

Precast and Prestressed Concrete Structures (315317)

MSBTE K-Scheme · Civil Engineering Semester 5 · Model Question Paper — Set A · Model Answers

Q.1 Attempt any FIVE of the following: (10 M)

a) Precast concrete with examples

2 M

Precast concrete: Precast concrete is concrete that is cast into a member of required shape and size in a reusable mould at a factory or casting yard (away from its final position), cured under controlled conditions, and then transported to site and erected in its final position.

Examples: fencing poles, paver blocks, manhole covers, door/window frames, slab panels, box culverts, piles.

(Definition 1 M, examples/points 1 M)

b) Module and modular co-ordination

2 M

Module: A module is a unit of size used as the basic increment for coordinating the dimensions of buildings and components. The **basic module M = 100 mm**; multi-modules such as 3M (300 mm), 6M, 12M are used for planning.

Modular co-ordination: It is the inter-dependent arrangement of dimensions of buildings and their components on the basis of the module, so that standard components fit together without cutting or wastage (adopted in IS 15916 / National Building Code for prefabrication).

(Module 1 M, modular co-ordination 1 M)

c) Basic principle of prestressed concrete

2 M

Prestressed concrete is concrete in which internal stresses of suitable magnitude and distribution are deliberately introduced (by stretched high-tensile steel) so that the stresses produced by external loads are counteracted to a desired degree.

Principle: Concrete is strong in compression but weak in tension. A compressive force (prestress) is applied to the member before it is loaded, so that the tensile stresses caused later by the loads are cancelled (or reduced) by the pre-compression, and the whole section remains in compression without cracks.

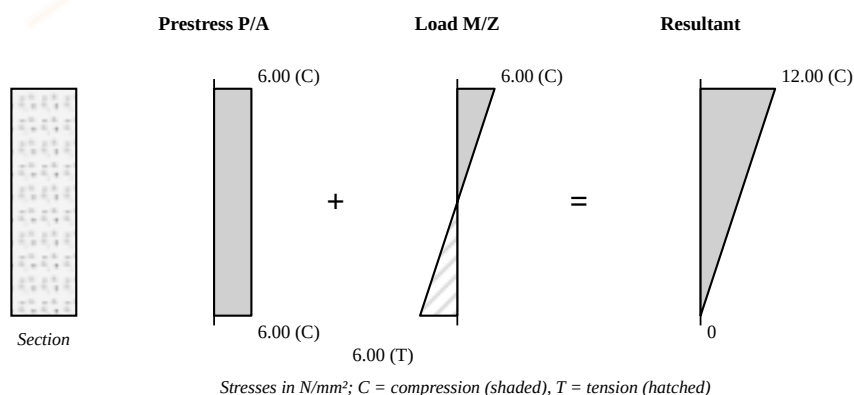


Fig.: Principle of prestressing – precompression cancels flexural tension

(Principle 2 M)

d) Pre-tensioning and post-tensioning

2 M

i) Pre-tensioning: The tendons are tensioned between fixed abutments **before** the concrete is placed; after the concrete hardens the tendons are released and the prestress is transferred to the concrete **by bond**.

ii) Post-tensioning: The concrete member is cast first with ducts; **after** it hardens the tendons are tensioned by jacks and anchored at the ends with mechanical anchorages; ducts are then grouted.

(1 M each)

e) Meaning of loss of prestress

2 M

Loss of prestress: The initial prestressing force applied to the concrete does not remain constant; it gradually **reduces** due to shortening of concrete and relaxation of steel. This reduction of the prestressing force (or stress in the tendon) from its initial value is called **loss of prestress**. Force remaining after all losses = effective prestress.

Losses: elastic shortening of concrete, shrinkage of concrete, creep of concrete, relaxation of steel, friction and anchorage slip (post-tensioning).

(Meaning 1 M, types 1 M)

f) Assumptions in analysis of PSC beams

2 M

1. Concrete is a homogeneous, elastic material.
2. Within the range of working stresses, both concrete and steel behave elastically (small creep is ignored).
3. A plane section before bending remains plane after bending, i.e. strain varies linearly with depth.
4. Bonded tendons have no slip – change of strain in steel equals change of strain in surrounding concrete.

(Any 4, ½ M each)

g) Autoclaved Aerated Concrete (AAC)

2 M

Autoclaved Aerated Concrete (AAC): AAC is a lightweight, precast cellular concrete made from cement, lime, fine sand or fly ash, gypsum and water, to which a small quantity of **aluminium powder** is added. The aluminium reacts to release hydrogen gas which forms millions of small air cells; the risen mass is cut into blocks/panels and **cured under high-pressure steam in an autoclave**.

Its density is only about 400–800 kg/m³, so it is light, thermally insulating and fire resistant. **Uses:** AAC blocks for walls/partitions, reinforced AAC wall and roof panels.

(Definition 2 M)

Q.2 Attempt any THREE of the following: (12 M)

a) Necessity of precast concrete

4 M

Precast concrete has become necessary in present-day construction for the following reasons:

1. **Speed of construction:** elements are cast in the factory while foundations are in progress at site, so total project time reduces.
2. **Quality control:** factory conditions (steel moulds, mechanised batching, vibration, steam curing) give uniform, high-quality concrete with accurate sizes.
3. **Mass housing / repetitive work:** standard elements of the same size are produced in large numbers, so cost per unit falls.
4. **Less formwork and scaffolding** at site; moulds are reused many times.
5. **All-weather work:** casting is not affected by rain or extreme climate; less dependence on skilled labour at site.

(Any four points, 1 M each)

b) Fencing pole and paver block

4 M

i) Precast fencing poles:

- RCC (or pre-tensioned) poles of square/tapered section, about 100–150 mm, height 1.8–2.4 m above ground, made in steel moulds.
- Reinforced with 4 longitudinal bars/wires and lateral ties; holes or hooks are left for barbed wire.
- About 0.5–0.6 m is embedded in a concrete block in the ground; strutted at corners.
- Durable, no corrosion/termite problem like steel or timber; used for compound walls, farms, highways, railways.

