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HIGHWAY ENGINEERING **Course Code : 313323**

Programme Name/s	**: Civil Engineering/ Civil & Rural Engineering/ Construction Technology/ Civil & Environmental Engineering/**
Programme Code	**: CE/ CR/ CS/ LE**
Semester	**: Third**
Course Title	**: HIGHWAY ENGINEERING**
Course Code	**: 313323**

I. RATIONALE

Efficient network of road is the life line of any nation. Highway engineering is one of the most favored-effective and economical modes of land transportation. It is instrumental in determining the economic development of the country. Highway and Transport facilities are an important part of urban infrastructure. Highway engineering is one of the branches of Civil engineering which deals with the process of design, construction, and maintenance of different types of roads. The basic requirements of efficient transportation are speed, safety, and comfort. It provides door to door service and connects to inaccessible parts of the country. Hence it is essential for Civil engineering student to acquire the knowledge of this course.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Undertake the construction of the given type of pavements including its maintenance (Roads).

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify the roads based on recommendations of IRC.
- CO2 - Implement geometrical features of different Highways.
- CO3 - Observe the various road construction activities.
- CO4 - Suggest the traffic control devices and intersections based on traffic flow survey data.
- CO5 - Suggest the relevant precautionary measures to control the drainage based on inspection to maintain the given section of roads.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical							
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
313323	HIGHWAY ENGINEERING	HEN	DSC	3	-	2	1	6	3	3	30	70	100	40	25	10	-	-	25	10	150

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Total IKS Hrs for Sem. : 1 Hrs
Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 15 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain the relevant modes of transportation with its importance. TLO 1.2 Explain Role of IRC, NHAI in the development of roads in India. TLO 1.3 Classify the Roads TLO 1.4 Decide the relevant factors influencing the ideal alignment of road pavement.	**Unit - I Introduction to Highway Engineering** 1.1 Different modes of transportation and importance of road transportation. 1.2 History of the Road development in India and the agencies involved in this work. (*IKS- Ancient Roads) 1.3 General classification of Roads. 1.4 Alignment: Definition, Requirements, importance etc. of an ideal road alignment and the factors affecting road alignment.	Video Demonstrations Lecture Using Chalk-Board Site/Industry Visit Presentations Cooperative Learning
2	TLO 2.1 Illustrate various functional terms related to geometrics of the given type of highway with sketches. TLO 2.2 Sketch /Draw the cross sections of roads in embankment and cutting for the given site condition.	**Unit - II Geometric Elements of Highway** 2.1 Definition, purpose, types, and its IRC recommendation of Various geometric elements /Technical terms of road pavement :Permanent way/right of way, road formation, Carriageway width, Road margin, side slopes, side gutter, Camber, Gradient, Super elevation, Curves, Road Widening, Sight distance, Design speed and factors affecting design speed 2.2 Standards cross-sections of EXPRESSWAY, NH, SH, MDR, ODR and VR in embankment and cutting.	Video Demonstrations Presentations Lecture Using Chalk-Board Site/Industry Visit Collaborative learning Case Study

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Undertake the specific test on given sample of bitumen to check its suitability in road construction. TLO 3.2 Differentiate between the flexible and rigid pavement. TLO 3.3 Explain the importance of each layer in given type of road. TLO 3.4 Explain the construction of the given pavement including joints and sealers. TLO 3.5 Describe the components of the hill road in given situation. TLO 3.6 Suggest relevant measures to control the landslide in the given situation.	**Unit - III Construction of Road Pavements** 3.1 Overview of highway construction materials: Aggregate, Cement, Sand, Water, Soil, Bitumen: Ductility, Flash and Fire Point Test, Softening Point Test, Extraction Test, Grade of Bitumen, Emulsion, Cutback, Tar. 3.2 Definition, Types, Structural Components of pavement and their functions. 3.3 Construction of WBM road, Flexible pavement / Bituminous Road. 3.4 Construction of Rigid Pavement (Cement Concrete): methods of construction, Alternate and Continuous Bay Method, Construction joints, filler and sealers. 3.5 Components, functions of Hill roads. 3.6 Landslides: define, Causes, Types, Prevention of landslides.	Video Demonstrations Presentations Lecture Using Chalk-Board Hands-on Site/Industry Visit Case Study
4	TLO 4.1 Conduct traffic volume survey at the given road intersection. TLO 4.2 Justify the importance of PCU in traffic volume study to suggest the solution to the given problem. TLO 4.3 Justify the importance of traffic control devices. TLO 4.4 Justify the Intersections in the given situation.	**Unit - IV Traffic Engineering** 4.1 Traffic Volume Study (TVS): Definition, Purpose of TVS, method of TVS. 4.2 Passenger Car Unit (PCU) and factors affecting it. 4.3 Traffic control devices and its types: road signs, marking, Signals, Traffic Island. 4.4 Road Intersections: Cloverleaf, Diamond and Trumpet Interchange	Model Demonstration Video Demonstrations Lecture Using Chalk-Board Hands-on Cooperative Learning Case Study
5	TLO 5.1 Describe with sketches the relevant method of providing drainage in the given type of Road. TLO 5.2 Identify the causes of failure based on inspection of given type of pavement. TLO 5.3 Suggest the maintenance and repair works required for given type of defective road.	**Unit - V Road Drainage and maintenance** 5.1 Drainage-Definition, necessity, types and sketch of drainage system. 5.2 Failure of flexible and Rigid pavement and Its Causes and preventive measures. 5.3 Necessity of Maintenance of Road & its Classification.	Video Demonstrations Presentations Lecture Using Chalk-Board Site/Industry Visit Cooperative Learning Case Study

