

ATME College of Engineering

13th K M Stone, Bannur Road, Mysore – 570028



A T M E

College of Engineering

DEPARTMENT OF CIVIL ENGINEERING

(ACADEMIC YEAR 2026-27)

SUBJECT: PRE-STRESSED CONCRETE

SUBJECT CODE: BCV703

SEMESTER: 7TH

INSTITUTE

Vision of the Institute

Development of academically excellent, culturally vibrant, socially responsible and globally competent human resources.

Mission of the Institute

- To keep pace with advancements in knowledge and make the students competitive and capable at the global level.
- To create an environment for the students to acquire the right physical, intellectual, emotional and moral foundations and shine as torchbearers of tomorrow's society.
- To strive to attain ever-higher benchmarks of educational excellence.

DEPARTMENT

Vision of the Department

To develop globally competent civil engineers who excel in academics, research and are ethically responsible for the development of the society.

Mission of the Department

- To provide quality education through faculty and state of the art infrastructure.
- To identify current problems in the society pertaining to Civil Engineering disciplines and to address them effectively and efficiently.
- To inculcate the habit of research and entrepreneurship in our graduates to address current infrastructure needs of society.

PROGRAM EDUCATIONAL OBJECTIVES (PEO's)

- Graduates who complete their UG course through our institution will be,
- **PEO 1-** Engaged in professional practices, such as construction, environmental, geotechnical, structural, transportation, or water resources engineering by using technical, communication and management skills.
- **PEO 2-** Engaged in higher studies and research activities in various Civil Engineering fields and a life time commitment to learn ever changing technologies to satisfy increasing demand of sustainable infrastructural facilities
- **PEO 3-** Serve in a leadership position in any professional or community organization, or local/state engineering board
- **PEO 4-** Registered as a professional engineer or developed a strong ability leading to professional licensure being an entrepreneur.

PROGRAM SPECIFIC OUTCOMES (PSO's)

- **PSO1:** Provide necessary solutions to build infrastructure for all situations through Competitive plans, maps and designs with the aid of a thorough Engineering Survey and Quantity Estimation.
- **PSO2:** Assess the impact of anthropogenic activities leading to environmental imbalance on land, in water & in air and provide necessary viable solutions revamping water resources and transportation for a sustainable development

PROGRAM OUTCOMES (PO's)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice. 44

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE SYLLABUS:

Pre-Stressed Concrete	
Sub Code: BCV703	IA Marks: 50
Hrs/ Week: 05	Exam Hours: 03
Total Hrs. 50	Exam Marks: 50
Module -1	
Introduction to pre-stressed concrete structures: Concepts of Prestressing- Historical development of prestressing-Design Codes for Pre-Stressed Structures- Advantages & Limitations of Pre-stressed Concrete Material - Need for High Strength Concrete- High Tension Steel- Types of Prestressing Steel	
Module -2	
Losses of Prestressing and Prestressing Systems: Losses– Immediate losses due to Friction and wobble, Elastic shortening Anchorage Slip - Time dependent losses due to Creep, Shrinkage and Relaxation losses - Introduction to Pre-stressing systems – Pre -Tensioning Devices – Post - Tensioning Devices - Anchorage Devices - Mechanical pre-stressing - Chemical Pre-stressing - Electrical Pre-stressing	
Module -3	
Principle and Methods of design: Combined Load Approach - Internal Couple Approach - Load Balancing Approach - Steel Stress in Bonded and Un-bonded tendons – Flexure and Shear – Crack and Deflection - Design as per IS 1343 - Design of Anchorage zone – End block- Cable Profiling for different beams - Mechanism of Transfer of Prestress in Pre-Tensioning System and Post Tensioned system	
Module -4	
Applications of Pre-stressing: Circular Prestressing – Introduction - Types and Design of Prestressed Concrete Pipes Pre-stressing in Buildings – Beams – One-way Slabs – Two-way Slabs – Flat slabs Structures – Tanks, Poles & Piles - Partial Prestress - behavior, advantages and disadvantages Remember the concepts of Prestressing	
Module -5	
Pre-stressing in Bridges: Composite Construction – Introduction - Analysis-IRC 112 Codal provisions for ULS and SLS – Design of a I-girder with cast in situ slab -Viaducts – Balanced cantilever bridges – Railway sleepers	

List of Course Outcomes (RBT)	Program Outcomes													Program Specific Outcomes	
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	Total	PSO 1	PSO 2
CO-1(L2)	1	-	-	-	-	3	1	1	-	-	-	1	6	1	-
CO-2(L3)	1	-	-	-	-	3	1	1	-	-	-	1	6	1	-
CO-3(L4)	3	1	-	-	-	3	1	1	-	-	-	1	9	1	-
CO-4(L4)	3	1	-	-	-	3	1	1	-	-	-	1	9	1	-
Total	8	2	-	-	-	12	4	-	-	-	-	4	30	4	-

1. Define Prestressed Concrete. Explain different types of prestressed concrete.

Prestressed concrete is a type of concrete in which **internal stresses** are intentionally introduced before applying any external load, in order to **counteract the tensile stresses** that will be imposed during service. This process **enhances the strength, serviceability, and durability** of concrete structures.

- In traditional reinforced concrete, steel resists tensile stresses that concrete cannot.
- In **prestressed concrete**, high-strength steel is tensioned and anchored to compress the concrete, so it remains mostly in compression under service loads, **preventing or minimizing cracking**.

❖ Types of Prestressed Concrete:

Prestressed concrete can be classified based on **method of prestressing**, **stage of prestress application**, and **bond between tendon and concrete**.

