	(6m + r) - 3j
	4.	(3m + r) - 3j

Codes:

	A	B	C
(1)	1	2	3
(2)	4	3	2
(3)	2	1	3
(4)	4	1	2

[MPSC : 2013]

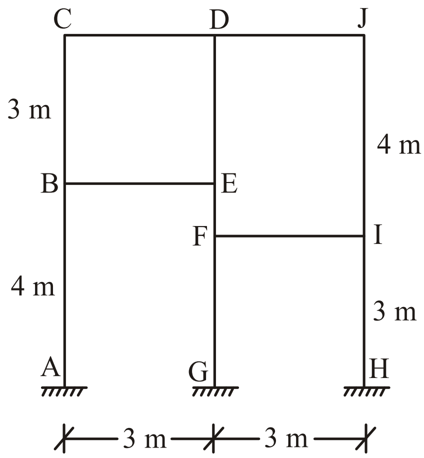
5. A rigid jointed frame with three bays and two stories has two fixed column supports and two hinged. The degree of static indeterminacy of structure is :
(1) 25 (2) 27
(3) 18 (4) 16
[MPSC : 2016]

6. The degree of static indeterminacy of pin jointed space frame is given by :
(1) m + r – 2j
(2) m + r – 3j
(3) 3m + r – 3j
(4) m + r + 3j
Where'm' = the number of unknown member forces
'r' = unknown reaction components and
'j' = the number of joints.
[MPSC : 2016]

7. The Kinematic Indeterminacy of a frame as shown is :

(1) KI = 1 (2) KI = 2
(3) KI = 3 (4) KI = 5
[MPSC : 2016]

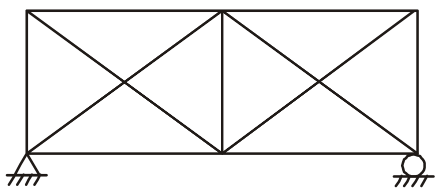
8. Determine the degree of static and kinematic indeterminacy of the frame structure as shown in the figure.



(1) 15, 8 (2) 12, 12
(3) 12, 10 (4) 15, 9

[MPSC : 2017]

9. In the pin-jointed truss shown in the figure, the static degree of indeterminacy is



(1) 2 (2) 1
(3) 3 (4) 4

[MPSC : 2017]

10. A structure is said to be statically indeterminate when

(1) The number of unknown reaction components exceeds the number of equilibrium conditions.
(2) The number of equilibrium conditions exceeds the number of unknown reaction components.
(3) The number of equilibrium conditions equal to the number of unknown reaction components.
(4) None of the above.

[MPSC : 2017]

11. Degree of static indeterminacy of a rigid jointed plane frame having 15 members, 3 reaction components and 14 joints is

(1) 2
(2) 3
(3) 6
(4) 8

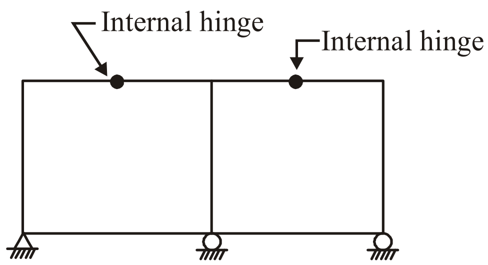
[MPSC : 2018]

12. A statically indeterminate structure is the one which :

(1) Cannot be analyzed at all
(2) Can be analyzed using equations of statics only
(3) Can be analyzed using equations of statics and compatibility equations
(4) Can be analyzed using equations of compatibility only

[MPSC : 2019]

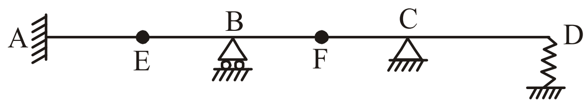
13. Degree of static indeterminacy for the frame shown below is ....



(1) 8 (2) 7
(3) 6 (4) 5

[MPSC : 2019]

14. The kinematic indeterminacy of the following beam after imposing the boundary conditions is

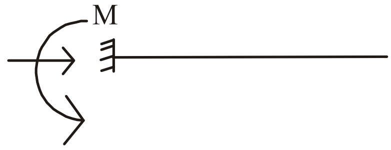


(1) 6
(2) 8
(3) 10
(4) 12

[MPSC : 2020]

GPSC

1. Choose the correct option classifying the following structure.



(1) Indeterminate to 1st degree
(2) Indeterminate to 2nd degree
(3) Determinate
(4) Unstable

[GPSC : 2018]

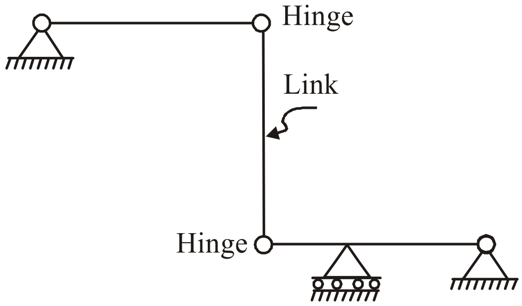
2. If a plane truss satisfies the condition m = 2j - 3 where m is number of member, and j is number of joints, then it is .....
(1) Determinate internally
(2) Determinate externally
(3) Indeterminate internally
(4) Indeterminate externally

[GPSC : 2018]

3. Structures having more reactions than that required for necessary and sufficient conditions are
a. Hyperstatic
b. Deteminate
c. Indeterminate
d. Hypostatic
(1) Only a (2) a and c
(3) Only b (4) b and d

[GPSC : 2018]

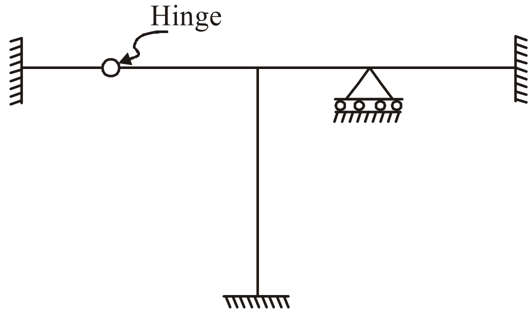
4. The degree of static indeterminacy of the strucutre shown in the following figure is



(1) 0 (2) 1
(3) 2 (4) 3

[GPSC : 2019]

5. The degree of static indeterminacy of the frame shown in the following figure is



(1) 2 (2) 4
(3) 6 (4) 8

[GPSC : 2019]

6. If in a Pin jointed plane frame (m + r) >2j, then the frame is
(1) Stable and statically indeterminate
(2) Stable and statically determinate
(3) Unstable
(4) Unstable and statically indeterminate

[GPSC : 2019]

7. A statically indeterminate structure is the one which
(1) Cannot be analyzed at all
(2) Can be analyzed using equations of statics only
(3) Can be analyzed using equations of statics and compatibility equations
(4) Can be analyzed using equations of compatibility only

[GPSC : 2019]

BPSC

1. Choose the correct statements from the following:
a. A stable and statically determinate real beam will have a stable and statically determinate conjugate beam.
b. A statically indeterminate real beam will have unstable conjugate beam.

