Program Name : **Civil Engineering Program Group**

Program Code : **CE/CR/CS**

Semester : **Fifth**

Course Title : **Precast and Pre-stressed Concrete (Elective)**

Course Code : **22508**

1. RATIONALE

Precast and Pre-stressed Concrete construction technology is widely used across the globe for its inherent advantages. It has been adopted in India from past many years, but was mostly limited to civil structures such as tunnels, bridges, flyovers and underpasses. Today, with critical housing shortages, rising labour and input costs and an increased emphasis on quality and timely delivery, more and more developers are opting for innovative construction practices like precast and pre-stressed concrete. Hence it is essential to make upcoming engineering community aware about this. This course is designed to provide basic knowledge of precast and pre-stressed elements, their design aspects, pre-stressing techniques, methods and basic design principles.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

a) Execute effectively construction work involving precast and pre-stressed concrete

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student will be able to demonstrate the following ***industry oriented*** COs associated with the above mentioned competency:

a. Select the relevant precast concrete element for a given type of construction.
b. Use the relevant components for the prefabricated structure .
c. Justify the relevance of pre-stressed element in a given situation.
d. Select the relevant methods / systems for given construction work.
e. Evaluate losses in a given pre-stressed concrete construction.
f. Propose a suitable cable profile for the given pre-stressed concrete member.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme											
				Theory							Practical				
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	3	70	28	30*	00	100	40	25@	10	25	10	50	20

(*): Under the theory PA, Out of 30 marks, 10 marks are for micro-project assessment to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T*** *– Tutorial/Teacher Guided Theory Practice;* ***P*** *- Practical;* ***C*** *– Credit,* ***ESE*** *- End Semester Examination;* ***PA*** *- Progressive Assessment.*

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes details in subsequent sections to be attained by the student by the end of the course, in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

