IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Performance Evaluation of Corrosion Degraded RCC Structure Using Acoustic Emission and Tomography**	
Project Number	**IMURA0664(5)**	
Monash Main Supervisor (Name, Email Id, Phone) **Monash Co-supervisor(s)** (Name, Email Id, Phone)	Dr Ye Lu , ye.lu@monash.edu Dr Arash Behnia , arash.behnia@monash.edu	*Full name, Email*
Monash Head of Dept/Centre (Name,Email)	Prof. Jeff Walker, jeff.walker@monash.edu	*Full name, email*
Monash Department:	Department of Civil Engineering	
Monash ADRT (Name,Email)	Prof. Emanuele Viterbo, Emanuele.Viterbo@monash.edu	*Full name, email*
IITB Main Supervisor (Name, Email Id, Phone) **IITB Co-supervisor(s)** (Name, Email Id, Phone)	A/Prof. Sauvik Banerjee sauvik@civil.iitb.ac.in	*Full name, Email*
IITB Head of Dept (Name, Email, Phone)	Prof. K.V.Krishna Rao, kvkrao@civil.iitb.ac.in	*Full name, email*
IITB Department:	Department of Civil Engineering	

Research Academy Themes:

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. Advanced computational engineering, simulation and manufacture
2. **Infrastructure Engineering**
3. Clean Energy
4. Water
5. Nanotechnology
6. Biotechnology and Stem Cell Research
7. Humanities and Social Sciences

The research problem

Define the problem

For the last two decades, there has been an increasing awareness on the deterioration and lack of performance of civil infrastructure systems worldwide. Cases of structure malfunction as result of severe steel reinforcement corrosion has been found to rise in number. Durability of steel reinforced concrete (RC) structures, in particular corrosion of steel bar has remain as one of the most concerned problems by

engineers especially for structures exposed to extreme environmental conditions such as marine or long-term acid contact. Structures suffering from steel reinforcement corrosion may lose their functionality in an unanticipated manner depending of the degree of damage incurred, which turnout to be hampering the safety of occupants and users. The cost of repair and replacement for corroded RC structures could be costly and economic activities may be forced to defer while the work is undertaken. This is detrimental in the cases for strategic infrastructures such as road bridges, ports and harbours. A robust inspection and assessment approach should be adopted at early the stage of corrosion activity to determine trend of damage development and to allow timely solution to salvage the structures.

At present, some techniques have been used to inspect corroded RC structures, including visual inspection, radiographic and half-cell potential (HCP) method. Nevertheless, these methods have found mixed success in implementations, particularly in cases of detecting and evaluating internal or invisible corrosion damage. Usually, the location of corrosion has to be identified priory so that measurement can be performed locally to obtain reliable assessment data. In addition, there is no solid analysis methodology for the measured data to be linked to the structural performance such as mechanical behavior, residual strength and prediction of remaining service lifespan if deterioration persisted. A more reliable and cost-effective assessment method is of high demand to resolve the maintenance issues of corroded RC structures. Realizing the potential of stress wave based non-destructive evaluation (NDE) techniques, namely acoustic emission (AE) and tomography, this study is engaged to investigate characteristics of wave data acquired from these NDE techniques to identify feasible wave properties that can be analysed, quantified and interpreted for large scale corrosion monitoring and detection as well as structural performance prediction. Statistical approaches and numerical analysis with finite element modelling will be developed to process the measured AE and tomography data as input data for calculating and predicting the structural performance of corroded RC members. This includes the residual capacity after corrosion, stiffness, load-deflection behaviour and remaining service life. A risk assessment scheme for corroded RC members will be proposed based on the integrated NDE techniques by incorporating suitable statistical and numerical analysis procedures.

Project aims

Define the aims of the project

This project aims to develop an accurate, efficient, and robust performance evaluation technique for reinforced concrete structures using AE and tomography. The specific objectives of this project are to:

1. Understand the unique changes in stress waves behaviour generated from RC members with regards to different conditions of steel reinforcement corrosion
2. Obtain numerical relationships between primary/ secondary AE parameters and condition of steel reinforcement corrosion
3. Identify suitable stress wave properties for effective tomography reconstruction to image interior damage of corroded RC members
4. Identify appropriate instrumentation and signal processing scheme using AE and tomography techniques to detect, locate and evaluate steel reinforcement corrosion in concrete
5. Evaluate structural performance of corroded RC members by statistical and numerical analysis with input data obtained from AE and tomography

Expected outcomes

Highlight the expected outcomes of the project

The direct outcomes are as follows:

a) Enhance understanding on propagation of stress waves in RC members with corroded steel reinforcements.
b) Identify unique characteristics of stress waves sensitive to condition of corrosion and damage of concrete that can be utilized for assessment of corrosion by implementations of AE and tomography measurements.
c) Establish theoretical approach to evaluate structural behavior and performance of corroded RC members by means of statistical and numerical analysis with measurement data from AE and tomography techniques as input.

This study is expected to generate the followings:

a. Monitoring and detection of early stage steel reinforcement corrosion in concrete structures.

b. Quantification on the condition and severity of steel reinforcement corrosion.
c. Damage appraisal of RC structures affected by steel reinforcement corrosion as well as prediction of their structural behaviour and performance.

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

Describe how the project will address the goals of one or more of the 6 Themes listed above.

Early detection and evaluation of steel reinforcement corrosion in concrete structures is important to trigger timely repair and maintenance before safety of structure becomes an issue that endangers life and hampers socio-economic activities. Proper maintenance of concrete structures could prolong the lifespan of structures significantly, mitigating economic loss through total re-construction. Strategic use of well-developed methodologies for AE wave based NDE techniques will offer fast, robust and reliable condition assessment of corrosion. In addition, the techniques are not damaging to structures and intervention to economic activities will be minimal. For a nation such as Malaysia and India which are fast moving towards fully developed status, the outcome of this research helps enhance the countries maintenance practices in a cost-effective way for concrete infrastructures. Moreover, prolonging the life-span of concrete infrastructures also means savings in resources and reduced greenhouse gas emissions with elimination of the need to build new infrastructure.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

The student should have the capacity and capability for independent scientific research. He or she should have the knowledge of mechanics of materials, structural engineering and reinforced concrete. He or she should also have the fundamental understanding of signal processing and basic programming skills with Matlab.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

Please provide a few key words relating to this project to make it easier for the students to apply.

corrosion, reinforced concrete, condition assessment, acoustic emission, tomography