IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	Coupled Corrosion-Fatigue of Steel Bridges: A Value-of-Information Approach Utilizing SHM data	
Project Number	**IMURA0927**	
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Research Clusters:

Research Themes:

Highlight which of the Academy's CLUSTERS this project will address? *(Please nominate JUST **one.** For more information, see www.iitbmonash.org)*		**Highlight which of the Academy's Theme(s) this project will address?** *(Feel free to nominate more than one. For more information, see www.iitbmonash.org)*	
1	*Material Science/Engineering (including Nano, Metallurgy)*	***1***	*Advanced computational engineering, simulation and manufacture*
2	*Energy, Green Chem, Chemistry, Catalysis, Reaction Eng*	2	*Infrastructure Engineering* ✓
3	*Math, CFD, Modelling, Manufacturing*	3	*Clean Energy*
4	*CSE, IT, Optimisation, Data, Sensors, Systems, Signal Processing, Control*	4	*Water*
5	*Earth Sciences and Civil Engineering (Geo, Water, Climate)* ✓	5	*Nanotechnology*
6	*Bio, Stem Cells, Bio Chem, Pharma, Food*	6	*Biotechnology and Stem Cell Research*
7	*Semi-Conductors, Optics, Photonics, Networks, Telecomm, Power Eng*	7	*Humanities and social sciences*
8	*HSS, Design, Management*	8	Design

The research problem

Highway bridges, exposed to the outside environment, are often subjected to a multitude of environmental stressors that can be both chemical or physical in nature. Among these, corrosion deterioration and fatigue have emerged as critical problems for steel bridges leading to underperformance under vehicular traffic loads and potentially reduced service life. While the nature and extent of corrosion deterioration depends on the time of exposure to water, oxygen, salts, and other corrosive agents, fatigue sets in under repeated vehicular loading often inducing cracks within steel girders. These two deterioration mechanisms when acting independently are harmful for bridge performance, and when acting in tandem can be far more detrimental. In fact, much of existing literature on this topic highlights the dramatic reduction of the anticipated fatigue life of steel bridge structures as a consequence of corrosion deterioration.

The problems of corrosion deterioration and fatigue-induced cracks on steel bridge structures are often addressed through periodic or need-based maintenance by highway agencies or transportation officials. While visual inspection constitutes an ad-hoc approach to detect bridge distress, elaborate structural health monitoring (SHM) techniques may be employed for better tracking of bridge condition and avoiding catastrophic failures leading to loss of lives and impaired bridge functionality. Since SHM instruments and data-mining efforts may be a costly affair in itself, adequate and efficient computational approaches are necessary to choose cost-effective instruments, and best utilize the measurement data to provide economical repair strategies for problem bridges. In this regard, a Value-Of-Information (VOI) approach has recently emerged that quantifies the economic merit of utilizing SHM strategies for maintenance planning of bridge to minimize the maintenance costs for structural upkeep along the design life. This project aims for a cost-effective tackling of coupled corrosion-fatigue problems in steel bridges using a VOI approach that utilizes SHM information from field measurements. Key aspects that this project will address includes the performance and reliability assessment of steel bridges under coupled corrosion-fatigue scenario and associated costs and benefits from the SHM system and data processing. The outcomes of the project aims to aid bridge owners and stakeholders for future decisions on maintenance, repair, and if necessary, rebuilding actions.

Project aims

The various aims of the project includes the following:

- A thorough understanding of the coupled corrosion and fatigue mechanisms of steel bridges
- A framework for structural reliability assessment of distressed steel highway bridges under corrosion deterioration and repeated vehicular traffic loading

- An investigation of the SHM approaches for degrading steel bridges, focusing on corrosion and fatigue deteriorations
- Development/framing of a methodology for VOI assessment considering the uncertainty of the deterioration process and choices among multiple SHM strategies
- Optimized maintenance planning along the design life based on the VOI information

Expected outcomes

- A technique for incorporating coupled corrosion-fatigue problems and state-of-the-art vehicular modeling for reliability estimation of steel bridges
- A framework for utilizing value of information (VOI) approach for decision making on the choice of SHM strategy
- An industry-ready module to aid stakeholders for maintenance planning along the bridge design life.

How will the project address the Goals of the above Themes?

Presently, across the globe, a significant percentage of bridges are undergoing deterioration due to aging and showing visible signs of distress under regular service loads. News of recent bridge collapse from within India and across other nations are a tragic testimony to the degrading infrastructure quality. This project addresses a critical problem in infrastructure engineering with respect to the management of steel bridge structures undergoing corrosion and fatigue problems. The outcomes of this project will aid decision makers decide on periodic maintenance policies and employ cost-effective SHM strategies for up-to-date tracking of bridge performance.

Capabilities and Degrees Required

Degree required: B.Tech / M.Tech in Civil Engineering

Capabilities required:

- Sound knowledge of structural engineering
- A formal course in probability and statistics
- A good background in mathematics
- Sound knowledge of and experience with scientific computing using Matlab/Python/R

Capabilities desired:

- Knowledge on structural reliability and risk assessment
- Knowledge on structural health monitoring techniques
- Experience of working using a computational cluster

Select up to **(4)** keywords from the Academy's approved keyword list **(available at http://www.iitbmonash.org/becoming-a-research-supervisor/)** relating to this project to make it easier for the students to apply.

Next Generation Infrastructure
Modelling and Simulation
Data Science, Optimisation, algorithms
Computer Simulation