

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

**COURSE CURRICULUM
COURSE TITLE: DESIGN OF STEEL STRUCTURE
(COURSE CODE: 3350601)**

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5 th Semester

1. RATIONALE

Civil Engineering structures are normally made up of either Steel Sections or of Reinforced Cement Concrete. Normally, industrial structures are constructed using steel sections. In industry, to cover wider area without any obstruction at floor level due to columns etc., normally steel roof truss is provided and hence Load calculation using IS 875 is required for such trusses.

Using our previous semester study of Structural Analysis and design provisions as per IS-800-2007, in this subject, students will analyse and design different components of steel structure.

In Steel Structure, Rolled Steel Sections are used and its connections at different stages on site is highly important for the safety of Structure and hence, study of Connection through Welding or Bolting is important. This course is therefore an important course for civil engineering students.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop required skills so that students are able to acquire following competencies:

- **Design of Tension & Compression members of Steel Structure along with Foundation, Steel Beam and Welded and Bolt Connection as per IS 800-2007**
- **Structure Detailing of Steel Roof Truss and Different Steel Structure Component**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- i. Calculate Dead Load , Live Load and Wind Load on panel points of a Roof Truss as per IS-875-1984
- ii. Design Bolt Connection of Angle Section to Gusset Plate & Welded Connection of Angle Section to Gusset Plate , Lacing System (Single or Double) for Built up Column , Batten System for Built up Column , laterally Restrained Simply Supported beam, Purlin made up Angle Section , Slab Base Foundation under Axially Loaded Column made up of Single H Section
- iii. Analyze and Design Axially Loaded Tension Member made up of Angle Section , Strut made up of Angle Section , Axially Loaded Column

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (InHours)			Total Credits (L+T+P)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	PA	ESE	PA	200
03	00	04	07	70	30	40	60	

Legends:L- Lecture;T- Tutorial/TeacherGuidedStudentActivity;P - Practical; C -Credit; ESE- End Semester Examination; PA-Progressive Assessment.

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit – I Calculation of Load on Roof Truss	1a. Calculate Dead Load , Live Load and Wind Load on panel points of a Roof Truss 1b. List types of Truss	1.1 Rolled Steel Section – ISA, I & H Section, Channel Section and its application in Steel Structure 1.2 Types of Truss, Pitch of Truss, Rise, Spacing of Truss, Purlin, Principal Rafter, Main Tie, Sag Tie, Members of Truss , Roofing material- GI and AC Sheets 1.3 Dead Load of Truss per panel point- Self Weight , Weight of Purlin , Wind Bracing , Weight of Roofing Material 1.4 Live Load per panel point in Truss as per IS – 875 – Part II -1984 when access is not provided 1.5 Wind Load per panel point in Truss using IS – 875 – Part III -1984

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit – II Bolt and Welded Connection	2a. D Design Bolt Connection of Angle Section to Gusset Plate 2b. D Design Welded Connection of Angle Section to Gusset Plate 2c. C Solve Numerical on Bolted Connection of Angle Section to Gusset Plate and for Efficiency of Joint having Chain Bolting 2d. C Solve Numerical on Welded Connection of Angle Section to	2.1 Rigid Connection, Pinned Connection, Semi Rigid Connection, Black Bolts, Turned Bolts, HSFG Bolts, Grade of Bolts 2.2 Lap and Butt Joint, Minimum and Maximum Pitch, Tack Bolting, Edge Distance, Gauge Distance, Bolt Hole 2.3 Shear Capacity of Bolt – V_{dsb} , Bearing Capacity of Bolt – V_{dpb} as per IS-800-2007, Bolt Value, Efficiency of Joint 2.4 Numerical on Bolted Connection of Angle Section to Gusset Plate and for Efficiency of Joint having Chain Bolting 2.5 Types of Weld, Fillet Weld and
Unit – III Tension Member	3a Analyze and Design Axially Loaded Tension Member made up of Angle Section 3b Solve Numerical for Analysis & Design type based on 1.2 for Single and Double Angle Sections on same side and either side of Gusset Plate	3.1 Examples of Tension Members in Civil Engineering Structures 3.2 Design Strength of Tension Member, Design Strength due to Yielding of Gross Section, Design Strength due to Rupture of Critical Section for Angle Section, Design Strength due to Block Shear in Angle Section as per IS – 800-2007 3.3 Slenderness ratio of Tension Member as per IS – 800 – 2007 3.4 Numerical for Analysis & Design type based on 1.2 for Single and Double Angle Sections on same side and either side of Gusset Plate

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit – IV Compression Member Strut & Column	<p>4a Analyze and Design Strut made up of Angle Section</p> <p>4b Analyze and Design Axially Loaded Column</p> <p>4c Solve Numerical on Column made up of ISHB , ISHB with Flange Plate , Double Channels Back to Back and Toe to Toe</p> <p>4d Solve Numerical on Strut made up of Single Angle, Double Angle same and either side of G.P as per 1.2 & 1.3 Built up Column , Effective Length of Column as per Table 11, IS-800-2007</p>	<p>4.1 Strut , Maximum Slenderness Ratio, Classification of Cross – Sections and Buckling Class as per IS-800-2007</p> <p>4.2 Angle Strut as per Cl. 7.5 , IS-800-2007</p> <p>4.3 Design Compressive Stress – fcd according to Tables of IS-800-2007</p> <p>4.4 Numerical on Strut made up of Single Angle , Double Angle same and either side of G.P as per 1.2 & 1.3 Built up Column , Effective Length of Column as per Table 11 , IS-800-2007</p> <p>4.5 Design Compressive Stress – fcd according to Tables of IS-800-2007</p> <p>4.6 Numerical on Column made up of ISHB, ISHB with Flange Plate, Double Channels Back to Back and Toe to Toe</p>
Unit – V Lacing & Battens	<p>5a Design Lacing System (Single or Double) for Built up Column</p> <p>5b Describe Objective of Lacing , Single Lacing , Double Lacing , Batten</p> <p>5c Design Batten System for Built up Column</p>	<p>5.1 Objective of Lacing , Single Lacing ,</p> <p>5.2 Double Lacing</p> <p>5.3 IS – 800-2007 requirements for Lacing System as per Cl. 7.6</p> <p>5.4 Numerical on Single and Double Lacing as per 1.2</p> <p>5.5 Objective of Batten , Batten</p> <p>5.6 IS – 800-2007 requirements for Batten System as per Cl. 7.7</p> <p>5.7 Numerical on batten as per 2.2</p>
Unit – VI Lateral Restrained Beam & Purlin	<p>6a Design of laterally Restrained Simply Supported beam</p> <p>6b Design of Purlin made up Angle Section</p>	<p>6.1 Main Beam , Secondary Beam , Standard I Sections , Laterally restrained and unrestrained beam</p> <p>6.2 Plastic Section Modulus – Annexure –H , IS-800-2007 , Section classification as per Table 2 – IS-800-2007 , Shear buckling , Shear Strength and Bending Strength of Section as per Cl. 8.4.1 and Cl. 8.2.1.2 of IS-800-2007 , Deflection as per Table-6 of IS-800-2007 , Shear Leg Effect , Web Crippling</p>

Unit	Major Learning Outcomes (in Cognitive Domain)	Topics and Sub-topics
Unit-VII Slab Base Foundation	7a Design of Slab Base Foundation under Axially Loaded Column made up of Single H Section 7b Solve Numerical on Slab Base Foundation under Column made up of Single H	7.1 Slab Base , Gusseted Base , Base plate and its Thickness as per IS-800-2007 , Concrete Block , SBC of Soil , Anchor Bolt , Cleat and Dummy Angle 7.2 Numerical on Slab Base Foundation under Column made up of Single H Section

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS(THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Calculation of Load on Roof Truss	08	02	00	09	11
II	Bolted and Welded Connection	06	01	02	04	07
III	Tension Member	06	00	02	05	07
IV	Compression Member Strut & Column	06	02	02	06	10
V	Lacing & Batten	04	01	02	04	07
VI	Laterally Restrained Beam & Purlin	08	02	04	08	14
VII	Slab Base Foundation	04	02	00	05	07
	Sketches As Mentioned In Drawing Work	00	03	04	00	07
Total		42	13	16	41	70

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

Note: This specification table shall be treated as general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (**outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes** (as given in a common list at the beginning of curriculum document for this programme) would be assured.

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (outcomes in psychomotor domain)	Approx. Hrs. Required
1	I	Find Forces in given Truss Members using Graphical Method due to D.L , L.L and W.L and Design Forces in the Members – Drawing Sheet – No: 01 ,A1 Size	08
2	II , III , IV	Draw Plan & c/s Elevation of Eaves Level Joint , Ridge Joint and Two Other Joints of a Truss Selected in Sheet No:01 with all design details like Size of Angle Section , G.P , Connection Details , Purlin , Roofing Material – Drawing Sheet – No: 02 , A1 Size	10
3	IV , VII	Draw Plan and c/s Elevation of Built up column made up of Double Channel provided back to back with Single or Double Lacing Draw Plan and c/s Elevation of Slab Base Foundation under column made up of H section Sheet No:03 – A1 Size	08
4	----	Prepare following Neat sketches in Sketch Book Different Types of Truss Truss Details – Spacing of Truss , Principal Rafter, Main Tie, Members, Ridge, span, Roof Covering, Purlin etc... Eaves Level Joint of Truss Ridge Level Joint of Truss Beam to Beam Connection at Same Level Beam to Beam Connection at Different Level Column to Beam Seated Connection (Weld & Bolt Connection) Column to Beam framed Connection (Weld & Bolt Connection) Gusseted Slab Base Foundation	14
5	I , II , III , IV , V, VII	Prepare a Report File related to Calculation work of Drawing Sheet No: 1 , 2 & 3	10
6		Site Visit of Industry Truss , Steel Structure Railway Platform – Report , Photographs	06
Total Hours			56

8. SUGGESTED LIST OF STUDENT ACTIVITIES

- i. Collect the Photographs of nearby Typical Roof Trusses and from Internet
- ii. Collect the Photographs of Elevated Steel Structure Water Tank
- iii. Collect the Photographs of Steel Columns with Lacing and / or Batten

9. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

- i. Site Visit must be arranged for Industrial Truss to explain Truss terminology and Connection Details
- ii. Show video of Fabrication work using Bolt and Weld