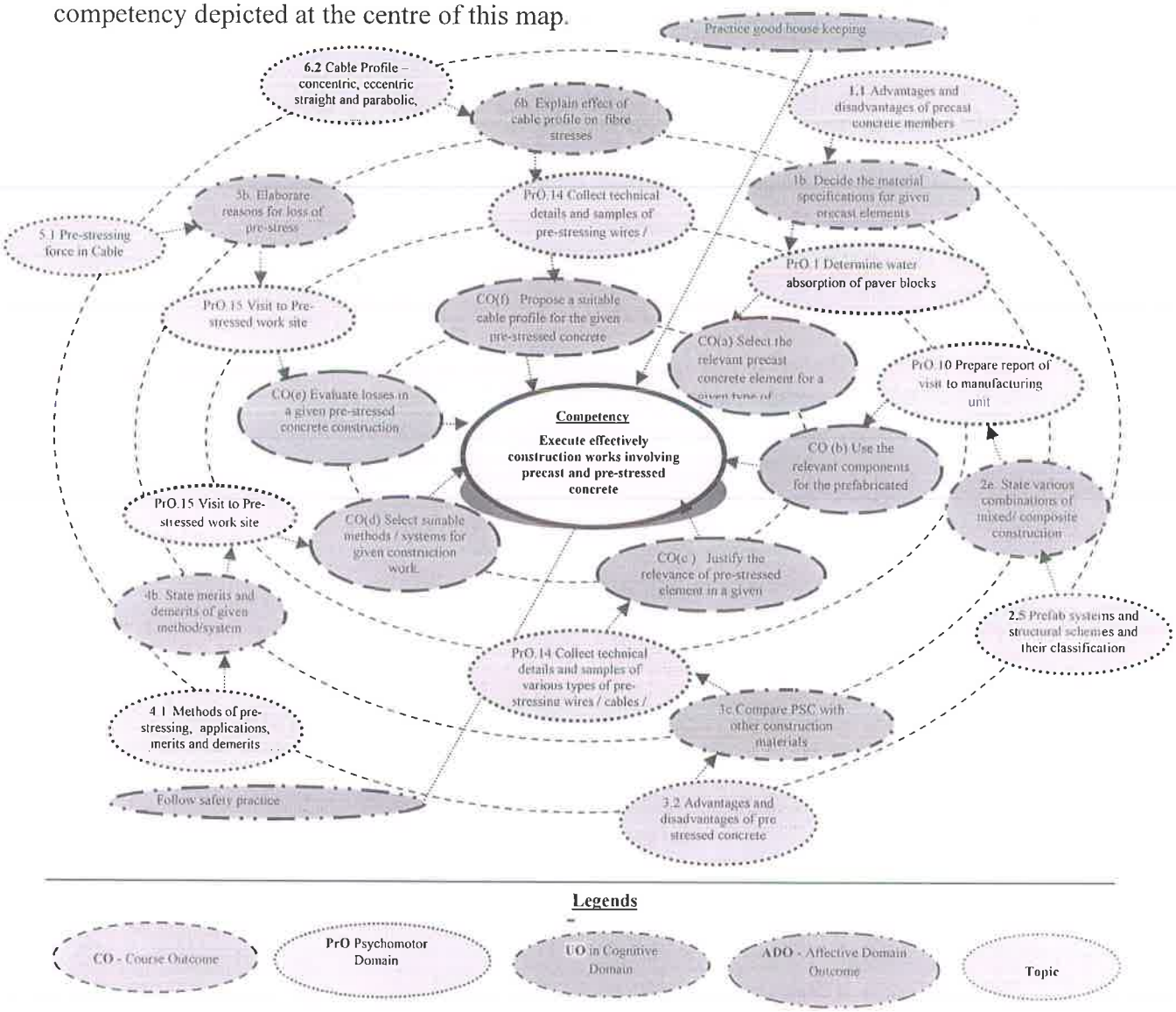

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No.	Practical Outcomes (PrOs) Ten compulsory* + any other two	Unit No.	Approx. Hrs. required
1	Determine water absorption of paver blocks of three different shapes of three different make and size.	I	02*
2	Determine water absorption of solid / hollow building blocks of three different sizes of three different make and size.	I	02*
3	Inspect any three elements (e.g. manhole covers, paver blocks, hollow blocks, solid blocks, curb stones etc) for dimension checking.	I	04*

S. No.	Practical Outcomes (PrOs) Ten compulsory* + any other two	Unit No.	Approx. Hrs. required
4	Prepare report of field visit to a manufacturing unit (of precast elements such as fencing pole, transmission pole, electric pole) with reference to the points such as manufacturing process, curing, stacking, handling, in-house inspection and testing.	I	04*
5	Determine compressive strength of given solid precast blocks	I	02*
6	Determine compressive strength of given hollow precast blocks	I	02*
7	Determine compressive strength of given paver blocks	I	02*
8	Perform load test on given manhole cover as per IS 12592:2002 Annex C	I	02
9	Observe Pressure Testing of given precast pre-stressed pipes	I	04
10	Prepare report of field visit to manufacturing unit (of precast elements such as lintel, chajja, door frame, wall panels, stair steps) with reference to the points such as manufacturing process, curing, stacking, handling, in-house inspection and testing.	II	04*
11	Determine flexural strength on given wall panels on site	II	04
12	Test in-situ the given prefabricated wall panel to judge its resistance against impact.	II	04
13	Test in-situ the given prefabricated wall panel to judge its resistance against flexure (holding the panel simply supported and applying impact force at centre till collapse)	II	02
14	Determine flexural strength of the given precast joists	II	02
15	Prepare the report, collect the samples of various types of pre-stressing wires / cables / strands along with their technical specifications/brochure.	III	02*
16	Prepare report of field visit to bridge site regarding pre-stressed member with reference to the points such as shape, dimensions, cable/ tendon, anchor block, method of pre-stressing, transfer of pre-stress, equipment used, etc.	III to VI	04*
	Total		**32**

Note

*i. A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practicals need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S.No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10

S.No.	Performance Indicators	Weightage in %
7	Submission of report in time	10
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

1. 'Valuing Level' in 1st year.
2. 'Organising Level' in 2nd year.
3. 'Characterising Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipments with broad specifications mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipments by administrators.

S. No.	Equipment Name with Broad Specifications	Exp. No.
1	Hot air electric oven having temperature range 5^0 C to 250^0 C, removable 2-3 stainless steel shelves, thermostat, digital temp controller, with mineral wool insulation, door walls with silicon rubber gasket and lock	1,2
2	Digital display balance of capacity 10 kg having LC 10 gm and of capacity 30 kg having LC 10 gm	1,2
3	Test frame for load test for manhole covers	9
4	Universal Testing Machine: Capacity – 1000 kN. Type: Mechanical type / digital, electrically Operated with accessories such as (1) Tensile test attachment for wire specimen, (2) Compression test attachment, (3) Transverse test attachment with bending Punch, along with service tools and operation manual	10, 13
5	Compression Testing Machine: Digital display manual control compression testing; machine; Max. Capacity (KN): 2000 ; Measuring range: 4%-100% of FS; Max. distance between two platen (mm): 330; Compression plate size (mm): 220×220; Max. piston stroke (mm): 0-20; Max. piston speed (mm/min): Approx. 30; Column clearance 300×200; Oil pump motor power (KW): 1.5	6, 7, 8

8. UNDERPINNING THEORY COMPONENTS

The following topics/subtopics should be taught and assessed in order to develop UOs in cognitive domain for achieving the COs to attain the identified competency.

