WESTERN SYDNEY
UNIVERSITY

School of Engineering, Design and Built Environment

Summer Scholarship Research Program 2021

Project Lists

Project 34: Innovations for Recycled Concrete

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Second Supervisor

Project Description

Concrete is a widely used material in construction as it has reliable and strong characteristics for building. However, concrete must be made more environmentally friendly to conserve planet earth. The cement in concrete alone produces 5-7% of the planets annual CO2 emissions. Concrete also consumes large amounts of natural resources including aggregate from quarries with a worldwide production of aggregate reaching 40 billion tonnes in 2014. In Australia nearly 40% of landfill space is taken by masonry waste, which can be used to replace virgin aggregate with recycled aggregate.

Unfortunately, the use of recycled aggregate/material in concrete exhibits poor characteristics. The complete replacement of virgin aggregate with recycled aggregate in concrete reduces the compressive strength by 30%.

This research intends to test methods to increase the strength of recycled concrete with supplementary strengthening measures and admixtures. A solution that has been studied over recent years and can be improved with more laboratory experimentation is known as CO2 Concrete. The process involves injecting recycled aggregate with CO2. The injection of CO2 into recycled aggregate densifies the recycled material by converting calcium hydroxide in calcium carbonate. The chemical reaction also permanently removes the involved CO2.

Recently waste glass has also become an issue in Australia due to international events. Glass can be recycled into concrete as a fine aggregate or cement. However, the addition of glass is known to accelerate the alkali-silica reaction which must be mitigated by the addition of admixture chemicals or mineral admixtures. The accelerated alkali-silica reaction can be mitigated with the employment of the correct proportions of supplementary cementitious materials. Glass can also be crushed to different sizes with varying desirable reactions.

The project will involve the casting of concrete with recycled materials to create a sustainable concrete. This can include replacement of course aggregate, fine aggregate or cement. Typically, when replacing virgin materials with recycled materials quality is lowered. Consequently, methods for improving the recycled material for use in concrete will be investigated. Concrete will then be tested with recycled materials. Tests can include compressive and flexural testing.

Project Aims

1. Analysis recycled material as aggregate and test improvement mechanisms.

   The injection of CO2 into aggregate has been studied. However, this concept can be taken further. Other powdered chemical can be added to aggregate to increase the density and reduce air pockets in aggregate further than injection of CO2 alone.

Recycled glass can also be added. This mitigation of alkali-silica reaction has been studied but researching different particle sizes and additional mineral admixtures would further current research. After treatment both of these methods will be teste with Australian standard tests including particle density and crushing value.

2. Test recycled materials in Concrete

   After materials are tested as aggregate, they must be mixed into concrete to ensure the reaction between the new aggregate and cement is not detrimental. This will include two key aggregate tests as per Australian standards, compressive strength and flexural strength. Laboratory concrete mixes will also be completed within Australian standard.

Project Methods

Australian Standard Techniques will be utilised including for aggregate testing:

- AS 1141.6.1, Methods for sampling and testing aggregates - particle density and water absorption of coarse aggregate - weighing-in-water method
- AS 1141.21, Methods for sampling and testing aggregates - aggregate crushing value

Australian Standard Techniques will be utilised including for concrete testing:

- AS 1012.2, Methods of testing concrete - determination of concrete mixes in the laboratory.
- AS 1012.9, Methods of testing concrete - determination of the compressive strength of concrete specimens.
- AS 1012.11, Methods of testing concrete - determination of modulus of rupture of concrete cylinders.

Opportunity for Skill Development

Student will get hands on experience in the concrete lab. This will allow for the learning of relevant Australian standards in the casting of concrete. This is valuable for understanding the material and experience can be used in real life concrete work. Student will also get experience in research both hands on in the lab but also in aspects such as academic writing and an introduction to the research world. Students will learn research skills that can possibly lead to HDR studies if they wished.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Students in any stage of Bachelor of Engineering and Bachelor of Construction Management are suitable for this project.

Project 35: Design and Construction of Storage Tanks for Liquefied Natural Gas (LNG)

Supervisor(s): Helen Wu - Helen.Wu@westernsydney.edu.au
Principal Supervisor

Project Description

Worldwide, the use of natural gas as a primary energy source will remain vital for decades to come. Owing to the low level of impurities, natural gas is considered to be a climate-friendly fossil fuel because of the low CO2 emissions, but is at the same time an affordable source of energy. In order to enable transport over long distances and oceans, the gas is liquefied, which is accompanied by a considerable reduction in volume, and then transported by ship. Thus, at international ports, many LNG storage tanks are required for temporary storage and further use. The trend towards smaller liquefaction and regasification plants with associated storage tanks for marine fuel applications has attracted new players in this market who often do not yet have the necessary experience and technical expertise. The research on LNG storage tanks is very limited in dynamic design and construction of the tanks.

