CA5313: SMART TECHNOLOGIES AND ADVANCES IN PAVEMENT ENGINEERING

Effective Term
Semester A 2026/27

Part I Course Overview

Course Title
Smart Technologies and Advances in Pavement Engineering

Subject Code
CA - Civil and Architectural Engineering
Course Number
5313

Academic Unit
Architecture and Civil Engineering (CA)

College/School
College of Engineering (EG)

Course Duration
One Semester

Credit Units
3

Level
P5, P6 - Postgraduate Degree

Medium of Instruction
English

Medium of Assessment
English

Prerequisites
Nil

Precursors
Nil

Equivalent Courses
Nil

Exclusive Courses
Nil

Additional Information
Nil

Part II Course Details

Abstract

This course explores the integration of smart technologies into modern pavement engineering. It introduces digitalization concepts, intelligent sensing, and data-driven management for the design, construction, and maintenance of road infrastructure. Core topics include digital twin applications in pavement systems, structural health monitoring, intelligent inspection, and life-cycle performance analysis. Students will learn how emerging technologies, such as IoT sensors, automation, and digital modelling, enhance pavement performance, durability, and sustainability. Through lectures, case studies, and simulation-based projects, the course emphasizes the use of real-time data and predictive analytics to support decision-making in pavement management. Practical sessions guide students in applying smart technologies to optimize maintenance strategies and resource utilization. By the end of the course, students will be equipped with the knowledge and technical skills required to promote the development of intelligent, resilient, and sustainable pavement infrastructure for future transportation systems.

Course Intended Learning Outcomes (CILOs)

	CILOs	Weighting (if app.)	DEC-A1	DEC-A2	DEC-A3
1	Explain the core principles of digital twin technology and its key application scenarios in road engineering, including the connection between digital twin and intelligent road digitalization, management systems, and monitoring/operation;		x	x	
2	Evaluate the role of digital twin technology in optimizing road construction processes, enhancing structural health monitoring accuracy, improving maintenance efficiency, and supporting road life-cycle analysis;		x	x	
3	Apply digital simulation platforms and case analysis methods to develop practical solutions for whole-life-cycle pavement management using digital twin techniques;		x	x	x
4	Demonstrate the ability to critically analyse and contribute to future developments in advanced and resilient road infrastructure.		x	x	x

A1: Attitude
Develop an attitude of discovery/innovation/creativity, as demonstrated by students possessing a strong sense of curiosity, asking questions actively, challenging assumptions or engaging in inquiry together with teachers.

A2: Ability
Develop the ability/skill needed to discover/innovate/create, as demonstrated by students possessing critical thinking skills to assess ideas, acquiring research skills, synthesizing knowledge across disciplines or applying academic knowledge to real-life problems.

A3: Accomplishments
Demonstrate accomplishment of discovery/innovation/creativity through producing /constructing creative works/new artefacts, effective solutions to real-life problems or new processes.

Learning and Teaching Activities (LTAs)

	LTAs	Brief Description	CILO No.	Hours/week (if applicable)
1	Lecture	Student will engage in lecture activities about the topics closely related to digital twin and pavement management system.	1, 2, 3, 4	
2	Tutorial	Students will participate in class discussions and activities focused on solving issues related to the design and evaluation of digital twin-based pavement management.	2, 3, 4	

Assessment Tasks / Activities (ATs)

	ATs	CILO No.	Weighting (%)	Remarks ("-" for nil entry)	Allow Use of GenAI?
1	Mid-term Test	1, 2, 3	25	-	No
2	Project assignments	2, 3, 4	25	-	Yes

Continuous Assessment (%)

50

Examination (%)

50

Examination Duration (Hours)

2

Minimum Continuous Assessment Passing Requirement (%)

30

Minimum Examination Passing Requirement (%)

30

Assessment Rubrics (AR)

Assessment Task

Mid-term Test

Criterion

ABILITY to UNDERSTAND and APPLY theories and knowledge to topics related to digital twin.

Excellent (A+, A, A-)

High

Good (B+, B, B-)

Significant

Fair (C+, C, C-)

Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Assessment Task
Examination

Criterion
ABILITY to UNDERSTAND and APPLY theories and knowledge to topics related to digital twin and pavement management system.

Excellent (A+, A, A-)
High

Good (B+, B, B-)
Significant

Fair (C+, C, C-)
Moderate

Marginal (D)
Basic

Failure (F)
Not even reaching marginal levels

Part III Other Information

Keyword Syllabus
Smart Technologies, Digital Twin, Intelligent Pavement Engineering, Structural Health Monitoring, Intelligent Inspection, Life-Cycle Management, Pavement Digitalization, Sustainable Infrastructure.

Reading List

Compulsory Readings

	Title
1	Nil

Additional Readings

	Title
1	Wang, Y., Li, Z., Liang, B., Tian, H., Guo, T., & Chen, F. (2025). Data Analytics for Smart Infrastructure: Asset Management and Network Performance. CRC Press.
2	Wang, Y., Li, Z., Liang, B., Tian, H., Guo, T., & Chen, F. (2025). Data Analytics for Smart Infrastructure: Asset Management and Network Performance. CRC Press.
3	Bertolini, L., & Giorgadze, I. M. (2024). A Semantic Digital Twinning Approach for the Management of Road Distress Data. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, X-4-W5-2024, 49-56.
4	Haverkamp, P., Anantheswar, A., May, M., Wadlig, G., Hildebrandt, J., Thiessat, K. A., ... & Lehner, W. (2025). Digital Twin Road: value and implications involving data and application. Discover Applied Sciences, 7(6), 510.

5	El Marai, O., Taleb, T., & Song, J. (2020). Roads infrastructure digital twin: A step toward smarter cities realization. IEEE network, 35(2), 136-143.
6	Consilvio, A., Hernández, J. S., Chen, W., Brilakis, I., Bartoccini, L., Di Gennaro, F., & van Welie, M. (2023). Towards a digital twin-based intelligent decision support for road maintenance. Transportation Research Procedia, 69, 791-798.
7	Jiang, F., Ma, L., Broyd, T., Chen, W., & Luo, H. (2022). Digital twin enabled sustainable urban road planning. Sustainable Cities and Society, 78, 103645.
8	Steyn, W. J., & Broekman, A. (2022). Development of a digital twin of a local road network: A case study. Journal of Testing and Evaluation, 50(6), 2901-2915.
9	Steyn, W. J., & Broekman, A. (2022). Development of a digital twin of a local road network: A case study. Journal of Testing and Evaluation, 50(6), 2901-2915.