10. SUGGESTED LEARNING RESOURCES

A. List of Books:

*** Students are permitted to appear in theory & practical examination with these books (highlighted and under lined)

S. No.	Title of Books	Author	Publication
1.	<u>***IS-800 – 2007</u>	----	Bureau of Indian Standard
2.	<u>***Handbook on Steel – SP-6</u>	----	Bureau of Indian Standard
3.	<u>***IS – 875 – 1984 , Part - III</u>	----	Bureau of Indian Standard
4.	Design of Steel Structures (By Limit State Method As Per Is: 800—2007)	S S Bhavikatti	I. K. International Pvt Ltd
5.	Design of Steel Structures	K. S. Sai Ram	Pearson Education India
6.	Design of Steel Structures: Theory And Practice	N. Subramanian	Oxford University Press (2010)
7.	Limit State Design of Steel Structures	S . K Duggal	Tata Mcgraw Hill Education Private Limited

B. List of Major Equipment/Materials

- i. Drawing Hall having Drawing Facilities
- ii. Models of Truss , Built up column , Beam and Column Connection

C List of Software/Learning Websites

- i. <http://nptel.iitm.ac.in> - Lecture series from IIT , Guwahati
- ii. elearning.vtu.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- Prof. B.G. Rajgor, H.O.D, App. Mech. , BBIT, V V Nagar
- Prof. B. G. Bhankhar , H.O.D , App. Mech., GP , Ahmedabad
- Prof. K. K. Patel, H.O.D , App. Mech. , GP , Rajkot
- Prof. C. H. Bhatt, LAM, DR. S & S. S. Gandhi Engg. College , Surat
- Prof. Bhruguli H Gandhi , LAM , GGP , Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- Dr. K. K. Pathak, Professor Department of Civil and Environmental Engineering
- Dr. M. C. Paliwal, Associated Professor, Department of Civil and Environmental Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT**COURSE CURRICULUM
COURSE TITLE: CONCRETE TECHNOLOGY
(COURSE CODE: 3350602)**

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering/ Transportation Engineering	5 th Semester

1. RATIONALE:

Cement mortar and concrete are the most widely used and versatile construction materials. It is the material of choice where strength, impermeability, durability, performance, fire resistance and abrasion resistance are required.

Concrete is generally a site-made material unlike other materials of construction and as such can vary to a great extent in its quality, properties and performance owing to use of natural materials except cement. 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. The knowledge and application of such aspects is essential in developing a good technician who should be conversant with the tests of various components of concrete and site practices to maintain quality of concrete works.

2. LIST OF COMPETENCIES

The course content should be taught and implemented with the aim to develop required skills so that students are able to acquire following competencies:

- Determine various properties/ characteristics & parameters of concrete with respect to Construction and Engineering Applications
- Evaluate Engineering Properties / characteristics of concrete for their suitability for Engineering Structures

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- i. Evaluate physical properties of cement, sand and aggregates.
- ii. Describe proper method for making and curing of concrete.
- iii. Measure important properties of fresh and hardened cement concrete including NDT.
- iv. Explain properties of various types of Admixtures and their utility
- v. Design Concrete Mix as per IS method
- vi. Explain various types of special concrete and their use.
- vii. Explain methods to prevent and repair different types of the crack
- viii. Prepare summary of at least one research paper on concrete from any journal of civil engineering

4. **TEACHING AND EXAMINATION SCHEME**

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				Total Marks
L	T	P		Theory Marks		Practical Marks		
			C	ESE	PA	ESE	PA	150
03	00	02	05	70	30	20	30	

Legends: L- Lecture; T- Tutorial/Teacher Guided Student Activity; P - Practical; C –Credit; ESE-End Semester Examination; PA- Progressive Assessment

5. **COURSE CONTENT DETAILS**

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
Unit-I Materials for Concrete	1a. Evaluate physical properties of cement 1b. Evaluate Physical Properties of sand and aggregates used in concrete 1c. Test quality of water used in Concrete	1.1 Importance of cement in preparation of concrete, Chemical compound of ordinary Portland cement, Bougue's compounds and its functions 1.2 Types and Grades of cement and its uses 1.3 Physical properties- Fineness, consistency of Cement, IST & FST, Soundness & Compressive Strength of cement and its I.S. Requirements, Its Importance & their related Test as per Indian Standards 2.1 Role of Coarse & Fine Aggregates in Concrete, Classifications of aggregate on the basis of its size, shape, texture and weight Sieve Analysis, Water Absorption Specific Gravity of Fine Aggregate & Coarse Aggregate, Coarse Aggregate Impact Value, Crushing Value & Abrasion Value, Flakiness & Elongation Index, its importance & their related Test as per Indian Standards 1.1 Requirements of quality for water in concrete.

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
Unit-II Fresh Concrete	2a. Evaluate workability , harshness, segregation and bleeding properties of fresh concrete 2b. List the factors affecting workability 2c. Describe methods of measurement of workability , slump test & compaction factor test 2d. Describe methods of mixing of concrete 2e. Describe methods of compaction of concrete 2f. Describe methods of Curing 2g. List Effect of curing on development of strength of concrete	2.1 Fresh concrete and its properties - Workability, harshness, Segregation and bleeding 2.2 Factors affecting workability 2.3 Methods of measurement of workability Slump Test & Compaction Factor Test 2.4 Relation between workability and strength of concrete 2.5 Methods of mixing of concrete – Hand & Machine Mixing and its Transportation and Placing 2.6 Methods of compaction of concrete and its suitability 2.7 Factors affecting compaction 2.8 Curing and its importance , its methods and suitability 2.9 Effect of curing on development of strength of concrete
Unit-III Admixtures	3a Explain properties of various types of Admixtures and their utility	3.1 Admixtures and its benefits , Types of Admixtures - Accelerator and Retarder Plasticizer and Super Plasticizer Water roofing and Air entraining admixture 3.2 Utility of Admixtures
Unit-IV Hardened Concrete	4a Evaluate Properties of Hardened Concrete 4b Describe the steps to conduct Non Destructive Test of Concrete	4.1 Hardened Concrete and its Properties 4.2 Compressive Strength ,Tensile Strength, Bond Strength, Flexure Strength Durability, impermeability 4.3 Factors affecting Compressive Strength 4.4 Creep of Concrete & its effect , factors affecting Creep 4.5 IS Test Procedure to find Compressive & Tensile Strength of Concrete, Acceptance Criteria , Mean Strength & Standard Deviation 4.6 Durability of Concrete & factors affecting it 4.7 Economy of Concrete & factors affecting it 4.8 Methods of Non Destructive Test of Concrete Rebound Hammer Test, Ultrasonic Pulse Velocity Test 4.9 Importance of NDT

Unit	Major Learning Outcomes (Outcomes in Cognitive Domain)	Topics and Sub-topics
Unit-V Concrete Mix Design	5a Design Concrete Mix as per IS method	5.1 Factors affecting quality of concrete, Advantages of Quality control. 5.2 Concrete Mix Design and its importance. 5.3 Nominal Mix and Design Mix. 5.4 Factors affecting concrete mix design. 5.5 Different methods of Mix Design and its suitability. 5.6 I.S. method to design a Concrete Mix As per IS 10262-2009. 5.7 Example of Mix design as per I.S. method
Unit - VI Special Concrete & Concreting Techniques	6a Explain various types of special concrete and their use.	6.1 Light weight concrete 6.2 Plum concrete 6.3 Fibre reinforced concrete 6.4 Polymer concrete 6.5 High density concrete 6.6 No fines concrete 6.7 Ferro cement 6.8 Fly ash concrete 6.9 Pumped Concrete 6.10 Ready mix concrete
Unit -VII Prevention & Repair Techniques For Cracks	7a Explain various types of cracks in concrete structures and their causes. 7b Explain methods to prevent and repair the cracks.	7.1 Deterioration of concrete and 7.2 Corrosion of reinforcement 7.3 Types of deteriorations and its effects 7.4 Prevention of concrete deterioration 7.5 Effect of corrosion of reinforcement in concrete and remedial 7.6 Types ,causes and remedies of concrete cracks before hardening 7.7 Types ,causes and remedies of concrete cracks after hardening 7.8 Prevention of cracks 7.9 Materials for repair of cracks 7.10 Methods used for repair of cracked Concrete
Unit-VIII Modern Trend And Research Development In Concrete Technology	8a Explain about latest Developments in the field of concrete works. 8b Prepare summary of at least one research paper on concrete during the course from any journal of civil engineering	8.1 latest research and development in the field of concrete technology 8.2 Journals available in the library, its publishers, Editors and place of publications. 8.3 The various authorities in the field of concrete technology and their field of specialization.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS& MARKS (Theory)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Materials for Concrete	08	3	8	3	14
II	Fresh Concrete	08	2	2	8	12
III	Admixures	03	2	1	2	05
IV	Hardened Concrete	08	2	2	8	12
V	Concrete Mix Design	05	1	2	6	09
VI	Special Concrete & Concreting Techniques	04	1	2	4	07
VII	Prevention & Repair Techniques For Cracks	04	1	2	4	07
VIII	Modern Trend And Research Development in Concrete Technology	02	1	1	2	04
Total		42	13	20	37	70

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

Note: This specification table shall be treated as general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (**outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

*Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes** (as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Approx. Hrs. Required
1.	I	Test the cement for soundness	02
2.	I	Grade Aggregate into Fine and Coarse	02
3.	I	Determine Flakiness and Elongation Index	02
4.	I	Test Crushing Value for Aggregate	02
5.	I	Test Impact Value for Aggregate	02
6.	I	Determine Aggregate Abrasion Value	02

7.	II	Measure Workability (Slump, Compaction Factor Test)	02
8.	IV	Plot the effect of W/C ratio on Compressive Strength of Concrete	04
9.	IV	Conduct Split Cylinder Test	02
10.	IV	Conduct Pull Out Test to determine Bond Strength	02
11.	IV	Demonstrate Non-destructive Tests of Concrete	02
12.	IV	Project :- Concrete Mix Design as per I. S. Method	04
TOTAL HOURS			28

FIELD VISIT: Arrange field visit to cement factory and Ready Mix concrete plant and prepare a report which should be a part of term work

8. SUGGESTED LIST OF STUDENT ACTIVITIES

- i. Collect few Samples from nearby site & find out different Properties of concrete
- ii. Undertake visit to construction site and prepare the report
- iii. Visit to concrete Testing Laboratory for awareness related to other concrete Testing Equipment, concrete Testing Report

9. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

- i. Show Video Clips of Concrete Testing, interact with students by asking questions
- ii. Show Picture Clips through Power Point regarding Testing of Concrete and its Commercial report
- iii. Video program on concrete tests – NPTEL & NITTTR - Bhopal

