



## **Engineering and Built Environment Project Conference 2014**

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22-26 September 2014



**Book of Abstracts**  
**Final Year Student Research Project Presentations**

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## **Heads of Schools Welcome**

*A very warm welcome to the University of Southern Queensland, Toowoomba Campus for the 2014 Engineering and Built Environment Project Conference.*

The annual Project Conference held on campus in Toowoomba forms the culminating point of your studies in engineering, spatial science and construction. Engineers Australia and other professional bodies have highly praised the Conference for being cross disciplinary and for the quality of your research presentations.

An important dimension of this Project Conference is the interaction that it generates between our graduating students and students who are within the penultimate stage of their studies. The interactions help provide those students with a sense of what will be expected of them in their final year.

This year we also welcome an Engineers Australia (EA) Accreditation Panel who will be conducting a five yearly review of our academic programs. Some of you may be invited to provide feedback to the panel on your experiences whilst studying at USQ and so we thank you for your efforts in participating in this important review.

The Conference is also an opportunity for you to showcase your skills, knowledge and achievements, and to interact with and learn from your peers. Please make the most of this week – share your knowledge and experiences with your colleagues, network with staff and other students and take the time to reflect on how far you have come in your learning journey and career.

Finally, we would like to acknowledge the efforts of the many academic and professional staff that have been instrumental in making this Project Conference a success. In particular, we would like to thank Dr Alexander Kist and Ms Carolyn Saffron for their outstanding work in organising the project conference and activities. We also recognise the efforts of the project examiners, Mr Chris Snook and Associate Professor Karu Karunasena, and your project supervisors in providing guidance during your project year.

On behalf of all the academic and professional staff we wish you an enjoyable and rewarding Project Conference.



***Professor Kevin McDougall***  
Head, School of Civil Engineering  
and Surveying



***Associate Professor Tony Ahfock***  
Head, School of Mechanical  
and Electrical Engineering

## Examiner's Welcome



On behalf of the course examiners, I would like to welcome you to the Engineering and Built Environment Conference 2014.

The Project Conference, inaugurated in 1998, is being attended by all penultimate and final year engineering and surveying students. This year there are more than 500 students attending at this multi-disciplinary conference.

These proceedings include extended abstracts of the verbal presentations that are delivered at the project conference. The work reported at the conference is the research undertaken by students in meeting the requirements of courses *ENG4111/ENG4112 Research Project* for undergraduate or *ENG8411/ENG8412 Research Project and Dissertation* for postgraduate students. The research is generally pursued over the full final year and will be nearing completion at the time of the conference.

The event also permits penultimate year students, who will undertake their research project in the following year, to experience the technical conference environment, gain appreciation of the standard and breadth of projects that may be pursued, and the presentation standards that will be expected of them.

As for any major event, success requires the effort of many individuals. I would like to thank the Assistant Examiners Dr Ian Brodie, Mr Andreas Helwig, Dr Ray Malpress and Mr Shane Simmons for their contributions. Academics chairing sessions and critiquing the presentations also play an important role and we thank them for taking time out of their busy schedules to assist with these tasks.

A special thanks to the professional support teams led by Ms Carolyn Saffron and Mr Terry Byrne. Without their help we would not be able to run this event. Last but not least we would also like to thank all attendees for discussing their work, engaging with their peers and providing valuable feedback during the presentations.

We hope you enjoy this opportunity to share ideas and discuss your work with your peers and faculty staff.

***Dr Alexander A. Kist***  
Examiner ENG3902 & ENG4903  
Toowoomba, September 2014

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# Electric water stunner for poultry

Sponsor – School of Mechanical and Electrical Engineering



**Salem Alakbari**

Bachelor of Engineering  
(Electrical & Electronic)

Supervisors: Dr Leslie Bowtell, USQ

**Keywords:** electric stunner, poultry welfare, single water bath, and multiple water baths

## 1. Introduction

This project is about the optional of electric water bath stunners. Electric water bath stunners are used commercially in developed countries like US, Australia, UK and other countries of the European Union. This project is focused on the stunning's of poultry only since it is also used stunning of there mammals.

In a typical electric water bath stunner, poultry including hens, ducks and turkeys are shackled in the position inverted and they are then dipped into a stunner. Current flows through the bird's legs through its body shackles to the electrode at the bottom of the water bath. Current received by birds vary because bird body impedances variations, shackle to leg impedance, depth of head immersion and entry position in bath.

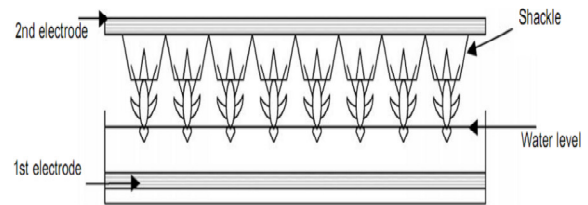
## 2. Background

The basic purpose of electric water stunner is to improve the welfare of the poultry. The aims of this project are based on following two facts commercial stunners are not perfectly efficiently. Constant current stunners are better in stunning compared to constant voltage stunners. Which can stun each bird equally for better welfare of the birds.

## 3. Methodology

This project aims to develop a constant current electric water bath stunner, which allows constant current to flow through each individual bird in the water bath. In order to evaluate the currents viewed by each bird as affect travel through the bath, a model was developed.

Following is the keeps the current flow through each bird.



**Figure: Electric water bath with bird hanging**

The birds hang inverted which it is passed through water bath. Head of the bird are supposed to be submerged in order to complete the electrical circuit path. There are two electrodes between which bird acts a resistor and current passes from one electrode to another.

## 4. Key Outcomes

Key outcome of this project is that all the future commercial electric water bath stunners will be constant current stunners in which constant current will flow through each bird for better welfare of the birds.

## 5. Further Work

Further work will be related to the improved of the constant current stunner by using active methods of constant current instead of passive method of voltage divider.

## 6. Conclusions

There are flaws in the commercial electric water bath stunner since they use constant voltage method. This is not very effective method of stunning so therefore this project is based on the development of constant current electric water bath stunner.

## 7. Acknowledgements

A great acknowledgement is to be expressed to Dr. Les Bowtell, my project supervisor. He was very cooperative with me providing all the information that helps me completing this assignment. Also, special thanks to my family.

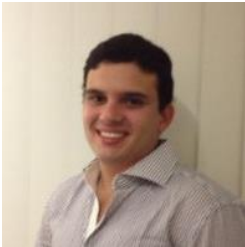
## References:

[1] Humane slaughter Association (unknown)  
Electrical water baths

[2] liveshock processing establishments (2005)  
industry animal welfare standards.

# Improving Design and Documentation Quality Using Lean and Agile Methodologies

Sponsor - School of Civil Engineering and Surveying, USQ



**Alejandro J.**

**Aldana S.**

Master of Engineering

Science

Major Civil Engineering

Supervisors: Mr Paul Tilley, USQ

**Keywords:** Design Management, Lean, Agile, Design Process, Documentation Quality.

## 1. Introduction

The main focus of this research will be investigate the application of Lean Design Management and Agile Project Management as a combined force to improve the design management and documentation quality in the construction industry.

Value generation, smooth and reliable flow of activities, team collaboration (including clients), continuing improvement and waste reduction are the key factors in Lean concepts to improve productivity in the design process. Agile Project Management has the same Lean characteristics; however, Agile differs from Lean in its capacity to adapt to changes rather than following a full schedule plan.

## 2. Background

Design process is an iterative complex system which involves the interaction of different disciplines and skills. It has been found that non-value activities, inefficient processes and waste come in high levels from the design stage. Different research was conducted to find alternative methods to improve the design process and address these problems.

## 3. Methodology

The methodology used to accomplish the research targets include: review of research papers and international case studies papers; conference procedures analysis; and surveys. The survey process is divided in two according to the target audience.

The first survey audience is the general construction and design industry; while the second survey audience are experts in the topic. The latter survey is a modification of the Delphi Methodology, which differs from the typical one by its lack of the iterative process.

Finally, all the data is analysed to determine patterns that affect (positive or negative) the design process and its impact and interaction with Lean and Agile concepts.

## 4. Key Outcomes

This research seeks to provide an interaction description between the Lean and Agile methodologies to improve the design process. In addition, it will describe the most important barriers to the implementation of the two methodologies and create a framework for design process and documentation quality.

At the moment, the review of varied literature has identified the following factors that significantly affect and define the application of Lean and Agile methodologies and the improvement for design process and documentation quality.

- Cultural Organisation
- Requirements capture
- Communication flow
- Adaptability

## 5. Further Work

Further work in the project will be the survey execution and analysis for factors identification, correlation and impact within the design process and Lean and Agile methodologies. Additionally, based on further review of new academic papers and the survey analysis results, a framework for the design work flow management will be defined and modified.

## 6. Conclusions

Lean and Agile Principles/Methodologies are applicable and beneficial for the construction design stage. The combination and interaction between the two concepts allow for better cooperation between the project participants and a clear understanding of the total design process. Additionally, it will increase the value generation for the client, reduce waste and improve documentation quality.

## Acknowledgements

Firstly, I would like to express my gratitude to my supervisor, Mr Paul Tilley, for his support, advice and knowledge provided during the research execution and design. Additionally, I would like to acknowledge all who participate in the two surveys.

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# Design of an Experiment to Study the Tensile Strength of [ZnO] Nanocomposite

## School of Mechanical and Electrical Engineering

**Abdulhadi Aldosari**



Bachelor of Engineering

Supervisors: Prof. Sami S. Habib, KFUPM

**Keywords:** research, preparation and tests.

### 1. Introduction

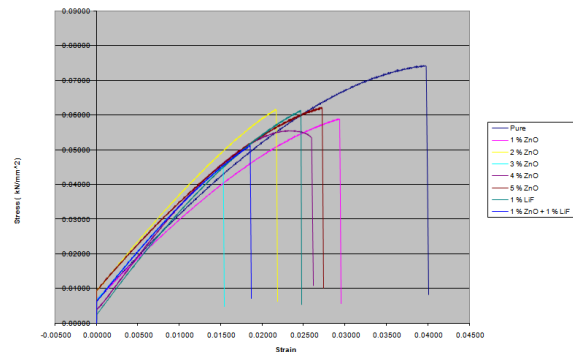
In this project, the effects of nanomaterials on the mechanical properties (Tensile Strength) of matrix materials are studied. Nanomaterials are nano-scale structures manufactured specifically to take certain nanoshapes. Some of them are wire-like, tube-like, and particle-like structures. In our project Zinc Oxide (ZnO) nanoparticles, lithium Fluoride (LiF) nanorods, and Carbon nanotubes (CNT's) are studied. Their addition to the matrix material encompassing them, which is epoxy and hardener, affects the mechanical properties of the matrix material generating new mechanical properties of the resulting nanocomposite materials.

### 2. Background

The materials used in building the aircrafts body and parts are of maximal importance. These materials should fit in their use of having maximum values of desired properties such as resistance to corrosion, high values of tensile strength or compressive strength, and lightweight structures. The modern technologies are used to find new materials in the form of nanocomposites to reach the high standards of properties desired by aircraft manufacturers. In our project new materials are studied in order to obtain nanocomposites that withstand extreme circumstances of different flight conditions.

### 3. Methodology

The project plan was divided to five major tasks. The first task is for purchasing the required materials, mold, aluminum foil, and beakers. The second task is the preparation of nanomaterials that include ZnO



nanoparticles, LiF nanorods, and carbon nanotubes. The third task for accomplishing the project is the preparation of the nanocomposite specimens. The fourth and fifth tasks are performing the tensile test and writing the report, respectively.

### 4. Key Outcomes

To perform the tensile testing, specimens must be prepared in order to get results. Those specimens contain the matrix material which is epoxy and a hardener. Epoxy and hardener alone are called a pure specimen. Other nanomaterials will be added to examine their contribution to the matrix material. The mechanical properties will change by this addition and stress-vs-strain curves will be generated.

### 5. Further Work

No further work required..

### 6. Conclusions

After performing the tensile tests on different specimens, we concluded that stress values, strain values, and young's modulus values in this experiment did not exhibit a uniform pattern. Researcher that may follow a precise and careful preparation of specimens to eliminate imperfections as possible to produce very fine specimens that take almost perfect shapes

### Acknowledgements

Would like to thank my supervisor Prof. Sami S. Habib. Who helped and gave me knowledge and motivation.

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# Cognitive Radio based on Software Defined Radio



**Irfaan Ali**

Bachelor of Engineering  
(Electrical and Electronic)

*operating parameters including, but not limited to, frequency range, modulation type, or output power to be set or altered by software, excluding changes to operating parameters which occur during the normal preinstalled and predetermined operation of a radio according to a system specification or standard.”*

(ITU-R SM.2152)

Supervisors: A/Prof Wei Xiang, USQ

**Keywords:** Cognitive Radio, Software Defined Radio, MATLAB®.

## 1. Introduction

As the demand for frequencies and bandwidth requirements increases along with the further developments in wireless technologies, careful planning and management of the RF spectrum is vital. The radio spectrum is a limited resource and it is this realisation that has instigated much research, development and effort into investigating *Dynamic Spectrum Access (DSA)* or *Cognitive Radio (CR)* technologies to define the future of wireless communications.

## 2. Background

Cognitive Radio systems have been identified as a solution to RF spectrum saturation, enabling dynamic reuse of already licenced and underutilised channels.

**Cognitive Radio System (CRS or CR)**, is defined by the International Telecommunication Union (ITU) as,

*“A radio system employing technology that allows the system to obtain knowledge of its operational and geographical environment, established policies and its internal state; to dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge in order to achieve predefined objectives; and to learn from the results obtained.”*

(ITU-R SM.2152)

**Software Defined Radios (SDR)** is defined as,

*“A radio transmitter and/or receiver employing a technology that allows the RF*

## 3. Methodology

The combination of a laptop computer with MATLAB®, a digital USB TV device and a Raspberry Pi computer is aimed at developing a CR solution.

## 4. Key Outcomes

This study aims at developing a cost effective test-bed for future cognitive radio research based on SDR technology. It aims to report on the methodologies, findings and results, and any recommendations.

## 5. Further Work

Tasks remaining in the project include further research and development of the transmitter algorithms for the Raspberry Pi platform.

## 6. Conclusions

The concept is important for future developments in the area of CR technologies. Some aspects of getting the MATLAB® program to function were challenging. The USB TV device was successively implemented as a FM receiver and spectrum analyser at the same time.

The idea is gaining more interest recently, with Telstra and Ericsson working together in developing ‘Software Defined Networking’.

## Acknowledgements

This research was carried out under the principle supervision of Associate Professor Wei Xiang.

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## Flexural Properties of sisal /Epoxy Composites

Sponsor – School of Mechanical and Electrical Engineering



Rafi Ali Alqahtani .

Bachelor of  
Engineering  
(Mechanical)

Supervisors: Dr Belal Yousif .

Keywords: sisal fiber ; Epoxy  
Composites ; Flexural Properties

**1. Introduction** Natural fibres received more attention to be used in composite structure in recent years. The natural fibres composites can be used in automobile and construction industry due to their relatively high specific strength/modulus.

**2. Background** Natural fibres are acquired from the nature, so it is a renewable source for new composite materials, and very important to study the natural fiber composite's properties and applications

**3. Methodology** The sisal fibre will be washed and dried at ambient temperature for several hours firstly, then treated with NaOH to modify its surface property. After treatment, the sisal fibre will be mixed together with epoxy resin in a mould for curing to acquire the sisal /Epoxy composite. After finished, the composite will be cut into specimens with size of 80mm \* 10mm \* 4mm, and testing their flexural properties.

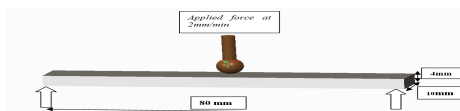


Fig. Dimensions of the flexural samples

**4.Key Outcomes** The main goal of this study is to study and understand the flexural behaviour of polymer composites based on sisal fibres and evaluate the flexural properties of the developed composites then study the fracture behaviour of the samples after the test.

**5. Further Work** How to develop sisal /epoxy composite and design experiments according to standards, and analyses the morphologic structure of composites.

**6. Conclusions** The natural fibres are Eco friendly plus high particular characteristics and are utilized in numerous manners to replace artificial fibres. At last, this field requires a lot of work to be done in order to produce improved quality natural fibre polymer composites.

**7. Acknowledgements** This research was carried out under the principal supervision of Dr. Belal Yousif . I thank him for his supervision, advice, expertise that has helped me from the very early stages of this project. Appreciation is also due to my sponsor Saudi Arabia Culture Mission

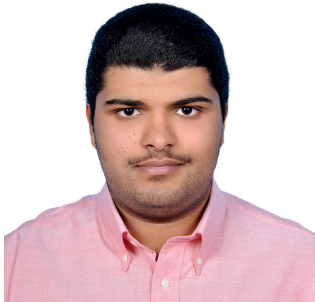
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# A Study on Fire Resistance of Fibre Composites Based on Natural Fibres.

Sponsor – School of Civil Engineering and Surveying- USQ

Student Name: Fahad AlRabiah

Degree : Bachelor of Engineering (Civil).



Supervisors: Dr Belal Yousif, USQ

**Keywords:** Natural Fibre Composites, Fire Resistance, Synthetic Fibre .

## 1. Introduction

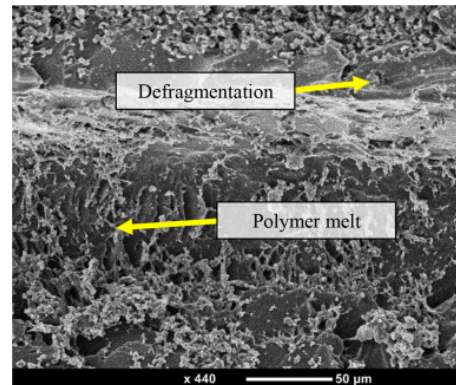
In the present world demand Fibre Reinforced Polymer composites FRP are the main icon to solve the problem of unrecyclable building materials and waste due to the emerging concept of green-building, as they are fully degradable. Moreover FRP are cheap to produce and is available via renewable resources. However, this icon imposes a great drawback on it's durability.

## 2. Background

As part of the demand of improving the properties of FRP, this research study is investigating the fire resistance of epoxy composites based on natural and synthetic fibre mostly concentrated on non-load bearing indoor components due to their vulnerability to environmental attack. The research focus on the influence of heat exposure duration on the mechanical strength of the materials to achieve the maximum goals of using it, and give it a chance to be used in wider applications to be substituted by the unrecyclable materials.

## 3. Methodology

Developing a sample for fracture testing, the samples are epoxy composite with glass fibres and the second set of samples will be epoxy composites with bamboo fibre. After that, prepare the fibre samples by treating them with 6% NaOH. Conducting the fire tests and analysis the results. Try to optimize the performance of the materials.



SEM of epoxy at 200 ° C.

## 3. Key Outcomes

Preparing the epoxy composites with bamboo fibre samples to be tested is already finalized in the USQ facilities. Initial experiment work is been done and the outcome where in accordance with the expectance of the research.

## 4. Further Work

With the time allowance, complete the main experiment. May create more samples with different treatment and add some natural enhancements to try to maximize the thermal resistance.

## 5. Conclusions

The main conclusion is that the FRP have a certain fire resistance that can be used in some reinforced structure but it have to be optimized to be involved in more applications. This field of research lack the studies of the fire behaviour inflowing the FRP.

## Acknowledgements

I would thank my supervisor Dr.Belal Yousef for his helpful feedbacks, assistance and his outstanding communication. I would like to thank my wife for her motivation and encouragement. Not to forget Mr.Mohan in the lab facilities and Ms. Sandra in the library.

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Z.N. Azwa, , B.F. Yousif, Polymer Degradation and Stability Volume 98, Issue 12, December 2013, Pages 2752–2759



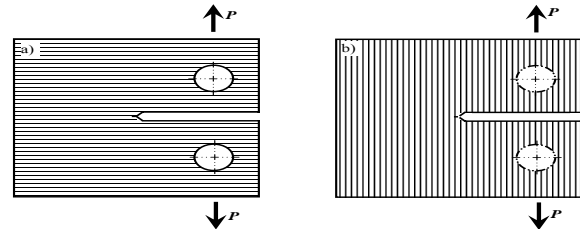
# Fracture Behaviour of Fibre/Polymer Composites Based on Synthetic and Natural Fibres

Sponsor – School of Mechanical and Electrical Engineering



**Rashed Altamar**

Bachelor of Engineering  
(Mechanical)



**Figure 1 - Sample Diagram**

Supervisors: Dr Belal Yousif, USQ Mr

**Keywords:** fracture behaviour, fibre reinforce polymer, bamboo fibre

## 1. Introduction

In this project, fracture toughness and energy associated with crack propagation behaviour of chemically treated bamboo fibres reinforced epoxy composite was studied according to ASTM 5045 standard. Fracture toughness records for both treated and untreated bamboo fibres-epoxy composite exhibited better results compared to the neat epoxy.

## 2. Background

In recent years, Engineers are being challenged to “go green” in many aspects of the engineering area including innovation of biodegradable and recyclable materials. Natural fibres considered as great recyclable materials to replace synthetic fibres in their applications and they gained high attention in the industry, lately a lot of researches have been conducted to study the mechanical properties of natural fibres and determine their ability. This project is going to study and compare the fracture behaviour of natural fibre (bamboo) with glass fibre to expand the knowledge related to natural fibres and their performance.

## 3. Methodology

Developing the samples for fracture testing, the samples will be epoxy composite with glass fibres and the second will be epoxy composites with bamboo fibre. After that both of the samples has been treated with 6% NaOH. Machining the sample by developing an initial crack, to conduct the fracture tests and

analysis the results by obtaining the energy required for the failure.

## 4. Key Outcomes

Preparing the bamboo reinforced epoxy, and glass fibre samples have been completed in the USQ lap facility. Also developing the crack on the samples as in (figure1) has been finished to study the fracture behaviour of the composites.

## 5. Further Work

Depending on the time, Scanning electron microscopy may be conducted for further study and evidences to the results. Also Abacus modelling can be established for verification and further understanding of the fracture behaviour of the composites.

## 6. Conclusions

Conclusions are expected to indicate that bamboo fibre will improve the fractured behaviour as reinforcement in the fibre/polymer composite.

## Acknowledgements

I would like to than my project supervisor Dr. Belal Yousef (USQ) for providing me with the necessary feedback and assistance along the way. I also would like to thank the faculty Liberian Sandra Cochrane for her assistance.

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## Tow Body Abrasion of Bamboo Fibre/Polyester Composites

Sponsor – School of Mechanical and Electrical Engineering, USQ



### Amer Oun

Master of Engineering Science  
(Mechanical)

Supervisors: Dr B.F. Yousif, USQ.

**Keywords:** Natural fibre; Abrasive wear; Interfacial adhesion; Worn surface

### 1. Introduction

Nowadays, the increased demand for the use of environmentally friendly composite materials based on natural fibers is an attractive idea to many researchers in the area of tribology. This is basically due to the advantages of these fibres compared to synthetic fibres which are low cost, non-abrasive, recyclable, and possess good mechanical properties. Therefore, many studies focus on the opportunity of using natural fibres in the reinforcement of polymer composites instead of inorganic fibres. Bamboo fibre is considered to be one of these natural fibres, having a small diameter, and strong interfacial adhesion to resin matrix. This motivates the current research.

### 2. Background

From the literature, few works have been carried out to investigate the tribological performance of natural fibres in abrasive and adhesive wear modes (Chand et al. 2007; Okubo et al. 2004; Chand & Dwivedi, 2007). The current research examines the adhesive wear and two-body abrasion of bamboo fibre/ polyester composites. Three materials were selected for this research and were tested under different dry contact conditions (applied load and sliding distance) using different abrasive paper grades.

### 3. Methodology

The materials used in this research were the same as materials that have been used in the previous studies by many researchers such as (El-Tayeb and Yousif, 2007, Okubo et al., 2004, Ratna Prasad and Mohana Rao, 2011). They are Bamboo Fibres Reinforced Epoxy (BFRE), Glass Fibre Reinforced Epoxy (GFRE), and Neat Epoxy (NE). The experiments were conducted in three different abrasive paper grades (G1200, G400, and G80) under different applied loads by using a Block-On-Ring (BOR) machine. Optical microscopy and the scanning electron microscopy are used to categorize the damage features on the worn surfaces of the composites.

### 4. Key Outcomes

The results of this project are as follows

- a) the reinforcement of bamboo fibre in the epoxy matrix may improve the wear behaviour of the neat epoxy under different applied loads as shown in figure 1 below.
- b) The presence of the fibre in the rubbing area help to carry the load out of the polyester region leading to reduce the removal of material and resist the shear force

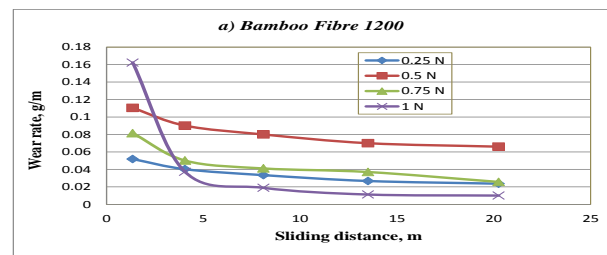


Fig1:Wear rate of BFRE composite under different applied loads

### 5. Further Work

In the future study, wet contact condition can be considered since in agricultural application, such materials are exposed to slurry environments and understanding their behaviour under such condition is important for industrial applications.

### 6. Conclusions

In this study, a new epoxy composites based on the bamboo fibres were developed. The abrasive wear and frictional behaviour of the new composites were investigated with the neat epoxy and glass/epoxy composites. Different parameters and abrasive paper grades were used in the experiments.

### Acknowledgements

I would like to thank Engineering surveying faculty and my supervisor.

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## Project Title: SMARTGRID COMMS FOR CONDITION MONITORING

Sponsor –School of Mechanical and Electrical Engineering

Student Name :SreekanthAnumula



Supervisors: Wei Xiang, USQ

**Keywords:** Condition monitoring, smart grid, Bandwidth.

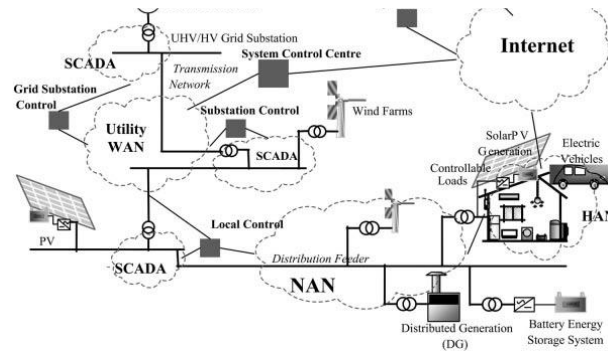


Figure 1: Example SMARTGRID COMMS Diagram

### 1.0 Introduction

The SMARTGRID is a general term for a series of infrastructural changes applied to the electric transmission, distribution systems [1][2]. By using latest communication and computing technology, additional options such as Condition Monitoring can now be implemented to further improve and optimise complex electricity supply grid operation. Life cycle optimisation of high voltage assets and other system components in the utility provide a case in point. Today utility experts agree that application of scheduled maintenance is not the effective use of resources. To reduce maintenance expenses and unnecessary outages and repairs equipment due to scheduled maintenance, utilities are adopting condition based approaches. Retrofitting an existing substation into SMARTGRID substation requires condition monitoring on a real time basis.

### 2.0 Background

The reliable operation of the system components is necessary and for maintaining optimal system conditions under normal operations and fault conditions. This includes utility entities to be self-healing in the event of faults. The research project solves the above issues by retrofitting an existing substation with the deployment of various transducers whose output is digitised and then communicated via the latest communication infrastructure with sufficient bandwidth for the information exchange for both operational monitoring and equipment life cycle maintenance purposes.

### 3.0 Methodology

Real time monitoring system is a supervisory system of the substation equipment, whose current operational parameters, are transformed to digital by asset sensors, transducers. The significant parameters that define asset operational and life status are collected and fed to communication network. The digitised information can be prioritised for the remote operator by publishing it to SCADA using RS485 as is now outlined in the IEC61850. The methodology adopted in this research project is determination of bandwidth and latency of the entire substation under mission critical conditions for each asset condition monitoring signals. On deciding the bandwidth of the entire substation data a hybrid communication model is being considered by modelling and designing the communication technologies using MATLAB Simulink software.

### 4.0 Key Outcomes

By use of hybrid series communication systems along with potential environmental interference in some, definition is required of how this impacts on a IEEE-61850 system as applied to SMARTGRID. Modelling of this is in regards to reliability, better maintenance, sufficient bandwidth, low delay, low signal degradation.

### 5.0 Conclusions

By retrofitting an existing substation into a smart substation this project is seeking to establish a reliable communication infrastructure model for online condition monitoring on a real time basis an existing upgraded substation to be part of a SMARTGRID. It is then has the potential to better reliably maintain equipment provided any serial communications has sufficient bandwidth and the necessary resilience. Modelling the signal is to reduce degradation modes of any serial or hybrid serial communication network associated.

In the future the use of sampled values in process bus applications is planned; it will be taken into account that sampled values need significant bandwidth and may require the use of Gigabit Ethernet networks

### 5.0 Acknowledgements

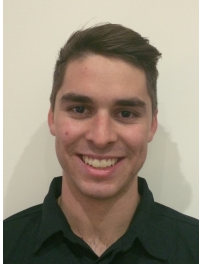
I would like to thank Wei Xiang and Dr Tony Ahfock on guiding me throughout my project tenure. My supervisor initiated my research since my proposal and supported for my progress of preliminary results, specifically with the hybrid modelling and designing of the communication systems.

### References

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2. "The Smart Grid: an Introduction", US Department of Energy.

# Fairlead Design for the Installation of High Voltage Conductors

Olitek Design Solutions



**Nathan Assailit**

Bachelor of Engineering,  
Mechanical

Supervisors: Mr Chris Snook, USQ  
Mr James Oliver, Olitek  
Design Solutions

**Keywords:** Machine Design; Winch; Fairlead

## 1. Introduction

The aim of this project is to design and develop a fairlead system to be used alongside a cable winch for use in the energy industry, in particular for the installation and removal of high voltage overhead power lines. The fairlead system will be used to spool high voltage conductors on and off the winch drums, whilst also measuring the tension and winching speed of the cable.

Fairleads are a common, simple device seen often in every day life. Think four-wheel drive winch systems as well as guides for rigging and anchors on yachts.

## 2. Background

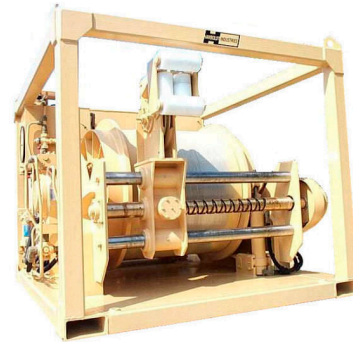
Olitek Design Solutions has been given the task of designing and manufacturing a complete power line installation system for their client, TEN Group. TEN Group is a Brisbane based company specialising in the sale and hire of machinery for the construction and maintenance of overhead and underground networks.

Due to the limited space available, a typical fairlead design has been deemed unsuitable, and as such a new design approach is required, and with that comes a number of challenges.

## 3. Methodology

Following a review of literature relevant to past and present fairlead designs, initial concepts were developed. Through consultation with industry experts and our client TEN Group, a final design concept was produced.

To turn the concept into reality, a number of hand calculations, backed up with Finite Element Analysis (FEA), were conducted.



**Figure 1: Common Fairlead Winch System**

## 4. Key Outcomes

The project has achieved the following key outcomes:

- Gained understanding of fairlead design principles via literature reviews
- Developed concept designs based on client requirements and technical feasibility
- Produced manufacturing drawings of the chosen fairlead roller system

## 5. Further Work

Beyond the scope of this project, further work will include:

- Manufacturing of the fairlead system,
- Functional testing and onsite commissioning of the system

## 6. Conclusions

Through the undertaking of a thorough review of literature, coupled with the insight of industry professionals, a successful fairlead design has been produced which meets key criteria put forward by the client and Olitek Design Solution's board of directors.

## Acknowledgements

I would like to thank Mr Chris Snook, Mr James Oliver and my work colleagues, as well as my friends and family for their support and guidance throughout the project's duration.

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# Effect of Variations in Load Profile on Power Transformer Cyclic Ratings

Sponsor – Ergon Energy Corporation Ltd. (EECL)



**Andrew Atkinson**

Bachelor of Engineering  
(Electrical & Electronic)

Supervisors: Dr Tony Ahfock, USQ  
Mr Greg Caldwell, EECL

**Keywords:** Power transformer, thermal modelling, cyclic rating, load profile, demand side management.

## 1. Introduction

Cyclic rating and demand side management (DSM) schemes are employed by electrical supply authorities to manage peak demand as an alternative to costly network upgrades. This project investigates and models the currently unknown impact of DSM altered load profiles on the cyclic ratings of power transformers.

## 2. Background

In response to electricity price increases, supply authorities are employing cyclic rating and DSM techniques to defer capital expenditure. A cyclic rating exploits transformer thermal inertia to permit loading above nameplate for parts of a 24 hour cycle, compensated for by loading below nameplate at other times such that insulation thermal limits are not exceeded (refer to figure 1). DSM aims to flatten load profiles. Both techniques ensure that existing transformers can supply load peaks thereby deferring network upgrades. Since DSM alters the load profiles on which cyclic ratings are based, a relationship must exist between the two. The plant rating engineer must understand all such dependencies.

## 3. Methodology

Thermal transformer models proposed by various researchers and AS60076-7 for the purpose of calculating cyclic ratings were studied. The AS60076-7 models and one selected from the literature were then implemented in MATLAB and compared to assess their suitability for use in the project and by plant rating engineers. DSM techniques were researched to reveal methods favoured by supply authorities. 12 diverse Ergon Energy transformers were selected for the final phase which involved simulated DSM modification of their load profiles and analysis of the resultant changes in cyclic ratings.

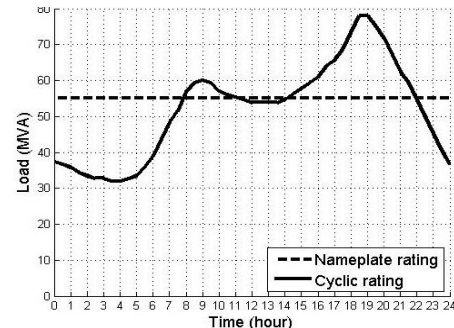


Figure 1 – Comparison of cyclic and nameplate ratings

## 4. Key Outcomes

Objectives achieved to date include: thorough understanding of cyclic ratings and DSM; application of heat transfer theory for thermal modelling; construction and evaluation of models using MATLAB (one based on research by Susa et al. (2005) and two based on AS60076-7 methods); implementation of a cyclic rating calculator in MATLAB based on the simplest AS60076-7 model and thermal limits; and modification of load profiles using a DSM algorithm.

## 5. Further Work

Final quantification of the effect on cyclic ratings of DSM is in progress. Additional work could include investigation into synthetic dielectric fluids and thermally upgraded paper as well as an assessment of the adverse maintenance effects of cyclic loading.

## 6. Conclusions

The project has the potential to further the understanding and confidence of plant rating engineers in cyclic ratings despite changing load profiles. The simplified AS60076-7 model has been shown to be suitably accurate, appropriate for a large transformer fleet and does not require costly modelling software.

## Acknowledgements

I would like to thank my supervisors, Dr Tony Ahfock and Mr Greg Caldwell, for their guidance, support and encouragement throughout the course of the project.

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# Dam Deformation Surveys With Modern Technology

Sponsor – Snowy Hydro



**Jack Atkinson**

Bachelor of Spatial  
Science (Surveying)

Supervisors: Dr Glenn Campbell, USQ

**Keywords:** Scanner, Dam, Deformation

## 1. Introduction

Deformation surveys are repetitive surveys that must be undertaken periodically on high risk structures such as large earthfill dams. This dissertation is to examine and test the ability of the Leica Nova MS50 terrestrial laser scanner (TLS) and utilise these findings to develop a deformation survey procedure that can be amplified by the inclusion of TLS.

## 2. Background

The Leica Nova MS50 is an instrument that has only recently come on the market. It provides the latest technology by combining a high precision total station technology with the capability of capturing highly accurate scanned data.

Existing deformation survey methods require manually placing survey targets on predefined stations located across the surveyed surface, placing the surveyor in danger from slips trips and falls on often steep and unstable ground. There is an identified need for an automated remote process to be developed, providing safety for the surveyor whilst having no compromise to the survey accuracy.

## 3. Methodology

By developing three separate testing scenarios, it will be possible to determine the accuracy of the Leica Nova MS50 and its suitability to be utilised in deformation surveys:

- **Angle of incidence test** – determining the effect the angle of incidence has on a distance read,
- **Difference in length detection** – examine the accuracy of the instrument and determine the difference in length measurement capabilities at nominal lengths, and

- **Laser Dot Size** – to examine the size of measuring laser at nominal lengths.

Following this testing, a suitable method can be developed to enable the TLS to be fully integrated within a deformation survey practice.

## 4. Key Outcomes

The Leica Nova MS50 combines the newest technologies to provide a single “multi-station” instrument that is capable of highly accurate measurements.

The testing scenarios developed can confirm the Leica MS-50 is appropriate for the task of dam deformation monitoring, and a procedure for integrating this instrument into deformation surveys can be assessed.

## 5. Further Work

It has been determined a new pillar network system could be developed on these structures to provide a more streamline survey.

## 6. Conclusions

The selected testing scenarios are to identify if the Leica Nova MS50 is capable of producing the accuracies required for dam deformation surveys. The method created for deformation surveys is to prove TLS's can be utilised in this field of survey. Further development in this field should be undertaken to provide surveyors and dam authorities with suitable alternatives to meet their surveying needs.

## Acknowledgements

John Kleven – Kleven Spain

Michael Thornton – Snowy Hydro

Glenn Campbell

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# Distribution Earthing Design and Analysis

Faculty of Health, Engineering and Sciences



**Glen Barnes**

Master Engineering Science  
(Power)

Supervisor: Dr Anthony Ahfock, USQ

**Keywords:** Earthing, Design, Evaluation

## 1. Introduction

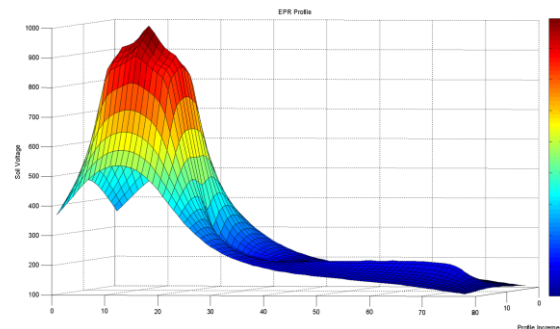
Electricity networks providing domestic distribution services require earthing systems to maintain an acceptable level of operational safety. These systems consist of copper conductors and electrodes buried at varying depths in the ground connected to the distribution apparatus. The impact on the environment and consumers during system disturbances can result in hazardous situations. A software based process built on sound engineering research to analyse various installation configurations for their Earth Potential Rise (EPR) characteristics was created and validated.

## 2. Background

Empirical approaches currently used are inconsistent in achieving safety compliance as they use a generic approach to address a multi-variable task. Recent industry advancements provide a consistent approach in addressing earthing related safety criteria. Effective design and evaluation techniques allow for greater economic prudence to be exercised as prescribed by industry reform. Standards detail minimum infrastructure separation requirements, irrespective of the physical environment and electrical network parameters. For these infrastructure networks to coexist in confined locations accurate evaluation processes need to be implemented.

## 3. Methodology

Finite empirical expressions were employed to estimate soil parameters that represent a two layer structure. An iterative search process was performed to converge on a best fit two layer equivalent using the least squares criterion. Multi-image reflection techniques were employed to analyse various physical arrangements of conductors and electrodes in stratified soil conditions. These techniques provided the ability to calculate the actual self and mutual resistance of individual components that comprise a buried earthing system. Soil voltage calculations provided the ability to visualise the magnitude of surface potentials and the



**Figure 1 – Earth Potential Rise Profile**

resultant impact on neighbouring infrastructure and the built environment. See figure 1.

## 4. Key Outcomes

The Matlab software created performs an accurate analysis of distribution earthing systems by comparison to rudimentary approaches widely used. The impact occurring on localised low voltage earthing systems resulting from a high voltage fault were significantly less than expected. This allowed for subsequent reduction in the separation requirements between functional earthing systems. It was also confirmed that the local soil characteristics are extremely influential in determining the infrastructure separation requirements.

## 5. Further Work

Further segmentation of grid conductors and electrodes with the application of mutual resistance calculations is necessary to increase accuracy. A graphical user interface incorporating drawing capability is intended. Further investigation in regard to the impact of network faults on complex multiple earth neutral environments.

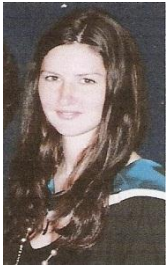
## 6. Conclusions

Earthing system design and analysis can be a complex process unless effective software design tools are made available. Compliance with relevant industry standards becomes difficult to realise and achieve, with additional and unnecessary expense usually the result.

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# An Energy and Carbon Audit of Mornington Peninsula Shire Council



**Melissa Baxter**

Bachelor of Engineering (Civil)

Supervisors: Guangan Chen, USQ

**Keywords:** carbon audit, local council, climate change

## 1. Introduction

This project aims to establish a methodology for measuring annual council carbon emissions from raw data provided by the local council, based on the case study of the Mornington Peninsula Shire Council (MPSC) in Victoria, Australia. The research is expected to result in a carbon footprint of the MPSC carbon emissions. The outcomes of this study will be used to outline recommendations for carbon emission reduction.

## 2. Background

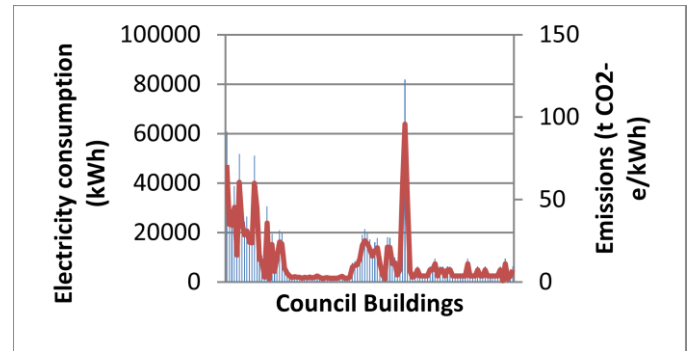
As part of a broader national response to climate change, local councils face the challenge of reducing their carbon emissions to mitigate climate change impacts on both its operations and the local community. A consistent and recognised carbon emission reporting approach should be adopted when managing emissions. The problem considered here is not whether mitigation is important, but rather how to measure emissions at local council level. With a direct link to local communities local councils are well placed to provide leadership in the area of carbon emission reduction.

## 3. Methodology

There is little guidance for councils for the reporting and accounting of greenhouse gas emissions. A thorough review of literature has been performed to provide an overview of international and national policy governing the area. The project involved the collection of raw consumption data from local council. The data was then analysed in accordance with national framework for carbon emission accounting. The inventory includes carbon emissions generated by electricity and gas consumption in council owned buildings, council owned fleet vehicles, emissions from solid waste and escaped fugitive emissions from landfills.

## 4. Key Outcomes

The preliminary results of the project have identified several areas we considered to be key for reducing carbon emissions for MPSC. i.e. electricity (refer Figure 1) produced a large quantity of emissions



**Figure 1 – Emissions from electricity consumption**

perhaps because it has a more carbon-intense emission factor. In addition, there was a high level of emission from waste sector. The magnitude of carbon footprint is yet to be confirmed. We aim to compare on a per capita basis the emissions from an average council worker compared with those for the average Australian.

## 5. Further Work

Further work will define recommendations for carbon emissions reduction to reduce carbon footprint with a discussion of the feasibility of each recommendation. The information gathered relating to emissions by source; will assist in targeting programs to support these reductions and form the basis for the development of a MPSC Climate Action Plan. My recommendations for reduction are unique to MPSC but the underlying concepts behind my approach are applicable to other councils. Hopefully other councils will utilise this methodology to carry out carbon footprint assessments.

## 6. Conclusions

This study is an example for how to convert energy consumption based data into carbon emissions to produce a carbon footprint in a straightforward manner. It is recognised that through measuring their carbon emissions, councils can develop management strategies and reporting on progress towards reduction commitments they can set a good example for the community in the battle against the deleterious effects of climate change.

## Acknowledgements

I would like to thank MPSC for their support through accessing the raw data. I would also like to thank Mr Guangan Chen for the guidance provided throughout the project.

## References

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## PRODUCTION AND OPERATIONS MANAGEMENT IN JORD BELLOWS INTERNATIONAL PTY LTD

Sponsor – Jord Bellows International Pty Ltd



### Androu Beshara

Degree: Bachelor Of Construction (Honours) (BCNH)

Supervisors: Mr Bob Fulcher, USQ

**Keywords:** Production and Operations Management System (POMS), Just In Time (JIT), Lean Manufacturing (LM), Total Quality Management (TQM), Technology in Manufacturing

### 1. Introduction

Within any organisation, specifically a manufacturing organisation, the Production and Operations management system is undeniably the backbone success that leads to desired efficiency, quality and maximum profitability. Production and Operations Management System (POMS) is solely concerned with effectively managing the business, production and industrial activities of the organisation. Its main objective is to produce a product or service efficiently within schedule, budget and with optimum utilisation of resources and minimum losses. This dissertation aims to investigate and analyse the Production and Operations Management System of an Australian Manufacturing company and compare their operations with newly proven and successful Production and Operations management literature, theories and methods in order to recommend improvements to the current Production and Operations Management System of the organisation.

### 2. Background

In the current economical environment Australian manufactured products are significantly more expensive in comparison to products coming from different parts of Asia. This is mainly driven by high labour costs and operations. Australian businesses are now expected to do more with fewer resources at hand by cutting back on costs and implementing efficient and cost effective Production and Operations Management Systems in order to compete with offshore manufactured products. The issue does not only lie with labour productivity, but what furthers this predicament is cost and time. The matter not only extends to the length of time a product will take to produce, but also, how much will it cost within that time frame? Research reveals that in the past 20 years, a shift has emerged in quality production with fewer labour hours in order to reduce the price of the product to compete in the market. By reducing the labour hours to manufacture a product through efficient and cost effective Production and Operations Management Systems, the cost of the product will effectively reduce and so its sell price. Thus, creating a more competitive market. Therefore, a successful Production and Operations Management system stems from the clever and effective methods to reduce labour cost whilst also providing a high quality product.

### 3. Methodology

The focal objective in the methodology was to investigate the Production and Operations Management System at Jord bellows and outline the successes and limitations of Just in Time (JIS) Management system, Lean Manufacturing (LM), Total Quality Management (TQM) and the use of technology in their operations. These findings were achieved by semi-structured interviews and detailed observation of the company's day-to-day operations. The findings also gathered ideas that have emerged from literature regarding Production and Operations Management systems.

### 4. Key Outcomes

By combining literature, interviews with staff members of Jord Bellows, along with direct observations of Jord Bellow's practices, the aim of the methodology was to assess the current Production and Operations management system of the company and implement new strategies and theories that can assist and provide improvement.

### 5. Further Work

Further work can be carried out with more interviews and daily observation. This is mainly because at times it was difficult to sit with staff members to discuss POMS when they are busy meeting deadlines for work.

### 6. Conclusions

As a result of this dissertation, Jord Bellows will implement a new Production and Operations Management System to capture their quotes, jobs and stock all under one new system called Workbench.

### Acknowledgements

Firstly, I would like to thank God for giving me the ability to complete my dissertation and a huge thank you to my wife for her continuous love and support. I would also like to thank Mr Bob Fulcher for his supervision and Special thanks to Jord Bellows International Pty Ltd for being my sponsor. Eager (2003) and Munizu (2013) work on Competitive Advantage and the use of Technology in Manufacturing has given me a great insight on assessing the POMS of Jord Bellows and recommend improvements.

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- Munizu, M. (2013). The Impact of Total Quality Management Practices towards Competitive Advantage and Organizational Performance: Case of Fishery Industry in South Sulawesi Province of Indonesia. Johar Educational Society, Pakistan.

# Investigation of Sub Five Minute Time of Concentration in Urban Drainage Design

Sponsor – School of Civil Engineering and Surveying



**Mitch Blyth**

Bachelor of Engineering Civil)

Supervisors: Ian Brodie, USQ

**Keywords:** Time of Concentration, Urban Drainage

## 1. Introduction

This research aims to investigate the impact of sub five minute time of concentration (TOC) in high density urban developments to determine if the current minimum time of concentration (as used Australia wide as part of hydrological calculations) is promoting inaccurate design solutions. The findings will allow conclusions to be drawn on realistic minimum time of concentrations for small urban design cases and recommendations for reducing the minimum time of concentration in current Urban Drainage Guidelines.

## 2. Background

This project looks to confirm that urban drainage guidelines in Australia are in touch with current urban site characteristics and that responsible design solutions are promoted in order to reduce risk to property and life.

## 3. Methodology

A mixed method research approach was used to investigate the project topic. Primary data was collected in the form of physical test data for time of concentration in impervious sub catchments which was then compared against comparative modelling results replicating the same design scenarios. Additionally, secondary data was collected in the form of a content analysis on the opinions and views of industry professionals and relevant authority representatives.

## 4. Key Outcomes

Early results indicate that sub five minute time of concentration is a very realistic time of concentration for urban impervious sub catchments. Preliminary modelling has confirmed that a reduced time of concentration can equate to a considerably higher catchment discharge.

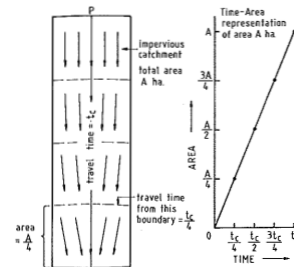


Fig. 4.6 – Time-area graph for simple catchment of area A and time of concentration  $t_c$

**Figure 1 – Time-Area Graph**

## 5. Further Work

The outcomes of this study should be considered during the consideration of on-site *water quality* design principles and devices, which is an important aspect of development engineering responsibility.

## 6. Conclusions

Investigation has confirmed that sub five minute time of concentrations are realistic and produce a higher flow from catchments. For this reason it is suggested that drainage guidelines consider minimum time of concentration of less than five minutes (down to the shortest duration of available IFD data that is available for that particular area).

## Acknowledgements

I would like to thank industry professional Gavin Fields and my project supervisor Ian Brodie for their guidance. Special thanks to Carolina Blyth for her assistance in the collection of data.

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# NUMERICAL AND SOFTWARE AIDED SIMULATOR ANALYSIS OF ADHESIVE WEAR BEHAVIOUR IN METALS

Sponsor- School of Mechanical and Electrical Engineering



## Vivekh Bondili

Master inn Engineering Science  
(Mechanical)

Supervisors: Dr Belal Yousif, USQ

### 1. Introduction

The general tribology in metals under different operating conditions cannot be predicted as metal fatigue, fracture and other disambiguation in metals happens unsaid, this is because the frictional and wear behaviour is not known very intricately. This project aims at simulating wear and frictional behaviour under different operating conditions so as to attain a vast amount of redundancies which can help in a better mechanical design and forecast tribology in commonly used metals. Three metals have been used under operating conditions mild steel, brass and aluminium in respect to different loads, sliding distance which is the duration. Furthering from the results, the metal testing block to be tested has to be modified with different materials put into one block as in making it an alloy. Thus the change which is the reduction in stress and strain parameters is aimed at to be attained.

### 2. Background

This project currently involves the simulation of metal contacts and the transient temperature on the live surface of contact. This project definitely aims at any of the friction parameters in the result window so as to define a new difference between the metals used.

### 3. Methodology

Quantitative research and programming were used to accomplish outcomes of this very project. This project aims at simulating wear and frictional behaviour under different operational conditions.

### 4. Key Outcomes

Simulation has been achieved and the frictional parameter has been seen such as transient heat. The technical outcomes are in the results of ansys program where analysis is the main criteria.

### 5. Further Work

Further tasks such in this area of discipline is perpetual towards designing and analysis. The further accomplishments of this project are microscopy and work piece composition, which has not been addressed. This area is for precision and other frictional parameters.

### 6. Conclusions

The vital conclusion is that the simulation analysis has been achieved and the frictional parameters have been shown.

### Acknowledgements

I would sincerely like to thank my supervisor Dr Belal Yousif for being a valiant and insightful mentor for guiding me through such a project wherein ones calibre is put to test. I would also like to thank my faculty and my fellow students for the support.

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Wear behaviour and mechanism of different metals sliding against stainless steel counterface  
*Department of mechanical engineering, University of southern queensland, Queensland, (2014)*

## Analysis of the Bus and Train Tunnel Fire Safety System

Sponsor – Department of  
Transport and Main  
Roads



**Jacinda Bouilly**

BEBB – Bachelor of  
Engineering Bachelor of  
Business

(Majoring Civil/Finance)

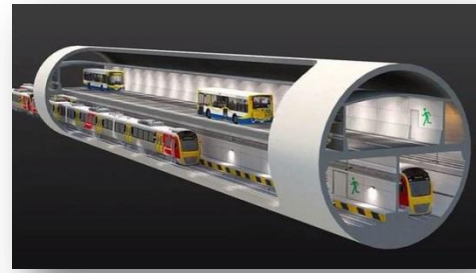


Figure 1 - BaT tunnel conceptual design

Supervisors: Ms Jo Devine, USQ

Mr Gavin Nicholls, DTMR

**Keywords:** Tunnel, BaT, Fire safety

### 1. Introduction

The proposal for a bus and Train (BaT) tunnel in Brisbane has been put forward and construction is scheduled to begin in 2016. The tunnel is planned to ease congestion in SEQ through increasing the efficiency of the public transport system. There are many unique factors about the BaT tunnel, including the fusion of two modes of public transport (Bus and Train) into a single decked tunnel. With the unique characteristics of the design, investigation into Tunnel fire safety and emergency response is required. Hence this research paper will investigate international tunnel fires and the causes of them, local experience with tunnel fire mitigation in Australia, and the potential area's that could cause difficulty with the unique design of the BaT tunnel.

### 2. Background

This is an important project as it is essential to investigate the risks of a project before construction begins. Tunnel fire safety is an area where many risks are unknown and hence further investigation is required. This project will collect knowledge of tunnel fire safety into one document and answer questions specific to the BaT tunnel and how the tunnel fire safety system will differ to a single modal, single decked tunnel.

### 3. Methodology

This study involved qualitative research. A root cause analysis was employed to assist in identifying the potential failure areas of the BaT tunnel. The root cause

analysis is a method of identifying the underlying issues with potential failures.

### 4. Key Outcomes

A key findings of the study showed that there will most likely be less risk involved with the BaT tunnel in terms of fires than common road tunnels. The main cause of fires in tunnels is the vehicles entering and causing common traffic accidents, or poorly maintained vehicles causing fires. BaT tunnel is expected to have reduced risk due to the ability to control the standard of vehicles that enter the tunnel. The ventilation system is another key area of the design that requires attention.

