

Program Name : Civil Engineering Program Group
Program Code : CE/CR/CS
Semester : Third
Course Title : Highway Engineering
Course Code : 22302

1. RATIONALE

Road Transportation is the most effective and economical means of transportation in our country. The need for travel to various places at faster speed has also increased. In order to professionally contribute to the field of highway engineering, the associated engineers and supervisors must have adequate knowledge and skills relating to technical aspects of continuously increasing volume of traffic flow, design of highway intersections/interchanges, geometric alignment and design, materials, structural design of pavement, new developments in road construction and use of modern and waste materials, techniques, design and maintenance of pavements. Agencies like NHAI and State Government and private organisation are intensely involved in improving and building road networks in India. Diploma Engineering students have good scope in jobs related to road construction as well as such infrastructural associated different projects works. This course provides scope of learning about various aspects of roads, carrying out survey, investigation, planning, design, construction and maintenance works related to road constructions.

2. COMPETENCY

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

- **Undertake construction and maintenance of pavements (Roads).**

3. COURSE OUTCOMES (COs)

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

- Identify the types of roads as per IRC recommendations.
- Implement the geometrical design features of different highways.
- Perform different tests on road materials.
- Evaluate traffic flow characteristics.
- Implement hill road construction using relevant materials, techniques and methods.
- Undertake maintenance of roads and drainage.

