SPARC
Scheme for Promotion of Academic and Research Collaboration

SHORT TERM COURSE ON

ADAPTIVE INFRASTRUCTURE SYSTEMS (BRIDGES) AND RESILIENCE IN LARGE EARTHQUAKES.

[Supported by SPARC]

DATE:
17-20 March, 2025

MODE:
In person

VENUE:
Vinod Gupta School of Management, Indian Institute of Technology, Kharagpur, 721302

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PROFILE OF THE PARTICIPANTS

The course is aimed at faculty members from engineering colleges (in the areas of civil, mechanical, aerospace, automotive engineering), research scholars engaged in research in the broad area of uncertainty quantification in structural engineering, scientists from research laboratories, and industrial practitioners (in the areas of structural engineering, aerospace and defence applications, railway and highway engineering, and automotive engineering who need to deal with uncertainties in loading and structural systems).

COURSE FEE

NIL

(However, on Campus boarding and lodging will be charged as per actuals. Expenses towards travel to be borne by participants)

INSTRUCTOR

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COURSE CONTENT

Day 1

Introduction to Adaptive Infrastructure Systems & Earthquake Resilience

Morning Session (Theory):

- Welcome and Course Overview
  - Objectives of the course
  - Importance of adaptive infrastructure and resilience
- Introduction to Adaptive Infrastructure Systems
  - Definition and key principles
  - Relevance to bridges in seismic zones
- Earthquake Hazards and Bridge Vulnerability
  - Seismic fundamentals: Earthquake mechanics and propagation
  - Bridge types and common vulnerabilities in seismic events

Afternoon Session (Case Studies and Tools):

- Case Studies of Earthquake Impact on Bridges
  - Historical examples (e.g., Kobe, Loma Prieta, Christchurch earthquakes)
  - Lessons learned and recovery challenges
- Bridge health Monitoring
  - Concepts
  - AI applications for Health Monitoring

Day 2

Structural Engineering for Earthquake Resilience

Morning Session (Theory):

- Introduction to Resilience Frameworks
  - Concepts: Robustness, redundancy, resourcefulness, and rapidity
  - Tools for resilience assessment
- Design Principles for Seismic Resilience
  - Structural dynamics and bridge response to earthquakes
  - Adaptive design strategies: Base isolators, dampers, and flexible connections
- Performance-Based Design
  - Criteria for seismic resilience and damage control
  - Performance objectives for critical infrastructure

Afternoon Session (Practical Applications):

- Retrofitting Existing Bridges
  - Techniques: Strengthening, damping, and foundation improvements
  - Cost-benefit analysis of retrofit projects
- Adaptive Systems in Action
  - Smart materials and self-healing structures
  - Real-time structural health monitoring systems

Hands-On Activity:

- Designing a seismic retrofit plan for a case study bridge using simplified modelling software.

Day 3

Systems-Level Resilience and Risk Management

Morning Session (Theory):

- Systems Approach to Infrastructure Resilience
  - Interdependencies between bridges, transportation networks, and communities
  - Role of redundancy and alternate pathways
- Risk Management and Disaster Mitigation
  - Probabilistic seismic hazard analysis (PSHA)
  - Risk communication and stakeholder engagement
- Modelling Resilience at a Systems Level
  - Use of resilience metrics and simulation tools
  - Scenario planning for seismic disruptions

Afternoon Session (Workshops):

- Innovative Technologies for Adaptive Bridges
  - Emerging trends: AI in monitoring, modular bridge designs
  - Incorporating sustainability into seismic resilience
- Emergency Preparedness and Rapid Recovery
  - Designing bridges for rapid repair or replacement
  - Case studies of successful recovery efforts

Hands-On Activity:

- Group activity to model and assess the resilience of a regional transportation network under earthquake scenarios.

Capstone Project:

- Teams design an adaptive resilience strategy for a bridge in a high-seismic-risk area, considering technical, economic, and social factors.

Day 4

Implementation Strategies and Future Directions

Morning Session (Applied Theory):

- New Seismic Zone map of India
- Generation of hazard compatible ground motion time histories.

Afternoon Session:

- Assessment of economic impact from earthquake on bridges
  - Develop travel cost estimation models
  - Computable general equitable model for estimation for indirect economic losses due to damaged bridge.
- Capstone Project Presentation and Peer Feedback

Wrap-Up:

- Certificates and Closing Remarks

ABOUT THE SPEAKERS

Satish Nagarajaiah

Satish Nagarajaiah is a professor of civil engineering and professor of mechanical engineering and material science nano-engineering at Rice University, Texas, USA. His teaching and research focus on structural dynamics, seismic isolation, adaptive structures, negative-positive stiffness structural systems, structural control/monitoring, sparse structural system identification, physics-informed/guided machine learning, and noncontact strain sensing/mapping using nanomaterials. Nagarajaiah has made pioneering contributions to the development of algorithms for nonlinear dynamic analysis of seismically isolated structures that have been implemented widely in practice—one of the first being San Francisco International Airport, recently being in the $5B Apple headquarters base-isolated building; adaptive stiffness structural systems—particularly adaptive passive negative stiffness systems for the protection of large structures & smart/adaptive passive tuned mass dampers; widely cited sparse structural system identification with physics guided/informed machine learning algorithms; non-contact optical smart strain sensing skin made of carbon nanotubes for producing strain maps—unlike any other existing technology. He has published over 400 journal and conference papers, two books, and numerous reports, which are widely cited. He is the senior editor of the international journal Mechanical Systems and Signal Processing (Elsevier), editor of the Structural Control and Health Monitoring International Journal (Wiley), and served as managing editor of the ASCE Journal of Structural Engineering. In the past two decades, he has delivered plenary and keynote lectures, distinguished lectures, and lectured in summer short courses worldwide. He is a Fellow of ASCE and a Fellow of SEI. He served on the board of governors of ASCE SEI, chaired the SEI technical activities division, was the founding chair of the SCHM committee of ASCE EMI, and served in many other capacities. He served as the president of the US panel of IASCM. He has been recognized by the US-National Science Foundation's early CAREER award, the Moissieff Award by ASCE, the Raymond Reese Research Prize by ASCE, the Takuji Kobori Prize by SCHM, and the prestigious Nathan M. Newmark Medal jointly by ASCE SEI & EMI, elected fellow of the United States National Academy of Inventors, elected Distinguished Member of ASCE, and elected member of Sigma Xi (scientific research honor society) for his outstanding contributions to science and engineering.

STG Raghukanth

STG Raghukanth is a Professor in Department of Civil Engineering, Indian Institute of Technology, Madras. His primary R&D interests are Structural Dynamics, Random vibrations, Machine learning, Steel structures, Earthquake engineering and Engineering Seismology. He has developed Empirical and Mechanistic models for simulating earthquakes and their ground motions. He is also involved in developing the seismic zone map of India based on probabilistic seismic hazard analysis.

Parama Barai

Parama Barai is Associate Professor in Finance Area of Vinod Gupta School of Management, Indian Institute of Technology, Kharagpur. Her research areas are in financial derivatives, investment management, mergers and acquisitions, corporate finance, and financial risk modeling. She has given advisory to major commodity exchanges of India regarding design of commodity contracts, market impact of government's policy interventions, and recommendations on improving liquidity.