Subject Description Form

Subject Code	CSE581
Subject Title	Smart Infrastructure
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Students should have fundamental knowledge in civil engineering and urban informatics
Objectives	1. To expose students to the new and innovative technologies for smart infrastructure; 2. To develop an understanding of the basic theory and practical use of cutting-edge sensing and construction technologies for smart infrastructure; and 3. To enable students to design, analyse, and implement health monitoring technology for smart infrastructure.
Intended Learning Outcomes	Upon completion of the subject, students will be able: (a) design appropriate and cost-effective smart infrastructure systems; (b) utilize various types of sensing technologies for smart infrastructure monitoring; (c) evaluate structural safety and performance based on analyzed data and other information; and (d) provide the findings for the client, designer, contractor, or other relevant sectors on the safety and sustainability of smart infrastructure through oral presentations and written reports.
Subject Synopsis/ Indicative Syllabus	1. Introduction (1 week) Infrastructure, built environment, safety, sustainability, recent developments in smart cities. 2. Basics of Structural Dynamics (1 week) Single degree of freedom system and frequency domain analysis. 3. Smart Sensors-Optic Fibers (1 week) Sensor applications in infrastructure monitoring. 4. Smart Sensors-Piezoelectric Transducers (1 week) PZT-based sensing technology in smart infrastructure.

	5. Smart Sensors-Smart and Multifunctional Concrete (2 weeks) Fundamentals and practices of smart and multifunctional concrete including self-sensing concrete, self-heating concrete, self-powering concrete, self-healing concrete, etc in smart infrastructure. 6. Smart Construction Technology-Modular Integrated Construction (1 week) Fundamentals and practices of steel and concrete modular integrated construction. 7. Smart Sensors-UAV Based Infrastructure Inspection(1 week) Unmanned Aerial Vehicles (UAV) based crack detection, structural displacement monitoring, and Smart maintenance. 8. Data-driven methods (1 week) Fundamentals and practices of data-driven methods in smart infrastructure. 9. Life-cycle Monitoring & AI-driven Constriction (1 week) AI-enhanced construction design and management. 10. Structure health monitoring system for infrastructure (1 week) Fundamentals and applications of structure health monitoring system. 11. Project works (2 weeks) Analysis of data from a practical smart structure or laboratory testing, writing report, oral presentation.

Teaching/Learning Methodology	Lectures will provide fundamental knowledge related to safety and sustainability of infrastructure. Real applications to some landmark infrastructure will also be demonstrated in detail. Students will be required to undertake various coursework activities, which will enable them to thoroughly digest the taught contents. Tutorials will provide opportunities for students and lecturers to communicate and discuss any difficulties relating to the lectures. It will also provide a forum for students and lecturers to discuss ongoing coursework and laboratory activities. Laboratory testing on a testbed and/or real practice on some structural health monitoring systems will help students to understand the basic sensing technology and materials used in smart infrastructures and the challenges for the real infrastructure.

Final projects will require students to conduct some problem-solving exercises independently, analyze the experimental data obtained from laboratory testing or a practical smart structure, prepare integrated reports, and give oral presentations. Final reports will improve the students' ability to data analysis and writing. Final oral presentations will improve the students' ability to presentation and communication.

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks		% weighting	Intended subject learning outcomes to be assessed			
			a	b	c	d
1. Continuous Assessment	Assignment 1 (individual)	15%		✓	✓	
	Assignment 2 (individual)	15%		✓	✓	
2.Final Project	Final report (in group)	45%	✓	✓	✓	✓
	Final oral presentation (in group)	25%	✓	✓	✓	✓
Total		100 %				

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Continuous assessment will be evaluated based on two individual assignments.

For final project, students are required to submit a written report (in group, 45%) and deliver an oral presentation (in group, 25%). Students are required to demonstrate individual contribution and are assessed individually in both the written report and the oral presentation.

Students must pass all the assessments and achieve a passing overall score / grade to pass the subject. Students who are found to commit acts of academic dishonesty, including but not limited to plagiarism, violating university's guideline on using GenAI, will result in direct disqualification in this subject and subjected to further disciplinary actions.