4. TEACHING AND EXAMINATION SCHEME

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



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

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

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

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

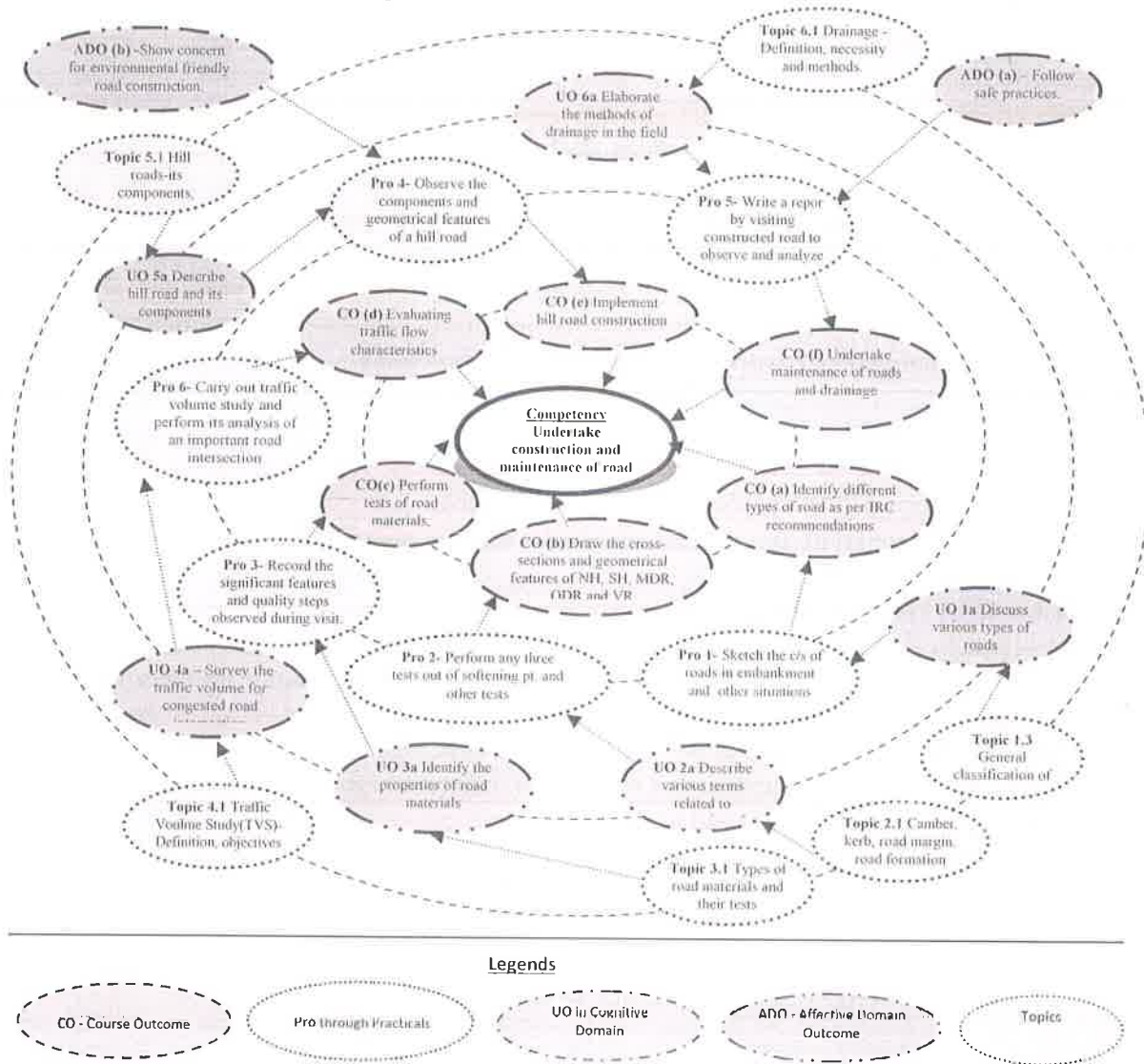


Figure 1 - Course Map

6. SUGGESTED PRACTICALS / EXERCISES

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



S. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Draw the sketches showing standard cross sections of NH/SH, MDR/ODR in embankment and cutting on A3 size sheets.	II	02*
2	Conduct Flakiness Index Test on the aggregates.	II	02*
3	Conduct Elongation Index Test on the aggregates.	II	02*
4	Conduct Angularity Number Test on the aggregates.	II	02
5	Conduct Softening point test on bitumen.	III	02*
6	Conduct Penetration test on bitumen.	III	02*
7	Conduct Flash and Fire Point test on bitumen.	III	02
8	Conduct Ductility test on Bitumen.	III	02
9	Visit the constructed road to suggest the possible remedial measures against the observed defects	III	02*
10	Prepare the photographic report containing details for experiment no. 9	III	02*
11	Carry out Traffic Volume Study (minimum two hours of peak period) for an important road intersection or roadway in your city/ town/ village.	IV	02*
12	Perform analysis of traffic volume data of experiment no. 11.	IV	02*
13	Draw the sketch of collision diagram for any one case.	IV	02*
14	Visit the hill road constructed site to understand its components and prepare the photographic report containing details.	V	02
15	Prepare the photographic report containing details for experiment no. 14.	V	02
16	Visit the road of any one type (flexible or rigid) to know the drainage condition.	VI	02
17	Prepare the photographic report suggesting possible repairs and maintenance for experiment no. 16.	VI	02
Total			34

Note

- i. A suggestive list of **PrOs** is given in the above table. More such PrOs can be added to attain the COs and competency. A judicious mix of minimum 12 or more practical LOs/tutorials need to be performed, out of which, the practicals marked as '*' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.
- ii. Hence, the 'Process' and 'Product' related skills associated with each PrO of the laboratory/workshop/field work are to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1	Preparation of experimental set up	20
2	Setting and operation	20
3	Safety measures	10
4	Observations and Recording	10
5	Interpretation of result and Conclusion	20
6	Answer to sample questions	10
7	Submission of report in time	10
Total		100



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

- Follow safety practices.
- Practice good housekeeping.
- Demonstrate working as a leader/a team member.
- Maintain tools and equipment.
- Follow ethical Practices.

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

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

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

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

S. No.	Equipment Name with Broad Specifications	Pro. No.
1	Thickness gauge containing openings for aggregate sizes 63, 50, 40,31.5, 25,20,16,12.5,10 & 6.3mm as per IS:2386(Part I)-1963	2
2	Length gauge containing openings for aggregate sizes 63, 50, 40,31.5, 25,20,16,12.5,10 & 6.3mm as per IS:2386(Part I)-1963	3
3	Ring and Ball test apparatus (Hot plate 160mm dia. with magnetic stirrer, brass ring, steel ball and glass vessel 600ml and glass thermometer +80 ⁰ c.	5
4	Standard Penetrometer with penetration needle 100gm weight, container 55mm dia. and 53mm ht. as per IS:1203.	6
5	Pensky Marten's Flash and Fire Point test apparatus 100x200x240mm with measurement range 0-95 as per IS:1209-1953	7
6	Ductility Testing Machine with ductility mould and base plate	8