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Draw the sketches showing standard cross sections of NH, SH, MDR, ODR, VR.	1	*Draw the sketches showing standard cross sections of NH, SH, MDR, ODR, VR in embankment and cutting on A3 size sketch book.	2	CO1 CO2
LLO 2.1 Identify components of Road.	2	*Visit the existing road to identify the component parts of road and prepare photographic report.	2	CO1 CO2
LLO 3.1 Interpret the result of Softening point test on bitumen.	3	*Conduct Softening point test on bitumen.	2	CO3
LLO 4.1 Interpret the result of Penetration test on bitumen.	4	*Conduct Penetration test on bitumen.	2	CO3
LLO 5.1 Interpret the result of Flash and Fire Point on bitumen.	5	Conduct Flash and Fire Point test on bitumen.	2	CO3
LLO 6.1 Interpret the result of Ductility test on bitumen.	6	Conduct Ductility test on Bitumen.	2	CO3
LLO 7.1 Interpret the result of Bitumen Extraction Test on bitumen.	7	*Conduct Bitumen Extraction Test.	2	CO3
LLO 8.1 Write the function of each layer of Pavement. LLO 8.2 Observe the working of Highway Construction machineries. LLO 8.3 Onsite testing of Material and sequential method of Construction.	8	*Visit the road under construction to identify layers in the flexible pavement/Rigid Pavement. prepare photographic report consisting of Materials, Machineries used, Method of Construction and on-site testing of Materials.	2	CO1 CO2 CO3
LLO 9.1 Identify the components of Hill Roads.	9	Visit the hill road to study its components, geometrics and prepare the photographic report containing details.	2	CO1 CO2 CO3
LLO 10.1 Perform traffic volume survey for a road intersection.	10	*Carry out Traffic Volume Study (minimum two hours of peak period) for an important road intersection or roadway in your city/ town/ village.	2	CO4
LLO 11.1 Analysis traffic volume data and Interpret data.	11	Analysis traffic volume data obtained from above experiment.	2	CO4
LLO 12.1 Examine and relate the meaning of the traffic signs, road markings, islands in your city.	12	*Draw and identify the traffic signs, road markings, islands, intersections in your city/ town/ village and prepare the photographic report.	2	CO4
LLO 13.1 Inspect the existing road drainage system in your area and identify its type.	13	Visit the road of any one type flexible or rigid to know the road drainage system.	2	CO1 CO2 CO5
LLO 14.1 Identify the defects in road.	14	*Visit the road to identify the defects in road and suggest the possible remedial measures for it and prepare photographic report.	2	CO1 CO2 CO5
LLO 15.1 Suggest possible repairs and maintenance of the road.	15	*Suggest possible repairs and maintenance of the road visited in your city/ town/ village.	2	CO2 CO5

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

- Develop Highway Intersection Model for smooth traffic flow.
- Differentiate geometric terms of different roads (NH, SH, MDR, ODR, VR) passing through your area.
- Advance Techniques of repairs like CBTR, White topping, Preventive maintenance, etc.
- Identify mode of transportation other than land transportation.
- List the National Highways/State Highways passing through Maharashtra.
- Collect the information relevant to transportation engineering about ongoing and completed road projects (Samrudhi-Mahamarg, Golden Quadrilateral, etc.).
- Role of MSRDC, NHAI and IRC in development and construction of roads.
- Asian Highways (AH) analysis.