1. Based on Method of Prestressing:

a) Pre-Tensioned Concrete

- **Tensioning is done before** casting the concrete.
- High-strength steel wires/strands are stretched between abutments.
- Concrete is poured around them and allowed to harden.
- Once concrete gains strength, the tendons are **cut**, transferring stress to concrete via bond.
- *Common in precast elements (e.g., railway sleepers, electric poles).*

b) Post-Tensioned Concrete

- **Tensioning is done after** the concrete has hardened.
- Tendons are placed in ducts within the concrete and not bonded initially.
- After the concrete gain's strength, tendons are **stressed and anchored externally**, then ducts are grouted (if bonded).
- *Used in bridges, slabs, beams, and larger in-situ structures.*

2. Based on Bond Between Tendon and Concrete:

a) Bonded Prestressed Concrete

- Tendons are bonded to concrete through grouting.
- Permanent composite action between steel and concrete.
- Better resistance to cracking and corrosion.
- *Typically used in post-tensioned applications where ducts are grouted.*

b) Unbonded Prestressed Concrete

- Tendons are greased and sheathed with plastic, so no bond with concrete.
- Stress is transferred through anchorages only.
- Easier to replace or inspect tendons.
- *Common in flat slabs and segmental bridge construction.*

3. Based on Application of Load / Structure Type:

- **Linear Prestressing** – in beams, slabs (prestressing acts along straight or curved lines).
- **Circular Prestressing** – in tanks, silos, pipes (prestressing applied circumferentially).

2. List the advantages of PSC over RCC

a. Higher Load-Carrying Capacity

- PSC uses high-strength concrete and steel, allowing it to carry **larger loads** compared to RCC.
- Internal prestressing resists tensile stresses more effectively.

b. Longer Spans with Less Depth

- PSC structures can span **longer distances** without increasing depth.
- Useful in bridges, auditoriums, and industrial buildings where large clear spans are needed.

c. Reduced Cracking and Deflection

- Prestressing eliminates or significantly reduces **tensile stresses**, preventing cracks.
- This leads to **improved durability** and **less deflection** under service loads.

d. Material Savings

- Due to efficient stress distribution, **less concrete and steel** are required.
- Lighter structures result in **economical foundations**.

e. Improved Durability

- Crack-free concrete resists **corrosion** and **weathering**, increasing service life.
- Particularly useful in **marine structures**, bridges, and water tanks.

f. Better Vibration and Impact Resistance

- PSC offers improved behavior under **dynamic, impact, and seismic loads** due to precompression.

g. Architectural and Functional Flexibility

- Allows for **thinner sections**, longer spans, and **aesthetically pleasing designs**.
- Useful in modern architecture and large open spaces.

h. Reduced Maintenance

- Less cracking means **lower long-term maintenance** costs compared to RCC.

i. Efficiency in Repetitive Production

- Especially with **pre-tensioned elements**, mass production is faster and more economical.

3. With a neat sketch explain pre-tensioning and post-tensioning system. List out the difference between them.

a. Pre-Tensioning System

◇ Explanation:

- In this system, **tendons (steel wires/strands)** are **stressed before** casting the concrete.
- Tendons are stretched between **anchoring blocks**.
- Concrete is poured around the tensioned steel.
- After the concrete gains strength, the tension is released — the force is transferred to the concrete via **bond**.

◇ Applications:

- Used mostly in **precast factories**.
- Ideal for **mass-produced elements** like railway sleepers, electric poles, prestressed slabs, etc.

b. Post-Tensioning System

◇ Explanation:

- Tendons are placed **inside ducts** in the concrete **before** it is cast.
- After concrete gains strength, tendons are **stressed and anchored** at the ends.
- In **bonded post-tensioning**, ducts are grouted to transfer force to concrete.
- In **unbonded systems**, tendons remain free to move (no grouting).

◇ Applications:

- Used in **in-situ construction** — bridges, buildings, slabs, large spans.

Feature	Pre-Tensioning	Post-Tensioning
Time of stressing	Before casting concrete	After concrete hardens
Bonding method	Bonded via direct contact	Bonded (grouted) or unbonded
Tendon placement	External to concrete formwork	Inside ducts in concrete
Application area	Precast factory	In-situ structures
Equipment needed	Heavy jacks and fixed abutments	Movable jacks and anchorage
Construction speed	Fast in factory settings	Slower but flexible on site
Maintenance	Less access to tendons	Unbonded systems allow inspection
Cost	Lower for mass production	Higher for custom on-site work

4. Explain the need for high strength concrete and high strength steel for prestressed concrete member.

A. High Strength Concrete: In prestressed concrete, the concrete is subjected to **initial compressive stresses** through prestressing. To effectively resist these and external loads **without cracking**, high-strength concrete is essential.

◇ Reasons:

➤ To Resist High Compressive Stresses

- Prestressing induces **large compressive forces**; only **high-strength concrete** can withstand them without crushing.

➤ Better Bond with Steel

- Pre-tensioned systems rely on **bond strength** between concrete and steel.
- High-strength concrete has a **denser microstructure**, which improves bond.

➤ Reduced Shrinkage and Creep

- High-strength concrete shows **less time-dependent deformation**, which helps maintain the prestress force over time.

➤ Crack Control and Durability

- It resists **crack formation** under service loads, ensuring long-term durability, especially in aggressive environments.

➤ Smaller Cross-Sections

- Using stronger concrete allows for **slimmer, lighter sections**—economical and architecturally favorable.

B. High Strength Steel: Prestressing steel must carry large tensile forces before transferring them to the concrete. For this, **high-strength, low-relaxation steel** is required.

◇ Reasons:

➤ To Develop High Prestressing Force

- Higher tensile strength means **more prestress can be applied**, which improves structural capacity.

➤ Efficient Material Usage

- Stronger steel allows for **smaller tendons**, reducing steel quantity and making the structure lighter and economical.

➤ Resistance to Relaxation

- High-strength steel is manufactured with **low relaxation properties**, minimizing long-term prestress losses.

➤ **Flexibility in Design**

- Longer spans, reduced section sizes, and better handling of eccentric forces become possible.

➤ **Fatigue and Corrosion Resistance**

- Special grades of high-tensile steel have good **fatigue strength** and improved **durability**.