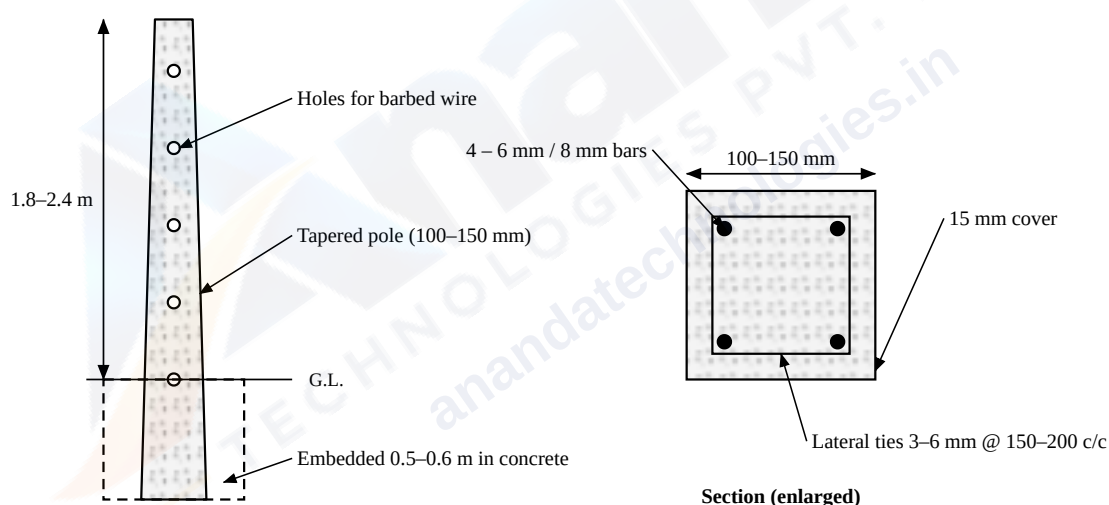


Fig.: Precast RCC fencing pole – elevation and cross-section

ii) Paver blocks:

- Small solid unreinforced precast blocks (60, 80, 100 mm thick) of shapes like rectangular, I-shape, zig-zag and hexagonal (IS 15658).
- Made by high-pressure vibro-compaction of zero-slump concrete; laid on a 20–40 mm sand bed over a compacted base.
- Joints are filled with fine sand; the blocks interlock and spread load to neighbours.
- Used for footpaths, parking, petrol pumps, industrial yards and low-speed roads; easy to lift and re-lay for repairs.

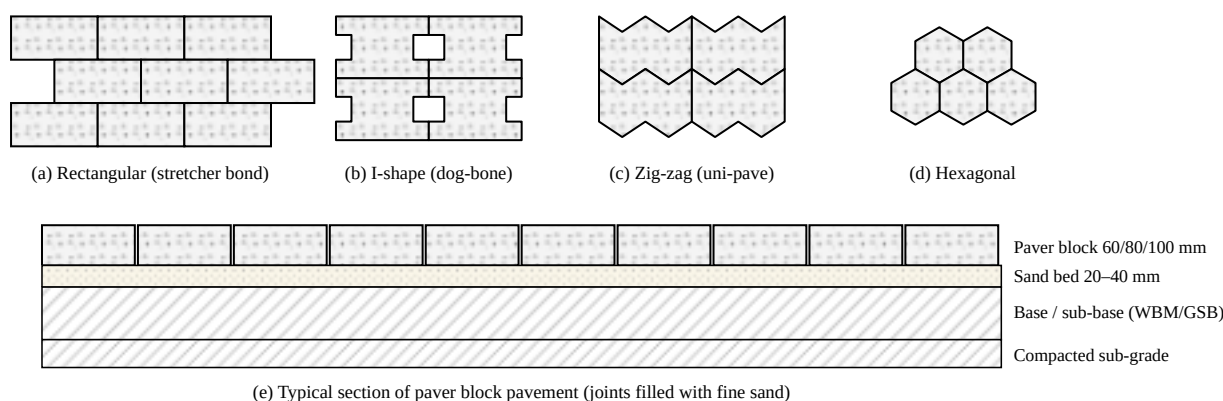


Fig.: Interlocking concrete paver blocks – common shapes and laying section

(Each element with sketch 2 M)

c) Precast box culvert

4 M

A **precast box culvert** is a closed rectangular (box) RCC unit, cast in segments in a yard and laid in line to carry water below a road, railway or canal bank.

Key features:

1. Monolithic box section – top slab, bottom slab and two side walls act together as a rigid frame; single or multi-cell.
2. Haunches (fillets) at the inside corners reduce stress concentration.
3. Double reinforcement cage (inner and outer) for earth pressure and wheel loads.
4. Standard segment length about 1–2.5 m; joined by **tongue-and-groove / spigot-socket joints** sealed with mortar or sealant.
5. Laid on a levelled bedding; very fast installation – traffic diversion time is short.
6. Better quality and durability than cast-in-situ culverts; no formwork in the stream.

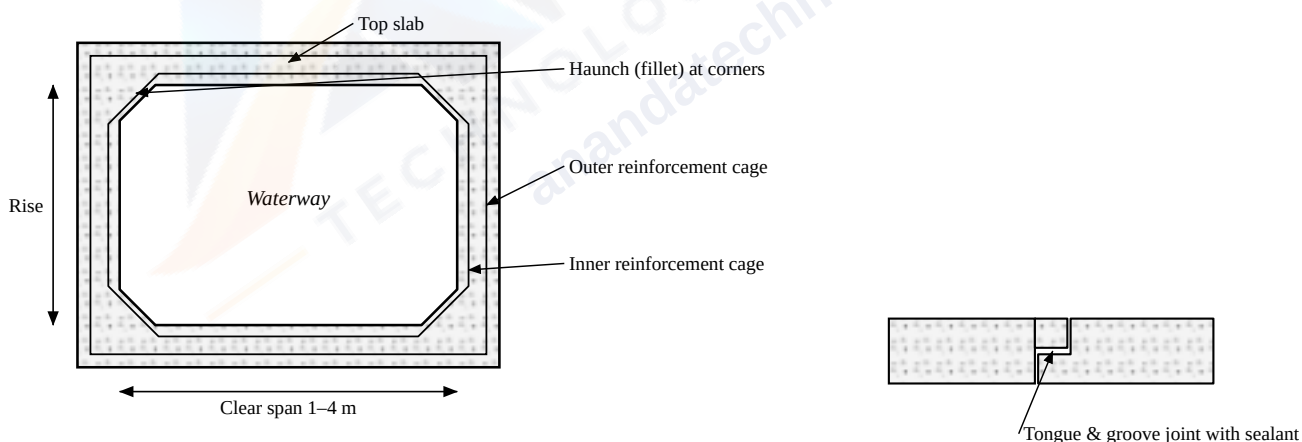


Fig.: Precast RCC box culvert segment (single cell)

(Features 3 M, sketch 1 M)

d) Materials for precast concrete

4 M

Material	Requirement / use in precast work
Cement	OPC 43/53 grade or PPC; rapid-hardening cement for early demoulding.

Fine aggregate	Clean, well-graded natural or manufactured sand.
Coarse aggregate	Hard, well-graded, usually 10–20 mm (smaller for thin units).
Water	Clean, potable water for mixing and curing.
Admixtures & mineral additions	Super-plasticizers, accelerators, fly ash / silica fume for high early strength and workability.
Reinforcement	HYSD bars, welded mesh; high-tensile wires/strands for prestressed units.
Inserts & lifting hooks	Lifting loops, anchors, sockets, dowels and plates cast-in for handling and connections.
Mould materials	Steel / FRP / timber moulds with mould-release oil.
Jointing materials	Non-shrink grout, epoxy, sealants, elastomeric bearing pads.