Assignment

- IS Codes used for Planning, designing, construction and maintenance of roads.
- Illustrate the terms 1) Granular Sub Base-GSB 2) Wet Mix Macadam- WMM.
- New techniques and machineries used for rapid Highway Maintenance around the world.
- Evaluate the camber and gradient of any one road of each type of pavement in your area of college.
- Develop the photographic model of typical pavement structure for actual visited site.
- Make a list of Mega Highway Projects around the world and advanced techniques/machineries used in it.
- Participate in RTO Safety week and Study its activities.
- Observe construction techniques of WBM/Flexible/ Rigid Road.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Ring and Ball test apparatus (Hot plate 160mm dia. with magnetic stirrer, brass ring, steel ball and glass vessel 600ml and glass thermometer +800c.	3
2	Digital Analytical Weighing Scale, Accuracy: 1 Mg capacity : 30 g to 300 g	3,4,5,6,7
3	1) Lab Safety products (Heat Resistant Gloves, PPE Kit for Laboratory work, etc.) 2) Laboratory items-Lab Utensils and Hand Tools and Sample Containers and Bags	3,4,5,6,7

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Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
4	Standard Penetrometer with penetration needle 100gm weight, container 55mm dia. and 53mm ht. as per IS:1203.	4
5	Pensky Marten's Flash and Fire Point test apparatus 100x200x240mm with measurement range 0-95 as per IS:1209-1953	5
6	Ductility Testing Machine with ductility mould and base plate	6
7	Bitumen Extraction Test Apparatus: - Centrifuge Extractor, Electrical Operation, Capacity 1500g, with a Dimmer stat for speed control from 2,400 to 3,600 rpm. Suitable for operation on 230 V, 50 Hz, Single Phase, A.C. supply.	7

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Highway Engineering	CO1	3	2	4	0	6
2	II	Geometric Elements of Highway	CO2	15	6	8	8	22
3	III	Construction of Road Pavements	CO3	15	6	8	8	22
4	IV	Traffic Engineering	CO4	6	2	4	4	10
5	V	Road Drainage and maintenance	CO5	6	2	4	4	10
Grand Total				**45**	**18**	**28**	**24**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Termwork, Assignment, Microproject (60% Weightage to process and 40% weightage to product), Question and Answer.

Summative Assessment (Assessment of Learning)

- Pen and Paper Test (Written Test)

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	-	-	-	2	-	3			
CO2	3	-	1	2	1	-	3			
CO3	3	3	2	3	2	1	3			
CO4	3	3	3	2	3	3	3			
CO5	3	3	3	3	3	3	3			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Khanna S.K., Justo, C E G and Veeraragavan, A.	Highway Engineering	New Chand and Brothers, Rookie, 2010, ISBN 978-8185240800
2	Kadiyali, L.R.	Traffic Engineering and Transport Planning	Khanna Publishers, New Delhi, 2008, ISBN: 978-8174092205
3	Duggal, Ajay K. and Puri, V. P.	Laboratory Manual in Highway Engineering	New Age International (P) Limited, Publishers, New Delhi, 2010, ISBN: 9788122403107
4	Raji A. K. and K. K. Babu	Transportation engineering theory and practice)	AICTE New Delhi ISBN 978-81-960576-1-9
5	N L Arora	Transportation engineering	New India Publishing House, New Delhi ...

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://iksindia.org/index.php	Indian Knowledge Systems (IKS)
2	https://www.youtube.com/watch?v=acfJIG9o8iw	Flakiness and Elongation Index of Aggregate
3	https://www.youtube.com/watch?v=TE8zYxUJHt0 https://ts-nitk.vlabs.ac.in/exp/ductility-test/	Ductility test on Bitumen.
4	https://www.youtube.com/watch?v=-yBXl4z70mI https://ts-nitk.vlabs.ac.in/exp/softening-point-test/	Softening point test on bitumen.
5	https://www.youtube.com/watch?v=9HZE6DNfF5U https://ts-nitk.vlabs.ac.in/exp/penetration-test/	Penetration test on bitumen.
6	https://www.youtube.com/watch?v=PR7q4-ilENA	Flash and Fire Point test on bitumen.
7	https://www.youtube.com/watch?v=JEySduXuxCc&t=563s https://www.youtube.com/watch?v=d48qDaiDyVI	Bitumen Extraction Test
8	https://www.youtube.com/watch?v=2VehMMP70HE&list=PLLy_2iUCG87C7nApYQjgkDA0p67fMaXnE	Geometric Design of Highways By Prof. Rajat Rastogi IIT Roorkee
9	https://www.youtube.com/watch?v=5zKC_aq4ypM&list=PLE88643285BC70E0F	Transportation Engineering and Road development Process by IIT Kharagpur
10	https://crridom.gov.in/	CSIR-Central Road Research Institute
11	https://www.irc.nic.in/	Indian Roads Congress (IRC)
12	https://nhai.gov.in/#/	National Highway Authority of India (NHAI)
13	https://msrdc.in/1307/Home	Maharashtra State Road Development Corporation Ltd.

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students