5. Write a short note on historical development of Pre-stressing.

◇ Introduction:

- Prestressing is a modern construction technique used to improve the performance of concrete in tension.
- The concept evolved as a solution to **concrete's low tensile strength** and **cracking issues**.

◇ Early Concepts (Pre-1900):

- As early as **1872**, engineers tried applying external compressive forces to concrete structures.
- However, due to **low-quality materials** (low-strength steel and concrete), these attempts were not very successful.

◇ Breakthrough by Eugène Freyssinet (France, 1928):

- The real development of prestressed concrete is credited to **Eugène Freyssinet**, a French engineer.
- In **1928**, he introduced:
 - Use of **high-strength steel** (over 1500 MPa).
 - Prestressing applied **before external loading**.
 - Developed the concept of **post-tensioning** using hydraulic jacks.
- His work led to the first **prestressed bridge in France**.

◇ Further Developments (1930s–1950s):

- Adoption of prestressing techniques in **Germany, UK, and the USA**.
- Development of **pre-tensioned systems** and **anchorage devices**.
- Improved materials and methods made prestressing practical and economical.

◇ Modern Era (Post-1950):

- Widespread use of both **pre-tensioning** and **post-tensioning** systems.
- Adoption in large-scale structures: bridges, dams, buildings, stadiums, and silos.
- Advancements in **grouting**, **anchorage systems**, **low-relaxation steel**, and **high-performance concrete**.

6. Explain IS-1343 Code applications.

IS 1343: Code of Practice for Prestressed Concrete (Indian Standard IS 1343: 2012 – Reaffirmed)

Introduction: IS 1343 is the Indian Standard code that provides guidelines for the design, materials, construction, and inspection of prestressed concrete structures. It is applicable to both **pre-tensioned** and **post-tensioned** concrete systems used in buildings, bridges, tanks, and other civil engineering structures.

◇ Applications of IS 1343 Code:

1. Design Guidelines

- Specifies **limit state** and **working stress** methods for designing prestressed concrete members.
- Covers:
 - Flexural strength
 - Shear strength
 - Torsion
 - Anchorage zone design
- Includes safety factors, partial load factors, and permissible stresses.

2. Material Specifications

- Prescribes minimum grades of concrete:
 - **M30** for pre-tensioned work
 - **M40** for post-tensioned work
- Specifies types and properties of **prestressing steel**:
 - Wires, strands, and bars
 - High tensile strength and low relaxation requirements

3. Permissible Stresses

- Defines limits for **compressive and tensile stresses** in concrete under different loading conditions.
- Sets maximum allowable stress in prestressing steel during jacking and service conditions.

4. Prestress Losses

- Details the estimation of prestress losses due to:
 - Elastic shortening
 - Creep and shrinkage of concrete
 - Relaxation of steel
 - Anchorage slip and friction (in post-tensioned systems)
 -

5. Construction Practices

- Provides guidelines for:
 - Tensioning procedures
 - Grouting of ducts
 - Anchorage and end-block reinforcement
 - Inspection and quality control

6. Serviceability Requirements

- Limits deflection and cracking to ensure durability and performance.
- Includes criteria for **camber**, **crack width**, and **vibration behavior**.

7. Special Provisions for Structures

- Additional guidelines for:
 - Prestressed bridge decks
 - Circular tanks
 - Segmental construction

7. Explain types of pre-stressing steel

Pre-stressing steel is a key component in pre-stressed concrete structures, where it is used to apply compressive force to the concrete to counteract tensile stresses. There are several **types of pre-stressing steel**, and they can be categorized based on form, composition, and mechanical properties.

Below are the main types:

1. Based on Form or Shape

a. Wires

- Single, small-diameter (usually 5–8 mm) high-tensile steel wires.
- Used mostly in pre-tensioned systems (e.g., railway sleepers, poles).
- Available in plain, indented, or crimped forms to improve bond with concrete.

b. Strands

- A strand consists of multiple wires (usually 7) twisted together in a helical pattern.
- Commonly 7-wire strands (one central wire + six surrounding wires).
- Widely used in post-tensioned systems.
- Available in sizes like 12.7 mm, 15.2 mm, and 15.7 mm diameter.

c. Bars

- Solid, round bars of high-strength steel (usually 10–40 mm diameter).
- Typically used in post-tensioning for short span structures.
- Threaded ends allow for easy anchorage and tensioning.

2. Based on the Type of Stressing System

a. Pre-tensioning Steel

- Tensioned before concrete is cast.
- Commonly uses **wires or strands**.
- The steel bonds directly to the concrete during curing.

b. Post-tensioning Steel

- Tensioned after concrete has hardened.
- Usually **strands or bars** inside ducts.
- Requires anchorage systems.

3. Based on Stress-Relaxation Characteristics

a. Low-Relaxation Steel

- Specially treated to reduce loss of pre-stress over time due to internal stress relaxation.
- Used in modern pre-stressed systems for long-term performance.

b. Normal-Relaxation Steel

- Older type with more relaxation loss.
- Less commonly used today.

❖ INTRODUCTION TO PRE-STRESSING SYSTEMS

Pre-stressing is a technique used in concrete structures to improve their performance by introducing internal compressive stresses before they are subjected to external loads. This counteracts the tensile stresses that develop under service conditions, allowing the concrete to perform better in tension.

◇ Pre-stressing eliminates or reduces these cracks by:

- Minimizing or eliminating tensile stresses
- Increasing load-carrying capacity
- Allowing for longer spans and thinner sections
- Improving durability and serviceability

◇ **Principle of Pre-stressing**

- High-strength steel tendons are tensioned.
- This tension is transferred to the concrete (either before or after the concrete is placed).
- The induced compressive stress in concrete counteracts tensile stress from service loads.

❖ PRE-TENSIONING SYSTEM

❑ **Definition:** Tendons are tensioned **before** concrete is cast.