(Any four materials with use, 1 M each)

Q.3 Attempt any THREE of the following: (12 M)

a) Storage and transportation of precast elements

4 M

Storage:

- Store on firm, level, well-drained ground close to the crane reach, in the order of erection.
- Slabs/beams are stacked flat on timber battens placed at the lifting points (about 0.2 L from ends), all battens in one vertical line.
- Wall panels are stored vertically in A-frame racks; limit stack height; protect edges and inserts.
- Continue curing; mark every unit (type, date of casting, weight) on the face.

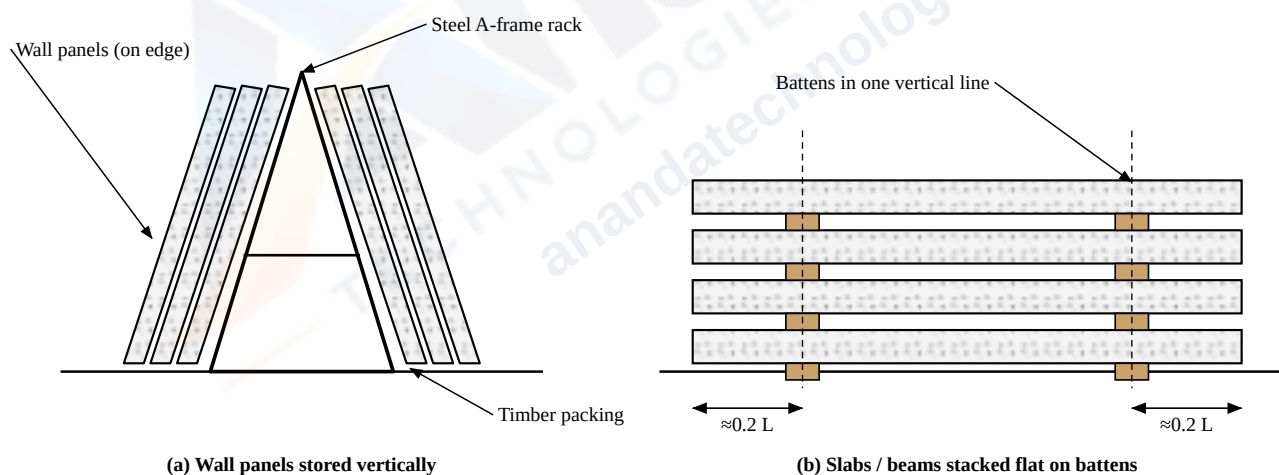


Fig.: Storage of precast elements at site / yard

Transportation:

- Transport only after the unit attains the required strength (shown by cube tests).
- Use flat-bed trailers / low-bed trucks; panels on A-frames, beams supported at the same points as in storage.
- Tie down with chains over rubber/timber padding; avoid impact and cantilever overhang.
- Plan route (turning radius, bridges, height) and keep the travel sequence matched with erection.

(Storage 2 M, transportation 2 M)

b) Requirements of structural joints

4 M

Requirements of structural joints between prefabricated elements:

1. **Strength:** the joint must safely transfer all forces (axial load, shear, bending moment) between the members.
2. **Ductility and stability:** it should deform without sudden failure (important in earthquakes).
3. **Durability:** steel inserts and bars in the joint must be protected from corrosion; good cover/grout.
4. **Water-tightness and weather resistance** (external joints sealed against rain and air).
5. **Accommodate tolerances and movements** due to temperature, shrinkage and creep.
6. **Fire resistance and sound insulation** equal to that of the members.
7. **Simple and quick to make at site** with little in-situ work; easy to inspect; economical.

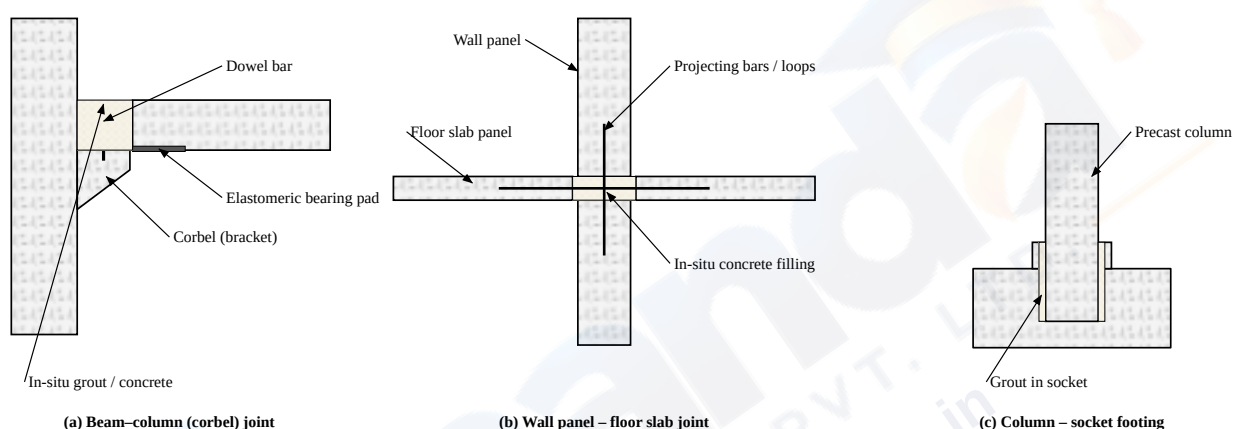


Fig.: Typical structural joints in prefabricated construction

(Any four requirements 4 M (sketch for clarity))

c) Pre-tensioning vs post-tensioning

4 M

Pre-tensioning	Post-tensioning
Tendons are stretched before casting concrete.	Tendons are stretched after the concrete hardens.
Prestress transferred to concrete by bond.	Prestress transferred by end anchorages (bond later by grouting).
Needs strong abutments / prestressing bed; done in factory.	No bed needed; can be done at site.
Suitable for small, mass-produced members (sleepers, poles, slabs).	Suitable for large, heavy, long-span members (bridge girders).
Tendons are generally straight (or harped).	Tendons can be curved (parabolic) to suit B.M.

(Any four points, 1 M each)

d) Applications of prestressed concrete

4 M

1. **Bridges:** long-span pre-tensioned and post-tensioned girders, box girders, segmental bridges.
2. **Railway sleepers** (pre-tensioned, mass produced).