### 5. Further Work

Remaining work for the dissertation is to complete the Root Cause analysis to ensure the study is complete. In the future best practices of Australian tunnel emergency response could be undertaken via interviews of previous and current tunnel operators to find practicable solutions to tunnel fire safety.

### 6. Conclusions

This paper provides much information on tunnel fires that have occurred in past and provides an insight into Australian tunnel guidelines. It shows that the risk of Fires occurring within the BaT tunnel is less likely than road tunnels.

### Acknowledgements

Special Acknowledgements go to Gavin Nicholls and Jo Devine who provided great support throughout the project. The Major references can be seen below.

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# Low-Cost Eye Tracker

School of Mechanical and Electrical Engineering



**Thomas Bradford**

Bachelor of Engineering  
(Computer Systems)

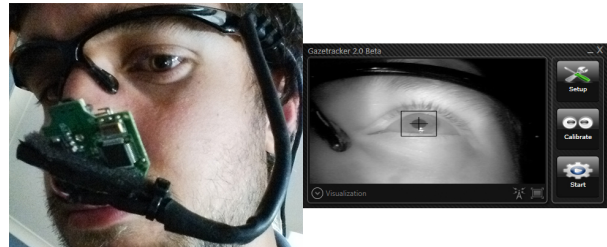


Figure 1 – Head-mounted eye tracking setup

Supervisor: Dr Alexander Kist, USQ

**Keywords:** low-cost, eye tracking, gaze estimation

## 1. Introduction

Eye tracking is the process of measuring the gaze direction of a person to determine their *line-of-sight* or *point-of-regard*. Eye trackers have been used for numerous applications including medicine, marketing, psychology, usability testing and human-computer interaction. With the increasing dependence on computers and technology, it is of increasing importance to study software usability testing and HCI to enhance the user experience. This project focuses on developing a low-cost eye tracker to analyse how learning tools are used by students.

## 2. Background

While commercial eye trackers exist, they are very expensive, making them a high-priced niche unsuitable as a general low-budget solution. These systems range in price from US\$5,000 to US\$40,000, limiting their application to high-end speciality products. A low-cost, open source eye tracker would allow anyone to explore eye tracking in many new ways. Modern technology advancements have enabled off-the-shelf video hardware to be suitable for eye tracking hardware while still maintaining its low cost and accessibility. The development of a low-cost eye tracker can greatly improve the accessibility to eye trackers for the analysis of the use of learning tools by students.

## 3. Methodology

The eye tracker was designed using a low-cost off-the-shelf webcam suitably modified for use with the system and mounted on the frames of safety glasses. Infrared LEDs are used to illuminate the eye. The ITU Gaze Tracker software is used to perform the eye tracking, while separate software is used to perform data representation and analysis using gaze coordinates including formulation of heat maps, saccade plots and eye tracking metrics related to the use of learning tools.

## 4. Key Outcomes

A head-mounted eye tracker was designed and constructed using low-cost off-the-shelf hardware for a total cost of less than AU\$50 (Figure 1). The performance characteristics of the eye tracking system are comparable to those of a commercial high-end solution, with an achieved accuracy of just 0.2 degrees.

## 5. Further Work

Currently, software is being developed for processing of gaze coordinates, data representation and analysis related to the use of learning tools. Performance evaluation and optimisation is also being conducted.

## 6. Conclusions

The outcomes of this project conclude that a low-cost eye tracking system can be developed using off-the-shelf hardware and open source software while achieving an appropriate level of performance. This eye tracking system can be used for a number of applications, depending on the software implementation.

## 7. Acknowledgements

I would like to thank Dr Alexander Kist for his role as my project supervisor. My family and friends were also supportive throughout the year, particularly my father, Steven, who assisted with the hardware implementation. Finally, thanks to the ITU GazeGroup for their Gaze Tracker software and useful resources.

## 8. References

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# Developing a Numerical Model for the Design of Sheet Pile Walls

Sponsor – School of Civil Engineering and Surveying, USQ



**Chane Brits**

Bachelor of Engineering  
(Honours) (Civil)

Supervisor: Dr Jim Shiau, USQ

**Keywords:** FLAC, Sheet pile wall, Design.

## 1. Introduction

The success of geotechnical work relies on factors such as proper planning, analysis and sheet pile wall design. This paper aids in the understanding of the limit equilibrium methods by developing an automatic excel spread sheet for simplifying the design of sheet pile walls. The aim of this research project is to investigate the suitability of modelling geotechnical stability problems using the computer program FLAC, by means of undergoing parametric studies and validating the accuracy of the results obtained from numerical analysis with analytical solutions.

## 2. Background

The analytical method of sheet pile wall design provides a basic understanding of the soil-wall system behaviour. The hypotheses on which these methods are based upon are very conservative, therefore developing numerical models, undergoing parametric studies and validating the results by comparing with analytical solutions, is definitely a topic to be researched. This will lead to more effective sheet pile wall designs in the engineering industry.

## 3. Methodology

The background information of the construction considerations and designing procedures of sheet pile walls using the analytical methods was researched and applied (Das, 1990). To accurately solve the tedious analytical equations an automated excel spread sheet design tool was developed. It was then decided to create an advanced numerical model using FLAC to solve geotechnical problems.

## 4. Key Outcomes

The key outcomes for this project is to develop an automatic excel spread sheet for sheet pile wall design, therefore solving monotonous analytical equations accurately and creating visual solutions expediently by entering known input data. Compared to analytical methods this design tool has been proven both accurate and successful.

## 5. Further Work

Continuing on from the work done thus far it would be beneficial to develop a numerical model in FLAC, either by means of using a graphical interface or by creating a coded script using the powerful built-in programming language called FISH.

## 6. Conclusions

In the engineering industry time is money and making use of an automatic sheet pile wall design tool proven both accurate and successful is definitely valuable. Analytical methods of design, has been found to be very conservative due to several simplifications and assumptions made. According to (Smith, 2006) the numerical investigation shows that FLAC is a suitable tool for analysing these geotechnical stability problems. The results have been examined in a qualitative and quantitative sense to verify the behaviour and make reasonable comparisons to available results. Through comparisons with classical methods the FLAC results have been demonstrated to be of a high degree of accuracy.

## Acknowledgements

Dr Jim Shiau for his technical expertise, continual guidance and enthusiasm. Last, but not least I would like to thank my family and friends for all their support and understanding.

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# Boom Spray Rig for Weed Seeker Units

Sponsor – Simplicity Australia



**Benjamin Buckler**

Bachelor of Engineering  
(Mechanical)

Supervisors: Dr Ray Malpress, USQ

Mr Graham Powell, Simplicity  
Australia

**Keywords:** Agricultural, Mechanical, Spray Rig

## 1. Introduction

This project is aimed at designing a broad acre boom spray rig to hold 96 Weed Seeker units over 36 metres with large floatation tyres. The boom is to convert into multiple configurations for transportation.

## 2. Background

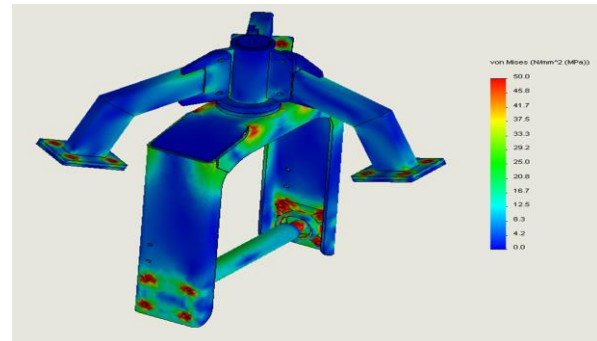
Technology in the last decade has seen dramatic improvements in pest control. The Weed Seeker unit detects weeds by infrared and has shown to reduce waste by up to 80%. This is due to reducing the need to blanket cover the entire field and only focus on the weed itself. The use of statics, stress analysis and the aid of FEA in computational mechanics in design has been the driving subjects to achieve design requirements in this project.

## 3. Methodology

The methodology started by consulting clients from various agricultural fields for advice on design requirements and researching existing spray rigs. Success in the geometry of multiple arm motions and space limitations was achieved by a 2D Cad program. Stress analysis was performed on the wing frame and forces attained. These forces were input into a FEA simulation program to establish high regions of stress in the frame. Figure 1 is a result of the loads on the wheel assembly hub.

## 4. Key Outcomes

The main achievement was designing an implement that collapses to comply with road regulations. The



**Figure 1 – Wheel Assembly Stress Analysis**

logic behind larger tyres was to create a smoother ride over rough surfaces and by being in-line created reduced wheel drag which was evident in other spray boom designs. This style of spray design has not been designed or developed before and is a first for Simplicity Australia to introduce a spray rig into their product catalogue.

## 5. Further Work

Tasks that remain are to investigate the forces applied on a tyre and whether it would be beneficial to introduce suspension to the wheel assembly. If suspension is required a new design of the wheel assembly will be needed to accommodate the springs and dampers. This aspect may not be achievable in the time frame for this year.

## 6. Conclusions

A spray rig boom has been designed. The introduction of larger tyres has been accomplished and the implement can be folded down for transportation. Persistence and considering many possible solutions was a driving factor to being able to complete this project.

## Acknowledgements

I would like to thank Graham Powell for his senior experience in agricultural mechanical engineering, providing very useful tips and inspiration. Bruce Jiggins also provided improvements in manufacturing processes.

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# BIM and IPD driving structural engineering and construction efficiencies



**Brock Buckley**

Bachelor of Engineering (Civil)

Supervisors: Dr Yan Zhuge, USQ

Sponsor: McVeigh Consultants

**Keywords:** Interoperability, building information modelling (BIM), integrated project delivery (IPD), structural engineering

## 1. Introduction

Traditional engineering design drawings were prepared by hand and since the 1980's-1990's two-dimensional computer aided design (CAD) has been the industry standard design and documentation tool. However currently the industry is undergoing another significant shift with the widespread adoption of building information modelling (BIM). This three-dimensional object database environment contains data rich information that can be easily visualised, scheduled and collaborated within project teams.

## 2. Background

This research project will focus on defining and implementing structural engineering integrated project delivery (S-IPD). In particular the ability for structural engineers to deliver structural steel and precast shop drawings during the detailed design phase. With the goal of demonstrating quantitative benefits in the Australian engineering and construction market to spur on industry acknowledgement and continued development towards integrated design delivery.

## 3. Methodology

S-IPD has been achieved by developing and documenting explicit workflows and protocols for use by structural engineers and shop detailers.

The following software was used to create a consistent and trusted workflow between supply chain specialists:

Revit: Develop structural engineering model which was exported to industry foundation classes (IFC) format for data transfer to shop detailer.

Tekla Structures: Used to import structural engineers IFC model and shop detail steel and precast elements. Shop model was then exported to IFC format and transferred to structural engineer.

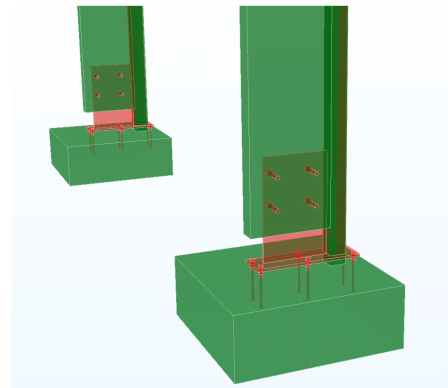


Figure 1 – S-IPD Model

Tekla BIMsight: Allowed structural engineering and shop detailing model review and mark-up. See figure 1.

## 4. Key Outcomes

S-IPD processes have been developed that enable structural engineering consultants and construction companies to realise the following:

- reduce construction time through early procurement, fabrication and erection of steel and precast elements
- create certainty around steel and precast design and construction workflows using BIM and IPD
- reduced or zero requests for information (RFI)
- generate additional business opportunities for structural engineering consultants, steel detailers, fabricators, sub-contractors and product manufacturers

## 5. Conclusions

This project has demonstrated that by introducing S-IPD, structural engineers can add further value to the supply chains and construction of both structural steel and precast elements. It also highlights the benefits for the engineering and construction industry to improve interoperability and project delivery methods over those currently used.

## Acknowledgements

I'd like to acknowledge and thank McVeigh Consultants and SteelCAD Drafting for their support in developing S-IPD.



# Using desktop hydrologic data to predict fish presence in streams in northern British Columbia

Sponsor – School of Civil Engineering and Surveying



**Benjamin Byrd**

Bachelor of Engineering (Environmental)

Supervisors: Dr Ian Bodie, USQ

Mr Kirby Ottenbreit, Stantec Consulting Ltd.

**Keywords:** Fish, stream crossing, presence/absence, hydrology, terrain mapping, logistic regression.

## 1. Introduction

Identification of fish-bearing streams is a key part of many environmental assessments in Canada in general, and specifically in British Columbia (BC), where fish and fish habitat are highly valued components of the natural environment.

The primary aim of this research is to create a method for using desktop hydrologic and terrain data to predict fish presence in streams in BC, for more efficient allocation of ground-truthing field work by fisheries biologists.

## 2. Background

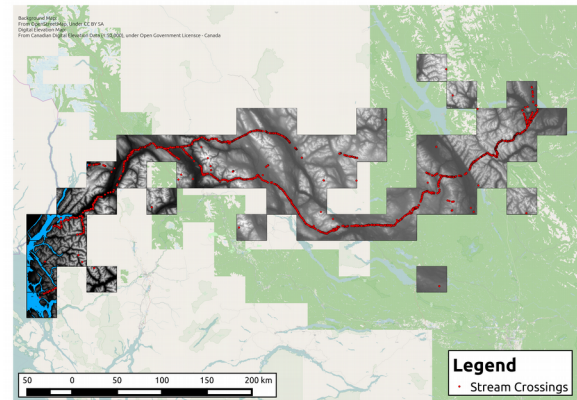
Pre-field identification of likely fish-bearing and non-fish-bearing streams has the potential to reduce cost and effort related to field inventories, and to help expedite and streamline the project design process.

Previous research has considered desktop level hydrologic, geologic and land-use data from single catchments with good results, but in some cases did not maintain similar predictive success for distant catchments (Filipe, Cowx & Collares-Pereira 2002; Porter, Rosenfeld & Parkinson 2000). This project draws from three distinct catchments, with the aim of developing a model that will be more generally applicable.

## 3. Methodology

Data on fish presence/absence, watershed area, and mean and maximum monthly flows was collected from 2057 stream crossing points (see Figure 1) as part of the environmental assessment for the Prince Rupert Gas Transmission (PRGT) project. Canadian Digital Elevation Data was used to identify the elevation and derive the slope for each site.

Each of these parameters, and derivatives of them, are assessed using logistic regression to identify any



**Figure 1: Stream crossings data set**

significant correlation between the parameter and fish-bearing status. Parameters showing significant correlation will be combined in a number of ways, including multiple logistic regression, to develop a predictive model.

## 4. Key Outcomes

Initial logistic regression analysis of watershed areas indicates that they are strongly predictive for fish-bearing status above particular cut-offs, but have little predictive value at lower watershed areas, or for predicting non-fish-bearing status.

## 5. Further Work

Analysis of other parameters is ongoing. Once initial regression of all parameters has been completed, those outcomes will identify which parameters will be carried forward to the predictive model. An initial aim to also model for correlations with stream classifications will not be completed.

## 6. Conclusions

Final conclusions for this research are incomplete. However, initial results from the watershed area parameters are encouraging.

## Acknowledgements

I would like to acknowledge the assistance of Mr. Ward Prystay in obtaining permission to use PRGT data.

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## Investigation of Energy Storage Medium to Improve Network Voltage Regulation

Sponsor – School of Mechanical & Electrical Engineering, USQ



**Heath Camilleri**

Bachelor of Engineering (Power)

Supervisor: Dr Les Bowtell, USQ

**Keywords:** Voltage Regulation, SWER, Pumped Storage, Hydroelectric.

### 1. Introduction

Ergon Energy currently has an extensive Single Line Earth Return (SWER) network. It supplies approximately 26,000 customers across vast areas of regional Queensland. It is of significant national importance as it provides rural customers with an affordable energy supply.

This project investigates the use of energy storage to improve voltage regulation on SWER feeders. It investigates the range of storage mediums available and focuses on the installation of a small scale pumped storage hydroelectric scheme.

### 2. Background

The load on Ergon Energy's SWER networks is steadily growing and many of these lines are reaching their capacity limit. Often, the first sign that of this is voltage fluctuations which usually results in expensive augmentation works.

It is therefore imperative that new and innovative ways of increasing the peak capacity of SWER networks are developed. These cheaper alternatives will reduce upward pressure on electricity prices.

One possible solution is to install technology that can store energy during periods of low demand and high network voltage and release energy during periods of high demand and low network voltage. This would negate the need for augmentation works and therefore reduce the cost to supply energy to these areas.

### 3. Methodology

A pumped storage hydroelectric scheme was designed and modelled on an Ergon Energy SWER feeder experiencing voltage fluctuations. This technology was compared to the battery storage system currently deployed in the Ergon Energy SWER network.



**Figure 1 – An Installed Micro Hydroelectric System (Gilbert Gilkes & Gordon, 2014)**

Network modelling was completed using PSS Sincal which is specialised network analysis software developed by Siemens.

### 4. Key Outcomes

The pumped storage scheme design, modelling and comparison to existing battery storage systems was successfully completed. The feasibility of using pumped storage technology to improve SWER network voltage constraints was assessed.

### 5. Further Work

A trial of this technology on the SWER network would validate the theoretical analysis completed as part of this project.

### 6. Conclusions

It is feasible to install pumped storage technology to improve network voltage fluctuation on a SWER feeder in some cases. The most important factor that determines this feasibility is the natural environment and the availability of an upper and lower water reservoir without the need for major civil works.

### Acknowledgements

I would like to thank my project supervisor, Dr Les Bowtell and my colleagues at Ergon Energy for their guidance and support.

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# Thermal Performance of an Earth Sheltered Shipping Container

Albury City Council, Riverina Institute of TAFE and Rocla



**Tyler Carey**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Steven Goh

**Keywords:** Shipping Container, Thermal Performance, Earth Sheltered

## 1. Introduction

My work focuses on the use of shipping containers as modular living units and the thermal effect that earth sheltering has on containers. With the help of Albury City Council, the National Environmental Centre Thurgoona (NEC) and Rocla, I have earth sheltered a container with the hope that it will provide a temperate environment for the storage of organic produce at the NEC. I aim to quantify not only the effect of earth sheltering but other passive heating and cooling methods with the help of permaculture students from the Riverina Institute of TAFE.

## 2. Background

In 2011 I travelled to Zambia to help build accommodation at local bible college. This spiked my interest in the potential for modular living units in third world countries and emergency situations. I paired this thought with an interest in sustainable living and the architecture of Adam Kalkins work and this project was born.

## 3. Methodology

After gaining development approval and donation of labour from Albury City Council, donation of Massbloc retaining units from Rocla and an agreement with the NEC excavation and construction could commence. Digital temperature data loggers were placed in the container along with a control container and an outdoor control. As permaculture students made alterations to the containers, they were documented and the temperature data analysed to see the impact on the containers thermal performance.

## 4. Key Outcomes

The main outcome of this project is to provide a more temperate shipping container for the NEC's organic farm to store produce. I also am to gain an understanding of local government requirements regarding the use of



**Figure 1 – Excavator and Earth Sheltered Container**  
shipping containers as modular building units and research the general opinion on shipping containers as modular living units and stigmas they may hold. Through data logging and analysis I aim to quantify the impact earth sheltering and other passive heating and cooling methods have on the thermal performance of a shipping container.

## 5. Further Work

Initially a green roof was desired as well as earth sheltering but the quantity of work involved exceeded the time this dissertation allowed. It is probable the permaculture students will complete this work in the future but it will not be considered in my dissertation.

## 6. Conclusions

As only winter data has been collected at this stage, I cannot make any clear conclusions regarding earth sheltering. However it is clear the aspect and amount of shade on the container have a significant impact on its thermal performance.

## Acknowledgements

I would like to thank Rob Fenton, Riverina Institute of TAFE, all of the staff and students at the NEC, Brad Ferris, Lindsay Pearson, Albury City Council, John Braeder, Rocla, Steven Goh and Jess Daly for being so supportive.

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# Mathematical Modelling of Shopfront Glazing

Sponsor – Mr Maxwell McDonald, Abbot Design Pty Ltd



**Ryan Chalmers**

Bachelor of Engineering (Civil)

Supervisors: Mr Karu Karunasena, USQ

**Keywords:** Shopfront Façade, Glass Impact Modelling, Safety Glass Design.

## 1. Introduction

Shopfront façade designs are increasing in size as designers use the shopfront as a design spectacle and maximise the display area. As such the design of shopfront glazing is becoming critical. Glass type, thickness and treatments are a major component of the design requirements. My mathematical model will provide design details for the specification and installation of shopfront glass façades for designs outside of already established sizes in the standard.

## 2. Background

Glazed shopfront facades are designed using AS1288-2006 Glass in buildings – Selection and installation. Traditionally glaziers provided shopfitters with a glazing certificate stating the shopfront glazing met AS1288. Shopping centres now require shopfront facades to be certified by qualified engineers. Glass specification is conducted during design and upon installation. From inspecting a significant number of installed shopfronts it is clear that many shopfronts do not meet the standard. Tinson (2010) found 65% of shopfronts studied did not meet the standard. Thus better understanding and clearer design methods are required.

## 3. Methodology

Currently AS1288 includes tables specifying glass type and thickness depending on the type of installation for areas likely to have human impact. These tables have been analysed and graphed. Using Strand7 FEA software the common types of installation will be modelled with appropriate concentrated loads that replicate kinetic energy of impact forces. The results from the FEA modelling will then be analysed and compared with the results of the AS1288 analysis. The model will produce solutions for the common types of shopfront glazing support types.

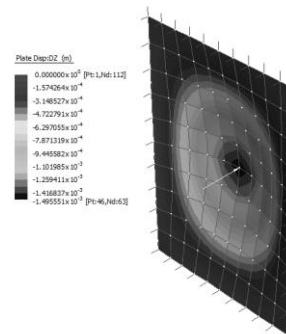


Figure 1 – Deflection of Glass Panel in Strand7

## 4. Key Outcomes

Analysis of AS1288 human impact tables have created mathematical formulas to be used in the model. Research into the impact forces that glazing designed for human impact has resulted in appropriate concentrated forces to be applied. Strand7 modelling is currently being conducted and the results compiled to generate the model Figure 1.

## 5. Further Work

Analysis and comparison of the AS1288 based model compared with the Strand7 results is still to be conducted. These results will be compared and if required, further modelling will be conducted.

## 6. Conclusions

If successful my mathematical model will be utilised in the design of glazed shopfront facades. Tables generated from the model will enable, designers, glaziers, engineers and inspectors to correctly specify and certify to glass designs and installations.

## Acknowledgements

Thanks go to Mr Karu Karunasena for his guidance and direction. A big thank you to my sponsor, Mr Max McDonald from Abbot Design Pty Ltd. Most of all to my wife, Nerrine, and children, Vienna, Aameeka, Eillah and Zahleea for their unconditional understanding and support and putting up with grumpy dad this year.

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# LIFE CYCLE MANAGEMENT OF TRANSFORMER UTILITY ASSET

Sponsor- School of Mechanical & Electrical Engineering



**HARSHAVARDHAN  
CHAMARTHI**

Master in Engineering Science  
(Electrical & Electronic)

Supervisors: Dr David Thorpe, USQ

**Keywords:** *Transformer fleet, transmission system, transformer aging*

## 1. Introduction

The life cycle management of transformers is quite tedious and many concerns are there and the need of the hour is to increase the efficiency of the existing systems and to bring the capital spending on new and replacement transformers to the lowest levels. But the picture is not rosy as the load is increasing day by day on the transformers and their condition is getting worse. The consumption of power is increasing at the rate of 2% every year. The main objective of the project is to analyse the risks of the transform fleets, the assessment of the condition, and making life cycle decision based on that. It also aims at the analysis of the factors of the ageing transformers by the prioritization of category of transformers based on the risks, analysis of cause of transformer failure and analysis of life cycle decisions. Also this dissertation aims to develop a proper scheme such as the condition based maintenance objective to thoroughly maintain the life.

## 2. Background

This project is very important as due to the increase in population and energy consumption there needs to be some advancement in the life cycle of an transformer in order to sustain its growth. This project will help to increase the efficiency of the transformers.

## 3. Methodology

The project management steps related to the risk assessment, ranking of the transformers on the basis of risks and then condition assessment and then taking the life cycle decisions are visualized. The secondary research about various aspects of the improvement in the transformer performance is taken into account.

## 4. Key Outcomes

As of now we have collected all the data and analysed the efficiencies of several transformers. I am now **now waiting** for the approval from Ergon energy company to investigate it in real world and find the alternatives.

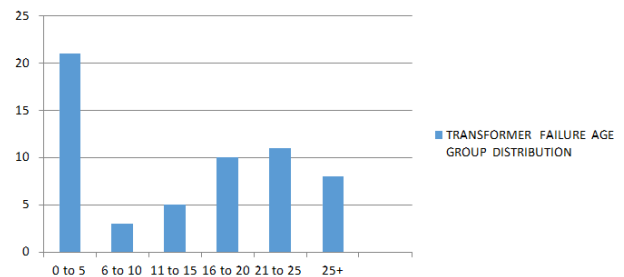


Fig 1. Transformer failure age group distribution

## 5. Further Work

The scope of study is quite huge still being limited to the cycle of transformers. The asset management approach takes three stages to get completed. As we have already discussed there is a risk assessment procedure in order to prioritize the transformer fleet, assessment of condition of different transformers and the life cycle decisions regarding the retirement, refurbish and replacement or relocation of transformers. Adding on to this I am planning to approach the ERGON ENERGY company in Toowoomba and have a detailed study of all the transformers and also its various pros and cons related to its age and other related factors that would help me to find a solution to all the ageing factors of the transformers and to utilize the most of it without harming the body.

## 6. Conclusions

As we have seen and discussed that there have been a number of challenges in the industry pertaining to the electrical utility. In many countries, many companies are facing huge debts and the new entrants are wary of such situation in which they have to face many roadblocks in order to build power plants. The prime focus in this study is to improve the efficiency of the transformers by managing the life cycle of them in utmost optimized manner.

## Acknowledgements

I would sincerely like to thank my supervisor Dr David thorpe for being a valiant and insightful mentor for guiding me through such a project wherein ones calibre is put to test. I would also like to thank my faculty and my fellow students for the support.

## References

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# Lateral Earth Pressure Problems involved with Cantilever Retaining Structures and Stability of those Structures.



**Scott Clayton**

Bachelor of Engineering  
(Civil)

Supervisors: Dr Kazem Ghabraie, USQ

**Keywords:** Pressure, Cantilever, and Stability.

## 1. Introduction

Retaining walls provide support for vertical or near vertical grade changes, while also preventing erosion or down slope movement. The backfill is usually associated with an amount of surface strip load, thereby creating lateral pressure which acts onto the non-yielding retaining wall. The purpose of this thesis is to calculate mathematically and graphically the lateral earth pressures and how stability of a retaining structure is influenced by these pressures.

Calculations will be made which will involve Rankine earth pressure theory and Coulomb earth pressure theory. It will also involve determining whether there are any correlations between these two theories.

A numerical approach will involve software known as OptumCE to determine the representation of the stresses experienced by the retaining wall and the influence it has on the backfill and foundations

## 2. Background

To determine the relevance of both Rankine and Coulomb in terms of their work contributing to both at-rest, active and passive earth pressures. Contrasting their work has been determined, extending to our existing practice.

## 3. Methodology

Research into existing background were undertaken in order to determine mathematically the lateral earth pressures and how these pressure directly affected the stability of the proposed cantilever retaining structure. From this, a graphical approach was then undertaken

using OptumCE, numerical values were established and tabulated for further research.

## 4. Key Outcomes

When friction angle is zero, the coefficients of both Rankine and Coulombs methods are equal. For a 2.5, 5 and a 7.5 metre high retaining wall, blasted rock backfill and foundation of clay/clay silt calculated to be the optimum soils. However, for a height of 10 metres, sand was the most optimum choice for backfill, with a blasted rock or gravel foundation.

## 5. Further Work

To analyse stability alternatives for failed scenarios, this will include nails, nails and grout, and possible freezing.

## 6. Conclusions

It has been identified that there is a key correlation between both Rankine and Coulomb. However, Coulombs approach considered the friction between both wall and soil. Therefore, Rankine's approach is considered a more simplified method.

## Acknowledgements

I would like to thank Dr Kazem Ghabraie for his continues support and ideas on possible research paths.

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# Laser Scanning for Forest Structure Analysis

Sponsor – School of Civil Engineering and Surveying



## Adam Coburn

Bachelor of Spatial Science  
(Honours), Major Surveying



Figure 1 – The point cloud obtained from a scan

Supervisors: Dr Xiaoye Liu

**Keywords:** *Laser Scanning, Forest*

## 1. Introduction

A forest inventory details data about a forest structure and contains elements such as tree heights, types, structure density and tree volumes. To compile such an inventory is extremely time consuming, both in the field and in the office. Manual measurements must be made of each individual structure. The data is then recorded in the field and later transferred to a database. It is a strenuous process that has vast room for improvement.

## 2. Background

In the modern era, new technologies are constantly redefining the way in which we complete both daily and specialised tasks. Laser scanning is the most recent technology in the surveying world yet it is already used for a variety of applications. Forest analysis is an area that has been somewhat tested however more testing is required before laser scanning becomes a staple form of measurement.

## 3. Methodology

To determine if laser scanning can be used to capture and analyse forest structures, a comparison against the current methods must be completed. This was executed by obtaining data on the same structure using both laser scanning and current methods. The results were then compared to determine the usability of laser scanning within this environment.

## 4. Key Outcomes

By determining diameter at breast height and tree height, it was possible to estimate tree volumes. This allowed for an accurate comparison between traditional methods and the scan data. Resultantly, the suitability of laser scanning within this field was able to be assessed.

## 5. Further Work

With time permitting, it would be ideal to produce a digital elevation model from the scan data. It would also be ideal to geo-reference the scans so that the structure is given its real world location and can be aligned with existing survey data of the area.

## 6. Conclusions

Terrestrial laser scanning is a relatively new technology. However the high accuracy, extremely detailed data that is captured has resulted in its uses constantly increasing. With some further advancements, the technology has the potential to become the traditional technique when capturing and analysing forest structures.

## Acknowledgements

I would firstly like to thank my supervisor, Dr Xiaoye Liu, for her continued guidance throughout the project. I would also like to thank James Derksen for his assistance in recording data using the laser scanner. Finally, I would like to thank Dr Zhenyu Zhang for his assistance with the laser scanner field work and processing.

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- Thies, M., Spiecker, H. (2004). Evaluation and future prospects of terrestrial laser scanning for standardised forest inventories. *International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences*, pp. 192-197.

# DEVELOPING A FRAMEWORK FOR MAPPING PROJECT COMPLEXITIES

Sponsor – School of Civil Engineering and Surveying



**Brett Cronan**

Bachelor of Construction  
(Management)

Supervisors: Jo Devine, Lecturer,  
Construction Engineering and  
Management and Program  
Coordinator; Bachelor of  
Engineering (honours)(civil)

Nateque Mahmood, PhD,  
Lecturer, School of Civil  
Engineering and Surveying

**Keywords:** Project Complexities, Project  
Management, Framework

## 1. Introduction

The purpose of this paper is to identify a framework that project managers can use in order to improve management tools and techniques when working on complex project.

## 2. Background

In today day and age we live in a ever changing, money driven, projectfied world. In a ever changing world, organisations are always searching for the latest, unsurpassed and value for money projects that define who they are. The increase in need for latest and greatest infrastructure has seen the rapid increase of need for the so-called 'best' project managers to lead these projects.

This paper will aim too show the relationship between uncertainty and complexities of a project. The paper will explore each of these two issues and how the uncertainly directly relates to complexities. This exploration will negate any confusion between the two factors and prove beyond doubt the findings of the paper.

## 3. Methodology

This paper provides and extensive literature review on the lack of harmony surrounding complex projects and thus will provide an extensive view and a significant investigation of the concepts. A framework based on project complexities will be constructed and proposed extending Remington and Pollack's (2007) framework.

## 4. Key Outcomes

The paper proposes a redeveloped and extended framework of project complexities. The framework will become steering wheel for project managers and will complement the traditional project management theories.

## 5. Further Work

There is still some work to be done with fine tuning the framework and also testing the framework on complex projects. Furthermore, the framework needs to be tested for workability within the industry and wether the tool can be viable.

## 6. Conclusions

After reviewing literature on project complexities, this review aimed to give a better understanding of what project complexities actually are. The paper identified a framework that project managers can use in order to identify complexities that may be associated with a project. Within the framework, tools and techniques were introduced that could reduce or alleviate the complexities of a project and ultimately reduce the complexities surround a project.

## Acknowledgements

I would like to thank Jo Devine and Nateque Mahmood for the assitance given to complete this project. Without their guidance this project would not be possible.

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Remington, K. and Pollack, J. (2007), Tools for Complex Projects, Gower, Burlington, VT.



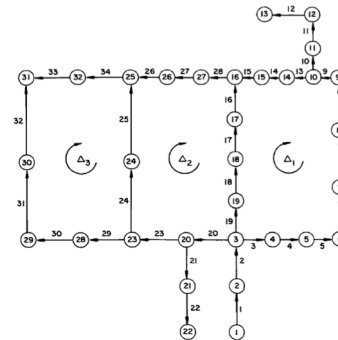
# Hydraulic Analysis and Optimisation Modelling of Water Supply Distribution Networks Using Genetic Algorithms

Sponsor – School of Civil Engineering and Surveying



**Sean Cummins**

Master of Engineering Science  
(Environmental)



Supervisors: Dr Laszlo Erdei, USQ

**Keywords:** Genetic algorithms, water distribution systems, optimisation

## 1. Introduction

Water distribution systems (WDS) are costly and complex. Choosing pipes is a nonlinear combinatorial problem with a vast solution space. Consider just 20 pipes and 10 pipe diameter choices - there are  $10^{20}$  combinations and each one which must be analysed using nonlinear hydraulic equations. Traditionally engineers have used rules of thumb and experience to design a WDS, but given the number of possible solutions it is unlikely to be optimal or even near optimal. Better methods of pipe selection are required to reduce costs while still meeting the hydraulic requirements of the network.

## 2. Background

Heuristic search techniques have emerged as means of providing solutions to non-linear, non-differentiable combinatorial problems with large solution spaces that, while not provably optimal, are significantly improved. One flavour of heuristic search has proven to be particularly popular and effective in WDS design optimisation - genetic algorithms (GA).

## 3. Methodology

From the literature, best practice techniques for GA application to WDS optimisation were identified and used to implement a GA program using the C programming language. Benchmark test networks as well as a real WDS were selected to test the GA performance. The parameters that govern GA performance were selected after undergoing a standardised calibration procedure suggested in the literature. 30 executions of the GA were performed

**Figure 1 – Hanoi WDS, a benchmark network**

against each test network and the performance characteristics recorded.

## 4. Key Outcomes

The GA found the best-known least-cost solutions to both of the chosen benchmark networks. The reliability of the GA was improved by seeding trials with the best result from previous trials.

## 5. Further Work

Still remaining is to test the GA against a real network and find whether a lower cost selection of pipes can be found. Future work could include investigating the performance of algorithm variants such as arithmetic crossover, Gaussian mutation and niching.

## 6. Conclusions

Genetic algorithms have been found to be an effective approach to finding good solutions to the problem of least-cost pipe selection in WDS design. The GA implemented here was able to find the best-known solutions to two benchmark networks.

## Acknowledgements

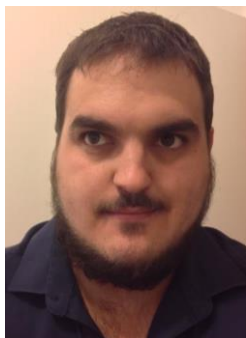
I would like to sincerely thank Dr Laszlo Erdei for his unfailing dedication and guidance throughout the project, and for supplying such an interesting topic.

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# Radio Astronomy on a Dime

School of Mechanical and Electrical Engineering



**Mark Currie**

Bachelor of Engineering  
(Electrical & Electronic)

Supervisors: Dr Andrew Maxwell, USQ

**Keywords:** Please include three keywords that describe your work.

## 1. Introduction

This project was undertaken to investigate the use of low level consumer SDR hardware and free ware with low cost satellite dishes and minor modification. The whole purpose of this dissertation is to create radio sky maps of the cosmos in a low cost automated portable manner.

## 2. Background

Since man has gazed up the stars the question of what lies beyond has puzzled even the most scientific researchers. It has not been until the last 80 years that scientists have really been able to dissect the cosmos.

Through radio spectroscopy and radio astronomy scientists are now able to learn the composition of the atmosphere of other planets and what is / is not present on the surface. To achieve this an array of radio telescopes is necessary connected by a base line. This costs millions of dollars.

## 3. Methodology

To achieve any results it was first necessary to discover what was possible given the limitation of the hardware. To achieve this a simple test apparatus was constructed to outline the possible issues as this had never been scientifically investigated. From the initial apparatus a second apparatus was built from the knowledge gained from the first design. This design was thoroughly tested in the anechoic chamber after being modelled mathematically

## 4. Key Outcomes

The key outcomes of this dissertation include the creation of two low cost radio telescopes using a USB SDR chip. Another key outcome was the use of and



**Figure 1 – Satellite dish**

manipulation of SDR decoding software. From this the entire system was assembled and tested ensuring functionality and design specification

## 5. Further Work

Further work on this project will be for a future student to attempt to create a baseline array for increased accuracy and precision.

## 6. Conclusions

Findings from this dissertation are that yes it is possible to create a radio telescope on a budget however it stretches the limits of DIY. The Use of a low level SDR chipset is possible and gives reasonable results.

## Acknowledgements

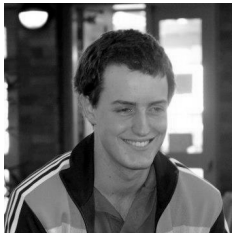
I would like to Thank DR Andrew Maxwell for his help and support throughout the duration of the Project. I would also like to mention the colleagues around me for their interest in the project and the University Of Southern Queensland for supply the test receivers and Anechoic chamber.

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# Quantification of the measurement error associated with in situ measurements of water absorption and attenuation using the AC-9 instrument

Sponsor – School of Civil Engineering and Surveying



**Alex Darton**

Bachelor of Spatial Science  
(Surveying)

Supervisors: Dr Glenn Campbell, USQ

**Keywords:** Remote Sensing, AC-9, *in-situ* measurement

## 1. Introduction

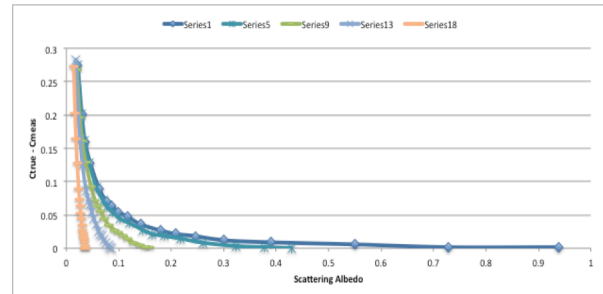
This project aims to provide a correction scheme for *in-situ* measurements of water absorption and scattering using the ac-9 instrument. This information is used in remote sensing applications where the water constituents are to be analysed. Computer simulations will be undertaken to obtain the data for the correction scheme. The data used to define the simulations will be sourced from research papers for Australian waters and tested against current research.

## 2. Background

Remote sensing of water bodies is a field that uses satellite imagery to obtain accurate concentration data on water quality parameters (phytoplankton, Coloured CDOM, Tripton) to evaluate the health of the water body. High accuracy field measurements of the Inherent Optical Properties (IOPs) are used to process remotely sensed imagery and obtain concentration values. This is due to the link between the absorption and scattering of light that is caused by the water quality parameters in the water body and the reflectance. The IOPs are characterised through measurements with the AC-9 instrument. Due to the design of the instrument these measurements require correction to ensure that high accuracy is achieved and a number of corrections exist.

## 3. Methodology

Data was synthesised for Australian waters from a number of sources. This data was compiled and setup for use in an optical environment simulator called Simulo a Monte Carlo random number simulation environment. This environment uses random numbers to decide on the fate of the photons as they travel through the AC-9 instrument within Simulo. This program simulated the operation of the AC-9



**Figure 1 – Scattering Albedo vs Measurement difference between measured and true Attenuation Coefficient for 5 datasets.**

instrument and output a large amount of information that was available for processing. IDL was then used to process the log files from Simulo to extract and process the required data and evaluate the results.

## 4. Key Outcomes

The key outcome of this project is the accurate correction of IOP measurements taken in the field. This will be completed through the correction scheme that is the main output for this project.

## 5. Conclusions

The current data points towards a distinct linear trend in the data. This supports the current correction theories. Analysis of further elements of the systems is producing other relationships that warrant further investigation. This requires further work to test the results that have been obtained and test other variables. Given the nature of light interaction with water no correction will be perfect.

## Acknowledgements

I would like to thank my supervisor Dr Glenn Campbell for his guidance and providing the inspiration for this project.

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# The Photogrammetric Analysis of Forested Areas

School of Civil Engineering and Surveying



**James Anthony Derksen**

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(Surveying)

Supervisors: Dr Xiaoye Liu, USQ



**Figure 1 - USQ UAV Octocopter fitted with Canon 1100D (Photograph by James Derksen 2014)**

**Keywords:** Photogrammetry, Forestry, Timber, Biomass, Volumes, Parallax, Stereoscope, UAV.

## 1. Introduction

Photogrammetry is the study, extraction and implementation of data from photographs other than that which is purely seen by the naked eye. Photogrammetry and its potential was realised soon after portable cameras started being used in the mid-1800s when it was discovered that capturing two photographs next to each other of the same object could be viewed in three dimensions after development through a device called a stereoscope, creating the effect of seeing the object real time (stereovision). This effect is caused by parallax, of which is used to this day to calculate the depths of objects in three dimensional photogrammetric surveys.

## 2. Background

Previously, the measurement of timber and biomass volumes had been performed in two ways. One involving the basic measurement of circumference and height, but this does have undesirable ambiguity. The other is the method of terrestrial laser scanning, which creates an almost perfect vegetation model albeit with a high cost. In the past ten years, computer processing power and the subsequent high powered photogrammetry software has meant that three dimensional models are becoming easier every year to make from nothing but photographs with simple control marks. This project looked at whether photogrammetry was a suitable method of measuring timber and biomass volumes of forested areas.

## 3. Methodology

This project looked at previous photogrammetry research as well as methods of data collection, processing software and photogrammetry target design. With what was researched, a tract of land covered by varying vegetation was selected, targets were designed and built, a control survey was conducted on the

property and an aerial photogrammetric survey was conducted using a USQ Engineering UAV. This data was processed by ERDAS Imagine and turned into a Digital Terrain Model and 3D mesh from which volumes were calculated. These were compared against conventional methods.

## 4. Key Outcomes

As researched and replicated in findings, timber and biomass volumes can be measured by means of photogrammetry, as long as everything that needs to be modelled is in at least two photographs. It was also found that using a larger F-stop camera setting led to more consistent sharpness resulting in a more accurate survey.

## 5. Further Work

Possible terrestrial photogrammetry in same area.

## 6. Conclusions

With the need for accuracy and precision of data increasing yearly, and continual gains in such with photogrammetry, the possibility and viability of using photogrammetry to calculate timber and biomass volumes in forested areas is high, with it expected to become common place in the near future.

## Acknowledgements

Dr Xiaoye Liu (USQ) for helping me formulate the idea and supervision. Terry Byrne (USQ) for his organisation, research and flying the UAV. Wade Mills (C.R. Kennedy) for getting me interested in photogrammetry in the first place.

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# Investigation of performance parameters of Solar boosted heat pump water heater.

Sponsor –School of Mechanical and Electrical Engineering



**Lindsay Dobson**

Bachelor of Engineering  
(Mechanical)

Supervisors: Dr Ruth Mossad,  
BEng, MEng Cairo PhD New Mexico  
SU

**Keywords:** Heat pump, Solar, Water heater

## 1. Introduction

This project aims to identify the limiting parameters that affect the coefficient of performance (COP) for a solar assisted heat pump (SAHP) water heating unit. A Computational Fluid Dynamic (CFD) analysis will be undertaken in ANSYS to validate the impact of changing the identified parameters.

## 2. Background

Water heating for domestic use has a high energy demand and contributes to a large portion of the economic cost of running a household. Heat pumps and Solar systems for domestic hot water heating are utilised throughout the world with success but are negatively affected in situations where low temperatures are encountered or solar irradiation levels are not high enough to adequately heat the water to the desired temperature. One increasingly popular energy efficient way of heating water is with the solar assisted heat pump (SAHP). The SAHP combines the advantages of solar water heating with the efficiency of the Heat pump to provide a system with low electricity costs.

## 3. Methodology

A literature review was conducted to identify previous experimental data. The data was analysed to identify the impacts of changing parameters on the COP for the system. A simulation model was developed to study the parameters of solar assisted heat pump. The model was explored by conducting a CFD analysis and the results compared with published experimental results for validation. The differences in COP for alternative configurations of the SAHP were identified within the parameters of the published experiments conducted. .

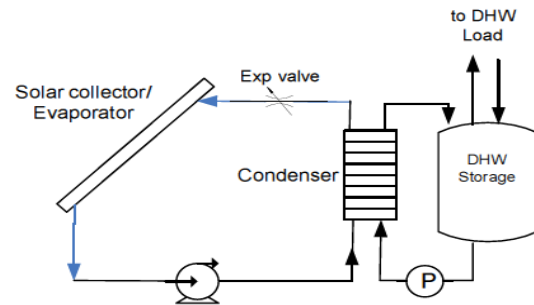


Figure 1 – SAHP configuration

## 4. Key Outcomes

The parameters with the largest effect on COP appear to be heat pump characteristics and the ability to control the heat pump inputs. Parameters that have been identified through initial investigation include climatic conditions; solar irradiation, wind speed, frost. Dynamic changes in the system relating to load demands, compressor speed, solar collector area and angle, water storage volume and the refrigerant used in the refrigeration cycle.

## 5. Further Work

Future work will include sensitivity studies to investigate ratio of different parameters and the effect of using a heat pump with a different refrigerant.

## 6. Conclusions

Optimisation is best achieved by consideration of geographical location combined with appropriate system control. Understanding the required limiting parameters for this control will enable the development of efficient systems with reduced demand on conventional resources

## Acknowledgements

I would like to acknowledge the understanding and continued support of my wife Shannon and 3 Children, Claudia, Lucas and Eva during this project. I would also like to thank Dr Ruth Mossad for her assistance and persuasion during this work.

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# Project Planning Framework

School of Civil Engineering and Surveying



**Gavin Doherty**

Bachelor of Engineering (Civil)

Supervisors: Mr Paul Tilley, USQ

Mr William Cullen, BMA

**Keywords:** Project Management; Project Planning, Project Framework.

## 1. Introduction

For a successfully executed Capital Project, it is fundamental that the planning stage of the project is completed to a high standard that is fit-for-purpose. To facilitate a successful planning stage for the associated business requirements and execution risks, this dissertation is to implement a Project Planning Framework that is tailored for projects that will be executed at BHP Billiton Mitsubishi Alliance (BMA), Peak Downs Mine.

## 2. Background

At Peak Downs Mine, there have been projects that have had execution/construction issues, which can be directly attributed to poor planning practices. These issues have impacted the success of the project's deliverables, including cost, schedule and quality failures. There are also projects that have been executed successfully and have met business commitments. This project is to produce an effective Project Planning Framework, to ensure planning processes are aligned and planning resources are focusing on the right tasks and deliverables. Currently the processes completed in the planning phase are not aligned, this Project Planning Framework will standardise planning processes and deliverables.

This dissertation is extending my existing knowledge within my Civil discipline and Project Management experiences, highlighting design and planning quality processes to produce an acceptable planned project.

## 3. Methodology

To produce an effective Project Planning Framework for Peak Downs Mine, the following methodology has been employed: 1. An effective literature review

completed to understand current benchmark project planning framework deliverables. 2. Planning Framework focussed interviews with content experts that have extensive subject matter experience. 3. Development of Project Planning Framework Deliverables. 4. A review of completed project close out reports to understand successful and unsuccessful delivered projects, and links to the planning stage – this is challenged against the developed project planning framework deliverables 5. Workshop with a cross section of Peak Downs Project Planning and Execution teams to further challenge the developed project planning framework. 6. Collate Deliverable Templates to finalise a robust Project Planning Framework.

## 4. Key Outcomes

The key outcomes that have been achieved thus far includes: A thorough literature review – this has been valuable with highlighting benchmark project planning practices. Planning focussed interviews with content experts – this has been valuable as it has confirmed that a robust project planning framework is required, and valuable feedback in deliverables have been analysed. Project Planning Framework Deliverables have been developed succeeding a literature review and content expert interviews. A review of completed project close out reports has been completed, and the drafted Project Planning Framework Deliverables effectively facilitates planning processes that have been proven successful, and negates poor planning practices that have resulted in poorly executed projects.

## 5. Further Work

The following tasks remain: 1. Workshop with a cross section of Peak Downs Project Planning and Execution teams to further challenge the developed project planning framework. 2. Collate Deliverable Templates.

## 6. Conclusions

Research completed has proven that a robust Project Planning Framework is required to make sure the right projects are being executed, and the right planning works has been completed to minimise execution/construction risks.

## Acknowledgements

Mr Paul Tilley, USQ, Mr William Cullen and Mr Herbert Gruber, BMA, have also been key contacts with sponsoring this industry driven dissertation and allowing access to business documents and resources.

# An Investigation into Stormwater Quality Treatment Practices in the Mackay Region



## Ross Donnelly

Bachelor of Engineering  
(Honours)

Majoring in Civil  
Engineering

Supervisors: Dr Malcolm Gillies, USQ

**Keywords:** Stormwater Quality Treatment (SWQT), State Planning Policy (SPP), Region Specific Outcomes

## 1. Introduction

The broad aim of this investigation is to review current stormwater quality treatment practices in the Mackay region, specifically the effectiveness of treatment and the costs associated with such systems. Based on this, comment will be made on how an alternative approach could be implemented which would more effectively reduce the pollutant loadings in our waterways while reducing the costs experienced in the development industry and incurred by local Councils, thus improving housing affordability.

## 2. Background

Common feedback from the development industry is that stormwater quality treatment is a waste of time and money, reduces the available footprint for developable land, can be an eyesore within their development and even if it is constructed, established and maintained adequately, will not be maintained once handed over to Council as their asset at the end of the 2 year maintenance period.

## 3. Methodology

Three key tasks have been undertaken. The first involved reviewing local SWQT devices to determine their effectiveness of design, construction and maintenance simply by visual inspection. Secondly a cost assessment was undertaken. This involved comparing actual costs incurred to budget estimates from design software MUSIC.

Thirdly (and most importantly) a review of current land uses across the Mackay region was undertaken using GIS mapping. The results of this assessment were then used to compare volumes of sediment and nutrient runoff between different land uses.

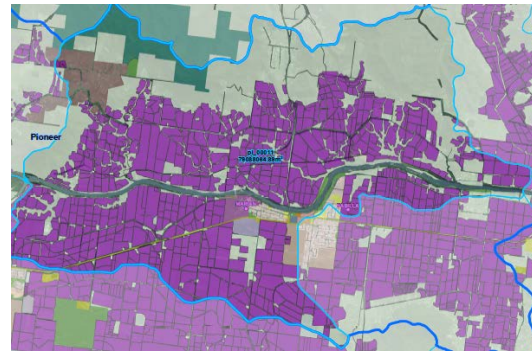


Figure 1: A typical land use map generated using GIS software (cane farming land shown in purple)

## 4. Key Outcomes

Site inspections to local developments indicated that the majority of current SWQT devices were of poor standard. Based on the cost assessment, construction costs for SWQT devices in the Mackay Region currently amount to approximately \$4,600 / lot.

The land use assessment indicates that there is approximately 108,500ha of cane farming land in the Mackay Region, whilst there is only approximately 4,700ha of land zoned for residential purposes.

## 5. Further Work

Maintenance and renewal costs still need to be reviewed and summarised and an overall cost/benefit analysis remains outstanding. Research into the benefits that could be achieved through improved cane farming practices will lead to recommendations regarding region specific outcomes.

## 6. Conclusions

Clearly a significantly greater volume of sediment and nutrient runoff occurs from cane farming land than residential land in the Mackay Region. The State Government should review the SPP to focus on more effective region specific outcomes that will improve the quality of our downstream waterways.

## Acknowledgements

Aurecon for providing the tools and systems required to undertake this project. Reece Zonta and Nicholas Moore who kindly donated their time to assist with the GIS analysis.

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## Determining the reduced Waterlevels of Warriewood Wetlands.



**Student: Sean Christian Doyle.**

Bachelor of Spatial Science (Surveying)

**Supervisor: Dr Dev Raj Paudyal.**

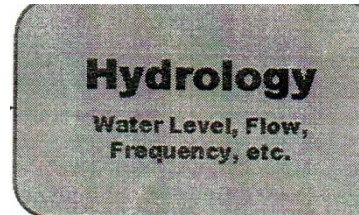


Diagram 1: The importance of water levels.

### Keywords:

**Water, Level and Measure.**

### 1. Introduction

Warriewood Wetlands are important to the community of Pittwater and the Pittwater Local Government is committed to the preservation and conservation of the Wetlands. This project will attempt to determine the water levels of the Wetlands and the Dissertation will begin by touching on the need for the work, the background of the need and will address the objectives. The literature review will follow in chapter 2 and will build on the need for the study including the current methods for measuring the levels and then look at some alternatives. Chapter 3 will include the methodology involved calculation processes and manipulation. Chapter 4 is about the presenting and analysing the data which then follows on to the final chapter where the conclusions lie.

### 2. Background

The Warriewood Wetlands are located in the Warriewood Valley on the Northern Beach's of Sydney. Wetlands are dependent on water as diagram 1 implies and are described as the transition between water bodies and land forms and there hydrological cycles can be quite complex while the biota that live in them can be unique to other habitats. Since settlement the Wetlands size has reduced and the hydrological cycle has been altered. For the long term health of the wetlands the hydro - period, hydrology and water budget need to be analysed and all three have water level as a common component.

### Methodology:

The methods used will be to design and implement a precise levelling run which will pass through and around the site. Two double levelling runs will run along the pathways which pass through them and 9 Water Level Depth Stations will be connected to these runs. Approximate co-ordinates will be scales off a topographic map for position and using the specially built instrument the depth's from these nine stations to the water level will be recorded. The reduced levels, water depth values will be used to calculate the water levels.

### Key outcomes:

The key outcomes will be to determine the water levels of Mullet Creek and the Wetlands and see if there is a relationship. And to develop a non damaging method for collecting water level data by constructing a special instrument. Finally the organization, calculation and the presentation of the Project in the form of a Dissertation.

### Further work:

Any further work would include developing a better Water Level Depth Measuring instrument, measuring more points throughout the site and over a much longer period to determine the hydro - period.