❑ **Procedure:**

1. Steel tendons are stretched between end anchors on a casting bed.
2. Concrete is poured and allowed to harden.
3. Once concrete gains strength, the tension is released.
4. The bond between steel and concrete transfers the force.

❑ **Applications:**

- Precast elements like railway sleepers, floor slabs, bridge girders.

❑ **Advantages:**

- Better bond between tendon and concrete.
- Mass production possible.

❖ POST-TENSIONING SYSTEM

❑ **Definition:** Tendons are tensioned **after** concrete has hardened.

❑ **Procedure:**

1. Ducts are placed in the formwork before concrete is cast.
2. After hardening, tendons are inserted into the ducts.
3. Tendons are tensioned using hydraulic jacks.
4. The tension is transferred to the concrete via anchorages.
5. Grout is often injected into ducts to protect tendons.

❑ **Applications:**

- Long-span bridges, slabs, high-rise buildings.

❑ **Advantages:**

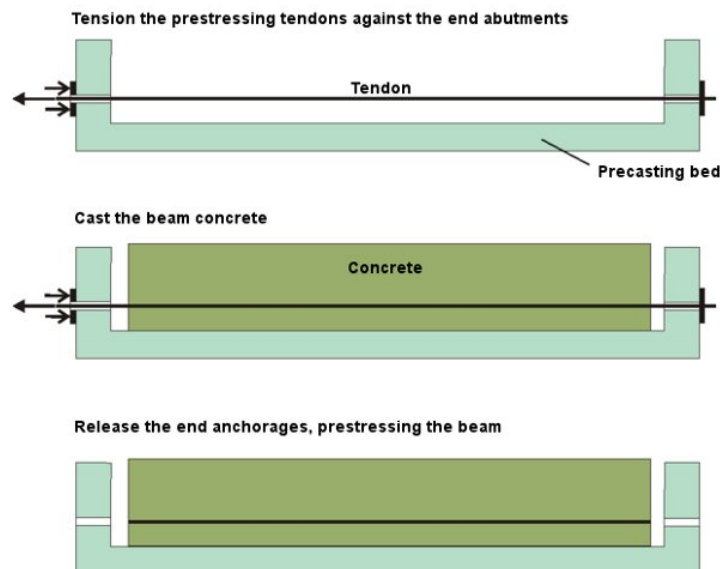
- More flexible for in-situ construction.
- Useful for long spans and complex geometry.

System	Type	Features
Freyssinet System	Post-tensioning	Uses wedge anchors and thick wires
Gifford-Udall System	Post-tensioning	Wire bundles grouted after stressing
Magnel-Blaton System	Post-tensioning	Rectangular anchorage blocks
Hoyer System	Pre-tensioning	Used in precast factories
Lee-McCall System	Post-tensioning	Button heads for anchoring wires

❖ **PRE – TENSIONING DEVICES**

- Pre-tensioning devices are tools or equipment used in pre-tensioning concrete structures, especially pre-stressed concrete (PSC) elements like beams, slabs, and girders.
- These devices apply tension to the high-strength steel tendons or wires before the concrete is cast, ensuring that when the concrete sets and the tension is released, it induces compressive stress in the concrete to counteract tensile stresses during service.

◇ **Primary devices for pre-tensioning**



- Prestressing bed: A long, heavy-duty casting platform where the entire pre-tensioning process is carried out. In a setup known as the Hoyer system or long-line method, multiple concrete members can be cast end-to-end on a single bed.

- End abutments (bulkheads): Massive, independently anchored structures located at each end of the prestressing bed. The high-strength steel tendons are anchored and tensioned between these abutments. They must be exceptionally strong to resist the enormous tensile force exerted by the tendons.
- Molds (shuttering): Placed within the prestressing bed to form the shape of the concrete member being cast. The tendons run through the mold as the concrete is poured around them.
- Hydraulic jacks: These are the devices that apply the tensioning force to the tendons. One or more hydraulic jacks stretch the tendons to the required length and stress level, as measured by calibrated pressure gauges or load cells.
- Anchoring devices (quick-release grips): Simple, effective grips that hold the tendons securely against the end abutments while the concrete cures. They are typically based on a wedge and friction principle, such as split-cone wedges with serrated pins.
- Harping devices: Optional devices used to profile or bend the tendons into a desired shallow curve, typically for long-span beams. They use hold-down anchors placed along the prestressing bed to create a sag in the tendons before the concrete is cast

❖ HOYER LONG LINE SYSTEM OF PRE – TENSIONING

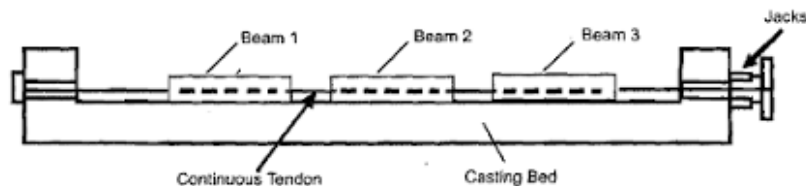


Figure : Hoyer's Long Line System of Pre-tensioning

- The Hoyer system, also known as the long-line method, is a pre-tensioning technique for producing precast, prestressed concrete members on a mass scale.
- It is an efficient and economical method used in factory settings for creating items like railway sleepers, beams, slabs, and poles.

◇ How the Hoyer system works

- Preparation: Two massive, heavy-duty end abutments (also known as bulkheads) are constructed at a significant distance from each other, sometimes over 100 meters. These abutments are anchored firmly to the ground to resist the immense forces involved.
- Tendon placement: High-strength steel tendons (wires or strands) are stretched continuously between the two fixed abutments.
- Tensioning: Hydraulic jacks are used to pull the tendons to the predetermined, high-tensile stress. The force applied is measured by calibrated gauges to ensure accuracy.
- Moulding: Formwork or moulds are placed along the prestressing bed, enclosing the tensioned tendons and creating the shape of the individual concrete members.