3. **Electric and telephone poles**, piles and sheet piles.
4. **Roofs and floors**: hollow-core slabs, double-T units, shell roofs, flat slabs of large span.
5. **Liquid-retaining structures**: circular water tanks, pipes (circumferential prestressing), silos.
6. **Others**: nuclear containment vessels, towers, stadium stands, ground anchors, pavements and runways.

(Any four applications, 1 M each)

Q.4 Attempt any THREE of the following: (12 M)

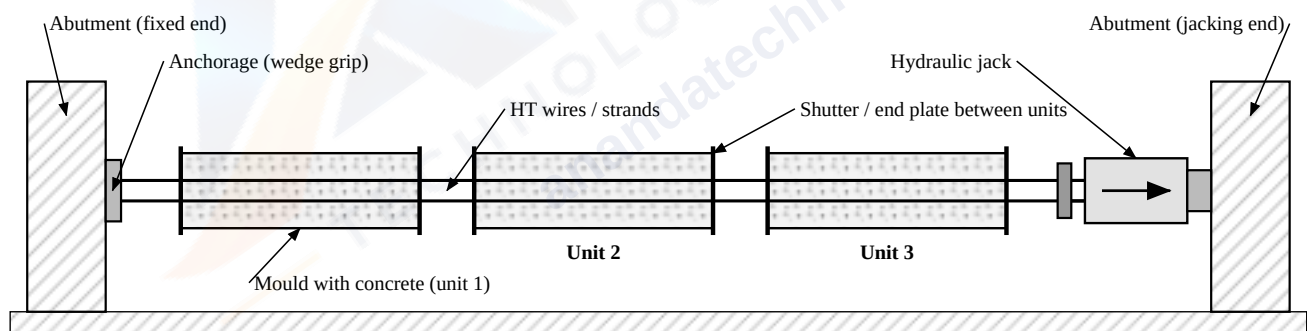
a) Hoyer system of pre-tensioning

4 M

The **Hoyer system** (long-line method) is the most common method of **pre-tensioning**, used for mass production in a factory.

Procedure:

1. Two strong **abutments** (end bulkheads) are built at the ends of a long casting bed, 50 m to 200 m apart.
2. High-tensile wires/strands are threaded through the end plates of a series of moulds placed in one line, anchored at the fixed end and stretched by a hydraulic jack at the other end; then anchored by wedge grips.
3. **Shutters (end plates)** are placed between the individual members, so that several members are cast in one line in one operation.
4. Concrete is placed, compacted and cured (often steam cured).
5. When the concrete reaches the transfer strength, the wires are released gradually from the abutments and **cut between the units**; the prestress is transferred to each member **by bond**. The members shorten and camber slightly.



Casting bed (length 50 m to 200 m; several members cast in one line)

After concrete hardens: wires released / cut between units → force transferred by bond

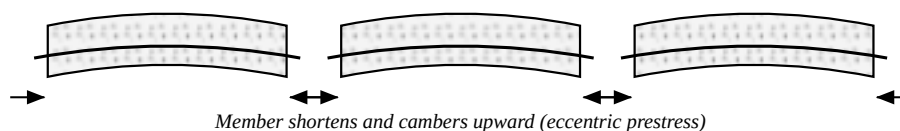


Fig.: Hoyer's long line system of pre-tensioning

(Explanation 2 M, labelled sketch 2 M)

b) Cable profiles

The cable (tendon) profile is the line followed by the tendon along the span. In a simply supported rectangular beam the following profiles are used:

Concentric tendon: tendon along the centroidal axis ($e = 0$). Produces uniform compression P/A over the section; it does not counteract bending, so it is used for axially loaded members, piles, poles and short beams.

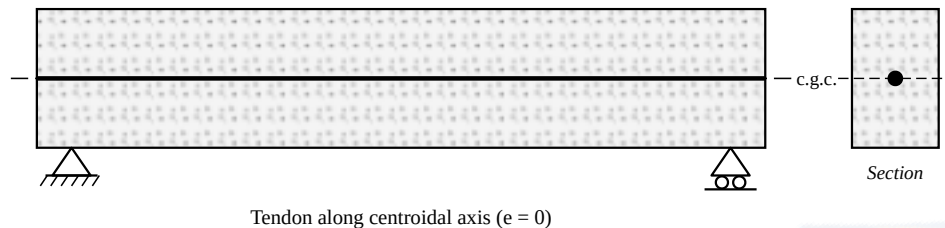


Fig.: (a) Concentric tendon

Eccentric straight tendon: tendon placed below the centroid at a constant eccentricity e along the whole span. It gives $P/A \pm Pe/Z$ – useful moment Pe at mid-span, but at the supports (where load moment is zero) the same Pe may cause tension at the top. Easy to provide in pre-tensioned members.

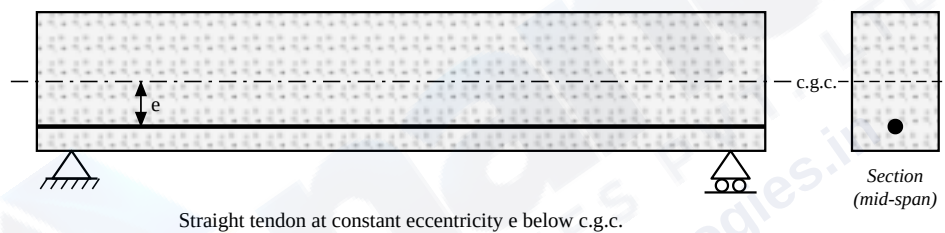


Fig.: (b) Eccentric straight tendon

Parabolic tendon: tendon follows a parabola with $e = 0$ (at the centroid) at the supports and maximum e at mid-span, matching the parabolic B.M.D. of a UDL. Moment due to prestress varies like the load moment, so stresses are favourable at every section; tendon slope also gives a vertical component that reduces shear. Common in post-tensioned members.

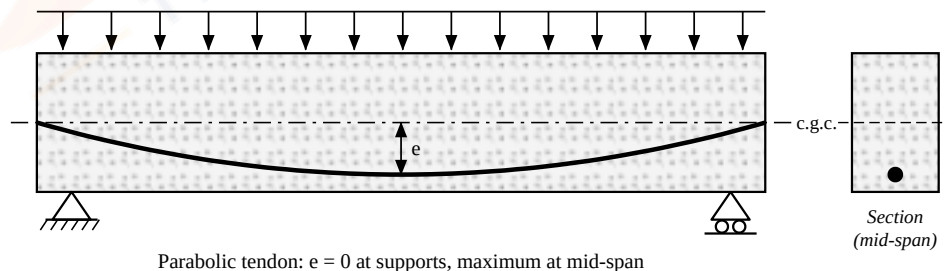


Fig.: (c) Parabolic tendon

(Sketches with labels)

c) Loss due to elastic deformation of concrete

When the prestress is transferred, the concrete shortens elastically by strain $\epsilon_c = f_c/E_c$, where f_c is the stress in concrete at the level of the tendon. The tendon, being bonded/anchored to the concrete,

shortens by the same strain and loses stress.