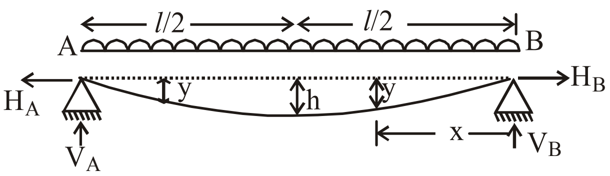
Answers 5. Arches & Cables

MPSC	**1.** (3)	**2.** (2)	**3.** (1)	**4.** (2)	**5.** (4)	**6.** (3)	**7.** (4)	**8.** (3)	**9.** (4)	**10.** (4)
	11. (4)	**12.** (1)	**13.** (4)	**14.** (3)	**15.** (4)	**16.** (2)	**17.** (3)	**18.** (4)	**19.** (1)	**20.** (3)
	21. (2)	**22.** (4)	**23.** (4)							
GPSC	**1.** (1)	**2.** (1)	**3.** (3)	**4.** (1)	**5.** (3)					
BPSC	**1.** (1)	**2.** (2)	**3.** (3)	**4.** (2)	**5.** (1)					
WBPSC	**1.** (4)	**2.** (3)	**3.** (4)							
TNPSC	**1.** (2)	**2.** (2)	**3.** (3)	**4.** (2)	**5.** (4)	**6.** (4)	**7.** (1)	**8.** (3)	**9.** (1)	**10.** (3)
	11. (2)									
MPPSC	**1.** (2)	**2.** (3)	**3.** (4)							
RPSC	**1.** (2)									
UKPSC	**1.** (3)									
APPSC	**1.** (3)	**2.** (3)	**3.** (1)							

Explanations 5. Arches & Cables

MPSC

1. Ans : 3



Here, we have, $H_A = H_B = \frac{wl^2}{8h}$

$$V_A = V_B = \frac{wl}{2}$$

For parabolic cable we have equation of parabola,

$$y = \frac{4h}{l^2}x(l-x)$$

Considering section x-x at distance x from B,

$$Mx = H_B.y + \frac{wx^2}{2} - V_B - x$$

$$\therefore\ M_x = \frac{wl^2}{8h}\left[\frac{4h}{l^2}x(l-x)\right] + \frac{wx^2}{2} - \frac{wl}{2}x$$

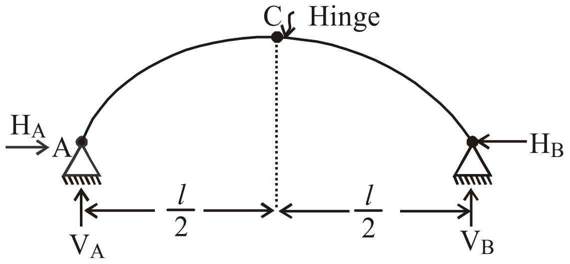
$$\therefore\ M_x = \frac{w}{2}x(l-x) + \frac{wx^2}{2} - \frac{wl}{2}x$$

$$\therefore\ M_x = \frac{w}{2}lx - \frac{wx^2}{2} + \frac{wx^2}{2} - \frac{wl}{2}x$$

$$\therefore\ M_x = 0$$

Hence, cable subjected to ud*l* will develope zero bending moment at any section.

2. Ans : 2



In three hinge arch, there are four unknown reactions and three equation of equlibrium and one extra condition of equlibrium i.e. $M_C = 0$ at internal hinge. Hence three hinge arch is statically determinate structure.

3. Ans : 1

Arches can be used to reduce the bending moments in long span structures. Essentially, an arch acts an inverted cable, so it receives its load mainly in compression although because of its Rigidity, it also resist some bending moment and shear depending upon how it is loaded and shaped. When an arch is subjected to udl then only compression forces will be resisted by the arch.

4. Ans : 2

As per eddy's theorem,

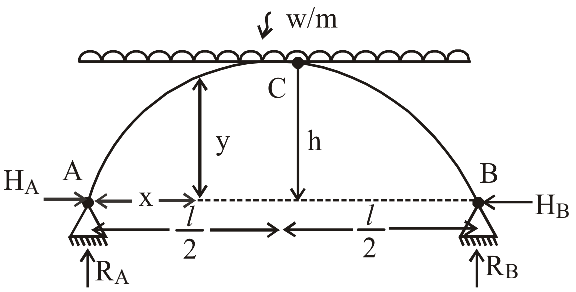
If a linear Arch is superimposed on a given arch then bending moment at any section on given arch is proportional to the ordinate of intersect between given arch and theoretical arch,

$$M_x \propto P$$

Where, P = Intersect between given arch and theoretical arch.

5. Ans : 4

For three Hinge parabolic arch subjected to Udl,



Here, we have, $H_A = H_B = \dfrac{wl^2}{8h}$

$$R_A = R_B = \frac{wl}{2}$$

Equation of parabolic Arch,

$$y = \frac{4h}{l^2}x(l-x)$$

Now bending moment at any section x-x, at a distance x from A,

$$M_x = R_A.x - w.x\frac{x}{2} - H_A.y$$

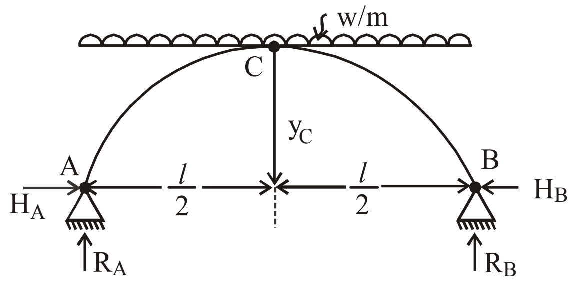
$$M_x = \frac{wl}{2}x - \frac{wx^2}{2} - \frac{wl^2}{8h}\left[\frac{4h}{l^2}x(l-x)\right]$$

$$M_x = \frac{wl}{2}x - \frac{wx^2}{2} - \frac{wl}{2}x + \frac{wx^2}{2}$$

$\therefore M_x = 0$

Hence at every point on arch bending moment will be zero.