10. SUGGESTED LEARNING RESOURCES

A. List of Books:

No.	Title	Author	Publisher
1	Concrete Technology	M.S. Shetty	S.Chand& co.Ltd
2	Concrete Technology	M.L.Gambhir	Tata McGraw Hill Ltd.
3	Properties of Concrete	A.M.Neville	Pitman
4	Concrete Technology	Dr. K.T. Krishna swami	Dhanpatrai & sons
5	Concrete Technology	R.S. Vashney	Oxford & IBH Publishing co, Bombay

LIST OF RECOMMENDED I.S. PUBLICATIONS:

I.S. 269	Specifications for O.P.C.
IS.12269	Specifications for O.P.C.53 Grade
I.S. 383	Specifications for coarse and fine aggregates
I.S. 516	Methods of tests for strength of concrete
I.S. 2386 Part I to VIII	Methods of tests for aggregate for concrete
I.S.456	Code of practice for plain and R.C.C.
I.S. 2340	Methods for sampling of aggregates for concrete
Sp 23	Handbook for concrete Mix Design
I.S.4031	Methods of physical tests on Hydraulic cement

I.S. 13311	Methods of non destructive testing of concrete
I.S. 1199	Methods of sampling and analysis of concrete
I.S. 10262- 2009	Recommended guidelines for concrete mix design

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B. List of Major Equipment/Materials

- (i) Ennore sand of 3 grades (ii) Cube Moulds of size 7.07cm (iii) Mortar Mixer
 (iv) Compression Testing m/c (v) Le-chatlier mould (vi) Water bath (vii) I.S sieve sets
 (viii) Moulds for Aggregate Crushing and Impact Test (ix) Impact test Apparatus
 (x) Thickness and Length gauge (xi) Cube Moulds of size 15cms (xii) Slump cone
 (xiii) Compaction factor Apparatus (xiv) Schmidt Rebound Hammer (xv) Table Vibrator.

C List of Software/Learning Websites

- i. www.issnge.org
- ii. www.springer.com
- iii. www.britannica.com
- iv. www.trb.org
- v. www.nptel.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. BG Rajgor**, H.O.D, App. Mech. , BBIT, V Vnagar
- **Prof. B G Bhankhar**, H.O.D, App. Mech., GP , Ahmedabad
- **Prof. K K Patel**, H.O.D, App. Mech. , GP, Rajkot
- **Prof. C H Bhatt**, Lam, Dr. S & S S Gandhi Engg. College, Surat
- **Prof. Bhruguli H Gandhi**, LAM, GGP, Ahmedabad

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. M C Paliwal**, Associated Professor, Department of Civil and Environmental Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT**COURSE CURRICULUM****COURSE TITLE: WATER SUPPLY & SANITARY ENGINEERING****(COURSE CODE: 3350603)**

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5 th Semester

1. RATIONALE:

Water is very important element in civilization. Social life from the ancient times developed on the bank of water-sources. If society wants to make remarkable growth, the mental as well as social health play vital role. For that purpose and to maintain the hygiene Pure, potable and palatable water needs to be supplied to the society. Water must be collected and disposed off in nature by giving proper treatment, so the natural flora and fauna will not get affected by sewage disposal.

This course focuses on students' acquisition of knowledge, skills & practices in water supply and sanitary engineering. Knowledge about domestic water supply & sanitation system (external & internal) and house drainage & disposal facilities is imparted. The technician must know about the quality of domestic water to be supplied to the society and treatment of waste water. The knowledge and application of such aspects is essential in developing a good technician who should be conversant with the collection, conveyance, treatment, maintenance and disposal of waste water.

2. LIST OF COMPETENCIES:

The course content should be taught and the curriculum should be implemented with the aim to develop required skills so that students are able to acquire following competencies:

- Design, construct, operate and maintain water conveyance system
- Design, construct, operate and maintain sanitation system
- Maintain the treatment and recycle system of waste water, sewerage and solid waste

3. COURSE OUTCOMES:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- i. Select appropriate treatment to raw water useful for domestic as well as construction purpose.
- ii. Maintain the pipe-network for water supply and Sewage disposal effectively.
- iii. Calculate and Estimate the impurities present in water used for domestic as well as construction works.
- iv. Prepare lay out plan and maintain water distribution and sewer-networks.
- v. Test raw water as per the standard practices
- vi. Plan and implement house plumbing work effectively.

4. SCHEME OF STUDIES AND EXAMINATIONS:

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
L	T	P	5	Theory Marks		Practical Marks		Total Marks
3	0	2		ESE	PA	ESE	PA	
					70	30	20	30

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit; ESE - End Semester Examination; PA - Progressive Assessment

5. COURSE CONTENT DETAILS:

Unit	Major Learning outcomes (In Cognitive Domain)	Topics and Sub Topics
Unit-I Sources, Quality and Demand of water	1a. Explain Importance of water supply engineering 1b. Identify sources of water for potable use 1c. Calculate water demand for future population 1d. Enlist factor affecting water demand 1e. Determine various impurities found in water source 1f. List Standards of quality of water with their permissible limits	1.1 Importance and necessity of water supply Engineering 1.2 Sources of water 1.3 Suitability of water 1.4 Choice of source 1.5 Types of demand 1.6 Population forecast 1.7 Computation of quantity of water 1.8 Fluctuation in demand 1.9 Factors affecting demand 1.10 Impurities in water 1.11 Collection of water sample 1.12 Physical Chemical and Biological tests 1.13 Standards of quality of water
Unit-II Treatment of Water	2a. State objectives of water Treatment 2b. Describe principles used in water treatment. 2c. Explain function of various stages of treatment of influent water	2.1 Objectives of water treatment 2.2 Location of water treatment plant 2.3 Layout of water treatment plant 2.4 Basic principles of working of treatment plant 2.5 Various stages of treatment of influent water <ol style="list-style-type: none"> i. Functioning of Coagulation treatment plant ii. Sedimentation iii. Filtration iv. Disinfection

		v. Water Softening
Unit-III Conveyance of Water	3a. List various materials used for pipe 3b. Explain various pipe joints in Distribution system 3c. List different valves and fittings used in pipe network 3d. Describe working principle of Laying of Pipes for Conveyance of Water 3e. Explain necessity of maintenance of water supply mains 3f. Describe Measures for conservation of water	3.1 Types of pipes used for conveyance 3.2 Pipe joints 3.3 Laying of Pipes 3.4 Distribution system 3.5 Types of valves 3.6 Types of Meters 3.7 Pipe fittings and fixtures 3.8 Necessity 3.9 Methods to prevent leaks 3.10 Measures for conservation of water
Unit-IV Sanitation System	4a. State objectives of sewage disposal 4b. Discuss methods of sewage collection 4c. Describe Conservancy system & Water carriage system 4d. Describe sewer appurtenances 4e. Explain Testing and maintenance of sewer 4f. Explain requirement and procedure for maintenance of sewerage system 4g. Explain functions of maintenance equipments and tools 4h. Describe Safety measures for sewer-men & Explosives in sewers	4.1 Sanitation System 4.2 Objective of sewage disposal 4.3 Methods of sewage collection 4.4 Conservancy system 4.5 Water carriage system 4.6 Classification of Drains 4.7 Sewer section 4.8 Sewer joint 4.9 Manhole 4.10 Flushing tank 4.11 Catch basin 4.12 Laying of sewer 4.13 Appurtenances and its locations 4.14 Hydraulic testing of sewer pipe 4.15 Maintenance of sewer 4.16 Procedure for maintenance of sewerage system 4.17 Causes of trouble and odor 4.18 Sewer cleaning operations 4.19 Requirements of maintenance 4.20 Functions of each maintenance equipments and tool 4.21 Selection of equipment for given maintenance job. 4.22 Explosives in sewers. 4.23 Safety measures for sewer-men
Unit-V Sewage Treatment and Disposal	5a. List the Characteristics of sewage 5b. Explain sewage treatment process & testing – sampling, B.O.D. Test, C.O.D. test 5c. Explain methods of sewage disposal	5.1 Characteristics of sewage 5.2 Sampling of sewage 5.3 Treatment of sewage 5.4 B.O.D. Test, C.O.D. test 5.5 Methods of sewage disposal
Unit-VI House Plumbing	6a. Explain house plumbing system 6b. Describe plumbing practice and safety precautions 6c. list sanitary fittings used in house plumbing & tools used	6.1 Plumbing terms 6.2 Plumbing tools 6.3 Pipes and pipe fittings 6.4 Fixing and jointing pipes and

		accessories 6.5 Traps 6.6 House drainage plant 6.7 Plumbing practice and operations 6.8 Safety and precautions 6.9 Sanitary fittings
Unit-VII Recycling of Waste Water and Solid Waste	7.a Explain different methods of recycling waste water 7.b Explain management and utilization of solid waste generated from society	7.1 Different recycling method with respect to quality of waste water 7.2 Utilization and management of solid waste 7.3

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Sources, Quality and Demand of water	6	3	4	3	10
II	Treatment of Water	7	3	2	6	11
III	Conveyance of Water	7	2	4	5	11
IV	Sanitation System	9	4	5	6	15
V	Sewage Disposal	6	2	4	4	10
VI	House Plumbing	3	0	2	3	5
VII	Recycling of Waste Water and Solid Waste	4	3	2	3	8
	Total:	42	17	23	30	70

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers.

The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (**Course Outcomes in psychomotor and affective domain**) so that students are able to acquire the programme outcomes. Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme.

Faculty should refer to that common list and should ensure that students also acquire those programme outcomes/course outcomes related to affective domain.

No	Unit No	Practical/Exercise (Outcomes in psychomotor Domain)	Approx Hours
1.		Numerical Example	Home Assignment
	II	Predict Population for given situation by various methods	
	II	Calculate hardness of water for data of given sample	

2.	Prepare Sketches of following	Home Assignment
	1 Layout of Water treatment plant 2 Layout of Sewage treatment plant 3 Sedimentation tank 4 Filters 5 Pipe Joint 6 Distribution System 7 Pipe Fittings 8 Manholes 9 Flushing Tank 10 Catch basin 11 Sanitary fittings 12 Water sampler 13 Aeration tank 14 Activated sludge process 15 Trickling Filter 16 House Drainage Plan	
3.	Design:	02
	1 Design septic tank (Student will be given data, I.S. 2470(II) and handouts on septic tank, and should be asked to design the septic tank.)	
4.	Laboratory Experiments	14
	1. Determine pH value 2. Determine Hardness of potable water 3. Determine Residual chlorine from given sample of water 4. Determine Turbidity of water sample 5. Determine B.O.D. of wastewater sample 6. Determine C.O.D. of wastewater sample 7. Determine S.V.I.&S.D.I. using Imhoff cone for wastewater	
5.	Visit following and prepare a detailed report	06
	1. Water Treatment Plant 2. Sewage Treatment Plant 3. Maintenance work of water supply mains and sewage system	
6.	Present Seminar on a relevant topic:	06
	The topic for the seminar should be given to the group of three students and they shall be asked to defend the seminar in presence of teacher and other students.	
Total Hours		28

8. SUGGESTED STUDENT'S ACTIVITIES

- i. Prepare a model of septic tank for given number of residents.
- ii. Prepare model/chart of Water/ wastewater treatment plant for given residential society/village

9. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

- i. Arrange visit to local/nearby Influent treatment, Effluent treatment, Sewage Treatment plants.
- ii. Demonstrate water distribution system, sanitation systems and solid waste disposal systems by arranging visit or showing video films, NPTEL lectures.

