GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester –V

Course Title: Concrete Technology
(Course Code: 4350601)

Diploma programme in which this course is offered	Semester in which offered
Civil Engineering	Fifth Semester

1. RATIONALE

After learning Construction material and technology in 3rd semester, this subject "Concrete Technology" is introduced in 5th semester. Concrete is the most widely used man-made construction material in the world and is second only to water as the most utilized substance on the planet. It is the material of choice where strength, impermeability, durability, performance, fire resistance and abrasion resistance are required. It plays an important role in nation building through infrastructure and private building construction. The knowledge of concrete and its properties in the plastic condition and in hardened condition are highly important in order to make Civil Engineering structure safe and serviceable. This course focuses on students' acquisition of knowledge, skills & practices in concrete works and also focuses on the recent advances in the field of concrete technology with emphasis on quality control of concrete.

2. COMPETENCY

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

- **Prepare concrete of required strength and other specifications with quality control measures.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

a) Select suitable concrete materials for different site conditions and required concrete works.
b) Prepare concrete of required specifications under different conditions.
c) Check the quality of concrete.
d) Design concrete mix proportions for required specification.
e) Prepare special concrete using relevant admixture and concreting materials.
f) Apply appropriate repairs and retrofitting techniques for concrete structures.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme	Total Credits	Examination Scheme

(In Hours)			(L+T+P/2)	Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
3	0	2	4	30*	70	25	25	150

(*):Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment 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, **CA** - Continuous Assessment; **ESE** -End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the subcomponents of the COs. *Some of the **PrOs** marked **'*'** are compulsory, as they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'*.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Determine Fineness (with sieve) and Soundness of cement.	I	02*
2	Determine compressive strength of cement.	I	02*
3	Determine Flakiness and Elongation index of coarse aggregate	I	02*
4	Determine Impact, Crushing and Abrasion value of coarse aggregate	I	04*
5	Determine specific gravity of fine and coarse aggregate	I	02*
6	Determine grading zone of fine aggregate	I	02*
7	Determine suitable proportion of all-in-aggregate as per grading limits	I	02*
8	Measure workability of concrete by slump test and compaction factor test.	II	02*
9	Determine compressive strength of concrete specimen.	III	02*
10	Determine tensile strength of Concrete specimen (cylinder and beam specimen)	III	02*
11	Non Destructive Test on concrete - Rebound Hammer		02
12	Design concrete mix proportions as per IS: 10262, guidelines	III	04*
	Total hours		**28 Hrs.**

Note

*i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.*

ii. *The following are some **sample** 'Process' and 'Product' related skills(more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.*

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Identify components	10
2	Prepare experimental setup.	20
3	Operate the equipment setup.	20
4	Follow safe practices .	10
5	Record observations correctly	20
6	Interpret the result and conclude.	20
Total		**100**

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practicals in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1	Le- Chatelier test apparatus and other relevant assembly	01
2	Assembly of compressive strength of cement determination along with a cement cube vibrating machine.	02
3	Thickness gauge with other relevant assembly	03
4	Elongation gauge with other relevant assembly	03
5	Aggregate impact testing machine	04
6	Aggregate crushing test apparatus	04
7	Los Angeles aggregate abrasion testing machine	04
8	Density bottles/ Pycnometer for specific gravity determination.	05
9	Slump cone test apparatus	08
10	Compaction factor test apparatus	08
11	Compression testing machine	2,4,9 and 10
12	Rebound hammer	11
13	Tools and Containers for mixing of concrete mixture	8 to 10 and 12
14	Concrete mixture and other required equipments for mixing	8 to 10 and 12
15	Vibrating table for concrete moulds	9,10 and 12
16	Electronic weighing balance, Different size concrete moulds, Gauging Trowel, Shovel, Sieve set, Small and big Containers etc	1 to 12

7. AFFECTIVE DOMAIN OUTCOMES

The following ***sample*** Affective Domain Outcomes (ADOs) are embedded in many of the above mentioned COs and PrOs. More could be added to fulfill the development of this competency.

a) Work as a leader/a team member.
b) Follow safety practices while using equipment.
c) Realize importance of green energy. (Environment related)

The ADOs are best developed through the laboratory/field based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

i. 'Valuing Level' in 1st year
ii. 'Organization Level' in 2nd year.
iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
Unit – I Cement, Aggregates and Water	1a. Determine Physical Properties of Cement. 1b. Select suitable type of cement as per site condition. 1c. Determine Physical properties of Aggregate. 1d. Determine Quality of water to be used for making concrete at site.	1.1 History of cement invention. 1.2 Overview of Cement Manufacturing. 1.3 Bogue's compounds and its functions 1.4 Physical and Chemical properties of cement. 1.5 Testing of cement as per BIS. 1.6 Various Grades and types of cements for different site conditions and its properties. 1.7 Role of Aggregate, types of aggregate and it's source, Classification of aggregate, Soundness of aggregate, Alkali Aggregate Reaction, Grading of aggregate. 1.8 Testing of aggregate as per BIS. 1.9 Quality of water, impurities in mixing water and permissible limits as per BIS.
Unit – II Fresh Concrete	2a. Measure workability of fresh concrete. 2b. Prepare concrete of required workability. 2c. Select suitable method of Batching, mixing, transporting, placing and finishing of fresh concrete as per site condition with	2.1 Concrete chain - Various stages of making fresh concrete at site 2.2 workability, factors affecting workability, Effect of water cement ratio, adjustments of materials to avoid segregation and bleeding , methods of Measurement of workability as per BIS - slump test, compaction factor test, flow table test,