Pre-tensioned members: $\text{loss} = \epsilon_c \cdot E_s = (f_c/E_c) \cdot E_s = m \cdot f_c$, where $m = E_s/E_c$ and $f_c = P/A + P \cdot e^2/I$.

Post-tensioned members: (i) if all cables are tensioned simultaneously, the jack applies the force after the concrete has shortened, so **there is no loss**; (ii) if cables are tensioned one after another, each cable shortens the concrete and causes loss in the cables already anchored – the first cable loses most and the last none; the average loss is taken as $\frac{1}{2} \cdot m \cdot f_c$.

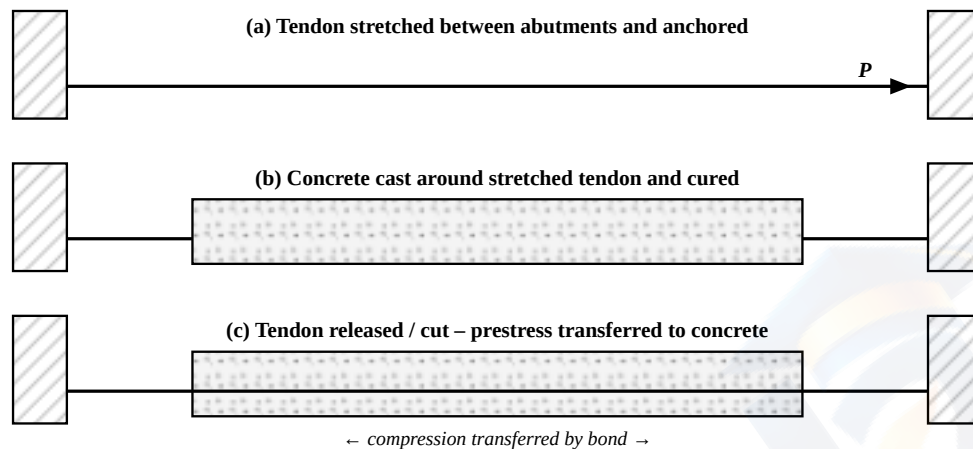


Fig.: Stages of pre-tensioning

(Explanation 2 M, expressions for pre- and post-tensioning 2 M)

d) Concentric cable – stresses at mid-span

4 M

Given: $b = 250 \text{ mm}$, $D = 500 \text{ mm}$, span $L = 6 \text{ m}$, prestress $P = 600 \text{ kN}$ at the centroid ($e = 0$), live load $q = 12 \text{ kN/m}$, density of concrete $= 25 \text{ kN/m}^3$.

Step 1 – Section properties

$$A = b \times D = 250 \times 500 = 125,000 \text{ mm}^2$$

$$I = bD^3/12 = 250 \times 500^3 / 12 = 2.6042 \times 10^9 \text{ mm}^4$$

$$Z = bD^2/6 = 250 \times 500^2 / 6 = 1.0417 \times 10^7 \text{ mm}^3$$

Step 2 – Loads and bending moment at mid-span

$$\text{Self weight } g = 0.25 \times 0.5 \times 25 = 3.125 \text{ kN/m}$$

$$\text{Total } w = g + q = 3.125 + 12 = 15.125 \text{ kN/m}$$

$$M = wL^2/8 = 15.125 \times 6^2 / 8 = \mathbf{68.06 \text{ kN}\cdot\text{m}}$$

Step 3 – Stresses

$$\text{Direct stress due to prestress} = P/A = 600 \times 10^3 / 125,000 = 4.80 \text{ N/mm}^2 \text{ (compression, uniform)}$$

$$\text{Bending stress} = M/Z = 68.06 \times 10^6 / 1.0417 \times 10^7 = 6.53 \text{ N/mm}^2$$

$$\text{Top fibre} = P/A + M/Z = 4.80 + 6.53 = \mathbf{11.33 \text{ N/mm}^2 \text{ (compression)}}$$

$$\text{Bottom fibre} = P/A - M/Z = 4.80 - 6.53 = \mathbf{-1.73 \text{ N/mm}^2 \text{ (tension)}}$$

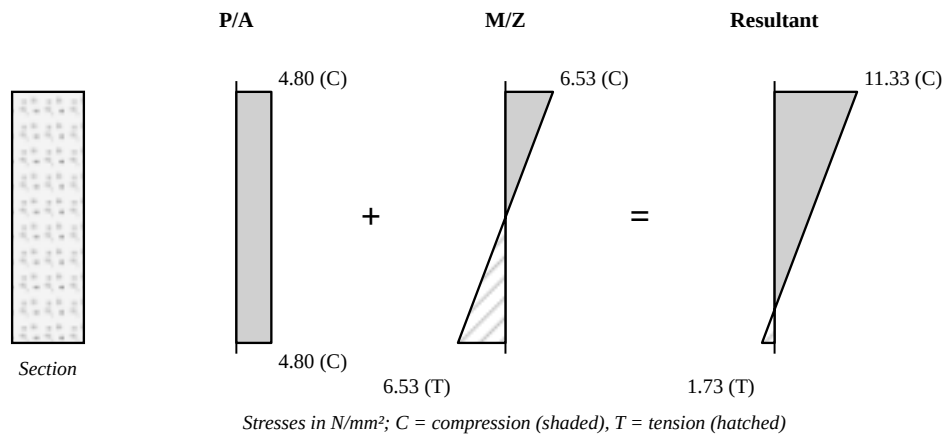


Fig.: Stress distribution at mid-span (concentric tendon)

Comment: With a concentric tendon the whole section gets the same compression 4.80 N/mm^2 ; a small tension remains at the bottom, so an eccentric tendon (or a larger P) would be more economical.

(Section properties & M 1 M, stresses 2 M, diagram 1 M)

e) Need of high-strength materials

4 M

Need of high-strength concrete:

1. Concrete must resist high compressive stresses near the anchorages and at transfer; high grade (IS 1343: M40 pre-tensioned, M30 post-tensioned minimum) is needed.
2. High-strength concrete has higher modulus of elasticity, so **elastic shortening, creep and shrinkage are less** → less loss of prestress.
3. Higher bond strength – essential to transfer prestress in pre-tensioned members.
4. Higher tensile (flexural) strength delays cracking; allows smaller, lighter sections.
5. Dense concrete gives better durability and protection to the highly stressed steel.

Need of high-tensile steel:

1. Total loss of prestress is about $150\text{--}250 \text{ N/mm}^2$ (shrinkage + creep + relaxation). If mild steel stressed to about $120\text{--}140 \text{ N/mm}^2$ were used, almost all the prestress would be lost.
2. High-tensile steel can be stressed to about $1000\text{--}1400 \text{ N/mm}^2$, so even after losses a large effective prestress (80–85 %) remains.
3. Less steel area is needed for the same force – lighter cables, smaller ducts.

