<u>Subject Description Form</u>

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 technologies and building materials; 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: 1. design appropriate and cost-effective smart infrastructure systems; 2. utilize various types of sensing technology and building materials for smart infrastructure monitoring; 3. evaluate structural safety and performance based on analyzed data and other information; and 4. 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. <u>Introduction (1 week)</u> Infrastructure, built environment, safety, sustainability, recent developments in smart cities. 2. <u>Basics of Structural Dynamics (1 week)</u> Single degree of freedom system and frequency domain analysis. 3. <u>Smart sensors-optic fibres (2 weeks)</u> Optic fibre-based sensing technology in smart infrastructure. 4. <u>Smart sensors-piezoelectric transducers (2 weeks)</u> PZT-based sensing technology in smart infrastructure. 5. <u>Smart sensors-Visual inspection (1 week)</u>

	Unmanned Aerial Vehicle (UAV) with imaging devices. 6. Smart sensing materials (1 week) Fundamentals and practices of smart sensing materials in smart infrastructure. 7. Data-driven methods (2 weeks) Fundamentals and practices of data-driven methods in smart infrastructure. 8. Structure health monitoring system for infrastructure (1 week) Fundamentals and applications of structure health monitoring system. 9. Project works (2 weeks) Analysis of data from a practical smart structure or laboratory testing, writing report, oral presentation.

Teaching/Learning Methodology	Fundamental knowledge related to safety and sustainability of infrastructure will be presented in lectures. Real applications to some landmark infrastructure will be demonstrated in detail. Assignments will help students consolidate their understanding and implementation of commonly used sensing and data processing techniques. 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 oral presentation will train the students on presentation and communication skills.
Assessment Methods in Alignment with Intended Learning Outcomes	(see table below)

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed			
		a	b	c	d
1. Continuous Assessment	30%		✓		
2. Project	70%	✓	✓	✓	✓
Total	100 %				

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

Continuous assessment will be based on individual project and lab reports.

Students must attain at least Grade D in both coursework and final examination

	(whenever applicable) in order to attain a passing grade in the overall result.
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.K. and Fujino, Y., (2009), Encyclopedia of Structural Health Monitoring, Chichester: John Wiley & Sons. 3. Clough, R.W. and Penzien, J., (1993), Dynamics of Structure, 2nd edition, New York: McGraw-Hilt. 4. Wu, Zhishen, Noori, Mohammad, & Zhang, Jian. (2018). Fiber-Optic Sensors for Infrastructure Health Monitoring, Volume I: Introduction and Fundamental Concepts. Momentum Press. 5. Udd, Eric, & Spillman, William B. (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, Baoguo, Ding, Siqi, Wang, Jialiang, & Ou, Jinping. (2019). Nano-Engineered Cementitious Composites. Springer Singapore Pte. Limited. Papers and reports 8. Llobet, Eduard. (2013). Gas sensors using carbon nanomaterials: A review. Sensors and Actuators. B, Chemical, 179, 32–45. https://doi.org/10.1016/j.snb.2012.11.014 9. Shrivas, Kamlesh, Ghosale, Archana, Bajpai, P.K, Kant, Tushar, Dewangan, Khemchand, & Shankar, Ravi. (2020). Advances in flexible electronics and electrochemical sensors using conducting nanomaterials: A review. Microchemical Journal, 156, 104944.

	https://doi.org/10.1016/j.microc.2020.104944 10. Pawar, Dnyandeo, & Kale, Sangeeta N. (2019). A review on nanomaterial-modified optical fiber sensors for gases, vapors and ions. Mikrochimica Acta (1966), 186(4), 1–34. https://doi.org/10.1007/s00604-019-3351-7 11. Zhou, G, & Sim, L M. (2002). Damage detection and assessment in fibre-reinforced composite structures with embedded fibre optic sensors-review. Smart Materials and Structures, 11(6), 925–939. https://doi.org/10.1088/0964- 1726/11/6/314 12. Sakiyama, Felipe Isamu Harger, Lehmann, Frank A, & Garrecht, Harald. (2019). Structural Health Monitoring of Concrete Structures using Fibre Optic Based Sensors: A Review. Magazine of Concrete Research, 1–45. https://doi.org/10.1680/jmacr.19.00185 13. Kasznar, Ana Paula P, Hammad, Ahmed W. A, Najjar, Mohammad, Linhares Qualharini, Eduardo, Figueiredo, Karoline, Soares, Carlos Alberto Pereira, & Haddad, Assed N. (2021). Multiple Dimensions of Smart Cities' Infrastructure: A Review. Buildings (Basel), 11(2), 73. https://doi.org/10.3390/buildings11020073 14. Verma, Anurag, Prakash, Surya, Srivastava, Vishal, Kumar, Anuj, & Mukhopadhyay, Subhas Chandra. (2019). Sensing, Controlling, and IoT Infrastructure in Smart Building: A Review. IEEE Sensors Journal, 19(20), 9036– 9046. https://doi.org/10.1109/JSEN.2019.2922409 Ota, Kaoru, Kumrai, Teerawat, Dong, Mianxiong, Kishigami, Jay, & Guo, Minyi. (2017). Smart Infrastructure Design for Smart Cities. IT Professional, 19(5), 42–49. https://doi.org/10.1109/MITP.2017.3680957