### Acknowledgements

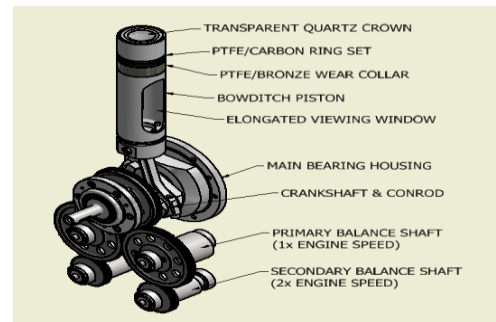
I would like to thank Dr Dev Raj Paudyal for his help and also the team from Total Survey Systems for their kindness and use of the SDL30 Digital Level.

# Optical Access Engine Development

School of Mechanical and Electrical Engineering

## Kevin Dray

Bachelor of Engineering  
(Mechanical)



Supervisors: Prof. David Buttsworth, USQ

**Keywords:** *Engine, Mechanical, Design*

An Optical Access Engine is an engine (in this case a single cylinder internal combustion engine) where the combustion process can be viewed/studied from outside the engine body.

This project has been to design (in part) such an engine for intended use in USQ's Engine Laboratory. A partial existing design from Oxford University's Prof. Richard Stone was provided to use as the basis of this design. The main focus has been to develop Prof. Stone's partial design into a verified & complete design package for USQ to invest in the manufacture of this engine.

### 1. Background

The need for such an engine is for the purposes of combustion research. By utilising various high speed camera technologies, thermal imaging and the diagnostic functions of lasers in conjunction with pressure, temperature and other transducers engineers can study the combustion process occurring in modern engines to a greater detail than ever before. This leads to improvements in engine design and thus more powerful, efficient & cleaner engines.

The concept of an optically accessible engine is not new, in fact it dates back to the 1930's. The versions in use today are designed around modern engine design and the available diagnostic technology. Companies such as Ricardo Group & Lotus are leaders in developing and providing this technology. Most major engine manufactures also develop their own research engines.

### 2. Methodology

The existing design was mainly of the crankcase and balance shaft arrangement. Drawings of the piston were non-existent and of the cylinder were limited.

The first step was to take what was provided and 3D model using design software (Autodesk Inventor). From there utilising the engine research performed, the

**Figure: Engine Internal Components & Main Bearings**

existing design was refined & continued until the engine was designed to the top of the cylinder block. Next the components and movements were analysed using a combination of hand calculations, F.E.A. & virtual simulation to validate the design with respect to strength, balance & fatigue. Finally using the modelling software detail drawings of the design were produced.

### 3. Key Outcomes

The main achievement or key outcome of this project was the successful development of the existing partial design into a design package able to be utilised for manufacture and further development. Another successful outcome was the application of virtual simulation software to validate the hand calculations with respect to balancing.

### 4. Further Work

It was hoped at the start of this project to reach the point of marrying up an existing engine head (Lancer 4G93) to this bottom end. Unfortunately time and parts availability prevented this from happening. It is hoped that another student will complete this to a working engine design.

### 5. Conclusions

This project has been concluded to the point of delivering detail drawings for manufacture of the engine bottom end up to & including the upper cylinder block.

### Acknowledgements

I would like to thank Prof. David Buttsworth for his input and guidance throughout the project.

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# Aquaplaning Assessment and Mitigation in Flat Terrains

Sponsor – Harrison Infrastructure Group



## Benjamin Dudman

Bachelor of Engineering  
(Civil)

Supervisors:

Trevor Drysdale (USQ), Tony  
Gallagher (Harrison Infrastructure  
Group)

**Keywords:** Aquaplaning,  
Hydroplaning, Mitigation, Assessment

## 1. Introduction

Aquaplaning is a very dangerous phenomenon and has the potential to affect all road users. It is the responsibility of road engineers and designers to ensure that roads are designed and constructed in a manner which minimises the potential for aquaplaning and ensures road users' safety.

## 2. Background

Roads in flat terrains can have very high levels of aquaplaning potential when superelevation is developed on curves. Solutions to minimise this risk and methods of assessing risk are researched and analysed in this project.

## 3. Methodology

Research was done to determine the major causes of aquaplaning and the current assessment methodology used in Queensland. Once this background knowledge was established, more detailed qualitative research was done to determine a raft of potential solutions to reduce the risk of aquaplaning in flat terrain. These solutions were assessed and compared using an evaluation matrix. The second major research element of this project was to determine various methods of aquaplaning assessment used world-wide. These were then compared against the method used in Queensland. The final part of this project was a case study performed on a section of the Toowoomba-Cecil Plains Road where the knowledge attained in the previous two sections was applied. The designed and "as-constructed"

geometries of the road were carefully analysed

and assessed for aquaplaning potential. Skid testing and texture depth testing of the road was also conducted.

## 4. Key Outcomes

This project identifies and evaluates a range of solutions to reduce the potential for aquaplaning in flat terrains. The aquaplaning assessment methodology used in Queensland is also compared against other methodologies used internationally. This project also determines whether the case study road poses significant aquaplaning potential based on various assessment methods and data collected from the site. Recommendations made regarding current and future treatments on the Toowoomba-Cecil Plains Rd to ensure aquaplaning potential is minimised is also a key outcome.

## 5. Further Work

To date some texture depth and skid resistance testing of the Toowoomba-Cecil Plains Road still remains. Comparison and evaluation of alternate assessment methodologies are also required before the completion of this project. Due to time restraints, Vericom testing of the Toowoomba-Cecil Plains Road to determine vehicle accelerations and the 85<sup>th</sup> percentile speed of various sections of the road will not be able to be completed.

## 6. Conclusions

In conclusion, it has been found that the most effective measure used for mitigating aquaplaning is careful consideration throughout the whole design process. Solutions become more expensive and less effective the later in the design process that aquaplaning is identified as an issue and addressed. Various geometric, drainage, surfacing and short term preventive actions may be taken to reduce the potential for aquaplaning in flat terrains, however the most effective solution is the careful co-ordination of road alignment and horizontal and vertical standard geometry early in the design process. Other methods may be used to assist good road design in mitigating aquaplaning potential, however these cannot be used in its place.

## Acknowledgements

Thank you to the Harrison Infrastructure Group for providing this project topic and giving access to information regarding works done on the Toowoomba-Cecil Plains Road as the basis for the case study.

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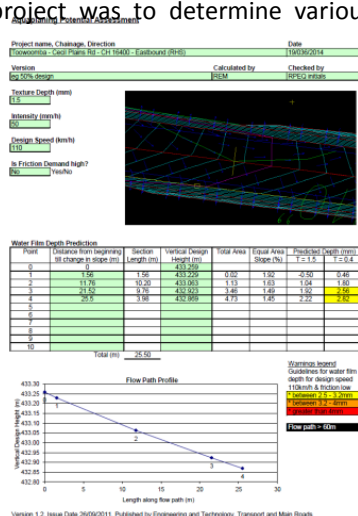


Figure 1 - Toowoomba-Cecil Plains Rd Aquaplaning Assessment

# Arc Flash Protection of a Low Voltage Motor Control Centre (MCC)

Sponsor – Cristal Pigment Australia



## Paul Dugdale

Batchelor of Engineering  
(Electrical/Electronic)

Supervisors: Andreas Helwig, USQ  
Tim Mace, Cristal Pigment Australia

**Keywords:** Short circuit, Incident energy, Flash-protection boundary

## 1. Introduction

An arc is plasma current that occurs as the result of a voltage differential between two points. The arc is created when the voltage level exceeds the equivalent value of the insulating strength limit of the air (or gas) between those particular points. The arc evolves in the vapour of conductive metal, creating a circuit, which electrically links the two termination points across the gap. Given the right conditions, an arc will continue to carry current until either the circuit's protective device operates, or the impedance (ionisation of the air) between the two points becomes too great to sustain the arc.

There are a number of hazards that are directly related to an arc flash event. These can include electric shock, thermal burns, projectiles, blast/pressure waves, blinding light, intense sound, fire, toxic gases/vapours, and various effects due to powerful magnetic fields and plasma.

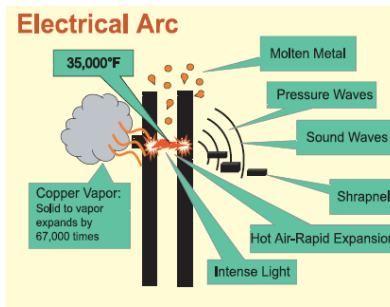
## 2. Background

One of the key performance indicators (KPIs) at Cristal Pigment (CPA) is to strive for a safety culture of "Zero Harm" (i.e. no workplace injuries). Zero workplace incidents/accidents aid the morale within the workforce, while also assisting in lowering insurance premiums. It can also help with the retention of workers as they see, and believe, their employer is concerned about their personal well-being.

CPA has two plants (one is 25 years old, while the other is 50). The motor control centres have never been assessed, and are unlikely to provide any arc flash protection. As such, there is an internal company drive to conduct a survey of the site's switch rooms (and operation methods), to assess their potential arc flash levels, and to investigate ways of reducing/mitigating the risk of damage and injury to equipment and personnel.

## 3. Methodology

An audit of all associated plant and equipment was carried out. The power network of the plant was then modelled, and a short circuit evaluation conducted. The network's protection was studied to establish whether it provided the necessary protection/co-ordination between devices. Finally, with the aid of a variety of standards, an arc flash study was conducted.



**Figure 1 – Electric Arc Model (Cooper Bussmann, 2014)**

The result of this study was a series of calculated values for the potential incident energy levels at certain points within the network. Working from tables in the American standard NFPA 70E, a hazard risk category was quantified for each particular incident energy calculation. This category is then used to guide the potential worker to the type of personal protective equipment (PPE) that will be necessary to carry out their work.

## 4. Key Outcomes

The result of this research has shown that the most dangerous place within the power network was in the wiring (and connections) between the LV terminals of the transformer and the main circuit breaker of the MCC. This was likely due to the location and type of protective device in use (which happens to be a 22kV fuse upstream of the HV termination of the transformer). When calculated, the clearing time of this fuse was found to be greater than 8 seconds, by which time life could be lost and irreparable damage would occur.

## 5. Further Work

Reviewing/updating the site's switching procedures, and carrying out a technical & safety cost benefit analysis of upgrading/replacing the MCC still require addressing.

## 6. Conclusions

This research suggests that the transformer's HV protective fuse should be replaced with a circuit breaker (for a faster response time). Also, isolation of a fault could be greatly sped up by the installation of optical protection within the MCC.

## Acknowledgements

I would like to acknowledge several people for their guidance, support, and sponsorship during my dissertation preparation. These include: Tim Mace and Cristal Pigment Australia for providing the project and access to the plant; Murray Newman for offering guidance from his wealth of experience; Archer Electrical Engineering for permitting the use of their "Power Tools for Windows" software (and licence) for my studies; Andreas Helwig for your guidance and support; and finally my family, who have always been supportive, even though they may feel that they have been placed second for the last 9 years.

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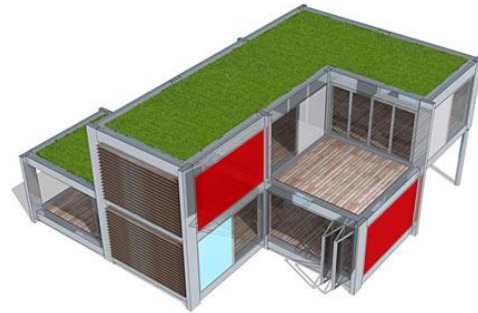
# Developing a Modular Construction Code for the Residential Sector

Sponsor – School of Civil Engineering and Surveying



**Richard J. Dugdell**

Bachelor of Engineering (Civil)



Supervisors: Dr Steven Goh, USQ

**Keywords:** Modular, Residence, Code

## 1. Introduction

Off-site construction and prefabricated building technologies will play a major role in the future of our built environment. Modular construction is one of these off-site construction methods which comprise of prefabricated units that are normally fully fitted out in manufacture and are installed on-site as load-bearing “building blocks.” (Lawson, Ogden, & Bergin 2012).

This project’s aim is to analyse the design and construction processes of a modular building, in particular, residential construction, and determine if existing codes and standards that are intended for traditional construction are suitable for the modular industry. It also aims to identify any gaps in the standards and codes where a proposed modular construction code would be beneficial.

## 2. Background

Modular construction is growing within Australia, not just in the residential sector, but over a broad range of building classes. It has been recognised that there is a need for a Modular Construction Code as PrefabAUS in conjunction with the newly formed Modular Construction Code Board have started the process of producing a modular building code for multi-level projects.

## 3. Methodology

The residential modular construction code outline will be produced with the aid of matrices, which include criteria to determine the adequacy of existing and required new codes. Example criteria include: Are existing standards satisfactory for design if additional influences of vibrations and stresses are added from transport and lifting of modules?

**Figure 1 – Modular Residence Impression (Rich 2005)**

## 4. Key Outcomes

Design and construction standards have been checked to determine their adequacy. It has been found that many of the design standards such as timber and steel structures standards will need further and revision before they are adequate for modular construction.

## 5. Further Work

A feasibility study is yet to be completed which will assess manufacturers claimed advantages that modular construction has over traditional construction to further reinforce the fact that a modular construction code is required.

## 6. Conclusions

A modular construction code will not be produced from this project, only recommendations as to what needs to be looked into further. Creation of an actual code would require further research and testing from industry professionals.

## Acknowledgements

I would like to thank Dr Steven Goh for his continued help and support on this project as well as the numerous businesses such as Hutchinson Builders, Happy Haus, & Hoek Modular Homes that have helped me gain insight into the modular building industry.

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# Exploring the Application of Closed Form Solutions in Geotechnical Problems

School of Civil Engineering and Surveying



**Timothy Eaton**

Bachelor of Engineering  
(Civil)

Supervisor: Dr Kazem Ghabraie, USQ

**Keywords:** Analytical solution,  
Mindlin's solution, Boussinesq's solution

## 1. Introduction

This project explores the uses and values of closed form solutions in specific areas of geotechnical engineering. Three closed form (analytical) solutions, Kelvin's, Boussinesq's and Mindlin's solutions have been chosen and researched to determine their applications in geotechnical engineering. These applications have been examined with the aim to modify, further define and/or extend upon them so that they may be applicable to new problems.

## 2. Background

With modern day computers and programs many problems in geotechnical engineering may be easily solved numerically. Although these solutions supply accurate answers, analytical solutions offer advantages over these and other types of solutions, in that they allow insight into the inner workings of the problem, whilst additionally serving as an efficient means for approximation (Sun et al. 2013). Literature on the applications of the analytical forms of Kelvin's, Boussinesq's and Mindlin's solutions covers geotechnical areas such as tunnels, piles, ground anchors and footings.

## 3. Methodology

A review of research on Kelvin's, Mindlin's and Boussinesq's solutions gave an indication of the ways each of the solutions could be applied to solve for certain problems. This method was used to develop some basic ideas on the ways to go about modifying the solutions. To date mathematical methodologies have been employed such as integration and trial and error to generate charts and equations. Figure 1 shows a circular load, the equation for which was obtained through integration.

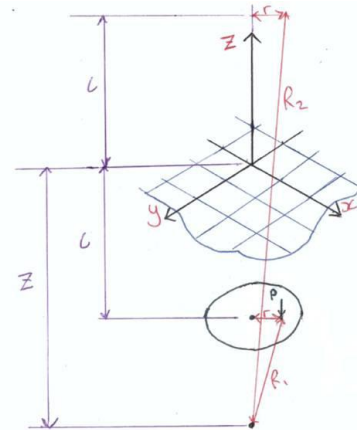


Figure 1: A uniformly distributed vertical circular loading beneath the surface (x-y plane).

## 4. Key Outcomes

A literature review has been performed, researching and identifying a number of related geotechnical equations. Additionally further research has been performed to gain an understanding of the geotechnical engineering areas of which they may be applied. From here some preliminary calculations have been performed. Mindlin's solution has been successfully integrated and a look into the possibility of a Mindlin's solution-based influence chart has been exercised.

## 5. Further Work

Further work will be performed on the solutions in order to modify them to fit new applications. From here any practical applications as well as the overall value of the findings will be assessed by comparing and analysing them with the literature.

## 6. Conclusions

From preliminary findings the general benefits of closed form solutions appear to be apparent. The ultimate practical value of analytical solutions in the chosen area of geotechnical problems is yet to be determined.

## Acknowledgements

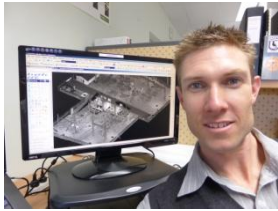
I would like to thank Dr Kazem Ghabraie for his formulation of great ideas as well as his unrelenting support and guidance on this challenging topic.

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Sun, H. S., Lei, G. H., Ng, C. W. W., & Zheng, Q. 2013. Displacements under linearly distributed pressures by extended Mindlin's equations. *Computers and Geotechnics*, 50, 143-149.

# TLS for 3D Zone Substation Modelling and Safety Clearances

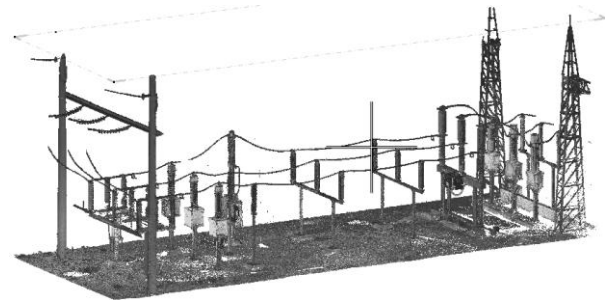
School of Mechanical and Electrical Engineering



**Darrin Edwards**

Bachelor of Engineering

(Power)



**Figure 1 – Point Cloud Model of a 132kV Feeder Bay**

Supervisors: Mr Mark Norman, USQ

**Keywords:** Zone Substation, Laser Scanning (TLS), 3D Modelling, Point Cloud, Safety Clearance.

## 1. Introduction

Essential Energy is a major electricity distributor operating in NSW, they are responsible for the operation and maintenance of more than 200,000 kilometres of power lines, 1.4 million poles and the network services of more than 800,000 homes and businesses across 95% of the state.

Zone Substations are an essential part of the electricity network in NSW, due to the aging network many of these assets now require major upgrades to maintain reliability and align with current Australian Standards.

## 2. Background

Maintenance and construction of Zone Substations requires accurate detailed drawings, to enable designers to produce quality designs. Unfortunately many of the drawings associated with these aging assets are also old, lacking accuracy and not easy to modify using current design and drawing standards. This project aims to determine if using Laser Scanning to produce “as built” 3D models would provide the required information accurately and in a format compatible with the current CAD procedures

## 3. Methodology

To determine the suitability of using a TLS, an Essential Energy Substation built circa 1950 with suspected low electrical clearances was scanned and modelled using a 3D CAD package. A high definition terrestrial laser scanner was used at this Substation to obtain the raw data and build a point cloud model. Using the point cloud model a thorough analysis could be conducted from a desktop environment and subsequent CAD 3D models were able to be produced.

## 4. Key Outcomes

The first major outcome of this project was to produce a useable accurate model of an “as built” Zone Substation utilising TLS technology and 3D modelling software. In the process of achieving this outcome the accuracy of the 3D model was compared against various site measurements to confirm that the level of accuracy within the model was suitable to proceed.

As a result of this the second major outcome of proving that the Substation safety clearances and lightning protection adhered to Australian Standards and Essential Energy Standards was also able to be achieved

The third project outcome was to justify the extra cost of this method by comparison against conventional survey techniques to highlight the extra value that the method provides to Essential Energy.

## 5. Further Work

Presentation of the outcomes of this dissertation to Essential Energy management to allow the technology to be utilised for future design projects, this will include Laser Scanning and 3D “as built” modelling.

## 6. Conclusions

The use of TLS technology is able to provide significant benefits for Substation design and development when used in place of conventional survey techniques.

## Acknowledgements

Thanks to Jason Streatfeild of Essential Energy for his support, and Dom Panetta for his ongoing assistance

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# USE OF FIBRE-OPTIC (FBG) SENSORS IN THE STRUCTURAL HEALTH MONITORING (SHM) OF A BATTLEFIELD HELICOPTER ROTOR BLADE

Sponsor – School of Mechanical and Electrical Engineering



**Michael Fairbanks-Smith**

Bachelor of Engineering  
(Mech)

Supervisor: Dr Jayantha Epaarachchi, USQ

**Keywords:** Helicopter, Composite, FBG.

## 1. Introduction

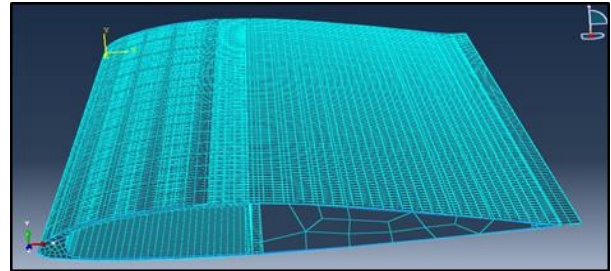
This project investigates the use of fibre-optic, fibre bragg grating (FBG) sensors in the SHM of a fibre reinforced plastic (FRP) composite helicopter rotor blade. The use of static strain and vibration testing for both pre & post small arms battlefield damage was utilised. A FEA was performed utilising ABAQUS software for comparison purposes.

## 2. Background

As the use of fibre composite components becomes more widely accepted, so does the inherent risk of sudden failure. This necessitates a sound SHM technique to warn of & prevent impending failure. Whilst this is true of civil FRP structures, it is particularly true of modern helicopters which utilise FRP components in primary structural & dynamic applications. Development of an advanced SHM method may extend component life, reduce operating & maintenance costs whilst improving safety & reliability. One such method which has not been fully investigated is the use of fibre-optic FBG sensors.

## 3. Methodology

Quantitative methodologies (FEA) & testing (flexural, tensile & calcination testing) have been employed to determine the rotor sub-component material properties. These properties enabled FEA modelling of the rotor blade system. Subsequently, a rotor blade test section was physically assessed using static strain & vibration testing. Ten surface mounted FBG & electronic strain sensors were positioned at highly stressed locations identified by the modelling. Testing was then conducted for both pre & post simulated battlefield damage. The FEA model will be validated with the experimental data & will be extended to simulate extreme blade operational conditions. The test data will be used to justify the rotor blade residual service life.



**Figure 1.** ABAQUS FEA rotor blade assembly model displaying sub-components and element mesh.

## 4. Key Outcomes

The key outcome of this project is the suitability of FBG sensors for measuring strains on an in-service FRP rotor blade. The complexity of such a component & the applied forces must be systematically researched, considered & applied. This highlights that accurate FEA modelling is a critical phase, which significantly impacts on the overall validity of the project outcomes. Furthermore, the design of laboratory testing methods is a significant project outcome, i.e., the design of the blade testing fixtures must not introduce stresses that would not otherwise be present in an in-flight environment.

## 5. Further Work

Whilst the modelling & physical testing of the component has been completed, final review & analysis of the obtained data is ongoing; however, significant conclusions can be drawn at this stage.

## 6. Conclusions

This project has confirmed that the use of FGB sensors for SHM of FRP components is a viable concept for further development; in particular in the area of component level, embedded optical FBG sensor systems.

## Acknowledgements

This project was conducted under the principle supervision of Dr Jayantha Epaarachchi. My sincerest thankyou is passed to Jayantha for his guidance, but in particular for his patience. I also wish to extend my appreciation to Mr Wayne Crowell for his invaluable assistance during testing phases.

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# Optimization of Water Sensitive Urban Design Techniques in Low-Density Residential Land Development

School of Civil Engineering and Surveying/Empire Engineering



**Kenny Festing**

Bachelor of Engineering (Civil)

Supervisors: Dr Ian Brodie, USQ

Mr Ross Wegner, Empire  
Engineering

**Keywords:** WSUD, MUSIC, SQIDs

## 1. Introduction

This research project considers the growing focus that is being placed on Water Sensitive Urban Design (WSUD) in land development in recent times. The various options for improving stormwater runoff quality will be researched and compared, with stormwater runoff sample analysis results supporting the initial research. Finally, this project seeks to undertake a feasibility analysis in order to provide a recommendation on the most suitable option for implementation within a proposed low-density residential subdivision in Bundaberg, QLD.

## 2. Background

The ultimate goal of this project is to provide the best solution to stormwater quality treatment in a proposed urban residential subdivision in Bundaberg. Traditionally, WSUD practices in Bundaberg have been relatively immature; however recent changes in State Government Planning Policy and a growing focus on WSUD legislation have resulted in a more proactive stance being adopted by the Local Government Authority & wider engineering community.

## 3. Methodology

Initially, this research project sought to identify the various options available for treating stormwater quality by undertaking an extensive literature review. Some of these options include bioretention devices, gross pollutant traps, constructed wetlands, infiltration systems and other proprietary devices. The next step in the research process was to obtain stormwater runoff samples from a range of different areas in the Bundaberg region. MUSIC modelling was then undertaken to a) identify the effectiveness of previously implemented treatment devices; and b) attempt to provide the most effective solution for implementation within the proposed land

development considering effectiveness, maintenance and costs.



**Figure 1 - Bioretention garden at Kepnock Place, Bundaberg.**

## 4. Key Outcomes

To date, all stormwater sample analysis has been completed, with results typically in line with initial predictions. MUSIC modelling will be utilised to confirm potential options for treatment devices by validating them against regional Water Quality Objectives (WQOs).

## 5. Further Work

Presently, additional MUSIC modelling is still required. This will allow the best solution to be recommended for implementation into the proposed subdivision.

## 6. Conclusions

Initial conclusions indicate different treatment devices can produce significantly varied results, and extensive research is required to correctly implement WSUD principles.

## Acknowledgements

I would like to thank my supervisor Dr. Ian Brodie for his invaluable support and guidance throughout this project. I would also like to extend my thanks to Mr. Ross Wegner of Empire Engineering for his tireless support and teaching, and for also contributing the initial project idea.

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# Hemp/PP natural fibre composites and its application as structural material

Sponsor – School of Civil Engineering and Surveying, USQ



**Michael Sefeti Filipe**

Bachelor of Engineering

Major – Civil Engineering

Supervisors: Mr Jing Wang, USQ

Centre of Excellence in Engineered Fibre Composites

**Keywords:** Hemp fibre, Polypropylene, Mechanical testing

## 1. Introduction

This research project aims to conduct a composite of Hemp fibre – matrix reinforced polypropylene (PP) by using extrusion/injection method. Once the composite is formed, it is compared with pure polypropylene composite by analysing both composites under microstructure analysis, thermal analysis and mechanical properties testing.

## 2. Background

Hemp fibre is a plant grown annually in central Asia which is well-thought-out to be an attractive reinforcement for thermoplastic polymers and is considered to be cheap, strong, light, abundant and renewable. In fact, hemp reinforced composite is already introduced to the automotive industry. However, PP composite is still widely used in many other industrial application since it is known to be stiff, has a high melting point, low density and relatively good resistance to impact, on the other hand it is derived from petroleum which is not renewable and non-biodegradable, and therefore has a high impact to the environment.

## 3. Methodology

- Single hemp fibre subjected to tensile testing.
- Hemp fibres are chopped to certain length and both polypropylene and hemp are compounded in the extruder to form pellets. These pellets are placed in the injection moulding machine to form specified shapes for mechanical testing.



Figure 1 shows the hemp/PP reinforced composite after extrusion/injection method. A 20cent coin is placed near the samples.

- Mechanical Testing: Test for tensile, flexibility, impact and bending test.
- Microstructure: Observation on the samples using SEM.
- Thermal: Sample tested on high temperatures using TGA.

## 4. Key Outcomes

The hemp/PP reinforced composite was mixed to a ratio of 40 Hemp: 60 PP which the outcome is shown above in figure 1. High temperatures of more than 100°C was used to form the composite which proper precautions were in place.

## 5. Further Work

The Hemp/PP reinforced composite and PP composite will be tested for microstructure, thermal and mechanical using the equipment's in P9 and Z block.

## 6. Conclusions

Conclusions of this project are still in the process of being tested and analysed which will be completed before residential school. However, it can be concluded that the formation of the composite was successful and it is stored for the next stage of the project.

## 7. Acknowledgements

I would like to take this opportunity to thank my research project supervisor, Mr Hao Wang for his help throughout the project and my direct supervisor Mr Jing Wang for his tremendous assistance in organising lab facilities booking and thoroughly guiding the project to this stage.

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# Hypersonic rocket manoeuvre in the TUSQ facility

Sponsor – School of Mechanical and Electrical Engineering



**Michael Fowler**

Bachelor of Engineering  
(Mechanical)

Supervisor: Professor David Buttsworth,  
USQ

**Keywords:** Hypersonic, Dynamic Testing,  
Aerodynamics

## 1. Introduction

A number of methods are currently used for the design and testing of hypersonic vehicles, of particular focus here is hypersonic shock tunnel testing. Current approaches to this testing use fixed sting mounted models, tethered models, and free-flight models to study its behaviour. An addition to these testing techniques and the focus of this project is the use of models with actuated control surfaces to allow the study of a model under dynamic conditions.

This project aims to design, construct, and validate; through demonstration of a simple manoeuvre, a sub-scale model with an on-board control surface actuation system suitable for use in the TUSQ facility.

## 2. Background

Renewed interest in sustained hypersonic flight has occurred in recent years and therefore further development for testing techniques suited to this complex flow are required. Complex flow characteristics make a CFD analysis difficult, making necessary the use of shock tunnel testing. Currently testing techniques fix the model or control surfaces at some angle of attack to the oncoming flow and observe the response. A tethered model with actuated control surfaces would indicate how the full-scale vehicle would behave whilst undertaking a manoeuvre.

## 3. Methodology

The first phase was a semi-analytical analysis of the expected forces and therefore responses of the model. This provides data to later compare with the experimental results and parameters for the design of the model. The design of the model (see Figure 1) covered all components including the fin actuation system, microcontroller, tethering method and model

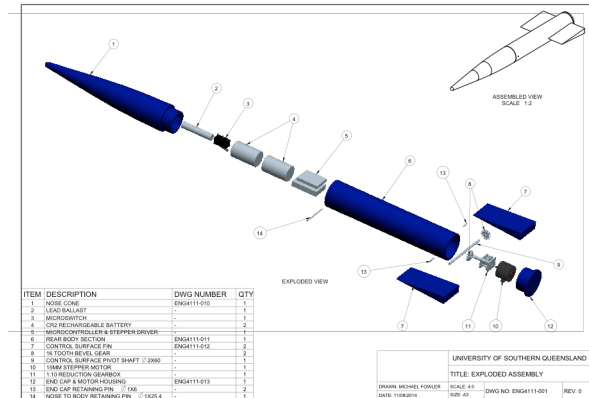


Figure 1 – Exploded Assembly of Model & Components

housing design. The final phase was building and testing of the model in the TUSQ facility.

## 4. Key Outcomes

At this stage only testing of the control actuation system electronics has been undertaken with no tests undertaken in the hypersonic facility yet. However the following has been identified; from the semi-analytical analysis it should be possible to perform a manoeuvre during the steady flow period, and a self-contained actuation system has been developed.

## 5. Further Work

It is still required to undertake two experimental campaigns in the hypersonic facility to collect the required data. If the results suggest the actuated control surface technique is valid it will permit future work in testing of models with other more complex geometries.

## 6. Conclusions

So far it has been shown that there is feasibility in experimentally undertaking simple manoeuvres in short duration hypersonic flows.

## Acknowledgements

I would like to thank my supervisor Professor David Buttsworth for his time in answering my many questions and guidance throughout.

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# SAFETY ASPECTS AND IMPLEMENTATION OF ZIP MERGES IN NSW

Sponsor – Roads and Maritime Services



**Chris Franks**  
Bachelor of Engineering (Civil)

Supervisors: Dr Soma  
Somasundarasawaran, USQ  
Mr Justin Drinkwater, Roads  
and Maritime Services

**Keywords:** Zip (Zipper) merge treatments

## 1. Introduction

Merging is a critical factor in the safe and efficient operation of roads. Zip merging is a relatively recent merge treatment that is being used more and more throughout NSW and Australia.

## 2. Background & Methodology

Design standards from around Australia and other parts of the world were sourced to gain an understanding of the type of treatments used and key features required in providing a safe road environment for road users when merging.

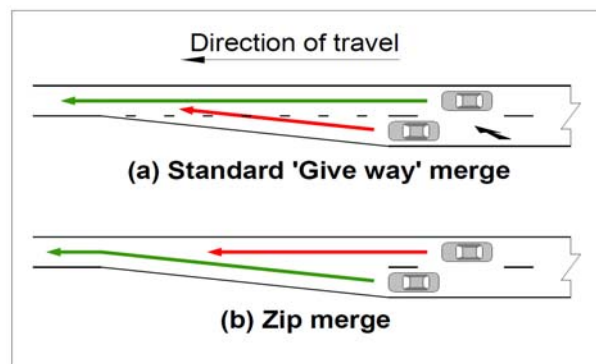
A number of zip merge sites were visited in the Hunter Region of NSW. Footage was captured at the merge areas for each location and the general behaviours of motorists were observed and recorded.

CrashLink, a road crash database of NSW was accessed to analyse crashes for a number of sites that have been converted from a standard merge (figure 1(a)) to a zip merge (figure 1(b)). A before-and-after study was performed to try and find evidence of reduced crash rates.

## 3. Key Outcomes

Some of the key advantages of this treatment found through researching prior literature and site observations have been summarised:

- Zip merging appears to encourage fuller use of the merge lane.



**Figure 1 – Diagram showing a key difference between a standard “give way” merge (a) and Zip merging (b)**

- Merge angles are reduced resulting from fuller use of the merge lane. This could lead to a lower severity of crashes
- Vehicles in adjacent lanes tend to adjust their speeds and position before the merge which allows for a smooth merge
- Zip merging shows potential to improve flow, efficiency and possibly safety

## 4. Conclusions & Further Work

Based on research undertaken in other countries, as reported in Styles and Luk (2006), it can be concluded that zip merging has some safety and efficiency benefits for road networks.

Further research into zip merging could include:

- Freeway on-ramps
- Road user surveys aimed at finding out the general opinion and knowledge of zip merges
- Alternative layouts

## Acknowledgements

I would like to thank my employer, Roads and Maritime Services for the opportunity to study part-time whilst working full-time in an Engineering discipline. Also, thanks to my supervisors Soma and Justin for assisting me throughout this research project.

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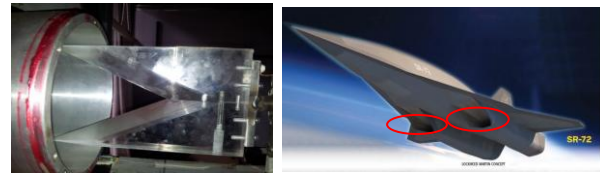
# Characterisation of the Flow Field over a Double Swept-Wedge Model

School of Mechanical and Electrical Engineering



**James Fuata**

Bachelor of Engineering  
(Mechanical)



(a)

(b)

**Figure 1 : (a) Double swept-wedge model (b) Approximate locations of double swept-wedges in scramjet intakes**

Supervisor: Dr David Buttsworth, USQ

**Keywords:** shock waves, hypersonic(s), aerodynamic heating

## 1. Introduction

This research project seeks to characterise the air flow over a double swept-wedge model (Figure 1a). This geometry is significant, as it can be found on intakes for hypersonic planes such as the Lockheed Martin concept SR-72 (Figure 1b).

Characterisation will be achieved by capturing the shock wave shapes with Schlieren Optical Imaging and using thermocouple sensors and pressure transducers to measure the heat and pressure on the model, respectively. Tests will be conducted at the University of Southern Queensland Hypersonic Wind Tunnel (TUSQ), with results being compared to theoretical values.

## 2. Background

For this model, a complex interaction between the swept oblique shock waves and the boundary layer (of air over the vehicle surface) occurs, in a process known as axial corner flow. A potentially disastrous consequence of this interaction is aerodynamic heating.

Theoretical values of the flow conditions and the heat transfer rate at Mach 6 (~7350 km/hr) for this geometry have yet to be found in freely available literature. One aim of this study is to generate reliable data that can be used to validate computational models.

## 3. Methodology

At the time of writing, a modified theory has been adopted to calculate the oblique shock wave flow conditions. Additionally, initial temperature data has been collected, with analysis completed using Matlab®. Axial corner flow theory is currently being reviewed to understand the corner shock conditions. Finally, the heat flux will be estimated from theory presented in Anderson (2006).

## 4. Key Outcomes

Currently, key outcomes include identifying the appropriate swept shock/boundary layer interaction

configuration and oblique shock theory amongst the vast body of knowledge in hypersonics research, and determining the post-swept shock flow conditions.

## 5. Further Work

Remaining tasks for this project include further research of similar studies to identify correlating parameters and capturing the shock wave shapes with Schlieren Optical Imaging. Further work includes a computational study using the experimental data and including embedded shock waves in the theoretical analysis, to better predict the heat flux.

## 6. Conclusions

A method has been identified to determine the swept shock waves generated over the model. Further, initial temperature data has been collected to determine the heat flux. Further tests will be conducted to collect pressure and additional temperature data. Generating a reliable set of experimental data can allow validation of computational models that can be used to improve thermal protection systems (TPS) for hypersonic flight vehicles.

## Acknowledgements

I would like to thank my supervisor, Dr David Buttsworth (USQ), for his time and guidance through the project. For the manufacture of the model and mounting sting, I thank Mr Chris Galligan (USQ) and Dr Ray Malpress (USQ), respectively.

I am also very grateful to Dr George Emanuel, for his time and help in explaining his modified oblique shock theory.

Most of all, I give eternal thanks to my darling wife, Jen, for loving, supporting and believing in me.

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# Millimeter Wave Mobile Communications for 5G Cellular Networks

School of Mechanical and Electrical Engineering



**Rakesh Kumar Gajula**

Master of Engineering Science-  
Electrical & Electronic  
Engineering

Supervisor: Dr Prof Wei Xiang, USQ

Computer Systems  
Engineering

**Keywords:** 5G Cellular, Millimeter Wave Spectrum.

## 1. Introduction

Wireless network started in the year 1980 as First Generation, and since then its use in mobile broadband communication is increasing every year, and the service provided by various wireless carriers is limited.

This high demand had made it possible in passing the wireless networks through Four Generations of Technologies. To meet the requirements of the customers, the present data transfer speed which is in Mbps, needs to be increased, by using Millimeter Wave Technology for 5G Cellular Networks.

## 2. Background

In 1980, the First generation system was developed using Analog System Design, and then every decade there is a stage of improvement and lead to the development of 2G in 1991 using Digital Modulation & TDMA System. Later by using the combination of W-CDMA and HSPA, 3G was developed in 2001, and then 4G came into existence in 2011 by the use of LTE

## 3. Methodology

The range of Millimeter wave frequencies is from 30 to 300 GHz, having wavelength of 1 to 10 mm. As these frequencies can transfer data at a rate of 1 Gbps, they are used predominantly in wireless LANs. However, the possibility of implementing 5G communication with use of Millimeter wave band can be increased by using CMOS technology and steerable antenna, and using the Adaptive beam forming and Multiple-input and Multiple-Output techniques.

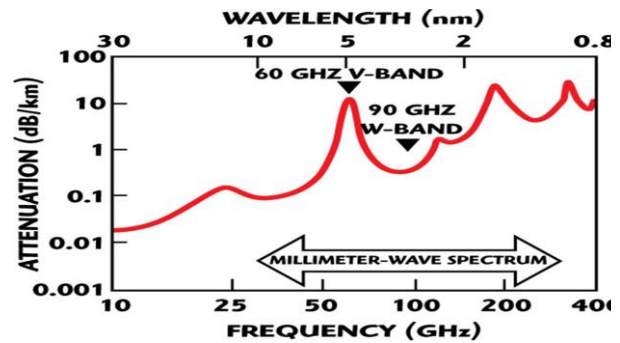


Figure 1 - frequency, wavelength and attenuation mm wave

## 4. Key Outcomes

The transmitter and receiver designed for understanding Millimeter Wave Spectrum in 5G, provides the outcomes that, by utilizing steerable directional antennas the 28 and 38 GHz frequencies can be used for the this Cellular Network System.

## 5. Further Work

The task of performing experiments under various weather conditions is to be done. Also, various frequencies which support 5G Cellular Network System in the Millimeter waves is to be studied.

## 6. Conclusions

From the experiments performed so far at NYC, the signal propagation characteristics through indoor and outdoor can be evaluated. The design issues like cell search, multiple access and analog to digital conversion needs more concentration.

## Acknowledgements

I would like to thank my supervisor for providing me with this topic, which made me get deeply involved in the ongoing research on 5G Technology, and provided me tips for finding information on IEEE Xplore.

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# Evaluation of the available working times for stabilised base materials in Downs South West Region (DTMR).

School of Civil Engineering and Surveying



**Pieter Geldenhuis**

Bachelor of Engineering (Civil)

Supervisors: Mr Trevor Drysdale, USQ

School of Civil Engineering  
and Surveying

**Keywords:** Working times, Stabilisation, Roads

## 1. Introduction

This project focussed on road construction, in particular pavement stabilisation and the effects of different binders on working times. Pavement stabilisation is a process employed to increase the strength of pavement layers where weak sub-soils are encountered (ADAA, 2012).

When stabilising pavement layers, it is essential to complete the placement and compaction of the layer within the available working time.

The main focus of this research is working time. This process forms part of road stabilisation and can be described as 'the time available, to the nearest hour, to fully compact a standard crushed rock base material stabilised with a cementitious binder' (VicRoads, 2000).

The project incorporates laboratory testing of a typical Downs South West granular material and innovative binders. Evaluating working times with these binders will provide more accurate information for the Department of Transport and Main Roads and contractors in the region. Background

This section describes the bigger picture and addresses question such as: Why is this project important? What is the state of the art in this area? How does this project build or extend existing knowledge or practice within your discipline?

## 2. Methodology

Initial review of literature from around the world will highlight the knowledge base available. Furthermore interviewing pavement professionals from DTMR in

Downs South West will set the scene for the region specific challenges.

A testing regime to evaluate the working times of the various binder blends will involve three phases. Firstly, UCS Design (demand) tests will identify the binder content requirement. Secondly reference sample testing will be done to set the binder/ material benchmark. Lastly, the working time testing done for both MDD and UCS will determine the working times for the binder/material combination.

## 3. Key Outcomes

The outcome of the research is to identify the working tie for the various binder/ material combinations. This will provide industry with binder options and accurate working times not available before in this region.

## 4. Further Work

Work to be completed for this project is the finalisation of testing and results to be reported. After this project further experimental research with binder blends could be done.

## 5. Conclusions

There is much scope in the area of binder innovation. The research will provide incremental information to industry in terms of working time in Downs South West.

It is important to note that while working time poses many challenges; stabilisation of pavements is an important part of pavement design in Downs South West Queensland.

## Acknowledgements

Trevor Drysdale - Supervisor

Dave Christian – Senior Pavement Technologist

Belinda Krause – DTMR Soil Laboratory Manager

Department of Transport and Main Roads

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# An innovative intelligent system for child care & safety applications using ZigBee Wireless Sensing Networks

School of Mechanical and Electrical Engineering



**Brad Goold**

Bachelor of Engineering  
(Computer Systems)

Supervisors: Dr. Hong Zhou USQ

**Keywords:** Wireless Sensor Networks; Indoor Localisation

## 1. Introduction

Wireless sensor networks are comprised of small wireless sensors that are interconnected via certain wireless communications protocols. These sensors are used to form small to large scale networks where information can be sourced at each sensor and routed back to a main base station. This information can be forwarded to the internet for remote monitoring and control. The use of the sensors can range from temperature sensing to gathering fire front information for bushfire analysis. The signal strength from these wireless sensors can also be used to determine the position of the sensor relative to other known points. This technique of localisation has been used in conjunction with the profiling/fingerprinting technique to determine the location of a single sensor in a wireless network.

## 2. Background

Evidence shows that the number of deaths of children drowning in swimming pools and in driveway accidents is not declining. Furthermore, Alzheimer's patients are known to wander, finding themselves confused and disorientated.

Market research has been undertaken upon the preliminary stage of this project and indicated that the use of WSN's is currently growing at an exponential rate. In addition, one of the main reasons that many people do not have a WSN in their home is the ease of use/understanding of the system.

## 3. Methodology

A review of the relevant literature and state of the market was undertaken. The literature outlined various methods for indoor localisation. It was found that the fingerprinting/profiling method of localisation was the most appropriate for this project in terms of metrics such as accuracy, project-time and depth of understanding. Profiling requires the use of a database to store location information for look-up requests when localising the target sensor. A collection tree routing protocol was utilised in the sensor network which routes the information to the base-station. The information is then forwarded to a program running on the laptop which stores and analyses the data.

## 4. Key Outcomes

With these applications in mind, we propose to use a WSN to track the location of the patient/child and provide a warning if they breach a predetermined area.

## 5. Further Work

The initial analysis software is purely text based. Further work has been proposed to access the localisation information remotely through the database enabling remote access from a range of client applications.

## 6. Conclusions

Upon successful completion of this project we believe that this idea can be used and implemented to improve health and safety in and around home.

## Acknowledgements

Firstly I would like to thank my wife for her incredible support throughout this degree. Secondly, my supervisor, Hong Zhou, for her guidance and direction.

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# Risk Assessment of Bridges on Rural Arterial Roads

Sponsor – School of Civil Engineering and Surveying



**Scott Grant**

Bachelor of Engineering - Civil

Supervisors: Professor Ron Ayers

**Keywords:** Road safety, risk assessment, bridge inspection

## 1. Introduction

Australia has an extensive road network with a relatively small population to fund it; this makes the effective management of road hazards difficult. To ensure the remedial work undertaken by road authorities is both effective and efficient, it is necessary to develop a systematic approach to assessing risks, identifying potential countermeasures and prioritizing treatments.

This project attempts to develop a risk assessment method specifically aimed at identifying road hazards for one particular aspect of the road network; bridges on rural roads. It is hoped that a risk assessment model specifically ‘calibrated’ to these types of road features will help to enhance the effectiveness of any road safety treatments undertaken.

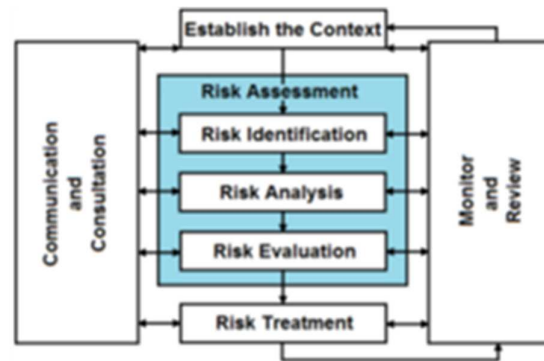
## 2. Background

Road safety programs such as ‘Black Spot’ have historically relied on crash data to identify locations that require treatment. However, these programs (by themselves) no longer satisfy the legal requirements for road authorities’ to provide a safe road environment.

To address this road authorities’ have adopted the ‘Safe Systems Approach’, which takes a holistic view of the road transport system and the interactions of its various elements (ATC 2011). A part of this approach identifies the need to be aware of the condition of all parts of the road network and take reasonable steps to manage them.

## 3. Methodology

The risk assessment process is well defined by Standards Australia (see figure 1). It is a systematic process that involves identifying, assessing and prioritizing risks.



**Figure 1:** The risk management process (SA 2011).

For this project, aspects of a road safety audit were combined with a level 1 bridge asset audit to identify potential hazards. These hazards were then analyzed using an evidence-based approach that establishes a quantitative level of risk making it possible to objectively evaluate the potential effectiveness of countermeasures applied on a cost-benefit basis.

## 4. Key Outcomes

The key outcome was the development of a risk assessment method that could be used to develop a realistic works schedule for bridges within a road network. Twelve bridges were assessed as part of the project and remedial actions were prioritized in a way that provided the greatest gains in road safety.

## 5. Further Work

Further work in defining a quantitative relationship between the condition of bridge elements and the risks they pose to road safety would provide a more objective and consistent method of assessment.

## 6. Conclusions

The risk assessment method developed for this project allows road authorities’ to identify safety hazards, evaluate potential treatments and prioritize them as part of an effective and efficient road maintenance schedule.

## Acknowledgements

I would like to thank my faculty supervisor, Professor Ron Ayers for his guidance and feedback.

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# Mapping Changes in Landscape-Scale Patterns of Vegetation in Coal Seam Gas Development Areas

School of Civil Engineering and Surveying



## Andrew Grigg

Bachelor of Engineering (Hons)  
(Environmental)

Supervisor:  
A/Prof Armando Apan

**Keywords:** land cover change, vegetation fragmentation, coal seam gas (CSG).

## 1. Introduction

In the past 15 years, the rate of coal seam gas (CSG) development in Queensland has increased dramatically. Drilling of gas wells, and installation of related infrastructure, often requires the removal of vegetation. This project aimed to determine the nature of land cover change in an area under intense CSG development.

## 2. Background

Research overseas indicates that landscape-scale land cover patch extent and configuration is potentially altered in areas of concentrated oil and gas extraction. These studies focus on oil and shale gas activity, mainly in North America. There has been little work on the nature and extent of the impact of oil and gas developments in Australia, or from CSG activity anywhere in the world.

## 3. Methods

The extent and fragmentation of vegetation in 1999, immediately before CSG development began, is compared to the extent and fragmentation of vegetation in 2013, after 1562 CSG wells had been drilled. Land cover was determined by binary classification of a LANDSAT 4 image taken in 1999 and a Landsat 8 image taken in 2013. Figure 1 is the combination of the classified images derived from the two satellite images. ArcGIS 10.2 was used for image manipulation, and vegetation patch metrics were determined using FRAGSTATS 4.2 software. For comparison, the same metrics were also calculated in hot-spot regions defined more closely around drilling sites.

## 4. Key Outcomes

A net increase in extent and decrease in fragmentation of vegetation is observed in the study area, despite clearing for well pads, roads, pipelines, dams and other infrastructure associated with CSG. Sub-regions of concentrated CSG activity, analysed for comparative analysis, produced similar results indicating that observed land cover change in the study area was not closely linked with proximity to CSG drilling. At a landscape scale, vegetation loss caused by CSG is not as significant as regrowth and clearing attributable to other activities.

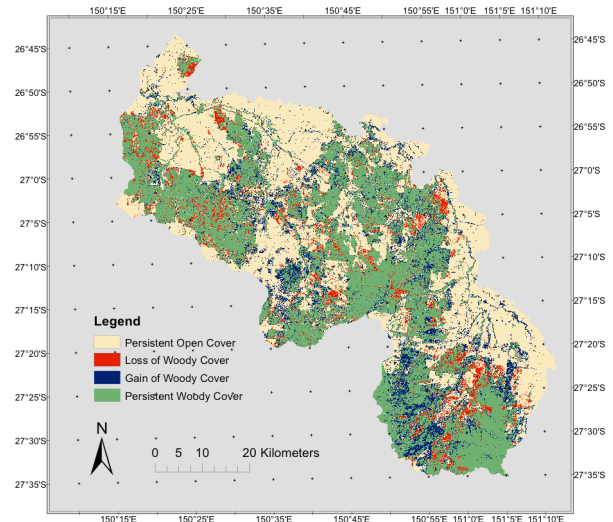


Figure 1: Map showing persistence and change in land cover during the period 1999 – 2013.

## 5. Further Work

Future work must focus on the specific causes and impacts of the changes identified in this study. While it is shown in this work that some changes are clearly attributable to CSG activity, other causes of change are significant and should also be identified and quantified in the literature. As for the impacts of change, analysis of the impacts on specific species, ecosystems or human actors is required. This analysis of impact should include a validation of the edge width assumed in this study.

## 6. Conclusions

While, on a small scale, CSG activity is known to cause deforestation, other causes of land cover change counteract and mask the effect of CSG on land cover extent and fragmentation at a landscape scale in Central Queensland.

## 7. Acknowledgements

I would like to acknowledge my supervisor, A/Prof Armando Apan and members of his research group, for their consistent support.

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# Agricultural Stock Watering Monitoring by Still Images Over UHF

Sponsor – School of Mechanical and Electrical Engineering



## Lachlan Groves

Bachelor of Engineering  
(Electrical & Electronic)

Supervisor:

Dr Alexander Kist,  
USQ

**Keywords:** Remote image monitoring, stock watering, telemetry

## 1. Introduction

This project reviews existing telemetry communication systems which are capable of transmitting still images over long distances using UHF signal, particularly for use on remote livestock properties.

It is the aim of the project to: develop a simplified and more cost effective solution to capturing a still image telemetry system via UHF and to provide limited digital input/output functionality in remote areas outside the mobile phone coverage area.

## 2. Background

This project is of significant importance due the cost savings potential in labour and time and other potential benefits such as improved safety for staff in remote areas and improved animal welfare. There is existing technology in the field of telemetry of stock watering although it is quite costly and mostly uses mobile phone technology that it generally not applicable for the majority of the livestock industry in rural Australia.

## 3. Methodology

The key areas of criteria for this project were: simplification, cost and capability to withstand extreme weather conditions. After investigation of existing technology, a simplified model was developed and built that was easy to use and install.

UHF data radios and serial cameras were evaluated and products were selected based on cost and features and a prototype was constructed. A MATLAB code was developed and still image capture was tested over a short distance prior to field testing. The project is currently being implemented on a rural property for trial and data collection.



Figure 1: Remote unit with cover removed

## 4. Key Outcomes

The key outcomes for this project were to:

Evaluate and select a suitable data radio and serial camera for the capture of a still image over a UHF radio link.

Simplify implementation in order for the unit to be installed and operated by a nontechnical person.

Design a unit housing which was vermin proof and could withstand extreme weather conditions.

## 5. Further Work

Further work would include:

Extend the range of the system by utilising the repeater functionality of the selected data radios. Currently, only two data radios are available for testing.

Utilise of the I/O capability of the data radio when operating in a MIMC mode to provide additional features such as pump control and water level monitoring.

## 6. Conclusions

The project has successfully captured images over UHF radio and trials are being conducted on a remote cattle station. The initial bill of material costs are significantly less than commercial products although a final costing has yet to be calculated.

## Acknowledgements

I would like to thank Dr Alexander Kist for his supervision and guidance during this project.

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# Great Artesian Basin (GAB) Water Cooling Systems for Municipal Supplies

Sponsor – School of Civil Engineering and Surveying



**Hayden Guse**

Bachelor of Engineering (Civil)

Supervisor: Dr Joseph Foley, USQ

**Keywords:** Great Artesian Basin, municipal water supply, water cooling.

## 1. Introduction

The Australian continent is commonly referred to as the 'driest inhabited continent on Earth' (Pigram, 2006). Due to a lack of surface water much of Australia relies on groundwater for both agricultural and municipal supply.

The Great Artesian Basin (GAB) is the world's largest artesian basin. The temperature of water being extracted from deeper sections of the GAB can be up to 99 °C. Queensland legislation requires water at the outlet of municipal systems to be at temperatures not exceeding 45 °C.