6. Ans : 3



Here,

$\Sigma F_x = 0 \Rightarrow H_A = H_B = H$

$\Sigma F_y = 0 \Rightarrow R_A = R_B = \dfrac{wl}{2}$

$\Sigma M_C = 0$, (From left)

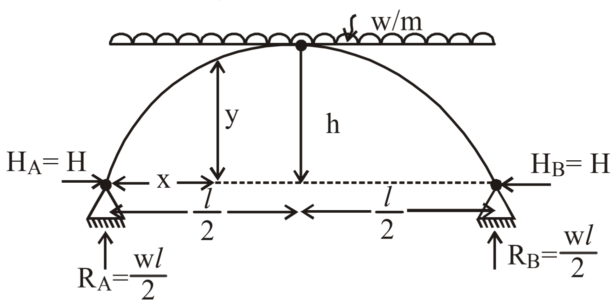
$$R_A \times \frac{l}{2} - (H \times y_c) - w \times \frac{l}{2} \times \frac{l}{4} = 0$$

$$\frac{wl}{2} \times \frac{l}{2} - (H \times y_c) - \frac{wl^2}{8} = 0$$

$$\therefore \quad H = \frac{wl^2}{8y_c}$$

7. Ans : 4

For two hinged parabolic Arch,



We have,

$$y = \frac{4h}{l^2}x(l-x)$$

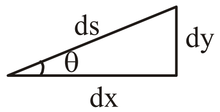
Moment of inertia of parabolic arch.

$I = I_0.\sec\theta$

Where,

I_0 = MOI about NA at crown

θ = Angle of tangent with horizontal



$$\frac{dy}{ds} = \sin\theta, \frac{dx}{ds} = \cos\theta, \;\; ds = dx - \sec\theta$$

Now,

$$M_x = R_A.x - \frac{wx^2}{2} = \frac{wl}{2}x - \frac{wx^2}{2}$$

We know,

$$H = \frac{\int \frac{m.y.ds}{EI}}{\int \frac{y^2 ds}{EI}}$$

$$= \frac{2\int_0^{l/2} \frac{\left(\frac{wl}{2}x - \frac{wx^2}{2}\right)\frac{4h}{l^2}x(l-x).dx.\sec\theta}{EI_0.\sec\theta}}{\left(\frac{4h}{l^2}\right)^2 \int_0^{l/2} \frac{x^2(l-x)^2.dx.\sec\theta}{EI_0.\sec\theta}}$$

$$\therefore \; H = \frac{wl^2}{8h}$$

8. Ans : 3

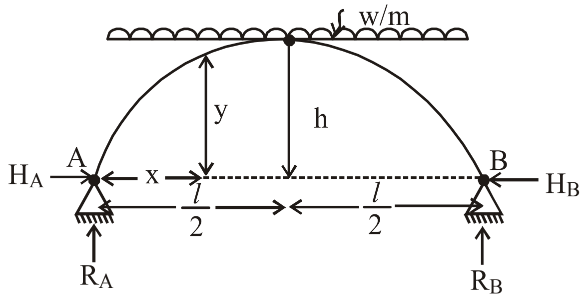
The tension in cable varies along its depth. The maximum tension (τ_{max}) occurs at supports as horizontal force and vertical force acting at supports is maximum.

Minimum tension occurs at the deepest point and is equal to horizontal thrust.

In given figure, point 'c' is the deepest point where minimum tension will occur.

9. Ans : 4

For three Hinge parabolic arch subjected to udl,



Here, we have,

$$H_A = H_B = \frac{wl^2}{8h}$$

$$R_A = R_B = \frac{wl}{2}$$

Equation of parabolic Arch,

$$y = \frac{4h}{l^2}x(l-x)$$

Now bending moment at any section x-x, at a distance x from A,

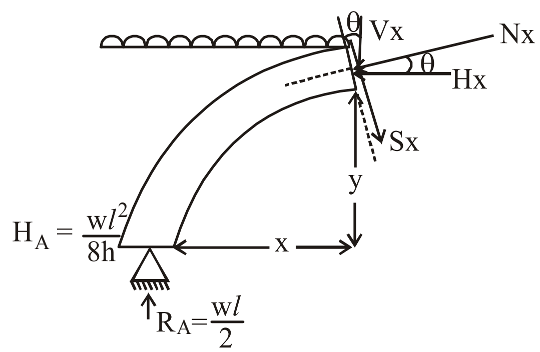
$$M_x = R_A.x - w.x\frac{x}{2} - H_A.y$$

$$M_x = \frac{wl}{2}x - \frac{wx^2}{2} - \frac{wl^2}{8h}\left[\frac{4h}{l^2}x(l-x)\right]$$

$$\therefore \; M_x = \frac{wl}{2}x - \frac{wx^2}{2} - \frac{wl}{2}x + \frac{wx^2}{2}$$

$$\therefore \; M_x = 0$$

Hence at every point on arch bending moment will be zero.



Here,

$$V_x = R_A - w.x$$

$$V_x = \frac{wl}{2} - w.x$$

$S_x = V_x.\cos\theta - H_x - \sin\theta$

$$\therefore\ S_x = \left(\frac{wl}{2} - wx\right)\text{Cos}\,\theta - \frac{wl^2}{8h}.\sin\theta$$

$$\therefore\ S_x = \text{Cos}\,\theta\left[\frac{wl}{2} - wx - \frac{wl^2}{8h}\tan\theta\right]$$

$$\therefore\ S_x = \text{Cos}\,\theta\left[\frac{wl}{2} - wx - \frac{wl^2}{8h}\left(\frac{4h}{l^2}(l-2x)\right)\right]$$

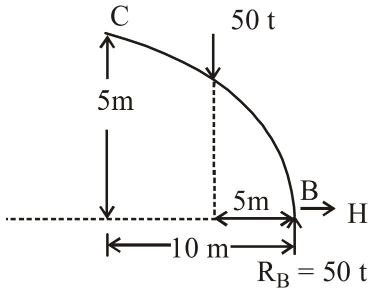
$$\therefore\ S_x = \text{Cos}\,\theta\left[\frac{wl}{2} - wx - \frac{wl}{2} + wx\right]$$

$\therefore\ S_x = 0$

10. Ans : 4

For given three hinged Arch,

Taking $\Sigma M = 0$ at crown point and considering equlibrium of right ride.