10. SUGGESTED LEARNING RESOURCES

(A) List of Books:

No	Name of book	Author	Publisher
1	Text book of water supply & Sanitary Engg.	S.K.Hussain	Oxford & IBH
2	Elements of Public Health Engineering	K.N.Duggal	S.Chand & Co.
3	Water supply & Sanitary Engg.	Vazirani & Chandola	Khanna Publishers
4	A Text book of water supply & Sanitary Engg.	S.K.Garg	Khanna Publishers
5	Water supply & Sanitary Engineering	Birdie G.S.	Dhanpatrai & Sons
6	A Text book of water supply engineering	V.N. Gharpure	Allied Book Stall, Baroda
7	A Text book of sanitary engineering	V.N. Gharpure	Allied Book Stall, Baroda
8	Water pollution & Disposal of Waste Water on Land	U.N.Mahida	Tata McGraw Hill
9	Municipal and Rural Sanitation	Ehlers & Steel	Mc Graw hill book
10	Water and Waste water Engineering	Gorden, Fair & Gayer Okun	John Willey & Sons

(B) List of Major Equipment/Materials:

- i. Spectrophotometer
- ii. Water Analysis Kit
- iii. B.O.D. Incubator
- iv. Reflux apparatus
- v. Various model of Fitting and Fixtures

(C) List of Software/Learning Websites

See NPTEL website

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty members of Polytechnic

- **Prof. S. M. Mistry**, H.O.D.Civil Engg., Dr. S. & S. S. Ghandhy College of Engg and Tech., Surat
- **Prof. R.M. Patel**, Sr. Lecturer Civil Engg. Government Polytechnic , Dahod
- **Prof. A.K. Popat**, Sr. Lecturer Civil Engg. Government Polytechnic , Dahod

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof. M. C. Paliwal**, Associate Professor, Department of Civil and Environmental Engineering
- **Dr. J. P. Tegar**, Prof & Head, Department of Civil and Environmental Engineering

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GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

**COURSE CURRICULUM
COURSE TITLE: ESTIMATING, COSTING & VALUATION
(COURSE CODE: 3350604)**

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5 th Semester

1. RATIONALE

Building Estimation and Costing is a vital part of Civil Engineering. No project can begin without the total Building Estimation and Costing done by the Engineer. The entire Cost of construction and the infrastructure used for the purpose of construction is estimated and the final costing is done on the basis of which a certain percentage of the Project cost is paid to the Engineer, the Architect and other consultants involved in the project. Valuation is one such important part of Building Estimation and Costing. Valuation is done after the project is complete on the latest trends of the land prices in the market. Therefore, this course has been designed so that the diploma civil engineer is able to prepare estimate and cost of a civil engineering project.

2. LIST OF COMPETENCY

The course content should be taught and learning imparted with the aim to develop theoretical knowledge and skills so that they are able to:-

- **Prepare estimate and cost of a civil engineering project**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Explain types of estimate and duties of an Estimator
- Undertake rate analysis of civil engineering works
- Determine the rates of various items of civil works
- Calculate estimated cost of civil construction projects
- Evaluate the actual value of any property.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				Total Marks
L	T	P		C	Theory Marks		Practical Marks	
				ESE	PA	ESE	PA	
03	00	04	07	70	30	40	60	200

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

Note: It is the responsibility of the institute heads that marks for **PA of theory, ESE and PA of practical** for each student are entered online into the GTU portal at the end of each semester within the dates specified by GTU.

5. COURSE DETAILS

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
Unit– I Estimation and Modes of Measurem ent	1a. Explain types of estimate and duties of an Estimator 1b. Distinguish the terms: Overhead charges, contingencies, water charges, provisional sum, prime cost, provisional quantities, spot items, day work.	1.1 estimating 1.2 Types of estimate and Data required 1.3 Overhead charges, contingencies, water charges, provisional sum, prime cost, provisional quantities, spot items, day work. 1.4 General rules for the measurements and its units of different items of civil engineering work.
	1c. Describe various terms used in estimation work	1.5 Quality and duties of good estimator
Unit– II Specificati ons of Civil Works	2a. Write specification for various items of civil works.	2.1 Importance specification 2.2 Types of specification 2.3 Principle of writing specification
	2b. Estimate the various types of civil engineering works	2.4 Specification of Earthwork in Excavation, cement concrete, Brick masonry, R.C.C. Work, Plastering Work, Painting, Flooring
Unit– III Rate Analysis of Civil Works	3a. State the factors affecting task work 3b. Differentiate between labour rates and market rates of materials	3.1 Task Work and Factors affecting it 3.2 Labour required for different works and Labour rates 3.3 Market rates of construction materials
	3a. Explain the concept of schedule of rates and the purpose of rate analysis 3b. Compare the rate analysis of various types of work and SOR	3.4 Schedule of Rates (SOR) 3.5 Rate analysis and factors affecting it rate analysis 3.6 Rate analysis for earthwork in excavation, C.C.Work, Brick masonry Work, R.C.C. Work, Plastering, flooring work.

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
Unit- IV Estimation of Civil Works	4a. State the various methods of detailed estimation 4b. Estimate the cost of one/ two room building 4c. Estimate the cost of two storied building	4.1 Methods of detailed estimation 4.2 One/ two room building 4.3 Two storied buildings (RCC footings, Column, beams, slab)
	4a. Estimate the cost of RCC retaining wall/ Culverts 4b. State the methods of calculating earthwork for roads and canals	4.4 RCC retaining wall/ Culverts 4.5 Methods of calculating earthwork quantities for roads and canals
Unit- V Valuation of Civil Engineering projects	5a. Differentiate between cost, price and value 5b. Differentiate between depreciation and obsolescence	5.1 Cost, Price and Value 5.2 Types of property and Objects of valuation 5.3 Depreciation and Obsolescence
	5a. Describe different forms of value 5b. Evaluate the actual value of any property. 5c. Describe the procedure for fixing the standard rents.	5.4 Different forms of Value 5.5 Valuation tables and Valuation methods for property and land 5.6 Types of rents and fixing standard rents

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Estimation and Modes of Measurement	08	06	08	00	14
II	Specifications of Civil Works	04	02	02	03	07
III	Rate Analysis of Civil Works	04	02	02	03	07
IV	Estimation of Civil Works	16	06	08	14	28
V	Valuation of Civil Engineering projects	10	04	04	06	14
Total		42	20	24	26	70

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table. The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED LIST OF EXPERIMENTS

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (*outcomes in psychomotor and affective domain*) so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme) would be assured.

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes

S. No.	Unit No.	Practical Exercises (Major Outcomes in Psychomotor Domain)	Approx. Hrs. Required
1	I	Interpret civil engineering drawings	02
2	I	List of various items to be provided to learn the modes of measurements according to prevailing IS 1200	02
3	II	Collect specifications for at least 10 items of construction work	7
4	III	Analyze rate for at least 10 items of residential building construction	7
5	IV	Estimate in detail for load bearing structure, RCC retaining wall, RCC culverts, earthwork for road works, etc.	28
6	V	Solve at least 10 examples related to various form of value, depreciation, loan amount, annual rent, capitalized value, year purchase, etc.	10
Total Hours			56

8. SUGGESTED LIST OF STUDENT ACTIVITIES

S. No.	Unit No.	Student Activities
i.	III	Compare the actual analysis rates of items with the S.O.R. of P.W.D.
ii	IV	Take measurements of any existing building and calculate its present value.

9. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

- i. Some live examples of estimation
- ii. Visit to architectural firms

10. SUGGESTED LEARNING RESOURCES

A List of Books

S.No.	Title Of Books	Author	Publication
1	Estimating and Costing in Civil Engg.	B.N.Dutta	Ubspd, New Delhi
2	Estimating and Costing in Civil Engg.	S.C.Rangwala	Charotar Publication, Anand,Gujarat
3	Estimating and Costing	M.C.Chakraborty	
4	A textbook of Estimating and Costing	G.S.Birdie	
5	Estimating and Costing	Vazirani and Chandola	

B. List of software

- i. Estimator
- ii. MS Project.

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Bhavesh V. Modi**, Principal B.V.P.I.T. (D.S.), UmraKh, Bardoli.
- **Prof. Krishnaraj A. Khatri**, Lecturer in Civil Engg. Deptt. B.V.P.I.T. (D.S.), UmraKh, Bardoli.
- **Prof. Anil K. Popat**, Lecturer in Civil Engg. Deptt. Government Polytechnic, Dahod.

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Subrat Roy**, Professor, Department of Civil and Environmental Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM

COURSE TITLE: ADVANCED CONSTRUCTION TECHNOLOGY

(COURSE CODE: 3350605)

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5 th Semester

1. RATIONALE

As a prerequisite to this course, it is expected that students have already learnt some basic concepts, principles and important aspects of construction technology in the third semester course (Code: 3330602). Now in this course of 'Advance Construction Technology', some advance aspects of construction technology will be covered. In today's times the construction activities is undergoing lots of changes/developments due to internal and globalised market demands of quality and faster completion of project works using modern techniques, use of modern and waste materials, and through mechanized construction. Today, we require high capacity machines with better output and greater efficiency to make construction process less stressful. This course has been designed so that diploma engineers would be able to use advanced construction technology

2. LIST OF COMPETENCY

The course content should be taught and learning imparted with the aim to develop in students' construction technology related advanced knowledge and skills so that they are able to:

- **Use advanced construction technologies**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course learning outcomes:

Select appropriate equipment/machines for different construction activities with right choices of techniques for a given application.

- i. Report the important operations of construction activities they visited where new techniques, machines and equipment are used.
- ii. Describe important aspects, operations and safety points pertaining to:
 - a. 'Deep Excavations';
 - b. Pile foundations ;
 - c. Cofferdams;
 - d. Caissons;
 - e. Drilling and Blasting
- iii. Discuss purpose, types, materials, design issues, and erection of temporary structures for construction activities.