	available resource materials. 2d. Select suitable method of Curing of concrete as per site condition.	vee bee test . 2.3 Methods of Batching, mixing of materials for making fresh concrete - hand mixing and machine mixing, mixing time. 2.4 Methods of Transportation of fresh concrete - conventional and through pumps and pipeline. 2.5 Placing of concrete - formwork stripping time, under water concreting 2.6 Compaction, importance of compaction, methods - hand 2.7 compaction, machine compaction - various vibrators and other equipments, time of vibration, vibrating techniques and precautions. 2.8 Methods of finishing of fresh concrete, Laitance & its removal. 2.9 Curing, importance of curing, period of curing accelerated curing, Conventional methods of curing - water curing methods, Special methods of curing- steam, membrane, Infrared, Electrical.
Unit– III Hardened Concrete	3a. Evaluate Properties of Hardened Concrete 3b. Conduct destructive tests and interpret its results. 3c. Conduct non destructive tests and interpret its results. 3d. Check the quality of concrete as per acceptance criteria.	3.1 Hardened Concrete and its Properties: Compressive Strength, Tensile Strength, Bond Strength, Flexural Strength, Durability and impermeability. 3.2 Factors affecting Compressive Strength. 3.3 IS Test Procedure to find Compressive & Tensile Strength of Concrete, Acceptance Criteria, Mean Strength & Standard Deviation. 3.4 Creep and Shrinkage of Concrete & its effect, factors affecting Creep and shrinkage. 3.5 Durability of Concrete & factors affecting it. 3.6 Importance of NDT. 3.7 Methods of NDT for Concrete- Rebound Hammer Test, Ultrasonic Pulse Velocity Test.
	4a. Differentiate Nominal Mix	4.1 Nominal Mix and Design Mix.

Unit– IV Concrete Mix Design	and Design Mix. 4b. Interpret test results of materials for concrete for concrete mix design 4c. Design concrete mix for required grade of concrete (for ordinary and standard grade)	4.2 Concrete Mix Design and its importance. 4.3 Different methods of Mix Design and its suitability. 4.4 Concrete Mix Design as per IS 10262. 4.5 Example of Mix design as per IS method for ordinary and standard grade of concrete without and with admixtures.
Unit– V Chemical Admixture, Special Concrete and Modern Trends	5a. Use relevant admixture according to purpose of concrete 5b. Prepare special concrete for given purpose 5c. Apply knowledge of modern trends and research in concrete technology in the field.	5.1 Admixtures in concrete: Purpose, properties and application for different types of admixture such as accelerators, retarders, water reducing admixtures, air entraining agents and super plasticizers. 5.2 Special Concrete: Properties, Advantages and limitations of the following types of Special Concretes Self-Compacting Concrete (SCC), Pervious Concrete, Fiber reinforced concrete, Ready mix concrete, Fly ash concrete, Recycled Aggregate Concrete, High performance Concrete, 3D printed Concrete 5.3 Modern trends and research in concrete technology, relevant journals and institutes.
Unit– VI Repair Rehabilitation and Retrofitting of Concrete Structures	6a. Differentiate repair, rehabilitation and retrofitting. 6b. Apply appropriate repair and rehabilitation techniques for damaged concrete structures. 6c. Apply appropriate retrofitting methods to concrete structures.	6.1 Definition of repair, rehabilitation and retrofitting 6.2 Deterioration of concrete, types, causes and prevention. 6.3 Corrosion of reinforcement, causes and prevention. 6.4 Repair and Rehabilitation stages- Removal of damaged concrete, Pretreatment of surfaces and reinforcement, Application of repair materials, Repair Procedure. 6.5 Repair and Rehabilitation material - Cement, Steel and special material like, Shotcrete, Epoxy resins, Epoxy mortar, Gypsum cement mortar, Quick setting cement mortar etc. 6.6 Repair and Rehabilitation techniques - Grouting, Guniting, Routing and

		sealing, Stitching, Drilling and Plugging etc. 6.7 Retrofitting Methods - Adding Steel Bracing, Jacketing Method, External Plate Bonding, Base Isolation Technique, Mass Reduction Technique, Wall Thickening Technique, Fiber Reinforced Polymer (FRP), Adding Shear Wall, Epoxy Injection Method, Section Enlarging Reinforcing Method etc.