- Casting and curing: Concrete is poured into the moulds, encasing the tensioned tendons. Once the concrete has gained sufficient strength (which can be accelerated with steam curing), the tensioning force is ready to be transferred.
- Transfer of prestress: The tension is released from the tendons by cutting them at the ends of the cast members. The tendons, attempting to shorten, are bonded to the concrete and transfer their tensile force into a compressive force within each precast member. This creates the internal prestress that strengthens the concrete.
- Cutting and demolding: The continuous line of connected concrete is cut into individual members, which are then removed from their moulds.

◇ **Advantages of the Hoyer system**

- **Mass production:** Multiple identical members can be cast in one go, greatly increasing efficiency and output compared to casting members individually.
- **Cost-effectiveness:** Since a single set of tensioning and anchorage operations can produce numerous members, the Hoyer system is highly economical for large-scale production.
- **Reduced need for end anchorages:** Unlike post-tensioning, the Hoyer pre-tensioning process relies on bond strength, so no expensive end anchorages are needed for the finished product.
- **Quality control:** As a factory-based method, the Hoyer system operates in a controlled environment, ensuring high quality and consistent results for every member produced.

◇ **Disadvantages of the Hoyer system**

- **Large space required:** The method requires a very long, dedicated prestressing bed, which can only be accommodated in a precast factory setting.
- **Strong abutments:** The end abutments must be extremely robust to withstand the massive prestressing forces, adding to the initial setup cost.
- **Transportation limitations:** The finished precast members must be transported from the factory to the construction site, which can be difficult for large or very heavy elements.

❖ **POST – TENSIONING DEVICES**

- Post-tensioning devices are specialized mechanical systems used in construction, particularly in post-tensioned concrete structures, to apply a compressive force to the concrete after it has cured. This enhances the strength, durability, and performance of the structure.

◇ **Types of Post-Tensioning Systems**

1. **Unbonded System**

- Tendons are greased and encased in plastic sheathing.
- Tendons remain unbonded to the concrete.

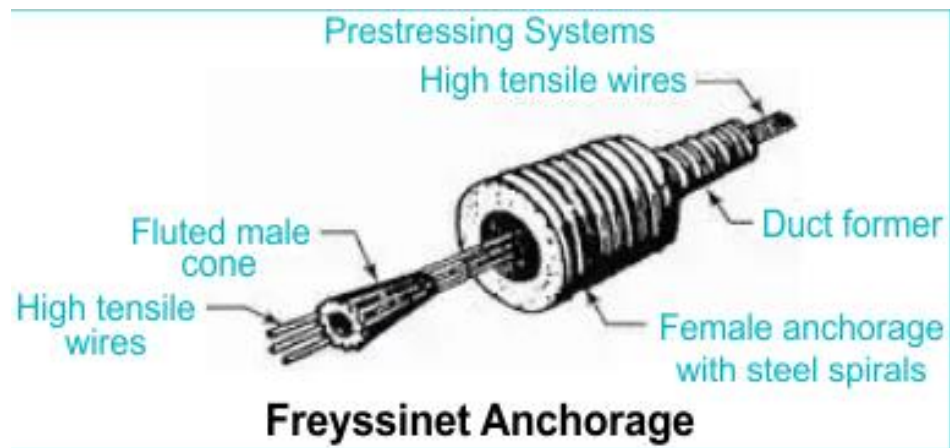
- Common in slabs and residential buildings.

2. Bonded System

- Tendons run through ducts and are grouted after stressing.
- Tendons bond to the concrete after grouting.
- Used in bridges, heavy civil structures.

❖ FREYSSINET POST – TENSIONING DEVICE

- The Freyssinet System is one of the earliest and most widely used post-tensioning systems, developed by Eugène Freyssinet in the 1930s.
- It played a pivotal role in the development of prestressed concrete technology and is still used today, particularly in bridges, buildings, tanks, and other large-scale concrete structures.
- It involves tensioning high-strength steel cables after the concrete has cured, providing a long-lasting compressive force that enhances a structure's strength, durability, and load-bearing capacity.



◇ How the system works

- **Casting the concrete:** Ducts or grooves, often made of metal or high-density polyethylene (HDPE), are placed inside the concrete formwork before casting.
- **Inserting the tendons:** A cable, called a "tendon," consisting of multiple high-strength steel wires or strands bundled around a helical spring, is inserted into the ducts. The spring maintains proper spacing between the wires.
- **Anchoring one end:** A special anchoring device, consisting of a reinforced concrete cylinder with a concentric conical hole, is embedded at each end of the tendon. The wires are secured at one end of the beam using the anchorage.
- **Casting the concrete:** Ducts or grooves, often made of metal or high-density polyethylene (HDPE), are placed inside the concrete formwork before casting.

- Inserting the tendons: A cable, called a "tendon," consisting of multiple high-strength steel wires or strands bundled around a helical spring, is inserted into the ducts. The spring maintains proper spacing between the wires.
- Anchoring one end: A special anchoring device, consisting of a reinforced concrete cylinder with a concentric conical hole, is embedded at each end of the tendon. The wires are secured at one end of the beam using the anchorage.

◇ **Key components**

- **Tendon:** A group of high-strength steel wires or strands with a helical spring to maintain spacing.
- **Duct:** A cylindrical sheath of metal or plastic that creates a hollow channel within the concrete for the tendon.
- **Anchorage:** The device, consisting of a concrete cylinder and a conical plug, that grips and holds the stressed wires.
- **Hydraulic jack:** A specialized tool that applies the tensile force to the tendons.
- **Grout:** A cementitious or other protective material injected into the duct to protect the tendons from corrosion and ensure a bond with the concrete.

