

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester-V

Course Title: Highway Engineering

(Course Code: 4350606)

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

1. RATIONALE

Road Transportation is the most effective and economical means of transportation in our country. Roads make a crucial contribution to economic development and growth and bring important social benefits. They are of vital importance in order to make a nation grow and develop. Agencies like NHAI, R&B and private organization are intensely involved in improving and building road networks. Construction of road is one of the major areas in which diploma holders in Civil Engineering may get very good opportunities for employment. The diploma holders are deals with construction and maintenance of highway. In order to professionally contribute to the field of highway engineering, the associated engineers must have adequate knowledge and skills relating to technical aspects of geometric design, alignment, quality of materials, construction process of road, new developments in road construction and use of modern and waste materials, techniques, design and maintenance of pavement. This course provides basic concepts regarding highway components, construction and maintenance practice.

2. COMPETENCY

This course is design to help the student to attain the following competency through various teaching learning experiences:

Undertake construction and maintenance of pavements.

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following COs:

- Explain road development plan and role of various agencies associate in highway engineering.
- Design of road geometry as per IRC.
- Understand road construction materials and construction process of highway.
- Describe use of various road making machineries.
- Know basic features associate with hill road.
- Aware about advances in highway engineering.

4. TEACHING AND EXAMINATION SCHEME

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

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

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

5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. As they are crucial for that particular CO at the 'Precision Level' of Dave's Taxonomy related to 'Psychomotor Domain'.

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Draw minimum four sketches showing standard cross section of NH, SH, MDR, in embankment and cutting.	II	02
2	Carry out minor filed project: Take road of minimum of 500 meter length. It should be included site selection, reconnaissance survey, fixing alignment and small cross drainage work, detailed profile survey along with alignment, cross section of the road and Cross drainage work. Prepare computer generated drawing of LS section of the road in cutting and filling.	II, III	06
3	Calculate examples based on road geometry (Minimum 10 examples).	II	04
4	Draw line sketches of various road construction equipments. (Minimum 10 equipments).	IV	02
5	Prepare table for permissible value of various road (WBM/WMM/BC) construction material properties recommended by IRC.	III	02
6	Visit of highway construction site and prepare report (following points should be include) 1) Understanding construction procedure of road. 2) Working of highway construction machineries including hot mix plant. 3) Inspection of road drainage condition. 4) Explore material testing laboratory available on site.	III, IV, V	06
7	Demonstration of pavement evaluation machineries: Bump Integrator and Benkelman Beam (Not required to perform).	VI	02
8	Seminar based on following topics:	-	04

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	Highway Material testing*, Highway Construction Machineries, Morden Tools and Techniques utilized in road construction, Road Maintenance Techniques, Construction of hill road, Software used in highway engineering and other topics suggested by faculty. *Weightage should be given for highway material testing.		
	Total		28

Note

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.
- ii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
For PrOs 1, 3, 4,		
1	Prepare drawing/sketches.	40
2	Neatness, accuracy in work and drawings.	20
3	Notation in the given drawing and writing text.	20
4	Answer the questions.	10
5	Submission of drawing in time.	10
	Total	100

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
For PrOs 2		
1	Calculate numerical based on given data.	50
2	Accuracy in calculation.	20
3	Draw sketches related to the example.	10
4	Answer the questions.	10
5	Submission of example in time.	10
	Total	100

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
For PrOs 5, 6, 7, 8, 9		
1	Participation in the site visit	40
2	Data collection during site visit	30
3	Technical involvement during site visit.	20
4	Preparation and submission of report.	10
	Total	100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

Major equipments must be made available in all institutions across the state for practical performance as prescribed in curriculum of **Basic Transportation Engineering (4340604)**. These equipments are California Bearing Ratio, Impact Testing Machine, Los Angeles Abrasion Testing Machine, Ring and Ball Apparatus, Standard Penetrometer, Flash and Fire Point test. These apparatus utilized for demonstration in highway engineering.