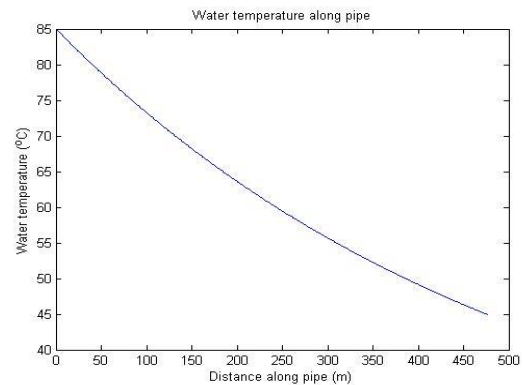
## 2. Background

There are many Western Queensland municipalities that rely solely on the GAB for a water supply. To meet legislative requirements, towns such as Thargomindah need to cool the extracted water. There are many methods used to achieve this cooling though all have some drawbacks. These drawbacks include water wastage, system cost and salinity issues.

Ground Heat Sink Pipe Loops (GHSPL) are buried pipelines that use the naturally cool soil at shallow depths (0.5 to 1.5 m) to extract heat from the piped fluid. This research aims to determine whether GHSPL (which is widely used in building heating) can be utilised to cool municipal water supplies.

## 3. Methodology

To establish the viability of a buried pipe cooling system a number of theoretical models were coded into MATLAB. Figure 1 provides an example model output. To calibrate the theoretical models, experimentation was carried out on the GAB bore pipe system at 'Tabooba', 125 km West of Goondiwindi.



**Figure 1 – Temperature distribution in buried polyethylene pipe from a 1-dimensional heat transfer model with input parameters simulating conditions at Thargomindah**

## 4. Key Outcomes

The key outcome of this research is to determine whether GHSPL systems are viable as municipal water cooling systems. Should GHSPL be found viable, a concept design will be delivered to minimise cost, maintenance and environmental impact, when compared to the current systems.

## 5. Further Work

The system concept design is yet to be finalised. To complete this design further model simulations will need to be run to determine an optimum layout.

## 6. Conclusions

GAB water is a finite resource and the current cooling systems are generally quite wasteful. Preliminary results indicate that GHSPL systems provide an improved environmental outcome while still achieving the cooling required.

## Acknowledgements

I would like Dr Joseph Foley for his support, assistance and understanding throughout this project. I would also like to acknowledge Ian Ryan (TRC), Simon Orphant (DNRM) and Geoff & Virginia Phillips (Owners of Tabooba) for their valuable input into this research.

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# Disaster Risk Management in South Asia

Sponsor – School of Civil Engineering and Surveying

## Nash Hancock

Bachelor of Engineering (Civil)

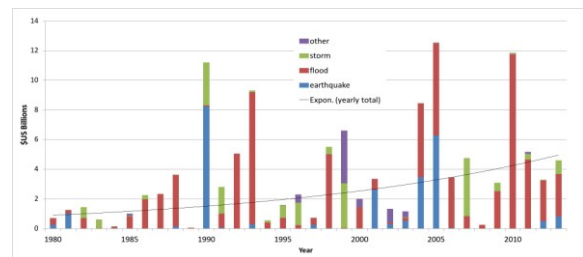


Figure 1 – Annual Financial Damage from Natural Disasters in South Asia 1980-2013 (Source EM-DAT 2014)

Supervisors: Dr David Thorpe

**Keywords:** Disaster, Risk, Management

## 1. Introduction

Since 1980 there have been on average more than 300 natural disaster events per year across the globe, killing an estimated 75 000 people each year, affecting more than 180 million lives and costing more than \$75 billion annually. The South Asia Region experiences on average about 40 natural disaster events each year, resulting in approximately 17 000 lives lost, affecting about 60 million people and causing damages amounting to at least \$3.7 billion annually (EM-DAT 2014).

These figures are quite significant and highlight the importance of effective disaster risk management techniques. Engineers play a key role in disaster risk management throughout the world.

## 2. Background

Global natural disaster risk management has been evolving over recent decades from a reactive and response orientated approach to a more holistic and integrated style. Despite global advances and increasing financial losses (see Figure 1), not to mention loss of life, disaster awareness and risk understanding remains low in the South Asia Region.

## 3. Methodology

The methodologies employed and the approach taken to achieve the aims and objectives of this research project involved a number of steps. As this project is predominantly a desktop assessment, literature review and the critical analysis of secondary sources of available information comprise a significant portion of the work. This includes a data analysis of disaster statistics (such as Figure 1). A gap analysis has been employed to find the key differences in approaches taken in south Asia compared to global methods and a number of case studies are to be conducted to analyse the techniques employed in individual disaster events.

## 4. Key Outcomes

This project has critically analysed the disaster risk management approaches taken by 3 South Asian countries (India, Bangladesh and Pakistan) and has identified the key gaps between the approaches of these countries and global standards. These gaps include the lack of land use planning and building code enforcement as well as the absence of regulating bodies for professions including engineers and architects. The various roles that key stakeholders hold, specifically in the restoration of engineering services post disaster events, have also been examined.

## 5. Further Work

In 2015 the World Conference on Disaster Risk Reduction will be held in Sendai, Japan. In the time leading up to this, and for the years after, work in the field of disaster risk reduction will continue to expand. With specific regard to this project, regions outside of South Asia could be examined to identify gaps in methodologies employed and the roles that various stakeholder play.

## 6. Conclusions

Education and awareness of disaster risk should be promoted in order to facilitate a fully integrated holistic approach to disaster risk management that encourages a global network of knowledge sharing and cooperation.

## Acknowledgements

I would like to acknowledge and thank my supervisor Dr David Thorpe for his assistance throughout this project.

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# Great Barrier Reef Marine Park Quantitative Pollutant Analysis for Environmental Management

Faculty of Health, Engineering and Sciences



**Reanna Harper**

Bachelor of Engineering  
(Environment)

Supervisors: Dr Ian Craig, USQ

**Keywords:** pollutant, GBRMP, management.

## 1. Introduction

The Great Barrier Reef (GBR) is an international, precious asset valued for its iconic beauty, unique ecological diversity and dynamic, interconnected systems.

The decline of the Reef is of increasing concern. An attributed cause is poor water quality. With a catchment area spanning over 344,400 km<sup>2</sup> (refer Figure 1) managing pollutant discharge from land sources into the GBR lagoon is an ongoing challenge.

Despite there being extensive focus on the GBR, discussion on individual pollutants and their quantified source remains fairly broad. The practical question remains: how much are individual industries polluting?

## 2. Background

This dissertation is initiated with the theory that the above disconnect presents a barrier to practical environmental management response by industries. Research aims to consolidate available data, and report on quantified relationships with specific industries. An intended outcome is to link the cause, by detailed source and quantity, with the reported effect.

International catchment management practices are also being investigated to inform potential quantified reduction targets for industry.

## 3. Methodology

The project is a theoretical analysis style dissertation. Methodology was broadly defined by three key stages: literature and industry scoping, intensive literature review and critical evaluation, and dissertation authoring. Quantified pollutants are being linked to their identified sources spatially in ArcGIS to depict overall catchment distribution.

Figure 1 GBR  
Catchment Areas

(Source: Reefplan.qld.gov.au)



## 4. Key Outcomes

Main chemical and nutrient pollutants entering the GBR lagoon have been identified. Significant insight into water quality impact and behaviour has been gained.

Agriculture appears the predominant pollutant source. Individual case studies in sub-industries (bananas, sugarcane, cattle) are providing quantified metrics.

Approaches to resource management may inspire environmental targets. For example, approaches employed by Chesapeake Bay (United States).

## 5. Further Work

Quantified data continues to be critically evaluated, and input into ArcGIS. It is uncertain whether emerging industries are predominant in terms of pollutant load or historical focus. Further discussion with industry researchers (via Department of Natural Resources and Mines) is scheduled to occur.

## 6. Conclusions

Conclusions being refined as part of further work. Recommendations for environmental management may include requirements for industry quantified reporting and performance improvement.

## Acknowledgements

Thank you to Dr Ian Craig and Dr Mark Silburn for support and invaluable insight. References

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# Modal Testing of Existing Supermarket Floor Systems and Predictive Finite Element Modelling for Better Design

School of Civil Engineering and Surveying



**Daniel Hatch**

Bachelor of Engineering (Honours)  
(Civil)

Supervisors: Dr Sourish Banerjee, USQ

**Keywords:** Floor vibration, modal testing, finite element modelling (FEM)

## 1. Introduction

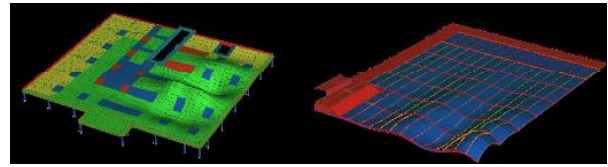
Floor vibration problems typically occur when the walking frequency of pedestrians matches the natural frequency of the floor system and resonance occurs. Serviceability problems, and in rare cases, structural failure are problems caused by resonance. Australian Standard AS1170.1-2002 Structural Design Actions provides static imposed actions for floor structures, however, little reference to dynamic actions is provided. Other sources are available for guidance, however they have limited applications to supermarket floor systems because of the random movement of pedestrians and wheeled trolleys and materials. This gap in knowledge is the motivation for this research.

## 2. Background

The liveliness of the floor system at the Imperial Centre due to vibration is well known. The magnitude of the floor vibration is unknown and is caused by pedestrian activity. This raises questions about structural performance and serviceability for longevity and future use. This project assesses the serviceability of two supermarket floor systems by implementing the existing procedures and investigates the validity of these procedures on supermarket floor systems. Erina Fair is not known to be lively and is used only for comparison.

## 3. Methodology

Determination of the dynamic behaviour of floor systems in service is quite complex. In this project, an actual measured response is obtained from the modal testing of two supermarket floor systems, whereas the numerical response is predicted using finite element



**Figure 1 – Strand7 Predicted Mode Shapes of Floor Systems**

modelling. The measured responses obtained from the Imperial Centre and Erina Fair are compared to the predicted numerical responses obtained from finite element modelling to validate the excitation models and assess the serviceability of the floor system.

## 4. Key Outcomes

The serviceability of the floor systems has been evaluated and a suitable excitation model has been developed/defined for supermarket floor systems. This will aid in future designs by having an excitation model that accurately represents the activities encountered within a typical supermarket.

## 5. Further Work

Further work includes long term vibration monitoring for trends and loading patterns in supermarket floor systems to build upon the suggested model.

## 6. Conclusions

Based on the short term modal testing and monitoring of the floor systems, the serviceability has been assessed and a suitable excitation model has been suggested for supermarket floor systems.

## Acknowledgements

I would like to thank Deborah Warwick from The Imperial Centre, Gosford and Matt McMahon from Erina Fair, Erina for allowing access to the supermarket floor systems. I would also like to thank Dr Sourish Banerjee as supervisor for this project.

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# Development of Ductile and Ultra-high Performance Engineered Cementitious Composite (ECC) with Lightweight Microsphere Additive

Sponsor – School of Civil Engineering and Surveying



## Gareth Grant Hesse'

Bachelor of Engineering BENH (Honours) (Civil)

Supervisor: Assoc. Prof. Yan Zhuge, USQ

**Keywords:** Polyvinyl-Alcohol Fibre; ECC; Microsphere.

### 1. Introduction

The design of Engineered Cementitious Composites (ECCs) has eventuated through the process of micromechanics. This research investigates the development of a new lightweight ECC that includes hollow glass microspheres as a lightweight additive. Figure 1 shows these microspheres in its powder form.

### 2. Background

Concrete has exceptional strength when under compression; however when exposed to tensile loading, the brittle behaviour governs its failure.

Tensile strength of concrete matrix can be improved by the addition of randomly dispersed short fibres. The allowable tensile loads carried by such composites are not as high as the conventionally reinforced concrete, however the addition of oil coated PVA fibre to the matrix results in a composite that behaves in a similar manner as an isotropic material that experiences strain-hardening, such as steel.

### 3. Methodology

Lightweight ECC mix designs with randomly dispersed uncoated PVA fibre and varying hollow glass microspheres were created and test specimens were prepared. The specimens were exposed to compression, flexure and impact testing. The results of these tests were analysed in order to assess if there was a reduction in density, an increase in compressive strength and whether strain-hardening was achieved.

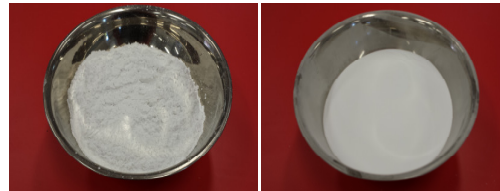


Figure 1 – Sphericel & Q-Cel Hollow Glass Microspheres

### 4. Key Outcomes

The addition of the adopted microspheres does reduce the composite density however it does not significantly improve the compressive strength. The combination of these microspheres and uncoated PVA fibre achieves only minor strain-hardening.

### 5. Further Work

A detailed analysis of the test results and characterisation of the lightweight ECC is still being undertaken, including also a microstructure analysis of the composite. Future research with the adopted microspheres and coated PVA fibre should be done.

### 6. Conclusions

The fundamental property of ECCs is its ability to achieve strain-hardening. The addition of microspheres do not effectively reduce the interfacial bond between the matrix and the uncoated PVA in order to achieve this property.

### Acknowledgements

A special thanks to my wife, Gaby Hesse', for all her support and understanding during this time. My supervisor Assoc. Prof. Yan Zhuge for her guidance. PHD student Ms. Si Chen for her sharing of information. Prof. Guoxing Lu, Dr. Changjian Shen and Dr. Dong Ruan from Swinburne University of Technology for undertaking the impact testing and providing results. Mr. Daniel Eising and Mrs. Piumika Ariyadasa for their assistance in the laboratory.

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# A Test Facility for Assessing the Performance of IEC61850 Substation Automation Designs

School of Mechanical and Electrical Engineering



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Bachelor of Engineering  
(Electrical and Electronic)

Supervisor: Dr Tony Ahfock, USQ

**Keywords:** Substation Automation Systems (SAS), IEC61850

## 1. Introduction

Substation automation systems, (SAS), have undergone dramatic changes since the introduction of powerful micro-processing and digital communications within the substation. Smart, multifunctional relays, known as IEDs (Intelligent Electronic Devices) have replaced traditional panels which contained multiple relays, meters, control equipment and status indicators.

ActewAGL Distribution, a power utility company in Canberra, Australia, has recently decided to undertake a review of its substation automation systems throughout its network. As a result, ActewAGL Distribution has decided to investigate the IEC61850 standard by constructing a test facility with the view of implementing the standard into its zone substations network in the near future.

## 2. Background

The IEC61850 – *Communications Networks and Systems in Substations* Standard was released in 2004 after IEC Technical Committee 57's work to produce an industry standard relating to the integrated control, protection and data acquisition while maintaining interoperability of different devices within the substation environment.

## 3. Methodology

The objective of this project is to build a test facility with devices that will be used in future substations to design an IEC61850 compliant substation automation system. Once the facilities construction and commissioning is completed, it will be evaluated using power system simulators over a variety of abnormal system network conditions.

Performance and cost comparisons will then be carried out that will justify the use of an IEC61850 design in



**Figure 1 – ActewAGL Distribution SAS Test Facility**

ActewAGL Distributions network The data collected will be reviewed and compared to the various substation automation systems currently in place.

## 4. Key Outcomes

The key outcomes were the successful development and evaluation of a substation automation system that utilised the IEC61850 standard incorporated with multiple vendor devices.

## 5. Further Work

The remaining work entails using the knowledge and experience gained from the evaluation of this test facility to design a compliant IEC61850 132/11kV zone substation, which is due for construction in early 2016.

## 6. Conclusions

Combined protection, monitoring, control and LAN based substation automation systems are becoming the industry standard.

This test facility has allowed ActewAGL Distribution to extensively test a single, global, future-proof standard for substation communications that allows it to operate sophisticated networking technologies with functionality that is superior to any current substation automation protocol.

## Acknowledgements

I would like to thank my colleagues at ActewAGL Distribution for their time and advice over the duration of this project. I would also like to thank Dr Tony Ahfock for his guidance and support.

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# Rigid Central Safety Barriers in Constrained Road Environment

School of Civil Engineering and Surveying, Roads and Maritime Services (RMS).



**Katherine Holzner**

Bachelor of Engineering (Civil)

Supervisors: Dr Ron Ayers, USQ

Mr Peter Ellis, RMS

**Keywords:** Road safety, central safety barriers, sight distance.

## 1. Introduction

Central safety barriers are installed to mitigate cross centreline crashes at sites where extensive improvement of road geometry is not feasible.

The in-service assessment of central safety barriers is important in order to understand the performance of the treatment for effective future application.

This study attempts to assess any possible relationship between sight distance models and road safety.

## 2. Background

Head-on crashes make up 5.5% of total rural road crashes in NSW but contribute to 27% off fatalities.

Central barriers effectively eliminate head-on road crashes. With the installation of a central barrier comes the introduction of a fixed hazard in close proximity to travelling vehicles. On curves, barriers can also impede the drivers' sight. Sight distance is often referred to as a parameter which is directly related to road safety. Few studies support this direct relationship.

Often the decision to install the treatment is reactive and comes with risk.

## 3. Methodology

A literature review was conducted to investigate previous research on cross centreline related crashes, types and performance of central safety barrier and sight distance models used internationally.

Six, mid-block, rural highway sites of concrete central safety barrier were isolated and investigated. The investigation included:



**Figure 1 – Rigid central safety barrier with reduced sight distance**

- Site visit and project data review
- Before-and-after crash analysis using Crashlink
- Sight distance checks within the design model

## 4. Key Outcomes

Typically, fatality and injury crashes post barrier installation have reduced with non-injury crashes increasing at some locations.

The stopping sight distance model combines a series of 85<sup>th</sup> percentiles which results and a very conservative model. European models (Harwood et al, 1998) provide for a more realistic stopping sight distance model.

## 5. Further Work

Detailed conclusions and recommendations have not been made. A careful consideration of the dynamic road environment is required when applying findings to an existing, undivided site for potential upgrade.

## 6. Conclusions

From the sites analysed, it appears that the road safety improvements have had a net positive impact on road safety.

## Acknowledgements

I would like to thank the RMS, especially Jo Parrott, Goran Kozaroski, Graeme Birch for their assistance with data and topic knowledge. Thanks to my supervisors for their guidance and understanding.

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# Understanding Time Management of Construction Project Managers under Occupational Stress



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(Civil)

Supervisor: Dr Vasantha Abeysekera, USQ

**Keywords:** time, management, construction

## 1. Introduction

Construction projects often run beyond time constraints and incur significant financial penalties as a result. The responsibility for this ultimately lies with construction project managers. This is one of the many pressures which result in unusually high levels of occupational stress for construction professionals compared with many other industries.

## 2. Aim

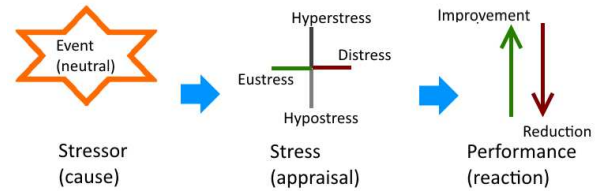
The objective of this dissertation is to understand the link between time management and occupational stress in construction project managers.

## 3. Background

Significant research has been conducted on technical methods of improving the time management of construction project managers, yet personal factors have received little attention. The literature reveals a link between time management and occupational stress, but the relationship is not well understood. This project seeks to understand the mechanism by which occupational stress affects the time management of construction project managers.

## 4. Methodology

Previous research conducted on occupational stress within the construction project management literature focuses upon an outdated model of stress. So, a more recent stress model developed by Hans Selye and promoted by Richard Lazarus, as shown in Figure 1, was considered for this dissertation. The stressors under investigation were proposed by Mei-yung Leung, Yee-Shan Chan and Jingyu Yu during a study on construction project managers in Hong Kong. A questionnaire has been developed to seek responses



**Figure 1 – Effect of Occupational Stress on Time Management**

from construction project managers in Australia on three key points:

- Is this stressor relevant to your occupation?
- How does this stressor affect your stress level?
- How does that stress affect time management?

## 5. Key Outcomes

The stress model depicted in Figure 1 provides an alternative approach to occupational stress for the construction industry, revealing that gains in productivity and efficiency can be realised by addressing the issue of occupational stress.

## 6. Further Work

Data obtained from the survey respondents must be analysed in detail to provide meaningful discussion and conclusions. The ramifications of these findings will be discussed with construction project managers to ascertain its usefulness.

## 7. Conclusions

Occupational stress among construction project managers is highly relevant to construction project time management and this concept has received inadequate attention in the literature. Financial benefits and individual health and wellbeing may all be improved by greater focus on this issue.

## Acknowledgements

Dr Vasantha Abeysekera for his guidance and all survey respondents for their insights and information.

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# MANAGEMENT OF THE DEFECTS LIABILITY PERIOD

School of Civil Engineering and Surveying



## Ramin Jamali

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(Management)

Supervisor: Dr  
Vasantha  
Abeysekera, USQ

**Keywords:** Defects, Defects Liability Period, Contracts

## Introduction

The study is focused primarily on developing strategies for improving the conditions of contract, in particular the AS4000 and the efficiency of contract clauses for managing defects in relation to the defects liability period.

The aim of this study is to examine practices adopted in the defects liability period including the role of retentions, warranties and guarantees to ensure project success. The paper will investigate current processes such as different terminologies used in contracts, how to deal with defective work and the powers and actions that clients can undertake to remedy defective works.

## Background

The study was undertaken due to the fact that there is a need to modify the existing conditions of contract in the AS4000. In the construction industry, defects occur inevitably and repeatedly. Defects are one of the main causes of project schedule and cost overruns. Construction defects is a major issue facing the construction industry, costing the industry substantial amounts of money for what the industry labels as rework.

Construction contractors have a legal obligation to deliver works that meet the standards and the description set out under the construction contract. Failing to meet these standards, for example by poor workmanship or by using lower quality materials than those agreed upon, would constitute defective work which would then be a breach of contract and the contractor is then forced to remedy the defects or pay excessive damages to the client.

## Methodology

A qualitative research approach was adopted to complete this research project. Interviews allow for a face to face discussion with another person, therefore enabling maximum potential for gathering information from an experienced and knowledgeable participant. Top contract administrators from medium to large organisations were targeted for the interview process to ensure satisfactory results. Contract administrators with a minimum of 15 years' experience and at least five years of experience with dealing with the AS4000.

## Key Outcomes

The key outcomes of this research project were to improve the conditions of contract, in particular the AS4000. Although current contractual clauses exist to protect all parties involved, some amendments are necessary to better their effectiveness and processes. Clauses 35 of the AS4000 should be modified to ensure that each party is aware of their responsibilities.

## Further Work

This research paper was mainly concerned with traditional contracting on civil projects, often referred to as design, bid build. However, further work is required to investigate different contracting options such as design and build and on different projects such as building project. Further work is required to identify the industries acceptance to changing the conditions of contract in relation to the defects liability period and its effectiveness and efficiency on future project.

## Conclusions

It is clear that current contractual clauses in the AS4000 cover some significant aspects related to the defects liability period such as the length of the defects liability period and how and when the contractor must be notified of any defective works.

However, the AS4000 lacks a few key components and will require some modifications in the future, issues such as the possible inclusion of retention bonds into the contract agreements will be investigated as a mechanism with dealing with defective works.

## Acknowledgements

A special mention to my supervisor Dr Vasantha Abeysekera for the continuous support and encouragement throughout this research study.

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# Securities Payments for Subcontractors in the Queensland Construction Industry

School of Civil Engineering and Surveying



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Bachelor of Engineering (Civil)

Supervisors: Dr Vasantha Abeysekera, USQ

**Keywords:** Payment, Contract, Defect

## 1. Introduction

The practice of retention or security payments as a risk management strategy to protect against defective work and poor performance is widely used throughout the construction industry. However, this process currently has inherent issues due to the form it currently takes. It has been noted that risk is commonly delegated to the lowest level and in numerous submissions retentions were stated to be the subject to abuse by a minority of the industry. This is further complicated by the lack of quality assurance as the persons who make payments to contractors rarely check quality of the work completed.

Accordingly, the aim of this study is to identify improvements in legislative and industry practice with respect to quality and the use of retentions in the contractor, subcontractor relationship

## 2. Background

The construction industry is unlike most other industries in Australia. When work is being undertaken, 5% of each payment up until 5% of the works total value is retained. The aim of this is to protect against defective or substandard work. At the completion of the works half of the retention is released and the remained is retained until the end of the defect liability period. In the 2012-2013 financial year 24% of all insolvencies lodged were from the construction industry and of those 30% were due to inadequate cash flow or poor economic conditions. This was further heightened during the global financial crisis. One of the main issues identified was when contractors commenced receivership actions, the subcontractor would invariably lose any retention monies held by that contractor. For these reasons it became justified to conduct a project into this complex area.

## 3. Methodology

The methodology that was undertaken was firstly to confirm the thesis, that there is an inherent issue with the securities payments for subcontractors. This was achieved through a littoral review to identify the measures that had been undertaken. A questionnaire survey was conducted in an informal manner with a semi structured format to establish industry opinion and possible recommendations. Industry was represented by 15 respondents, with a mixed background of quality surveyors, contractors and subcontractors from various trades and company sizes.

## 4. Key Outcomes

This research project is expected to identify that current legislation and practice fails to adequately protect subcontractors in the area of security payments. It will aim to identify possible improvements in the status quo which may lead to recommendations to amend securities of payment legislation.

## 5. Further Work

It is likely that further study will be required into the feasibility of a risk based retentions program. It is also likely that further industry consultation is required to test the recommendations that are identified through the project.

## 6. Conclusions

This study has provided a snapshot of industry feel towards the current practice and that subcontractors are still not adequately protected under the current legislation. It is expected that this research will result in identifying weaknesses in the current legislation and practice with a view to provide recommendations and strategies improve the status quo.

## Acknowledgements

I wish to thank Dr Abeysekera for his guidance and support through this research. I also wish to thank Ms Katie Acton for her support and patience.

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# Optimisation of an Air Gliding Skateboard

School of Mechanical and Electrical Engineering



**Benjamin John**

Bachelor of Engineering (Mechanical)

Supervisors: Dr Ruth Mossad, USQ

**Keywords:** Skateboard, Optimisation, Fluid Simulation.

## 1. Introduction

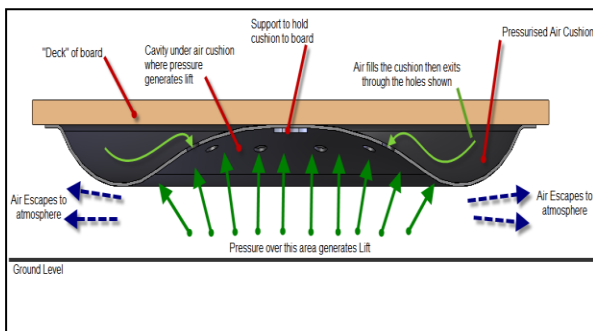
A Skateboard is a type of sporting or recreational equipment. The skateboard is generally propelled forward with one foot while the other remains on the board, or alternatively it can be used in skate parks and half pipes. Since the release of the 1985 movie "Back to the Future" the idea of a "hoverboard" has been entertained by people worldwide. This project aims to move toward the eventual development of a marketable and effective hoverboard using the concept of an air bearing to keep the rider elevated from the ground.

## 2. Background

Quite extensive research has been conducted on Hovercraft for marine and military uses. Very little research has been conducted on hover devices designed to support a single person. The most relevant research comes for Shan et al. (2008) who experimentally proved the concept of an air bearing supporting a rider on a board.

## 3. Methodology

This research project aims to expand upon the work of



**Figure 1 – Air Flow Through Board**

Shan et al. (2008) by using CFD to create an optimum configuration of air outlet holes in the board. The optimum configuration will be achieved when power

losses through the system are lowest which will enhance battery life in moving towards a marketable and effective hoverboard. In the preliminary stage of the project, a feasibility study was conducted to ensure that the appropriate power, pressure and flow rates could be achieved through commercially available suppliers. Once this had been established, a set of dimensionless parameters were obtained using Buckingham's Pi Theorem. Once this optimum configuration is determined, a prototype board will be manufactured. This will then be tested experimentally to compare to the CFD results.

## 4. Key Outcomes

At this point in the project the key outcomes that have been determined are the dimensionless pi groups.

$\Delta P = \text{Pressure Drop}$	$v = \text{Inlet Velocity}$	$P = \text{Inlet Pressure}$	$N = \text{Number of holes}$
$D_1 = \text{Hole Diameter}$	$D_2 = \text{Dist. from C/L}$	$\rho = \text{density of air}$	$\mu = \text{viscosity of air}$
$\pi_1 = \frac{\Delta P}{\rho}$	$\pi_2 = \frac{\rho v^2}{P}$	$\pi_3 = \frac{D_2}{D_1}$	$\pi_4 = \frac{\mu}{\rho D_1}$

It is believed that the primary factors that influence the efficiency will be the hole diameter and the number of holes. Some energy losses due to friction will certainly occur and the magnitude of these is hoped to be reduced through the selection of the optimum hole configuration.

## 5. Further Work

Tasks to be completed are the CFD simulations and the construction of a prototype model. The experimental results from the prototype and the simulations need to be compared.

## 6. Conclusions

The key conclusion at this point in the project is that the concept is achievable through commercially available products. Flight time can be improved through efficiency improvements.

## Acknowledgements

I would like to acknowledge my supervisor Dr Ruth Mossad who has provided invaluable experience. Andrew Tuxford for his creative prompting and my wife Sarah for her never-ending patience.

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# Feasibility and Design of a Battery Energy Storage System for Peak Shaving in a Mining Operation

Sponsor – Sandfire Resources



**Daniel Johnston**

Bachelor of Engineering (Electrical and Electronic)

Supervisors: Dr Leslie Bowtell, USQ

Ms Carmel Johnston, Sandfire Resources

**Keywords:** Energy, storage, cost.

## 1. Introduction

Sandfire Resources operates a copper mine in WA which is powered by 12 diesel generators. The idea of using a battery energy storage system (BESS) was researched to establish its capability and limitations and determine if it can replace a number of generating sets to offer financial and environmental savings. A research, design, feasibility study approach was adopted to satisfy both USQ project objectives and the industry sponsor's requests.

## 2. Background

The resource and utility sectors are two of the biggest contributors to harmful emissions and offer opportunities for improvement. Environmental and financial savings can be made in current practices. This study was conducted to establish the ability of a BESS to replace peaking plants and accommodate for peak demands.

## 3. Methodology

Research was conducted and a system was designed in consultation with renewable energy specialists from Juwi. Testing (to be carried out) is used to establish EMC, harmonic content and efficiency in various power converters and configurations. A cost analysis of the system was compared to the capital and operational expenditure of the current system to establish any financial savings. It is hoped that the cost comparison will reflect the theoretical comparison in Figure 1. The study also included an analysis of greenhouse gas emissions.

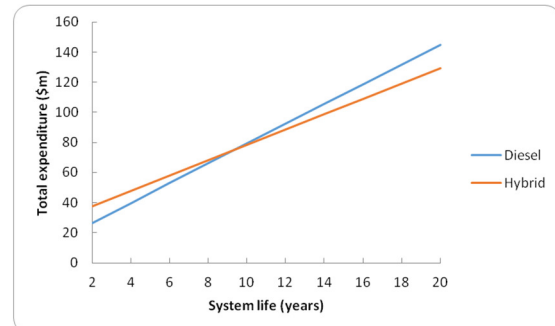


Figure 1: Diesel powered and hybrid cost comparison.

## 4. Key Outcomes

Testing and costing of the BESS are yet to be carried out. USQ battery shop will be used in the September/October to determine a preferred power converter and limitations through efficiency, EMC and harmonics studies. This will form the main justification of BESS implementation according to AS/NZ Standard compliance, capability and financial benefits.

## 5. Further Work

Mature battery technologies such as lithium ion, lead acid and nickel metal hybrids were considered. Further research needs to be conducted into new battery technologies which could offer greater efficiency. This report is limited to BESS. Exciting technologies exist that could prove highly competitive such as flywheels and pressure energy storage.

## 6. Conclusions

The conclusions are yet to be determined. While the proposal is capable of delivering peak power demand at a reduced emission level it needs to be established if it is at a reduced financial cost and able to be commissioned within industry standards.

## Acknowledgements

I would like to thank my USQ sponsor, Les Bowtell, for his advice. Also I would like to thank Sandfire Resources for their willingness to part with sensitive information. In particular, Carmel Johnston, who is an ok sister and a wealth of information.

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# Design and Development of a Fibre-Optic Microphone

School of Mechanical and Electrical Engineering



Isaac Kennedy

Bachelor of Engineering – Beng  
(Electrical and Electronic)

Supervisors: Dr John Leis, USQ

**Keywords:** Fibre-optic, microphone, interferometry

## 1. Introduction

The aim of the project is to design and develop a fibre-optic microphone. The proposed application for the microphone is the photo-acoustic detection of gas.

Fibre optic sensor theory presents many ways to construct a fibre-optic microphone. As such, this project requires examination of this theory in order to consider possible options and develop the most appropriate design for the application.

## 2. Background

The development of the laser and low loss optical fibre in the 1960s greatly increase use and research into optical fibre technology for communication purposes. The 1970s brought about research into the sensing application of fibre-optics (Grattan & Sun 2000).

Fibre-optic sensor theory has led to the possibility of the fibre-optic microphone. Several working systems have been developed including for use in photoacoustic detection of gases (Breguet et al. 1995).

In order to increase the sensitivity of the microphone beyond that of similar device, a lock-in amplifier will be employed for its ability to detect and amplify signals with extremely low signal to noise ratio.

## 3. Methodology

Interferometry involves combining two waves and examining the interference produced in order to determine information about the waves. Fibre optic sensors often employ interferometry by splitting the path of light from a source into two, allowing one path

to be modulated in some way, and examining the interference produced when the two paths are recombined. In order to produce a microphone with an easily detectable output, it is necessary to construct a fibre-optic interferometer.

A lock-in amplifier produces a DC output when locked on to a carrier frequency. Variations in the carrier frequency cause the output to vary. The operation of the lock-in amplifier makes it possible to track carrier signals of extremely low signal to noise ratio and produce a quality output. The use of a lock-in amplifier will greatly increase the sensitivity of the microphone.

## 4. Key Outcomes

A literature review covering theory relevant to the fibre-optic microphone revealed many options for constructing a fibre-optic microphone. Through careful consideration a proposed design has been developed.

Construction and testing of the device has begun and shown promising results.

## 5. Further Work

Further refinement of the design is necessary before the device can be considered operational. Experimentation will be necessary to develop a sensor head which effectively transfers the incoming soundwaves to the optical fibre.

Once a sensor head has been developed, the lock-in amplifier will be incorporated in order to increase the sensitivity to a desirable level.

## 6. Conclusions

Fibre-optic microphones are not only a feasible alternative to conventional designs but offer several advantages including electromagnetic immunity and high sensitivity.

## Acknowledgements

I would like to thank my supervisor Dr. John Leis for his guidance and advice throughout the project.

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# Mansell Power Lifter Control Circuitry Redesign

Sponsor – Buchanan Advanced Composites



**Callum K. Keys**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Dr John Leis, USQ

Dr John Grant-Thomson,  
Buchanan Advanced  
Composites (B.A.C.)

**Keywords:** Embedded systems, H-bridge, microprocessor.

## 1. Introduction

The Mansell Power Lifter is a key element of the Mansell Infant Retrieval System which functions as a means to seamlessly transport by both aircraft and road ambulances, neonates and infants that are in a critical condition. It is one element of a three-part system which is shown in Figure 1. The Power Lifter can be identified in the figure as the mobile support structure which carries the other two components of this three part system; the Neosled and Neocot. The main advantage of the Mansell Power Lifter is that it is specifically designed to alleviate the physical strain placed on its operator when loading and unloading both patients and medical equipment into emergency vehicles. This is possible through the unique framework of the system that allows the Power Lifter to raise and lower in a scissoring action from 270mm above ground to an approximate maximum height of 1 meter. This functionality is engaged by the operator using a control panel that drives two actuators to raise or lower either separately or simultaneously, the front and rear of the Power Lifter. These actuators are connected in a H-bridge configuration.

## 2. Background

The Mansell Power Lifter was developed over a decade ago, and during this time certain components within the systems control PCB have ceased being manufactured and are now obsolete. Due to the increasing difficulty to source these components, it has become necessary to consider design alternatives for the system's control circuitry to ensure production is possible well into the future. Throughout the design process it has been essential to consider compatibility and interchangeability with the existing system.



Figure 1 – Mansell Infant Retrieval System

## 3. Methodology

In order to develop a prototype system to control the Power Lifter, it was first necessary to become familiar with the existing circuitry and system functionality. Investigations found the optimal solution for redesign was to replace existing analogue circuitry with a microprocessor. Once a microprocessor was selected, the system functions were modelled using finite state automata. Using the developed software model, the microprocessor was programmed accordingly, and hardware interfacing was then commenced. The key sections of the analogue circuitry are interfacing inputs to the microcontroller from the existing user control panel, outputs from the microcontroller to driver the H-bridges, and current sensing feedback to the microcontroller.

## 4. Key Outcomes

The main outcome of this project was to develop and validate the prototype for the updated circuitry to control the Mansell Power Lifter. The project requirement of backwards compatibility and interchangeability with existing systems has been met.

## 5. Further Work

Future work would include developing a final PCB layout for the system.

## 6. Conclusions and Acknowledgments

This project illustrates the necessary process for industry relevant embedded system design. Much appreciation and thanks to Dr John Leis, Dr John Grant-Thomson and B.A.C. for the welcomed guidance.

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# The Effect of Road Roughness on Traffic Speed and Road Safety

Sponsor – School of Civil Engineering and Surveying, Queensland Department of Transport and Main Roads



**Bernie-Anne King**

Bachelor of Civil Engineering

Supervisors: Prof Ron Ayers, USQ

Mr Partha Parajuli, Qld Dept. of Transport and Main Roads

**Keywords:** Roughness, Speed, Safety, NAASRA

## 1. Introduction

Pavement roughness is an important component of road quality. It is perceived by most traffic authorities as the best indication of ride comfort. This road parameter has been compared with traffic speed and crash statistics to determine the relationship and its effects on driver safety. The research investigates the Downs South West Region of the Queensland Department of Transport and Main Roads (DTMR). This region covers nearly 400 000 square kilometres, which is about 23% of Queensland (Queensland Government 2013a, p.3).

## 2. Background

DTMR have recently completed a speed review, which evaluates the suitability of the networks posted speeds. Roughness was highlighted as a parameter which would limit the design speed of the road, however the extent and effect of roughness was uncertain.

A greater understanding of the effect of pavement roughness will also allow transport authorities to make informed designs for the road networks, ultimately making travel safer for the wider community.

Overseas studies have indicated that higher roughness levels have a greater history of crashes, as well as cause drivers to lower their travelling speed. A Swedish study by Ihs (2004), found that the correlation between roughness and accident rates was very high on roads with an AADT greater than 12000vpd. This is represented in figure 1, where the accident rate is presented in crashes per 100 million axle pair kilometres.

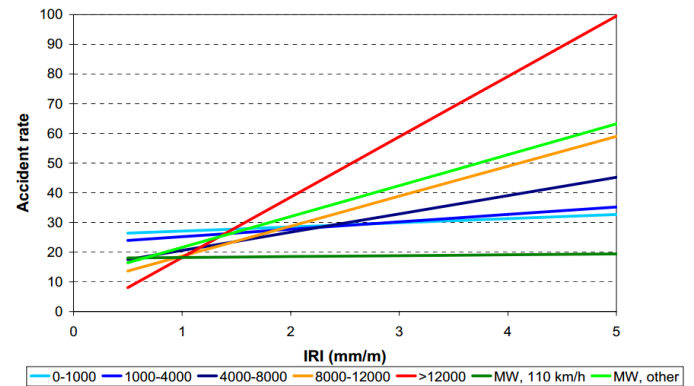


Figure 1: Relationship between IRI and speed (Ihs 2004 p.4)

## 3. Methodology

A case study approach was utilised, using roughness readings, speed data, crash statistics and road information from DTMR databases. This data was used to model the relationship between crash history and pavement roughness. The crash model for 100 million vehicle kilometres travelled (VKT) was utilised. At the selected locations, a comparison of driver speed and roughness was also completed. These case studies also investigated the other road parameters which may have affected the crash statistics or travelling speeds.

## 4. Further Work

A similar study on a wider scale, would give the findings in my research and in other similar studies further credibility. Completing simulated tests on pavement with varying roughness would also give this topic some further information, and limit the variables of the model.

## Acknowledgements

I would like to thank Prof Ron Ayers for his guidance and feedback throughout the course of this project. I would also like to acknowledge my colleagues at the Qld Dept. of Transport and Main Roads, particularly Partha Parajuli for his assistance and knowledge.

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Queensland Government 2013a, 'Downs South West' Department of Transport and Main Roads, Australia

# Development of an Improved Free Flight Model Release Mechanism for the TUSQ Hypersonic Wind Tunnel

Sponsor – School of Mechanical and Electrical Engineering



**Ben Kistemaker**

Bachelor of Engineering  
(Mechanical)

Supervisor: Dr David Buttsworth, USQ

**Keywords:** Design, wind tunnel, hypersonic.

## 1. Introduction

This project aims to further the application of hypersonic free flight wind tunnel testing by developing an improved model release mechanism for the USQ hypersonic wind tunnel facility. Free flight model experiments will then be conducted in the USQ facility to validate the release mechanism and to further demonstrate the application of the free flight method for hypersonic model testing.

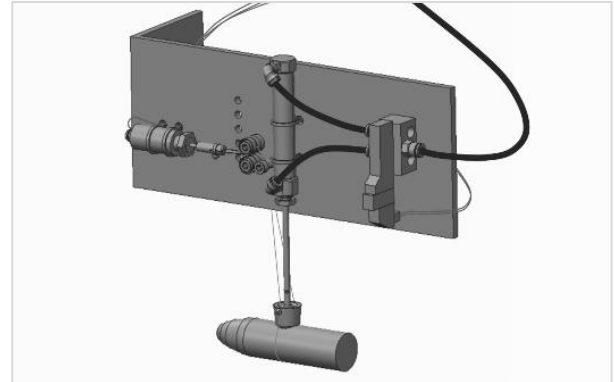
## 2. Background

Aeronautical progression through supersonic and into hypersonic regimes have required the implementation of a new type of wind tunnel, commonly referred to as an expansion or shock tunnel. Such a tunnel has been developed at the University of Southern Queensland and is capable of producing a hypersonic flow of 200ms duration.

Recent experiments in the USQ tunnel, designated TUSQ, have advanced the use of free flight testing, whereby the model is dropped freely through the flow. Model drag is determined using Schlieren image analysis or via an on-board accelerometer and gyroscope package. Such testing eliminates the interference of a fixed model support but adds a new challenge of accurate and repeatable model release. This challenge has not been met by the current release mechanism, which utilises a silk thread to support the model and a solenoid cutter to actuate the release.

An improved model release mechanism will increase the reliability of test results, will enable the model to be dropped at different angles of attack and will reduce setup time between each drop.

In addition, the conduct of experimental model drops in the TUSQ facility will further establish the free flight method for hypersonic model testing.



**Figure 1 – Release mechanism currently being tested**

## 3. Methodology

The project began with an understanding of the facility and design requirements, as well as broad research into the relevant theory; this led to an understanding of actuation methods that *might* work. Targeted research and the conceptual modelling of various concepts led to a selection of mechanisms that *should* work. Physical testing then confirmed what *would*, or most commonly, what *would not* work, given the very small timing requirements of the end solution.

Bench testing is currently being completed for a physical prototype of the release mechanism, based on a combination of pneumatic and solenoid actuation.

## 4. Further Work

Hypersonic tunnel runs for validation of the mechanism and further establishment of the free flight testing method are still to be conducted.

## 5. Conclusions

The design of a mechanism for response times measured in milliseconds, rather than seconds, requires an understanding of the underlying principles but also a good deal of practical judgement and experimentation. It is expected that the final mechanism will improve repeatability and setup time for future free flight experimentation in the TUSQ facility.

## Acknowledgements

A special thank you to Dr David Buttsworth whose advice and in-lab assistance has been appreciated.

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# Alkali-Silica Reaction in Concrete Bridge Piles: Strengthening with Fibre-Reinforced Polymers.

Sponsors – Department of Transport and Mainroads (TMR),  
Boral Concrete and Wagners.



**Tracey Knight**

Bachelor of Engineering (Civil)

Supervisors: A/Prof Yan Zhuge, USQ  
Dr. Wayne Roberts, TMR

**Keywords:** Alkali-Silica Reaction, Concrete,  
Fibre-Reinforced Polymers.

## 1. Introduction

Unexpected and premature degradation of concrete bridge structures due to Alkali-Silica Reactivity (ASR) is a significant problem facing most, if not all, road and infrastructure authorities around the world. Alkali-Silica Reaction occurs between the highly alkaline cement paste and reactive non-crystalline silica in concrete aggregates producing an expansive gel. Deleterious ASR expansion can inflict serious damage and expose the structure to other forms of structural damage. This project focuses on the use of fibre-reinforced polymers to reinstate the compressive strength of ASR affected concrete bridge piles.

## 2. Background

The Queensland Department of Transport and Main Roads (TMR) has an extensive need for concrete infrastructure. A TMR asset survey has shown that approximately 105 Queensland bridges are known to be suffering from the effects of ASR (Carse, 2000). A number of studies have shown that physical restraint or containment significantly reduces deleterious ASR expansion. Fibre-reinforced polymers are a strong, lightweight material that can be manipulated to encase ASR affected structures with the potential to restore structural integrity.

## 3. Methodology

Replicating damage caused by ASR-like expansion and cracking in laboratory test samples has been achieved by using the ASTM

C1260 – Standard Test Method for Potential Alkali Reactivity of Aggregates. Map cracking and significant damage was evident in initial cylindrical samples after 11 weeks. The final concrete cylinders will be removed from the sodium hydroxide solution in September, at which time, they will be wrapped in two variants of fibre-reinforced polymer and compressive strength testing will then be conducted on the retrofitted and non-retrofitted samples.



Figure 1: Map cracking in sample

## 4. Key Outcomes

ASR damage replication in the laboratory has been successfully achieved. A baseline development of compression strength loss due to deleterious ASR has been investigated and retrofitting techniques have been explored.

## 5. Further Work

Final testing of the FRP-wrapped ASR-damaged concrete cylinders is to be conducted in the coming weeks.

## Acknowledgements

I would like to thank Dr. Yan Zhuge (USQ) and Dr. Wayne Roberts (TMR) for their invaluable support and direction. I extend many thanks to Tony Thomas and the staff at Boral Teven Quarry, Boris Humpola and Tanya Ramsey from Wagners, Daniel Eising (USQ) and Angela Rosas without whom this project would not have been achievable.

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# 3D Modelling of the O.O. Madsen Bridge During Flood

Sponsor – Southern Downs Regional Council



**Russell Knipe**

Bachelor of Engineering – Civil

Supervisors: Dr Andrew Wandel, USQ

Mr Stephen Bell

**Keywords:** CFD, Flood models, Bridge

## 1. Introduction

Australia is a continent of droughts and flooding rains. As urban development increases more and more emphasis is being placed on hydraulically efficient drainage channels. While it simply isn't practical to avoid placing objects bridges in the way of floodwater, it is important to consider the effect of the objects on flow especially for buildings within the floodplain.

## 2. Background

The O.O. Madsen is one of the major bridges at Warwick that crosses the Condamine river, and frequently becomes overtopped by water during large flood events. These flood events leave the guard rails clogged with debris, and the local population feel that this contributes to increased flood depths upstream. This project aims to investigate the effect of the bridge as an obstruction of the channel, specifically the guard rails. A flood study undertaken by Jacobs identified that the rails contributed to the floods. The objective of this project is to confirm these findings.

## 3. Methodology

The CFD modelling program ANSYS Fluent was used to model the bridge. CFD Fluent is a 3D fluid modelling program that uses a complex series of equations to solve fluid problems. The bridge is too large to be modelled in its entirety, so the bridge has been broken up into a series of sections for modelling. The input parameters are taken from the Jacobs flood study (e.g velocity, depth etc.) and the results are compared to results from the flood study as well as photographs.

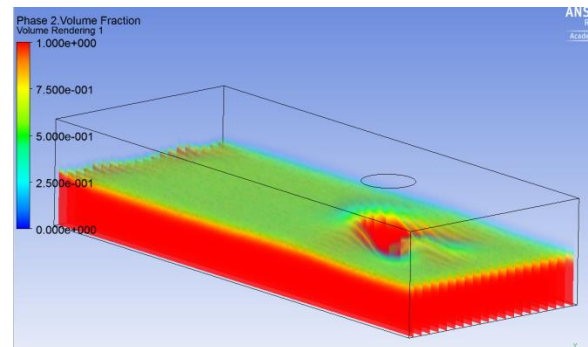


Figure 1 - Fluid Moving Around Bridge Pier

## 4. Key Outcomes

The results from this model will help Southern Downs Regional Council and Main Roads to update the guard rail designs for the bridge. These guard rails may be collapsible or may simply need to be shorter in conjunction with the appropriate standards and main roads specifications.

## 5. Further Work

The final results of the model are yet to be confirmed as parametric studies are still being completed. Additional forms of guardrails are still being investigated and modelled. Results will be obtained soon and the report finalised.

## 6. Conclusions

Preliminary results indicate that the bridge rails do contribute significantly to a loss of head over the bridge. More analysis has to be done to ensure the current results are accurate.

## Acknowledgements

Thanks must be given to my supervisor Andrew Wandel, whose knowledge and expertise in Fluent were essential to this project. Special thanks to the project sponsor Southern Downs Regional Council. and to Jacobs for information and data about their flood study. Finally, thanks to my family who haven't seen me for most of 2014.

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# Investigation of the effects of substandard road geometry at urban signalised intersections



## Yasaswi Kodali

Bachelor of Engineering  
(Honours) (Civil)

Supervisors:

Professor Ron Ayers, USQ  
Mrs Jade Hogan,  
Lead Road Designer at RMS

**Keywords:** Road Design, substandard geometry, signalised intersections,

## 1. Introduction

Road design standards generally provide parameters that are suitable for the design of roads in Greenfield sites. The constrained nature of an urban environment however, often requires road designers to propose substandard horizontal and/or vertical geometry.

Constraints are amplified in an urban environment at intersections, which are a point of conflict for motorists, pedestrians, cyclists and other road users. Geometric design at an intersection influences intersection safety, shapes road user expectations and defines driver behaviour (FHWA, 2014).

The aim of this research project is to investigate the effects of substandard geometry on the type, frequency and severity of crashes at signalised intersections in an urban environment.

## 2. Background

It is the intention of this research to enable road designers to make sound geometric design decisions during the design phase of a project that maximises safety whilst balancing the costs of adjusting existing infrastructure in a constrained urban environment. In particular, it is expected that the outcomes of this research project will provide road designers and engineers with an understanding of whether using values outside the normal design domain in an urban environment has an explicit effect on intersection related crashes.

## 3. Methodology

Substandard intersections identified in this study are located in the Greater Sydney region and have horizontal and/or vertical geometry outside the Normal Design Domain (NDD) parameters as identified in the Austroads Guide to Road Design.

Signalised intersections that are geometrically compliant with NDD parameters were also identified in the near vicinity of every substandard intersection and

have been used as 'base cases' for statistical crash data comparison against the substandard sites.

In order to identify if a particular type of geometric deficiency increases the risk of crash to drivers, substandard intersections have been categorised into horizontally substandard, vertically substandard or a combination of both.

Detail survey, ALS survey and/or Gipsicam data was used to analyse and identify suitable sites. Crash data, obtained from Roads and Maritime Services' database, was collated and analysed to determine trends/differences in type, severity and frequency of crashes.

## 4. Key Outcomes

Research conducted suggests that urban signalised intersections with substandard horizontal and vertical geometry outside the Normal Design Domain (NDD) parameters present a higher likelihood of a crash risk to drivers.

It was noted that there were only a small number of arterial roads with a combination of geometric elements outside the Normal Design Domain in the Greater Sydney region.

## 5. Conclusions

This study supports the theory stated in Austroads Design Guides that a design should not adopt combinations of substandard vertical and horizontal geometry and has potential safety implications. If their implementation is unavoidable due to cost and constraints of a built-up urban environment, a site specific risk assessment should be undertaken in the design phase of the project to assess the associated risks. Mitigation measures should be implemented to ameliorate the effects of the substandard geometric layout.

## Acknowledgements

I would like to express my appreciation to Professor Ron Ayers from USQ for his supervision of this research project. I would also like to express a sincere thank you to my local supervisor, Jade Hogan, for her guidance, support and valuable critique of the research.

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U.S Department of Transportation and the Federal Highway Agency (FHWA), 2014, Signalised Intersections: An informational guide

# Feasibility Study of Incorporating Barometric Pressure Transducers in Miniature UAV for Obstacle Avoidance in an Indoor Environment

Sponsor – School of Mechanical and Electrical Engineering



**Anand Koirala**

Master of Engineering Science  
(Electrical and Electronics)

Supervisors: Dr Tobias Low, USQ

**Keywords:** UAV, Obstacle avoidance, Pressure Sensor

## 1. Introduction

This project aims to study the feasibility of using pressure sensor to pick up sudden changes in air pressure within the vicinity of the drone's propeller if an obstacle happens to come along its path. Pressure sensors will be hard-wired in a circuit board and attached physically to the drone itself for recording of the sensed data.

## 2. Background



Drones that are supposed to be used in constrained indoor environment must be precise and agile enough in their flight so as to avoid obstacles such as walls, ground, ceiling, windows, and various objects. For such autonomous flight it is of utmost importance to understand and anticipate the changing aerodynamic environment (Belatti). The onboard sensors can fail in many cases such as unavailability of GPS signals, flying under low lighting conditions and or weakly textured environments (Bristeau et al. 2011). If we could integrate sensors to monitor the airflows around the propellers the drone could be implemented to operate in indoor missions for search and rescue or for

mining application even if the environment is completely new to the drone.

## 3. Methodology

To achieve success the methods would be based on increasing complexity in each task as the project progress. Initially two sensors and one propeller would be used and the drone be kept stationary in hovering state. Some obstacles of measurable geometrical shapes would be introduced into the flow field to test the validity of theoretical limitations that has been set.

## 4. Key Outcomes

Simplified air flow model was generated after specific assumptions. Theoretical calculations have been made suggesting proceeding with practical and validity test the theoretical limit set.

## 5. Further Work

This project is now in the stage of programming the Arduino board to interface the pressure sensors through I2C communication protocol. This is the major repetitive part of the project where the sensors will be calibrated and the data recorded for further analysis and improvement. As, the complexity of practical tests would be increased in progressing to the next stages this work will continue until the final submission of dissertation paper.

## 6. Conclusions

This project is genuine idea of studying the viability of incorporating barometric pressure sensor to monitor the air flow around propeller and upon success augments the existing drone's control technology.

## Acknowledgements

I would like to thank my supervisor Dr. Tobias Low, as this project being genuinely his idea that we have decided to implement into reality.

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# The value of public space – a town square in a small urban community

School of Civil Engineering and Surveying



**David Kraljik**

Bachelor of Spatial Science  
(Surveying)

Supervisors: Marita Basson, USQ  
Paula Grant, USQ

**Keywords:** public space, town square, social values

## 1. Introduction

In Western society, planned public space in the form of town squares has been evident since around 500 B.C. Since then public space has played an important role in communities providing social, economic and cultural value to its members and visitors alike. With the recent success of squares, for example Federation Square in Melbourne, it seems there has been a resurgence in the development of town squares particularly in small urban communities throughout Victoria.