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Precast concrete Elements	1a. Explain the concepts of precast concrete in the given situation. 1b. Select the material of relevant specifications for the given pre-cast elements. 1c. Describe the design considerations and IS provisions for given pre-cast element. 1d. Classify the joints of the given pre-cast elements. 1e. Recommend the precast element in the given situation on the basis of different test carried on it. 1f. Justify the need of different tests to decide the relevance of precast element in the given situation.	1.1. Advantages and disadvantages of precast concrete members, 1.2. Materials used- PCC, RCC, PSC, SCC, Ferro-cement, Aerated and Foam concrete 1.3. Non-structural Precast elements - Paver blocks, Fencing Poles, Transmission Poles, Manhole Covers, Hollow and Solid Blocks, Door & Window frames, curb stones. 1.4. Structural Precast elements – tunnel linings, Canal lining, Box culvert, bridge panels, foundation, sheet piles 1.5. Materials required, IS specifications, casting tolerances, fabricating systems, design considerations, joints, testing, storage and transportation, equipment ; for elements mentioned above 1.6. Testing of Precast components
Unit – II Prefabricated building	2a. Describe the various elements for a Prefabricated building 2b. Describe modular co-ordination design considerations with IS provisions for prefabricated elements. 2c. Explain the requirements of structural joints of the given pre-fabricated element. 2d. Describe the procedure of the storage, transportation and erection for a given precast element. 2e. Suggest the various combinations for mixed / composite construction. 2f. Recommend the relevant equipment required for the construction of given Prefabricated element with justification. 2g. Depict the effect of	2.1 Precast Structural Building components such as slab panels, beams, columns, footings, walls, lintels and chajjas, staircase elements, 2.2 Prefabricated building using precast load bearing and non load bearing wall panels, floor systems, 2.3 Material characteristics, Plans & Standard specifications 2.4 Modules, modular co-ordination, modular grid, finishes 2.5 Casting tolerances for above elements 2.6 Prefab systems and structural schemes and their classification 2.7 Design considerations and requirements 2.8 Joints – requirements of structural joints and their design considerations for above elements 2.9 Manufacturing, storage, curing, transportation and erection of above elements, equipment needed 2.10 Introduction to Mixed and composite construction 2.11 Ecological aspect of use of Prefabricated building

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	Prefabricated building on the surrounding environment of the given building.	
Unit– III Introduction to Pre-stressed Concrete	3a. Explain the principle of pre-stressing the given element. 3b. Describe the applications of pre-stressed concrete elements in the given situation. 3c. Distinguish the PSC with other construction materials in given situation. 3d. Justify the need of high strength material for PSC. 3e. Select relevant type of pre-stressing steel for given member.	3.1 Principle of pre-stressed concrete and basic terminology. 3.2 Applications of pre-stressed concrete 3.3 Advantages and disadvantages of pre-stressed concrete 3.4 Materials used and their properties, Necessity of high-grade materials 3.5 Types of Pre-stressing steel -Wire, Cable, tendon, Merits-demerits and applications
Unit– IV Methods and systems of pre-stressing	4a. Select the relevant method of pre-stressing for given structural element. 4b. Illustrate the merits and demerits for given method/system of pre-stressing. 4c. Explain Hoyer system of pre-tensioning with diagram. 4d. Explain relevant system of post- tensioning based on the given criteria with diagram.	4.1 Methods of pre-stressing – Internal and External pre-stressing, Pre and Post tensioning- applications, merits and demerits 4.2 Systems for pre tensioning – process, applications, merits and demerits - Hoyer system 4.3 Systems for post-tensioning - process, applications, merits and demerits - Freyssinet system, Magnel Blaton system, Gifford Udall system. 4.4 Cover requirement for tendons
Unit– V Losses of pre-stress	5a. Identify the reasons for loss of pre-stress in the given element. 5b. Describe the situations in which the given elements exhibit the loss of pre-stress. 5c. Calculate the loss of pre-stress during anchoring in the given situation. 5d. Calculate the loss of pre-stress occurring in the	5.1. Pre-stressing force in Cable, Meaning of Loss of Pre-stress 5.2. Loss of pre-stress during the tensioning process - loss due to friction, length effect, wobbling effect and curvature effect. (Simple Numerical problems to determine loss of pre-stress) 5.3. Loss of pre-stress at the anchoring stage, 5.4. Loss of pre-stress occurring subsequently: losses due to shrinkage of concrete, creep of concrete, elastic shortening, and creep in steel. (Simple