- iv. Describe equipment and tackles used , problems encountered and their solutions in erection of steel structures

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

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

Note: It is the responsibility of the institute heads that marks for PA of theory, ESE and PA of practical for each student are entered online into the GTU portal at the end of each semester within the dates specified by GTU.

5. COURSE DETAILS

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
Unit – I Modern Materials and Equipment used in Special Constructi ons	1a. describe the features of special types of civil engineering structures 1b. discuss properties of advance materials and byproducts such as fly ash, red mud, furnace slag and their suitability to civil works.	1.1 Features and functions of the special types of civil engineering structures: Multistoried building, Chimney, Elevated service reservoir, Dams and retaining walls, Bridges and hydraulic structures, Industrial structures, Marine and offshore structures, Tall structures. 1.2 Effect of lateral forces on building like Wind, Water and Earthquake 1.3 Admixtures and its Classification 1.4 Use of Waste products and Industrial Byproducts in bricks, blocks, concrete and mortar.
	1c. Discuss main features of hauling equipment and hoisting equipment. 1d. State the factors affecting the selection of of hauling equipment and hoisting equipment.	1.5 Hauling equipment: Trucks, Wagon, Dumpers, Scrapers and rippers. 1.6 Hoisting equipment: Derrick-Pole, Gin Pole, Crane, Power driven scotch derrick crane, Hand operated crane, Locomotive crane, Gentry crane, Tower crane, Lattice Girder, Winches, Elevators, ladders.

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
	1e. Discuss main features of hauling equipment and hoisting equipment. 1f. State the factors affecting the selection of hauling equipment and hoisting equipment.	1.1 Conveying equipment: Belt conveyors, Buckets, Chutes 1.2 Pumping equipment: Water pumps and concrete pumps.
	1g. Discuss main features of compacting and pile driving equipment. 1h. State the factors affecting the selection of compacting and pile driving equipment.	1.9 Compacting equipment: Rollers (earth compaction), Smooth surface roller, sheep foot roller, pneumatic rollers, tamping roller, vibrating roller and compactors. 1.10 Pile Driving Equipment including types of hammer driving, drilling equipment with types of drill.
	1i. Discuss main features of vibrators and crushers. 1j. State the factors affecting the selection of vibrators and crushers.	1.11 Vibrators: for concrete consolidation: Internal, Needle, Surface, Platform and form vibrators. 1.12 Crushers and other Equipment: used for Production of aggregate Jaw crusher, Gyratory crusher, Roll crusher, Cone crusher, Rod and ball mill, screens, Log washer.
	1k. Discuss main features of bituminous road construction and dredging equipment. 1l. State the factors affecting the selection of bituminous road construction and dredging equipment	1.13 Bituminous road construction Equipment 1.14 Equipment for large concrete works 1.15 Dredging equipment
Unit- II Excavation and related Equipment	2a. Differentiate between shallow and deep excavation with examples/sketches. 2b. Explain timbering operation in trenches. 2c. Explain the dewatering procedure	2.1 Shallow and deep excavation. 2.2 Dewatering situations, necessity and method of dewatering. 2.3 Dewatering
	2d. Discuss main features of excavation machinery and earth moving vehicles. 2e. State the factors affecting the selection of excavation	2.4 Excavations Machinery: Power Shovel, Drag line, Calm Shell, Scoop, Trenching equipment, Wheel mounted belt loaders.

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
	machinery and earth moving vehicles 2f. Discuss main features of earth moving machinery.	2.5 Earth moving Vehicles: Tractors, Boulders, Graders, Scrapers, Rippers.
	2g. State the factors affecting the selection of Earth moving machinery.	2.6 Earth moving machinery: Handling, Hoisting, Conveying, Pumping, and Compacting, Pile driving, Drilling equipment, Plants for Grouting, Guniting and Hot Mix Plant, Concrete Mix Plant, Ready Mix Plant
Unit- III Pile Foundation	3a. Classify pile foundations. 3b. Explain the factors affecting the selection of types of piles. 3c. Justify the use of pile foundation for a given situation. 3d. Describe the features of the equipment, tools and method of construction of under reamed piles. 3e. Describe pile driving method. 3f. Discuss efficiency of group of piles.	3.1 Pile foundations, Classification. 3.2 Sheet piles based on materials. 3.3 Classifications of piles based on materials like concrete, steel, timber, composite, sand, concrete (pre-cast, Cast –in – situ, Pre-stressed) including cased and uncased with advantages and disadvantages. 3.4 Selection of type of piles. 3.5 Pile accessories and tools. 3.6 Pile driving methods. 3.7 Failure or settlement of piles. 3.8 Under reamed piles including method of it' construction. 3.9 Group action of piles and its efficiency.
Unit-IV Coffer Dams and Caissons	4a. Explain purpose, use and principles of working of coffer dams. 4b. Describe the major features of types of coffer dams with sketches. 4c. State the selection criteria of types of coffer dams 4d. State the leakage points and suggest leakage prevention in coffer dams.	4.10 Coffer dams: Types, requirements, Selection criteria, Design features, Leakage points and leakage prevention in coffer dams.
	4e. Differentiate between Coffer dams and caissons 4f. Describe the uses of caissons.	4.11 Caissons: Materials used, Sinking loading of caissons

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
	4g. Classify the types of caisson. 4h. Explain method of sinking of caissons. 4i. State the problems and suggest suitable solutions in well sinking	
Unit-V Drilling and Blasting	5a. Classify various types of Drilling and their suitability. 5b. Describe drilling operations 5c. Justify with example the necessity of drilling at construction site.	5.1 Drilling: Types, Drilling requirements, 5.2 Selecting the drilling pattern for blasting 5.3 Effect of air pressure on drilling operation 5.4 Bentonites/mud slurry in drilling 5.5 Factors affecting the selection of drilling method and equipment
	5d. Describe the step-by-step blasting process of using explosives with safety precautions. 5e. Explain the precautions required in blasting and drilling operations, in storage and in handling of explosives	Blasting 5.6 Explosives for blasting: Dynamite, Blasting caps Prime line, Safety fuse, Stemming, Blast hole, Prime detonators 5.7 Process of using explosive 5.8 Types of blasting, Precautions 5.9 Storage of explosives 5.10 Features of magazine building
Unit-VI Erection of Steel Structures	6a. Describe various types of formworks with its advantages 6b. Discuss the principles of using slip formwork 6c. Describe cantilever method of Pre-stressed concrete bridge Construction 6d. Sketch the formwork for columns, beams and slabs and others for given problem situation with labels	6.1 Formwork: Requirements of a good form work, Loads, guiding points for design 6.2 Column form work 6.3 Slab and beam formwork 6.4 Slip form work 6.5 Hanging form works and Trestles 6.6 Form work for domes and arches. 6.7 Cantilever method of Pre-stressed concrete bridge construction
	6e. Describe problems faced and solutions adopted in erection of various types of steel structures such as roof truss, bridge girders. 6f. Discuss various types of equipment and tackles used in 6g. erection of various types of steel structure	6.8 Roof truss: erection problems Building / Industrial component, Equipment and tackles used for erecting these 6.9 Plate girder Launching a portion of bridge Girder, Large span lattice girder 6.10 Erection of chimney

Unit	Major Learning Outcomes (Major outcomes in cognitive domain)	Topics and Sub-topics
		Erection of overhead tank.

6.0 SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Modern Materials and Equipment for Special Constructions	10	08	06	05	19
II	Deep Excavation	04	03	02	02	07
III	Pile Foundations	08	06	04	02	12
IV	Coffer Dams and Caissons	08	06	04	04	14
V	Drilling and Blasting	04	03	02	01	06
VI	Erection of steel structures	08	06	04	02	12
	Total	42	32	22	16	70

Legends: R = Remember U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7.0 SUGGESTED LIST OF EXERCISES/PRACTICALS

The practical/exercises should be properly designed and implemented with an attempt to develop abilities and skills (**outcomes in psychomotor and affective domain**) so that students are able to acquire and demonstrate the course learning and programme outcomes. Following is the list of practical exercises for guidance.

*Note: Here performance outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed and demonstrated appropriately, they would contribute to the development of demonstrated learning in behavioral terms in affective domain. As a whole, the total approach towards acquisition of knowledge, skills, abilities and behavior and demonstration of the same would lead to the development of **Course Outcomes**. Thus over all development of **Programme Outcomes** (as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours Required
		Part-A (Sketches With Nomenclature and Short Details-Study and Information Based in Sketch book)	08 hrs
1	II	Plants And Equipment Used In Construction a. Earthmoving machineries b. Equipment for excavation c. Handling equipment d. Hoisting equipment e. Conveying equipment f. Pumping equipment g. Compacting equipment h. Concrete vibrating equipment i. Pile driving equipment j. Plants for Grouting, Guniting. k. Drilling equipment l. Concrete and mixing plant	
	III	Various types of timbering.	
	III	Dewatering methods.	
	III	Different types of shallow and deep foundations.	
	IV	Different types of pile foundations.	
	V	Different types of coffer dams.	
	VI	Different types of caisson.	
	VI	Slip form work	
	V	Blast hole	
	VI	Slab and beam formwork	
	VI	Column formwork	
VI	Crib and Trestle		
		PART-B (Site Visit And Preparation Of Detailed Report Recording Main Operations (May Be With Photos) As Observed And Discussed With Site Officers, Of Atleast One Visit)	08 hrs
2	II	Prepare a site visit report regarding your visit in which construction work is going on with advanced equipment's stating list of equipment including its selection criteria and its advantages.	
	III/IV	Prepare a site visit report regarding your visit in which deep foundation work is going on including type of deep foundation selection criteria.	
	V	Prepare a site visit report regarding your visit in which cassion / cofferdam construction work is going on.	
	VI	Prepare a site visit report regarding your visit in which	

S. No.	Unit No.	Practical Exercises (outcomes in Psychomotor Domain)	Approx Hours. Required
		drilling/ blasting work is going on.	
	VI	Prepare a site visit report regarding your visit in which erection of steel structure work is going on.	
		Part-C (Seminar Presentation)	06 hrs
3	I to VI	Topic of Seminar shall be given to a group of students. The students are required to submit and present / defend the Seminar in presence of students and teachers and report including PowerPoint presentation to be attached with submission. Each individual student's contribution in group work need to be made explicit.	
		Part-D –Prepare A Case Study (Any One)	06 hrs
4	I to VI	Based on advanced construction technology curriculum, on any one related topic narrating the case with specific operations/ problems faced/resolved from nearby construction work area with short details.	
Total Hours			28 rs

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

- Prepare experimental journals based on practical performed in laboratory.
- Assignments on solving field problems of construction or numerical problems
- Prepare chart displaying various types of pile foundation, coffer dams, caissons, etc.
- Prepare the schematic diagram for various types of plants.