7. AFFECTIVE DOMAIN OUTCOMES

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

- a) Work as a leader/a team member.
- b) Follow ethical practices.
- c) Practice environmental friendly methods and processes. (Environment related)

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

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

8. UNDERPINNING THEORY

'Only the major Underpinning Theory is formulated as higher level UOs of *Revised Bloom's taxonomy* in order development of the COs and competency is not missed out by the students and teachers. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Unit – I Highway Developments	1a. Explain Highway Development in India considering future scope. 1b. Explain 20 year road development plan for India. 1c. Describe functions of various agencies involved in highway engineering. 1d. Explain funding system for highway.	1.1. Scope and Importance of Highway in India. 1.2. Road classification in India: Nagpur Plan, Bombay Plan, Lakhnow Plan. 1.3. Concept of Smart Highways. 1.4. Role of various agencies for planning, construction and maintenance of road (IRC, NHAI, R&B, MORTH, CRRI). 1.5. Funding system of state government and central government for the road construction and development.
Unit – II Highway	2a. Explain various terms used in road geometry.	2.1 Cross sectional elements: Right of Way, Width of Carriageway, Road

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
Geometric Design	2b. Explain road alignment. 2c. Draw various cross section of highway in embankment and cutting. 2d. Discuss various sight distance. 2e. Solve numerical based on highway geometry.	Margins, Kerbs, Medians, Formation Width, Camber, Shoulders, Side Slope, Lateral and vertical clearance, Typical Cross-sections. 2.2 Road Alignment a) Horizontal Alignment: Design Speed, Super elevation, Horizontal curve, Widening on horizontal curve, Transition curve. b) Vertical Alignment: Road gradient, Vertical curves 2.3. Standard cross section of national highway in Embankment and Cutting. 2.4. Sight Distance: Stopping Sight Distance, Overtaking Sight Distance, Intermediate Sight Distance. 2.5. Simple Numerical based on sight distances.
Unit– III Highway Construction	3a. To know the road materials and it's characteristics. 3b. Describe road construction method.	3.1 List various highway construction materials, give their characteristics. 3.2 Road pavement: Flexible and rigid pavement, typical cross-sections, functions of various components. Construction of WBM/WMM road, merits and demerits of WBM/WMM road. 3.3 Construction of Flexible pavement, types of bitumen (emulsion, cutback, tar) terms used in bituminous road: prime coat, tack coat, seal coat, merits and demerits of bituminous road. 3.4 Construction of rigid pavements: methods of construction alternate and continuous bay method, construction joints, filler and sealer, merits and demerits of concrete road.
Unit– IV Highway Construction Equipment	4a. Discuss various machineries for road construction.	4.1 Earthwork and transporting equipments: Dozer, Scraper, Grader, Tripper Truck. 4.2 Compaction Equipments:

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		Shipsfoot Roller, Pneumatic Tyred Roller, Vibratory Roller, 4.3 Bituminous Hot Mix plants: Batch mixing plant, Drum Mixing plant, Cold mix Plant, Paver Finisher. 4.4 Batching and Mixing plant for Cement Concrete road construction.
Unit- V Hill Road	5a. Describe components of hill road. 5b. Discuss drainage and protection work on hill road. 5c. Explain causes of landslide and classification.	5.1 Hill road components and it's function. 5.2 Drainage of hill road, Side drainage, catch water drain, cross drain. 5.3 Landslide: Types, Causes and prevention
Unit- VI Advances In Highway Engineering	6a. Know different highway engineering design software. 6b. Discuss Recycled and innovative materials in pavement construction. 6b. Explain basic concept of Bituminous Mix Design. 6c. Discuss Pavement Evaluation Machineries.	6.1 Brief overview of Highway Design Software: MX ROAD, IIT PAVED, IIT GRID. 6.2 Uses of various Recycled and new innovative materials in pavement construction. 6.3 Brief overview of bituminous mix design and marshal stability test. 6.4 Use of Bump Integrator, Benkelman Beam for pavement evaluation.

Note: The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Highway Developments	04	04	04	00	08
II	Highway Geometric Design	12	02	06	10	18
III	Highway Construction	14	02	08	10	20
IV	Highway Construction Equipments	04	02	02	04	08
V	Hill Road	04	02	04	02	08
VI	Advances In Highway Engineering	04	02	02	04	08
Total		42	14	26	30	70

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

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- a) Prepare seminar on relevant topic.
- b) Collect various drawing and other details related to road construction from R&B/NHA department and prepare report on it.
- c) Undertake micro project related to highway construction.
- d) Search the software/freeware on the course content and learn its application.
- e) Observe the components of roadway nearby area and draw your observation sketches with necessary details.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects.
- c) '**L**' in **section No. 4 does not** means only traditional lecture method, different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning** but to be assessed using different assessment methods.
- e) With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- f) Guide students on how to address issues on environment and sustainability.
- g) Demonstrate through of video lecture construction work of rigid and flexible pavement.
- h) Expert lecture on latest software for highway engineering.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be **individually** undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations

where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than **16 (sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry oriented COs.