## 2. Background

Public space in the form of town squares has historically provided community members a place to communicate, to be seen and heard, for leisure, to socialise, shop, rest, watch and play. These activities remain important and relevant in today's society. Modern day challenges, including private/public competition for limited space, rapid advancements in technology and the increasing use of social media, are all issues faced by urban planners in developing high quality, relevant public space.

## 3. Methodology

Literature on the historical and modern day significance of public space along with the values communities attach to public space, with particular reference to town squares, was analysed providing the basis for this mixed methods research. Analysis of demographic data on the case study town of Bacchus Marsh, Victoria was conducted while observational data was collected and analysed from an existing public space in a location with similar demographics. The results of the research and observations then formed the basis of a framework for the development of a town square in the case study town.



Figure 1 – Federation Square, Melbourne

## 4. Key Outcomes

Analysis of the available literature, demographic data and observations enabled the creation of a design framework focussed specifically on town squares. This framework will be applied to a suitable and convertible public space in the case study town.

## 5. Further Work

The completion of a concept design for submission to local government for consideration of the framework and proposal would further complete the process. Further to this, the inclusion of community ideas and attitudes would be beneficial, if not essential, in completing the developed framework and concept design.

## 6. Conclusions

From the research it is evident that public space in the form of a town square remains an important feature in any community. Aside from various social, economic and cultural benefits, its facilitation of face to face human contact can help to build and foster a sense of belonging which is an important aspect of forming strong, resilient communities.

## Acknowledgements

The research could not have been completed without the help and support of my supervisors Marita Basson and Paula Grant along with the librarians at both USQ and The University of Melbourne, all of whom I would like to sincerely thank.

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# Kinetic Energy Recovery In Motor Vehicles Using Compressed Gas

Sponsor – School of Mechanical and Electrical Engineering



**Rick Kruger**

Bachelor of Engineering  
(Mechanical)

Supervisors: Dr Ray Malpress, USQ

**Keywords:** Kinetic Energy Recovery, Compressed Gas, Regenerative Braking, Vehicle Efficiency

## 1. Introduction

Kinetic energy recovery, also known as regenerative braking, is the process of recovering energy from a moving vehicle under braking conditions. The energy is stored for later use during acceleration. It can increase both performance and efficiency, therefore addressing the key issues of sustainability and the environment.

This project seeks to investigate the viability and performance of a kinetic energy recovery system using compressed gas.

## 2. Background

Kinetic energy recovery addresses sustainability through reduced fuel consumption. This is critical given that oil reserves are expected to be exhausted within the next 50 years. Kinetic energy recovery can also reduce vehicle emissions, which are concerning for both health and environmental reasons.

Hybrid electric vehicles are the most predominant kinetic energy recovery technology used in current passenger vehicles such as the Toyota Prius. While addressing fuel consumption and reduced emissions, these technologies are not without their limitations. The additional components needed increases weight which reduces efficiency. Efficiency is also affected due to conversion losses from one form of energy to another.

Using the engine to compress gas reduces the amount of additional components needed and hence the weight of the system. It also helps to limit energy conversion losses.

## 3. Methodology

A literature review was conducted to analyse the ability of an internal combustion engine to compress gas. Key

performance parameters were identified that would affect the amount of gas compressed and stored. Any issues to implementation were also identified and solutions established. Using the analysis of the engine as a compressor, a model is to be devised using Matlab that takes into account key considerations such as heat transfer and valve timing. To simplify the model, a set of assumptions will be used for the initial conditions and input parameters. The model will determine the amount of gas that can be compressed and stored during a predefined rate of deceleration, by calculating the pressure and temperature of the compressed gas at the end of each revolution.

## 4. Key Outcomes

The literature review revealed that variable valve timing is a key component to allowing the engine to operate as a compressor or a pneumatic motor. The project also analyses and evaluates of the viability of using an internal combustion engine to compress gas and how this technology compares to other regenerative braking technologies.

## 5. Further Work

Completion of the simulation model is still required. An analysis of the results is also required to compare the recovery of kinetic energy using compressed gas against other technologies used for regenerative braking.

Further opportunities exist to develop more complex models that can also account for optimised variables such as a variable transmission speed during braking.

## 6. Conclusions

Using an internal combustion engine to compress gas is a conceptually viable technology. With the addition of variable valve timing and optionally an additional valve, the engine can be operated as a compressor and a pneumatic motor. Further modelling is still required before conclusions can be drawn on the energy recoverable and how this compares to current technologies.

## Acknowledgements

Firstly, I would like to thank my supervisor Dr Ray Malpress for his ongoing support and guidance.

I would also like to thank my wife for her infallible support, and above all her inexhaustible patience.



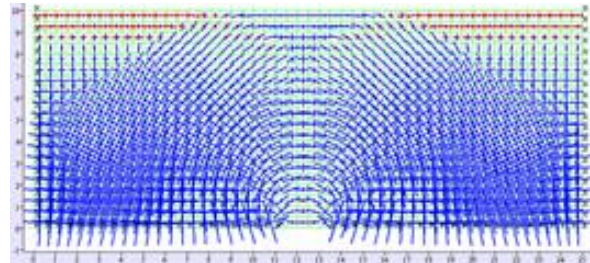
# A PHYSICAL AND NUMERICAL INVESTIGATION INTO SINKHOLE FORMATION

Sponsor – School of Civil Engineering and Surveying



**Brian Lamb**

Bachelor of Engineering,  
Civil



**Figure 1 - Principle stress vectors (undrained clay;  $h/w = 5$ )**

Supervisors: Dr Jim Shiau, USQ

**Keywords:** Sinkhole, Stability, Modelling

## 1. Introduction

Sinkholes are a global phenomenon which can result in a major impact to a community. This paper aids in understanding the phenomena of sinkholes better through physical and numerical simulations.

## 2. Background

There are many different causes of sinkholes, but all are linked to the overburden's soil pressures. The pressures increase to a breaking point where then the overburden material, the material above an underground cavity, falls into the cavity, leaving in many cases a conical shape and circular ground opening.

This paper is focused on investigating sinkholes by generating idealised physical, 2D and 3D models, describing the sinkhole phenomena so it can be further explained. Fast Lagrangian Analysis of Continua (FLAC) software produced by the Itasca Consulting Group, Inc. is used for the 2D and 3D analysis.

The trap door scenario used in the analysis combined with the strength reduction method for solving for factor of safety is a new way of analysing sinkholes.

## 3. Methodology

The research is conducted by closely examining a physical model to simulate the formation and collapse of a sinkhole and then by analysing sinkhole structures through utilizing finite difference software FLAC. In FLAC soil with both cohesion and friction angle ( $c-\phi$ ) is tested as well as undrained clay and drained sand. The completion of 2D and 3D numerical models allows for numerous sinkhole simulations, with varying

material properties and different overburden depth to cavity width ratios. The sinkholes are analysed through a strength reduction method, which can produce the factor of safety of the formation.

## 4. Key Outcomes

$c-\phi$  soil was more stable when compared to undrained clay and drained sand. Zero cohesion soils appear to fail immediately once the cavity is open. A non-zero friction angle though does aid in increasing safety and stability of overburden. An arching effect of soil stresses appears to play a key role in the stability of the overburden.

## 5. Further Work

Future work is to conduct more 3D simulation models for the further investigation into sinkhole behavior.

## 6. Conclusions

By completing these simulations with different overburden depth to cavity roof width ratios the sinkhole phenomenon mechanics is explained.

## Acknowledgements

I would like to thank Dr Jim Shiau for his assistance with the project, and also Mr David Lamb and Mr Chris Galligan for their assistance with the physical model construction.

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# Risk Assessment Tool For The Design Of Surface Runoff Dams For Open Cut Mining

Sponsor – School of Civil Engineering and Surveying



**Bernard Lariviere**

Bachelor of Engineering (Civil)

Supervisors: Dr Malcolm Gilles, USQ

**Keywords:** Risk, Mining, Surface Runoff Dams

## 1. Introduction

Mines in Australia often face many challenges to keep the mine operational in extreme weather. The mining of the open pit is a complex process as the mining walls and faces are typically dynamic. This in turn complicates any consideration of the surface runoff and how it should be taken into account to prevent the cut face and pit from being inundated.

## 2. Background

This project is intended to provide a risk assessment tool for the application in design and management of earth-filled embankment run-off dams used in open cut mines within Australia. The tool is intended to be used by the mining and engineering management to deal with the dynamic nature of the pit face and providing a technical and legal insight combined with a risk analysis in constructing and maintaining surface run off dams.

## 3. Methodology

Methodology of this project involves applying a literature review of current legislation, design, construction and maintenance methods for surface runoff dams and applying the findings to a designed database of possible failure modes. By analysing commonalities of surface runoff dam designs, construction and maintenance, improvements to the process can be suggested by applying the information from the database into a risk matrix.

## 4. Key Outcomes

Key outcomes of the project include a risk management tool for surface runoff dams that can be used to help make risk management decisions quickly and accurately. The project also aims to create a better understanding of factors influencing risk and risk management



**Figure 1–Inundated Yallourn open cut coal mine, VIC June 2012**

## 5. Further Work

The parallels in scope of this project can be extended to similar earthwork projects ranging from mine tailings dams to bulk water supply dams. As with the development of new technologies, there will always be ways of improving and managing risk.

## 6. Conclusions

In conclusion this tool can add value to the mining industry as far as occupational hazards and economical cost savings by identifying potential risks and hazards before they occur.

## Acknowledgements

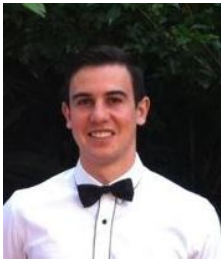
I would like to thank all those at Anglo American and Hatch that have contributed to sharing their knowledge and experience in assisting with the guidance and completion of this project. In particular I would like to thank Dr Malcolm Gilles for his support and guidance as my supervisor as well as my family for their support, patience and understanding.

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<<http://www.theage.com.au/victoria/yallourn-coal-mine-flood-worsens-20120715-224ef.html>>

# Assessing the true cost of design variations – a designer’s perspective

Sponsor – School of Civil Engineering and Surveying



**Ben Liddell**

Bachelor of Engineering (Civil)

Supervisor: Paul Tilley, USQ

**Keywords:** design changes, documentation quality, variations, cost impacts

## 1. Introduction

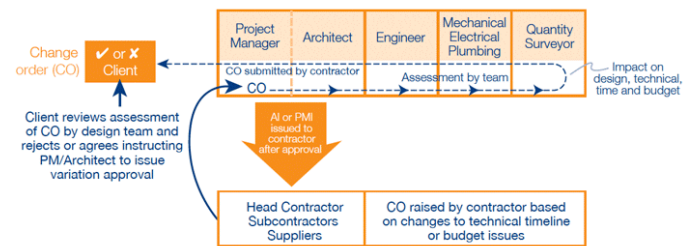
Variations are prevalent within the building, engineering and construction industry. Variation orders are a legal means of changing a projects scope of works as defined by the contract documents. They have the ability to be beneficial and detrimental to the design and construction process. Clients, consultants, contractors and subcontractors deal with variations on most major projects. Their opinion of variations is largely determined by past experiences; good or bad. Some project participants may see them as a means to improve the overall quality or functionality of the design. Others may see them as an unavoidable component of the design and construction process, imposing additional costs and schedule delays on the project and the parties involved.

This project focuses on the negative aspects of variations, primarily the causes of design changes and the overall cost implications imposed on designers. Case-study data will be obtained from private design firms and local government design teams. Strategies will be formulated to mitigate the cost impacts of variations.

## 2. Background

The designer/s ability to produce the “perfect” design in a cost and time restrictive environment is near impossible. Along with the unpredictable nature of construction industry it is inevitable that design changes and variations will arise during the life of a project. Variations may initiate reviews, redesign, and reproduction of drawings along with the associated administration costs. The ability of design consultants to quantify the costs of variations imposed on their

businesses will help identify strategies to mitigate unnecessary financial burdens.



**Figure 1: Typical Variation Order Process**

## 3. Methodology

- Research background information relating to design variations and the overall cost implications.
- Evaluate current methods of reducing cost impacts of design variations.
- Obtain case-study data from industry sources, with particular focus on the reasons why design changes are made and the overall cost implications that variations impose on designers.
- Provide recommendations on how the cost impacts of design variations can be reduced.

## 4. Key Outcomes

Key outcomes for this project are yet to be determined.

## 5. Further Work

The analysis of case-study data and recommendations for reducing cost impacts.

## 6. Conclusions

Conclusions for this project are yet to be determined.

## Acknowledgements

I would like to thank my supervisor Paul Tilley for his support and guidance throughout this year. I would also like to thank my family for their continual support during my academic studies.

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# Terrestrial Laser Scanning for Building Information Modelling

Sponsor – Ultimate Positioning Group



## Brenton Light

Bachelor of Spatial Science  
(Surveying)

Supervisors: Dr Zhenyu Zhang, USQ

**Keywords:** Terrestrial Laser Scanners, Building Information Modelling, Point Clouds

## 1. Introduction

The aim of this project is to investigate the suitability and implementation of Terrestrial Laser Scanners in Building Information Modelling.

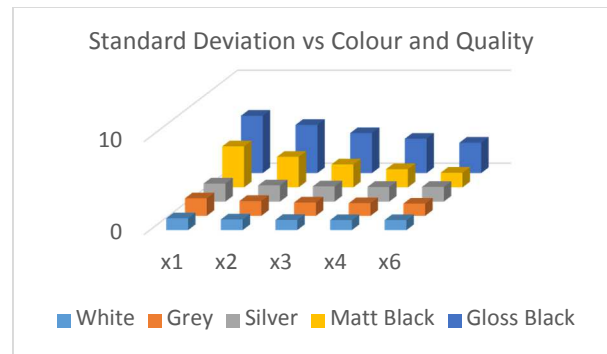
## 2. Background

Building information model (BIM) provides detailed information on building components, geometry, spatial relationships, and other properties in three-dimensional (3D) space. BIM helps understand geometric properties of buildings and provides the base for a number of forms of functional analysis and has many applications in areas such as facility management, maintenance, heritage protection, deformation monitoring, town planning and the support of decisions. The key idea behind a BIM is to obtain accurate 3D building data in order to adequately describe the buildings structure.

Terrestrial laser scanners (TLS) offer the ability to collect highly accurate high density 3D point clouds. Applications of TLS in BIM have not yet been extensively tested. Moreover, efficient methods and workflows for efficiently extracting building structure information from large TLS data sets have yet to be developed.

## 3. Methodology

This project first involved researching the different types of TLS and their potential suitability for use in BIM. Once it was deemed at least theoretically suitable, the project then moved onto the testing and verification of TLL, and then onto scanning some different buildings and analysing data obtained, and



developing workflows in order for surveyors to undertake this work in parallel with current workflows.

## 4. Key Outcomes

The key outcome behind this project was to look behind the hype and determine whether TLS were suitable for more conventional firms and what workflows they could be adopted for.

## 5. Further Work

Final modelling in the BIM software is still to be completed. In the future, following on from this project, I would like to also look into how TLS stacks up with terrestrial photogrammetry for this type of surveying using equipment like the Trimble V10 imaging rover.

## 6. Conclusions

TLS are a very exciting technology for traditional survey firms. They open up a vast array of new possibilities. However, they need to be fully understood so their limitations and strengths can be utilised to optimise the end product.

## Acknowledgements

I would like to thank my supervisor Zhenyu for supervising me in this project. I would also like to thank my employer Mosel Steed for being extremely patient. Finally I would like to thank the Ultimate Positioning Group for generously sponsoring this project by allowing me use of their Trimble TX5 Laser Scanner, without them this project would not have been possible.

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# Groundwater recharge prediction for broadscale irrigation modelling: A case study in MIA-Main Canal irrigated areas

Sponsor – CSIRO Land and Water



**Surya Makireddi**

Bachelor of Engineering  
(Civil)

Supervisors: Dr Ian Brodie, USQ

Dr Jai Vaze, CSIRO

**Keywords:** Hydrology, irrigation modelling, groundwater recharge

## 1. Introduction

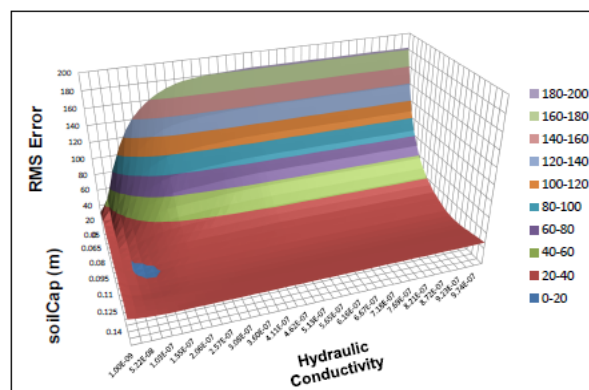
Australia is a vast country with different climatic zones. Groundwater is the dominant water resource in inner Australia where large parts are either desert or semi-arid. Groundwater occurs beneath the watertable in soils and aquifers. Conserving groundwater and replenishing is equally important in those regions. Replenishing occurs through groundwater recharge from rainfall and irrigation water or seepage. It is necessary to quantify recharge for an efficient groundwater resource management.

## 2. Background

The project focuses on quantifying recharge under irrigated agriculture within the study area which is a group of irrigation districts irrigated by the Main Canal in the Murrumbidgee Irrigation Area (MIA), NSW. The project utilises an irrigation model (Hughes et al. 2013) recently developed by researchers at CSIRO to simulate irrigation diversions and calculate recharge. The project develops a prediction model specific to the study area as an extension to the irrigation model which could be used in calculating recharge for any required period of time in the past or in future.

## 3. Methodology

The irrigation model outputs annual groundwater recharge for the study area. Thus, a range of annual recharge estimates were obtained for the modelled period of time 1970-2012 for different input parameters. Separately, various recharge estimates from existing research studies done within the MIA were collated. The recharge estimates from the



**Figure 1: Root-mean-square error surface**

irrigation model were matched with the collated values in corresponding years and root-mean-square (RMS) error calculated. Development of RMS error surface constitutes prediction model and is shown in figure 1. The set of input parameters for which the error is least are determined to be prediction parameters.

## 4. Key Outcomes

Hydraulic conductivity of  $7.78e-07$ m/s and topsoil thickness of 0.105m were found out to be prediction parameters.

## 5. Further Work

Future work and recommendations are pending in the report.

## 6. Conclusions

Prediction model was built as a means of comparing outputs from irrigation model with existing recharge estimates and arrive at prediction parameters. It has served its purpose although the model can perform better with the availability of more existing estimates. The concept of the prediction model could be easily applied to other irrigation districts.

## Acknowledgements

I would like to thank Dr. Ian Brodie (USQ supervisor), Dr. Jai Vaze, Dr. Justin Hughes and Dr. David Robertson (CSIRO supervisors) for their guidance.

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# Performance Evaluation of Traditional and NBN Internet Access

School of Mechanical & Electrical Engineering



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Master of Engineering Science  
(Electrical & Electronic)

Supervisors: Dr Alexander A Kist, USQ

**Keywords:** Speed Test, Latency, Internet Speed, Roundtrip time, QoS, QoE.

## 1. Introduction

Internet and access to various intranet infrastructure are delivered to homes and business through various modes, these include ADSL, ADSL2+, UMTS, Satellite & National Broadband Networks, The aim of this paper is to measure the Objective End-to-End Quality of Service (Network Performance) of these networks taking various factors such as client machine specifications & limitations, server capability, individual application and web server availability into consideration.

## 2. Background

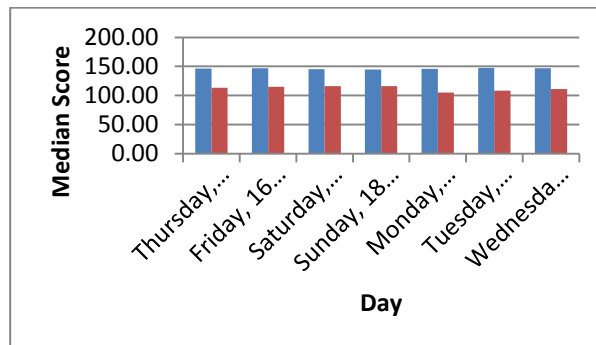
Quality of services can be categorised based on users and application perspective. IEEE 802.1p though clarifies QoS to some extent by defining the priority levels based on service, there exists clear lack of definition on the measurement from user's point of view.

## 3. Methodology

The Main aim of this research is to systematically analyse and test the Quality of Service parameters on the ADSL, Telstra's/Optus 4G and Fibre to the Home/National Broadband Network. This research primarily focussed on the Technical QoS parameters and aims to provide a more detailed understanding of the QoS and what it means for the end user.

## 4. Key Outcomes

An analysis of these test results has provided us with a definite set of results eliminating the ambiguity on the advertised speed and thus will enable us to advice users on their actual performance of their internet connections.



**Figure 1** - Graph - ADSL 2+ Location 1 - Comparison of Peak and Off-Peak

## 5. Further Work

Continuing this research, we need to stipulate methodologies to define and measure subjective QoE as (sQoA & sQoU) from user's perspective; this may include conducting user surveys and comparing the field data parameters.

## 6. Conclusions

.In this research analysis after a thorough study of test results we concluded that the ADSL2+, HSPA+/4G and NBN QoS parameters are within the acceptable standards with uptime of upto 97%. This is in line with the QoS promise white papers released by individual service providers. Our current results show that test run over a long period of time like 24 hours or even a week provided us with a better results and a median score proving our hypothesis.

## 7. Acknowledgements

I would like to take this opportunity to thank my supervisor, Dr. Alexander A. Kist for his guidance and exceptional support on my thesis.

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# Early Warning Collision Detection And Automatic Response



Jivaalinie Maniam

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Supervisors: A/Prof Wei Xiang, USQ

**Keywords:** ADHOC; VANET; Collision detection.

## 1. Introduction

Over the last decade we have seen many advancements in the Internet, mobile technology bluetooth and wireless networks all of which contribute to the vehicle ad hoc network (VANET), which uses available cars as mobile nodes within a mobile network (MANET). The effective vehicle network range creates a constantly changing network. The VARNET application coupled with Road Side Units, GPS and navigation systems offer tremendous opportunities for road reports, accident and traffic reports.

As the system grows available applications will also increase, providing drivers with the most up to date information and services while they are travelling. This research project investigates the design of an effective distress signal deployment to emergency services based on best approach from the data researched.

## 2. Background

The VANET system allows spontaneous deformation and formation of mobile networks where vehicles act as routers supporting peer to peer and peers to remote communication. This system can be used in early traffic warning systems, Emergency vehicle awareness, road works and driving conditions and collision prevention and detection.

Any action taken to improve road safety will benefit all motorists and with the collision detection unit being able to send accurate data on accident severity and location will improve response time and ultimately reduce road deaths.

## 3. Methodology

Achieving the desired outcomes requires research into existing systems and their limitations with respect to the task of sending a message with the collision detection unit to emergency services using passing vehicles, roadside units or direct messaging to services. By comparing systems and locations, consideration can be given to terrain, range of signals, cost of devices and setup costs, density of population or vehicle nodes and deployment of systems and be used to obtain best approach methods, which can be adopted with the collision detection unit. Varying traffic conditions, traffic densities and locations can be simulated and worst case scenarios can be investigated such as unit has been destroyed or no available network.

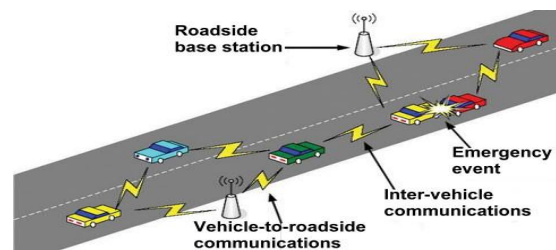


Fig 1 Vehicle Ad Hoc Network Angelina Reeba (2012)

Devices such as air bags and impact sensors can detect the impact of a collision. If this is combined with the vehicle decelerating at greater than or equal to 5G then steps can be taken to securely send a distress signal using the VARNET and Roadside Units (RSU) giving incident location and local traffic conditions to the emergency services.

## 4. Key Outcomes

By utilising the VANET and sudden impact detection an accurate distress message can be sent to: passing vehicles, road side units and emergency services eliminating human errors with incorrect location information to the authorities. This improves the response time for emergency services to reach the scene which can lead to lives being saved. The research into an effective network topology is essential for early warning collision detection and automatic response to be a viable safety feature for new and existing vehicles.

## 5. Further Work

For the deployment of any vehicle network the security and privacy will be critical. The implications of any malicious attack would be not only detrimental to the VANET but would be dangerous if not fatal for real accident scenarios. Further work into security would investigate active position detection using vehicle positioning.

## 6. Conclusions

Lives can be saved by early accurate accident information. Until the VANET system is widely used and new vehicles have the Collision detection units installed aftermarket units and mobile applications should be made more available.

## Acknowledgement

Thanks to A/Prof Wei Xiang, my supervisor, for all his valued assistance.

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# Pre – Treatment of Coal Seam Gas Produced Water

School of Mechanical and Electrical Engineering

## Byron Manthey

Bachelor of Engineering  
(Mechanical)



Supervisors: Dr Vasantha Aravinthan, USQ

**Keywords:** Produced formation water, coal seam gas produced water, coal seam gas.

### 1. Introduction

Produced water or produced formation water (PFW) is a bi-product of coal seam gas (CSG) production. This research addresses pre-treatment of Coal Seam Gas produced water using coagulation and flocculation as the primary means of pre-treatment.

Produced formation water is high in suspended solids, high in alkalinity and high in turbidity. As a result of the quality of the water it is unable to be disposed directly into the natural environment without treatment.

### 2. Background

Large amounts of PFW are produced throughout Australia with the national water commission estimating more than 7500 GL of PFW will be produced by the CSG industry in the next 50 years (Davey A et al, 2012). Currently the main method of treatment is reverse osmosis, no published research into pre-treatment using coagulation or flocculation has been identified. This research will identify the efficiency and the ability of natural and common coagulants and flocculants as a means of pre-treatment.

### 3. Methodology

PFW was collected from the Surat Basin and has been analysed to identify particular water characteristics including; pH, Turbidity, Total Dissolved Solids and Alkalinity. Preliminary experiments have been conducted using the jar test method. From results of initial testing the mathematical modelling software Minitab has been utilised to optimise the dosage of coagulants and identifies the most effective pH level.

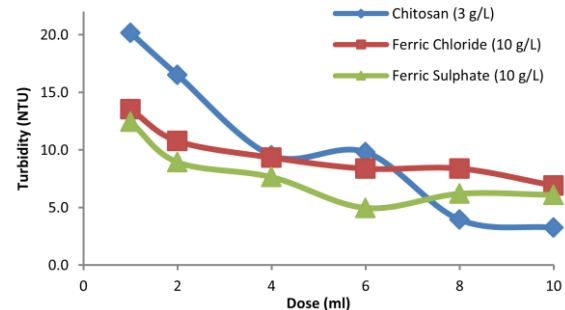


Figure 1 – Turbidity Removal

### 4. Key Outcomes

The key outcomes for this project are to identify and optimise a suitable coagulant and flocculent for use in the pre – treatment of PFW and provide a basis for further research in the field.

### 5. Further Work

Refinement using the mathematical modelling software Minitab is yet to be completed.

### 6. Conclusions

Pre-treatment of PFW using Coagulants and flocculants is a viable option, providing a cost effective alternative to current used technology. The application of the natural flocculent Chitosan has proven to be the most effective in turbidity removal.

### Acknowledgements

I would like to acknowledge my supervisor Dr Vasantha Aravinthan for her ongoing encouragement, support, guidance and her passion for excellence in research. I also would like to thank Friederike Eberhard and Raed Ahmad for their assistance and support in the laboratory. My wife Jackie and my family for their love and support during this project. I also thank my employer Australian Rig Construction for the provision of the PFW.

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# Alternatives to SF<sub>6</sub> in HV Circuit Breakers

## Michael Marland

Bachelor of Engineering (Power)



Supervisor: Mr Andreas Helwig, USQ

**Keywords:** SF<sub>6</sub>, sulphur hexafluoride, HV circuit breakers, Global Warming Potential (GWP).

## 1. Introduction

Sulphur hexafluoride (SF<sub>6</sub>) is a synthetic gas extensively used in the high voltage (HV) electricity transmission and distribution industry. The unique and unrivalled properties of SF<sub>6</sub> gas that enable it to resist/recover from spark conduction have positioned it as the preferred HV arc interruption medium. HV circuit breakers (CBs) utilising SF<sub>6</sub> boast less frequent maintenance requirements and reduced installation footprints compared to their Oil/Air predecessors.

Unfortunately however, SF<sub>6</sub> has an extremely high global warming potential (GWP), 22,800 times that of carbon dioxide. This high global warming potential combined with a long shelf life (3000 years in atmosphere) has seen the gas identified as one of the six most potent contributors to climate change.

This research project seeks to investigate alternatives to SF<sub>6</sub> in HV CBs as well as the environmental and OH&S benefits that could be contributed to its replacement.

## 2. Background

SF<sub>6</sub> HV CBs were introduced in the 1970's and currently service the majority of applications above 66kV. Environmental awareness has seen SF<sub>6</sub> free, vacuum and solid dielectric designs in applications below 66kV, however replacements designs in the higher voltage ranges are still developing.

## 3. Methodology

The focal point of this research project has been an SF<sub>6</sub> audit of an Australian region, namely Central Western NSW. The Bathurst, Dubbo, Lithgow and Orange region, present a fair mix of generation, transmission and distribution infrastructure. Site visits and data acquirement were conducted to determine the exact amount of SF<sub>6</sub> in service throughout the region's 500kV-11kV electrical network spectrum (15

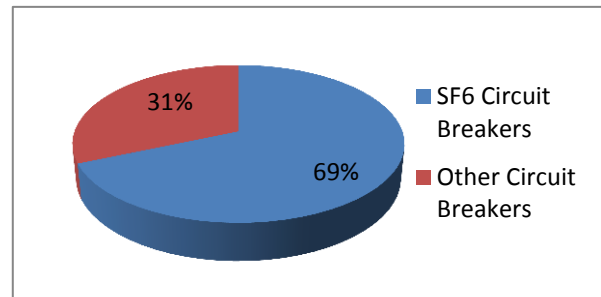


Figure 1 – 66-132kV Circuit Breakers in service in Central Western NSW

transmission and 44 distribution substation sites). The collected data was evaluated in terms of design trends, mass (kg) of SF<sub>6</sub> in service and CB types. Research into SF<sub>6</sub> eliminating designs was conducted and an environmental/cost benefit and lifecycle analysis of SF<sub>6</sub> reduction is intended to be the consolidating keynote.

## 4. Key Outcomes

With over 90% of data collected the Central Western NSW electrical network utilises over 5200kg of in service SF<sub>6</sub> in applications above 66kV. Typically between 2% and 0.4% of the CB's name plate capacity' is lost during any given handling activity. Significant improvements in vacuum interrupter construction, solid dielectric and dry-air designs are currently the front runners of SF<sub>6</sub> free HV CB designs.

## 5. Further Work

A consolidating environmental/cost benefit and lifecycle analysis of SF<sub>6</sub> reduction in the region is currently being undertaken. Exploration into possible replacement designs or leakage reduction has been the desired direction of the project post research.

## 6. Conclusions

SF<sub>6</sub> is an environmentally potent substance despite its unrivalled functionality in HV applications. SF<sub>6</sub> free CB designs are progressing and SF<sub>6</sub> reliance reduction and awareness is high on industry agendas.

## Acknowledgements

I would like to thank Mr Andreas Helwig for his mentorship and continual support, as well as Mr Dane Bland for his help in data acquirement.

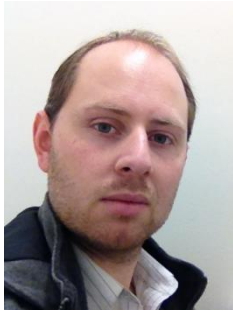
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# The PID Controller Design Using Genetic Algorithms

School of Mechanical and Electrical Engineering



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Bachelor of Engineering  
(Electrical & Electronic)

Supervisors: Dr Paul Wen, USQ

**Keywords:** Genetic Algorithms, PID, control

## 1. Introduction

Controller theory has never been a topic which has been perfectly understood and implemented. Further to this, the most popular controller device, the PID controller, has not had a definite set of rules to determine their optimum settings. Genetic Algorithms have made progress on optimising these existing controllers but there is much more research required to fully understand the functions and depth of these algorithms.

## 2. Background

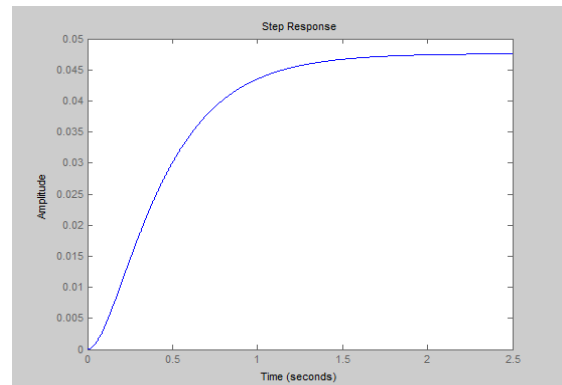
Genetic Algorithms are programs that mimic evolution and natural selection. They are essentially a group of randomly selected individuals made up of a string of chromosome (usually a line of binary numbers). These individuals are compared to each other and are given the chance to 'breed' based on their performance. The selected individuals breed via the swapping a section of DNA with another individual, their performance is evaluated and the cycle is repeated until an optimum individual is determined.

## 3. Methodology

The genetic algorithm, plant and PID controller is programmed and simulated in MatLab. MatLab was chosen as the preferred method as it provides all the required functions to easily modify the algorithm and to test and evaluate the algorithm. It also provides a means to loop the program tens to hundreds of times in order to prove the validity of the results. It also give graphical plots to aid the understanding of what is happening. Please see figure 1 for an example.

## 4. Key Outcomes

The keys outcome is to compare different individual parameters inside the genetic algorithm and to determine how they affect the speed and accuracy of



**Figure 1 – Uncontrolled Step Response**

this optimisation process in direct relation to PID controller optimisation.

## 5. Further Work

Additional work to be completed is to test the algorithm against models proposed by other researchers such as Mitsukura et al[1] and Yingying[2]. As their models are not available, replicas must be made and tested as described in their articles.

## 6. Conclusions

Conclusive conclusions are yet to be reached but will be determined and explained during the conference.

## Acknowledgements

I would to acknowledge my Supervisor for his support, encouragement and in opening my eyes to the interesting subjects of controller theory and genetic algorithms. And special thanks to my wife who has always seen more in me than I could of myself. Other acknowledgement for Holland[3] for the invention of the genetic algorithm.

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# Reliability-Centered Maintenance analysis of a Rio Tinto Iron Ore Locomotive Engine

Sponsor – Rio Tinto Iron Ore



**Caleb Mayne**

Bachelor of Engineering  
(Mechanical)

Supervisors: Dr Steven Goh, USQ

Mr John McArthur, Rio Tinto  
Iron Ore

**Keywords:** RCM, Diesel Engine

## 1. Introduction

Rio Tinto Iron Ore (RTIO) operates a fleet of 106 General Electric (GE) Evolution Locomotives. The maintenance of these assets is critical to ongoing performance and production; if they are not maintained to continue performing their function, production targets will never be met. Conversely, if the assets are over-maintained, excess resources are consumed with no benefit in reliability.

Reliability-Centered Maintenance (RCM) is a widely accepted and systematic methodology for developing maintenance strategies. RCM focuses on maintaining machinery functions, rather than the machinery itself.

## 2. Background

RTIO's Pilbara railroad operation is unique for a number of operational and climatic reasons, and a number of fleet-wide issues have negatively impacted the Evolution locomotive reliability. This has led to the concern that the GE standard maintenance tactics are not optimised for RTIO's operational context. RTIO wants to review the maintenance tactics applied to the diesel engine, to evaluate if the maintenance tactics are effective and efficient.

## 3. Methodology

The engine was divided into subsystems and the functions (and functional failures) of each subsystem were defined according to the manufacturer's training material. The failure modes, failure effects and failure consequences were identified by reviewing the asset maintenance records, network operational delay data, sessions with RTIO diesel mechanics and a literature review of common diesel engine failure modes. The recommendations were developed using Weibull



**Figure 1 – Diesel Injector spray pattern testing**

analysis, component testing and consultation with senior mechanics, engineers and a literature review of diesel engine condition monitoring technology.

## 4. Key Outcomes

The project found that life extension of high pressure diesel pumps may be viable, warranting further investigation and testing. Diesel injectors are not candidates for life extension, as only one injector produced an atomised spray pattern during testing (refer to figure 1). Redesign of the valve train pushrods may be desirable. Acoustic emissions condition monitoring has potential to enable condition-based maintenance of high pressure fuel and valve train components. The current maintenance regime is recommended as appropriate overall.

## 5. Further Work

The engine cooling, lubrication, mainframe and exhaust air systems require analysis. Additional work is required to evaluate service life extension for high pressure diesel pumps and determine the root cause of poor diesel injector performance.

## 6. Conclusions

The project has developed an RCM analysis that can be built upon and referenced in future locomotive engine maintenance strategy and tactic development.

## Acknowledgements

I would like to thank my wife Lisa, Jack Barnett, Hugh Carlisle, David Leonard, Peter Mitchell, Lindsay Urquhart, James Lawrence and John McArthur of RTIO and Dr. Steven Goh of USQ.

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Moubray, J. (2001). RCM II: reliability-centered maintenance: Industrial Press Inc.

# Teleprotection Signalling over an IP/MPLS network

School of Mechanical & Electrical Engineering



**Nigel McDowell**

Bachelor of Engineering  
(Electrical/Electronic)

Supervisor: Dr Alexander Kist, USQ

**Keywords:** teleprotection-over-packet, MPLS signalling, smart grid

## 1. Introduction

Protection of electricity networks have developed to incorporate communications, referred to as protection signalling. Due to the evolution of the electricity supply system, there are many developments pending within the scope of protection signalling and protection engineering in general. This project investigates the use of current and emerging communications technologies (i.e. packetised networks) being applied and incorporated into current protection signalling schemes and technologies.

## 2. Background

The purpose of the project is to provide a more cost-effective solution to protection schemes running obsolescent hardware. While the medium-term goal of the industry is to move entirely to IEC 61850 communications, legacy teleprotection relays using non-IP communications will still exist for many years to come. For companies to be ready for an IEC 61850 rollout a fully deployed IP/MPLS network will be necessary and it can be seen that various companies worldwide are readying themselves in this way. However, in the short-term for these companies, this means maintaining their existing TDM network (which runs current teleprotection schemes) and IP/MPLS network. This is a costly business outcome that can be minimised with the migration of services from and decommissioning of TDM networks.

## 3. Methodology

A requirements analysis was undertaken in-line with the requirements of current protection schemes. A conceptual design was produced and approved before construction and testing began. System testing has been split into two main categories, network channel and protection testing. Tests were performed under laboratory conditions as well as in the field.

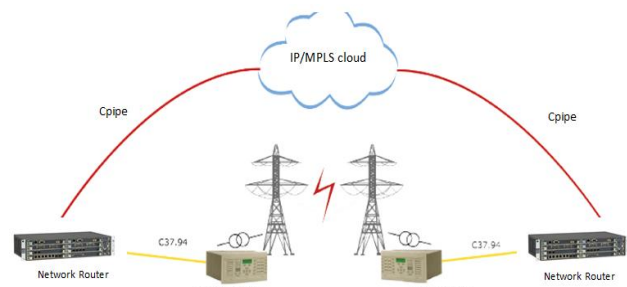


Figure 1 – Proposed IP/MPLS Teleprotection Scheme

## 4. Key Outcomes

Network channel testing was the primary test category. The testing proved that teleprotection traffic with correct QoS markings assured that the system met latency and stability requirements. Furthermore, MPLS resiliency features (secondary LSPs & Fast-reroute) were tested and proved automatic path failover was possible under fault conditions at sub-30ms speeds.

## 5. Further Work

Packetised networks are inherently prone to variance in one-way delays and current differential protection schemes are highly sensitive to this. Further analysis and investigation into the effects of variation in one-way delay need to be conducted. This testing should be best conducted over a range of network equipment and relays.

## 6. Conclusions

While the results provided by this project were positive, a larger cross-section of devices needs to be tested before the industry should consider a full-scale rollout using this technology.

## Acknowledgements

I would like to acknowledge and thank my supervisor Dr Alexander Kist and my senior engineer Mr Andrew Howard for their technical expertise, guidance and support over the course of this project.

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# Research and Development of a Road Safety Strategy for Scenic Rim Regional Council

Sponsor – Scenic Rim Regional Council



**Seren McKenzie**

Bachelor Engineering (Civil)

Supervisors: Dr Soma Somasundaraswaran,  
USQ

Mr Patrick Murphy, Scenic  
Rim Regional Council

**Keywords:** Road Safety Strategy, Local Government.

## 1. Introduction

Every day on Australian roads, more than three lives are lost. The number of injuries related to road accidents is closer to one hundred per day. The Australian Bureau of Statistics reports that approximately 90 percent of passenger travel and 20 percent of freight travel is by road.

This project identifies an appropriate approach to road safety for a medium sized regional Council, and develops a Road Safety Strategy to be adopted by the Council to ensure Scenic Rim Regional Council meets its obligations to the road users in ensuring a safe network.

## 2. Background

Australia is one of the many countries who have committed to the United Nations Decade of Road Safety 2011-2020 project, and has since published a National Road Safety Strategy.

Few Queensland Councils have produced Road Safety Strategies, despite controlling large road networks across Queensland. Scenic Rim Regional Council is responsible for a transport network totalling 1,810 kilometres of roads, and over 100 bridges.

## 3. Methodology

The research aspect of the project included determining a suitable approach to road safety for the Local Government to adopt, which should be in accordance with best practice approaches in leading departments within Australia and leading countries around the world.

Councils legal obligations in ensuring a safe network were reviewed, the current state of assets within Scenic Rim Regional Council were determined, and a review of crash statistics for the region was undertaken.

## 4. Key Outcomes

The Safe System Approach to Road Safety should be adopted by Council for the Strategy, with specific focus on actions related to Safe Roads and Roadsides, and Safe Speeds. Particular items to address in renewing roads are widening of roads to allow for cycle lanes, speed design and traffic calming in built up areas, and road design and layout in new developments.

## 5. Further Work

Detailed review of legal obligations and crash data is currently underway, which will assist in determining the actions in the Strategy. Council need to determine if they wish to accept the Road Safety Strategy and commit to the actions.

## 6. Conclusions

Local Governments with transport networks have a role in road safety and should have a Strategy which follows international best practice of the Safe System Framework.

Council would benefit from improved records of traffic incidents and analysis of current data such as asset condition, and traffic count and speed data, which will contribute to ensuring they maintain a safe road network.

## Acknowledgements

I wish to acknowledge the help of staff at Scenic Rim Regional Council for providing data for analysis. I would like to thank Dr Soma Somasundaraswaran for his understanding and patience.

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# Resonator Probe for Photoacoustic Measurement

School of Mechanical and Electrical Engineering



**David McLaughlin**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisor: Dr John Leis, USQ

**Keywords:** photoacoustic spectroscopy, digital signal processing, multivariate gas analysis.

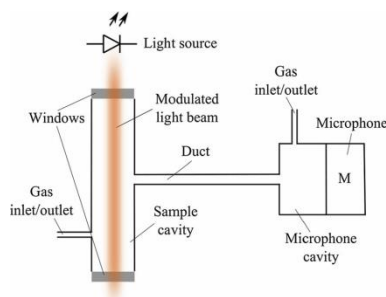
## 1. Introduction

In 1880, Alexander Graham Bell discovered that a modulated beam of light striking a solid object created an audible sound. The primitive technology of the time prevented exploitation of the technique, and the research field lay dormant for almost a century.

With the maturation of laser technology in the 1970s, the field now known as photoacoustic spectroscopy experienced a renaissance. Narrow wavelengths of light could be matched to the absorption spectrum of specific molecules and atoms, allowing for quantitative and qualitative analysis of samples.

## 2. Background

Recent technological advances allow for detection thresholds down to the low parts per billion, requiring a measurement apparatus that exhibits resonance at the modulation frequency. The signal is, unfortunately, highly sensitive to changes in the ambient temperature.



**Figure 1: Photoacoustic resonator arrangement**

This research focuses on development of algorithms for identifying and tracking the resonant frequency of a photoacoustic cell, similar to that shown in Figure 1, in real time and under variable ambient conditions, using only a computer soundcard and MATLAB.

## 3. Methodology

The two distinct problems requiring a solution during the execution phase of this project were the detection of a low-level acoustic signal in a comparatively high noise environment, and continuously tracking changes in the resonant frequency of the signal.

The approach to solving these problems was broadly similar. Acoustic signals were simulated using MATLAB, with the signal and noise amplitudes varied to mimic a variety of conditions. To detect the signal against the noise background, the same signal was used repeatedly, and the results of the processing were assessed to find the optimal detection technique. The simulated signal frequency was then varied to verify the detection algorithm and the performance of the tracking algorithm with step changes to the parameters.

## 4. Key Outcomes

Research on photoacoustic resonator construction and frequency detection methods has been completed, and the software simulations for tracking are functionally complete. Physical modelling has not been completed.

## 5. Further Work

Testing the algorithms developed with measurements from a photoacoustic cell has not yet been completed. The construction of a Helmholtz resonator to acquire raw data is the next step in this research project.

## 6. Conclusions

Theoretically, there is no impediment to the capture and analysis of the signal from a photoacoustic cell using a computer, nor in tracking the change in the resonant frequency using a software algorithm.

## Acknowledgements

I would like acknowledge the valuable contribution of Dr John Leis for the inception and supervision of the photoacoustic resonator research project.

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# Repair or Replace, The Future of the Raleigh Bridge

School of Civil Engineering and Surveying

## Peter McRae

Bachelor of Engineering (Civil)



Supervisors: Dr Sourish Banerjee, USQ

**Keywords:** Bridge, Restoration, Replacement

### 1. Introduction

The Old Raleigh Bridge was once a vital link over the Bellinger River and is now in need of repair. The concrete spans are in good condition but the three truss spans now require repainting and have suffered damage from repeated vehicle collisions during the bridge's time as part of the Pacific Highway.

### 2. Background

The Old Raleigh Bridge was constructed from 1933 to November 1935 over the Bellinger River at Raleigh, New South Wales. The bridge was on the Pacific Highway when constructed but has since been bypassed by the Raleigh Deviation in 1998 and is now part of the local road network. The main three spans of the bridge are Pratt type steel through trusses and the remaining smaller spans are constructed of cast in-situ reinforced concrete spans.

### 3. Methodology

The dissertation involves comparing several options for the future of the Old Raleigh Bridge. The options are being compared based on weight, cost and the service they will provide. The options range from repairing and repainting or replacing only the truss spans to the replacement of the entire bridge. Pre-2004 design loads, T44, have been considered for the options and compared to current SM1600 design loads as they may allow a wider range of options. The use of T44 standard for design loading has been allowed on some Roads and Maritime Services bridges under certain conditions (Roads and Maritime Services, 2014). An artist's impression of the option of a concrete deck supported on steel I beams is shown in Figure 1.

### 4. Key Outcomes

Two short traffic counts were conducted and the ADT estimated. Various options are also being compared



Figure 1 – An artist's impression of a steel girder replacement.

and their weights estimated. The ideal replacement option in terms of future maintenance would have been replacing the superstructure with Super T girders due to the low maintenance of concrete bridges. However, the weight of this option is several times the existing truss spans and so it is unlikely that the piers could support its weight safely. So a more light weight option will need to be considered.

### 5. Further Work

Further investigations into the condition of the bridge will be carried out by Roads and Maritime Services. These detailed investigations will be compared to previous inspections and will be used to make a more informed decision as to the future of the bridge. The options of replacing the superstructure, truss spans, of the bridge with another type will require more detailed investigations of the changes in the loading on the piers.

### 6. Conclusions

The option of replacing the truss spans of the bridge with another superstructure type is likely possible depending on further investigations. The future of the Old Raleigh Bridge will depend on the rate that it continues to deteriorate and the availability of funding for any repairs or future replacement.

### Acknowledgements

I would like to thank colleagues at Roads and Maritime and also Dr Sourish Banerjee as supervisor for this project.

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# Development of a Prioritisation System for Sealed Road Defects

School of Civil Engineering and Surveying



**Aaron Meehan**

Master of Engineering Science

(Civil)

Supervisor: Professor Ron Ayers, USQ

**Keywords:** Sealed Road, Risk Management, Maintenance Management

## 1. Introduction

Sealed roads are a major asset for local government road authorities and effective management of defects is critical in a local government's asset management strategy. This dissertation project examines the role and requirements of local government in managing sealed road defects and determines a model for system development that reflects best practice.

The system will be developed for a sealed road network taking into account the size and type of assets, budget, resources and any other constraints that the local government authority may operate within. The dissertation is specifically directed for the Western Downs Regional Council road network.

## 2. Background

A local government road authority has an obligation to provide economic and efficient maintenance services to keep its road network both functional and safe for community use. An authority needs to demonstrate that it has reasonably discharged its responsibilities and provided adequate duty of care. The road authority exercises its duty of care to the general public in a number of ways, including planning and undertaking repairs and maintenance in accordance with its priorities, budget and resources.

## 3. Methodology

The project involved initial research to identify the responsibilities and risks to a Queensland local government road authority, particularly in relation to their obligations under the *Civil Liability Act 2003*. Further research of available international and domestic systems was undertaken to examine the current methodologies employed by local government road

authorities and associated parties in managing defects on the road network.

The pre-system research provided detailed guidance in establishing principles of best practice in system design and essential requirements. The methodology advanced to developing a formatted system for prioritising road inspections, prioritisation of defects, and setting appropriate levels of intervention.

## 4. Key Outcomes

Principles of best practice have been developed where an authority can demonstrate both duty of care and sound maintenance management. An effective system is highlighted with a framework that has justified risk management strategies, diligent documentation, and achieves a high level of compliance by being designed with due regard to the authorities network, budget and available resources.

## 5. Further Work

The system methodology and framework will need to be trialled for a period of time. The management and backlog of the road network should be continually reviewed to ensure the system elements are adequately performing to the expectation of the road authority.

## 6. Conclusions

Road authority's need to ensure that their road management systems create safer roads and sound asset performance to the community's expectations. A defect and inspection prioritisation system will improve an authority's operational efficiency.

## Acknowledgements

I would like to thank Professor Ron Ayers for his guidance and understanding during the course of the project. I would also like thank the risk management staff at LGM for their assistance.

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## MANAGEMENT OF ENGINEERING ASSETS: ASSET MAINTENANCE AND MANAGEMENT

School of Mechanical and Electrical Engineering



### JORGE MENDOZA

Master of Engineering Science  
(Mechanical)

Supervisor: Dr David Thorpe,

Senior Lecturer USQ  
(Engineering/Technology  
Management)

**Keywords:** Asset Management, ISO5500, Life Cycle,  
Whole life, PASS 55

### 1. Introduction

Asset Management is the structured system, that link the management of physical infrastructure with the aim of raising whole life value for money (Whoodhouse, 2004). So it involves, among other things, a long-term view, sustainability, risk awareness and multi-disciplines collaboration. It is not a tool itself, but describes the binding process for many modern tools and methods.

### 2. Background

In recent business environment practice, the governments and private enterprises allocate the highest expenditures in the cost of infrastructure and maintenance, trying to provide proper service for the community/customer and their stakeholders. This is a continuous process and the demand for quality design, construction and maintenance of infrastructure has become an essential requirement for all the governments and companies throughout world. The approach of Asset management in an engineering environment includes the total economic analysis of infrastructure for the total whole life cycle of assets.

An example for successful use of Asset Management is The Power Systems Business Group (PSBG) of China Light & Power Company (CLP) has developed and implemented a structured asset management framework that has proved invaluable to the company's business performance (Cheung, 2010)

Over the last 10 years, PSBG has achieves more than 90% reduction in Customer Minutes Lost (CMLs) while simultaneous responding to a 20% load growth, expanding their assets, and maintaining their tariff competitive. The experience that good asset management results were built upon a foundation of critical factors such as: *Sustained Organization Commitments, Organization Alignments, Change Management, Collaboration between Asset Managers and Service Managers, and Information System Support.*

### 3. Methodology

For validation of the key components of the objective model a survey of industry aspect from a variety of background will carry out. A review of the available surveying and questionnaire techniques will perform to evaluate which is suitable to achieve the main objectives.

### 4. Key Outcomes

Adopt appropriate framework to ensure that they can provide lifecycle management of their asset in the most cost effectively and sustainable manor while providing the require service.

This dissertation aims to outline the high-level requirements and suggest quantitative measures for the organization.

### 5. Conclusions

To state the framework and performance indicator to achieve their goals and objective

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# Excessive Coal Pyrites from Pulverisers at Millmerran Power Station

Sponsor – Millmerran Power Station



**Cameron Millar**

Bachelor of Engineering  
(Mechanical)



Figure 1 'good coal' being rejected by MPS mills. Raw coal, much larger than pictured, is getting stuck in the pyrites removal system, therefore calling for a size upgrade

Supervisors: Mr Bob Fulcher, USQ

Mr Andrew Hassall, Intergen  
(MPS)

**Keywords:** Power Generation, Coal Pyrites, Mills

## 1. Introduction

Excessive coal pyrite (rejects out of the mills) issues at the Millmerran Power Station (MPS) have recently become more of an issue as the plant ages towards 13 years old. Coal pyrites are generally rocks that are too hard to crush by the coal mills and are rejected through a pyrites system. In more recent years, it is becoming obvious that 'good uncrushed coal' is being rejected from the mill into the pyrites system, mainly due to worn mill components.

## 2. Background

The investigation into the pyrite system has been ongoing by previous MPS engineers as the system has had dramas for years of not being able to empty the pyrite boxes when they are full of oversized particles. The pyrites removal system as a design standard should be able to empty the mill of its contents at any stage if there is a mill breakdown during service. The current system that is in place at MPS is unable to handle the raw coal that's coming into the mill.

## 3. Methodology

To determine the full depth of the problem, the knowledge of the MPS workers was needed as they are they people dealing with the mills every day. Much time was spent at the power station yarning with the employees everything pyrites related.

Tests on quantities coming out of the pyrites system were conducted alongside the effect that the air flow through the mill has on the amount of pyrites produced.

It was also seen firsthand that the size of removal system of the pyrites is far too small for the size of raw coal, which it often has to remove from the mills.

## 4. Key Outcomes

After the tests it was clear to see that there were far too many pyrites coming from the mills than what the whole system was designed to produce. It was also proven that the size of pyrites removal system is too small to handle the size of pyrites.

## 5. Further Work

The next stage of the investigation is to determine the economic viability of upgrading the pyrites removal system to a larger system to handle the large raw bits of coal and rock. I also need to determine whether the upgrade of the mill internals would be a viable option so the large number pyrites can be reduced.

