**Program Name** : **Civil Engineering Program Group**

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

**Semester** : **Third**

**Course Title** : **Concrete Technology**

**Course Code** : **22305**

## 1. RATIONALE

Concrete is the most widely used construction material today for different kinds of infrastructural development works. The versatility and mouldability of the concrete and its high compressive strength have contributed largely to its wide spread use in development and construction works. The contents of course will focus on learning about quality of concrete with regards to mix design, preparation, transporting and placing in position for various structures. It will also provide guidelines for effective supervision and quality control of concreting work. With good knowledge of concrete materials namely cement, aggregates, water and admixtures and concreting operation namely selection of materials, mixed design, mixing, placing, compacting and finishing, curing, one can obtain concrete of desired workability and required strength. The content of this course will also enable students to acquire knowledge and skills for carrying out various tests on different materials of concrete for quality construction works. Effective learning on above aspects will assist students to become a useful professional civil engineer contributing to the profession of construction and development works.

## 2. COMPETENCY

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

- **Use relevant types of concrete in different site conditions.**

## 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 demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Use relevant types of cement in different site conditions.
b. Use relevant aggregates for required concrete works.
c. Prepare concrete of desired compressive strengths.
d. Prepare concrete of required specifications.
e. Maintain the quality of concrete.
f. Use relevant admixtures for concreting for different weather conditions.

## 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 | 7 | 3 | 70 | 28 | 30* | 00 | 100 | 40 | 25# | 10 | 25 | 10 | 50 | 20 | |

*(*): Under the theory PA; Out of 30 marks, 10 marks of theory PA is for micro-project assessment to facilitate attainment of UOs and the remaining 20 marks is for tests and assignments given by the teacher.*
***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.