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given situation. 5e. Compile the IS recommendations for percentage loss in the given pre-stressing method.	Numerical problems to determine loss of pre-stress) 5.5. IS recommendations for % loss in case of Pre and Post tensioning
Unit– VI Analysis and design of Pre-stressed rectangular beam section	6a. Explain the assumptions made in the analysis of pre-stressed concrete beams 6b. Outline the cable profiles in the given situation. 6c. Predict the effect of the given cable profile on fiber stresses. 6d. Calculate maximum stresses induced in given beam 6e. Describe the steps adopted in the design of given pre-stressed beam element.	6.1 Basic assumptions in analysis of pre-stressed concrete beams. 6.2 Cable Profile in simply supported rectangular beam section – concentric, eccentric straight and parabolic, 6.3 Effect of cable profile on maximum stresses at mid span and at support. 6.4 Numerical problems on determination of maximum stresses at mid spans with linear (concentric and eccentric) cable profiles only. 6.5 Simple steps involved in Design of simply supported rectangular beam section (No numerical Problems)

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'.*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Precast concrete Elements	08	02	04	06	12
II	Prefabricated building	10	02	06	08	16
III	Introduction to Pre-stressed Concrete	06	02	02	04	08
IV	Methods and systems of pre-stressing	06	00	04	04	08
V	Losses of pre-stress	08	02	04	06	12
VI	Analysis and design of Pre-stressed rectangular beam section	10	02	04	08	14
Total		**48**	**10**	**24**	**36**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary from above table.*

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related ***co-curricular*** activities which can be undertaken to accelerate the attainment of the various

outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a. Undertake micro-projects.
b. Prepare journals based on practical performed in laboratory.
c. Poster presentation on any one topic.
d. Prepare short film related to manufacturing process of precast units.
e. Prepare short film related to pre-stressing process adopted on site.
f. Market survey specific to properties of various type of materials used in Precast and Pre-stressed concrete.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (***MOOCs***) may be used to teach various topics/sub topics.
b. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
a. Guide student(s) in undertaking micro-projects.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student assigned to him/her in the beginning of the semester. S/he ought to submit it by the end of the semester to develop the industry oriented COs. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than ***16 (sixteen) student engagement hours*** during the course.
In the first four semesters, the micro-project could be group-based. However, in higher semesters, it should be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. A suggestive list is given here. Similar micro-projects could be added by the concerned faculty:

a. Collect pictorial information about pre-stressing jobs
b. Collect data of pre-stressed components manufactured in your vicinity.
c. Write a detailed report of visit to any one prefabricated unit.
d. Collect data for materials required for precast elements, with their suppliers, sale price etc.
e. Prepare a power point presentation on systems of pre-stressing
f. Present a seminar on testing of precast units.
g. Collect samples of at least five precast elements from your area.
h. Prepare a report on comparison of cast in situ and precast elements with respect to time required, quality and cost.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1	Pre Cast and Pre Stress Technology: Process, Method and Future Technology	Marzuki , Nor Ashikin	Createspace Independent Pub ISBN 10: 1499353391 ISBN 13: 978-1499353396
2	Handbook on Precast Concrete buildings	--	Indian Concrete Institute
3	Precast Concrete Structures	Elliott, Kim S.	CRC Press, New York, 2011 ISBN- 13: 9781498723992
4	Design Of Pre-stressed Concrete Structures	Lin, T.Y.	John Wiley and Sons, New York, 2014 ISBN- 8: 0471018988
5	Pre-stressed Concrete	Krishna Raju, N.	Tata McGraw Hill, New Delhi, 2012 ISBN 10: 1259003361 ISBN 13: 9781259003363
6	Pre-stressed Concrete Structures	Nagarajan, Pravin	Pearson Education India ISBN 9332517614, 9789332517615
7	IS 12592: 2002Precast Concrete Manhole Cover and Frame	BIS, New Delhi	BIS, New Delhi
8	IS 15658: Precast concrete blocks for paving - Code of Practice	BIS, New Delhi	BIS, New Delhi
9	IS 15916: 2011 Building Design and Erection Using Prefabricated Concrete - Code of Practice	BIS, New Delhi	BIS, New Delhi
10	IS 15917: 2011 Building Design and Erection Using Mixed/Composite Construction - Code of Practice	BIS, New Delhi	BIS, New Delhi
11	IS 458 - 2003 Precast Concrete Pipes (with and without reinforcement) — Specification	BIS, New Delhi	BIS, New Delhi

14. SOFTWARE/LEARNING WEBSITES

a. http://www.asnu.com.au
b. www.youtube.com for videos regarding precast and prestressing procedures.
c. www.nptel.ac.in
d. www.discoveryforengineers.com
e. Website of Precast Concrete Engineers Society (PSEI)
f. Website of Masterbuilder (Precast Concrete Structures-Design aspects and its implementation in India)