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

- a) Evaluate camber and gradient of a pavement in nearby area.
- b) Prepare model of ground profile of road in cutting and filling.
- c) Prepare computer generated drawing of longitudinal section of various road in cutting as well as filling.
- d) Generate report/output from the software related to highway engineering.
- e) Use and study different types of software related to highway.
- f) Prepare a model of smart highway.
- g) Draw dimensional cross section of rigid pavement and flexible pavement.
- h) Draw different types of road pattern.
- i) Prepare organization structure of various agencies related to highway.
- j) Prepare a map showing existing location of NH, SH & NE of India.
- k) Collect all the details of all types of existing NH, SH, NE across the country.
- l) Collect the information of ongoing major road construction across the India.
- m) Prepare documentary of WBM and BM road construction.
- n) Carryout market survey about alternative materials used in road construction.
- o) Prepare chart showing different types of road alignment.
- p) Collect typical sample of the drawings and legal documents required for road construction from nearby R & B/NHAI Office.
- q) Prepare report on methods of economic evaluation of highway projects.
- r) Prepare report on procedure of financing of road projects and administration of roads including road safety audit.
- s) Collect accidental data from nearby traffic department/RTO and technically analyse with respect to road design.
- t) Study application of different material like: Glass, Fiber, Plastic, Geo-Textiles, and Geo-Membrane in road construction.
- u) Explore Advance technique of maintenance and repairs of highway.
- v) Case study on landslides causes, prevention and control measure.
- w) Report on use of Geo-textile, Geo-grids and Geo-synthetics in construction of hill road.
- x) Prepare model of typical cross section showing details of typical hill road partially in cutting and partially in filling.
- y) Case study of land subsidence in hill road.
- z) Any other micro-project suggested by subject faculty.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Highway Engineering	Khanna S.K, Justo C.E.G and Veeraragavan A.	New Chand and Brothers, Roorkee, 2010, ISBN 978-8185240800
2	Principles and Practices of Highway Engineering	Dr. L. R. Kadyali, Dr. N.B. Lal	Khanna Pulishers, Delhi, 2013, ISBN 8174091653
3	Principles, Practices and Design of Highway Engineering	Dr. S. K. Sharma	S. Chand, & Company Pvt. Ltd., Delhi, 2012, ISBN 8121901316
4	Highway Engineering	Bindra S. P.	Dhanpat Rai Publication Delhi, 2008, ISBN 978-8189929862
5	A Textbook of Highway Engineering	Srinivasa Kumar	Orient Blackswan, 2011, ISBN 978-8173716812
6	Highway Construction and Maintenance	Avinash Gupta	Random Publication, 2017 ISBN 978-9386314055
7	Laboratory Manual in Highway Engineering	Ajay K Duggal, Vijay P. Puri	New Age International Pvt. Ltd. ISBN 978-9386286703
8	IRC:37-2015, IRC:58-2015, MORTH: Manual for maintenance of road.	IRC	--

14. SOFTWARE/LEARNING WEBSITES

- <https://www.cadd.co.in/software/mxroad.php>
- <https://iit-pave-software91621.peatix.com>
- <https://morth.nic.in/>
- <https://nhai.gov.in/>
- <http://www.rnbgujarat.org/>
- <https://nptel.ac.in/>
- <https://swayam.gov.in/>
- <https://ts-nitk.vlabs.ac.in/List%20of%20experiments.html>

15. PO-COMPETENCY-CO MAPPING

Semester V	HIGHWAY ENGINEERING (Course Code: 4350604)									
	POs and PSOs									
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning	PSO 1	PSO 2	PSO 3 (If needed)
Competency	Undertake construction and maintenance of pavements.									
(CO a) Explain road development plan and role of various agencies associate in highway engineering.	3	-	-	-	2	2	3			
(CO b) Design of road geometry as per IRC.	3	3	3	2	2	3	2			

(CO c) Understand road construction materials and construction process of highway.	3	2	2	3	3	3	3			
(CO d) Describe use of various road making machineries.	3	2	-	2	3	3	3			
(CO e) Know basic features associate with hill road.	2	2	-	2	2	2	3			
(CO f) Aware about advances in highway engineering.	2	2	2	2	2	2	3			

Legend: '3' for high, '2' for medium, '1' for low or '-' for the relevant correlation of each competency, CO, with PO/ PSO

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1	Dr. V. P. Kukadia	G.P. Porbandar	0286-2220553	vijaykukadia1110@gmail.com
2	Miss P. P. Patel	G.P. Porbandar	0286-2220553	purvi2068@gmail.com
3	Dr. M. M. Vala	G.P. Porbandar	0286-2220553	monicaba.vala@gmail.com