

<b>Course Title</b>	Condition assessment, Repair, Rehabilitation and Artificial Intelligence
<b>Course Code</b>	19STE541A
<b>Programme</b>	Structural Engineering
<b>Department</b>	Civil Engineering
<b>Faculty</b>	Faculty of Engineering and Technology

#### Course Summary

This module introduces the basic concepts and techniques of Artificial Intelligence (AI), structural health monitoring and retrofitting. Topics covered are Expert systems, uncertainty, Neural Network, and fuzzy Logic, and their applications of AI in Construction Management. This module also provides an in depth knowledge about causes of structural failures and structural health monitoring of the structures. Students will be trained to develop Efficient and cost-effective approaches for repair, rehabilitation and retrofitting of structures. Students will be trained in forensic investigations, issue reports and provide expert testimony during depositions and trials.

#### Course Outcomes

After undergoing this module students will be able to:

- CO 1.** Explicate characteristics of AI that make it useful to real-world civil engineering problems, different causes of structural failures of buildings, bridges and other constructed facilities, sensors
- CO 2.** Discuss Artificial Neural Network (ANN), Fuzzy logic (FL) and expert systems (ES), sensors and Data acquisition systems and their applications in specialisations of civil engineering
- CO 3.** Identify suitable Sensor and SHM technique for a given structure, and AI models for applications Specialisations of civil engineering
- CO 4.** Design Efficient and cost-effective approaches for repair, rehabilitation and retrofitting of structures Conduct forensic investigations, issue reports and provide expert testimony during depositions and trials
- CO 5.** Apply concepts of ANN, FL and ES in specializations of Civil Engineering
- CO 6.** Compare and contrast different failures and recommend code standards and practices to avoid failures in the future
- CO 7.** Impute different types of loads acting on formwork and check for their stability

#### Course Contents

##### Unit 1 Artificial Intelligence:

Introduction to Artificial Intelligence (AI), branches of AI, and applications of AI to civil engineering Expert systems superiority over conventional software, components of an expert system, expert system life cycle, expert system development process, nature of expert knowledge, techniques of soliciting and encoding expert knowledge; Inference- Forward chaining, backward chaining, rule value approach.

Knowledge based approaches in engineering Expert Systems:

Fundamentals of Neural Networks: Research history, model of artificial neurons, neural networks architectures, learning methods in neural networks, single layer neural network system, Applications of Neural Networks in Structural engineering:

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 Faculty of Engineering and Technology  
 M.S. Ramaiah University of Applied Sciences  
 Bangalore-560054

*(Signature)*  
 M.S. Ramaiah University of Applied Sciences  
 Bangalore-560054

*(Signature)* Registrar  
 M.S. Ramaiah University of Applied Sciences  
 Bangalore - 560 054

Unit 2 Introduction, Fuzzy set - Membership, Operations, Properties, Fuzzy Relations; fuzzy models in Structural Engineering Application of AI in Structural Engineering  
Environmental Problems and Natural Hazards: Effect of corrosive, chemical and marine environment, pollution and carbonation problems, durability of RCC structures, damage due to earthquakes and flood, strengthening of buildings, provisions of BIS 1893 and 4326

Unit 3 Structural Health Monitoring:  
Review of Structural Modelling and Finite Element Models: Modelling for damage and collapse behaviour of structures, finite element modelling, theoretical prediction of structural failures

Unit 4 Signals, Systems and Data Acquisition Systems: Acoustic emission sensors, ultrasonic sensors, piezoceramic sensors and actuators, fibre optic sensors and laser shearography techniques, imaging techniques. Health Monitoring/Diagnostic Techniques: Vibration signature analysis

Unit 5 Building and Erecting the Formwork:  
Location of job mill, storage, equipment, form for wall footings, column footings, slab on grade and paving work, highway and airport paving, external vibration, prefabricated panel systems, giant forms, curved wall forms, erection practices, column heads, beam or girder forms, suspended forms, concrete joint construction, flying system forms; Causes of failures- case studies, finishes of exposed concrete, design deficiencies, safety factors, stripping sequence, re-shore installation, advantages of re-shoring.

Unit 6 Classification of Techniques:  
Integrated Health Monitoring Systems: Intelligent Health Monitoring Techniques, neural network classification techniques, extraction of features from measurements, and case studies

Unit 7 Information Technology for SHM:  
Information gathering, signal analysis, information storage, archival, retrieval, security; wireless communication, telemetry, real time remote monitoring, network protocols, data analysis and interpretation.

Unit 8  
Classification of techniques. Project Based Health Monitoring Techniques: Health monitoring techniques based on case studies, practical aspects of testing large bridges for structural assessment, optimal placement of sensors, structural integrity of aging multistorey buildings, condition monitoring of other types of structures.  
Case studies: Buildings- heritage buildings- high rise buildings, water tanks, bridges and other structure

#### Course Resources

##### a. Essential Reading

1. Class Notes
2. Krishnamoorthy C.S., Rajeev S., (1996) Artificial Intelligence and Expert Systems for Engineers, CRC Press, CRC Press LLC
3. Rajasekaran S. and Vijayalakshmi P. G.A., (2005) Neural Network, Fuzzy Logic, and Genetic Algorithms - Synthesis and Applications, Prentice Hall
4. Adeli H., Karim A., (2001) Construction scheduling, cost optimisation, and management, Spon Press, New York

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Bangalore-560054

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M.S. Ramiah University of Applied Sciences  
Bangalore-560058



**b. Recommended Reading**

1. Winston P.H., (1999) Artificial Intelligence, Pearson Educati
2. Lugur G. F., (2002) Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Addison – Wesley
3. Russel S. and Norvig P., (2002) Artificial Intelligence: A Modern Approach, Prentice Hall

**c. Magazines and Journals**

1. Journal of Structural Engineering. CSIR-Structural Engineering Research Centre, CSIR Campus, Chennai
2. ACI Structural Journal, ACI Structural Journal American Concrete Institute, 38800 Country Club Dr, Farmington Hills, MI48331-34349 USA

**d. Other Electronic Resources**

<http://nptel.ac.in/>

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M.S. Ramaiah University of Applied Sciences  
Bangalore-560054

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Faculty of Engineering  
M.S. Ramaiah University of Applied Sciences  
Bangalore-560054

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