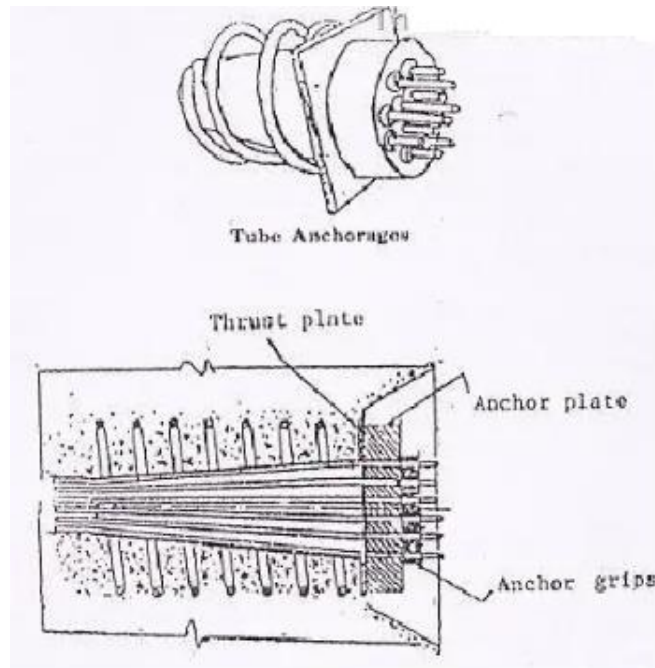
◇ **Applications:** Segmental bridges, Precast and cast-in-place concrete bridges, Buildings (especially with large spans), Water tanks and silos, Retaining walls, nuclear containment structures, Foundation slabs and anchorage systems for ground stabilization.

◇ **Advantages of the Freyssinet System**

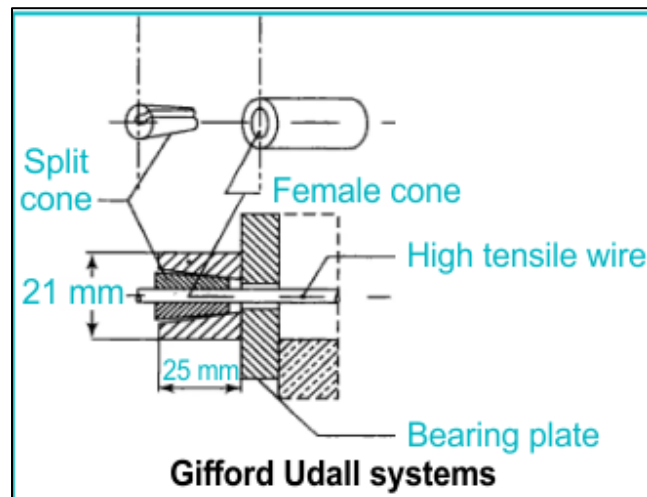
- Proven performance over decades
- High load capacity
- Flexibility in tendon layout and number
- Effective corrosion protection after grouting
- Precision in stressing operations

❖ **GIFFORD-UDALL POST-TENSIONING SYSTEM**

- The Gifford-Udall Post-tensioning System is an early and historically significant method of post-tensioning concrete, developed in the UK during the mid-20th century by engineers Guy Gifford and George Udall.
- This system was one of the pioneering commercial methods used to introduce post-tensioning techniques in structural concrete.
- Unlike systems that stress multiple wires at once, the Gifford-Udall system stresses and anchors each individual wire using a small, double-acting jack and special wedge grips. This flexibility allows for the formation of cables with any desired number of wires.



◇ Components



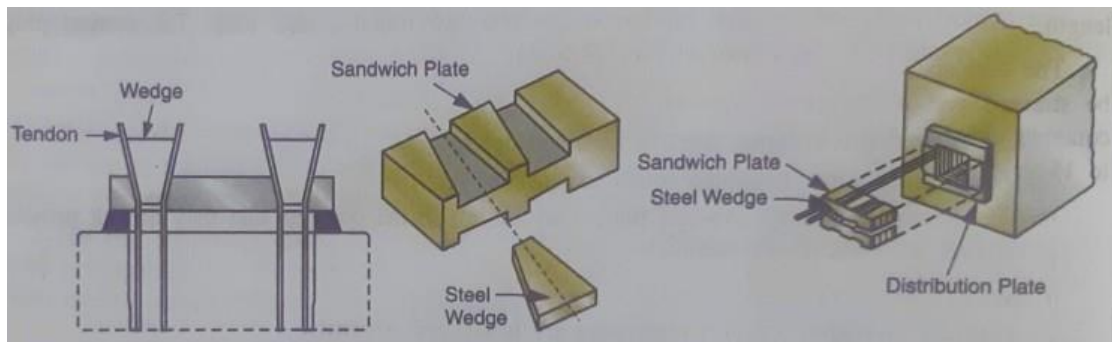
- High-strength steel wires: The individual wires are typically 5 mm or 7 mm in diameter.
- Udall grips: These are small, two-piece split conical wedges used to anchor the wires. The serrated grips fit into the tapered holes of the bearing plate, securing the tensioned wires.
- Bearing plate: This can be a square or circular plate with tapered holes that accommodate the individual anchor wedges. It transfers the prestressing force to the concrete.
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◇ **Process**

- **Duct preparation:** A duct is placed in the formwork according to the engineered profile, typically using a fabricated steel tube or helix unit that also serves as part of the anchorage.
- **Wire placement:** Individual high-strength steel wires are inserted into the duct.
- **Anchorage installation:** A bearing plate with tapered holes is installed at each end of the member.
- **Stressing:** After the concrete has cured, a double-acting jack is used to independently pull and tension each wire. The "Udall grips" (split cone wedges) are inserted into the tapered hole to lock the tensioned wire in place.
- **Grouting:** Grout can be injected into the duct through a grout entry hole in the bearing plate to protect the wires and bond them to the concrete.

❖ **MAGNEL BLATON POST-TENSIONING SYSTEM**

- The **Magnel-Blaton system** is a **bonded post-tensioning method** developed in the early 20th century by the Belgian engineer **Victor Magnel** and the French company **Blaton**.
- It was one of the pioneering techniques for prestressing concrete and remains a foundational system in the evolution of post-tensioning technology.
- The Magnel Blaton system is a method of post-tensioning concrete, where high-tensile steel wires are tensioned and anchored after the concrete has been cast and hardened.