$\Sigma M_C = 0$

$(+ 50 \times 5) - (50 \times 10) - 5H = 0$

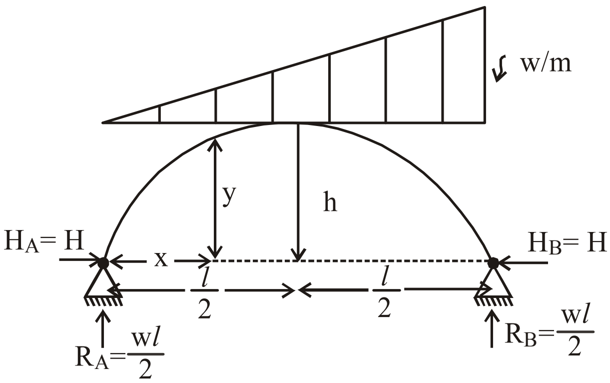
$\therefore\ 5H = 250 - 500 = -250$

$\therefore\ H = -50$ t

$\therefore\ H = 50$ t $(\leftarrow)$

11. Ans : 4

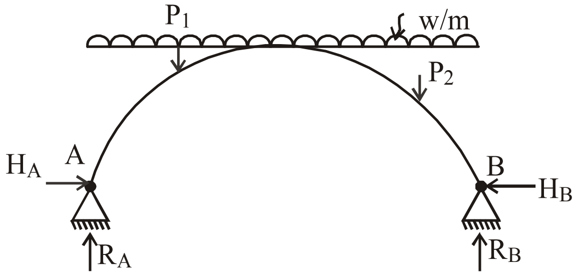
For two Hinged parabolic Arch,



$$\therefore\ H = \frac{wl^2}{16h}$$

12. Ans : 1

Consider typical Arch system subjected to vertical load only,



Since No horizontal external load acting on arch,

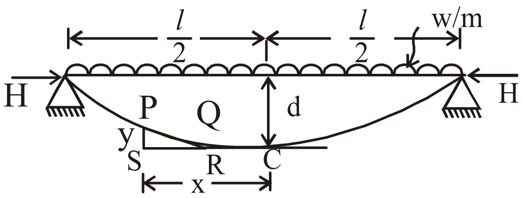
To satisfy, $\Sigma f_x = 0$

$H_A = H_B$

Means Horizontal thrust at each of the support must be same.

13. Ans : 4

Consider a cable of length ACB, supported at A and B & Length of cable before dip occurs is l and after dip it is L and carrying UDL,



Let C be the lowest point on the cable, taking C as origin consider a point P (x,y) on the cable and draw a tangent to cable at point P meets the horizontal line CS at R from geometry of curve we have

$$CR = RS = \frac{x}{2}$$

Consider tension in cable is T, then triangle PSR represents some scale the triangular force are in equlibrium then

$$\frac{PS}{wx} = \frac{RS}{H} = \frac{PR}{T}$$

$$\therefore\ \frac{y}{wx} = \frac{x}{2H} \Rightarrow \frac{dy}{dx} = \frac{wx}{H} \qquad \text{................(1)}$$

Now,

$$ds = \sqrt{dx^2 + dy^2} = dx\sqrt{1+\left(\frac{dy}{dx}\right)^2} = dx\sqrt{1+\left(\frac{wx}{H}\right)^2}$$

$$\left[1+\left(\frac{wx}{H}\right)\right]^{1/2} = 1+\frac{w^2x^2}{2H^2}+......$$

Neglecting Higher Powers,

$$ds = dx\left[1+\frac{1}{2}\left(\frac{wx}{H}\right)^2\right].dx$$

Then,

$$\int_0^{l/2} ds = \int_0^{l/2}\left[1+\frac{1}{2}\left(\frac{wx}{H}\right)^2\right].dx$$

$$\therefore\ \frac{L}{2} = \left[x+\frac{w^2x^3}{6H^2}\right]^{1/2}$$

$$\therefore\ \frac{L}{2} = \frac{l}{2}+\frac{w^2l^3}{48H^2}$$

Then, total length, $L = l + \frac{w^2l^3}{24H^2}$

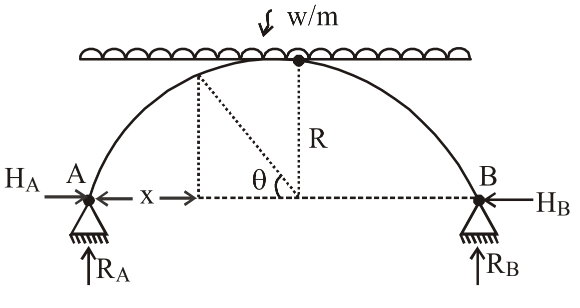
But we have for parabolic cable,

$$H = \frac{wl^2}{8h}$$

$$\therefore\ L = l+\frac{8d^2}{3l}$$

14. Ans : 3

For three hinged semi-circular Arch subjected to UDL over entire span,



Here,

$\Sigma F_x = 0 \Rightarrow H_A = H_B = H$

$\Sigma F_y = 0 \Rightarrow R_A + R_B = w \times 2R$

$\Sigma M_B = 0$

$(R_A \times 2R) - (w \times 2R \times R) = 0$

$R_A = wR$

$R_B = wR$

Taking,

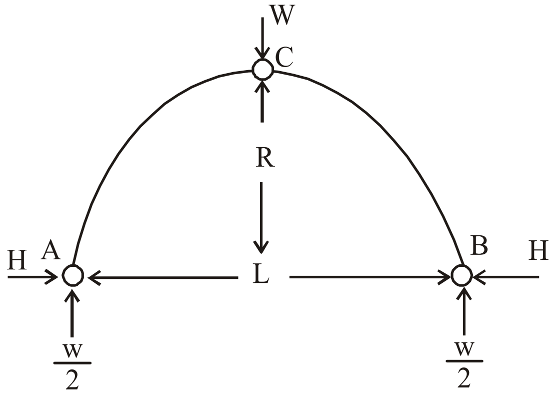
$\Sigma M_C = 0$ (From left)

$$(R_A.R) - (H \times R) - \left(wR.\frac{R}{2}\right) = 0$$

$$\therefore\ H = \frac{wR}{2}$$

15. Ans : 4

For given three hinged parabolic Arch,



Taking,

$\Sigma M_C = 0$ (from right)

$$\therefore\ (H \times R) - \left(\frac{w}{2}\times\frac{L}{2}\right) = 0$$

$$\therefore\ H = \frac{wL}{4R}$$

As given,

$H = w$

$$\therefore\ w = \frac{wL}{4R}$$

$$\therefore\ \frac{L}{R} = 4$$

8. Ans : 2

Effective length :

It is the length of the fillet weld for which the specified size and throat thickness of weld existance.

The Actual length of weld = Effective legnth + 2 × size of weld

$$\ell = \ell_{eff} + 2S$$

$$\ell_{eff} = \ell - 2S$$

Actual length of the weld in no case should be less than to times the size of the weld.

$$\ell_{eff} = \ell - 2S$$
$$= 200 - 2 \times 12$$
$$\ell_{eff} = 176\text{mm}$$

9. Ans : 4

The types of welded joints can be classified depending upon the type of weld.

1) Groove weld (Butt weld) :

These type of welds are provided when the members to be jointed are lined up i.e. in one plane.