Student will study and understand an overview of the state of the art in the design and construction of liquefied natural gas (LNG) tanks, e.g. requirements and design for operating conditions, thermal design, dynamic design, hydrostatic and pneumatic tests, soil surveys and permissible settlement, modelling of and calculations for the structure, and the actions due to fire, explosion and impact.

Project Aims

The project aim is to design of storage tanks for Liquefied Natural Gas (LNG).

- Literature review
- Concept design of LNG tanks
- Data analysis and calculations
- Detailed design of LNG tanks

Project Methods

Numerical analysis and computer simulation will be conducted in this research.

Opportunity for Skill Development

Students will develop research skills refer to the ability to search for, locate, extract, organise, evaluate and present important information that is relevant to the topic.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Students should be enrolled in a degree at the School of Engineering, Design and Built Environment.

Project 36: Design for Additive Manufacturing and its Application in Metals

Supervisor(s): Richard Yang - R.Yang@westernsydney.edu.au
Principal Supervisor

Leo Zhang - Leo.Zhang@westernsydney.edu.au
Second Supervisor

Project Description

Additive manufacturing (AM) is a novel manufacturing technology due to its nature of sustainability and becoming more and more popular recently. Additive manufacturing is a category of fabrication techniques that synthesise objects using CAD models as three-dimensional blueprints. As a new advanced manufacturing technology, further researches are urgently needed to explore new design philosophy and principles on Design for Additive Manufacturing to get expected higly quality AM materials and products. Currently stainless steel is one of the most popular 3D printing material for AM and will be research material in this proposed project.

Project Aims

In this project it aims to further investigate the new design philosophy and principles on Design for Additive Manufacturing and apply these new principles to manufacture high-quality product using stainless steels.

Project Methods

In this project, the research will be conducted theoretically and experimentally. In the theoretical analysis, the fundamental analysis of stainless steels will be conducted by using the MSC Simufact software to get the comprehensive understanding on AM for a typical mechanical parts and then based on the results, the Design for AM will be implemented to obtain a high quality product using AM. In the experimental work, the mechanical part will be printed out and tested for validation at the end of the project.

Opportunity for Skill Development

- Problem-solving and critical thinking skills: This project will develop student's ability to define problems clearly, develop testable hypothesis, find the appropriate solutions to problems.
- Hands-on skills: This project will enhance student's hands-on ability to work on AM printer available at Advanced Manufacturing Precinct at Penrith campus.
- Computer-aided engineering skills: Student will learn to use finite element analysis software. The student will use the finite element method to solve problems while understanding the fundamentals and theory of finite element analysis and design optimisation.
- Communication skills: student will improve this skill through the meeting with supervisors. Students will present information in a clear and organised manner. Write the report in a scientifically appropriate style.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

No specific prerequisites.

Project 37: Additive Manufacturing of Nanocomposites

Supervisor(s): Richard Yang - R.Yang@westernsydney.edu.au
Principal Supervisor

Leo Zhang - Leo.Zhang@westernsydney.edu.au
Second Supervisor

Project Description

Additive manufacturing (AM) is a novel manufacturing technology due to its nature of sustainability and becoming more and more popular recently. Additive manufacturing is a category of fabrication techniques that synthesise objects using CAD models as three-dimensional blueprints. As a new advanced manufacturing technology, further researches are urgently needed to get expected mechanical properties of 3D printed materials. Currently nano composites is one of the most popular 3D printing material for AM and will be research material in this proposed project.

Project Aims

In this project it aims to further investigate the mechanical properties of 3D printed nano-composites materials to manufacture high-quality material for engineering application.

Project Methods

Fundamental analysis of 3D printed nano-composites materials will be conducted by using the MSC Digimat Software in a multiscale modelling sense to get the comprehensive understanding on AM of 3D printed nano-composites materials. In the experimental work, the nano-composite material will be printed out and tested for validation at the end of the project.

Opportunity for Skill Development

- Problem-solving and critical thinking skills: This project will develop student's ability to define problems clearly, develop testable hypothesis, find the appropriate solutions to problems.
- Hands-on skills: This project will enhance student's hands-on ability to work on AM printer available at Advanced Manufacturing Precinct at Penrith campus.
- Computer-aided engineering skills: Student will learn to use finite element analysis software. The student will use the finite element method to solve problems while understanding the fundamentals and theory of finite element analysis and design optimisation.
- Communication skills: student will improve this skill through the meeting with supervisors. Students will present information in a clear and organised manner. Write the report in a scientifically appropriate style.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

No specific prerequisites.