Conclusion: Only high-strength materials make prestressing effective and economical.

(Concrete 2 M, steel 2 M)

Q.5 Attempt any TWO of the following: (12 M)

a) Prefabricated building construction and process

6 M

Prefabricated building construction is a method in which the main components of a building (wall panels, slabs, beams, columns, staircases) are manufactured in a factory or site casting yard, transported to site and assembled with suitable joints to form the complete building.

Process:

1. Planning and design using modular co-ordination; selection of the prefab system (large panel, frame, or box system).
2. Manufacture of components: mould preparation, reinforcement, casting, compaction and curing.
3. Demoulding, quality checks and marking of components.
4. Storage and stacking in the yard; transportation to site on trailers.
5. Erection by cranes on prepared foundations, temporary propping, alignment.
6. Jointing (grouting / in-situ concrete / welding of inserts), finishing and services.

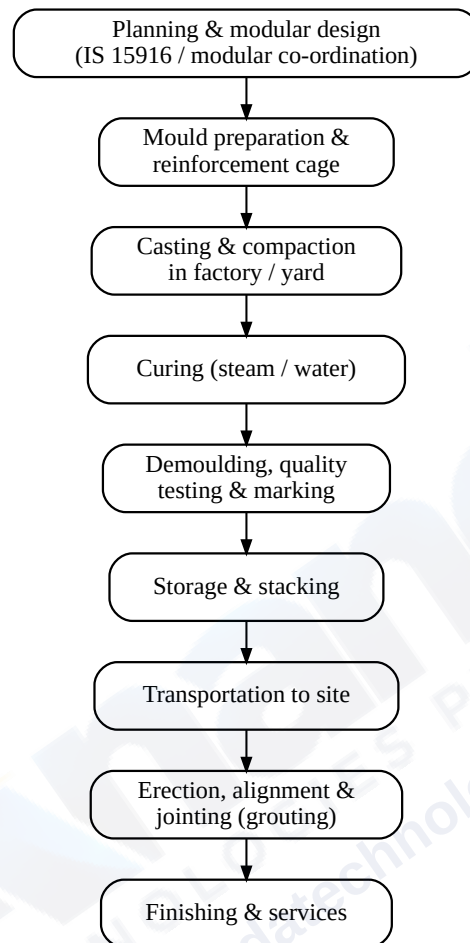


Fig.: Process of prefabricated building construction

(Meaning 2 M, process with flow chart 2 M (6 M: full process + sketch))

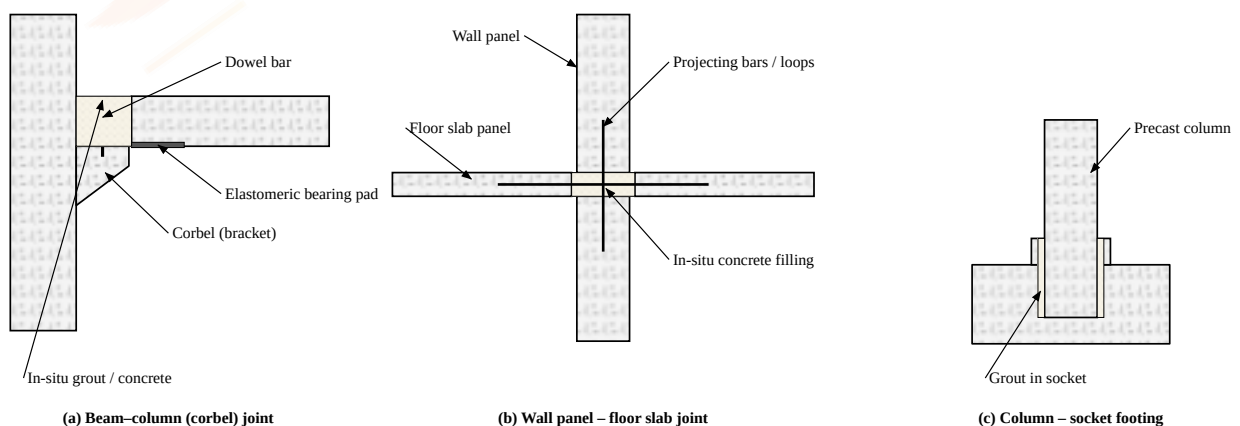


Fig.: Typical joints made at the jointing stage

b) Freyssinet system

6 M

The **Freyssinet system** (developed by E. Freyssinet, France) was the first post-tensioning system. It uses **conical wedge anchorages** and a **double-acting jack**.

Components:

1. **Female cone:** a cylinder of high-strength concrete (or steel) with a conical hole, embedded at the end of the member, with spiral reinforcement behind it.
2. **Male cone:** a serrated (grooved) conical plug that fits inside the female cone; it has a central hole for grouting.
3. **Cable:** 8, 12 or 16 wires (5 mm or 7 mm Ø) or strands placed in a duct/sheath, arranged around the male cone.
4. **Double-acting jack:** one action grips and pulls the wires, the second action (inner ram) pushes the male cone into the female cone.

Process:

1. Member is cast with the duct and female cones in position.
2. Wires are threaded, passed around the male cone and gripped in the jack.
3. Jack pulls all the wires of the cable together to the required force (checked by gauge pressure and elongation).
4. The inner ram pushes the male cone forcibly into the female cone, wedging the wires between them; jack pressure is released – wires remain anchored by friction.
5. Cement grout is injected through the hole in the male cone to fill the duct and bond the wires.

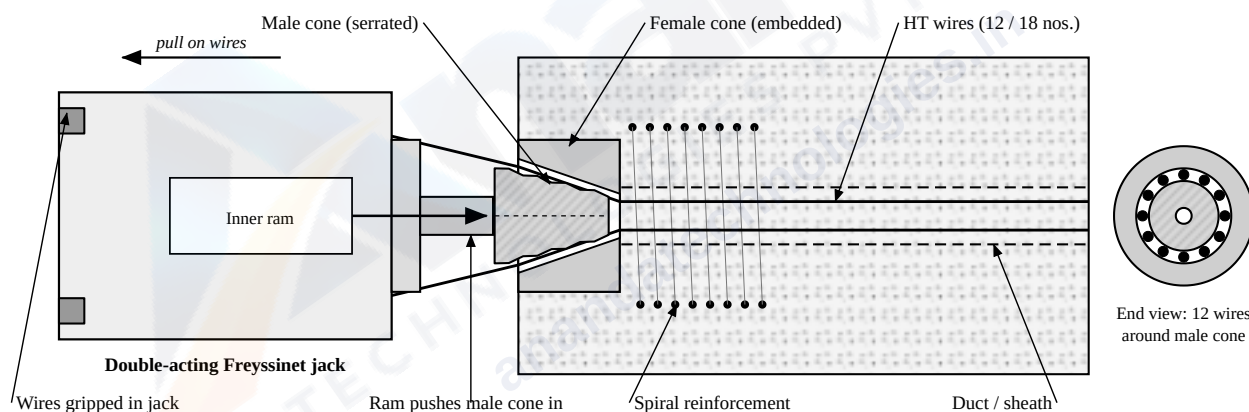


Fig.: Freyssinet system – conical wedge anchorage and double-acting jack

Applications: long-span bridge girders, box girders, large roof beams, water tanks and other heavy post-tensioned members where large forces in multi-wire cables are required.