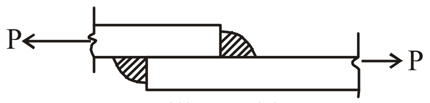
Butt Weld

Note :

1) Square butt welds are used for plates upto 8 mm of thickness only.
2) Groove welds are most suitable form of the weld for transmitting alternating stresses.

2) Fillet weld :

These are provided when two members to be jointed are in different planes or overlap each other. For such joints critical stress is shear stress.



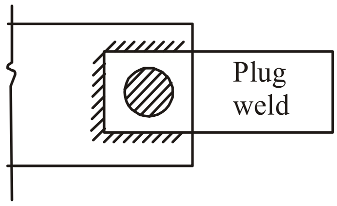
Fillet weld

Note :

Mitre fillet weld profile is the Ideal one as for minimum weld material. It provides the required strength.

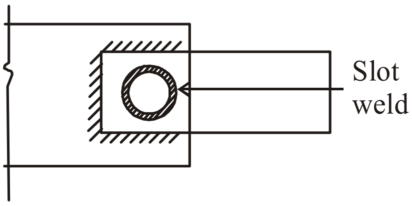
3) Plug welds :

In these type of welds small holes are made in one plate and is kept over another plate to be connected and then entire hole is filled with filler material.



4) Slot weld :

In slot weld fillet welding is made along the pheriphery of hole.



Note :

Plug and slot welds are used to reduce the unsupported dimensions of cover plates in compression.

10. Ans : 1

Section Modulus :

It is the ratio of moment of inertia of the beam cross-section about neutral axis to the distance of extreme fibre from neutral axis. It is denoted by Z.

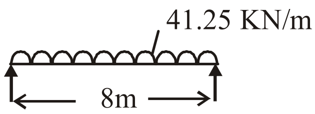
$$Z = \frac{I}{y_{max}} \quad mm^3$$

If section modulus of an area of cross-section is known, the maximum bending stress may be obtained by

$$\sigma_{max} = \frac{M}{Z}$$

Note :

Section modulus represents the strength of the section. Greater section modulus indicates stronger section.



$$M_{max} = \frac{WL^2}{8}$$

$$= \frac{41.25 \times 8^2}{8}$$

= 330 kN.m

= 330 × 10^6 N.mm

$$Z = \frac{M}{\sigma_{bc}} = \frac{330 \times 10^6}{165}$$

Z = 2 × 10^6 mm^3

11. Ans : 2

Purlins :

- These are horizontal steel members, laid longitudinally and tranverse to truss and these are designed as continuous beam.
- They are supported on principal rafter.
- They are used to support common rafters of a roof when span is large.

Rafters :

- These are inclined members running from the ridge to the eaves.
- They support the roof coverings.

Sag tie :

- Purlins always carry a tendency to sag in the direction of sloping roof.
- Therefore sometimes sag ties are provided at third points along the purlins to take the sag.

Strut :

- The internal member of truss subjected to axial compression is known as strut.

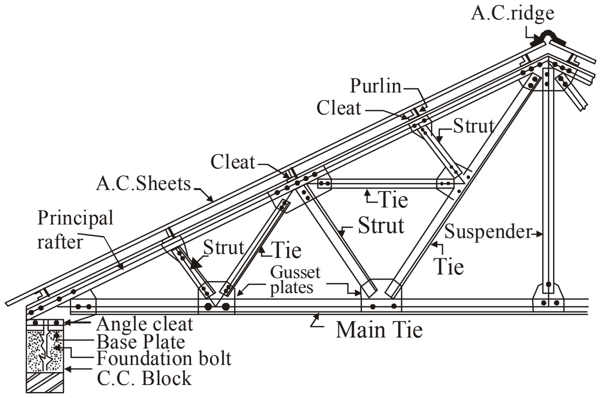


Fig. Details of Steel Roof Truss

12. Ans : 1

In eccentrically loaded connection, the bolt is subjected to both shear and tension.

IS 800 : 2007 clause 10.3.6

Bolt subjected to combined shear and tension shall satisfy

$$\left(\frac{V_{sb}}{V_{dsb}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \leq 1.0$$

Where,

V_{sb} = Factored shear force on bolt

V_{dsb} = Design shear capacity

T_b = Factored tensile force on bolt

T_{db} = Design tension capacity

Note :

IS 800 : 1984 clause 8.9.4.5

$$\left\{\frac{\tau_{vf\ cal}}{\tau_{vf}} + \frac{\sigma_{tf\ cal}}{\sigma_{tf}}\right\} \leq 1.4$$

13. Ans : 4

Fillet weld :

Critical stress for fillet weld is shear stress.

The design stress of fillet weld, $f_{wd} = \frac{f_{wn}}{y_{mw}}$

Where,

f_{wn} = nominal strength of fillet weld = $\frac{f_u}{\sqrt{3}}$

The design strength of a fillet weld depends on its throat area & is given by

$$P_{dw} = L_w\ KS\frac{F_u}{\sqrt{3}\ \gamma_{mw}}$$

Where,

L_w = Effective length of weld in mm

S = Size of fillet weld in mm

F_u = Smaller of ultimate strength of the weld and the parent material in N/mm^2

γ_{mw} = Partial safety factor

= 1.25 for shop welding

= 1.5 for site welding

Note :

If the length of the welded joint exceeds 150 times the throat size of the weld, the joint is classified as long joint and the weld strength will be less.

14. Ans : 2

Bracket type of connections are made wherever two members to be secured together do not intersect. When Bolts are subjected to direct shear & shear due to twisting moment, these are called bracket connection type 1. If bolts are subjected to direct shear and tension due to bending moment, these are called bracket connection-type 2.

Type 1 :

The total force in each bolt is the resultant of direct shear and shear due to twisting moment.

- Force in bolt due to direct shear, $f_1 = \frac{P}{n}$

Where, n = no of bolts

Net force P in above problem is zero.

$\therefore F_1 = 0$

Force in bolt due to Torque T,

$$F_2 = \frac{T \times r_n}{\sum r^2}$$

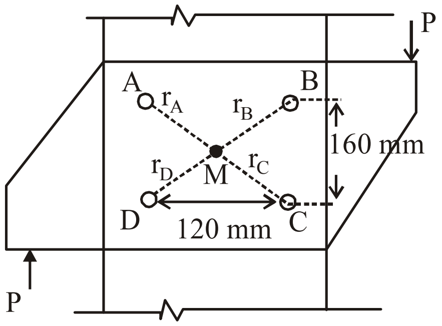
Where T → Torque generated = P × e_0

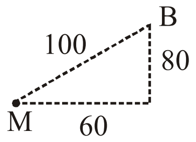
$r_1, r_2 ......r_n$ → The distance of bolts from the center of rotation of the bolt group.