9. SPECIAL INSTRUCTIONAL STRATEGIES (if any)

- Arrange visit to nearby following sites and write visit report
 - For a High Rise Building, Docks, Jetties, Pile driving sites, etc. those who are using all kind of advanced equipment.
 - For a Hot Mix Plants, Concrete Mix Plants, RMC, Aggregate Crusher site, etc.

10. SUGGESTED LEARNING RESOURCES

A) List of Books

Sr. No.	Title of Book	Author	Publication
1.	Building construction	S.P. Arora and S.P. Bindra	Dhanpat Rai
2.	Building Construction Engineering	Gurcharansingh	Jain Book Agency
3.	Construction, planning	Robert L. Peurifoy	Mc Graw Hill India

Sr. No.	Title of Book	Author	Publication
	equipment and methods		
4.	Building Construction	Sushil Kumar	Standard Publishers
5.	Learning from failures	R.N. Raikar	Structural Designers and Consultants, New Delhi
6.	Durable structure through planning for preventive measures	R.N. Raikar	Structural Designers and Consultants, New Delhi
7.	Diagnosis and Treatment structure in Distress	R.N. Raikar	Structural Designers and Consultants, New Delhi
8.	Building structures	James Abrose.	Wiley Publishers
9.	Standard handbook of civil engineering	Gurcharansingh	S P P
10.	Building construction	B.C. Punmia	Laxmi Publication, New Delhi
11.	Building construction	S.C. Rangwala	Charotar Publishing House Pvt. Ltd. Anand
12.	Civil Engineering Practice (I,II,III)	Kaushik, Asawa and Ahuja	Publishing House, New Delhi
13.	Civil Engineering Construction	Antill and Ryan	Angus and Robertson
14.	Pile Foundations	Tomlinson	Longman Group, U. K.
15.	Relevant IS codes	-	BIS, New Delhi

B) List of Major Equipment/ Instrument with Broad Specifications: (Teachers are requested to provide here a sample list)

C) List of Software/Learning Websites

- i. www.sskphdmm.com
- ii. www.nptel.iitm.ac.in

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. P. D. Gohil**, Sr. Lecturer in Civil Engineering, Sir Bhavsinhji Polytechnic Institute, Bhavnagar.
- **Prof A. K. Popat** Sr. Lecturer in Civil Engineering , Government Polytechnic, Dahod
- **Prof. D. V. Jariwala** Sr. Lecturer in Civil Engineering , Government Polytechnic, Bharuch
- **Prof. H.K.Rana** Sr. Lecturer in Civil Engineering , Government Polytechnic, Valsad

Coordinator and Faculty Member from NITTTR Bhopal

- Dr. V H Radhakrishnan, Professor, Department of Civil and Environmental Engineering

GTUQuestionPapers.com

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

**COURSE CURRICULUM
COURSE TITLE: HIGHWAY ENGINEERING
(COURSE CODE: 3350606)**

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5 th Semester

1. RATIONALE

Road transport is one of the most common modes of transport. Population of the country is increasing day by day. The need for travel to various places at faster speed has also increased. In this scenario standards of highway engineering are continuously being improved. Highway engineers must know the future traffic flows, design of highway intersections/interchanges, geometric alignment and design, highway pavement design and materials, structural design of pavement thickness, and pavement maintenance etc. At diploma level, students are expected to study about these aspects of highway engineering because they are supposed to design and construct different types of roads in villages, towns and also roads connecting different villages and towns.

2. LIST OF COMPETENCY:

The course content should be taught and learning imparted with the aim to develop required knowledge & skills so that they are able to acquire following competency:

- **Design simple roads for connecting towns and villages in hilly and plain areas.**
- **Supervise testing of materials, construction of roads including highways.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- i. Explain the importance of highway engineering
- ii. Explain the geometrical aspects with respect to design and construction of roads
- iii. Discuss traffic and its characteristics.
- iv. Conduct various tests on the materials used in highway construction work.
- v. Explain essential features and requirements of hill roads.
- vi. Explain various aspects related to the construction and maintenance of highways.
- vii. Explain ideal road alignment
- viii. Demonstrate the basic Requirements of Curves
- ix. Supervise construction of road pavements, drainage and materials

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: L - Lecture; T - Tutorial/Teacher Guided Student Activity; P - Practical; C - Credit; ESE - End Semester Examination; PA - Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit—I Introduction to Highway Engineering	1a Discuss various types of roads development plans. 1b Explain ideal road alignment. 1c Comprehend Highway Project Report.	1.1 Importance of roads in India & its' Characteristics. 1.2 Road classifications in India (Nagpur plan & Third road development (Lucknow) plan. 1.3 Fixing location of Urban roads. 1.4 Requirements of an ideal road alignment & the factors affecting road alignment. 1.5 Details of highway project report.
Unit—II Geometric Design of Highway.	2a Describe various terms used in Highway and its standards. 2b Demonstrate the basic Requirements of Curves. 2c Calculate minimum and maximum Super elevation	terms used in Highway 2.1 Camber – definition, purpose, types, IRC – recommendations. Kerbs, Road margin, road formation, right of way. 2.2 Design speed IRC – recommendations. 2.3 Gradient - definition, types IRC – Recommendations. 2.4 Sight distance - definition, types IRC - recommendations. 2.5 Curves - Necessity, types- Horizontal, vertical and transition curves, Widening of roads. 2.6 Super elevation, definition, formula for calculating minimum and maximum 2.7 Super elevation and method of providing super elevation 2.8 Simple problems on geometric design of roads.
Unit—III Construction of Road Pavements, Drainage and Materials.	3a Discuss Highway construction materials and their relevant Tests. 3b Explain pavement structure. 3c Describe various Equipments used in High Way construction. 3d Explain importance of Drainage and it's Maintenance 3e Describe Construction of bituminous road 3f Define following terms Bitumen, Emulsion, Cutback, Tar, grades of bitumen, prime coat, tack coat, seal coat	3.1 Types of road materials and their Tests -Soil, Aggregates, bitumen, cement concrete, test on soil sub grade- C B R test, Test on Aggregate- Los Angeles abrasion, Impact, & shape test, test on Bitumen- penetration, Ductility and Softening point test. 3.2 Pavement – Types, Components and structure of pavement. 3.3 Construction of bituminous road- Terms used –Bitumen, Emulsion, Cutback, Tar, grades of bitumen, prime coat, tack coat, seal coat, surface dressing construction, it's Merits & demerits. 3.4 Construction of cement concrete pavement, Construction joints, joints filler & sealers. 3.5 Equipments used in Highway Construction. 3.6 Importance, necessity and methods of drainage.

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		3.7 Surface drainage – side gutter, catch water drain, surface drainage. 3.8 Sub surface drainage –Longitudinal & cross drains.
Unit—IV Traffic Engineering.	4a Discuss traffic and its characteristics. 4b Explain causes of accident with Collision diagram. 4c Enumerate various traffic control devices.	4.1 Traffic characteristics and traffic volume study. 4.2 Passenger car unit and factors affecting it. 4.3 Accident studies and its causes, collision diagram. 4.4 Traffic control devices – road signs, marking, Signals, traffic island. 4.5 Advantages & disadvantages of signals. 4.6 Road intersections, Intersection at Grade, grade 4.7 Separators.
Unit—V Hill Road.	5a Describe hill roads and its component 5b Explain drainage and protective works. 5c Discuss landslides for Causes & Prevention 5d Classify landslides	5.1 Hill roads, its' components , functions types of curves. 5.2 Width of pavement formation, camber, sight distance, widening at curve. 5.3 Drainage: Side drains; catch water drains, cross drains, retaining wall & breast wall. 5.4 Construction procedure of hill roads. 5.5 Causes of landslides & its classification. 5.6 Prevention of landslides.
Unit—VI Maintenance and Repair of Roads.	6a Comprehend necessity of road maintenance. 6b Explain pavement failures. 6c . Classify maintenance 6d Discuss Maintenance and repairs of pavements.	6.1 Flexible & Rigid pavement failures and their causes. 6.2 Need for high way maintenance. 6.3 Classification of maintenance. 6.4 Special repair of flexible & Rigid pavements.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Highway Engineering	4	1	1	3	5
II	Geometric design of Highway	8	2	3	10	15
III	Construction of road pavements, drainage and materials.	8	2	5	13	20
IV	Traffic Engineering.	8	2	3	5	10
V	Hill Road.	6	2	3	5	10
VI	Maintenance and Repair of Road.	8	1	2	7	10
Total		42	10	17	43	70

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Note: This specification table shall be treated as only general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills (**Course Outcomes in psychomotor and affective domain**) so that students are able to acquire the programme outcomes. Following is the list of practical exercises for guidance.

Note: Here only course outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme.

Faculty should refer to that common list and should ensure that students also acquire those programme outcomes/course outcomes related to affective domain.

S. No.	Unit No.	Practical/Exercise/Project (Outcomes in Psychomotor Domain)	Approx. Hrs. Required for Practical	Approx. Hrs. Required for Project
1	I	Draw the dimensional sketches of cross section of road, road junction, road curve and widening.	2	0
2	II	Demonstration the following tests. - On Aggregate 1. Impact test. 2. Crushing test. 3. C B R test. - On Bitumen 1. Flash & Fire test. 2. Softening point 3. Penetration test	2	0
3	IV	Visit to a road under construction/constructed to study of 1.WBM road 2. Rigid & Flexible pavement for observing the type of Construction with brief report.	4	0
4	V	Visit Road construction site to study Equipments. And draw the line sketches of various Equipments and note down their special features and specification.	4	0
5	VI	Traffic volume study and its representation on an intersection of road	8	8
6	VII	Seminar	8	
Total			28	08

8. SUGGESTED LIST OF STUDENT ACTIVITIES

- i. Undertake site visit related to road construction and maintenance work and prepare report.
- ii. Visit to material Testing Laboratory for awareness related to other material Testing
- iii. Visit websites of road construction equipment/heavy earthmover manufacturing companies and prepare a report on different kind of equipments/earthmover being used in road construction.

9. SPECIAL INSTRUCTIONAL STRATEGIES (If any)

- i. Lecture cum demonstration of various types of equipments used in road construction.
- ii. Field demonstration about the maintenance of Roads.

