Railway and Road Structure Researcher

Project & Job Description

With one of the most extensive rail networks in the world (48,000 km of track), rail transportation is vital to Canada. Newer, more powerful locomotives hauling heavier freight at higher operating speeds are capable of producing twice the tractive effort of older locomotives. This has raised concerns regarding the risks associated with exceeding the load carrying capacity of in-service rail support systems (e.g. bridges and rails). There is now a growing need to investigate the longitudinal stresses that rail infrastructure is being subjected to and to evaluate the potential requirement for rehabilitation. Similar challenges face road infrastructure and one of the challenges is how to future proof new infrastructure, such as the Third Crossing, against unexpected loading. Past studies exploring structural health monitoring (SHM) techniques for rail and road infrastructure have focused on the application of discrete strain sensor technologies making it difficult to understand the full behaviour of rail infrastructure under locomotive loading. This research project will investigate the potential for using distributed and novel sensors to monitor infrastructure assets such as rail bridges and the new Third Crossing.

The current SWEP project is part of a large multi-year investigation into the use of advanced sensing technologies to assess structures. As a result, the successful candidate will have the opportunity to work with experienced researchers in this field. This SWEP project is designed to give the successful candidate the opportunity to experience what is involved in being a civil engineering researcher by joining a research team evaluating the use of sensors to improve the assessment of civil infrastructure. The candidate will work on an experimental campaign involving lab, and field based, experiments using sensors to improve structural assessments. There will be four main tasks within the project: (i) experiment design and construction, (ii) conducting a series of experiments including the use of advanced instrumentation, (iii) analysis of the experimental results and experimental modification, and (iv) results dissemination to the research team. The research will involve the use of both conventional and novel sensor technologies. The novel technologies include several dynamic fibre optic sensor systems, which are the only ones in use for civil engineering applications in Canada. The successful candidate will work under Dr. Hoult’s direct supervision but will also interact with other graduate students in Dr.
Hoult’s research group so that they can maximize their exposure to a variety of research projects.

In order to facilitate more accurate structural assessments, engineers require better information about the performance of structures. Thus projects such as this, that increase our understanding of structural behaviour, play an important role at all three levels of government. The City of Kingston and the Ministry of Transportation Ontario would both benefit from the sensing and assessment techniques that would be developed as a result of this research since in the future they would be able to existing structures in service longer and improve the design of new structures. In addition, CN Rail has been a long-time partner in this research as the techniques developed allow them the opportunity to more accurately assess their infrastructure. The research also fits within Queen’s Strategic Research Plan, namely in the areas of: (i) Environment and Sustainability and (ii) Advanced Technologies. A key step in assessing structures is to develop a better understanding of complex structural behaviour. Reducing the number of structures that have to be repaired and replaced, even by a small percentage, will have a significant benefit since 50% of industrial CO₂ is generated by the construction industry. Additionally, even a small reduction in repair and replacement costs use would represent significant savings in an industry that is worth $73.8 billion. These savings on infrastructure could then be used by governments to fund other environmental initiatives such as green energy. This research will also further the state-of-the-art in terms of the use advanced sensor technologies (e.g. fibre optic sensors and digital image correlation). These technologies will not only assist in the design of new structures but could also be used for the assessment of in-service civil infrastructure assets.

Description of Role

A research assistant (RA) is required for a 16 week project to participate in a research program designed to enhance our understanding of the assessment of structures using advanced sensor technologies. Working under Dr. Hoult’s supervision, the candidate will work as part of a research team. The project will involve designing, constructing and running a series of experiments intended to investigate how data from state-of-the-art sensor technologies can be used to assess structures. The successful candidate will help to conduct a series of experiments aimed at improving structural assessment by advancing the state of the art. The experimental campaign will take place both in the laboratory and the field. The RA will then work with the research team, led by Dr. Hoult, to analyse and model the results. Finally, the RA will disseminate these results to the research team.

The successful candidate will work mainly in the Ellis Hall Structures Lab but also
at field sites in the area including rail bridges owned by industry research partner CN. The Ellis Hall Structures Lab enables structural specimens, from scale models to full size structural elements, to be tested to destruction under controlled conditions. The successful candidate will work with members of the research team in the lab and the field to develop improved structural assessment techniques through the use of advanced sensor technologies.

The overall progress of the candidate will be supervised by Dr. Hoult. The candidate will also be supervised by graduate students who are experts in their individual field in order to give the graduate students invaluable training experience.

Required Qualifications

It is anticipated that the successful candidate will have finished their second or third year in Civil Engineering (although highly qualified candidates from a related discipline will also be considered). The successful candidate will be self-motivated and able to work independently.