Note :

For max Resultant, F_2 should be maximum and for F_2 to be maximum, r should be maximum.

$\therefore$ Select bolt with max r.





by pathagorous th^m, r = 100

$$F_2 = \frac{T \times r_n}{\sum r^2} = \frac{P \times (50 + 200 + 150) \times 100}{4 \times 100^2}$$

$$= \frac{P \times 400 \times 100}{4 \times 100^2}$$

= P

Resultant force = $\sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

$= \sqrt{0 + P^2 + 0}$ (Where θ is the

$= \sqrt{P^2}$ angle between

= P F_1 and F_2.)

15. Ans : 2

IS Codes for RCC :

IS 456 : 2000	→	Plain & Reinforced concrete-code of practice.
IS 10262 : 2009	→	Guidelines for concrete mix design proportioning.
IS 1343 : 2012	→	Code of practice for prestressed concrete.
IS 519 : 1959	→	Method of tests for strength of concrete.
IS 2386	→	Method of tests for Aggregates for concrete.
IS 3370	→	Concrete structures for the storage of liquids.
IS 432 : 1982	→	Specification for mild steel and medium tensile steel bars for concrete Reinforcement.
IS 1786 : 2008	→	High strength deformed steel bars and wires for concrete-specification.

IS Codes for Steel :

IS 875 : 1987 (Part 1)	→	Code of practice for design loads part 1 - Dead loads
IS 875 : 1987 (Part 2)	→	Imposed (live) loads
IS 875 : 1987 (Part 3)	→	Wind loads

IS 875 : 1987 (Part 4)	→	Snow loads
IS 875 : 1987 (Part 5)	→	Special loads and load combinations.
IS 800 : 2007	→	General construction is steel code of practice.
IS 1893 : 2002	→	Criteria for earthquake resistance design of structure
IS 808 : 1989	→	Dimensions of Hot Rolled Steel Sections

16. Ans : 4

As per IS 800 : 2007 section 7.8

7.8.1 → Compression members composed of two angles, channels or tees back-to-back in contact, shall be connected together by riveting, bolting or welding so that ratio of most unfavourable slenderness of each member between the intermediate connections is not greater than 40 or 0.6 times the most unfavourable ratio of slenderness of the strut as a whole, whichever is less.

7.8.2. → Where the legs of the connected angles or the connected less are 125 mm wide or more, or where webs of channels are 150 mm wide or over, not less than two rivets or bolts shall be used in each connection, one on line of each gauge mark.

7.8.4 → The rivets, bolts in these connections shall be sufficient to carry the shear force and moments and in no case shall be less than 16 mm diameter for members upto and including 10 mm thick; 20 mm diameter for members upto and including 16 mm thick, and 22 mm diameter for members over 16 mm thick.

17. Ans : 3

As per IS 800 : 1984 caluse 8.9.4.5

Bolt subjected to combined shear & Tension shall satisfy

$$\frac{f_{sb}}{f_{asb}} + \frac{f_{tb}}{f_{atb}} \le 1.4 \qquad \text{.............(1)}$$

Where,

f_{sb} → Shear stress on bolt

f_{asb} → Permissible shear stress

f_{tb} → Tensile stress on bolt

f_{atb} → Permissible tensile stresses

Note :

As per IS 800 : 2007 clause 10.3.6

$$\left(\frac{V_{sb}}{V_{dsb}}\right)^2 + \left(\frac{T_b}{T_{db}}\right)^2 \le 1.0 \qquad \text{............(2)}$$

Tricks :

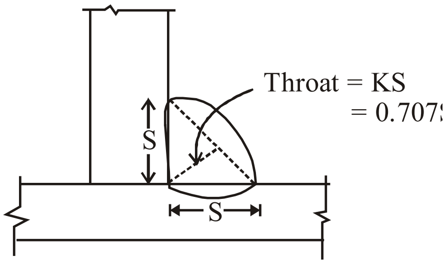
If asked in terms of stresses use equation (1) and if asked in terms of forces use equation (2).

18. Ans : 1

- For design purpose effective throat thickness is most important dimensions.
- It is the shortest distance from the root of the fillet weld to the face of the diagrammatic weld (line joining the toes)
- Effective throat thickness should not be less than 3 mm.
- It should not exceed 0.7t or 1.0t under special circumstances, where t is the thickness of thinner plate of element.

Effective throat thickness = K × size of weld = KS

Where K is a constant



Angle between fusion faces	60^o-90^o	91^o-100^o	101^o-106^o
K	0.7	0.65	0.60↓
Angle		107^o-113^o	114^o-120^o
K		0.55	0.50

8. Numerical Methods

Syllabus

Computer-aided analysis and design of structures, application of computer programming to structures. numerical methods such as

i. Finding area by Simpson's rule, trapezoidal rule;

ii. Finding root of an equation by
   a) Newton-Raphson techniques.
   b) Bisection method.

iii. Solution of simultaneous equations by
   a) Gauss elimination method.
   b) Gauss- Jordan method.
   c) Iteration method.

Content		Page No.

1 Numerical Integration

MPSC

1. The area under the polynomial for three equal intervals (h) calculated by Simpson's rule is ....

(1) $\frac{h}{6}\{f(x_0)+4f(x_1)+2f(x_2)+f(x_3)\}$

(2) $\frac{h}{3}\{f(x_0)+4f(x_1)+2f(x_2)+f(x_3)\}$

(3) $\frac{h}{3}\{f(x_0)+4f(x_1)+f(x_3)+2f(x_2)\}$

(4) $\frac{h}{6}\{f(x_0)+4[f(x_1)+f(x_2)]+2f(x_3)\}$

[MPSC : 2016]

2 The value of $\int_1^6 \frac{dx}{1+x^2}$ by using Trapezoidal rule is :

(1) 1.4108
(2) 1.3108
(3) 1.8104
(4) 1.0418

[MPSC : 2016]

3. What is the area of bending moment diagram of a simply supported beam subjected to triangular load of intensity 'W' kN/m at centre of span (L) and zero at both ends using Simpson's rule, assuming an equal interval of $\left(\frac{L}{2}\right)$?

(1) $\frac{WL^3}{8}$

(2) $\frac{WL^3}{12}$

(3) $\frac{WL^3}{16}$

(4) $\frac{WL^3}{18}$

[MPSC : 2016]

4. From the following table the area bounded by the curve and the x=axis from x=7.47 to *x* =7.52 is :

x	7.47	7.48	7.49	7.50	7.51	7.52
y = f(x)	1.93	1.95	1.98	2.01	2.03	2.06

(1) 0.09569
(2) 0.09659
(3) 0.09965
(4) 0.09865

[MPSC : 2016]

5. Match the following :

A. Newton-Raphson method
B. Simpson's 1/3rd rule
C. Trapezoidal rule
D. Gauss Elimination
E. Gauss-Jordan method

1. f (x) is a linear function of 'x'
2. The number of intervals must be even
3. Diagonal matrix
4. Solution of algebraic and transcendentel equations
5. Forward elimination and Backward substitution

Select the Correct response.