(Components/process 3 M, sketches 2 M, applications 1 M)

c) Equipment for prefabricated construction

6 M

Equipment	Application
Tower crane	Lifting and placing panels/slabs on multi-storey buildings; large reach.
Mobile (truck/crawler) crane	Erection of columns, beams, girders on site; moves from place to place.

Gantry / EOT crane	Handling units inside factory and stacking yard.
Trailers / low-bed trucks	Transporting heavy and long elements to site.
Forklift	Moving small units (blocks, pavers, kerbs) in yard.
Spreader beam & slings / lifting frame	Even lifting of long units at fixed lifting points without bending.
Chain-pulley blocks, jacks	Small lifts, fine adjustment and levelling during erection.
Props, braces, wedges	Temporary support and alignment until joints harden.
Batching plant, transit mixer, vibrators / vibrating table	Producing and compacting concrete for precast units.
Steam-curing chamber	Accelerated curing for early demoulding.
Grout pump, welding set	Filling joints / ducts and welding of connection plates.

(Any six equipment with application, 1 M each)

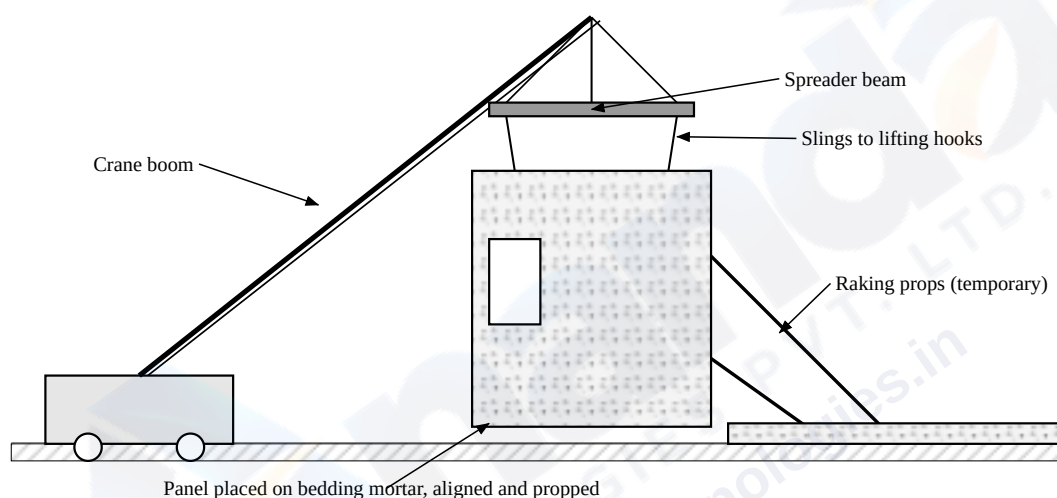


Fig.: Erection of a precast wall panel by crane with spreader beam

Q.6 Attempt any TWO of the following: (12 M)

a) Loss of prestress – pre-tensioned beam (numerical)

6 M

Given: $b \times D = 250 \times 400 \text{ mm}$, $A_p = 350 \text{ mm}^2$ at $e = 60 \text{ mm}$, $f_{pi} = 1120 \text{ N/mm}^2$, $f_{pu} = 1600 \text{ N/mm}^2$, $E_s = 210 \text{ kN/mm}^2$, $E_c = 35 \text{ kN/mm}^2$, creep coefficient $\theta = 1.6$, shrinkage strain $\epsilon_{sh} = 300 \times 10^{-6}$ (IS 1343 value for pre-tensioned members). Self-weight moment neglected (conservative).

Step 1 – Section properties

$$A = b \times D = 250 \times 400 = 100,000 \text{ mm}^2$$

$$I = bD^3/12 = 250 \times 400^3 / 12 = 1.3333e+09 \text{ mm}^4$$

$$Z = bD^2/6 = 250 \times 400^2 / 6 = 6.6667e+06 \text{ mm}^3$$

Step 2 – Prestressing force and stress in concrete at tendon level

$$P = A_p \times f_{pi} = 350 \times 1120 = 392,000 \text{ N} = 392.0 \text{ kN}$$

$$f_c = P/A + P \cdot e^2/I = 392,000/100,000 + 392,000 \times 60^2 / 1.3333e+09 = 3.920 + 1.058 = \mathbf{4.978 \text{ N/mm}^2}$$

$$\text{Modular ratio } m = E_s/E_c = 210/35 = 6.00$$

Step 3 – Individual losses

Loss	Formula	Working	Loss (N/mm ²)	% of f_{pi}
1. Elastic deformation of concrete	$m \cdot f_c$	6.00×4.978	29.87	2.67
2. Creep of concrete	$\theta \cdot m \cdot f_c$	$1.6 \times 6.00 \times 4.978$	47.79	4.27
3. Shrinkage of concrete	$\epsilon_{sh} \cdot E_s$	$300 \times 10^{-6} \times 210,000$	63.00	5.62
4. Relaxation of steel	IS 1343 table ($f_{pi}/f_{pu} = 0.70$)	table value	70.00	6.25
Total loss			210.66	18.81

Result: Total loss = 210.66 N/mm² = **18.81 %** of initial prestress. Effective stress in steel = 1120 – 210.66 = **909.34 N/mm²**. (Friction and anchorage slip do not occur in pre-tensioned members.)

(f_c 1 M, each loss 1 M, total % 1 M)

b) IS 1343 recommendations for losses

6 M

IS 1343 (Code of practice for prestressed concrete) requires each loss to be **estimated separately** using the values below, and the maximum initial stress in the tendon not to exceed 80 % of its ultimate tensile strength. The resulting typical percentage losses (as tabulated in standard textbooks for design) are:

Type of loss	Pre-tensioning (%)	Post-tensioning (%)
Elastic deformation (shortening) of concrete	4	1
Creep of concrete	6	5
Shrinkage of concrete	7	6
Relaxation of steel	8	8
Total (approx.)	25	20

In post-tensioning, friction and anchorage-slip losses are additional and are calculated separately (jacking force is adjusted to compensate).