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	**Cement, Aggregates and Water**	**06**	**2**	**4**	**4**	**10**
II	**Fresh Concrete**	**08**	**4**	**4**	**6**	**14**
III	**Hardened Concrete**	**08**	**4**	**4**	**6**	**14**
IV	**Concrete Mix Design**	**06**	**2**	**2**	**6**	**10**
V	**Chemical Admixture, Special Concrete and Modern Trends**	**08**	**2**	**4**	**6**	**12**
VI	**Repairs, Rehabilitation and Retrofitting of Concrete Structure**	**06**	**2**	**4**	**4**	**10**
Total		**42**	**16**	**22**	**32**	**70**

Legends: *R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)*

Note*: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly 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) Conduct a market survey for cement for various companies, cement grade and price.
b) Conduct a market survey for fine aggregate for various types and prices.
c) Conduct a market survey for coarse aggregate for various types and prices.
d) Conduct a market survey for various types of admixtures and price
e) Visit and collect photographs of Batching, mixing, transporting, placing and finishing of fresh concrete from two different construction sites.
f) Visit and collect information and photographs of workability tests carried out on fresh concrete on construction sites.

g) Visit and collect information regarding quality control measures for concrete taken by site engineers on any construction site.
h) Visit the nearby RMC plant.
i) Prepare presentation on at least one research paper related to latest trends of concrete technology from any journal of civil engineering.

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/subtopics.
b) Guide student(s) in undertaking micro-projects.
c) ***'L' in section No. 4*** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d) About ***20% of the topics/sub-topics*** which are relatively simpler or descriptive in nature is to be given to the students for ***self-learning***, but to be assessed using different assessment methods.
e) With respect to ***section No.10***, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
f) Guide students on how to address issues on environment and sustainability.
g) Guide students for using data manuals.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should ***not exceed three.***

The micro-project could be field application based, internet-based, workshop-based, laboratory-based or theory based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain a dated work diary consisting of individual contributions in the project work and give a seminar presentation of it before submission. The duration of the micro-project should be about **14-16** ***(fourteen to sixteen) student engagement hours*** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

a) Compare at least two physical properties of cement of two different companies with different prices.
b) Compare at least two properties of fine aggregate from two different sources with different prices.
c) Compare at least two properties of coarse aggregate from two different sources with different prices.
d) Measure the effect of water cement ratio on workability of concrete by slump test.

e) Measure the effect of water cement ratio on workability of concrete by compaction factor test.
f) Measure the effect of water cement ratio on compressive strength of concrete.
g) Measure the effect of curing on the compressive strength of concrete.
h) Measure the effect of admixture on workability and strength of concrete.
i) Prepare special concrete with non conventional material.
j) Measure the quality of concrete at two different places with non-destructive tests.
k) Prepare a computer program or spread sheet for Concrete Mix Design as per IS:10262 .

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author	Publication with place, year and ISBN
1	Concrete Technology Theory and Practice	M S Shetty	S Chand & Company Ltd, New Delhi ISBN-13:978-9352533800
2	Concrete Technology	Shanthakumar A R	Oxford University Press, New Delhi ISBN-13: 978-0199458523
3	Concrete Technology Theory and Practice	M L Gambhir	McGraw Hill Education (I) Pvt Ltd, New Delhi ISBN-13: 978-1259062551
4	Concrete: Microstructure, Properties, and Materials	P Kumar Mehta Paulo J M Monterio	McGraw Hill Education (I) Pvt Ltd, New Delhi ISBN-13: 978-9339204761
5	Properties of concrete	A M Nevill J J Brooks	Pearson Education ISBN-13: 978-9353436551
6	IS 10262		Bureau of Indian Standards

14. SOFTWARE/LEARNING WEBSITES

a) NPTEL Course :-Concrete Technology by IIT, Delhi https://nptel.ac.in/courses/105102012
b) Concrete Technology laboratory Tests : https://www.youtube.com/playlist?list=PLkyVnO47pDX9YJglk1o2iYzWgABo5I_xA Video series for Concrete Tec
c) Virtual Lab by Ministry of Education, Government of India www.vlab.co.in

15. PO-COMPETENCY-CO MAPPING

Semester V	Concrete Technology (Course Code: 4350601)						
	Pos						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/ development of solutions	PO 4 Engineering Tools, Experimentation &Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning

Competency	Prepare concrete of required strength and other specifications with quality control measures.						
Course Outcomes COa)Select suitable concrete materials for different site conditions and required concrete works.	2	-	-	3	2	2	2
COb) Prepare concrete of required specifications under different conditions.	2	-	-	3	2	2	2
COc) Check the quality of concrete.	2	-	-	3	2	2	2
COd) Design concrete mix proportions for required specification.	2	2	3	3	2	2	2
COe)Prepare special concrete using relevant admixture and concreting materials.	2	-	-	3	2	2	2
COf) Apply appropriate repairs and retrofitting techniques for concrete structures.	2	-	-	3	2	2	2

*Legend: '**3'** for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

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