The upgrade of the removal system will need the design of with a new system, one that has to be designed yet.

## 6. Conclusions

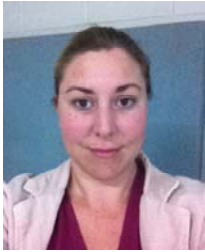
Whether the internals of the mills gets upgraded or not to produce fewer pyrites, the pyrites removal system is currently not doing what it is needed to do. Therefore the upgrade of the removal system is the first problem that has to be dealt with.

## Acknowledgements

Thanks must go out firstly to Andrew Hassall, Engineer at MPS who has helped me with absolutely everything throughout this investigation. Also thanks must go to Bob Fulcher who has given me much needed feedback, ideas and support throughout the year. Cheers lads.

# The impact of a new light rail network upon walkability in a Central Business District

School of Civil Engineering and Surveying



**Nadya Miller**

Bachelor of Spatial Science  
(Surveying)

Supervisors: Mrs Paula Grant, USQ  
Mrs Marita Basson, USQ

**Keywords:** Walkability, Light Rail, Connectivity

## 1. Introduction

Traditionally in Australia, development has occurred in a way that has encouraged car use rather than public or active transport. A number of negative impacts have resulted including increasing urban sprawl, greenhouse gas emissions, and rates of obesity. Recently there has been an increasing amount of research into walkability and how it can best be encouraged when designing neighbourhoods to reduce those problems associated with car dependency.

The recent construction of a light rail system on the Gold Coast presents an opportunity to utilise and apply findings from existing research to existing pedestrian infrastructure and to identify levels of walkability and connectivity to a number of important destinations from new light rail stations.

## 2. Background

Southport is a significant Central Business District of the Gold Coast with a number of attractors including businesses and public facilities. Research has identified that perceptions about comfort, convenience and cost in conjunction with levels of connectivity, mix of uses and feelings of personal safety are some of the key determinants of peoples' tendency to walk.

This project aims to determine to what degree the walkability concepts have been considered during the design and construction of pathways from new light rail stations to important destinations and to provide recommendations which will aid policy makers when designing the next stages of this network and future networks.



**Figure 1 – Southport Light Rail Station 5**

## 3. Methodology

Literature has been reviewed and analysed to aid in identifying the important determinants of walkability and to choose a predesigned walkability audit. Route audits were carried out by the writer to five important facilities in the vicinity of Station 5 (See Figure 1).

## 4. Key Outcomes

An analysis of the audits revealed that generally the routes to the chosen facilities scored well for walkability. The various factors that contribute to or detract from that result are identified and discussed. Two audits indicate that additional destinations could be identified to improve connectivity from the station.

## 5. Further Work

Auditing other stations along the network may identify further recommendations. More work could be suggested with shop owners to encourage more active shop fronts and temporary uses for vacant businesses.

## 6. Conclusions

When planning pedestrian infrastructure more rigorous methods of identifying important destinations and improved connectivity to them could be employed, thus encouraging exercise, reducing emissions and ultimately leading to a more pleasant and sustainable CBD.

## Acknowledgements

Paula Grant and Marita Basson, thank you so much!

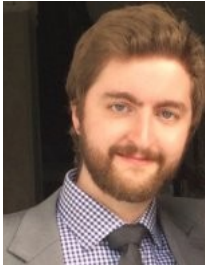
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# Hyper-Spectral Airborne Meteorite Detection

School of Mechanical and Electrical Engineering



**David Moorhouse**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Dr Tobias Low, USQ

**Keywords:** Hyper-spectral Imaging, Meteorites, UAVs

## 1. Introduction

This project investigates the use of hyper-spectral imaging from an unmanned aerial vehicle (UAV) to identify meteorites. Hyper-spectral imaging equipment and software has been developed for use with a UAV.

## 2. Background

Meteorites are small parts of other worlds which assist in unlocking the mysteries of the universe. Meteorite collection is isolated to a few locations and is undertaken manually, with limited return on the investment. Automating meteorite detection using low cost equipment would allow a significant increase in the collection rate, adding to scientific knowledge in the field.

## 3. Methodology

By capturing the reflected sunlight of potential meteorites in many different bands of colour, spectral signatures have been extracted for analysis. These signatures have been compared to documented meteorite spectra in the literature and spectra from meteorite samples which have been captured with the equipment built for this project.

## 4. Key Outcomes

A low cost hyper-spectral line scan camera has been built and has been found to be functional after going through several prototype stages. Software has been written to capture, process and analyse hyper-spectral images from the camera. This software also measures the correlation between the captured spectrum and a pre-defined target and will map global coordinates to the result of the match.



*Figure 1: Hyper-spectral Camera and meteorite samples*

## 5. Further Work

Adding software that compensates for lens distortion will allow for the whole spatial range of the camera to be analysed which would allow for areas to be analysed more quickly and/or more thoroughly. Automatic gain and exposure software would allow for changing brightness and a system that measures the ambient spectrum could be used to adjust for changing spectral conditions. Fitting the camera to a UAV to allow the practical application of the technology would be valuable.

## 6. Conclusions

Hyper-spectral imaging can be used to differentiate between materials and has been applied to meteorites specifically. Preliminary testing has indicated some ability of this system to differentiate between particular meteorites and some terrestrial rock under specific lighting conditions. Theoretical investigations show that this process should be achievable from a UAV.

## Acknowledgements

I would like to thank Fergus McCracken for providing technical advice on the project as well as access to his rapid prototyping resources; Seeing Machines for loaning parts of the optical hardware; Ashley Norris and Nicholas West for sparking my interest in meteorite hunting and Dr. Tobias Low for his supervision.

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# System dependant IDMT protection settings

Sponsor – School of Mechanical and Electrical Engineering



**Greg Nagel**

Bachelor of Engineering  
(Electrical/Electronic)

Supervisor: Dr Tony Ahfock, USQ

**Keywords:** Underground cable, IDMT over-current protection, finite element analysis (FEA).

## 1. Introduction

Underground power cable systems are being used more frequently in urban and industrial installations. These cables have many benefits, such as; safety, aesthetics, periodic maintenance and a major reduction in transient faults. The advancement of microprocessor-based protection devices has seen greater accuracy and configurability, offering protection trip initiation at the millisecond level. The advancement in protection devices calls for more accurate protection settings and improved engineering techniques to analyse the operating conditions of the underground cables.

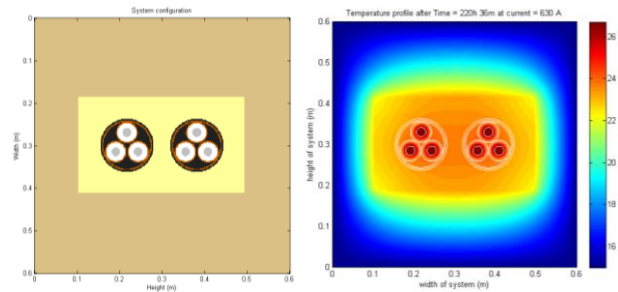
## 2. Background

Power distribution cables are often protected primarily by differential protection schemes, where 'current in' is compared to 'current out'. This scheme is very effective for isolating faults that exist between the measurement points. If a fault occurs downstream, over-current protection is used to prevent overheating, a major contributor to insulation failure and costly outages.

While cable manufacturers use thermal analysis to approximate cable specifications, these values assume worst case conditions. De-rating factors improve the accuracy (Gemscab, 2014), however, approximations often result in over-protection of the cable system.

## 3. Methodology

A cross-section of the cable system is split into finite elements representing the system (fig. 1<sub>L</sub>). Using FEA and the heat generated in the conductors by the electrical load, the system is simulated through time until a steady-state temperature profile is achieved (fig. 1<sub>R</sub>). The steady state thermal matrix is then injected with varying fault currents until the system reaches the



**Figure 1 - Cable system layout 'coloured by numbers' (left), Steady state thermal profile using FEA (right)**

damage point, 90°C. The damage time is used to produce a break curve to which a range of standard IDMT curves are fitted to determine not only the best curve but also the values that would be programmed into the settings of a protection relay.

## 4. Key Outcomes

Using this method, it can be shown that the system protection could be varied depending on the ambient conditions and load to offer adequate protection whilst improving the selectivity of the protection scheme.

## 5. Further Work

The simulation created for this project is highly configurable, meaning it could be used for almost any underground cable installation.

Mehairjan's (2010) statistical analysis of a 10 kV underground network suggests that 67% of faults occur at cable joints. Further analysis into the thermal profile of both healthy and degrading cable joints will be conducted to investigate whether varying protection settings could improve the longevity of the system.

## 6. Conclusions

It is clear that the rating of underground cable systems varies depending on environmental and operating conditions. Protection systems could be improved using these methods, or even dynamically updated to ensure the protection provided is always adequate.

## Acknowledgements

Thanks to my colleagues for engaging in technical discussions about this topic.

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# Develop Process Bus Architecture for integrating sampled value IEDs

Sponsor – School of Mechanical and Electrical Engineering



**Luke Napier**

Bachelor of Engineering (Power)

Supervisors: Dr Tony Ahfock, USQ

Mr Robert Coggan, Ergon Energy

**Keywords:** Process Bus, Sampled Values, IEC61850-9.

## 1. Introduction

Ergon Energy as a Distribution Network Service Provider (DNSP) is responsible for operating, maintaining and constructing new infrastructure in a manner which best meets the needs of their customers. A key component in their infrastructure are zone substations, which converts high voltages used for efficient transmission of power to voltages suitable for power distribution to residential and light industrial customers.

Ergon Energy as an organisation has a group within the organisation to develop standards. This group is tasked to investigate new technology which could improve upon the present standards to ensure Ergon Energy meets its obligation as a responsible DNSP.

## 2. Background

A Zone Substation consists of two categories of equipment; Primary and Secondary. Typically in the life of the substation the secondary equipment would be replaced twice before the primary equipment would need to be replaced.

The development of IEC61850-9 has introduced new technology into the market which has the ability to overcome technical issues which are being encountered with secondary equipment replacement. These issues include; limited number of Current Transformer (CT) cores to implement standard protection schemes and the CT performance requirements to ensure protection relay operation.

## 3. Methodology

The methods adopted to determine the impact of the new technology on the operation of the substation

includes both a numerical and practical approach. The numerical assessment is used to determine the impact on the CT performance characteristics and the new architecture's availability vs existing practices.

The practical method performs a number of tests with varying current waveforms into existing conventionally connected and IEC61850-9 compliant protection relays. The results of the tests will be analysed to determine the change in system response due to the introduction of the new technology.

## 4. Key Outcomes

The testing of conventional and IEC61850-9 compliant equipment using appropriate test equipment to accurately assess the change in the systems performance.

Developed a good understanding of the variables that impact on the system's availability. The methodology that was used can be reapplied to assess different architecture requirements.

## 5. Further Work

Comparing the test results with other manufacturers IEC61850-9 compliant equipment could identify other changes. Review the IEC61869-13 standard and determine if the Merging unit that was tested as part of this project complies with the requirements defined in the standard.

## 6. Conclusions

The secondary system's availability can be maintained with the introduction of the new architecture.

The introduction of the new hardware has had an impact on overall systems response to a transient input.

## Acknowledgements

I would like to thank Robert Coggan for his assistance and time working with me in the test lab.

I would also like to thank Alstom Grid who supplied the IEC61850-9 equipment for testing.

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# REFINEMENT AND DEVELOPMENT OF MATLAB MODELS FOR APPLICATION OF VARIABLE COMPRESSION RATIO IN INTERNAL COMBUSTION ENGINE

School of Mechanical and Electrical Engineering



**Shiva Rethinam Navaneethan**

Master of Engineering Science  
(Mechanical Engineering)

Supervisors: Dr Ray Malpress, USQ

**Keywords:** Engine Simulation Model, Matlab, Spark Ignition Direct Injection Engine, Variable Compression Ratio, Part load efficiency, Fuel Economy.

## 1. Introduction

With the ever increasing demand for fossil fuel, there is always the need for the development of vehicles with less fuel consumption. The engine simulation models (ESM) play a vital role in the engine development, as accurate results could be achieved in short time and less expense. In spark ignition (SI) engines, the high compression ratio (CR) as in diesel engines could not be achieved due to knocking. The engines run under part load in majority drive time, which requires high CR for increased efficiency. The concepts such as spark ignition direct injection (SIDI) technology and variable compression ratio (VCR) favour in increasing the CR. With the introduction of SIDI engines in the market and the attainability of VCR with less change in production engines, the interest in incorporating VCR in DI spark ignition engines is increasing. The work described in this paper, involves modifying the existing thermodynamic Matlab engine simulation model (ESM) compatible for SIDI, and determining the fuel economy increase by incorporating VCR functionalities in the model.

## 2. Background

The thermodynamic engine simulation model in Matlab devised by David simulates the thermodynamic analysis of conventional SI engine in single cycle. This is further improvised for more accuracy by Ray. The VCR, fuel usage in driving cycle etc., were included. The current work is focused on enhancing the ESM for DI SI engine, and testing for fuel economy under different CR combinations at part load and full load conditions to determine the optimum CR values.

## 3. Methodology

Selecting the most efficient SIDI engine type with obtaining the parameters for modifying the ESM, and testing the model to confirm the increase in thermal efficiency at single engine cycle. And running the model in driving cycle at different CR combinations to determine the CR values for increased fuel economy and part load efficiency. Additional works such as developing the GUI and versioning will be performed in parallel.

## 4. Key Outcomes

The parameters and functionalities to be altered to suit the DISI engine were identified, and the plan to achieve the desired outcome was devised. The spray guided combustion system is found to be most efficient. And the related parameters are collected.

## 5. Further Work

The implementation in Matlab ESM, testing the model at variable compression ratios for selecting CRs offering best fuel economy at part load, and development of GUI and versioning of the ESMs will be done in parallel.

## 6. Conclusions

So far, the direct injection type to be modelled is studied and the parameters required to be included in the model are collected through the literature review. The possible method to determine the part load efficiency and resulting fuel economy is devised by understanding the existing models. The implementation in Matlab is being carried out in parallel with additional works such as GUI development.

## Acknowledgements

I would like to thank my supervisor Dr.Ray Malpress, for his expertise and support

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# High Speed Rail in Australia: A Case Study for a Sydney-Wollongong Link

School of Civil Engineering and Surveying



**Matthew Newman**

Bachelor of Engineering (Civil)

Supervisor: Dr Soma Somasundaraswaran,  
USQ

**Keywords:** High Speed Rail, Transport Engineering

## 1. Introduction

The aim of this project is to investigate whether or not the Australian Government should include in their High Speed Rail Network (HSR), a link between Sydney and Wollongong, rather than through the Southern Highlands.

## 2. Background

By 2050, it is predicted that there will be approximately 355 million trips completed on the East coast of Australia, requiring further duplication of the Hume Highway and a third airport in Sydney. To help with this 'congestion', a strategic plan was prepared, aimed at how to implement a high speed rail along the eastern seaboard. While the report briefly discusses arguments for and against a Wollongong link, this research is intended to highlight the real need for it.

## 3. Methodology

In order to properly analyse the need for a Sydney-Wollongong link, the method employed looks at a number of factors. First, the social and economic factors of the Australian community are compared with foreign countries to see where we stand as a Nation. Then, travel demand modelling was employed to determine potential ridership for the link, and ultimately the potential revenue. Finally, a strategic design has been developed to look at a possible route and the cost associated with it.

## 4. Key Outcomes

The socioeconomic factors studied revealed that Australia has the same GDP per capita as Germany, a lower unemployment rate than Spain, and a similar

sized population to Korea. The conclusion drawn from this investigation, there are no real reason why Australia shouldn't already have HSR.

The travel demand modelling displayed, based on weekday trips only, A HSR line between Sydney and Wollongong could easily be supported by the predicted ridership levels, i.e. starting at around 8 million passengers per year, increasing to 9.3 million within 10 years.

The strategic alignment design prepared for my paper was estimated to cost approximately \$17.6 billion (2012), only \$7 billion more than the Southern Highlands route proposed by AECOM. Coupling this with a 50% increase in ticket prices, the Sydney-Wollongong line, on its own, would reach a break even point after 70 years in service.

## 5. Further Work

Further work required to progress to a more detailed design, is to refine the alignment, optimizing its route for costs, and conducting site specific investigations regarding soil and geotechnical conditions. Based on past experiences, these task would require considerably more time and resources.

## 6. Conclusions

Although a HSR route through Wollongong may be approximately \$7 billion more than a route through the Southern Highlands, there is potential for a significantly higher number of passengers, and hence higher revenue. But it would also reduce congestion on state highways and improve the services between Sydney and Wollongong.

## Acknowledgements

This project would not have been possible without the help of individuals within Transport for NSW and its subsidiaries.

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# INVESTIGATION IN FAILURE ANALYSIS AND MATERIALS SELECTION IN TOTAL HIP REPLACEMENT PROSTHESIS

Sponsor – School of Mechanical and Electrical Engineering



## Liem Nguyen

Bachelor of Engineering  
(Mechanical)

### Supervisor:

Dr Steven Goh, Senior  
Lecturer at University of  
Southern Queensland

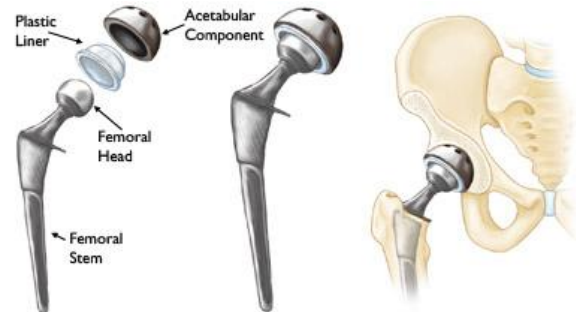


Figure 1 - Total Hip Replacement Prosthesis

**Keywords:** Total Hip Replacement, Hip Replacement Prosthesis

## 1. Introduction

There have been many studies and researches on the topic of total hip replacement prosthesis. The main interest in this topic is about failure analysis and materials selection for the prosthesis.

This project is a research project. The aim is to investigate the failure modes of the prosthesis and from there the materials selection used for the prosthesis design is recommended. This is done by developing a 3D model of the prosthesis and analysing the stress distribution on the prosthesis at many different situations. The results are then validated with previous studies and researches on this topic.

## 2. Background

Hip replacement is also known as hip arthroplasty is a surgical procedure where the human hip joint is replaced by a prosthetic implant. The purpose of replacing hip joint is to help relieve physical pain and fix the severe damage of the hip as well as increase mobility for the patients.

Even the history of hip arthroplasty is more than 100 years; we still have encountered enormous challenge, mainly to deal with the failure of materials and the prosthesis design. Understanding the mechanism of the hip prosthesis will help improve the design and the performance of the prosthesis in human body.

## 3. Methodology

The method used to investigate the failure modes of the prosthesis is called Finite Element Analysis. The common prosthesis design is chosen and modelled on Creo Parametric software. The loading (radial and axial load) is applied in many different situations to find the stress distribution along the femoral head and stem in figure 1 to predict the failure modes. The materials

selection is recommended based on the stress analysis results and validated by previous studies.

## 4. Key Outcomes

At this stage the prosthesis model is still being analysed on Creo Parametric. It is expected to produce the stress distribution and the conceptual design can be recommended based on the obtained results.

## 5. Further Work

Finite Element Analysis and Materials Selection for the prosthesis are still remaining in this project. If the conceptual design is proven to be valid the next step would be to produce it and undertake further testings.

## 6. Conclusions

The project so far has shown that there is feasibility in improving the prosthesis design and materials selection to increase the performance and reduce the risk of potential failures.

## Acknowledgements

I would like to thank my supervisor Dr. Steven Goh for his time, energy and kindness in guiding me throughout my project and answering all the questions and concerns I have had in my research.

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# Behaviour of Fibre Composite Walkways & Grating

Sponsors – BAC Technologies, Nepean Engineering & Innovation, Centre of Excellence in Engineered Fibre Composites



**Lachlan Nicol**

Bachelor of Engineering  
(Civil)

Supervisors: Dr Allan Manalo, USQ

**Keywords:** FRP Grating, Fibre composite, Walkways, Boardwalks

## 1. Introduction

With the increasing push for alternative materials in the construction of boardwalks and walkways, fibre reinforced polymer, (FRP) grating, has been a popular solution. However since this particular type of product is relatively new to Australia, very little is known on its behaviours and limitations.

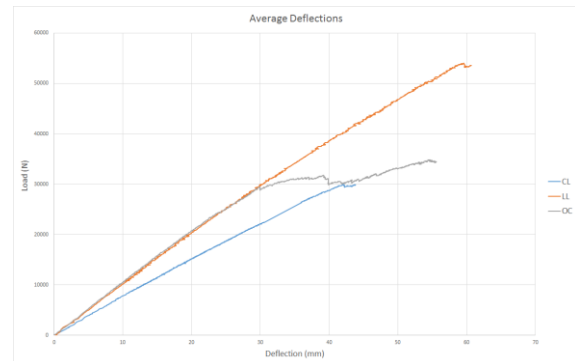
This research project primarily focuses on the investigation into the FRP gratings to help establish a knowledge base on the materials strength and behaviour under various loading cases.

## 2. Background

For a very long time within the engineering and construction industries, there has been a somewhat non varying selection of materials used in the construction of boardwalks and walkways. Traditional materials such as concrete and timber have shown dilapidation and deterioration over an extended period in time. It has recently come to light that new materials such as FRP hold certain non-corrosive properties which are ideal for use in walkways and boardwalks where the environment may be corrosive.

## 3. Methodology

The procedures involved testing and analysing the behaviour of full scale grating as well as component samples. The full scale load tests consisted of loading different samples under a line load, concentrated centre load, as well as an off centre concentrated load. The deflection, stress, and strain for these sample were recorded and analysed. A deflection summary for the loading cases is displayed in Figure 1.



The sample tests consisted of compression testing, flexural load tests, as well as a burn out test. The compression and flexural tests involved loading the sample sized test specimens until full failure. The burn out test was an investigation into the ‘make up’ of the grating and involved burning away the resin matrix and recording the ratio of glass fibres in the sample.

## 4. Key Outcomes

From the results of the full scale tests, it is apparent that that line loading provides a larger deflection before failure than the two concentrated load tests. It is interesting to observe that the line load and centred load are relatively linear, whereas the off centre load begins rather linear but tends to vary from its linear pattern as it works further towards failure.

## 5. Further Work

Work yet to be completed involves a computer simulation analysis using Strand7 to verify results found in the various loading cases. If time permits, an investigation into the change of geometry of the samples tested will be looked at.

## 6. Conclusions

At this stage of investigation, it can be concluded that the mechanical behaviour of FRP grating varies under the different types of loading cases. The difference between line loading and concentrated loading is fairly significant, as well as the behaviour of the grating when the load is moved closer to the supports rather than directly in the centre.

## Acknowledgements

I would like to thank and acknowledge Dr Allan Manalo for guiding me through this research project. I would also like to thank my sponsors: Buchannan’s Advanced Composite Technologies, Nepean Engineering & Innovation, as well as the members of the CEEFC who helped with my testing.

# Investigations into Cambooya's water supply pressure with respect to local contributing bores.

School of Civil Engineering and Surveying



**Grant Norman**

Bachelor of Engineering  
(honours)

Civil Major

Supervisors: Dr Joseph Foley, USQ

**Keywords:** Municipal water supply, bore interaction, pressure mapping.

## 1. Introduction

Regional and rural communities within Australia are often introducing bore water into local water supplies. This is implemented so that the drier regions of Australia still have access to a constant and sustainable water supply. However, when the bore water is being introduced into a municipal supply system, the changes in pressure become a concern. The water supply pressure must be equal to or less than what the bore pump is producing otherwise the system will be running inefficiently. This is not only inconvenient for water consumers but also leads to higher costs due to the much more frequent requirement for maintenance and replacement pumps. In addition, the interaction of the diurnal cycle of pressure at the bore head will produce unintended consequences in regard to the delivery of bore water into the network. This diurnal issue is further compounded by the groundwater rise that has occurred in the local Toowoomba regional basin due to the recovery since the drought.

## 2. Background

Municipal water pressures vary greatly throughout the day. To analyse how a water network interacts with bore water a model will be developed.

Water networks in the Toowoomba region are designed with the full intention of introducing groundwater sources. Bores are monitored physically with routine checks but their interaction is yet to be modelled in anyway. Modelling this interaction is advantageous to bore monitors as it not only allows to see how the system is performing at the present, but allows the monitoring personnel to observe the system in different scenarios. Ultimately a model will allow engineers to optimise the network.

## 3. Methodology

To understand and process the relationship between the municipal water supply and the bores a hydraulic modeller was used. This model would be a replication of the location



of analysis and would therefore imitate the properties of pipes, pumps, topography and water sources. Realistic demands were being applied to the model so that an accurate representation of the network could be attained.

To make sure these results were viable, physical data was gathered from the location of analysis. The pressure data gathered was then compared to the model's node pressure to see if the system was operating similarly.

## 4. Key Outcomes

There has been success in gathering the pressure readings around the location of analysis. There have also been positive steps towards a completed model but because the model is not yet finalised there can be no comparison or recommendations made at this point.

## 5. Further Work

The hydraulic model still needs to be tuned so that the comparison between model and physical data can occur. Other work still to be completed includes recent methodologies, the collection of more physical data during an on-peak period, collaboration of results, discussion and any future work that this model could be applied to.

## 6. Conclusions

Gathering physical data at off peak times has shown that the system is capable of supplying the required pressure throughout the town. As on-peak measurements are yet to be taken it is unknown if the system can also supply the town during the busier hours of the day.

## Acknowledgements

I would like to acknowledge the assistance of a few people who have made this project possible to complete and in an effective and efficient manner. Firstly, I would like to thank my supervisor, Joseph Foley for his help in understanding the task and ideas of how to go about the analyses. Secondly, I would like to thank Matthew Norman, Campbell Olsen, Damian Darr and Rob Coyer from the Toowoomba Regional Council (TRC). These people made many mandatory documents available by dedicating work hours to the cause.

# An analysis of road pavement materials used in foamed bitumen stabilisation

Sponsor – Coffey Pty. Ltd.



**Adam O'Callaghan**

Bachelor of Engineering - Civil

Supervisors: Dr Soma Somasundaraswaran, USQ

Mr Peter Sheen, Coffey Pty. Ltd.

**Keywords:** Foamed bitumen, stabilisation, road pavement materials.

## 1. Introduction

Foamed bitumen is an insitu stabilisation process which uses expanded bitumen as a binding agent. The process produces a bound pavement which acts as a flexible pavement. The process can be used for improvement of both road base and sub-base materials.

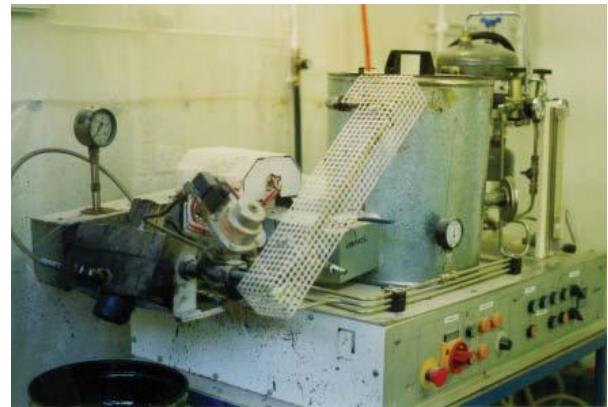
The application of foamed bitumen stabilisation is not limited to use on good quality pavement materials. The purpose of this project is to examine the material properties of road base materials used in foamed bitumen stabilisation, the effects on the pavement strength and the serviceability of the pavement.

## 2. Background

Foamed bitumen stabilisation is an insitu stabilisation process and consequentially reduces the time of road closures. The reconstruction of a road pavement can be complete within a day and the road can be reopened to traffic after the final compaction is complete with no detrimental effects on the pavement. The speed of the reconstruction means that work on the pavement can begin at the completion of the morning peak and be complete for the afternoon peak meaning less inconvenience to road users and residents.

## 3. Methodology

The methodology used to complete this project involved a detailed analysis of road base materials used in foamed bitumen stabilisation from various sites in New South Wales, Queensland and Victoria. This analysis involved conducting a number of tests on samples from different sites along Eastern Australia and using some historical data from testing conducted over the last 15 years.



**Figure 1 – Laboratory scale foamed bitumen machine**

## 4. Key Outcomes

The key outcomes of this project are to determine the effects of variations in material properties, bitumen content and if marginal materials can be successfully used in in foamed bitumen stabilisation.

## 5. Further Work

Further analysis to be completed involves the evaluating the effects of air voids on pavement strength and the influence of varying the bitumen content on air voids and pavement strength

## 6. Conclusions

Testing and analysis of the data is still in progress. Early analysis indicates that some material properties have more of an effect on the pavement modulus more than others.

## Acknowledgements

I would like to thank my supervisors Dr Soma Somasundaraswaran and Peter Sheen, Coffey for their assistance in allowing me access to the required testing equipment and historical data and finally my wife and children for their understanding and support

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# VOLTAGE CONTROL IN MICROGRIDS

Sponsor – School of Mechanical and Electrical Engineering

## O.Vara Prasad Yadav

Master in Engineering Science  
(Electrical and Electronic Engineering)



Supervisors: Andreas Helwig, USQ

**Keywords:** Energy dispatch operation, Load models, rural electricity, and equitable power sharing methods

### 1. Introduction

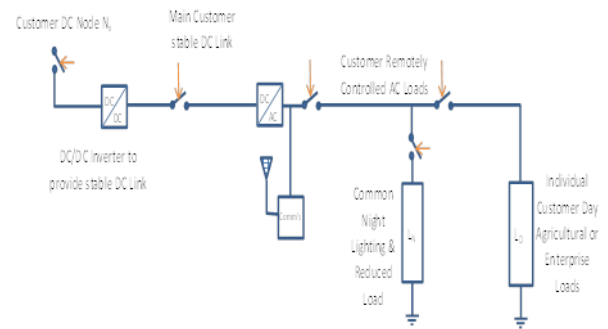
In India where micro-grid development is being implemented to supply electrical power to remote communities with no access to the current three phase HV network; this can become quite a problem, as competition for electrical energy sources by the small number of clients. Micro-grid networks are equipped for producing sufficient energy to better the life ambitions of a small number of connected clients. This project is to look at one possible best answer for provincial very small micro-grids, based on small clusters of agricultural extended family groups.

### 2. Background

The first lighting network was implemented by Thomas Edison in the year 1878. He used DC to supply the power to power both lights and electrical motors. He created the first technology for a complete low-voltage DC network in the year 1882 to supply around 1200 lights in the Pearl Street, New York; serving an area about 2.6 km<sup>2</sup>. This was in fact the first micro-grid. It is estimated that around 400 million people have no electricity [1], and will not have access to electrical power resources in the near future. This precludes improvements in living standards and business opportunities as without a stable and reliable electrical power source, connectivity to the global information network is not possible.

### 3. Methodology

In this paper, a low voltage DC micro grid protection is to be designed and similarly the load profiles will be developed. Similarly the conductor and pole spacing to be used to interconnect distributed resources and loads requires consideration in the design. For designing the LV DC micro grid system, the DC micro grid is connected to battery such that battery gets charged and can be used for producing the power during night times, as well as cloud transients for the main PV supply during the day.



**Figure 1: Typical Customer Node Inverter and Load Arrangement for proposed DC Micro-grid. (In the figure2 the arrow marks indicates communications controlled relay-switch.)**

### 4. Key Outcomes

This project will be able to find the financial analysis of the cost of electricity, sensitivity study to find an optimal possible configuration for the micro grid.

### 5. Further Work

DC micro grid can be developed by using the control system with different types of sources and energy storage which will effect on operational costs. It would be possible to investigate the DC micro grids based on its stability and reliability.

### 6. Conclusions

From the research paper it can be known that the LV residential loads can be supplied with DC and the operation control strategies for energy dispatch between load users can be developed. Finally the energy availability versus energy demand is investigated by modelling the data in homer energy software.

### Acknowledgements

I hereby express my gratitude to my supervisor Andreas Helwig for his constant support, guidance throughout the work. It would not have been possible for me to write the work without his help, he constantly encouraged me from the beginning onwards to reach the expectations of the project.

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# Evaluation of Precise Point Positioning Services

School of Civil Engineering and Surveying



**Daniel O'Sullivan**

Bachelor of Spatial Science  
(Surveying)

Supervisor: Associate Professor Peter  
Gibbings Faculty of Health  
Engineering and Sciences,  
USQ

**Keywords:** Precise-Point-Positioning, Post-Processing,  
GNSS.

## 1. Introduction

The aim of this study is to evaluate the performance of online Global Navigation Satellite Systems (GNSS) post processing services. Identical data will be processed by a selection of service providers and the solutions compared.

## 2. Background

There are various post processing options available on the web that allow users to upload and process GNSS data. Whilst studies have been undertaken to examine reliability and accuracy of post processed solutions, gaps in existing research identifies a need to examine repeatability of results, to include different GNSS constellations in a processed solution and to identify if any bias exists in the results. This study aims to test the findings of previous research as well as to address the identified gaps

## 3. Methodology

Observation data was collected from two existing coordinated trigonometric stations as well as the USQ continually operating reference station utilising static dual frequency GNSS receivers. Sessions were conducted over a 24 hour period and were repeated three times in order to provide sufficient data to undertake the necessary comparisons.

Raw data collected during these observation sessions were submitted to four post processing service providers. The service providers utilise either a Precise Point Positioning (PPP) method or differential baseline method to develop their respective solutions. The solutions derived from identical data which will be

processed by each service provider will be compared to assess precision. In addition, the solutions will be compared to published Land Property Information (LPI) coordinates in order to assess accuracy, Global Positioning System (GPS) based solutions will be compared to GPS + GLONASS based solutions in order to examine the effect and finally, PPP derived solutions will be compared to differential baseline derived solutions for the existence of any bias.

## 4. Key Outcomes

The key outcomes of the study will include:

- Adding weight to previous studies on the reliability of post processing services by repeating previous tests and including repeated occupations on surveyed marks,
- Identifying the effects of the inclusion of GLONASS and GPS data on a processed solution in order to assess suitability for use, and
- Identifying the effects (if any) of bias caused by the varying types of software used in the processing of solutions so that the best method of post processing is adopted for a given requirement.

## 5. Further Work

The processing and comparison of data is currently being undertaken and final analysis will be completed once this has occurred.

## 6. Conclusions

Insufficient data has been analysed to enable any conclusions to be drawn at this stage.

## Acknowledgements

I would like to thank Associate Professor Peter Gibbings for providing guidance and feedback and my employer Newton Denny Chapelle for the use of equipment and resources.

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# Intelligent Decision Support System for Business Development

Sponsor – School of Mechanical and Electrical Engineering



**Charles Paige**

Bachelor of Engineering  
(Computer Systems)

Supervisors: Dr Hong Zhou, USQ

**Keywords:** Bilevel Programming, Decision Support System, Web application.

## 1. Introduction

Managers and board members are often required to make business decisions in the face of incomplete or hard to assess information. The aim of this project is to develop a Decision Support System (DSS) that can supplement such decision making processes by modelling aspects of the given business using mathematical bilevel programming.

As part of this project, the system will be used to solve a pricing model for an electric retailer's participation in a demand response market environment.

## 2. Background

Bilevel programming can be used to model complex optimization problems involving multiple stakeholders, something that standard mathematical techniques are unable to handle. The problem solving methods used in this project come from a set of proposed algorithms that are able to solve a wider range of problems than methods based on traditional Karush-Kuhn Tucker conditions. (Shi, 2005)

## 3. Methodology

- Select and implement a single algorithm as proof of concept and for testing purposes.
- Perform requirements elicitation and analysis.
- Design and implement the system database.
- Develop the first system prototype - bringing the algorithm and database together. The architecture for this is shown in Figure 1.
- Apply the system to the electricity retailer's pricing problem.
- Iteratively test, assess and improve the system.

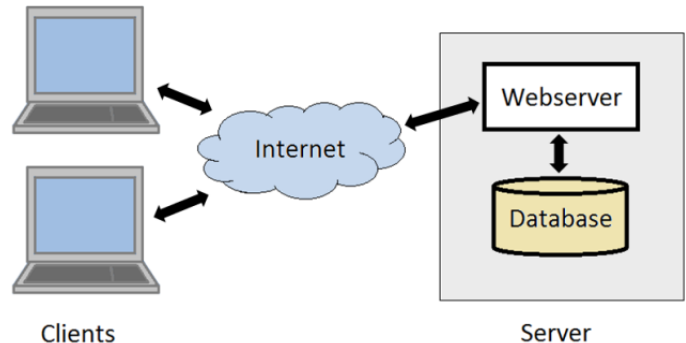


Figure 1 - Architecture

## 4. Key Outcomes

The key outcome of this project is the development of a web application that can store, solve and analyse bilevel programming problems. It is also essential that the project shows how this bilevel theory can be used to aid in a business's decision making - to this end the system will be used to solve an electric retailer's dynamic pricing problem.

## 5. Further Work

Future progress will be focused on finalizing and then running the test cases for the energy retailer's pricing problem. Development will also continue on the system itself, with several desired features still to be added.

## 6. Conclusions

Development of the pricing problem test cases is still in progress, but the DSS prototype has already been used to solve several complicated bilevel problems with multiple variables and decision makers.

## Acknowledgements

I would like to express my gratitude to my supervisor, Dr Hong Zhou, for her guidance throughout this project.

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# Quantifying the Cost of Climate Change on Coastal Drainage Systems

School of Civil Engineering and Surveying, USQ & Moyne Shire Council



**Kristen Pannan**

B. Eng (Civil)

Supervisors:

Dr Ian Brodie, USQ

Mr Ian Harper, Moyne Shire Council



**Figure 1 – Catchments & 2080 oceanic inundation zone**

**Keywords:** Coastal drainage, sea-level rise, climate change, cost

## 1. Introduction

This study aims to identify the potential impacts of Climate Change on the cost of coastal drainage systems via analysis methods that use inputs of both current and projected future sea levels, storm surge and rainfall events. A moderately developed, low lying coastal catchment in Port Fairy, Victoria provides the case-study area for this project. Cost comparisons of the current and future drainage system requirements allow insight into the proportional increase in cost of infrastructure which will be required to service future coastal communities.

## 2. Background

This project was created in conjunction with Moyne Shire Council, in response to exposures flagged in the last year's Port Fairy Coastal Hazard Assessment report regarding the potential for oceanic inundation in built-up areas (Flocard et al. 2013). Continuing demand for further coastal development pose difficulties for local council in terms of gauging feasibility and requirements for adequacy of coastal drainage infrastructure toward the planning horizon of 2080, as explored in this report.

## 3. Methodology

The Thistle Place case study catchment was surface-modelled in AutoCAD Civil3D. Drainage conditions were inspected and analysed using DRAINS hydrological modelling software. Current and future schemes to meet Infrastructure Design Manual (IDM, 2013) requirements were then costed using Rawlinsons Australian Construction Handbook 2014.

## 4. Key Outcomes

This work has expanded upon previous studies by producing a simulation which models the impacts of both sea-level rise and precipitation intensity changes on

drainage system requirements in a small coastal catchment. A percentage expected cost increase for a localised area drainage has been defined by this study, as well as a method of modelling to pre-empt adjustments in funding for drainage infrastructure. This may assist coastal councils with feasible planning.

## 5. Further Work

With improved processing power and more time, modelling over greater durations and optimisation of the coordination of storms could improve the reliability of results.

## 6. Conclusions

The greatest threat to functionality of coastal drainage systems is a combination of oceanic storm surge and precipitation events, and highlights the importance of this method for consideration of these two factors in joint occurrence.

## Acknowledgements

Moyne Shire Council staff for their assistance in the conception of this project and continued support, in particular Ian Harper, Brandon Cocking, Sally Hertzell and Leah Johnston. James Carley of the Water Research Laboratory at the University of NSW for his time and assistance with wave modelling inputs. My employers The CSE Group for the provision of advice and resources required to complete this study. I wish to thank my supervisor Ian Brodie, for assistance in direction and keeping me on the straight and narrow.

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# Evaluation of Flexural, Tensile and Impact properties of nano Al<sub>2</sub>O<sub>3</sub> filled vinyl ester composites post-cured conventionally and in microwaves.

School of Civil Engineering and Surveying



Varun Kumar PARUCHURI  
Master of Engineering Science  
(Mechanical)

Supervisors: Dr Jayantha Epaarachchi  
Dr Gayan Kahandawa

## 1. Introduction

In the recent times, composites have been exploited in immense areas like aerospace, transportation, civil and marine engineering. Applications those of in marine, aerospace and transport deliver impeccable performances whilst those in civil engineering are highly cost driven. This project allows me to acquire the profound cognizance in the field of composite materials and their applications in day to day basis.

## 2. Background

This project involves the production of a range of epoxy resin specimens with different percentage by weight of reinforcement. Actually, in the nearby future, I have a plan of pursuing Ph.D. in the field of "*Evaluating and Analysing the strength and properties of fibre reinforced composites*". So, I felt this would be a challenging start for me to grasp knowledge in the study of composites.

## 3. Methodology

As I mentioned in background, this project involves in the production of a wide range of epoxy resin specimens. It is done by considering the samples at different weight percentages starting from 5%. In order to enhance the flexural properties of composites, a wide range of fillers are being used. In this project, nano Al<sub>2</sub>O<sub>3</sub> powder will be used as filler. These fillers persuade significant influence on the final structural properties of composites. Finally, after preparation, these samples are cured in a microwave and are heated up to 100C before they are packed for cooling.

## 4. Key Outcomes

Here, flexural, tensile and impact properties are measured. The ultimate aim of this project is to evaluate the flexural and impact strengths of aluminium filled vinyl ester composites post cured in microwave and in conventional methods too.

## 5. Conclusions

Hereby, I conclude by stating that I have performed an innovative task on how to proceed and accomplish to meet the event of evaluating the physical properties of vinyl ester composites.

## Acknowledgements

I thank Dr Jayantha Epaarachchi and Dr Gayan Kahandawa for supporting me in doing this project. I also sincerely thank Mr Wayne Crowell for assisting me in the technical operations that have been performed in the laboratory. Finally, I very proudly say that my project has been sponsored to me by "Engineering and Surveying Department, USQ".

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# Development of Advanced Turbulent Combustion Models



**Matt Pichlis**

Bachelor of Engineering

Mechanical Major

Supervisors: Dr Andrew Wandel, USQ

**Keywords:** Turbulent Combustion, Combustion Modelling, Multiple Mapping Conditioning

## 1. Introduction

For combustion systems it is important to maximise efficiency to reduce running costs and pollution. An effective way of analysing and improving combustion systems is through the use of simulations. This is a much cheaper and easier method than using experiments. However because combustion is so complex the most accurate simulations are only able to calculate for very small and simple volumes ( $< 1 \text{ cm}^3$ ). Therefore models are used to simulate for a realistic size combustion chamber.

The relatively new Multiple Mapping Conditioning (MMC) model has been developed and validated for certain cases. The aim of this project is to further develop the Multiple Mapping Conditioning model. The model is to be developed for the application to a partially stirred reactor, where the fuel and oxidiser inside the reactor do not completely mix before being released. It will then be tested and validated over a range of conditions as well as comparing the efficiency and accuracy with other available models.

## 2. Background

Due to the increasing concern of energy security and the environmental issues related to energy production there is a requirement to develop improved systems. Systems are needed to be more efficient and therefore reduce pollution, while still being economical. This can be achieved through the development of new alternative energy sources or by improving existing sources such as combustion systems.

## 3. Methodology

The model is developed in MATLAB and compared with results obtained by Ren and Pope (2004) to test the validity. Ren and Pope tested three different models for the combustion of hydrogen and air within a partially stirred reactor. The same conditions had previously been simulated using the MMC model and deemed to be inaccurate (Wandel, 2005). To develop the model the boundary conditions are to be altered to try and achieve more realistic results.

## 4. Key Outcomes

An extensive literature review has been performed to determine the strengths and limitations of this model in comparison to other forms of combustion simulation. The model has been developed to use newer and easier forms of chemical reaction simulation and the boundary conditions have been altered to represent a more realistic simulation.

## 5. Further Work

The model needs to be validated by testing for a range of conditions before the overall performance can be determined. The results will all be compared with other models to try and determine the most effective method of simulating turbulent combustion.

## 6. Conclusions

At this stage testing is still underway and no definitive conclusions have been reached. The model still needs to be verified before it can be decided if it is suitable for the simulation of a partially stirred reactor.

## Acknowledgements

I would like to thank Dr. Andrew Wandel for his help and input throughout this project.

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Evaluate the flexural, tensile and creep properties of NanoAl<sub>2</sub>O<sub>3</sub> filled poly ester composite post cured conventionally and in microwaves.

Sponsor – School of Mechanical Engineering



## **Pondicheery Giridhar Sen**

MENS

Supervisors: Dr. Jayantha Epaarachchi  
Dr. Gayan Kahandawa

Keywords: Polyester resin, TTS (Time, Temperature, Super position), Nano Aluminium Oxide.

### **INTRODUCTION**

Composites are being used in wide range in different fields such as aerospace marine transportation and civil engineering etc. Application in aerospace, marine are very much performance driven while civil engineering applications are largely cost driven. In order to reduce the cost of composites a wide range of fillers are being used. In this project Nano Al<sub>2</sub>O<sub>3</sub> will be used as fillers. These fillers not only reduce the cost of composites but also have a significant influence on the final structural properties.

### **BACK GROUND**

As different types of composites are used these days in this project I want to find the flexural, tensile and creep properties of Nano Al<sub>2</sub>O<sub>3</sub> filled poly ester composites post cures conventionally and in microwaves.

### **METHODOLOGY**

This project involves the production of a range of poly ester resin specimen with different percentage by weight of fillers. After preliminary curing, the specimens will be post cured in microwaves and in an oven and tested for the flexural tensile and creep properties

### **KEY OUT COMES**

We can find the flexural and tensile strength of the composite material can be estimated, and the behaviour of the composite with change in the percentage of fillers.

### **FUTURE WORKS**

Evaluate time, temperature and super position of the composite materials to enhance their strength.

### **CONCLUSION**

We can estimate what percentage of fillers by weight is ideal for use for an ideal composite

### **ACKNOWLEDGEMENT**

I would like to thank Dr. Jayantha Epaarachchi, Dr. Gayan Kahandawa to supervise the project and helping me in each and every time I went wrong and I also thank Mr. Wayne Crowell who always supported me in the laboratory.

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# EVALUATE THE THERMAL AND TENSILE PROPERTIES OF GLASS POWDER FILLED POLYESTER COMPOSITES POST CURED CONVENTIONALLY AND IN MICROWAVES.

School of Mechanical and Electrical Engineering



**Mahesh Narayan**

Master of Engineering Science

(Mechanical Engineering)

Supervisors: Dr. Belal Yousif, USQ

Mr. Mohan Trada, Technical  
Officer, USQ

## 1. Introduction

Composite materials are those which are made by combining two or more materials which may have different physical properties or chemical properties. These materials have a wide range of applications in modern engineering world.

In this project, I am assessing the thermal and tensile properties of glass powder filled polyester composites. The properties of polyester composites are changed by adding fillers such as glass powder. Different percentage by weight of fillers is added and the changes in properties are determined. The catalyst used for this process is MEKP (Methyl Ethyl Ketone Peroxide).

## 2. Background

The properties of composite materials can be altered by changing the fillers and resin. Different materials are combined together to obtain desired quality levels. This makes the composite materials a highly preferred one in many applications which require strength enhancement, improved thermal stability and lower cost.

## 3. Methodology

In this process, the polyester is taken and weighed and different percentage of fillers (glass powder) is added along with almost 2% of catalyst. It is then poured to the mould to obtain the desired shape to do the thermal and tensile testing. The material is then cut to the

required dimensions and finally post cured in a conventional oven and in microwave and the final properties are evaluated.

## 4. Key Outcomes

The thermal and tensile properties of glass powder filled polyester composites can be measured. By using the different percentage of fillers, the properties of composite materials can be varied and this will help me in determining the suitable composition, which can be used in a real engineering domain.

## 5. Further Work

In this project, I am evaluating only the thermal and tensile properties of glass powder filled polyester composites. I am doing this by adding different percentage of fillers to the resin. The different properties such as electrical properties, design flexibility can also be evaluated.

## 6. Conclusions

The final properties of the composite materials make it a preferred one in engineering applications which require low thermal conductivity and more strength to weight ratio.

## Acknowledgements

I would like to thank Dr. Belal Yousif, who is my supervisor for the support he is giving me in fulfilling the project. He is the one who is helping me in each and every step. I would like to thank Mr. Mohan Trada, who is the technical officer for this project lab. He has helped me a lot in getting the materials required for accomplishing this project. I am thankful to my former supervisor Dr. Harry Ku who has depicted the outline of this project.

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# The affect of lighting interchange ramps on safety – A study of the M1

Sponsor –Roads and Maritime Services, NSW



**Scott Power**

Bachelor of Civil  
Engineering

Supervisors: Mr Trevor Drysdale, USQ

Mr Justin Drinkwater Industry  
Advisor, Roads and Maritime  
Services, (RMS)

**Keywords:** Lighting, Safety, Cost-Benefit

## 1. Introduction

The implementation of street lighting throughout the world varies greatly on road networks particularly grade separate interchanges. Grade separated interchanges along the M1 Motorway between Sydney and Newcastle (NSW) will be looked at closely with the configuration of the street lighting at the entry and exit ramps being the particular focus. Crash data at each interchange will be analysed and compared to see if street lighting configurations that comply with the standards perform better or worse than street lighting configurations that fail to conform to the standards.

## 2. Background

The M1 was selected due to its inconsistent use of street lighting layouts at grade separated interchange exit and entry ramps along with the high volume of traffic and availability of crash records. There is no clear direction in the preferred positioning and level of lighting along interchange ramps even though the RMS design standards refer users to use AS1158. The installation and on going maintenance cost on each project can vary greatly due to difference lighting layouts adopted.



Figure 1: Exit Ramp Diverge Area

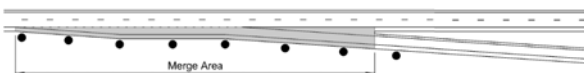


Figure 2: Entry Ramp Merge Area

## 3. Methodology

Interchange ramps along the Sydney to Newcastle M1 were inspected to determine the current lighting layout and classified as CIL, PIL or no lighting. The crash data along each ramp was analysed to determine any relationships considering traffic volumes, crash type and weather conditions, to determine if additional or less lighting may have prevented accidents or have no impact on the outcome. Figures 1 & 2 illustrates a typical diverge and merge lane and the Australian Standard lighting layout.

## 4. Key Outcomes

If there is no significant safety benefit of completely lighting an interchange ramp and AS1158 specifies minimal lighting or PIL, then there is scope to reduce the number of light post installed on interchange ramps and reduce the overall project and on-going maintenance cost.

## 5. Further Work

Crash Data along at each interchange needs to be analysed to draw relationships between lighting and road safety to determine the correct approach to lighting of grade separated interchange and achieve consistency across the state.

## 6. Conclusions

The aim is to be able to recommend on whether or not changes are required to existing design standards for street lighting on entry and exit ramps for grade separated interchanges and be able to provide a clear direction for RMS project managers and lighting designers.

## Acknowledgements

I would like to thank my employer Roads and Maritime Services for providing me with the opportunity to work full time gaining experience in the industry of civil engineering and supporting me through my university degree. Thanks to Justin Drinkwater, Peter Styles and Trevor Drysdale for there support and direction on my research project.

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# WIRELESS SENSOR NETWORK FOR GREENHOUSE ENVIRONMENT MONITORING

Sponsor: School of Mechanical and Electrical Engineering



**Bikesh Pradhan**

Master of Engineering Science  
(Electrical and Electronic Engineering)

Supervisors:  
Wei Xiang

**Keywords:** WSN, ZigBee, OPNET

## 1. INTRODUCTION

This proposal presents the Wireless Sensor Network for Greenhouse Environment Monitoring based on ZigBee technology. Agricultural parameters like temperature and humidity are monitored in real time for the better management and maintenance of the agricultural production in greenhouse. In recent years, wireless sensor technology that integrates sensor technology, MEMS technology, wireless communication technology, embedded computing technology and distributed management are rapidly developed.

## 2. BACKGROUND

In 2001, serodio manage a set of greenhouse by developing and testing a similarly distributed data acquisition and control system. Liu and Ying developed the the greenhouse monitoring and control system based on the Bluetooth technology that collect and transmit the data to the control system in 2003. Wireless sensor networks with systematic frames were introduced and expatiated their agricultural applications such as monitoring greenhouse, irrigation, precision farming and so on (Qiao 2005). In this paper, wireless sensor network based on ZigBee standard is presented for monitoring the greenhouse environment parameters such as temperature and humidity. It is more suitable for modeling wireless sensor network to overcome the limits of wired network in the agriculture fields.

## 3. METHODOLOGY

To simulate and model data in the ZigBee network, OPNET simulator can be implemented which is powerful computational software. This software facilitates the environment suitable for simulation of wireless sensor network based on ZigBee technology. It provides several ZigBee network components such as ZigBee coordinators, ZigBee routers and ZigBee end devices. Different perspectives of wireless sensor network must be studied to model the actual network.

## 4. OBJECTIVES

The objectives of this research are:

- Extensive literature review and background research on the various wireless sensor networks, sensor devices and ZigBee technology.
- Design the system based on ZigBee technology for measuring temperature and humidity of the soil.
- Analysis of different network topologies and sensor devices for energy efficiency and low cost.
- Analyse and evaluate the performance of a ZigBee wireless sensor network with the OPNET simulator.

## 5. CONCLUSION

This research will seek to analyse different wireless sensor network based on ZigBee to monitor the environment parameters such as temperature and humidity for the better management of the greenhouse to improve the production. Applying the ZigBee based WSN helps to overcome the limits of wired systems which will be low cost, low rate, low power consumption and self forming wireless communication. OPNET simulator is used to analyse and evaluate the performance of design of the system for the monitoring the greenhouse.

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# Prevention Of Electrical Accidents With Safe Personal Protective Bonding and Earthing

Sponsor – Own project

## Andrew Pratt



Bachelor of Engineering  
(Power)

Supervisor: Dr Bob Burgess, USQ

**Keywords:** Personal Protective Bonding, Safety, Electrical accidents.

### 1. Introduction

Working on powerlines is an inherently dangerous occupation. Powerline construction and maintenance can be performed with the power line either energised or de-energised. Logically it would seem that work on a deenergised line is safer. However, a line worker can still be exposed to lethal electrical hazards from causes such as lightning, induction or accidental energisation. Sadly, there have been many tragic examples where line workers have been electrocuted whilst working on de-energised powerlines.

Personal Protective Bonding and Earthing (PPBE) is the practice of temporarily installing cables to short circuit a de-energised line and to connect it to earth. The goal in the application of PPBE is to ensure that equipotential conditions are maintained at the work site. This protects the worker against the risk of electrocution should the powerline be unexpectedly energised.

### 2. Background

The aim of the project is to determine if current PPBE work practices provide adequate protection for line workers, or whether improvements are needed.