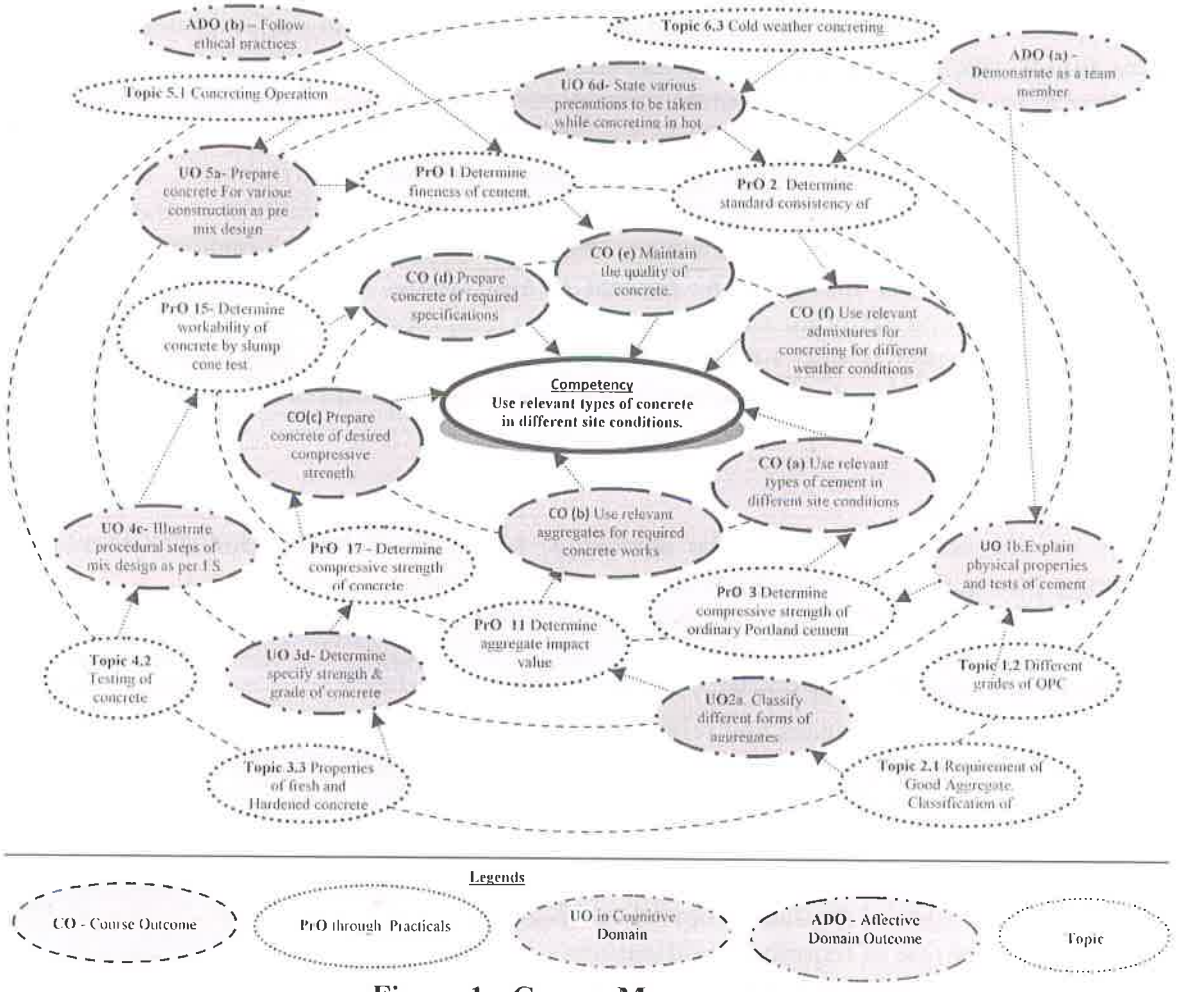


**Figure 1 - Course Map**

## 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) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| 1 | Determine fineness of cement by Blaine's air permeability apparatus Or by sieving. | I | 02* |
| 2 | Determine standard consistency, initial and final setting times of | I | 02* |

| S. No. | Practical Outcomes (PrOs) | Unit No. | Approx. Hrs. Required |
|---|---|---|---|
| | OPC. | | |
| 3 | Determine compressive strength of ordinary Portland cement. | I | 02 |
| 4 | Determine specific gravity of ordinary Portland cement. | I | 02 |
| 5 | Determine silt content in sand by volume. | II | 02 |
| 6 | Determine bulking of sand. | II | 02 |
| 7 | Determine bulk density of fine and coarse aggregates. | II | 02* |
| 8 | Determine water absorption of fine and coarse aggregates. | II | 02 |
| 9 | Determine Fineness modulus of fine aggregate by sieve analysis. | II | 02* |
| 10 | Determine Fineness modulus of coarse aggregate by sieve analysis. | II | 02 |
| 11 | Determine aggregate impact value. | II | 02* |
| 12 | Determine aggregate crushing value. | II | 02 |
| 13 | Determine abrasion value of aggregate. | II | 02 |
| 14 | Determine aggregate elongation index and flakiness index. | I | 02 |
| 15 | Determine workability of concrete by slump cone test. | IV | 02* |
| 16 | Determine workability of concrete by compaction factor test. | IV | 02 |
| 17 | Determine compressive strength of concrete for 7 days | IV | 02* |
| 18 | Determine compressive strength of concrete by any one method of NDT . | IV | 02 |
| | **Total** | | **36** |

***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 practical LOs/tutorials 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. *Hence, the 'Process' and 'Product' related skills associated with each PrO of the laboratory/workshop/field work are to be assessed according to a suggested sample given below:*

| S. No. | Performance Indicators | Weightage in % |
|---|---|---|
| a. | Preparation of experimental setup | 20 |
| b. | Setting and operation | 20 |
| c. | Observation and recording | 10 |
| d. | Safety measures | 10 |
| e. | Interpretation of results and conclusion | 20 |
| f. | Answer to sample questions | 10 |
| g. | 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:

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

## 7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

| S. No. | Equipment Name with Broad Specifications | PrO. S. No. |
|---|---|---|
| 1 | Blaine's air permeability apparatus as per IS: 4031 ( part 1)-1999, and sieve no. IS 90 micron - IS Brass Sieve (200 mm dia), 90 Micron size. | 1 |
| 2 | Vicats apparatus- VICAT mould of dia. 80 mm & 40 mm high glass base plate, initial needle, final needle. Consistency plunger M.S. base plate (non porous) of weight 300 gm. Vicat mould split type with camping ring. | 2 |
| 3 | Compression testing machine-2000 kN capacity, Cement mortar cube vibrator-, moulds size 50 $cm^2$ ( 7.07 cm x 7.07 cm) | 3,17 |
| 4 | Lee Chartlier flask and Kerosine | 4 |
| 5 | Measuring Cylinder of 100 ml capacity | 2,3,5,6, |
| 6 | Measuring Cylinder 1000 ml capacity | 2,3,5,6, |
| 7 | Density basket as per IS specification | 7 |
| 8 | I S sieve set ( sizes- 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 1.18 mm, 600 µ, 300 µ. 150 µ and pan) , sieve shaker with adaptors | 1,9,10 |
| 9 | Aggregate impact testing m/c with mould, | 11 |
| 10 | Aggregate crushing mould | 12 |
| 11 | Los Angeles abrasion testing m/c | 13 |
| 12 | Elongation gauge and thickness gauge. | 14 |
| 13 | Slump cone(top dia.100mm, bottom dia.200mm, Height 300mm) | 15 |
| 14 | Compaction factor test apparatus | 16 |
| 15 | Table vibrator, moulds(150mm x150mmx 150mm) | 17 |
| 16 | NDT apparatus – rebound concrete hammer, ultrasonic pulse velocity meter | 18 |
| 17 | Hot Air Oven | 8 |
| 18 | Weighing Balance | For All |