◇ **Key components and working principle**

1. **Casting:** Concrete is first cast with a duct or sheath placed in the formwork, through which the steel wires will later pass.
2. **Anchorage:** After the concrete reaches sufficient strength, the high-tensile steel wires (typically 5–8 mm in diameter) are fed through the duct. The anchorage consists of several parts at each end of the member:
 - Sandwich plates: Metallic plates with tapered, wedge-shaped grooves on their faces that hold up to eight wires.
 - Flat wedges: Grooved flat wedges are driven into the plate grooves to secure the wires.
 - Distribution plate: A bearing plate that distributes the prestressing force from the sandwich plates to the concrete.

3. **Tensioning:** A special hydraulic jack pulls two wires at a time until the desired tension is achieved.
4. **Anchoring:** The two wires are then anchored by driving the grooved wedges between them and the sandwich plate. This process is repeated for each pair of wires until the entire cable is tensioned.
5. **Grouting:** Once the tensioning is complete, the ducts are typically grouted with a cement paste to protect the steel from corrosion and create a bonded tendon.

❖ DIFFERENCES

Aspect	Freyssinet System	Gifford-Udall System	Magnel-Blaton System
Origin	Developed by Eugène Freyssinet (France, 1928)	Developed by Gifford & Udall (UK, 1950s)	Developed by Victor Magnel & Blaton (Belgium/France, 1920s-30s)
Tendon Type	High tensile steel wires or strands	High tensile steel wires or strands	Flat rectangular steel bars
Duct/Sheath	Metallic or plastic ducts	Metallic ducts	Metallic ducts
Prestressing Type	Initially unbonded, later evolved to bonded post-tensioning	Bonded post-tensioning	Bonded post-tensioning
Anchorage System	Wedge-type anchorage with special anchor plates	Wedge-type anchorage	Special wedge anchors for flat bars
Grouting	Grouted to protect tendons and bond them in later versions	Grouted after tensioning	Grouted after tensioning
Key Innovation	Introduced the concept of prestressing by post-tensioning with high tensile steel wires	Adapted and commercialized post-tensioning in UK, focused on wedge anchorage	First to develop bonded post-tensioning using grout and flat bars
Typical Applications	Bridges, buildings, water tanks, large concrete members	Bridges, buildings, water tanks	Bridges, slabs, beams, water-retaining structures
Advantages	High strength, reliable anchorage, adaptable to complex shapes	Simple wedge anchorage, relatively easy to install	Bonded system improves durability and load transfer
Limitations	Early versions were unbonded (less corrosion protection), required skilled labor	Older system, less common today, potential grouting issues	Flat bars less flexible, more complex anchorage

❖ ANCHORAGE DEVICES

- Anchorage devices are the **end hardware components** used to transfer and maintain prestressing forces from **tendons (wires/strands/bars)** into the **concrete**.
- Anchorage devices are critical components in prestressed concrete that secure the tensioned steel tendons and transfer the prestressing force to the concrete member.
- Since prestressing steel carries very high tensile forces, safe and efficient anchorage is crucial.

- The type of anchorage used depends on whether the prestressing is done before (pre-tensioning) or after (post-tensioning) the concrete is cast.

◇ **For Wires and Strands**

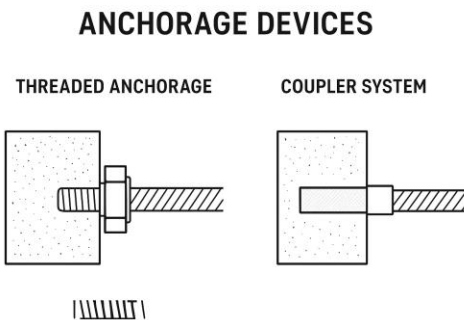
1. Wedge Anchorage

- Uses **conical wedges** to grip the strand.
- Widely used in modern systems (e.g., Freyssinet, CCL, VSL).
- Consists of:
 - **Anchor Head** (steel plate with conical holes)
 - **Wedges** (split steel pieces that grip strand when pulled)
 - **Bearing Plate** (transfers force to concrete)

2. Button Head Anchorage (older system)

- Wire ends are upset into button heads and anchored in a steel plate.
- Rarely used now.

◇ **For Bars**



1. Threaded Anchorage

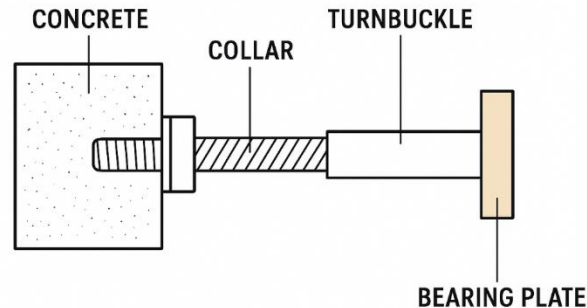
- Bars are threaded at ends, and nuts/plates anchor them.

2. Coupler System

- Used when prestressing bars are extended.

❖ MECHANICAL PRE-STRESSING

MECHANICAL PRESTRESSING



- In prestressed concrete, the prestressing force can be generated through various means. The primary methods based on the source of the force are mechanical, electrical, and chemical prestressing.
- Mechanical prestressing involves the use of mechanical devices to tension the high-strength steel tendons. The most common method involves a hydraulic jack, though other mechanical systems exist.

◇ Types of Mechanical Pre-stressing Systems

1. Turnbuckle System

- Uses a **turnbuckle (threaded sleeve)** between two tendons/bars.
- By rotating the sleeve, the tendon is stretched.

2. Screw Jack System

- a. Uses threaded bars and nuts.
- b. Tightening the nuts stretches the tendon.