8. UNDERPINNING THEORY COMPONENTS

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

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit—I Overview to Highway Engineerin g	1a. Describe key features of the given type of road. 1b. Explain significant aspects of the given road development plans as per IRC. 1c. Explain ideal road alignment	1.1 Scope and Importance of roads in India and its' Characteristics. 1.2 Different modes of transportation. 1.3 General classification of roads. 1.4 Road classifications in India (Nagpur plan) Third road development



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	and its requirements. 1d. Prepare the list of factors affecting given type of road alignment. 1e. Suggest the ideal requirements of road alignment for the given road condition.	(Lucknow) plan. 1.5 Development of Urban roads. 1.6 Requirements of an ideal road alignment and the factors affecting road alignment.
Unit—II Geometric Design of Highway	2a. Explain various functional terms related to geometrics of of the given type of highway with sketches. 2b. Describe the given type of road curves and their necessity. 2c. Calculate SSD, Super-elevation, and widening of roads required for the given road construction problem. 2d. Sketch the cross sections of roads in embankment and cutting for the given site condition.	2.1 Various terms used in Highway: Camber: Definition, purpose, types as per IRC – recommendations. 2.2 Kerbs: Road margin, road formation, right of way. 2.3 Design speed and various factors affecting design speed as per IRC – recommendations. 2.4 Gradient: Definition, types as per IRC – Recommendations. 2.5 Sight distance (SSD): Definition, types IRC – recommendations, simple numerical. 2.6 Curves: Necessity, types: Horizontal, vertical curves. 2.7 Widening of roads: types and problems 2.8 Super elevation: Definition, formula for calculating minimum and maximum Super elevation and method of providing super-elevation 2.9 Standards cross-sections of national highway in embankment and cutting.
Unit—III Constructi on of Road Pavements	3a. Describe the properties of given type of road materials 3b. Explain function/s of components of given type pavements with sketches/s. 3c. Describe with sketches the construction method for the given type of road pavement. 3d. Explain procedure for testing the given parameter of road construction. 3e. Describe with sketches the road construction method for the given situation.	3.1 Types of road materials and their Tests – Test on aggregates-Flakiness and Elongation Index test, Angularity Number test, test on Bitumen-penetration, Ductility, Flash and Fire point test and Softening point test. 3.2 Pavement – Definition, Types, Structural Components of pavement and their functions 3.3 Construction of WBM road. Merits and demerits of WBM road. 3.4 Construction of Flexible pavement / Bituminous Road, Types of Bitumen and its properties, Emulsion, Cutback, Tar. Terms used in BR-prime coat, tack coat, seal coat, Merits and Demerits of



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
		BR. 3.5 Construction of cement concrete- methods of construction-Alternate and Continuous Bay Method, Construction joints, filler and sealers, merits and demerits of concrete roads.
Unit—IV Traffic Engineering.	4a. Prepare survey plan for the traffic volume for congested road intersection. 4b. Interpret the observations recorded in traffic volume study to suggest the suitable solutions for traffic problems. 4c. Explain the given collision diagram to express various causes of accidents. 4d. Explain with sketches the working of various traffic control devices with their functions. 4e. Suggest suitability of traffic control device for the given situation with justification.	4.1 Traffic Volume Study(TVS)-Definition of Traffic Volume and Traffic Density. Objectives of TVS 4.2 Passenger Car Unit (PCU) and factors affecting it. 4.3 Traffic control devices – road signs, marking, Signals, Traffic island, Signals-Types, 4.4 Road signs-Types-Regulatory, Prohibitory and Informatory, Sketches of road signs. Types of road markings. 4.5 Traffic island-Types-Divisional, Channelizing, Pedestrian, Rotary. 4.6 Road intersections- Grade and grade separated intersections. 4.7 Accident studies with causes, Collision Diagram.
Unit—V Hill Roads	5a. Describe with sketches the given components of the hill road 5b. Suggest the drainage protective works on hill roads for the given situation with justification. 5c. Explain with sketches the causes of landslides in the given type of hill road. 5d. Suggest preventive measures to check landslide for the given condition with justification.	5.1 Hill roads, its components, functions 5.2 Types of hill road curves. 5.3 Drainage of hill roads: Side drains, catch water drains, cross drains, 5.4 Construction procedure of hill roads. 5.5 Landslides- Types and Causes 5.6 Prevention of landslides.
Unit—VI Drainage, Maintenance and Road Repair.	6a. Describe with sketches the relevant method of providing drainage in the given type of field. 6b. Interpret the information of the causes of failure of given type of pavement. 6c. Suggest suitable preventive measures for the given type of pavement.	6.1 Drainage-Definition, necessity and methods . 6.2 Surface drainage: side gutter, catch 6.3 Water drain. Subsurface drainage- Longitudinal and Cross drains. 6.4 Classification and necessity highway of maintenance. Causes of failure of pavement-WBM road.



Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	measures to avoid failures in the given type of pavement with justification. 6d. Suggest the maintenance and repair works of given type of defective road	Bituminous road. 6.5 Causes of failure of rigid pavement- Cement concrete road 6.6 Need for highway maintenance. Classification of maintenance. 6.7 Special repair of flexible and Rigid pavements.

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

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Highway Engineering	04	02	02	--	04
II	Geometric Design of Highway.	14	04	06	06	16
III	Construction of Road Pavements	10	04	06	06	16
IV	Traffic Engineering	08	04	04	06	14
V	Hill Roads	06	02	04	04	10
VI	Drainage, Maintenance and Road Repair.	06	02	04	04	10
Total		48	18	26	26	70

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

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

10. SUGGESTED STUDENT ACTIVITIES

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

- Undertake micro-projects related to road construction.
- Observe the components of roadway and record the details of the same with necessary sketches.
- Collect the information of NH and SH constructed and under construction across the country.
- Visit the crowded area i.e. city/town/village and note down the traffic control devices to suggest the possible action for smooth traffic flow.
- Collect the typical samples of drawings and legal documents required for road project form PWD office.
- Search the software/freeware on the course content and prepare the detailed report stating their applications.



11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

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

- a. Massive open online courses (*MOOCs*) may be used to teach various topics/sub topics.
- b. '*L*' in *item No. 4* does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
- c. About *15-20% of the topics/sub-topics* which is relatively simpler or descriptive in nature is to be given to the students for *self-directed learning* and assess the development of the COs through classroom presentations (see implementation guideline for details).
- d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for *co-curricular activities*.
- e. Guide student(s) in undertaking micro-projects.
- f. Demonstrate various concepts using videos of construction work of flexible and rigid pavement.
- g. Encourage students to refer different websites to have deeper understanding of new concepts of road works.
- h. Recommend the students to collect statistical and physiological data of present road conditions across the country.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably be *individually* undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should *not exceed three*.

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

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

- a. Collect all the details of all types of existing NH, SH across the country.
- b. Evaluate the camber and gradient of any one road of each type of pavement in the vicinity of area of college.
- c. Develop the photographic model of typical pavement structure for actual visited site.
- d. Advance Techniques of repairs like CBTR , White topping, Preventive maintenance, overlays, MSA (Million Standard Axle Load), utility system, encroachment , forest land under roads
- e. Any other micro-projects suggested by subject faculty on similar line.

13. SUGGESTED LEARNING RESOURCES



S. No.	Title of Book	Author	Publication
1	Highway Engineering	Khanna S.K. , Justo, C E G and Veeraragavan, A.	Nem Chand and Brothers, Roorkee, 2010, ISBN 978-8185240800
2	Road, Railways, Bridge and Tunnel Engg	Birdi, Ahuja,	Standard Book House, New Delhi, March 2010, ISBN: 978- 8189401337
3	Traffic Engineering and Transport Planning	Kadiyali, L.R.	Khanna Publishers, New Delhi, 2008, ISBN: 978-8174092205
4	Principles, Practice and Design of Highway Engineering,	Sharma, S.K.	S. Chand Publication, New Delhi, 2012, ISBN:9788121901314
5	Laboratory Manual in Highway Engineering	Duggal, Ajay K. and Puri, V. P.	New Age International (P) Limited, Publishers, New Delhi, 2010, ISBN: 9788122403107

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

- <https://www.youtube.com/watch?v=1fc4NVP9wXk>
- <https://www.youtube.com/watch?v=m8U76Bm8kDY>
- <https://www.youtube.com/watch?v=1ORIZ1shRIM>
- <https://www.youtube.com/watch?v=Xf89KDibIFE>