PPBE provides a low impedance parallel path for fault current to bypass the line worker in the event of an unintentional energisation of the power line. Whilst current generally follows the path of least resistance, in a parallel circuit, at least some current will flow in each branch.

In a fault situation where thousands of amps may flow, the question is ‘how much current will flow through the line worker?’

According to the Australian Standards, as little as 50mA can cause ventricular fibrillation and this may result in the death of the line worker. (AS60479, 2010).

### 3. Methodology

A practical analysis of PPBE techniques will be made using real data collected from the field. A real 11kV feeder has been selected and information such as conductor type and soil resistivity will be collected from several sites and used in the project analysis.

The electrical performance of PPBE will be analysed to determine the prospective step and touch voltages a line worker may experience should the powerline be unexpectedly energised. This includes consideration of the hazards for workers at the pole top and on the ground.

### 4. Key Outcomes

It is hoped this research will identify any potential failings of current work practices in the use of PPBE. If problems are identified, then solutions will be designed to overcome these problems for future work.

### 5. Conclusions and Further Work

At the time of writing my analysis is ongoing and I have not drawn any final conclusions.

It is generally not possible to completely eliminate the risk when working on the powerlines. For example, energisation due to an act of vandalism is rare but still possible. Therefore, consideration is required of ‘what constitutes an acceptable risk?’ I intend to present my findings in this context and provide an objective analysis of how the level of risk can be assessed.

### 6. Acknowledgements

I would like to thank Leith Elder and Peter Bereicua who have provided me with encouragement and support for my project. I would also like to thank my project supervisor, Dr Bob Burgess, for his expert guidance and feedback.

### 7. References

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# Prioritized Fountain Code for video transmission



**Chengyuan Qin**

Master of Engineering Science

Supervisors: Dr Wei Xiang, USQ

**Keywords:** Fountain Code, Unequal Error Protection, Unequal Recovery Time

## 1. Introduction

This research aims to realize Unequal Error Protection (UEP) and Unequal Recovery Time (URT) for video transmission based on Fountain code. Although traditional Fountain code can recover lost bits, it protects data uniformly. However, in video transmission, some bits are more important than the other. The essential data should be decoded first (URT) with less error (UEP). Thus, in our research, Fountain code are enhanced with UEP and URT property.

## 2. Background

Today, Automatic-Repeat-Request (ARQ) error control method cannot meet the requirement of large scale video broadcasting. Our proposed coding scheme is designed to reduce clients' retransmission requests. In addition, with UEP and URT property, this coding algorithm can adapt to the condition of receivers' demand. Current research of URT and UEP fountain code focus on increasing the More Important Bits (MIB) chosen probability and prioritized linking MIB to easy decoded encoding symbols. Our research tend to combine these methods together and find a quantitative optimizing.

## 3. Methodology

According to the encoding and decoding mechanism, linking MIB to low degree encoding symbols and increasing chosen rate could realize UEP and URT. However, the most challenging task is find the optimal parameters. An adaptive method are employed to conduct quantitative analysis. Instead of finding a theory to calculate the best value, we just try a set of parameters, compare the results with requirements and then adjust the parameter until it basically meet the specific needs.

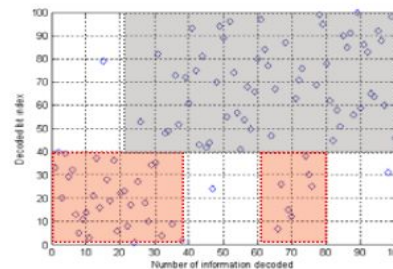


Figure 1 – Decoding sequence statistics (Woo & Cheng 2008)

## 4. Key Outcomes

After running the simulation we have find the optimal parameters for  $k=100$ ,  $k=1000$ , and  $k=5000$  ( $k$  denotes the original file' packet number), in overhead of  $\gamma=0.9$ ,  $\gamma=1.1$  and  $\gamma=1.2$  (overhead means the number of received decoded symbol divided by the ratio of source file packet number). In fact, these result are not our final goal. We tend to run more simulations obtain more results in order to conclude an empirical equation.

## 5. Further Work

We hope to develop a theory to calculate the optimal parameters. It could be an empirical equation or an equation derived from the decoding process. Because the adaptive method is time consuming and inefficient.

## 6. Conclusions

Through the research, we find that in order to realize UEP and URP, the decoding rate of Less Important Bits (LIB) must be sacrificed.

## Acknowledgements

I would like to thank my supervisor Dr Wei Xiang, who never lose hope on his student and encourage me when I was low. I also owe thanks to my pear Gengkun Wang and Pan Gao for helping me with my research.

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# Evaluate the thermal and tensile properties of nano Al<sub>2</sub>O<sub>3</sub> filled polyester composites post cured conventionally and in microwaves

Sponsor – School of Mechanical and Electrical Engineering



**Pravien Kumar Babu Rathinam**

Master of Engineering Science  
(Mechanical Engineering)

Supervisor: Dr Mainul Islam, USQ

**Keywords:** nano Al<sub>2</sub>O<sub>3</sub>, Polyester composites, Post cured conventionally.

## 1. Introduction

Composite materials are widely used in the structures of many transportations and constructions. These composites have their roles in performance issues, in case of transportations and they affect the cost of materials, in case of civil construction applications.

Nano Al<sub>2</sub>O<sub>3</sub> fillers are added to influence the structural properties of polyester composites.

## 2. Background

The main aim of this project is to study the behaviour of nano Al<sub>2</sub>O<sub>3</sub> filled polyester composites. Fillers will influence the structural properties and also to reduce the cost of composites.

## 3. Methodology

This project involves the production of a range of polyester resin specimens with different percentage by weight of fillers. After the preliminary curing, the specimens will be post cured conventionally and in microwaves. The posts curing processes involves heating the samples at 60°C and cool them in the facility.

## 4. Key Outcomes

Fillers will influence the structural properties of polyester and also reduces the cost of composites.

## 5. Further/Future Work

The future work involves preparing a range of polyester resin specimen with different percentage by weight of fillers. And conducting various thermal and tensile analysis to study the behaviour of the filled polyester composites.

## 6. Conclusions

Based on the thermal and tensile analysis and by the theoretical predictions of the filled polymer behaviour, we can differentiate the usage of polymers with different percentage by weight of fillers.

## Acknowledgements

At first I like to thank the USQ for providing me this opportunity. And I would like to thank my supervisors Dr. Mainul Islam and the senior technical staff Mr. Mohan Trada for helping me to successfully execute my project.

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# MicroROV

Sponsor – School of Mechanical and Electrical Engineering



## Matthew Robe

Bachelor of Engineering (BEng):  
(Mechatronics)

Supervisors: Dr Andrew Maxwell, USQ

**Keywords:** Underwater, exploration, robotics

## 1. Introduction

Underwater exploration has occurred for many years by humans, and has been typically quite a dangerous exercise where people commonly die 10 meters below the surface of the water. Remotely Operatable underwater Vehicles (ROVs) were originally created to do what humans could not, discover the depths of the ocean and scientifically categorise what is there. As they are remotely operable, they remove the dangerous natures involved in underwater exploration. However, an operator still needs to be in close proximity of the vehicle to control it through a tether.

This project will explore the design and development of new types of ROV for exploration, implementing low cost component solutions, and affordable wireless systems. The design is required to be capable of live remote control with simultaneous viewing of telemetry data over a server with possible autonomous capabilities examined for future implementation.

## 2. Background

As a typical ROV is not very affordable for institutions or individuals, there is a large requirement for this issue to be filled with an appropriate solution. This project aims at filling the gap for marine archaeology. Currently there is no method for archaeologists to communicate with people on the surface. This project will build upon existing mid-cost platforms and will potentially allow easier communication between marine archaeologists and their supervisors as well as taking possible payloads for emergencies.

## 3. Methodology

An analysis of current methodologies for existing ROVs will be performed. Followed by thorough research into the critical design aspects for the vehicle moving towards a system design specification. A prototype will then be modelled examining the cost efficiency, and applicability of a final design.

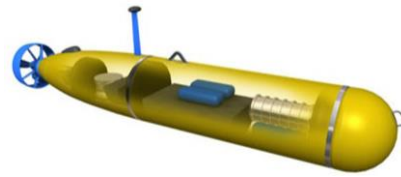


Figure 1 – BlueFin Model (kision, (2009))

## 4. Key Outcomes

Key outcomes of this work will be the discovery and itemisation of low cost components available to ROV enthusiasts suitable for low cost, and importantly, low maintenance designs in the underwater archaeology field. Additionally, design aspects of the possible wireless communications will be discussed.

## 5. Further Work

There are still aspects of the system design and specifications to complete. Beyond this, a demonstration platform will be modelled with component simulation (motors, payloads, control systems) verifying the system design. Additionally, beyond the scope of this project, aspects of autonomous application also need to be investigated.

## 6. Conclusions

The current research shows that it should be possible for a wireless solution for ROV communication to be obtained for a reasonable cost. An increase in the availability of low cost robotic components suitable for this design will allow further system design moving towards a demonstration platform.

## Acknowledgements

I would like to thank my supervisor, Dr Andrew Maxwell and Andrew Bolous for assisting with workshopping plausible solutions and system design concepts.

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# Experimental Investigation on the Alkali Silica Reaction Effect on Concrete Strength Degradation

Sponsor – Department of Transport and Main Roads (TMR)



**Angela Rosas**

Bachelor of Engineering (Civil)

Supervisors: Associate Prof Yan Zhuge, USQ  
Dr Wayne Roberts, Department of Transport and Main Roads

**Keywords:** ASR, accelerate tests, tensile strength.

## 1. Introduction

The aim of this project is to conduct series of testing to assist the Department of Transport and Main Roads (TMR) of Queensland to gain a better understanding of the effect caused by Alkali Silica Reaction (ASR) on concrete structures.

## 2. Background

Since the 1940s Alkali Silica Reaction (ASR) has been known worldwide as a cause of deterioration in concrete structures. ASR is a chemical process that results from the use of certain aggregates in concrete mixing where particular elements of the aggregate, such as silica, reacts with alkali-sodium and potassium oxides- dissolved in the concrete pore solution. This reaction usually occurs with moisture as the final reactive composition.

Alkali + silica → gel reaction product

Gel reaction product + moisture → expansion

## 3. Methodology

Various acceleration testing methods were investigated and ASTM C1260 method was chosen for assessment of ASR affected concrete samples. The ASTM C1260, is a rapid test for determining possible reactivity in short period of time, 3 mortar bar specimens (200mm x 50mm x 50mm) were casted using glassy basalt and low-alkali cement and water. The specimens were left in hot water mixed with sodium hydroxide (NaOH) and stored in an oven at 80° Celsius. Specimen length was measured and recorded regularly.

## 4. Key Outcomes

ASTM C1260 was adapted in line with USQ laboratory facility limitations and availability of consumables. In the first batch the release agent affected the water and NaOH reaction. In addition, the screw was not expelled



**Figure 1 – ASR affected concrete sample**

according to the accelerated method. The second attempt used fabric waterproof cloth tape and the 316 stainless steel screws were replaced by engineering studs. The ASR effect on concrete strength degradation has been investigated from the 2<sup>nd</sup> group of samples.

## 5. Further Work

The indirect tensile test will be conducted on the damaged and standard specimens to compare the average strength capacity of the samples. This testing will use 3 samples of standard cylinders and 3 of damaged samples at intervals of 28 days, 7 weeks and 12 weeks.

## 6. Conclusions

The basalt glassy aggregate is reactive. Some changes have been made to fix the small expansion measured on the batch. The mapping cracks, as shown in figure 1, have been produced earlier than expected.

## Acknowledgements

I would like to acknowledge my supervisors Professor Associate Yan Zhuge, and Dr Wayne Roberts for all their support during the project; and Boral, Wagners and LabTek for supplying good quality material. I also would like to thank Tracey Knight, Daniel Eising, Piumika Ariyadasa. Last but not least, special thanks to my family and friends.

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<http://www.fhwa.dot.gov/pavement/concrete/pubs/hif09004/hif09004.pdf>

# VAR Controller for STATCOM Solar Inverter

Sponsor – School of Mechanical and Electrical Engineering

**Student Name: Akshay Jaishil Sahay**



Degree: Bachelor of Engineering,  
Electrical and Electronics Major

Supervisors: Dr. Leslie Bowtell, USQ

**Keywords:** Inverter, Solar Inverter, STATCOM, Power Factor Correction, Smart Meter, Unipolar operations, bipolar operations.

## 1. Introduction

Due to the increase in demand for electrical energy, the need for using renewable sources of energy is rapidly growing. It has also become essential that the power quality in the electrical grids are improved due to the sensitive nature of modern electronics.

## 2. Background

There are some areas in parts of Australia where the power factor in the Electrical Grid dips below 0.7 lag at peak operating hours, which then prevents the usage of high current electrical devices. The inverter which has been designed and implemented, uses an Energy meter to read the power factor in the Electrical Grid and it then boosts the current using the reactive power (VAR) accordingly to help correct the power factor. The inverter also uses techniques from Masoud and Sharma's paper's to alleviate DC injection into the grid.

## 3. Methodology

The methodology included the reading of various journals and addressing the issues that were highlighted in these journals. An existing schematic was then redesigned to alleviate the problems that were addressed in the Journals. The redesigned inverter was then converted into a PCB and an EDMI energy meter and a SIEMENS s7 200 PLC was used for power factor correction.

## 4. Key Outcomes

The key outcomes of this project includes a much cleaner sinusoidal wave being injected into the electrical grid from this inverter due to it having both unipolar and bipolar current controllers. It also managed to correct the power factor using the PLC and the Energy Meter.



Figure: 1 – Four Quadrant STATCOM Inverter

## 5. Further Work

The recommended further work for this project is the research and development of a suitable enclosure for the Inverter and all its peripheral devices, and also for the development of a SCADA network so that Utility operator can control the inverters from their end and improve power factor in the Transmission lines.

## 6. Conclusions

Upon the completion of this project, it can be concluded that the power factor in the Electrical Grid can be successfully corrected using the reactive power (VAR) from a STATCOM inverter with the help of an Energy Meter and a PLC.

## 7. Acknowledgements

I would like to take this opportunity to acknowledge the following people who have continuously supported me and have given me innovative ideas and encouragement through the duration of this project. Firstly my family and also my supervisor Dr. Bowtell for the continued support through the project, the USQ Lab technicians Mr Terry Byrne, Mr Graham Holmes and Mr Brett Richards for continuously providing material support and technical advice. I would also like to acknowledge Mr Peter Taylor of PT automations for giving me suggestions on how to interface the Energy Meter.

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# Numerical Modelling of Deep Braced Excavation

Sponsor–Kurdistan Regional Government-Iraq



**Samal F. Hama Salih**

Master of Engineering Science  
(MENS)/Civil

Supervisors: Dr. Jim Shiau, USQ

**Keywords:** deep excavation, FLAC, FISH, Nicoll Highway

## 1. Introduction

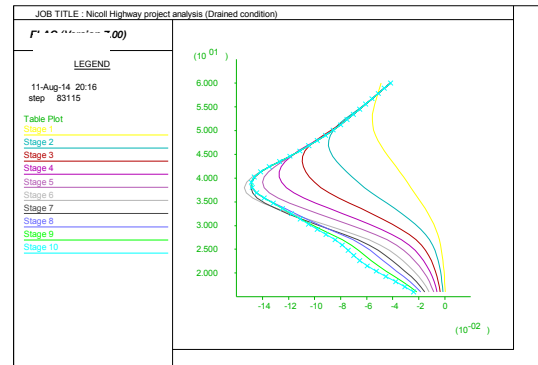
Deep excavation or the construction of basements includes the construction of retaining walls, excavation, the installation of struts, the constructions of foundations and floor slabs. This thesis endeavours to illustrate the use of explicit finite difference software (FLAC) to numerically model. A FISH code (script from command driven) will be developed and it can be used to study the behaviour of wall deformation and ground settlement during the stages of construction of deep excavation. This numerical model will be developed based upon a case study of failed geotechnical deep excavation in Singapore and will be supported by case history (Nicoll Highway project) data from other published sources.

## 2. Background

Analysis of deep excavation is usually required before going into design. Theoretically, analysis of deep excavation involves simulations of elastoplastic behaviour soil, interface behaviour between soil and diaphragm walls and the excavation process Ou (2006, p1). A complete deep excavation design includes excavation procedure, retaining walls, strutting system, dewatering system, monitoring system and protection of surrounding structures. Many studies carried out to analyse and design of deep excavation includes numerically simulation, experimentally and local experience with similar excavations. Finite element method of analysis has been widely used to study the behaviour of wall deformation and ground settlement during the excavation process.

## 3. Methodology

2D finite difference method is adopted to make numerical modelling. This program simulates the



**Figure1 x-displacement of diaphragm wall at the end of each excavation stage**

behaviour of structures built of soil, rock or other materials that may undergo plastic flow when their yield limits are reached. Materials are represented by elements, or zones, which form a grid that is adjusted by the user to fit the shape of the object to be modelled. Each element behaves according to a prescribed linear or nonlinear stress/strain law in response to the applied forces or boundary restraints.

## 4. Key Outcomes

The outcomes of this research are to develop numerical modelling to analyse the stages of construction of deep braced excavation and study background information of deep braced excavation.

## 5. Further Work

Auto generated mesh scripts from FLAC software can be developed and it can be used in the designing similar construction process of deep braced excavations. These scripts may also be used for industry design, as a design tool.

## 6. Conclusions

Scripts from FLAC has been developed and checked based on the published literatures. These scripts have been used to investigate and re-analyse the geotechnical design of Nicoll Highway project. Numerical results from the developed model are compared favourably with those from published papers.

## Acknowledgements

I would like to thank my USQ supervisor Dr Jim for his assistance and encouragement in the research project.

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Ou, C-Y 2006, *Deep excavation: theory and practice*, Taylor & Francis/Balkema, London; New York.

# FEA ANALYSIS OF TRACTOR AXLE MODIFICATION

School of Mechanical and Electrical Engineering



## Richard Sambamo

Bachelor of Engineering  
(Mechanical)

Supervisor: Mr Chris  
Snook, USQ

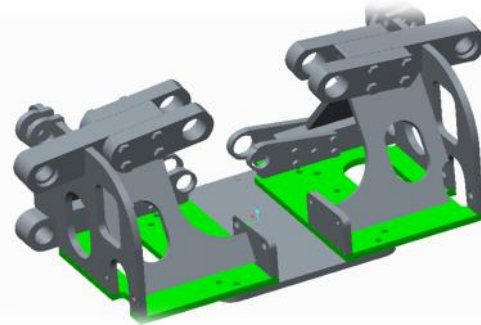


Figure 1: Solid Model of the axle.

**Keywords:** FEA software, axle, agriculture, controlled traffic farming.

## 1. Introduction

Tractor is one of the major and important agriculture implements. It is versatile in its uses because of the power built into it and the wide variety of attachments the tractor is able to tow. Tractors are playing an even more important role in the modern Controlled Traffic Farming (CTF) which is being embraced by many Australian farmers. The initial costs involved are slowing the take up of CTF and tractor axle modification is certainly one of the costs.

## 2. Background

Controlled farming has certainly been in practice for considerably long time and major tractor suppliers have not embraced the growing need of this changing market. Controlled farming seeks to separate the field into farm cropping sections and permanent roads which can be used by all agricultural implements such as combine harvester. Extending the front axle brings the front wheels in line with the rear wheels and ensures that they are always on the same track thereby creating some permanent roads on the field. The extended axle should however be of suitable strength and this project seeks to verify the structural stability of this particular modified axle.

## 3. Methodology

Literature review on different finite element analysis software was done to evaluate the accuracy of the results, ease of use, interface, processing times, computer requirements and the overall cost of setting up. The underlying theory of finite element analysis was also reviewed. 3D solid models were then created from the CAD files supplied by the client using Autocad 2014 and Creo 2.0. The individual parts were assembled to produce the solid model as shown in the Figure 1.

Finite Element model was then created in Creo Simulate and analysed using the same platform.

## 4. Key Outcomes

The key outcome of the project is to determine whether the modified axle will withstand the forces involved in farming especially at speeds over 40km/hr. A positive outcome can act as a guarantee to the farmers since modifications to the tractor's original axle may lead to nullification of the manufacturer's warranty. This can eventually increase the uptake and implementation of controlled traffic farming.

## 5. Further Work

Structural and dynamic analysis is currently underway, but initial results indicate that the stress levels in the axle are within limits. I intend to use another platform other than Creo 2.0 to verify and validate the results. I would recommend creation of a parametric model and an optimisation analysis for further work.

## 6. Conclusions

Although the initial indications from the analysis performed so far are positive, they are however not conclusive at this point. Further analysis is currently underway.

## Acknowledgements

I would like to thank my Supervisor Mr Chris Snook for his guidance on this project.

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# Effective Road Pavement Rehabilitation Design for Local Government Roads within the Sunshine Coast Region

Sponsor – Sunshine Coast Council



**Tom Sanders**

Bachelor of Engineering (Civil)

Supervisors: Professor Ron Ayers

**Keywords:** Pavement, Rehabilitation, Local Government

## 1. Introduction

Roads are an integral part of our community and provide the network to support our economy. Since the early 1900s there has been an emphasis on providing a cohesive road network. Currently government authorities are faced with the challenge of overcoming financial and technical deficiencies which prevent a cohesive network.

This project seeks to critically evaluate current pavement rehabilitation practices used within the Sunshine Coast region through the use of laser survey condition data, Falling Weight Deflectometer (FWD) testing and historical construction records.

## 2. Background

Pavements are designed to provide adequate structural performance to satisfy functional requirements of applied traffic loads. Evaluating the performance of pavements across a range of design treatments is necessary to determine effective rehabilitation of road pavements.

A large number of roads on the Sunshine Coast are approaching the end of their useful lives. Current available investment levels, existing pavement age and increased traffic growth mean that sustainable and effective pavement rehabilitation treatments are important.

## 3. Methodology

- Perform a comprehensive literature review of current pavement rehabilitation methods.
- Research geological history of the Sunshine Coast and collect available soil test information.

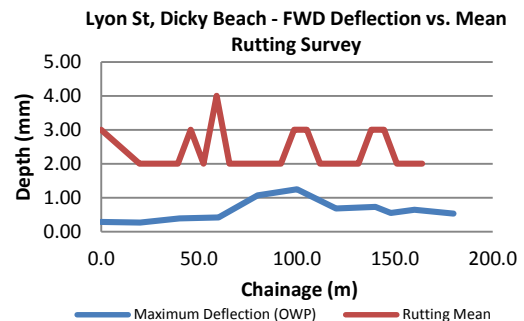


Figure 1 - Lyon St, Dicky Beach – Deflection vs. Rutting

- Analyse results from non-destructive laser survey condition data, FWD testing and historical construction records.
- Critically evaluate the effectiveness and performance of current practices; and propose improvements to rehabilitation design.

## 4. Key Outcomes

Often several options present a viable solution, so each project needs to be considered based on its relevant site conditions and factors. The correlation between severity of rutting and maximum deflection assists in determining structural deficiencies of pavement structures.

## 5. Further Work

Additional testing of the accuracy of non-destructive test methods is needed. Validating historical construction data within Council's Pavement Management System; and further geotechnical investigation are required to assist in understanding local conditions.

## 6. Conclusions

Evaluation of effective pavement rehabilitation practices needs to be ongoing to ensure best value for money in government authorities.

## Acknowledgements

I would like to thank my supervisor Prof. Ron Ayers for his understanding and support; Sunshine Coast Council for sponsorship; and my work colleagues for their contribution and help throughout the year.

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- TMR. (2012). *Pavement Rehabilitation Manual*. Brisbane: QLD Dept. Transport & Main Roads.

# Preliminary Movable Bridge Design for the Boyd River at Broadmeadows

Sponsor – School of Civil Engineering and Surveying, USQ



**Ben Savage**

Bachelor of Engineering  
(Civil)

Supervisors: Dr Kazem Ghabraie, USQ  
Dr Sourish Banerjee, USQ

**Keywords:** Movable Bridge, flood, damage, access.

## 1. Introduction

Bridges are frequently damaged or even washed away during floods resulting in costly repairs or replacement and the loss of access. Flood water carries debris that is pushed up against a bridge and imposes a significant drag force. The resulting rise in the water level upstream causes scour around abutments and bridge piers and creates significant stresses within the structure (see figure 1). Flood waters exert forces many times those under normal conditions (Parke et al 2008). This project explores movable bridge options for frequently flooded rivers. The aim is to mitigate both bridge damage as a result of major flooding, and access problems due to minor flooding.

## 2. Background

Conventional movable bridge types can be categorized into three main types: bascule, swing and vertical lift. Traditionally these bridges are designed to open and give way to water traffic; however the role of movable bridges giving way to floods has not been explored. The Boyd River at Broadmeadows floods frequently with heights that vary between 0.3-8 metres and widths of 40-165 metres. The river profile features a steep slope on one bank and a mild slope on the other that provides a significant challenge to bridge design.

## 3. Methodology

In this project, bridge design is undertaken in two main parts: conceptual and preliminary design stages. Conceptual design starts with the gathering of design data that helps in forming a list of requirements called the design goal checklist (DGC). Proposal sketches and comments are produced then checked against the DGC, often contributing to it. A final step considers



**Figure 1: Remains of the Buccarumbi Bridge 20km downstream from Broadmeadows.**

practicalities such as the cost of materials. This iteration continues until a large DGC has been created and the winning design best satisfies the requirements of the list. The preliminary design stage takes the winning design from the conceptual stage and puts it through a more in depth analysis. At this point considerations such as choice of material, choice of component type, e.g. box versus plate girders, and preliminary sizing of members are carried out.

## 4. Key Outcomes

The conceptual design stage produced a variety of proposals that included a mix of conventional and unconventional movable bridge types including a floating swing bridge.

## 5. Further Work

Detailed design on the final proposal needs to be carried out to highlight any inadequacies in the preliminary design. A check with AS 5100 - Bridge Design would also be required to ensure the design conforms to current Australian Standards.

## 6. Conclusions

Movable bridges have evolved over hundreds of years. Their purpose has changed from the protective role of a drawbridge on a medieval castle, to enabling both land and water traffic to continue along their passage during the industrial revolution. This project is attempting to change the purpose of movable bridges again to a structure that can protect itself from a flood.

## Acknowledgements

I would like to thank my supervisors Dr Kazem Ghabraie and Dr Sourish Banerjee for their insight, guidance and advice throughout the entire project.

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Parke, P and Hewson, N (ed.) 2008, *ICE Manual of Bridge Engineering*, 2<sup>nd</sup> edn, Telford, London.

# An Analysis of Electrical Distribution Network Switching and Commissioning Errors

Sponsor – Essential Energy



**Daniel Saw**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Andreas Helwig, USQ

**Keywords:** Electrical Network, Safety, Switching, Commissioning, Errors.

## 1. Introduction

Distribution Network Service Providers (DNSP's) own and maintain Electricity Distribution Networks within a given geographical area. Distribution networks are typically a grid of overhead and underground conductors, substations and various isolation and protection equipment. The network is switched on a daily basis to allow electricity workers to carry out a variety of tasks such as new connections, alterations, maintenance and emergency repair works.

## 2. Background

DNSP's have a legal obligation to ensure that the workplace is as safe as possible. Switching and Commissioning work is a high risk activity that requires specific control measures to be put in place. Essential Energy is a DNSP that operates in rural and regional NSW. Safety incidents and near misses reported into the Essential Energy safety database, between 2009 and 2013 that relate to switching and commissioning incidents will form the basis of this study.

## 3. Methodology

440 incidents relating to switching and commissioning errors were reported in Totalsafe between 2009 and 2013. Incidents with an assessed risk rating of low or very low were removed, leaving a total of 184 high risk switching and commissioning incidents. Information reported on these incidents was used to classify the incident as either an environmental, equipment,

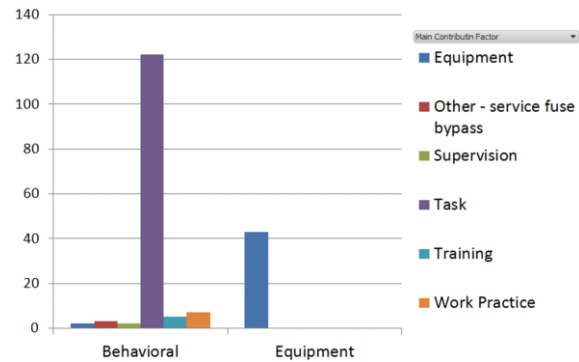


Figure 1 – Main Contributing Factor

behavioural or medical event.

## 4. Key Outcomes

It was found that most switching and commissioning incidents were a behavioural event in that the assigned task was not performed in accordance with established company procedures.

## 5. Further Work

A further breakdown of task errors into skill based, decision and perception errors is required. An analysis of existing risk mitigation measures and recommendations remains.

## 6. Conclusions

The electrical safety area that represents the greatest risk for staff undertaking switching and commissioning for a DNSP is errors caused by human behaviour. Risk mitigation strategies must adequately address this issue.

## Acknowledgements

I would like to acknowledge Tony Flick (Essential Energy) for providing the Totalsafe data spreadsheet for use in this dissertation and my supervisor Andreas Helwig (USQ) for providing immediate feedback when a review was requested.

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# Regulating Rescue Package Descent through Controlled Autorotation

Sponsor – School of Civil Engineering and Surveying



**Ian Saxby**

Bachelor of Computer Systems

Supervisors: Mark Phythian, USQ

**Keywords:** Autorotation, Rescue, Automation.

## 1. Introduction

Within the UAVOutBackChallenge competition, there is a requirement to deliver a rescue package from a Remotely Piloted Aircraft. The rescue package is to contain a commercial 500ml water bottle.

The focus of this project is to design, implement and test a device that, when released, utilises the helicopter autorotation technique for safe descent and landing.

## 2. Background

Previous research has focused on the autorotation technique identifying that it is capable of similar descent velocities as parachutes. Prototype examples within previous research have not included control of collective rotor blade adjustments for simplicity.

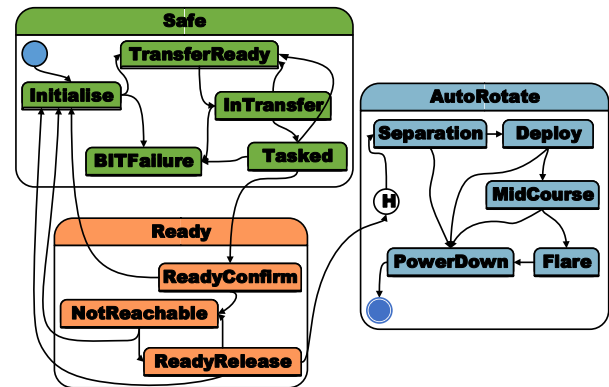
This project includes software controlled cyclic and collective rotor blade adjustments for controlled descent and flared landing.

## 3. Methodology

This project focuses on system design, implementation and testing of a prototype. Development activities included system, hardware and software design and implementation, underpinned by a system safety program. This project investigated helicopter autorotation dynamics and existing autorotation control algorithms. Modelling and experimental assessment is used to validate hardware and software control.

## 4. Key Outcomes

The key outcomes of this project are the design and implementation of the prototype. Hardware and software development of aircraft and package controllers, power and Built in Test management devices have been achieved. The Package controller includes a state based phasing of control. The Package



**Figure 1 – Package System State Transitions** system state machine, figure 1, identifies the primary modes of operation (Safe, Ready and Autorotation) pre and post release from the host aircraft.

A ground test environment has been fabricated and used to provide limited experimental data. Rotor blade retention and deployment has been verified under a small number of test conditions. Hazards identified within the system safety program have been eliminated or controlled within the resultant design.

## 5. Further Work

Aspects of software for communication and control pre and post release are being completed. Optimisation of flight path and flare control requires further development through additional flight modelling.

## 6. Conclusions

The developed prototype may support aerial delivery, though the cost, complexity, failure modes and associated safety implications need to be balanced against the simplicity of a parachute.

## Acknowledgements

Mark Phythian, my supervisor, for his continued patience and understanding. Don Luke, Bryan Walker and Keith Smith being instrumental in fabricating components of my prototype design. To my beautiful Susanne for her constant support and encouragement.

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# Numerical Modelling of Mining Subsidence

School of Civil Engineering and Surveying



**Kieran Seccombe**

Bachelor of Engineering  
(HONS) (Civil)

Supervisors: Dr Jim Shiau, USQ

**Keywords:** Subsidence, Modelling, FLAC

## 1. Introduction

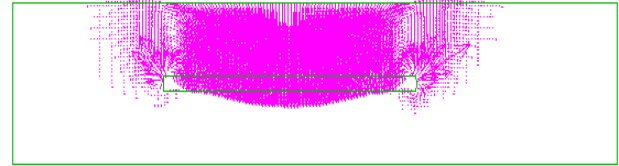
Mining subsidence is a process in which the natural soil level is displaced in both the horizontal and vertical direction due to the implementation of underground mining (*A simple Approach to Subsidence Prediction 2010*). This process has been associated primarily with longwall mining and is the focus of this dissertation.

## 2. Background

There is particular concern about the effect subsidence has on areas that are considered residential, infrastructural and environmentally sensitive. The effects of subsidence can cause serious damage to the surrounding landscape and change the dynamics of the environment permanently, with concerns of localised loss of underground water flow and also river catchments. The effects can cause major damage to infrastructure where primary structural members have shifted and even been removed by compressive and tensile force produced by the displacement of the natural level of the soil. There is a requirement to accurately model the surface subsidence in order to assess the viability of mining in a particular area.

## 3. Methodology

FLAC/slope is a graphical interface that has been primarily used for analysis in the fields of mining, rock mechanics, underground engineering and research. According to *Peng, Luo & Zhang (1997)*, the use of the explicit time step solution and the integration of motion equations into the program have made it ideal for the analysis of progressive failure and collapse



## 4. Key Outcomes

When dealing with modelling of real world situation there needs to be validating data to support the results obtained in the model. A key outcome of this project is to obtain relevant data from Kestrel Coal Mine to ensure the FLAC model is producing accurate results that make sense. Another key outcome is to incorporate geological strata into the model making it a non-homogenous model.

## 5. Further Work

Many literary articles have mentioned the impact of multiple longwall excavations have much more significant effects on the surrounding environment. The future task for this project would be to model the effect of subsidence due to the implementation of multiple longwalls. A change in analytical methodology for the modelling of subsidence can be undertaken. Instead of the current technique of strength relaxation, a stress relaxation method may be employed.

## 6. Conclusions

It is hoped that results are produced that correlate to with the validating data provided by Kestrel Coal Mine. It is also the purpose of this project to provide a simple approach and methodology to the modelling of underground subsidence. A seamless integration of the geological strata is key to the success of the FLAC model.

## Acknowledgements

I would like to thank Dr Jim Shiau for his support and help so far on this project. I would Also like to thank Kestrel for providing me with the opportunity to tour of the underground coal mine and answering all of my questions.

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# Hydraulic Modelling of the Water Distribution System of Tavua-Vatukoula, Fiji

Sponsored by the School of Civil Engineering and Surveying



**Kemueli (Kemu)  
Senokonoko**

**BENG  
(Environmental)**

Supervisor: Dr Laszlo Erdei, USQ

**Keywords:** water supply, distribution network, hydraulic modelling, EPANET

## Introduction

Like many other countries, Fiji is facing with the pressing need to ensure sufficient infrastructure development as required by an increasing population and economy. The efficient use of the limited water resources calls for long-term forward planning policies, sufficient capital investments, and the better utilisation and operation of the existing assets.

## Background

The Tavua-Vatukoula regional water supply system serves about 19,000 people in Tavua Town and nearby subdivisions, villages and settlements, together with agro-industry, commercial centres, Government centres and schools. The system has various operational problems due to aged pipes, frequent breakages due to landslides, and cannot cater for planned industrial development. To address these problems, a significant augmentation program is under way, to which this study will contributing by the assessment of the existing Water Supply Delivery Network (WSDN).

## Methodology

Foundation studies will be carried out in applied hydraulics and hydraulic software applications based on a broad literature review. Data and system information for the historical and current water supply networks of Tavua-Vatukoula will be collected, with on-site measurements if necessary. Modelling will mainly be carried out using the well-known EPANET (v2) software, also using other software for result analyses. Current and future operational conditions will be simulated and analysed for a report, as well as to provide input for a concurrent study by another student.

## Key Outcomes to Date

1. Studies in hydraulics, water supply network design, familiarisation with typical software applications were completed, together with a comprehensive review of relevant literature.
2. Sufficient system data were gathered for design purposes in cooperation with the Water Authority of Fiji, including a site visit and field work.
3. Hydraulic models for simple benchmarks systems were constructed in the EPANET 2 software package to demonstrate user proficiency.
4. An initial, complete EPANET model of the current system was constructed for hydraulic analyses.

## Further Work

The complete hydraulic model is too large (over 600 nodes) for effective analyses, and currently is being skeletonized to prevent information overload. The final raw model will be calibrated and analysed for typical operational scenarios. Finally, the effect of possible future operational conditions will be examined to determine the effective remediation and network extension.

## Conclusions

This study shall provide a significant and important contribution to a recently started water supply augmentation project. The established hydraulic models will enable both the capability assessment of the existing system, and its cost-effective upgrade and extension.

## Acknowledgements

I would like to thank my supervisor for his untiring support, and the Water Authority of Fiji for providing comprehensive data to make this study possible.

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# OPTIMISATION OF OUTSIDE AIR PRE-COOLING VIA UNDERGROUND CONDUCTIVE HEAT TRANSFER

Sponsor – Own Project



**Nathan Shepherd**

Bachelor of Engineering  
(Mechanical)

Supervisors: Dr Ruth Mossad, USQ

**Keywords:** Earth to Air Heat Exchange, Underground Pre-Cooling, Conductive Heat Transfer

## 1. Introduction

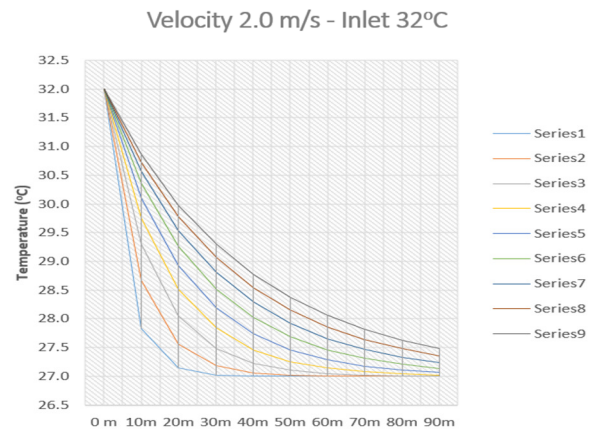
The purpose of this research project was to provide building services mechanical engineers who are designing an underground pre-cooling system in NQ, in particular Townsville, with recommended selection criteria dependent on the outside air design quantity identified as part of the design process.

## 2. Background

A challenge that engineers face is the requirement to deliver a product that is both energy efficient and will provide a cost benefit over the life of the structure. Soil temperatures below ground surface level can remain relatively constant for the entire duration of the year. At sufficient depth, the soil temperature is typically cooler than that of the ambient air temperature in summer. This means that this difference in temperature can be used as a means of precooling during this time. There are three methods associated with the use of the earth as a heat exchanger. This dissertation focuses particularly on the use of earth to air heat exchange systems.

## 3. Methodology

Site based measurements were undertaken, whereby soil temperatures at depths of 1 and 2 metres and ambient air on and air off temperatures were obtained. Through the use of these site based measurements and Ansys (Modelling Software) a comparison model and simple straight run model was developed to portray the effects that, pipe diameter, velocity of airflow, and length of run has on ambient outside air supply temperatures. This allowed theoretical results from ANSYS to be compared against existing results obtained from site and against previous literature and conclude with the recommended findings.



## 4. Key Outcomes

Upon review of the results, it could be seen that pipe diameter had the greatest effect on performance relative to pipe length. It could also be seen that as velocity of air flow increased, the performance of the system decreased. Through review of existing literature, pipe material was found to have minimal effect on performance and that capital expenditure would be the determining factor on material selection.

## 5. Future Work

Use Camel (Modelling Software) to analyse the effects that various lower ambient outside air supply temperatures have on plant/equipment capacity.

Compare the cost savings identified from the decrease in plant size and associated operating costs against the initial capital outlay of a proposed system.

## 6. Conclusions

The ideal system selection is highly dependent on the design airflow quantity, however it can be concluded that a number of smaller pipes performs greater than a single large pipe, and that increasing velocity should be considered before increasing pipe diameter.

## Acknowledgements

I would like to thank Dr Ruth Mossad, my supervisor for her ongoing guidance and valuable advice. I would also like to thank my wife Lauren for her constant support and encouragement throughout the duration of this project, and also for her patience over the past 8 years of part time study.

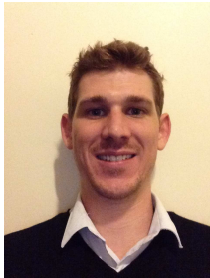
## Reference

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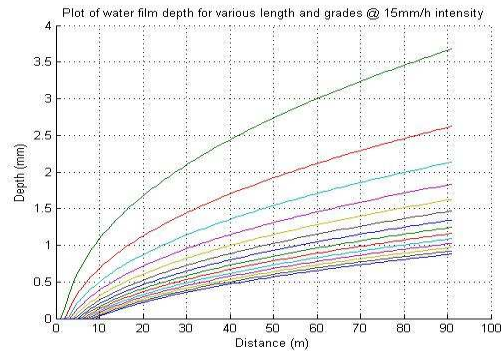
# AQUAPLANING: AN INVESTIGATION OF SURFACE FLOW CALCULATION AND ROAD SAFETY IMPLICATIONS

Sponsor – School of Civil Engineering and Surveying



**Liam Sheridan**

Bachelor Engineering Bachelor Business



Supervisors: Dr Malcolm Gillies, USQ

**Keywords:** Aquaplaning water depth

## 1. Introduction

This research project will numerically analyse current methods used for calculating surface flow depth and the accuracy of different models. It will investigate the implications of aquaplaning on various road design principles.

## 2. Background

Essentially aquaplaning can be described as the separation of a tyre from the road surface due to a build-up of water underneath the tyre. This separation is often the cause of drivers losing total control as braking and steering can no longer manoeuvre the vehicle. This often results in a crash unless there is a sufficient increase in the contact between road and vehicle to enable the driver to regain control of the car.

The water film depth for aquaplaning can be calculated by a number of empirical equations which link longitudinal slope, length of flow path, rainfall intensity and texture depth. This research analyses existing methods to calculate water film depth to discover if they are applicable today.

## 3. Methodology

Compare values of flow depth calculated using a variety of formulae, ranging from basic empirical relationships to sophisticated hydraulic models.

Determine how standard vales of texture depth and rainfall intensity were established and investigate if these are relevant today.

**Figure 1 – Water film depth**

Determine if the time of concentration should be factor into models by calculating the time required for the flow path to be fully drained after a storm event.

## 4. Key Outcomes

The modelling shows that the rainfall intensity has a large impact on the depth of flow. However research shows drivers slow down during heavy storm events therefore a threshold for design must be chosen as the upper limit after which a driver will slow. Empirical model will be conservative in their approach and overestimate the flow depth

## 5. Further Work

This research could be expanded to analyse existing crash data at known aquaplaning blackspots in wet conditions. It could also investigate new technologies for measuring and calculating film depth as well as vehicle improvements to reduce the likelihood of aquaplaning.

## Acknowledgements

I would like to thank my supervisor Dr Malcolm Gillies for taking on the project and providing guidance. Also special thanks to Roads and Maritime Services and my expert colleagues in the Road Design section who gave me comprehensive knowledge and experience.

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# Flexural Behaviour of Geopolymer Concrete Beams Reinforced with Fibre Composite Rebars

School of Civil Engineering and Surveying

## Ashley James Simpson

Bachelor of Engineering (Civil)



Supervisors: Dr Allan Manalo, USQ

**Keywords:** Sustainability, Reinforcement, Geopolymer.

### 1. Introduction

For over a century, a majority of major civil construction projects have utilised traditional Portland cement as the primary structural construction material, supplemented with steel reinforcement for strength and ductility. However, the use of internal steel reinforcement is problematic due to the long-term degradation of structural integrity caused by rusting; leading to high maintenance costs and in some cases dangerous consequences. The production of Portland cement also produces high levels of carbon dioxide, and waste material. Several new materials have recently been gaining some recognition within the industry, including Geopolymer concrete (GPC), and Glass Fibre Reinforced Polymer Rebars (GFRP). The production of Geopolymer concrete not only produces almost no harmful emissions, but also utilises waste products from the production of Portland cement and other industries. A structure utilising GPC reinforced with GFRP, an inorganic, non-corrosive, high strength material, may present a viable alternative for wide use within the construction industry, producing buildings with a much longer service life, and greatly reduced maintenance costs.

### 2. Background

Although much information already exists on the performance of Geopolymer concrete with steel reinforcement, as well as GFRP within regular concrete, no research exists on the behaviour of a hybrid structure utilising both GPC and GFRP. In

particular, how such a structure would perform in flexure. Knowing a structures behaviour can help to validate its use within the industry.

### 3. Methodology

Multiple specimens with different internal reinforcement configurations were constructed and loaded in flexure. These specimens were compared against a control specimen utilising steel reinforcement on the compressive side. Sensors and strain gauges measured the deflection, and strain both internally and externally on each specimen and data was collected via a software interface. Along with the experimental a theoretical analysis was undertaken to predict the behaviour of the structure using existing standard formulas and methods. This would allow the comparison of theoretical and experimental data to ascertain whether or not the structure would perform like existing structures.

### 4. Key Outcomes

The hope is that this research will reveal the structural performance of a GPC-GFRP structure, allowing further validation of these materials within the industry, and promoting future research into more resilient materials.

### 5. Further Work

So far, research suggests that there may be a potential for further research into optimal structural configurations, and perhaps GPC mixture designs. Flexural behaviour is within acceptable boundaries for use within the industry, suggesting structural performance is adequate.

### 6. Conclusions

Geopolymer concrete and Glass fibre reinforced polymer rebars are showing promising potential for use in the construction industry and it is believed that an almost completely maintenance free structure could be created using a combination of them.

### Acknowledgements

First and foremost I would like to thank my supervisor Dr. Allan Manalo of USQ, for helping to direct my focus and for all of his help and advice while performing the experimentals, and to fellow student, and research assistant Ginghis, whom assisted me in the experimentals

# Cost-benefit of Various Pavement Reconstruction Profiles for the Townsville Region

Sponsor – Townsville City Council



**John Henry Single**

Bachelor of Engineering (Civil)

Supervisors: Prof. Ron Ayers, USQ

**Keywords:** cost-benefit, reconstruction, pavement

## 1. Introduction

Councils all over Australia face the same issue; cost effectively reconstructing or rehabilitating trunk roads under traffic. Over the past ten (10) years, the Townsville City Council has undertaken numerous pavement reconstruction or rehabilitation projects of varying profiles. The identification of a cost effective and successful reconstruction or rehabilitation profile would, from a planning perspective, assist a Council in preparing their works programs and securing the appropriate funding required. This project has sought to determine the most cost effective and successful reconstruction or rehabilitation of four (4) varying profiles constructed within Townsville.

## 2. Background

Townsville has expanded rapidly in the last few decades which has generated a substantial increase in traffic loads on an aging road network. Consequently, reconstruction or rehabilitation works are required to be completed under traffic (refer to Figure 1), adding to the complexity and costs. Identification of a cost effective profile will, at the least, assist Council in preparing their works programs and securing the appropriate funding required.

## 3. Methodology

This project incorporates qualitative and quantitative methodologies centred on collation and assessment of as constructed data, traffic data, construction details, costs and performance. The key aspect to undertaking this project involved in-service testing in order to effectively analyse the current performance of the rehabilitated or reconstructed pavements. Falling Weight Deflectometer (FWD) testing was undertaken at the four (4) locations where back-analysis of the results provided insight into the pavement materials' in-service moduli. This information was input into the software program CIRCLY to determine the in-service life of the rehabilitated or reconstructed pavement and to estimate the remaining life. A comparison of costs (inclusive of time) versus pavement performance will provide insight into the most cost effective reconstruction or rehabilitation profile for use in Townsville.



**Figure 1 – Reconstruction occurring under traffic**

## 4. Key Outcomes

At the time of writing, the data collation component of the project has been completed with preparation of this data for assessment being undertaken. It has been challenging in obtaining the required information, particularly as constructed details are not available, it has been assumed that works have been completed as designed and in accordance with construction tolerances.

## 5. Further Work

FWD testing has only recently been completed; consequently analysis of the pavement performance is still to be completed at the time of writing. Following performance assessment, a cost-benefit analysis is to be undertaken. These works are anticipated to be completed in time for the conference.

## 6. Conclusions

As previously mentioned, the main cost-benefit analysis is yet to be completed and consequently the key outcome is pending.

## Acknowledgements

Thanks must be given to the Townsville City Council for their assistance in funding the FWD testing and providing access to their databases in order to collate the necessary information. Special thanks must also go to Northern Pavement Consultants for their assistance in developing and undertaking the FWD testing regime and my supervisor Prof. Ron Ayers for his advice and guidance. Lastly, thanks must go to Northern Consulting Engineers for their understanding during this time.

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# Underwater Acoustic Positioning System Akin to GPS

Sponsor – School of Mechanical and Electrical Engineering



**Wayne Smith**

Master Engineering Science (Mechanical)

Supervisors: Professor John Billingsley and  
Dr Tobias Low.

**Keywords:** Location system, Electronic, Underwater  
Acoustics, Signal Processing.

## 1. Introduction

This project will investigate an underwater acoustic positioning system akin to GPS. The concept is to have an array of buoys floating on the ocean's surface, each generating an acoustic signal. An underwater device is to receive acoustic signals from buoys, which have known location, and then process the received signals, enabling the underwater device to determine its location with respect to the buoys. This project is researching background aspects required for an implementation design of the above concept.

## 2. Background

Underwater Users such as humans or robotic submersibles will use the acoustic location system to navigate between locations, and then once they arrive at their destination they use other senses to perceive their environment.

Projects potential applications include Virtual tourism, underwater avatars, and remote cameras on the barrier reef, Embedded Software agents, and real world portals for online worlds. Industrial applications include Automated prospecting; mining; construction; and maintenance; Abalone fishing robot; asset management; Swarm robotics; Island tourism; Archeology and underwater rescue.

## 3. Methodology

As part of my methodology, a literature review is performed to obtain knowledge useful for the projects task and objectives. Various mini-studies are performed, with the task of investigating various aspects and problem areas identified in the literature. This involved the construction of hardware and various experiments. Experiments were performed to test various hardware configurations Experiments were conducted to test trial signal processing algorithms.

## 4. Key Outcomes

The key outcome of this work is solid foundation of information upon which a prototype system may be constructed.

## 5. Further Work

More experiments.

## 6. Conclusions

This work identified key elements required for the proposed underwater location system including hardware and signal processing elements.

## Acknowledgements

Appreciation is due to my supervisors Professor John Billingsley and Dr Tobias Low for their helpful guidance.

# The impact of Compact Urban Form on the provision of Public Road Transport

School of Civil Engineering and Surveying



**Martin Stager**

Bachelor of Engineering (Civil)

Supervisors: Ms. Marita Basson, USQ

Mrs Paula Grant, USQ

Dr Nateque Mahmood, USQ

**Keywords:** Compact Urban Form, Road Public Transport, Transport Modelling

## 1. Introduction

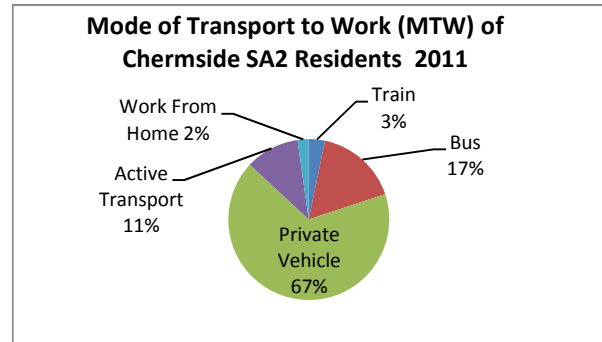
Compact Urban Form (CUF) refers to a compact, mixed use urban environment with moderate to high population densities. The design of CUF focuses on reducing the reliance on automobiles through providing and promoting alternative modes of transport such as active and public transport. In recent decades this approach has been promoted by cities around the world as one method of achieving a more 'sustainable' urban form.

## 2. Background

Recent estimations show that the demand for Urban Public Transport (UPT) in Brisbane will grow by thirty-three percent over the next twenty years. All UPT within Queensland is heavily subsidised by the State Government. Most studies and city planning projects highlight the need to increase the patronage of Road Public Transport (RPT) as a means of reducing street congestion. This project will determine whether CUF enables a more effective provision of RPT or the reverse on an individual statistical level

## 3. Methodology

A review of the literature was undertaken to provide an understanding of how different urban forms affect RPT patronage, employment and residential densities. Planning trends from other countries were researched to gain examples of applicable density ratios. Chermide, Brisbane was selected as the case study area due to its location in relation to the Central



**Figure 1 – Chermide Mode of Transport to Work (ABS 2011)**

Business District and Brisbane City Council's Long Term Infrastructure Plan indicating that the suburb will become a principal community hub and major transport node. Current and projected employment and residential density figures for the case study area were collected and will be used to model the effects on all modes of transport. Please see Figure 1 for an example of the collected data from the Australia Bureau of Statistics (ABS). Translink's current planning model, BSTM\_MM, will be utilised for this project.

## 4. Key Outcomes

This project aims to deliver recommendations on the levels of employment and residential densities within a statistical area that would provide a maximum road public transport usage.

## 5. Further Work

As most of the data collected is predominately focussed on journey to work, this research would benefit from future surveys that would include other trip generators of travel such as school, university, shopping and recreation.

## 6. Conclusions

It is hoped that this study can be adapted into a means of assessing other city areas on a statistical area level.

## Acknowledgements

I would like to thank my three supervisors Ms Marita Basson, Mrs Paula Grant and Dr Nateque Mahmood.

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# Investigation of the effect of positive and negative crossfalls on road safety at roundabouts

Sponsor – School of Civil Engineering and Surveying



**Vernon Stanton**

Bachelor of Engineering (Civil)

Supervisor: Dr Soma Somasundaraswaran,  
USQ

**Keywords:** Roundabouts, Road Safety, Accidents  
Crossfall

## 1. Introduction

Roundabouts are a common form of road intersection and are used to allow self-regulating flows of traffic. As part of a roundabout there are generally three critical geometric considerations, namely, approach geometry, the circular carriageway and the departure geometry. In many instances this geometry is compromised and designed to slow traffic. Consequently, the crossfall of a roundabout becomes an important design consideration. The crossfall must be design to allow a smooth transition and adequate drainage performance of the circular carriageway. There are two common approaches to roundabout crossfall in Australia, positive and negative crossfalls. This report will aim to investigate and analyse the road safety performance of existing roundabouts with these different crossfalls to evaluate the safety benefits each arrangement may offer.