## 8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit – I Cement** | 1a. Describe the given types of cement and their | 1.1 Chemical Constituents of OPC and their effects on properties of OPC, Bogue's |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | relevant use with justification.<br>1b. Justify the need for the given chemical constituents for given type OPC.<br>1c. Describe the practical significance of the given types of cements for the given conditions.<br>1d. Suggest the method to judge the quality of the given type of cement with justification. | compounds and their properties, hydration of cement. Physical properties of OPC: fineness, standard consistency, setting time, soundness, compressive strength.<br>1.2 Different grades of OPC. 33, 43, and 53 with specifications of physical properties as per relevant IS codes.<br>1.3 Testing of OPC: Field tests and laboratory tests-fineness test, standard consistency test, setting time test, soundness test, compressive strength test, Storage of cement and effect of storage on properties of cement.<br>1.4 Physical properties, I.S. Specifications and field applications of different types of cements: Rapid hardening cement, Low heat cement, Portland pozzolana cement, sulphate resisting cement, blast furnace slag cement, White cement. |
| **Unit– II Aggregates** | 2a. Identify the type of given aggregate samples based on and source shape and size.<br>2b. Explain the methodology to suggest suitability of given fine aggregate.<br>2c. Explain the methodology to suggest suitability of given coarse aggregate.<br>2d. Describe the permissible limits of solids for using sea water in mixing concrete. | 2.1 Aggregates: Requirement of good aggregates, Classification according to source, size and shape.<br>2.2 Fine aggregates: Properties, size, specific gravity, bulk density, water absorption and bulking, fineness modulus and grading zone of sand by sieve analysis, silt content in sand and their specification as per IS 383, bulking of sand. Concept of crushed Sand.<br>2.3 Coarse aggregates: Properties, size, shape, surface texture, water absorption, soundness, specific gravity and bulk density, fineness modulus of coarse aggregate by sieve analysis, grading of coarse aggregates, crushing value, impact value and abrasion value of coarse aggregates with specification.<br>2.4 Water: Quality of water, impurities in mixing water, and permissible limits for solids as per IS: 456, use of sea water for mixing concrete. |
| **Unit– III Concrete** | 3a. Justify use of different grades of concrete and their properties for given applications, with justification.<br>3b. Select w/c for a given grade of concrete, with justification<br>3c. Interpret the given data obtained from test on given type of concrete sample | 3.1 Concrete: Necessity of supervision for concreting operation, different grades of concrete (ordinary Concrete, standard concrete and high strength concrete as per provisions of IS 456.<br>3.2 Water cement ratio Duff Abraham w/c law, significance of w/c ratio, selection of w/c ratio for different grades of concrete prepared from different grades of OPC as per graphs specified in IS 10262, maximum w/c ratio for different grades of concrete for different |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| | 3d. Describe the factors affecting overall durability of given type of concrete. | exposure conditions.<br>3.3 Properties of fresh concrete: Workability, Factors affecting workability of Concrete. Determination of workability of concrete by slump cone test, compaction factor test. Range values of workability requirement for different types of concrete works. Segregation, bleeding and preventive measures.<br>3.4 Properties of Hardened concrete: compressive strength, durability, impermeability and dimensional changes of concrete. |
| **Unit-IV** Concrete Mix Design and Testing of Concrete | 4a. Explain the given method of concrete mix design for the given situation.<br>4b. Interpret the given data obtained from test on given type of concrete.<br>4c. Describe the need of NDT for the given field situation.<br>4d. Interpret the given data obtained from NDT on given structure. | 4.1 Concrete mix design, objectives, methods of mix design, study of mix design procedure by I.S. method as per I.S. 10262-(Only procedural steps)<br>4.2 Testing of concrete: Significance of testing, determination of compressive strength of concrete cubes at different ages, interpretation and co-relation of test results.<br>4.3 Non- destructive testing of concrete: Importance of NDT, methods of NDT,<br>4.4 Rebound hammer test, working principle of rebound hammer and factor affecting the rebound index, Ultrasonic pulse velocity test, specification for deciding the quality of concrete by Ultrasonic pulse velocity as per I.S.13311 (part 1 and 2). |
| **Unit –V Quality Control of Concrete** | 5a. Explain the sequential operations of concreting in given situation.<br>5b. Explain the given type of form works and stripping time.<br>5c. Select given method of waterproofing for given situation with justification<br>5d. Identify the type of construction joint to be used in given situations of concreting works, with justification. | 5.1 Concreting Operations: Batching, Mixing, Transportation, Placing, Compaction, Curing and Finishing of concrete.<br>5.2 Forms for concreting: Different types of form works for beams, slabs, columns, materials used for form work, requirement of good form work. Stripping time for removal of form works per IS 456-2000 provision for different structural members.<br>5.3 Waterproofing: Importance and need of waterproofing, methods of waterproofing and materials used for waterproofing.<br>5.4 Joints in concrete construction: Types of joints, joining old and new concrete, methods of joining, materials used for filling joints. |

| Unit | Unit Outcomes (UOs) (in cognitive domain) | Topics and Sub-topics |
|---|---|---|
| **Unit-VI Chemical Admixture in concrete, Special Concrete and, Extreme weather concreting** | 6a. Justify the need of given admixtures in concrete mix.<br>6b. Describe the characteristics and uses of given type of concrete.<br>6c. Explain effects and preventive measures in the given type of weather concreting.<br>6d. Select the type of weather concreting in the given situation with justification.<br>6e. Select the type of industrial flooring in the given situation with justification. | 6.1 Admixture in concrete: Purpose, properties and application for different types of admixture such as accelerating admixtures, retarding admixtures, water reducing admixture, air entraining admixture and super plasticizers.<br>6.2 Special Concrete: Properties, advantages and limitation of the following types of Special concrete: Ready mix Concrete, Fiber Reinforced Concrete, High performance Concrete and self compacting concrete, light weight concrete.<br>6.3 Cold and Hot weather concreting: Effect of cold and Hot weather on concrete, precautions to be taken while concreting in cold and hot weather condition.<br>6.4 Concrete as industrial flooring material and various techniques: Vacuum dewatering flooring, Free Movement flooring. Techniques of groove cutting and various materials used for groove filling in concrete flooring. |