Reading List and References

Books

1. Mehmood, R., See, S., Katib, I., & Chlamtac, I. (2020). Smart infrastructure and applications: foundations for smarter cities and societies. Springer.
2. Boller, C., Chang, F. and Fujino, Y. (2009), Encyclopedia of Structural Health Monitoring, Chichester: John Wiley & Sons.
3. Clough, R. and Penzien, J. (1993), Dynamics of Structure, 2nd edition, New York: McGraw-Hilt.
4. Wu, Z, Noori, M, & Zhang, J. (2018). Fiber-Optic Sensors for Infrastructure Health Monitoring,
   Volume I: Introduction and Fundamental Concepts. Momentum Press.
5. Udd, E, & Spillman, W. (2011). Fiber optic sensors: an introduction for engineers and scientists (2nd ed.). John Wiley & Sons, Inc.
6. Xu, W., & University of Washington. Mechanical Engineering, degree granting institution. (2019). Fabrication, Characterization and Application of PZT- Silane Nano-Composite Thin-Film Sensors and Actuators. ProQuest LLC.
7. Han, B., Zhang, L. & Ou, J. (2017) Smart and Multifunctional Concrete Toward Sustainable Infrastructures, Springer.

Journal Papers

1. Verma, Anurag, Prakash, Surya, Srivastava, Vishal, Kumar, Anuj, & Mukhopadhyay, Subhas Chandra. Sensing, Controlling, and IoT Infrastructure in Smart Building: A Review. IEEE Sensors Journal, 19(20), (2019) 9036– 9046. https://doi.org/10.1109/JSEN.2019.2922409
2. Y.Q. Ni, Y. Xia, W.Y. Liao, J.M. Ko, Technology innovation in developing the structural health monitoring system for Guangzhou New TV Tower, Structural Control and Health Monitoring 16 (2009) 73–98. https://doi.org/10.1002/stc.303.
3. S. Taheri, A review on five key sensors for monitoring of concrete structures, Construction and Building Materials 204 (2019) 492–509. https://doi.org/10.1016/j.conbuildmat.2019.01.172.
4. S. Das, P. Saha, A review of some advanced sensors used for health diagnosis of civil engineering structures, Measurement 129 (2018) 68–90. https://doi.org/10.1016/j.measurement.2018.07.008.
5. H. Qin, S. Ding, A. Ashour, Q. Zheng, B. Han, Revolutionizing infrastructure: The evolving landscape of electricity-based multifunctional concrete from concept to practice, Progress in Materials Science (2024) 101310. https://doi.org/10.1016/j.pmatsci.2024.101310.

6. I. Galan, B. Müller, L.G. Briendl, F. Mittermayr, T. Mayr, M. Dietzel, C. Grengg, Continuous optical in-situ pH monitoring during early hydration of cementitious materials, Cement and Concrete Research 150 (2021) 106584. https://doi.org/10.1016/j.cemconres.2021.106584.
7. C. Guo, L. Fan, C. Wu, G. Chen, W. Li, Ultrasensitive LPFG corrosion sensor with Fe-C coating electroplated on a Gr/AgNW film, Sensors and Actuators, B: Chemical (2019) 334–342. https://doi.org/10.1016/j.snb.2018.12.059.
8. J.M. López-Higuera, L.R. Cobo, A.Q. Incera, A. Cobo, Fiber optic sensors in structural health monitoring, Journal of Lightwave Technology 29 (2011) 587–608. https://doi.org/10.1109/JLT.2011.2106479.
9. C. Dumoulin, G. Karaiskos, J.-Y. Sener, A. Deraemaeker, Online monitoring of cracking in concrete structures using embedded piezoelectric transducers, Smart Materials and Structures 23 (2014) 115016. https://doi.org/10.1088/0964-1726/23/11/115016.
10. R.M. Lawson, R.G. Ogden, R. Bergin, Application of Modular Construction in High-Rise Buildings, J. Archit. Eng. 18 (2012) 148–154. https://doi.org/10.1061/(ASCE)AE.1943-5568.0000057.
11. J. Kim, K. Lee, J.H. Jeon, Systematic literature review of wearable devices and data analytics for construction safety and health. Expert Systems with Applications (2024) 125038. https://doi.org/10.1016/j.eswa.2024.125038