Project 38: Optimal Design of Additively-manufactured Porous Materials for Biomedical Engineering

Supervisor(s): Richard Yang - R.Yang@westernsydney.edu.au
Principal Supervisor

Leo Zhang - Leo.Zhang@westernsydney.edu.au
Second Supervisor

Project Description

Additive manufacturing (AM) is a novel manufacturing technology due to its nature of sustainability and becoming more and more popular recently. Additive manufacturing is a category of fabrication techniques that synthesise objects using CAD models as three-dimensional blueprints. As a new advanced manufacturing technology, further researches are urgently needed to explore new design philosophy and principles on optimal design of Additively Manufactured porous materials for biomedical applications. Additively manufactured materials are naturally porous materials which can be widely applied to biomedical and medicine areas. Titanium will be the research material in this proposed project considering its wide application for biomedical engineering.

Project Aims

In this project it aims to further investigate the new design philosophy and principles on optimal design of additively manufactured porous materials and apply these new principles to manufacture high-quality product using titanium alloys for biomedical applications.

Project Methods

In this project, the research will be conducted theoretically and experimentally. In the theoretical analysis, the fundamental analysis of titanium alloys will be conducted by using the MSC Simufact software to get the comprehensive understanding on AM for a typical mechanical parts and then based on the results, the optimal design of additively-manufactured porous materials will be implemented to obtain a high quality product by using AM. In the experimental work, the mechanical part will be printed out and tested for validation at the end of the project.

Opportunity for Skill Development

- Problem-solving and critical thinking skills: This project will develop student's ability to define problems clearly, develop testable hypothesis, find the appropriate solutions to problems.
- Hands-on skills: This project will enhance student's hands-on ability to work on AM printer available at Advanced Manufacturing Precinct at Penrith campus.
- Computer-aided engineering skills: Student will learn to use finite element analysis software. The student will use the finite element method to solve problems while understanding the fundamentals and theory of finite element analysis and design optimisation.
- Communication skills: student will improve this skill through the meeting with supervisors. Students will present information in a clear and organised manner. Write the report in a scientifically appropriate style.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

No specific prerequisites.

Project 39: Lean and Digital transformation in Australian Construction Industry

Supervisor(s): Wenchi Shou - w.shou@westernsydney.edu.au
Principal Supervisor

Jun Wang - Jun.Wang@westernsydney.edu.au
Second Supervisor

Project Description

A significant number of literatures have concentrated on lean construction and digitalisation application in construction projects for improving productivity. Globally, countries such as the UK, USA, Singapore, South Korea, Denmark and Finland are considered pioneers in applying lean concepts and digital technologies into the discipline of construction project management. Both Lean Construction and digital technologies have also been embraced by Australian construction companies but to a lesser extent and currently, a systematic analysis on Lean Construction and digitalisation practices within the context of the Australian Construction industry is limited. Hence, this research will attempt to examine, to what extent, has Lean Construction methodology and relevant digital technologies been applied and implemented in the context of the Australian construction industry and aims to answer the following questions:

- Question 1: What is the current status of Lean Construction research in Australia?
- Question 2: What are the emerging trends in digitalisation practices?

Project Aims

This research aims to understand the current state of Lean Construction and digitalisation application in Australian construction industry. In order to achieve this aim, the below objectives must be satisfied:

- Objective 1: To analyse the factors limiting the application of Lean Construction methodology and digital technologies in Australian construction industry and strategies to remove such limitations
- Objective 2: To identify the opportunities for enhancing Australia's construction productivity with the integration of lean and digital technologies such as internet of things, and 4D Building Information Modelling.

Project Methods

The methods of Focus Group Study is selected for understanding the existing lean and digital practices in Australia. Focus group is a controlled group discussion on specific topics in a defined environment. It is particularly useful to obtain results from the interactive group discussion rather than from individuals. Leung, Yu, and Chan (2013) summarised that the number of interviewees that need to be involved in a focus group, which can vary from two, three, four to six (mini-group), seven to ten (small), to eleven-twenty (super-group).

Focus group allows interviewees to examine and challenge the views to avoid the negative impact of individual bias. The pros and cons of lean construction and digitalisation application in Australia and the identification of the opportunities for enhancing construction productivity by integrating both concepts and tools will be discussed in three focus group studies.

Opportunity for Skill Development

- Evaluate previous research, its relevance to the topic given and where the given topic builds onto the previous research;
- Recognise potential valuable research outcomes to the particular field and to the realm of Construction Management;
- An ability to undertake self-motivated research.

Students are required to have the following skills/meet the following pre-requisite(s) to apply

Students must be enrolled in Bachelor of Construction Management (Honours).