10. SUGGESTED LEARNING RESOURCES

S. No.	Title of Books	Author	Publication
1	High way Engineering	Dr. L R Kadiyali & Dr. N B Lal	Khanna Publishers. Delhi
2	Traffic Engg. & Transport planning	Dr. L R Kadiyali	Khanna Publishers. Delhi
3	High way Engineering	S K Khanna & Justo	Khanna Publishers. Delhi
4	Highway Engineering	S P Bindra	DhanpatRai & Sons Delhi
5	Highway Engineering	Gur charan singh	Standard Publishers. Delhi
6	Highway Engineering	C A O'Flaherty	Edward Arnold ltd. London
7	Road, Railway, Bridge & Tunnel Engineering	Ahuja & Birdi	Standard book house Delhi
8	Transportation Engineering Vol. I & II	V N Vazirani & S P Chaondola	Khanna Publishers. Delhi
9	Road Engineering	P K Bhattacharjee	Orient Longmans Delhi Calcutta-Bombay-Madras

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE**Faculty Members from Polytechnics**

- **Prof. N. J. Patel**, Lecturer in Civil Engineering, Shri K J Polytechnic Bharuch

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Subrat Roy**, Professor, Department of Civil and Environmental Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

**COURSE CURRICULUM
COURSE TITLE: IRRIGATION ENGINEERING
(COURSE CODE: 3350607)**

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5th Semester

1. RATIONALE

In India water requirement is rapidly increasing due to vast industrial development and population growth. We are mostly dependent on rain as a predominant source of water. Looking to scarcity of water in our country, it is essential to store the water in appropriate manner for anticipated requirement. Irrigation engineering is the artificial process of applying water to the soil to help in growing agriculture crops or maintaining the landscapes when there is shortage of natural water by rain. It deals with the analysis and design of irrigation systems which include dams, weir, barrage, canals, drains and other supporting system etc. This course has been designed to develop theoretical and practical knowledge in order to implement the irrigation designs and operate irrigation systems.

2. LIST OF COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competencies:

- **Implement the irrigation designs and operate irrigation systems.**

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- Explain various methods of irrigation
- Compute water requirement for crops
- Implement sprinkler irrigation system and drip irrigation system
- Explain the methods to control the level in Reservoir Planning
- Explain process of evaluation of irrigation project

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				Total Marks
L	T	P		Theory Marks		Practical Marks		
			C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: **L** - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit: I. Water Requirement of Crops	1a. Justify the need and scope of irrigation engineering 1b. Differentiate the terms related to irrigation engineering 1c. Differentiate the various methods of irrigation and ill-effects of over-irrigation	1.1 Need and scope of irrigation Engineering, related terms: Duty, Delta, Base period, Crop period, Kor period, Core depth, Demand, Gross command area, Cultivable Command area, Intensity of Irrigation, Time factor, Capacity factor, Overlap allowance. 1.2 Types of irrigation projects 1.3 Methods of irrigation 1.4 Ill effects of over irrigation
	1d. Explain suitability of soils for crops 1e. Distinguish Duty, base period, crop period for major crops 1f. Compute water requirement for crops	1.5 Soil characteristics: Suitability for crops, Water holding capacity, Soil moisture, Quality of Irrigation water 1.6 Duty, base period, crop period for major crops 1.7 Consumptive use of water 1.8 Assessment of irrigation water
Unit: II Advanced Irrigation Methods, water logging and land reclamation	2a. Differentiate between sprinkler and drip 2b. Irrigation methods 2c. Describe the use sprinkler and drip irrigation system with sketches 2d. State the precautions and maintenance of sprinkler and drip irrigation system	2.1 Advanced Irrigation Methods: • Sprinkler Irrigation, • Drip Irrigation
	2e. Explain the causes of water logging, its ill-effects and the Preventive measures 2f. Describe reclamation of land	2.2 Water logging: causes, ill-effects, Preventive measures 2.3 Reclamation of land
Unit: III Reservoir Planning	3a. Interpret surveys required for irrigation project 3b. Describe the methods to calculate the capacity of Reservoir and control the level 3c. Explain the area capacity Curve	3.1 Survey for irrigation project. 3.2 Methods of calculating capacity of Reservoir. 3.3 Data collected for irrigation project. 3.4 Area Capacity curve. 3.5 Silting of reservoir 3.6 Rate of silting, Factors affecting

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		silting 3.7 Fixing control valves.
Unit: IV Dams and Spillways	4a. Describe the various types of dams and the various factors affecting their site selection. 4b. Differentiate the earthen and gravity dams 4c. State types of failures of dams and their remedial measures	4.1 Types of dams: Earthen and gravity dams
	4d. Distinguish the major features of different types of spillways and their appropriate locations. 4e. State types of failures of Spillways and their remedial measures	4.2 Spillways: features, location, causes failures
Unit: V Evaluation of Irrigation Project	5.1 Describe the main criteria for evaluation of irrigation project 5.2 Explain process of evaluation of irrigation project 5.3 Evaluate a case study	5.1 Theory of water evaluation for Farming use. 5.2 Methodology to value water and evaluate hydraulic investment 5.3 Results of applied methodology 5.4 Case study of irrigation project.

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Water Requirement of crops	08	4	6	6	16
II	Irrigation Methods, Water logging and Land reclamation	18	4	12	10	26
III	Reservoir Planning	06	4	4	4	12
IV	Dams and Spillway	06	4	2	4	10
V	Evaluation of Irrigation Project	04	0	4	2	06
		42	16	28	26	70

Legends: R = Remembrance; U = Understanding; A = Application and above levels (Revised Bloom's taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table. The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (*outcomes in psychomotor and affective domain*) so that students are able to acquire the competencies/course outcomes. Following is the list of practical exercises for guidance.

Note: outcomes in psychomotor domain are listed here as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of Course Outcomes related to affective domain. Thus over all development of Programme Outcomes (as given in a common list at the beginning of curriculum document for this programme) would be assured.

Faculty members should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes

S. No.	Unit No.	Practical/Exercise (Outcomes' in Psychomotor Domain)	Hrs. Required
		Draw Sketches of	06
1.	I	Methods of Irrigation	
2.	III	Layout of drip irrigation	
3.	III	Layout of sprinkler irrigation	
4.	V	Types of Dams	
5.	V	Types of Spillways	
		Solve Numerical From Given Data to	10
6.	II	Compute base period, duty and delta	
7.	II	Calculate CCA, GCA, IA	
8.	III	Design sprinkler Irrigation system	
9.	III	Design drip Irrigation system	
10.	IV	Calculate the reservoir capacity	
		Visit Field and Prepare Report	08
11.	I to VII	Arrange field visit to irrigation department	
12.	I to VII	Arrange field visit to nearby irrigation project	
		Present in a Seminar	04
13.	I to VII	Select one topic as a Seminar in group of two or three students and present it using modern teaching aids before teachers and students.	
		Total	28

8. SUGGESTED LIST OF STUDENT ACTIVITIES

- i. Prepare prototype/ model of Spillway and advanced irrigation methods.

9. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

- i. Some live examples of estimation
- ii. Visit to architectural firms

10. SUGGESTED LEARNING RESOURCES

S. No.	Title of Books	Author	Publication
1.	Irrigation theory and practice	A.M.Mitchel	Vikas Pub. House Pvt. Ltd, Delhi.
2	Irrigation, Water Resources and Water Power Engg.	Dr. P.N. Modi	Standard Book House, Delhi.
3.	Hydrology and Water Resources	R.K. Sharma	Dhanpat Rai and Sons, Delhi.
4.	Ground water assessment, Development and management	K.R. Karanth	Tata Mc Graw Hill Pub. Co. Ltd., New Delhi.
5.	Ground water	H.M.Ragunath	New Age international Ltd., New Delhi.
6.	Hydrology and Water Resources Engg.	S.K.Garg	Khanna Pub., Delhi.
7.	Watershed management in India	J.V.S. Moorthy	Willey Eastern Ltd.
8.	Design of small dams.	U.S.B.R.	
9.	Water Resources Engg- Principles and Practice	C. Satyanarayan Murthy	New Age International Ltd., New Delhi

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE**Faculty Members from Polytechnics**

- **Prof. M. J. Zala**, Lecturer, Civil Engg Dept., BBIT, V.V.Nagar
- **Prof. R.M. Patel**, Lecturer, Civil Engg Dept. G.P. Dahod
- **Prof. A. K. Popat**, Lecturer, Civil Engg Dept. G.P. Dahod
- **Prof. D. V. Jariwala**, Lecturer, Civil Engg Dept., G.P.Valsad
- **Prof. H. K .Rana**, Lecturer, Civil Engg Dept., G.P.Valsad

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. A. K. Jain**, Professor, Department of Civil and Environmental Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: ENVIRONMENTAL ENGINEERING & POLLUTION CONTROL
(COURSE Code: 3350608)

Diploma Programme in which this course is offered	Semester in which offered
Civil Engineering	5 th Semester

1. RATIONALE:

The understanding about environment is very essential for engineers as it guide for sustainable development. We all appreciate that the use of water, air and other resources must be available as required for human kind and polluted component must be disposed off in nature by giving proper treatment. So the natural flora and fauna will not get affected by sewage disposal.

In present time, solid waste, Noise, Air pollution, land pollution also wants more attention. This course focuses on students' acquisition of knowledge, skills & practices in environmental engineering and pollution control .Knowledge about Environment Impact Assessment, air-pollution control, noise-pollution control, solid waste management etc is imparted in this course. The technician must know about the quality of domestic water to be supplied to the society and treatment of waste water.

The knowledge and application of such aspects is essential in developing a good technician who should be conversant with environmental problems and their solutions.

2. LIST OF COMPETENCY

The course content should be taught and the curriculum should be implemented with the develop required skills, so that students are able to acquire following competency:

- Assess the problems of various kinds of pollution in the environment
- Prepare proper EIA report for impact of pollution due to industries on the environment.
- Take appropriate measures to control the pollution level for mankind.