	A	B	C	D	E
(1)	1	2	3	4	5
(2)	2	3	1	5	4
(3)	3	1	2	5	4
(4)	4	2	1	5	3

[MPSC : 2017]

6. The follwing data is given for the velocity of a body as a function of time. It is required to find the velocity at t = 21 sec.
For the purpose a quadratic polynomial
v (t) = $at^2 + bt + c$ is to be used.
The velocity profile is given as

t in sec	0	13	14	15	18	20	22	24
v(t) in m/s	02	25	248.5	316.6	517.35	535.35	570	589.5

The correct set of equations that will find a, b and c is

(1) $\begin{bmatrix} 169 & 13 & 1 \\ 225 & 15 & 1 \\ 334 & 18 & 1 \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 248\times 5 \\ 316\times 6 \\ 517\times 35 \end{bmatrix}$

(2) $\begin{bmatrix} 176 & 14 & 1 \\ 225 & 15 & 1 \\ 400 & 20 & 1 \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 248\times 5 \\ 316\times 6 \\ 535\times 35 \end{bmatrix}$

(3) $\begin{bmatrix} 169 & 13 & 1 \\ 196 & 14 & 1 \\ 225 & 15 & 1 \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 225 \\ 248\times 5 \\ 316\times 6 \end{bmatrix}$

(4) $\begin{bmatrix} 324 & 18 & 1 \\ 484 & 22 & 1 \\ 225 & 15 & 1 \end{bmatrix}\begin{bmatrix} a \\ b \\ c \end{bmatrix} = \begin{bmatrix} 517\times 35 \\ 589\times 50 \\ 316\times 6 \end{bmatrix}$

[MPSC : 2017]

7. The area under straight line is an estimate of the integral of (x) between the limits a and b and the result of this integration is called trapezoidal rule. The formula used in area calculation by this rule is

(1) $I = (a - b)\dfrac{f(a) + f(b)}{4}$

(2) $I = (b - a)\dfrac{f(b) - f(a)}{2}$

(3) $I = (b - a)\dfrac{f(a) + f(b)}{2}$

(4) $I = (b - a)\dfrac{f(a) + f(b)}{3}$

[MPSC : 2018]

8. The two segment trapezoidal rule of integration is exact for integrating at most .....order polynomials
(1) First
(2) Second
(3) Third
(4) Fourth

[MPSC : 2018]

9. The curve in a trapezoidal rule passing through the coordinates of a straight line has a polynomial of ____.
(1) First order
(2) Second order
(3) Third order
(4) Fourth order

[MPSC : 2019]

10. The value of $\int_{-3}^{3} x^4 dx$ by using Trapezoidal rule is :
(1) 112 (2) 114
(3) 113 (4) 115

[MPSC : 2019]

11. A river is 80 meter wide. The depth 'd' in metres at a distance 'x' metres from one bank is given, by the following table :

x :	0	10	20	30	40	50	60	70	80
d :	0	4	7	9	12	15	14	8	3

Hence the area of c/s of the river using Simpson's rule is :
(1) 713 sq. met.
(2) 710 sq. met.
(3) 715 sq. met.
(4) 716 sq. met.

[MPSC : 2019]

12. A cross-section area of river flow can be calculated by using following formula _____.
(1) Simpson's rule
(2) Trapezoidal rule
(3) Both 1 and 2
(4) Thumb rule

[MPSC : 2019]

2. Ans : 2

Working rule for Bisection Method :

1) Let f(x) = 0 be the given equation.
find 'a' and 'b' such that f (a) < 0 and f (b) > 0 or [f (a) f (b) < 0]

2) Find first approximation root using bisection method → $x_0 = \frac{a+b}{2}$

3) Calculate f (x_0) and examine its sign

a) If f (x_0) < 0, roots lies between x_0 and b and for second approximation roots are given by

$$x_1 = \frac{x_0 + b}{2}$$

b) If f (x_0) > 0, roots lies between a and x_0, and for second approximation roots are given by

$$x_1 = \frac{x_0 + a}{2}$$

Calculate f(x) and repeat step (a) and (b) untill the required approximation of root is obtained,

for real roots of equations, $f(x) = x^3 - x - 1 = 0$

x = 0, f (0) = 0 - 0 - 1 = -1

x = 1, f (1) = 1^3 - 1 - 1 = -1

x = 2, f (2) = 2^3 - 2 - 2 = 5

Since, f (1) is negative and f (2) is positive, roots lies between 1 and 2. Therefore 1st approximation

is $x_0 = \frac{a+b}{2} = \frac{1+2}{2} = 1.5$

x = 1.5, f (x) = 0.875, which is positive, therefore roots lies between 1 and 1.5

2nd Approximation is given by,

$$x_1 = \frac{1+1.5}{2} = 1.25$$

∴ The real roots of equation is 1.25

3. Ans : 1

a) Modelling :

Mathematical modelling is the process of describing a real world problem in mathematical language solved within a symbolic system, usually in the form of equations and then using these equations both to help understand the original problems and also to discover new feat about the problem.

b) Validation :

In Mathematical terms, Validation is the process of assessing whether or not the quantity of intrest for a physical system is within some tolerance determined by the intended use of model - of the model predection.

Although, prediction sometimes refers to the situation where no data exist.

c) Convergence :

In mathematics, convergence is a property (displayed by certain innumerable series and functions) of approaching a limit more and more explicity as an argument of the function increases or decreases or as the number of terms of the series gets increased.

- An iterative method is said to be of order 'p' or has rate of convergence p, if P is the largest positive real number for which there exist a finite constant c ≠ o, such that $|\xi_{R+1}| \le C |\xi_R|^P$
C is a constant which is independent of R.

d) Pivoting :

In the first stage of elimination, the first column of the augmented matrix searched for the largest element in magnitude brought as first pivot.

- In second stage of elimination, the second column is searched for the largest element in magnitude among the n-1 elements leaving the first element and this element is brought as the second pivot by interchanging the second row of Augmented matrix with the later row having the largest element in magnitude. This procedure is continued untill the upper triangular system is obtained.
- Therefore partial piovting is done after every stage of elimination.
- There is another procedure called complete pivoting.

In this procedure, we search the entire matrix. A is the agumented matrix for the largest element in magnitude and bring it as the first pivot.