IS 1343 recommendations for calculating each loss:

- Elastic shortening:** pre-tensioned – loss = $m \cdot f_c$ ($m = E_s/E_c$, f_c = stress in concrete at tendon level). Post-tensioned – nil if all tendons are stressed together; if stressed one after another, average loss $\approx \frac{1}{2} m \cdot f_c$.
- Shrinkage:** total residual shrinkage strain = 300×10^{-6} for pre-tensioning and $200 \times 10^{-6} / \log_{10}(t + 2)$ for post-tensioning (t = age of concrete at transfer in days); loss = $\epsilon_{sh} \cdot E_s$.

3. **Creep of concrete:** $\text{loss} = \theta \cdot m \cdot f_c$, where creep coefficient $\theta = 2.2$ (loading at 7 days), 1.6 (28 days), 1.1 (1 year).
4. **Relaxation of steel** (1000 h values): initial stress $0.5 f_{pu} \rightarrow 0$; $0.6 f_{pu} \rightarrow 35 \text{ N/mm}^2$; $0.7 f_{pu} \rightarrow 70 \text{ N/mm}^2$; $0.8 f_{pu} \rightarrow 90 \text{ N/mm}^2$ (or manufacturer's test values).
5. **Friction** (post-tensioning): $P_x = P_0 \cdot e^{-(\mu\alpha + kx)}$ with μ and k as per the code / manufacturer.
6. **Anchorage slip:** $\text{loss} = E_s \cdot \Delta / L$ (Δ = slip, L = cable length).

Note: values above are those of IS 1343:1980 used in MSBTE text books; IS 1343:2012 (revised) gives a more detailed procedure.

(Table of % losses 3 M, IS values for each loss 3 M)

c) Effect of cable profile on stresses

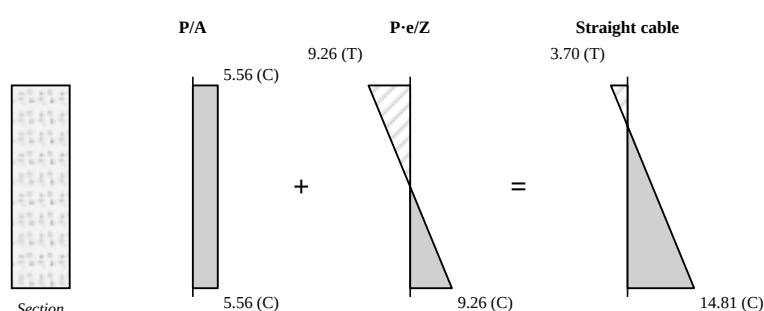
6 M

The stress at any section is $f = P/A \pm P \cdot e/Z \mp M/Z$. The load moment M is **maximum at mid-span and zero at the supports**, so the eccentricity of the cable should also be maximum at mid-span and zero (or small) at the supports.

1. **At mid-span:** a large eccentricity gives a large hogging moment $P \cdot e$ which counteracts the sagging load moment; the bottom fibre stays in compression. Hence both straight-eccentric and parabolic cables give the same favourable stresses at mid-span.
2. **At supports:** $M = 0$. With a **straight eccentric** cable the full $P \cdot e$ still acts, causing **tension at the top** and very high compression at the bottom near the ends. With a **parabolic (or concentric at ends)** cable, $e = 0$ at the support, so the stress is uniform P/A – no tension.
3. Therefore a profile that follows the B.M.D. (parabolic for UDL, harped for point loads) keeps the stresses within limits at every section; this is why curved cables are used in post-tensioned beams.
4. A concentric cable gives only P/A everywhere – it does not counteract bending and is uneconomical for beams.

Illustration ($b = 200 \text{ mm}$, $D = 450 \text{ mm}$, $P = 500 \text{ kN}$, $e_{\text{max}} = 125 \text{ mm}$): stresses at the support ($M = 0$), N/mm^2 :

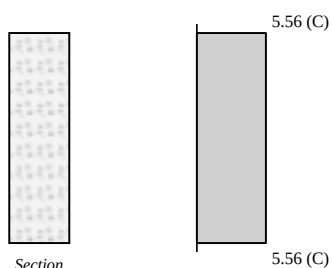
Cable profile	Top fibre	Bottom fibre
Straight eccentric ($e = 125 \text{ mm}$)	-3.70	+14.81
Parabolic ($e = 0$ at support)	+5.56	+5.56



Stresses in N/mm^2 ; C = compression (shaded), T = tension (hatched)

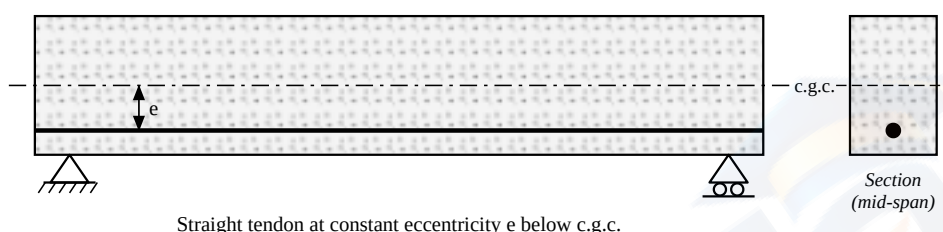
Support – straight eccentric cable

Parabolic cable



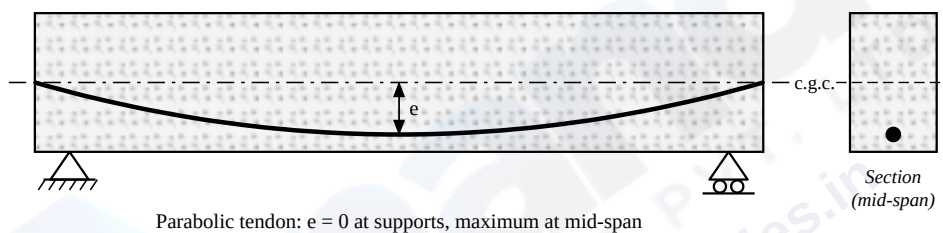
Stresses in N/mm^2 ; C = compression (shaded), T = tension (hatched)

Support – parabolic cable



Straight tendon at constant eccentricity e below c.g.c.

Fig.: Straight eccentric cable



Parabolic tendon: $e = 0$ at supports, maximum at mid-span

Fig.: Parabolic cable

(Mid-span 2 M, support 2 M, sketches/stress diagrams 2 M)

Note: This is a **model question paper prepared by Ananda Technologies** only for practice and exam preparation, based on the pattern of previous MSBTE question papers and the K-scheme syllabus. It is **not an official MSBTE paper**, and it does **not** mean that these questions will come in the exam. Answers follow standard textbook points; marks shown are indicative. Free for students — anandatechnologies.in