This project offers a unique opportunity for a student to apply the skills they have gained as part of their core undergraduate studies to a research project. Courses that will be useful include: CIVL 231 – Solid Mechanics II and CIVL 330 – Structural Analysis, CIVL 331 – Structural Design I, CIVL 340 – Geotechnical Engineering I and CIVL 341 – Geotechnical Engineering II. Skills developed as part of this project will benefit students who are hoping to work for companies that conduct research and development, students hoping to pursue a career in academia, and students who wish to work for structural or geotechnical engineering consultancies.

Learning Plan

Skills Development

At the end of this project it is anticipated that the following skills will have been developed:

- Experimental planning
- Experimental construction and testing
- Health and Safety
- Professional skills
- Project management
- Communication
Development Opportunities

Experimental planning skills – the candidate will be given the opportunity to design experiments and then follow the process through to implementation. These skills will be developed through a combination of weekly meetings with Dr Hoult, ongoing instruction from a graduate student, and interactions with the Department’s technical staff. Dr Hoult will meet with the RA on a weekly basis to review the previous week’s activities as well as to discuss the week ahead including the ongoing experimental campaign. The RA will work directly with graduate students who will guide and instruct the RA on a day to day basis. Interactions with technical staff will also be required to arrange for the ordering of supplies and the fabrication of experimental equipment, which will give the RA an opportunity to communicate technical concepts to a variety of individuals.

Experiment construction and testing skills – the candidate will be involved in the instrumentation, construction, and running of experiments, both in the lab and in the field. Skills will be gained through hands on work conducted under the supervision of experienced researchers and technical staff. The RA will spend a minimum of 50% of their time in the Department’s laboratory facilities (in Ellis Hall). In the lab the student will work directly with a graduate student who will teach them how to fabricate specimens including how to install fibre optic sensors. The RA will also work with the graduate student and technician to setup and test several specimens including learning how to use advanced data logging equipment.

Health and Safety – one of the most important aspects of work in civil engineering is that the work is conducted safely. The candidate will be given both formal training and informal guidance about how to work safely in a civil engineering environment. Before starting work in the lab, they will take the Department’s online safety training course, CIVL 801. They will also meet with Dr Hoult to discuss the specific safety training required for their project. This training will give them an appreciation of the importance of safety and what it means to create a safety culture that they can carry with them throughout their career.

Professional skills – the candidate will work with colleagues in the Civil Engineering Department including faculty members, graduate students, and technicians to develop skills such as time management and preparation. The weekly meetings with Dr Hoult as well as other meetings throughout the project will enable the candidate to develop these skills. For example, many of these meetings will require the candidate to prepare in advance as well as to take notes during the meeting and execute a series of tasks within a specified time frame.

Project management – the candidate will be given the opportunity to undertake a set of experiments as part of the larger research project. The candidate, with the help of Dr. Hoult, will learn how to budget both time and money to ensure a successful outcome. At
the beginning of the project, Dr Hoult will lay out clear steps and deadlines that need to be accomplished during the week. As the project progresses the candidate will be given more ownership of the project to the point where, towards the end of the project, the candidate will use the weekly meetings to update Dr Hoult on their progress.

Communication – both oral and written communication skills will be developed over the course of the summer. The candidate will not only interact with Dr Hoult but also other members of Dr Hoult’s research team, other graduate students, and the technical staff. The candidate will be asked to attend the weekly structures group meeting where they will present their research and research needs to the other researchers in the structures group. In addition, the deliverables for this project will include a comprehensive data set to be used for ongoing analysis, a final handover document of the type that would be requested by a client as well as the potential for conference and/or journal publications should the research prove successful.

Unique Opportunities

As a result of several recent investments from the Canada Foundation for Innovation (CFI), the Natural Sciences and Engineering Research Council, and Transport Canada, the Civil Engineering Department has lab facilities and equipment that are unique amongst civil engineering departments in Canada, and in many cases the world. The fibre optic strain measurement systems used by Dr Hoult’s research group are exciting new tools for understanding structural behaviour that will provide the candidate with a skill set not available to students outside of Queen’s. Dr Hoult’s collaborations with industry and government also mean that the successful candidate will be given the opportunity to interact with engineers and technical staff from a variety of backgrounds who have a wealth of experience. This will not only allow the successful candidate to gain exposure to a number of potential career paths but also develop a network of contacts. In addition, the Department is among the top, if not the top, civil engineering research group in Canada and so the candidate will have the opportunity to interact with a number of researchers undertaking cutting edge research.