4. Ans : 3

In Bisection method the absolute relative approximate error in the estimated value of root is given by -

$$|\in_{abs}| = \left|\frac{X_m^{new} - X_m^{old}}{X_m^{new}}\right| ......(1)$$

$X_m^{New} \rightarrow$ root from latest iteration

$X_m^{old} \rightarrow$ root from old iteration

Case 1 :

$f(X_L)\, f(X_U) > 0, \quad X_L = X_M$ and $X_U = X_V$

$$|\in_{abs}| = \left|\frac{X_m^{new} - X_{Lower}}{X_m^{new}}\right|$$

$$|\in_{abs}| = \left|\frac{\frac{X_m + X_U}{2} - X_l}{\frac{X_M + X_U}{2}}\right|$$

$$|\in_{abs}| = \left|\frac{X_U - X_L}{X_L + X_U}\right| \qquad X_u = X_{upper}$$

$$X_L = X_{Lower}$$

Case 2 :

$f(X_L)\, f(X_U) < 0, \quad X_l = X_l$ and $X_U = X_M$

$$\therefore \quad |\in_{abs}| = \left|\frac{X_M^{new} - X_U}{X_M^{new}}\right|$$

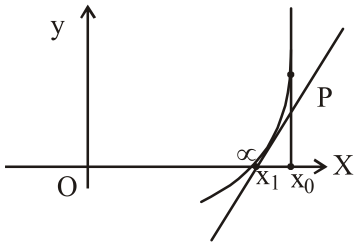
$$|\in_{abs}| = \left|\frac{\frac{X_M + X_L}{2} - X_U}{\frac{X_M + X_L}{2}}\right|$$

$$|\in_{abs}| = \left|\frac{X_{Lower} - X_{Upper}}{X_{Lower} + X_{Upper}}\right|$$

5. Ans : 3

Newtons Raphson Method is also called as Newtons method. It is also a chord method in which we approximate the curve near a root, by a straight time.

- The point of intersection of tangent with the x-axis is taken as the next approximation. Hence, it is also called as Tangent Method.



- The iteration method is defined as,

$$X_{R+1} = X_R - \frac{f(X_R)}{f'(X_R)}, \quad f'(X_R) \neq 0$$

- Newton-Raphson method has second order or quadratic convergence.

$$\in_{n+1} = \frac{1}{2} \in n^2 \frac{f''(\xi)}{f'(\xi)}$$

- This method is used for solving both algebraic and transcendental equation and also used when roots are complex.
- It is also known as open End method.
- Iteration formula is given as :

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}, \qquad f'(x_n) \neq 0$$

6. Ans : 3

Given equations,

$f(x_1 y_1) = x^2 + 2xy = 6$

$f(x_2\, y_2) = x^2 - y^2 = 3$

Jacobi Matrix is given as,

$$[A] = \begin{bmatrix} \frac{\partial f_1}{\partial x} & \frac{\partial f_1}{\partial y} \\ \frac{\partial f_2}{\partial x} & \frac{\partial f_2}{\partial y} \end{bmatrix}$$

Let $X_1 = X_o + h$

$Y_1 = Y_o + k$

Such that $f_1(X_1, Y_1) = 0$ and $f_2(X_2, Y_2) = 0$

Newton Raphson equation will be given by :

$$F_{1_0} + h\frac{\partial f_1}{\partial x} R \frac{\partial f_2}{\partial y}$$

$$F_{2_0} + h\frac{\partial f_2}{\partial x} + \frac{\partial f_2}{\partial y}$$

Here, F_{1_0} and F_{2_0} are the value of function at (x_0, y_0)

$f_1 = x^2 + 2xy = 6$

$$\frac{\partial f_1}{\partial x} = 2x + 2y$$

$$\frac{\partial f_2}{\partial x} = 2x$$

$f_2 = x^2 - y^2 - 3$

$$\frac{\partial f_2}{\partial x} = 2x \quad \frac{\partial f_2}{\partial y} = -2y$$

$$\therefore [A] = \begin{bmatrix} 2x+2y & 2x \\ 2x & -2y \end{bmatrix}$$

$$|A| = (2x+2y)(-2y) - (2x)(2x)$$

$= -4xy - 4y^2 - 4x^2$ ....(1)

Finding Initial Approximation by Newtons Raphsons Method,

We find the value of 'x' and 'y' to be

(1.414, 0.517)

By substituting the values in equation (1)

$= -4xy - 4y^2 - 4x^2$

$= -4(1.414)(0.517) - 4(0.517)^2 - 4(1.414)^2$

$= -2.924 - 1.069 - 7.997$

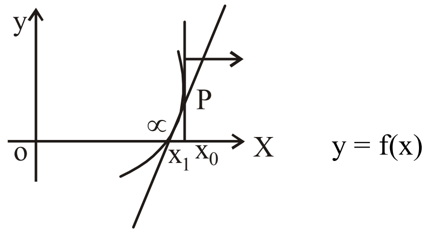
$= -12$

7. Ans : 4

- **Sign bit** is the representation of a number indicating whether it is negative or positive; applicable to both two complement and signed magnitude representation.
- Whereas, Partial **Derivative** of a function of several variables is its derivative with respect to one of those variables, with the other held constant.
- Floating - Point form representation of real number.
- This representation does not reserve a specific number of bids for the integer part or the fraction part. Instead it reserves a certain number of bits for the number called Mantissa or significant and a certain number of bits to say where within that number the decimal place sits called the exponent.
- The mantissa is the fraction part of a common logaritham (that is the base 10 logarithm) which represent the digits of the given number but not its order or magnitude.

8. Ans : 3

- Newton Raphson method is also a chord method in which we approximate the curve near a root, by a straight line.
- The point of intersection of tangent with the x-axis is taken as the next approximation. Thus it is also called as Tangent method.



- Finding the roots of equation means finding the value of 'x' where it cuts the x-axis.

Iteration method is defined as,

$$x_{R+1} = x_R - \frac{f(x_R)}{f'(x_R)}, \qquad f'(x_R) \neq 0$$

Equation given,

$x^3 - 2x - 5 = 0$

By using initial approximation x = 2,

i.e. $x_k = 2$ in the given Newton Raphson formulae above

$f(X_R) = f(2) = (2)^3 - 2 \times 2 - 5 = -1$

$f'(X_R) = f'(2) = 3x^2 - 2 = 3 \times (2)^2 - 2 = 10$

$$\therefore X_2 = 2 - \frac{(-1)}{10} = 2 + 0.1 = 2.1$$

9. Ans : 3

$$x_{R+1} = x_k - \frac{f(x_R)}{f'(x_R)}, \qquad f'(x_R) \neq 0$$

Using the above formula,

We have,