ATME College of Engineering

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

DEPARTMENT OF CIVIL ENGINEERING

(ACADEMIC YEAR 2025-26)

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 l-** 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.