3. Leverage System

- a. Uses **levers and fulcrums** to magnify applied force and stretch tendons.

4. Rack & Pinion / Gear System

- a. Uses gear arrangements to mechanically stretch tendons.

◇ Components

- **Tendon/Bar** → High strength steel bar or wire.
- **Collar/Nut** → Provides grip to the tendon.
- **Turnbuckle / Screw Jack / Lever** → Mechanical device for tensioning.
- **Bearing Plate** → Transfers stress to the concrete.
- **Concrete Member** → Receives compressive prestress.

◇ **Advantages**

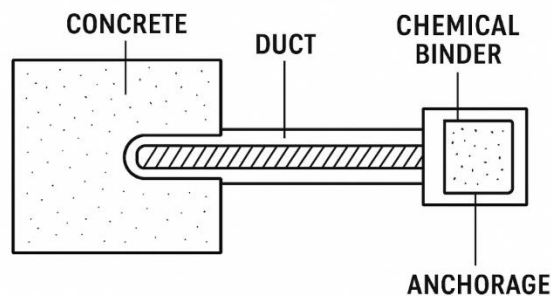
- Simple system, no need for hydraulic pumps.
- Suitable for short span members and precast factories.
- Low initial investment compared to hydraulic jacks.

◇ **LIMITATIONS**

- Not suitable for very high prestressing forces (modern structures need higher capacity).
- Time-consuming and labor-intensive.
- Limited accuracy in controlling prestress compared to hydraulic methods.
- Rarely used in large-scale projects today, but still found in small precast units (railway sleepers, poles, pipes).

❖ **CHEMICAL PRE-STRESSING**

CHEMICAL PRE-STRESSING



- Chemical pre-stressing is a **method of inducing prestress** in concrete using the **expansion property of cement** and special admixtures (expansive cements).
- Instead of applying tension mechanically (jacks) or thermally (heating tendons), **expansion of concrete itself** develops tensile stress in the reinforcement, which in turn applies **compressive stress** to concrete.

◇ **Principle**

- **Expansive cement** is used in the mix (containing admixtures like calcium sulfoaluminate).
- After hydration, the cement undergoes **controlled expansion**.
- The embedded reinforcement (steel) **restrains this expansion**, and as a result:
- The steel goes into **tension**.
- The concrete goes into **compression** (prestressed).

◇ **Materials Used**

- High-strength steel reinforcement (bars/wires).
- Expansive cement types (e.g., sulfoaluminate cement).
- Chemical admixtures: calcium chloride, gypsum, aluminates, etc.

◇ **Process**

1. Concrete is prepared using expansive cement.
2. Steel reinforcement is embedded in concrete (no external stressing equipment needed).
3. During hydration → **concrete expands**.
4. The steel reinforcement resists this expansion → develops tensile stress.
5. The **prestressing force** is thus locked into the member.

◇ **Advantages**

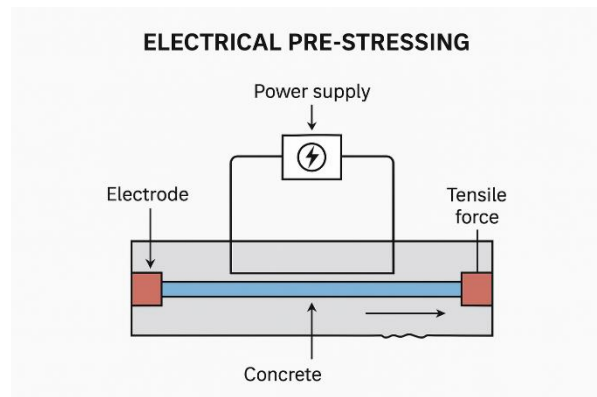
- No need for external stressing devices (jacks, wedges).
- Simple and economical for factory-made elements.
- Useful for thin sections like slabs, pipes, and tanks.
- Reduces shrinkage cracks due to counter-compression.

◇ **Limitations**

- Prestress level is relatively low (compared to mechanical/hydraulic methods).
- Prestress depends on cement properties → variation in performance.
- Not suitable for heavily loaded structural members.
- Requires special cement which may not be locally available everywhere.

❖ **ELECTRICAL PRE-STRESSING**

- Electrical pre-stressing is a method of inducing prestress by heating steel tendons electrically before anchoring them in concrete.
 - Current is passed through the steel tendons → they expand due to heat.
 - While in the expanded state, the tendons are anchored to the concrete.
 - As the steel cools → it contracts, inducing tensile stress in the steel and compressive stress in the concrete.



◇ **Equipment Used**

- **Power supply (transformer/rectifier)** – for controlled heating.
- **Electrodes** – connected at tendon ends.
- **Anchorage system** – wedges, plates, or collars to hold tendons.

◇ **Principle**

- Based on the thermal expansion and contraction of steel.
- Heating → elongation.
- Cooling → contraction → induces prestress.

◇ **Process**

- Tendons (high-strength wires/bars) are placed in ducts inside the concrete member.
- A low-voltage, high-current supply is passed through the tendons → heating them.
- Tendons expand and elongate.
- Ends are anchored against the concrete while hot.
- When the steel cools → it shortens → prestress is induced.

◇ **Advantages**

- Simple and fast method (no hydraulic jacks needed).
- Useful for mass production of precast elements (like poles, sleepers, pipes).
- Reduces labor as stressing and anchoring are automatic during cooling.

◇ **Limitations**

- Requires continuous electric power supply.
- Heating may cause oxidation/scaling of steel surface.
- Difficult to control uniform heating for long tendons.
- Limited to small/medium-size members; not practical for long-span bridges.

❖ **IMPORTANT QUESTIONS**

- List and explain the various losses in pre-stressed concrete.
- Define Anchorage. Explain with sketch Freyssinet system of Post-tensioning.
- Explain with as neat sketch Hoyer's long line systems of Pre-tensioning.
- Explain Post-tensioning anchorage devices and explain any one in details.