3. COURSE OUTCOMES

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- i. Appreciate components of Environment.
- ii. Elaborate Ecology and Ecosystem
- iii. Describe Acid Rain, Ozone layer depletion
- iv. Explain Green House effect
- v. Describe remedial measures to control noise pollution
- vi. Describe remedial measures to control air pollution
- vii. Measure pollutants – sampling, Physical characteristics , chemical characteristics , biological characteristics

- viii. Explain control measures to prevent land pollution
- ix. Evaluate the quality of environmental impact assessment

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
L	T	P		Theory Marks		Practical Mark		Total Marks
			ESE	PA	ESE	PA		
03	00	02	05	70	30	20	30	150

Legends: L- Lecture; T- Tutorial/Teacher Guided Student Activity; P - Practical; C -Credit; ESE-End Semester Examination; PA-Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub Topics
Unit-I Introduction to Environmental Engineering and Ecology	1a Explain importance of Environmental engineering 1b Appreciate components of Environment. 1c 2.a Elaborate Ecology and Ecosystem 1d Explain Ecological “Pyramid” concept of Numbers, biomass , Energy 1e Describe biogeochemical cycles Explain Biodiversity	1.1 Introduction 1.2 Component of Environment a. Atmosphere b. Hydrosphere c. Lithosphere d. Biosphere 1.3 Importance of Environment 1.4 Need for public Awareness 1.5 Concept of Ecology 1.6 Ecosystem 1.7 Component of Ecosystem a. Abiotic b. Biotic 1.8 Balanced Ecosystem 1.9 Ecological Pyramid a. Pyramid of Numbers b. Pyramid of biomass c. Pyramid of Energy 1.10 Biogeochemical Cycles a. Hydrological cycle b. Carbon cycle c. Nitrogen cycle d. Phosphorous cycle e. Sulphur cycle 1.11 Biodiversity
Unit-II Environmental Problems	2a Describe Acid Rain 2b Describe Ozone layer depletion 2c Explain Green House effect	2.1 Environmental problems in present world 2.2 Acid Rain a. Causes of acid rain b. How acid rain affects the

		<p>environment</p> <p>c. Remedial measures to prevent acid rain</p> <p>2.3 Ozone layer Depletion</p> <p>a. What is stratospheric ozone?</p> <p>b. Ozone layer depletion</p> <p>c. Ozone chemistry</p> <p>d. the ozone hole: the science</p> <p>e. Consequences ozone depletion</p> <p>f. Ultraviolet and Health</p> <p>2.4 Green House Effect</p> <p>a. Human influence on the climate</p> <p>b. Green house gases</p> <p>c. The importance of methane</p> <p>d. Effect of Green house-effect</p> <p>2.5 International policies for climate change</p>
<p>Unit-III Air and Noise Pollution and its Control</p>	<p>3a list various sources of air pollution , pollutants & Air quality Index with values</p> <p>3b State adverse effects of air pollution</p> <p>3c Describe remedial measures to control air pollution</p> <p>3d Enlist sources of noise pollution</p> <p>3e State adverse effects of noise pollution</p> <p>3f Describe remedial measures to control noise pollution</p>	<p>3.1 Introduction</p> <p>3.2 Air-pollutants</p> <p>a. Primary</p> <p>b. secondary</p> <p>3.3 Sources of air pollutant</p> <p>a. Anthropogenic sources</p> <p>b. Natural sources</p> <p>3.4 Air quality Index</p> <p>3.5 Health effect of air pollution</p> <p>3.6 Efforts to Reduce Air Pollution</p> <p>a. Control pollutants at source</p> <p>3.7 Introduction</p> <p>3.8 Computation of Noise pollution</p> <p>3.9 Noise measurement instruments</p> <p>3.10 Sources of noise</p> <p>3.11 Impacts of Noise</p> <p>3.12 Control of noise pollution</p> <p>a. control at source</p> <p>b. control in transmission path</p> <p>3.13c. using protection equipments</p>
<p>Unit-IV Water Pollution</p>	<p>4a Enlist sources of water pollution</p> <p>4b State adverse effects of water pollution</p> <p>4c Describe treatment to control water pollution</p> <p>4d Measure pollutants</p> <p>4e Describe procedure for sampling</p> <p>a. Physical characteristics</p> <p>b. chemical characteristics</p> <p>c. biological characteristics</p>	<p>4.1 Introduction</p> <p>4.2 Sources of Pollution</p> <p>a. point source</p> <p>b. non-point source</p> <p>4.3 Groundwater pollution</p> <p>4.4 Causes of Pollution</p> <p>4.5 Measurement of pollutants</p> <p>a. sampling</p> <p>b. Physical characteristics</p> <p>c. chemical characteristics</p> <p>d. biological characteristics</p> <p>4.6 Control of pollution</p> <p>a. sewage</p> <p>b. Industrial wastewater</p> <p>c. agricultural wastewater</p> <p>d. construction site storm water</p> <p>4.7 e. storm water from urban area</p>

Unit-V Land, Radio-active and Thermal Pollution	5a Describe causes of land pollution 5b Explain control measures to prevent land become polluted 5c State sources of radio-active pollution 5d Describe control measures for radio-active pollution 5e Describe Effects of Radioactive pollution 5f Enlist sources of thermal pollution 5g State adverse effects of thermal pollution 5h Describe Solution to overcome the problem	5.1 Introduction 5.2 Causes of land pollution 5.3 Effect of Land pollution 5.4 Solution for Land pollution 5.5 Introduction 5.6 Causes of Radioactive pollution 5.7 Effects of Radioactive pollution 5.8 Radioactive waste management 5.9 Introduction 5.10 Causes for thermal pollution 5.11 Major problems due to thermal pollution 5.12 Solution to overcome the problem
Unit-VI Environment Impact Assessment	6a Explain Environmental Impact Assessment(EIA) 6b Explain the process/method of environmental assessment. 6c State the format of EIA 6d Evaluate the quality of environmental impact assessment	6.1 Purpose of EIA 6.2 Strategic environmental assessment 6.3 Environmental assessment process 6.4 Environmental Impact Statement 6.5 EIA report 6.6 Advantages and constraints in use and results

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	In Introduction to Environmental Engineering And Ecology	7	4	4	4	12
II	Environmental Problems	5	3	3	3	9
III	Air and Noise Pollution and its Control	8	4	4	6	14
IV	Water Pollution	8	3	3	4	10
V	Land, Radio-active and Thermal Pollution	7	5	5	7	17
VI	Environment Impact Assessment	7	2	2	4	8
Total:		42	21	21	28	70

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

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

7. SUGGESTED LIST OF EXERCISES/PRACTICAL:

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills (**outcomes in psychomotor and affective domain**) so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

*Note: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes** (as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

No	Unit No.	Exercise (outcomes in psychomotor domain)	Hours
1.	All	Case study of environmental associated problems	04
2.		Draw Sketches with description (any Five)	Home Assignment
	All	1 Temperature variation in atmosphere 2 Balanced Ecosystem 3 Estonian pyramid 4 Hydrological cycle 5 Carbon cycle 6 Nitrogen cycle 7 Construction of green house 8 Fabric filter 9 Wet collectors 10 Absorbers cyclones 12 Vapour condensers 13 Electrostatic Precipitators	
3.		Laboratory Experiments	10
	All	1. Determine pH value of water sample 2. Determine Turbidity of water sample 3. Determine total dissolved solids in water sample 4. Determine B.O.D. of domestic wastewater sample 5. Determine C.O.D. of industrial wastewater sample	
4.		Visits	06
	All	1. Industry having air-pollution control measures adopted. 3. Nearby GPCB laboratory 3. Industry where stake-sampling can be carried out 4. Visit Chemical industry and write a report mentioning the impact on nature of that particular industry Note: submit detailed report on visits carried out	
5.		Seminar:	06

	All	The topic for the seminar should be given to the group of three students and they shall be asked to defend the seminar in presence of teacher and other students. Each student is required to defend the seminar individually	
Total			30

8. SUGGESTED STUDENT'S ACTIVITIES

- i. Visit nearby polluted-site, photographed it and suggest necessary measures to minimise it.
- ii. Make photo-collection/videos of pollution emission points
- iii. Surf websites of NGOs working for environmental protection and prepare a report

9. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

- i. Show Charts/Pictures/videos of Different Polluted Sites and of Pollution Control Projects and Events,
- ii. Arrange visit to different effluent treatment plants, solid waste segregation and disposal plants at industries and civic bodies.

10. SUGGESTED LEARNING RESOURCES

(A) List of Books:

No	Name of book	Author	Publisher
1	Textbook of Environmental Engineering	P. Venugopala Rao	PHI Learning Pvt. Ltd.
2	Ecology, the link between the natural and the social sciences	Eugene Pleasants Odum	Oxford and IBH Publishing
3	Environmental Engineering: A design approach	Arcadio P. Sincero and Gregoria A. Sincero	Tata Mc-Graw Hill Publications
4	Air Pollution	M N Rao H V N Rao	Tata Mc-Graw Hill Publications
5	Chemistry for Environmental Engineering and Science	Clair Sawyer, Perry McCarty and Gene Parkin	Tata Mc-Graw Hill Publications
6	Environmental Noise Pollution-Causes, Evils, Legislation and Control	Dr. Vijendra Mahandian	Deep & Deep Publications Pvt Ltd
7	Environmental Chemistry	S. K. Benerji	PHI Learning Pvt.Ltd.
8	Water Pollution	B K Sharma	GOEL publishing House, Meerut
9	Water pollution & Disposal of Waste Water on Land	U.N.Mahida	Tata McGraw Hill
10	Environmental Pollution Control Engineering	C S Rao	New Age International

			Publishers
11	Water and Waste water Engineering	Gorden ,Fair& Gayer Okun	John willey& Sons
12	Pollution-Causes, Effects and Control	Roy M Harrison	The Royal Society of Chemistry
13	Conducting Environmental Impact assessment in Developing Countries	P. Modak A K Biswas	United Nations University Press
14	Climate Change and India: Vulnerability assessment and Adaption	P R Shukla Subodh K Sharma and Others	Universities Press (India) Pvt Ltd.
15	Global Environmental Issues- A Climatological Approach	David D. Kemp	Routledge

(B) List of Major Equipment/Materials:

- i. Spectrophotometer
- ii. Water Analysis Kit
- iii. B.O.D. Incubator
- iv. Reflux apparatus
- v. Sample treatment plants

(C) List of Software/Learning Websites

- i. www.envfor.nic.in/division/introduction-8
- ii. www.ce.ncsu.edu
- iii. www.ce.cmu.edu
- iv. research.ce.udel.edu
- v. [moef.nic.in/sites/default/files/ngrba/EIA%20Report\(DraftFinal\).pd](http://moef.nic.in/sites/default/files/ngrba/EIA%20Report(DraftFinal).pd)

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE**Faculty Members from Polytechnics**

- **Prof. S. M. Mistry**, H.O.D. Civil Engg., Dr. S. & S. S. Ghandhy College of Engineering and Technology, Surat
- **Prof. B.V. Modi**, Principal BVPIT (DS), UMRAXH

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. J. P. Tegar**, Prof & Head, Department of Civil and Environmental Engineering
- **Prof. M. C. Paliwal**, Associate Professor, Department of Civil and Environmental Engineering