***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 | Cement | 04 | 02 | 02 | 02 | 06 |
| II | Aggregates | 06 | 02 | 02 | 06 | 10 |
| III | Concrete | 10 | 02 | 02 | 10 | 14 |
| IV | Concrete Mix Design and testing of Concrete | 12 | 02 | 04 | 10 | 16 |
| V | Quality Control of Concrete | 10 | 02 | 06 | 06 | 14 |
| VI | Chemical Admixture in concrete, Special Concrete and Extreme weather concreting | 06 | 02 | 04 | 04 | 10 |
| **Total** | | **48** | **12** | **20** | **38** | **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:

i. Market survey to select type of cement for various types of construction works.
ii. Visit to site under construction to collect detail information about the ingredients of concrete mix.
iii. Visit to nearby RMC plant and draw flow chart.
iv. Visit to site under construction to observe concreting operations.
v. Visit to site under construction to observe the quality of fresh concrete.
vi. Visit to site under construction to observe form work, scaffolding used and joints in concrete.
vii. Visit to site under construction and make a check list of effect of each property of Cement and aggregate on quality of concrete.
viii. Search the software/freeware for the course content and prepare report stating their applications.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various learning 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***.
e. Guide student(s) in undertaking micro-projects.
f. Assign unit wise tutorials to group of 4 to 5 students for solving problems unit wise.
g. Assign micro projects to group of 4 to 5 students and let them prepare and present the project through PPT. Group shall submit a report which is limited to 5 pages.
h. Use of video animation films to explain concept, Facts and applications related to Concrete Technology.
i. In respect of item 10 above teacher needs to ensure to create opportunity and provisions for such co curricular activities.

## 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-project are group-based. However, in the fifth and sixth semesters, it should be preferably 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. In special situations where groups have to be formed for micro-projects, the number of students in the group should ***not exceed three.***

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-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

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. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

A suggestive list of micro-projects are given here. Similar micro-projects could be added by the concerned faculty:

a. Undertake any one micro-projects (Group of 4 to 6 students)

i. Prepare cast in situ concrete of given grade. It includes visit to site, observations, records,field tests of cement, sand and coarse aggregate. Follow the concrete chain operations.

ii. Using IS code method of mix design obtain ingredients of concrete and prepare concrete.

**Note: Any other relevant micro project suggested by subject teacher.**

## 13. SUGGESTED LEARNING RESOURCES

| S. No. | Title of Book | Author | Publication |
|---|---|---|---|
| 1 | Concrete Technology | Gambhir, M.L. | Tata McGraw Hill Publishing Co. Ltd., New Delhi, ISBN-13: 978-1-259-06255-1 |
| 2 | Concrete Technology | Shetty, M.S. | S. Chand and Co. Pvt. Ltd., Ram Nagar, New Delhi-110055 ISBN, : 978-8-121-90003-4 |
| 3 | Concrete Technology | Santhakumar ,A. R. | Oxford University Press, New Delhi ISBN-13: 978-0-195-67153-7 |
| 4 | Concrete Technology | Neville, A. M. and Brooks, J.J. | Pearson Education Pvt. Ltd., New Delhi ISBN 978-0-273-73219–8 |
| 5 | Properties of Concrete | Neville A. M. | Pearson Education Pvt. Ltd., New Delhi ISBN 978-0-273-75580-7 |

## 14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://nptel.ac.in
b. www.w3schools.com
c. www.engineeringcivil.com/various-lab-test-on-cement.html
d. www.engineeringcivil.com/various-lab-test-on-aggregates.html
e. www.aboutcivil.org/tests-on-concrete.html
f. https://theconstructor.org/practical-guide/non-destructive-testing-of-concrete/5553/
g. nptel.ac.in/courses/105104030/34
h. nptel.ac.in/courses/105104030/
i. nptel.ac.in/courses/105102012/38
j. https://www.youtube.com/watch?v=cbL5q0HBlnE
k. www.nbmcw.com/concrete/3834-steel-fibre-concrete-composites-for-special applicati.