

An Indian-Australian research partnership

**Project Title:** Machine learning applications for reliability analysis and life-cycle assessment of highway bridges

**Project Number** IMURA0617

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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](http://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

Over the past several decades structural reliability evaluation of highway bridges have emerged as a powerful metric to indicate the likelihood of bridge failure under traffic loads. Reliability estimation procedures depend on a multitude of critical variables, such as bridge modelling parameters, bridge geometric parameters and traffic load models. This project involves the investigation of machine learning algorithms to develop multi-dimensional bridge reliability models. Such models will be parameterized on critical parameters affecting bridge performance and enable bridge engineers and decision makers for prompt yet precise estimation of bridge reliability without the need to run computationally complex finite element bridge models. This study will also track and quantify the contribution of individual parameter uncertainties on the output reliability uncertainty.

## Project aims

*Define the aims of the project*

To investigate classical and modern statistical learning techniques and uncertainty propagation methods to predict the confidence interval of service-load reliability estimates and life-cycle metrics for highway bridges

The primary objectives of this research includes the following:

- A thorough analysis of metamodeling techniques rooted in statistical learning for reliability assessment of structures
- Impact evaluation of different live load traffic models and parameter uncertainties on the likelihood of bridge failure under extreme load conditions
- Assessment of computation runtime reduction using metamodels for reliability analysis as opposed to naïve Monte-Carlo simulations
- Development of confidence intervals around mean reliability estimates using uncertainty propagation techniques for error analysis
- Impact assessment of parameter uncertainty on the life-cycle analysis metrics, such as accrued cost estimates and sustainability parameter

## Expected outcomes

*Highlight the expected outcomes of the project*

The expected outcomes of this project are outlined below:

- Holistic framework for reliability estimation and life-cycle assessment of highway bridge structures encompassing the uncertainties stemming from input parameters
- Optimal combination of metamodeling technique and error propagation method for best predictive estimates of the confidence intervals around mean failure probability estimates

## 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.*

Highway bridge constitute critical elements of the infrastructure system. This projects focuses on the application of machine learning algorithms to develop parameterized reliability models to quantify the reliability of highway bridges in terms of critical input parameters. Such models will reduce the computational complexity and computer runtime required in precise estimation of highway bridge reliability and also help understand the impact of input parameter uncertainty on output reliability estimates.

## 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.*

### Essential:

- A Bachelor Degree in Civil Engineering with a High Distinction or equivalent from a reputable (IIT or equivalent) institute in India or a Master Degree in Civil from a reputable institute in India.
- Relevant courses in probability and statistics.
- Demonstrable excellent oral/written communication skills in English.

- Relevant skills in programming in MATLAB or R

Desirable:

- TOEFL or IELTS scores to demonstrate English language proficiency.
- Conference/journal publications.

### **Potential Collaborators**

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

Dr. Colin Caprani

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

Machine learning, traffic load modelling, structural reliability