## 2. Background

Current research into road safety impacts at roundabouts revolves upon the selection of entry path geometry with the aim of slowing of approach traffic. A successful roundabout lowers the speed differential between conflicting traffic streams. The application of crossfall is not explicitly considered in any research to date. *Austrroads: Guide to Road Design*, Australia's most widely adopted road design guide does not present explicit statement for positive or negative crossfall. The correct application of crossfall could improve road safety at roundabouts by lowering the rate of occurrence for specific types of accidents.

## 3. Methodology

There are two types of data required to establish the relationship between roundabout crossfall and accident rates. Accident data would be collected using New South Wales and Queensland accident databases. The accident data would be limited to reported incidents within the systems that have occurred at roundabouts. The collection of roundabout design information would involve collection of data using a combination of design plans, survey information, Road Browser software, aerial imagery and on site measurement.

## 4. Key Outcomes

The research project to date has reviewed literature and proposed a methodology to analyse accident with respect to crossfall and roundabout geometry. The review has proved that crossfall is not extensively considered in current roundabout design theory. Collection of accident data has been completed. Analysis of the data to indicate causes and a breakdown of accident type remains.

## 5. Further Work

Analysis of the collected accident and roundabout design data is required to discuss the relationship between crossfall and accident rates at roundabouts.

## 6. Conclusions

The research project is expected to highlight a link between specific accident types at roundabouts depending on the use of crossfall at a roundabout.

## Acknowledgements

I would like to thank Patrick Kenny, former RTA Principal Road Design Engineer for assisting to develop the idea for research into this topic. I would also like to thank Soma Somasundaraswaran for his supervision of my research to date, Owen Arndt and David Gough of Queensland's Department of Transport and Main Roads for providing information to support my research.

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# Machine Vision Detection of Crop Diseases

School of Mechanical and Electrical Engineering



**Nathan Stern**  
Bachelor of Engineering  
(Mechatronics)

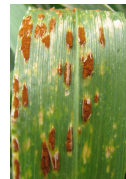


Figure 1: Leaf rust.

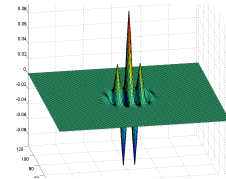


Figure 2: Gabor filter

**Supervisor:** Dr Cheryl McCarthy, USQ

**Keywords:** K-means Clustering, Gabor Filters, Artificial Neural Networks.

## 1 Introduction

Each year diseases in crops such as wheat cause severe yield losses and a reduction of harvest quality.

Diagnosis of diseases in crops is a time-consuming process that involves an initial estimate of the problem by growers and their consultants, followed by further laboratory analysis by qualified agronomists. This reliance on on-site experts can result in an accurate diagnosis taking up to several weeks. As such, there is a need to provide growers with accurate computerised, automated disease recognition capabilities.

## 2 Background

To date, research into detection of plant diseases around the world has focussed on an array of machine vision technologies, including colour space extraction (Davies 2012), filtering techniques (Daugman 1985), and classification using Neural Networks.

This project sought to compare and where possible, expand on these methods and establish a protocol, which can be applied to a general imaging solution on available devices, such as smart-phones and other imaging devices.

## 3 Methodology

Initial research into the topic resulted in the need for a multi-faceted approach: an initial investigation into imaging technologies, followed by a multi-stage segmentation and extraction process to isolate the infected regions (see figure 1) of the image using colour vision methods, which are similar to human vision processes. Classification of these regions involved filtering with algorithms, which closely match the function of the human eye, followed by applying “artificial intelligence” machine-learning techniques for the final-stage disease recognition.

## 4 Key Outcomes

Using a multi-stage approach allowed the project specification tasks to be analysed individually. Research into sub-segmentation of the diseased segments using different colour spaces and K-means clustering has yielded positive results. Using 4-dimensional complex filtering such as Gabor (figure 2) and Log-Gabor filters to isolate salient features has identified a strong correlation between samples of the same disease.

## 5 Further Work

Initial stages at extracting one leaf from a photograph with many leaves in it has proven to be more difficult than extracting disease spots from a single leaf. Work with fine tuning the classification stages is ongoing. Whilst steps to load the software onto a smart-phone have been investigated, the validation stages to date have focussed on getting the software to run efficiently on a PC, so that porting the software entirely to a smart-phone remains a topic for future work.

## 6 Conclusions

The key conclusion is that it is possible to apply biological methodologies to machine vision applications. By applying a set approach to a number of different disease samples, it was possible to use machine learning to “teach” the software to recognise the different diseases, and to identify which known disease a new image most closely matches.

## Acknowledgements

I would like to thank my family, for their tolerance and support during the long duration of my project. I would also like to thank Dr Cheryl McCarthy and the other staff at the NCEA for the initial introduction to machine vision in agriculture.

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# Investigation of Wonga Wetlands Lagoon Capacity

AlburyCity



**Tegan Streller**

Bachelor of Engineering Honours  
(Civil)

Supervisors: Dr Vasanthadevi Aravinthan,  
USQ

Mr Allan Hruz, AlburyCity

**Keywords:** Constructed wetland, reclaimed water,  
water balance.

## 1. Introduction

Wonga Wetlands is located in the Murray River Valley immediately downstream from the city of Albury. The wetlands were commissioned in 1999 as part of AlburyCity Wastewater Treatment Plant and Reclamation and Reuse project at Nursery Valley and commenced operations in 2000. AlburyCity manages the wetlands as a way of indirectly discharging to the Murray River and to additionally treat the reclaimed water by further pathogen removal.

In recent years Wonga Wetlands has been experiencing decrease in the volume held within its lagoons. As part of AlburyCity's EPA licence AlburyCity are unable to directly discharge to the Murray River. Due to decrease in volume, to comply with the EPA licence AlburyCity has been required to redirect usually discharged reclaimed water to the lagoons to other avenues to not breach their EPA licence.

## 2. Background

Due to the volume decrease in the lagoons AlburyCity must determine the cause and establish a corrective action plan. This will ensure the wetlands are capable of storing and treating the reclaimed water from AlburyCity's waste water treatment plant.

If the decrease in volume continues AlburyCity will be unable to store the reclaimed water in the lagoons and will be required to find alternative solutions.

## 3. Methodology

Research will be undertaken of published scientific papers to establish the functions of constructed wetlands. From the information gathered further case

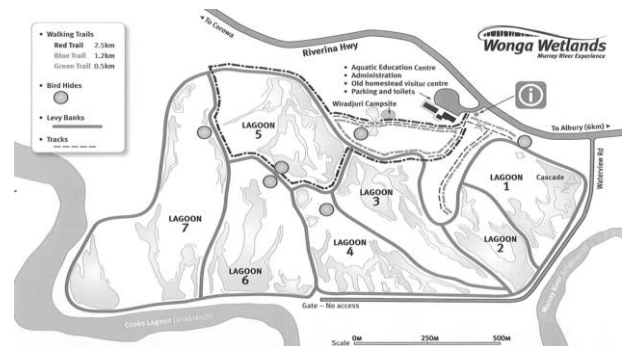


Figure 1- Wonga Wetlands Lagoons

studies will be conducted on constructed wetlands to establish if any other wetlands may have experienced capacity failure. Research will be undertaken into the quality and quantity of water discharged in comparison to previous years, in conjunction with monitoring river levels and ground water levels. A water balance will be undertaken to establish the current capacity and comparison to original capacity.

## 4. Key Outcomes

The key outcome will be to determine the current volume of the lagoons and the reason why the lagoons are unable to hold the volume of reclaimed water. Once achieved, AlburyCity will be able to determine a corrective action plan to allow for the sustainability of Wonga Wetlands.

## 5. Further Work

To develop a corrective action plan for Wonga Wetlands, ensuring the wetlands are a sustainable source for AlburyCity's reclaimed water.

## 6. Conclusions

Conclusions are expected to establish a reason for the wetlands decrease in volume and the lagoons current capacity.

## Acknowledgements

I would like to thank AlburyCity for providing the project and the means for accomplishment. Also thanks to my supervisor Dr Vasanthadevi Aravinthan for her ongoing guidance and support.

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# COMPARITIVE ANALYSIS OF THE USE OF FIBRE COMPOSITE MATERIALS WITHIN BUILDING, MARINE AND AUTOMOTIVE SECTORS

Sponsor – School of Mechanical and Electrical Engineering

## S.HarshaVardhan

Master of Engineering Science-Mechanical Engineering



Supervisors: David Thorpe

Co-Supervisor: Steven Goh

**Keywords:** Fibre reinforced polymer composites,  
Construction, Marine, Automotive

## 1. Introduction

Engineering fibre composites can replace a number of structural engineering and building materials (such as timber), because of their high strength to weight ratio, lightweight and ease of installation. Such materials have an impact on areas like sustainability, resilience and energy management.

Therefore a project has been proposed to identify and analyse the adoption of engineered fibre composite materials, or other advanced engineering materials, by various engineering sectors and manufactures. Research will be undertaken into how well these materials are involved and adopted by the engineering sectors.

## 2. Background

This project aims to understand the reasons for the adoption of fibre composites by the various engineering sectors. Also investigates is the process in which the various Construction, Automotive and Marine sectors adopt Fibre composite materials. With the help of this project I will extend my knowledge on the use and adoption of Fibre composite materials in various engineering sectors. My background being the same major is really helpful to develop my insights on these materials.

## 3. Methodology

The Methodology I am undertaking is a comparative analysis of the different sectors based on a comprehensive literature review. It's a qualitative research method that includes the data collected and the analysis as well. The literature review that will be done is on the information related to the adoption of the Fibre composite materials.



Fig 1- Fibre Composite Material

## 4. Key Outcomes

An evaluation of the factors influencing the use of Fibre composite materials in different sectors will be done. Assessing the impediments will be done to using these materials would affect to those advanced materials currently being produced. The topic being rationale gives more interest to work on.

## 5. Further Work

The findings from this research will help to identify the influencing factors governing decision making processes involving the adoption and use of Fibre composite materials within Construction, Marine and Automotive sectors. The future work may include validating the findings in this research by a sector-by-sector investigation.

## 6. Conclusions

The findings and the hypothesis suggest the future work to validate accordingly. I'm still working on the project; I haven't reached the conclusion yet. I will also make suitable recommendations to improve the adoption of the Fibre composite materials by these sectors. This research and the hypothesis in the future would help the readers by giving a clear justification on the sectors that adopt fibre composite materials and why some of them do not.

## Acknowledgements

I would like to thank Dr David Thorpe and also Dr Steven Goh for helping me with their immense knowledge and support throughout. This project is a desktop search work and is sponsored by The University of Southern Queensland.

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# Improving Electricity Network Utilisation Using Distributed Energy Storage Systems

Tony Sunzu



Bachelor of Engineering (Electrical and Electronic)

Supervisors: Dr Les Bowtell, USQ

**Keywords:** Distributed Energy Storage Systems

## 1. Introduction

Electricity network capacity utilisation is one of the biggest problems faced by power companies in Australia and around the world. The fact that electrical energy generation and consumption happen in real time means that supply and demand must be balanced in real time.

When electricity consumption is at its highest a peak demand is created. A network peak demand only occurs a few times a year, usually when experiencing extreme temperatures. To be able to supply the peak demand, millions are spent on infrastructure expansion. This results in overinvestment in infrastructure that only operates a few times a year. Ultimately energy consumers pay for the underutilised infrastructure through increased electricity price.

## 2. Background

Distributed energy storage systems can be used to store energy during off peak period for use during peak period. By reducing energy demand during peak period, the required generation and transmission capacity to meet peak demand can be reduced, unnecessary infrastructure expansion can be avoided and the existing network capacity can be improved.

## 3. Methodology

An energy audit was conducted to determine the average daily power consumption for a typical household during summer and winter. The obtained data was used to approximate the energy required to run a household over the course of peak period. Based on the energy requirement an energy storage system was designed.

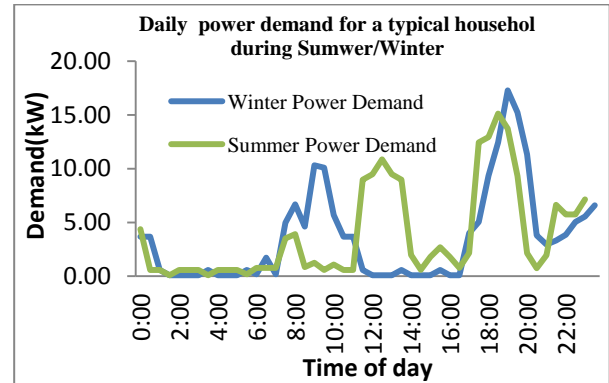


Figure1: Daily power demand for a typical household

## 4. Key Outcomes

The factors affecting the network capacity utilisation was determined. The main factor was found to be the peak demand. A storage system to meet the energy requirement was designed, the NSW network capacity to charge storage systems without creating a peak in the off peak period was determined and a cost analysis was conducted to determine the payback period.

## 5. Further Work

Further work would be to look at other effects of distributed energy storage systems on the power grid.

## 6. Conclusions

With the power grid as the sole source of energy to charge storage systems, the winter peak demand could be reduced by up to 85 percent and the summer peak demand could be totally avoided. By integrating a PV system as a backup energy source to charge the battery banks, the peak demand could be easily controlled.

## Acknowledgements

I would like to thank my supervisor Dr Les Bowtell for his continuous guidance and support throughout this research project. I would also like to thank Mr Andreas Helwig for his valuable and constructive suggestions throughout this research project. Finally, I wish to thank my girlfriend, family and friends for their support and encouragement throughout my study.

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[online] Available at:  
<http://energyaction.com.au/peak-demand-what-is-it> [Accessed 10 Apr. 2014].

# Flexural Behaviour of Sandwich Panels under Elevated Temperature

Sponsor: School of Civil Engineering and Surveying



**Swetha Surendar**  
Master of Engineering  
Sciences (Structural)

Supervisor: **Dr. Allan Manalo, USQ**

**Keywords:** Flexural behaviour, Sandwich Panels, Elevated Temperature.

## 1. Introduction

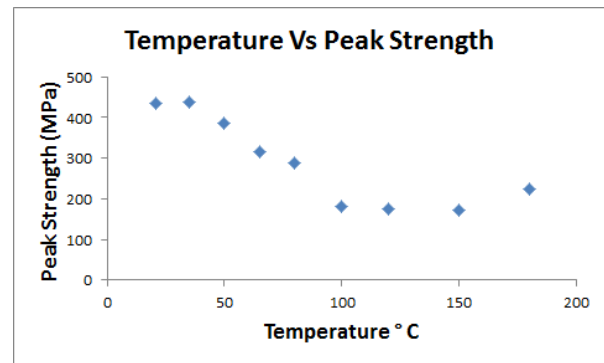
The composite sandwich panels are formed by attaching two skins separated by a core material. This arrangement gives the composite a high bending stiffness but a reduction in the overall density of the composite. The top and the bottom skins carry the in-plane and the bending stresses (compression at the top and tension at the bottom), while the cores carry the shear loads and the normal loads. Due to their many advantages these panels have found their applications in the field of aerospace, marine, and automobile industries. The fibre reinforced sandwich panels are being investigated for their applications in the field of civil/structural engineering.

## 2. Background

A novel sandwich panel made up of glass fibre composite skin and a modified phenolic core is specifically designed and manufactured for the purpose of civil and structural applications. Past studies on sandwich panels indicate core shear and top skin compression as the key failure modes under ambient testing environments. However, during the service life of a structure, it is likely to be subjected to various operating environment conditions and the effect of the elevated temperature is one among them. From the literature review, it is observed that there exists a gap in the research to explain the behaviour of the glass fibre reinforced sandwich panels under elevated temperature. Hence, the proposed study will investigate the behaviour of fibre reinforced sandwich panels under ambient and elevated temperature.

## 3. Methodology

The skin and the panels were tested for their flexure using the Three Point Bending Test under nine different temperatures from 21°C to 180°C. The effects of temperature were applied using an environment chamber. A DMA (Dynamical Mechanical Analysis) of the skin and core was performed to analyse their material properties at elevated temperatures. The results from the flexural test



**Figure 1 – Temperature Vs Peak Strength of Skin**

and DMA will be used as inputs for the finite element analysis (FEA) of the panels. The results from the experiments and the numerical simulation will be used to develop an empirical relation describing the behaviour of the panels.

## 4. Key Outcomes

The results from the flexural test of the skin and the sandwich panels reveal an increase in the peak strength of the specimens at 180°C. The increase in strength is significant in case of the skin as shown in the figure 1. While there is a steady decrease in the Young's Modulus of the sandwich panels, a steep increase in the young's modulus is observed at 180°C for the skin.

## 5. Further Work

FEA simulation on the behaviour of the panels will be performed. An empirical relation is to be developed using the results obtained from the experimental and numerical studies.

## 6. Conclusions

The increase in the peak strength of the specimens may be attributed to the phenomenon of the resin turning brittle. However in case of the sandwich panels the phenomenon of core softening restricts the increase in the peak strength at higher temperatures though the resin turns brittle.

## Acknowledgements

I would like to thank the support provided by LOC Composites and the Centre for Excellence in Engineered Fibre Composites (CEEFC), USQ in all aspects of this project.

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# Topological optimisation of large reinforced concrete box culverts under SM1600 load

School of Civil Engineering and Surveying



**Juliana Sweeney**

Bachelor of Engineering (Civil)

Supervisor: Dr Sourish Banerjee, USQ

**Keywords:** optimization, box culverts, topology

## 1. Introduction

This research project is concerned with finding the optimum large box culvert through topology optimisation using finite element analysis. The objective function will be to minimise the total strain energy while the design constraints include minimising volume as a fraction of the initial volume and geometric restrictions to ensure symmetry and appropriate cover to reinforcement.

## 2. Background

While there are studies in the literature about optimising four-sided culverts that comply with overseas standards, this study aims to research the characteristics of the optimum three-sided box culvert in a way that is practical and useful to the Australian industry. This means the optimised culvert must comply with the latest Australian specifications, must be subjected to standard SM1600 loads for main roads and must be feasible and constructible.

## 3. Methodology

All the 24 standard large box culvert sizes specified by AS1597.2 were investigated. A MATLAB script was written to generate all possible load combinations of SM1600 loads for culverts installed in embankment conditions with fill depths ranging from 0m to 2m. To aid the reinforcement design of the box culverts, a Strand7 model of each culvert was built and a MATLAB script was written to automate the design. A model of each culvert was created in ABAQUS (see figure 1), with the aid of a script written in Python programming language. The ABAQUS Topology Optimisation Module (ATOM) was then used to find the optimised culvert based on analysis of the Von Mises stress. A feasibility analysis was carried out to identify advantages and disadvantages of the optimised culvert in relation to cost, constructability and other parameters.

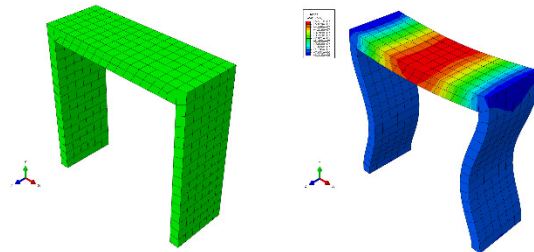


Figure 1 – Mises stress on the deformed box culvert

## 4. Key Outcomes

The use of MATLAB and Python programs coupled with Strand7 and ABAQUS software allow us to see a picture of how the box culvert behaves under load and what methods can be utilised to optimise its design.

## 5. Further Work

To validate the results obtained, an optimised box culvert could be constructed as per designed in this study and load tested. That would allow the confirmation of the conclusions reached, especially regarding constructability.

## 6. Conclusions

The results indicate there are benefits to applying finite element analysis to optimise the topology of the box culvert. Moulds can be made taking into consideration the best topology. Culverts utilise materials more efficiently, becoming more environmentally responsible and yielding a more economic product.

## Acknowledgements

The author would like to acknowledge Dr. Sourish Banerjee for his help and level of commitment to supervising this project.

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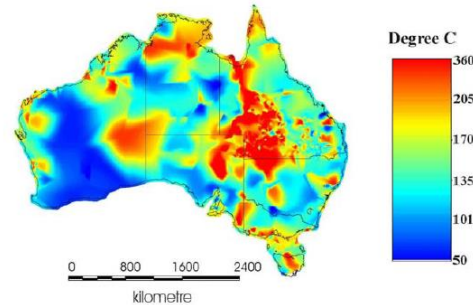
# Supercritical CO<sub>2</sub> Geothermal Energy System Analysis

Sponsor – School of Mechanical and Electrical Engineering

## Patrick Taylor



Bachelor of Engineering  
(Mechanical)



Supervisor: Dr Ruth Mossad, USQ

**Keywords:** Geothermal, Supercritical, Carbon Dioxide

## 1. Introduction

Geothermal energy is one of many potential non-carbon based alternative energy sources. It is an attractive option due to the scale of energy that can be harnessed and the fact that it does not suffer the intermittency of some other alternative energy sources.

## 2. Background

Historically, the key challenges to geothermal energy viability have been availability of a quality heat source close to point of the energy consumer, water consumption due to geothermal fluid leakage and also the financial risk due to the heavy investment associated with exploration and drilling.

The basis of this project is to investigate a potential system that addresses the first two of those challenges; through utilisation of heat from deep granite and replacement of water with a different geothermal fluid such as Supercritical Carbon Dioxide (SCCO<sub>2</sub>).

Brown (2000) proposed a novel renewable energy concept in his paper “*A Hot Dry Rock Geothermal Energy Concept Using Supercritical CO<sub>2</sub> Instead of Water*”. His paper is the foundation stone for this project and much recent work by others to investigate the feasibility of using SCCO<sub>2</sub> as a geothermal heat mining fluid.

## 3. Methodology

Over the course of the project, the feasibility of using SCCO<sub>2</sub> as a geothermal heat mining fluid is investigated. A scaled Computational Fluid Dynamics (CFD) model of the wellbore and geothermal reservoir is performed to validate and compare SCCO<sub>2</sub> with water as a geothermal working fluid. Parameters that affect the system’s performance (such as well bore diameter, reservoir depth and permeability) are investigated and the results compared with equivalent water based systems.

**Figure 1 – Temperature plot of the earth’s crust at a depth of 5km (Australia)**

## 4. Key Outcomes

The key outcomes of this project will be to validate previous recent work on the SCCO<sub>2</sub> Hot dry rock concept but with the development of a scaled CFD model to better predict ideal operating parameters for the SCCO<sub>2</sub> system.

## 5. Further Work

At the time of writing, a schematic of the system is being assembled leading to a mathematical model which will be utilised for the comparison between water and SCCO<sub>2</sub> as a geothermal fluid.

## 6. Conclusions

The project is not yet at stage to reach confident conclusions. It is predicted that SCCO<sub>2</sub> will be found to have good potential as a geothermal system working fluid.

## Acknowledgements

I would like to sincerely thank Ruth Mossad for her guidance in this project. Inspiration for the topic choice was through personal reading of some of the preceding studies on this topic including Brown (2000), (Pruess & Azaroual, 2006) and several others.

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- Pruess, K., & Azaroual, M. (2006). *On the Feasibility of Using Supercritical CO<sub>2</sub> as Heat Transmission Fluid in an Engineered Hot Dry Rock Geothermal System*. Paper presented at the Thirty-First Workshop on Geothermal Reservoir Engineering, Stanford University, Stanford, California.

# The potential of an Ancillary Hybrid Photo Voltaic/Pumped Hydro Power system to alleviate the problems associated with the installed intermittent generation in Queensland.



## Aden Tomasel

Bachelor of Engineering (Power)

Supervisor: Mr Andreas Helwig,

Sponsor – School of Mechanical and Electrical Engineering

**Keywords:** Renewable, Hybrid Pumped Hydro, Intermittent Generation.

## 1. Introduction

This Thesis aims to investigate the energy storage potential of a hybrid renewable generation grid connected and pumped hydro-generation plant for act as an ancillary service for South East Queensland. The system is intended to aid in regional voltage support as grid security is becoming increasingly compromised due to the rapid increase of installed industry and domestic intermittent generation capacity in Australia. Therefore the main aim in this study is for the potential mitigation of South East Queensland's rapid and drastic fluctuations in the afternoon shoulder demand profile, due to weather induced rapid losses in solar generation.

## 2. Background

The afternoon peak demand fluctuations that South East Queensland is experiencing due to the regional installed solar capacity is having widespread repercussions in the form of many differing complications upon the electricity grid. The demand fluctuations as a result of these generation sources are rapid and largely unpredictable of which conventional large-scale generation systems simply cannot compensate for. As a result of grid demand deviations, expensive energy has to be purchased in order to maintain grid security so that supply can remain at a satisfactory level.

## 3. Methodology

The renewable simulation package HOMER Energy was used to model the grid, solar and pumping elements within the intended system. The model constructed in HOMER had the single purpose of detailing how much energy would have to be consumed, from which source at what cost to satisfy the pumping load. MS Excel was also used to model the economics of the project to yield figures such as capital cost, energy cost and to approximate when such a system would in fact be a viable option in Queensland.

## 4. Key Outcomes

The main outcomes that wanted to be achieve within the project was if this proposed system would be an effective and cost effective solution to alleviate the demand

fluctuation problems in South East Queensland. This system, however after preliminary modelling, was found with the current energy market costs (and oversupply of generation capacity) it is currently too expensive to be a viable option. Therefore research was then conducted to calculate with the trends in solar technology and electricity prices, when this system will become viable.

## 5. Further Work

The addition of another bulk water supply (being the upper catchment for the hydropower plant) for the region of Toowoomba requires further investigation. Due to the ever imposing droughts suffered by the region water is becoming an ever more precious commodity, making this a potential first example of linking bulk water supply and energy storage to reduce both water costs and aid sustainable energy penetration in Queensland and SE Australia's electricity market.

## 6. Conclusions

Solar generation is only going to increase and become more wide spread as energy costs are increasing. Therefore it can be concluded that new much needed additional pumped hydro energy storage which is needed for sustainable energy storage will in time become a financially viable option. As renewable energy penetration increases, such fast response storage will be needed to respond and alleviate potential system issues resulting from the fluctuations that will inevitably occur with wind and solar generation. Additionally in Queensland, bulk water prices for town supply and irrigation will need also to be potentially linked together as a dual purpose energy storage and water project.

## Acknowledgements

Special thanks to the supervisor of this thesis Mr Andreas Helwig. He was instrumental throughout the entire duration of the project, always providing constructive feedback and boundless knowledge. (Rachel Carnegie, 2013), (AEMO, 2011)

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# LiDAR Data for DEM Generation and Flood Plain Mapping



**Michael Topp**

Bachelor of Spatial Science  
(Surveying)

Supervisors: Dr Xiaoye Liu, USQ

**Keywords:** Flooding, LiDAR, ArcGis

## 1. Introduction

Intense flooding events occur more often than not within Australia affecting many people. In 2011 an event like this occurred in Toowoomba where the Central Business District (CBD) sustained extensive damage and lives were lost.

Airborne Light Detection and Ranging (LiDAR) data is a rapidly developing piece of technology that can collect large amounts of spatial data in a short period of time. This large amount of spatial data allows for fast generation of Digital Elevation Models (DEM).

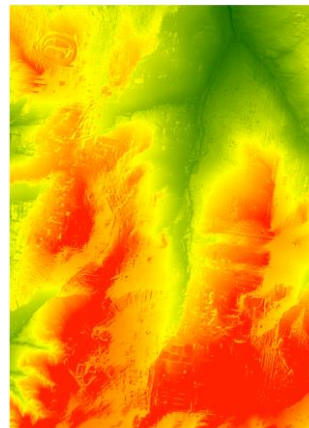
The DEM is an extremely useful output of LiDAR data which can be used as a tool for spatial analysis. This project looks to utilise these outputs to map the flood plain within Toowoomba.

## 2. Background

Flash flooding is resulting in extremely large damage bills to infrastructure and also resulting in loss of life. Continuous rebuild costs and loss of life affect nearly everyone in multiple ways. Through the use of Airborne LiDAR and flood plain mapping, the severity of such flash floods may be reduced. There is already extensive study into the use of LiDAR data for flood plain mapping; however this project aims to build on the practical uses of these flood plain maps.

## 3. Methodology

The first part of this project involved extensive study into the literature and previous works in this field. The next step involved obtaining the Airborne LiDAR data of Toowoomba before the flood in 2011. Once obtained the ground LiDAR data was used in ArcGIS to generate a DEM. The DEM was then used within ArcHydro to generate catchments, streams and perform terrain analysis.



## 4. Key Outcomes

To date the DEM has been generated in ArcMap at a high resolution covering approximately 35km<sup>2</sup> of Toowoomba as it was before the flood event. This has then been used in ArcHydro to generate multiple sub catchments and streams within the area. Terrain analysis has then been completed on the data showing slope characteristics. This data is extremely interesting as the slopes highlight that within Toowoomba there is a significant drop in height from the top of the catchment to the CBD. This combined with narrowing of streams results in damaging waters.

## 5. Further Work

Within this project there is still the hydrological modelling to be completed. The Model for Urban Stormwater Conceptualisation (MUSIC) is one of the software packages in use within Australia and will be used for the modelling. Further work also needs to be completed into the practical application of this modelling.

## 6. Conclusions

LiDAR data is an extremely useful data set that has multiple practical applications. The use of this data in software packages such as ArcGIS and MUSIC to produce flood plain maps is one of these applications which may save lives and money in the future.

## Acknowledgements

I would like to acknowledge Dr Xiaoye Liu for her extensive knowledge and help provided in this research project.

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# Infant Transport Incubator Cold Performance

Sponsor – Wenross Holdings Pty Ltd



## Anthony Vadalma

Bachelor of Engineering Major  
Electrical and Electronics

Supervisors: Dr John Leis, USQ

Dr John Grant-Thomson,  
Wenross Holdings Pty Ltd

**Keywords:** Neocot, Temperature, Cold test.

## 1. Introduction

The Mansell Infant Retrieval System is a medical device designed to be able to transport critically ill infants to a nearby medical facility. The system consists of four main components: the Neocot, Neosled, Powerlifter and the Power Supply Unit. This project is concerned with the heating element of the Mansell Neocot. The Neocot regulates the internal ambient temperature, with the aim of keeping temperature variations to no more than  $\pm 1^{\circ}\text{C}$  with the common temperature setting being  $36^{\circ}\text{C}$ . The Neocot is capable of setting temperatures from  $28^{\circ}\text{C}$  to  $39^{\circ}\text{C}$  depending on requirements.

## 2. Background

The Mansell Neocots heating element was formerly fibreglassed into the floor of the Neocot. Should a fault occur with the heating element, the floor of the Neocot would need to be cut-out, the element removed then re-fibreglassed into the floor. This is expensive and time consuming. The newly designed heating element is removable so that if a fault was to occur the element could simply be unbolted and replaced. The purpose of this project is to test the operation of this heater to specifications outlined in the IEC.60601-2-20 Australian Standard for a cold test. This standard indicates that the Neocot must be placed in an environment with an ambient temperature of  $-5^{\circ}\text{C}$  while operating at  $36^{\circ}\text{C}$  and remain in there for 15 minutes. After 15 minutes it is to be removed and placed in an environment of  $20\text{-}25^{\circ}\text{C}$  and remain there for 30 minutes. The internal temperature is to at no time drop below  $33^{\circ}\text{C}$  or rise above  $39^{\circ}\text{C}$  (IEC 2009).

## 3. Methodology

In order to test that the heater meets the IEC60601-2-20 Australian Standard it was necessary to develop some temperature sensing hardware. An in-depth literature review was undertaken on all the possible probes, voltage amplifiers and noise reduction configurations that could be used. In the end two types of probes were chosen, thermistors and LM35. Data was logged using a LabJack connected to a laptop. MATLAB code then needed to be developed to average the number of voltage samples being taken.

## 4. Key Outcomes

Two cold tests were undertaken on different Neocots using the developed temperature sensing device. The first cold test proved that the Neocot passed the requirements of the IEC.60601-2-20 Australian Standard. A second cold test was then undertaken to prove that the results obtained were correct. Using the new probes it was found that the Neocot once again passed the requirements of the IEC.60601-2-20 Australian Standard.

## 5. Further Work

Remaining in the project is to complete the VBA automation program if time permits.

## 6. Conclusions

The Mansell Neocot newly designed heating element has passed all of the requirements outlined in the IEC.60601-2-20 Australian Standard.

## Acknowledgements

I wish to acknowledge Dr John Grant-Thomson for providing me with the opportunity to undertake this project. I would also like to thank Mr Paul Priebbenow for help and advice on the development aspect of my project. I would also like to acknowledge Mr Norman Watt owner of Wenross Holdings Pty Ltd for funding this project. I would also like to thank Dr John Leis for providing programs to communicate with the LabJack as well as advice and support. Lastly I would like to acknowledge Bidvest for providing the use of one of their cold trucks to undertake the cold tests.

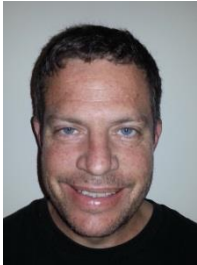
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IEC (2009), *Medical Electrical Equipment – Particular requirements for the basic safety and essential performance of infant transport incubators*, Standard IEC.60601-2-20:2009, International Electrotechnical Commission



# Inflow / Infiltration Strategic Management Project

Sponsor – Shoalhaven Water



**Ivan Wady**

Bachelor of Engineering  
(Environmental)

Supervisors: Dr Vasanthadevi Aravinthan  
(USQ)

Ms Carmel Krogh, Shoalhaven  
Water

**Keywords:** Inflow, Infiltration, Wastewater

## 1. Introduction

An overflow containment risk standard adopted by the Environmental Protection Agency requires wastewater system licence holders to assess and review the system capacity based on size, location, climate and environmental sensitivity. As a result of rainfall and groundwater, additional flows enter the system, this additional flow is known as Inflow and Infiltration (I/I) and during periods of heavy rainfall excessive I/I can occur. This results in failure of the sewerage network and effluent escaping to the surrounding environment.

To develop a strategic management plan for short and long term I/I abatement programs it is essential to understand the impact local climatic conditions have on the design and subsequent operation of the wastewater system.

## 2. Background

The impact of wastewater overflows on the local environment can be significant. The pathogens in wastewater can affect the health of the public and the local ecosystems. In addition wastewater utilities bear the additional operating costs for the conveyance, treatment and discharge into the environment. The successful development/implementation of a management plan will ensure an efficient and effective wastewater service for the community.

## 3. Methodology

A review of the design standards used by wastewater authorities from various states was undertaken to determine how I/I values were incorporated into the design of wastewater systems. A problematic catchment within the Shoalhaven Water network was

identified and baseline data of average dry weather flow, rainfall events and peak wet weather, over a 3 year period, was gathered. The design flows were calculated using the baseline data and the current Shoalhaven Water design standard and compared to design flows that incorporate local customised I/I values for different storm events.

Several storm events during the analysis were considered with the frequency, duration and timing of the storm event compared to the diurnal curve. A field trial methodology for the detection of I/I is then developed along with proposed rectification measures.

## 4. Key Outcomes

The required outcome is to establish a strategy to proactively identify I/I problems within the Shoalhaven Water wastewater system. This outcome includes improvements that can be made to the design guidelines, gathering/processing of data, field investigations and rectification measures.

## 5. Further Work

Customisation of I/I values for different catchments in the Shoalhaven region. In addition implementation of long term flow monitoring into sub-catchments to enable refinement of the customised I/I values and enable the success of rectification works to be measured.

## 6. Conclusions

The current design methodology used by Shoalhaven Water needs to incorporate customised I/I values for each wastewater catchment. Based on the revised system parameters catchments with high levels of I/I can be identified and resources for detecting/rectifying sources of I/I allocated.

## Acknowledgements

I would like to thank my supervisor Dr Vasanthadevi Aravinthan for her guidance, support and knowledge of wastewater system design and Shoalhaven Water as my sponsor for the support and resources they have provided.

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- Water Services Association of Australia (2002) *Sewerage Code of Australia WSA 02-2002*, Second Edition Version 2.1

# Measurement of Waste in Concrete Construction using Lean Construction Methodologies

Sponsor – School of Civil Engineering and Surveying



**George Watson**

Bachelor of Engineering  
(Honours)

Supervisors: Dr Vasantha Abeysekera,  
Senior Lecturer (Construction  
Management) USQ

**Keywords:** Lean Construction, Concrete, Waste

## 1. Introduction

This research project studies the application of lean construction methodologies to the Australian construction industry. To achieve this the report will examine production processes involved in construction and identify and measure waste with the aim of improving performance. The scope of this project will include the process of concreting with associated processes such as formwork and rod reinforcement. This report endeavours to both classify and measure the wastes present in particular structural concreting processes.

## 2. Background

The construction industry has been slow to implement environmentally friendly practices with many Australian companies yet to implement waste minimisation strategies (Faniran & Caban 1998). The principal outcome of all lean construction elements is increasing value generation while eliminating waste.

## 3. Methodology

A literature review was conducted to collect information and determine the research gaps present. This information was used for evaluation and selection of methods of classification of waste from a lean construction perspective. A suitable format for waste reporting based on the literature review was developed. Waste classifications and corresponding remedial actions were selected to formulate typical report recommendations. The method for waste reporting relies on analysis of the construction process for which sub-processes add value and which do not. Once these

waste sub-processes are identified they are classified according to the chosen method. This has been represented in a case study for concrete paving at the Wellcamp Airport.

## 4. Key Outcomes

This research has led to the development of a useable waste reporting format providing waste classifications and corresponding remedial actions. This format has been applied to a concrete paving project. This case study includes classification of wastes, process mapping and application of reporting formats.

## 5. Further Work

There are a number of possibilities for further work on this project. Firstly this method of process analysis, classification and reporting can be applied to other types of concreting activities and other fields of construction. Another avenue to be explored is the possibility of modification of standards or legislation.

## 6. Conclusions

The key conclusion of this project is that it is possible to apply lean production principles from manufacturing to the construction industry. This has been demonstrated by the application of lean construction principles to a real-world concreting project. The main concept for readers to take away from this project is that waste in construction is any lack of efficiency and not just unused materials.

## Acknowledgements

I would like to thank my supervisor who has given me guidance and direction in my project. I would also like to thank Wagners Constructions for access to data and project documentation for my case study.

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# Non-Contact Visual Soil Moisture Content Estimation

Sponsor – National Centre for Engineering in Agriculture. Institute for Agriculture and the Environment.



**Paul Watson**

Bachelor of Engineering  
(Electrical / Electronic)

Supervisor: Dr Alison McCarthy, USQ

**Keywords:** Soil Moisture, Non-Contact, Visual

## 1. Introduction

Drought in recent years has highlighted the importance of a sustainable water resource. Improvements in irrigation management can significantly increase water use efficiency and productivity, and reduce runoff. Measurement of Soil Moisture Content (SMC) is essential for improving irrigation management.

Off-the-shelf SMC sensors require contact with the soil and measure only a fixed point. In a field situation it is often not practical to install multiple SMC sensors. An alternative approach uses non-contact methods to estimate SMC. Satellite imagery of plants utilising spectral bands in the visual, infrared and microwave wavelengths has been used to extract crop vigour and estimate SMC (Gibson and Power 2000). However, this technology has a limited spatial resolution (30 m<sup>2</sup>) and temporal resolution (every 2-3 weeks). This project is researching on-ground cameras to provide high spatial and temporal resolution SMC estimation.

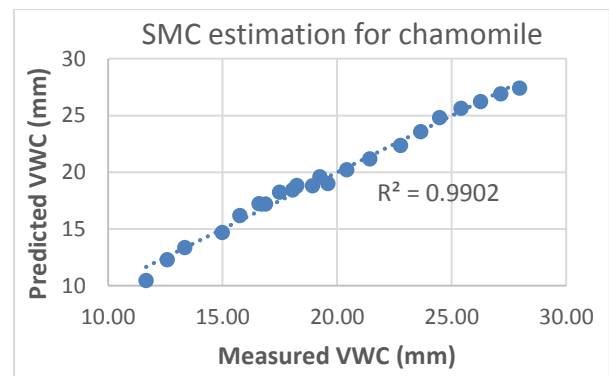
## 2. Camera-based Estimation System

A camera-based estimation system has been developed. Red and near infrared images of plants are processed using MATLAB® Image Processing Tool box and ColorWorker® software. A MATLAB® program has been developed that performs the following image analysis: (i) overlays images of different spectral bands; (ii) selects key regions in the visual image; (iii) selects key regions in the infrared image; and (iv) calculates reflectance in the visible and infrared bands. Multiple regression analysis has been conducted to analyse the calculated reflectance and develop a model that predicts SMC.

## 3. System Performance

The camera and image analysis system has been evaluated on chamomile, lettuce and lucerne plants. There are two replicates of the plants grown under three irrigation levels (20%, 30% and 40%) and two soil types (sandy loam and silt loam). Daily digital images are taken of plants with band pass filters in red and near infrared bands. An on-site weather station provides micro climate at the experiment location at 30 minute intervals.

Data analysis has revealed a correlation between the estimated soil water content (mm) and days since irrigated, with the spectral response of plant foliage in the near infrared (>850nm). Figure 1 shows the predicted versus actual SMC for a period of 22 days.



**Figure 1 – Model performance for chamomile grown in silt loam with high irrigation treatment (where VWC is Volumetric Water Content).**

## 4. Conclusions

Initial data analysis has shown a correlation between SMC and plant response for chamomile. The remaining plant types and spectral data are being further analysed.

Heat stress, disease and nutrition will have an effect on a visual based SMC estimation system. These effects could be studied in future research.

## Acknowledgements

I would like to thank my project supervisor Dr Alison McCarthy for her support throughout the entire project.

I also thank my wife Brooke for her support.

## References

Gibson, P. J. and Power, C. H. (2000), *Introductory Remote Sensing : Digital Image Processing and Applications*, Routledge, London.

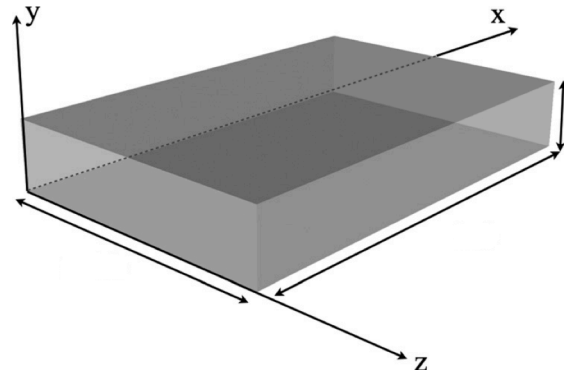
# Numerical Simulations of Water Surfaces for Improved Evaporation

School of Civil Engineering and Surveying



**Wesley Williams**

Bachelor of Engineering  
(Civil)



Supervisors: Dr Andrew Wandel, USQ

**Keywords:** Thermal Boundary Layer, Computational Fluid Dynamics, Evaporation

## 1. Introduction

The forecast of increased evaporation presents a challenging issue that needs to be resolved in order to reduce economic losses which stem from spasmodic regional water restrictions and the purchase of water in the agricultural industry due to low water availability.

With the aim of complimenting existing literature, the research undertaken will help determine how generated waves effect the temperature distribution immediately next to water surface and will also help characterise conditions in which retard or promote evaporation in open water storage reservoirs.

## 2. Background

Being able to satisfactorily quantify the rate of evaporation from open water storage reservoirs within Australia will enable the correct implementation of measures to mitigate losses that are expected in the coming decades due to a rising climate, estimated changes in precipitation rates and currently experienced changes in wind patterns.

## 3. Methodology

This project will be completed in entirety by developing a computational fluid dynamics model to perform large eddy simulations on a rectangular prism which contains a water surface. Computational Fluid Dynamics (CFD) will be used to determine how generated waves affect temperature distribution immediately next to the water's surface and to characterise conditions which retard or promote evaporation in open water storage reservoirs.

**Figure 1 – Computational Fluid Dynamics Domain**

## 4. Key Outcomes

Different limnological conditions caused by subsurface currents can effect the aqueous thermal boundary layers temperature and density. These conditions need to be characterised as they directly effect the evaporative potential of a water body.

## 5. Further Work

Pollutants and natural tannins which find their way into water bodies need to be considered in future models to be developed. The temperature and surface tension of a water body is effected by them.

## 6. Conclusions

The loss of water can be mitigated by the use and application of a monomolecular film to an open water reservoir surface. Adequate future predictions of evaporation losses based on meteorological data also provides a greater understanding of naturally occurring conditions which promote or retard evaporation in open water storage reservoirs. This can allow water resource managers to adequately predict rates of evaporation. The amount of variables to be considered when undertaking an evaporation analysis or when developing an evaporation model is large and will never be perfect in a practical sense. An understanding of environmental conditions that promote and retard evaporation losses from open water storage reservoirs needs to be appreciated above all.

## Acknowledgements

Dr Andrew Wandel has provided me with some great advice and insight into computational fluid dynamics and evaporation modelling and I thank him for all his efforts during this project. The support provided by my employer has also been greatly appreciated during the development of this research project.



# Performing Direct Numerical Simulations (DNS) to Develop Turbulent Combustion Models

Sponsor – School of Mechanical and Electrical Engineering



**Joshua Wilson**

Bachelor of Engineering  
(Mechanical)

Supervisor: Dr Andrew Wandel, USQ

**Keywords:** Direct Numerical Simulation (DNS), turbulent combustion

## 1. Introduction

Turbulent Combustion is an area of research which continues to be studied due to two main reasons; firstly it is a field which we still don't fully understand and secondly it has many applications including internal combustion engines, power stations and turbine engines to name a few. With a better understanding of turbulent combustion and the use of models to predict its behaviour we may be able to improve the efficiency of these systems.

## 2. Background

Currently we lack accurate modelling techniques which can predict the full behaviour of turbulent combustion, one such behaviour is the rate of mixing on different scales, and this is the area of research that this project investigates. Direct Numerical Simulation (DNS) is a tool to simulate turbulent combustion and these results are used to validate models due to its ability to fully capture the behaviour of the combustion.

## 3. Methodology

The primary methodology for this project is to use a DNS code written in FORTRAN77. By the process of performing DNS all of the data and behaviour of the turbulent mixing can be analysed in detail and it is possible to investigate the rates of mixing at different scales in an attempt to improve modelling techniques.

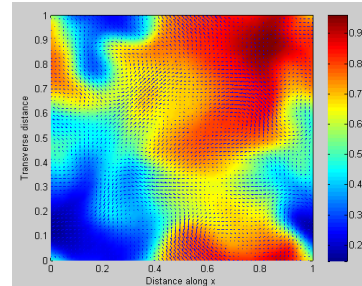


Figure 1: Mass fraction of oxygen

## 4. Key Outcomes

The key outcomes of my work so far include successfully performing Direct Numerical Simulation to investigate the phenomenon of turbulent combustion and various conditions. DNS has also been performed for different initial scalar fields of mixture fraction and the code has been modified so that they can be simulated more easily. The results have been compared to other work in the field and the results have been verified.

## 5. Further Work

The primary task which still remains is to write the new subroutine which will be used to investigate the rates of mixing and determine if the conditional mixing occurs at a faster rate than the global mixing.

## 6. Conclusions

So far there have been no conclusions for this project; however within a few weeks the code should be able to produce productive results for investigating the rates of mixing at different scales.

## Acknowledgements

I would like to thank my supervisor Dr Andrew Wandel for his expertise, also my friends and family for their continued support.

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Pope S.B, 'Small scales, many species and the manifold challenges of turbulent combustion', 2012



# Foam Bitumen Stabilisation in North West NSW

Sponsor – Roads and Maritime Services



**Joshua Wilton**

Bachelor of Engineering  
(Civil)

Supervisors: Mr Trevor Drysdale, USQ  
Mr Bikendra Adhikari, Roads and Maritime Services

**Keywords:** Foamed Bitumen, Pavement Rehabilitation, Expansive Clays.

## 1. Introduction

Foam bitumen stabilisation is a pavement rehabilitation technique that uses the existing and/or imported granular material and binds it together with bitumen (Leek & Jameson, 2011). It has been used in NSW before but only recently been applied to the existing road pavement in North West NSW between Narrabri and Moree on the Newell Highway. This section of the Highway is prone to pavement failures due to the expansive black clays in the area. Hence, why foam bitumen is now being trialled to see if an increase in flexibility can help increase the pavements life span. The report focuses on monitoring a number of foam bitumen stabilised projects between Narrabri and Moree on the Newell Highway.

## 2. Background

Foam bitumen stabilisation is still a relatively new form of stabilisation, especially for NSW. The success of the foam bitumen is important for this remote area due to the costly exercise of carting road-base not being economically feasible. Therefore in order to determine whether it will be successful, monitoring the recent projects is vital.

## 3. Methodology

An extensive amount of research into the foam bitumen process was needed to achieve an understanding on how it works. Once an understanding was achieved, the field data on each of the projects was collected and analysed to help determine if the construction methods or materials used are the cause of any pavement failures. This in turn assisted with the monitoring of the project sites after construction.



**Figure 1 – In-situ Stabilisation using foamed bitumen on the Newell highway near Bellata**

## 4. Key Outcomes

It has been found through monitoring the project sites that longitudinal cracking has occurred at the different foamed bitumen projects. The cause of the cracking is yet to be determined. Although, core samples of the pavement have shown that the addition of too much quicklime may be one of the main contributing factors other than that of the expansive sub-grade.

## 5. Further Work

Further monitoring and tests on the foam bitumen projects will be needed to achieve a full understanding of why the longitudinal cracking is occurring. Future foam bitumen projects in the area may want to consider a mix design with the addition of less lime.

## 6. Conclusions

In conclusion foam bitumen stabilisation between Narrabri and Moree on the Newell highway needs further research in order to determine whether different mix designs will be successful. In order to achieve this more projects will need to be undertaken with different mix designs.

## Acknowledgements

I would like to acknowledge the Roads and Maritime Services (RMS) for their support and co-operation in providing the information that was needed to complete my research. I would like to acknowledge Mr Trevor Drysdale for his supervision and contribution of knowledge that has assisted in giving the report its professional edge.

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# Locomotive Cooling System Strategy Optimisation

Sponsor – School of Mechanical and Electrical Engineering



**Mark Windebank**

Bachelor of Engineering

-Mechanical



**Corrosion Inhibitor Concentration Chart: Dash 9 Locomotive**

Cooling System Capacity: 1448L			Cooling System Capacity: 1448L			Cooling System Capacity: 1448L		
Conductivity Reading (mS/cm)	Nitrite Concentration (NaNO <sub>2</sub> ppm)	Required Concentration (litres)	Conductivity Reading (mS/cm)	Nitrite Concentration (NaNO <sub>2</sub> ppm)	Required Concentration (litres)	Conductivity Reading (mS/cm)	Nitrite Concentration (NaNO <sub>2</sub> ppm)	Required Concentration (litres)
0.3	281.89	38	2	708.70	25	3.7	1135.62	11
0.4	385.99	27	2.1	731.89	24	3.8	1155.73	11
0.5	331.1	36	2.2	728.97	23	3.9	1185.84	10
0.6	302.21	35	2.3	764.08	22	4	1230.95	9
0.7	302.32	35	2.4	800.19	22	4.1	1286.06	8
0.8	407.43	34	2.5	834.3	21	4.2	1351.17	8
0.9	432.54	33	2.6	870.41	20	4.3	1386.28	7
1	457.65	32	2.7	884.52	19	4.4	1311.39	6
1.1	482.76	31	2.8	900.63	18	4.5	1336.5	5
1.2	507.87	31	2.9	916.74	18	4.6	1361.61	4
1.3	532.98	30	3	932.85	17	4.7	1386.72	4
1.4	558.09	29	3.1	948.96	16	4.8	1411.83	3
1.5	583.2	28	3.2	965.07	15	4.9	1436.94	2
1.6	608.31	28	3.3	981.18	15	5	1462.05	1
1.7	633.42	27	3.4	997.29	14	5.1	1487.16	0
1.8	658.53	26	3.5	1013.4	13	5.2	1512.27	0
1.9	683.64	25	3.6	1029.51	12	> 5.1	> 2650	**

Figure 1 – Conductivity Tester and Reference Table

Supervisors: Dr Ray Malpress, USQ

Mr John McArthur, Rio Tinto

**Keywords:** Coolant, conductivity, corrosion, filtration, inhibitor concentration.

## 1. Introduction

Locomotive diesel engines, like most combustion motors, rely on cooling systems to transfer heat from engine components. Typically, water is the fluid medium used in this heat transfer process which, due to its electrolytic capacity, enables corrosion within the cooling system.

Inhibitors are added to the water to prevent corrosion occurring however particular types of inhibitors are consumed over time and require management to ensure the system components remain protected.

## 2. Background

Rio Tinto Iron Ore (RTIO) have identified areas of concern with the coolants used in their diesel electric locomotives. The key concerns regarding the coolant include unidentified sediments, component corrosion, inconsistent inhibitor concentrations, a disconnection in response to abnormal coolant test results, and the lack of a documented process for used coolant disposal.

In addition to these concerns, a recommendation was received from GE Transport, the OEM, to consider the use of an alternative corrosion inhibitor.

## 3. Methodology

A simple regression analysis of historical test results identified key relationships between coolant characteristics. R<sup>2</sup>-values were calculated to determine the comparative accuracy of the new method of determining inhibitor concentration.

An adapted standard corrosion planned interval test was defined to identify corrosion rates over a range of inhibitor concentrations and varieties.

Test results utilised from external sources include spectrochemical and spectrophotometrical analysis,

high performance chromatography, and a magnetic field Particle Quantification. These res

## 4. Key Outcomes

A safer alternative method was identified and implemented to measure inhibitor concentration which was easier for the technicians to carry out.

Analysis of samples has shown the reclamation system is inadequate and improvements implemented in the bulk mixing process has produced a more consistent inhibitor concentration.

A procurement issue allowing ordering of multiple coolant concentrations was identified and corrected to ensure initial inhibitor concentrations were consistent.

## 5. Further Work

Remaining work includes the planned interval tests for corrosion wear rates by concentration and variety of inhibitor and sediment quantification analysis to determine filtration requirements in the recycling process.

## 6. Conclusions

A safer and easier method for determining inhibitor concentration, Fig 1, has been recommended to, and implemented by, RTIO. Tests still to be completed will provide further guidance on coolant management.

## Acknowledgements

I would like to thank John McArthur from RTIO and Dr Ray Malpress for their assistance. The resources listed below were particularly helpful in directing my literature review.

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## Methods of Feeding out White Cottonseed to Livestock



### Damien Wooldridge

Bachelor of Engineering  
(Mechanical Major)



Figure 1 - Trip Hopper Feeder (Source: (Feeders, 2012))

Supervisors: Guangnan Chen, USQ

**Keywords:** feeding, livestock, white cottonseed

### 1. Introduction

In the ever changing climates, livestock producers are often pushed to find alternate feeds for their cattle during drought. White cottonseed is an extensively used feed source for such a purpose. However they prove to be difficult to handle. This project aims to research and develop a cost-effective system that can feed out white cottonseed in an automated fashion, thus reducing the work for the producer and ultimately reducing labour costs for the property.

### 2. Background

Due to the ever changing climates, farmers are often faced with a challenge of sustaining sufficient feed to continue the production of high end beef products. When the natural source of feed is little to none, specific diets are implemented to effectively keep the livestock healthy. One particular source for this sustainability is the use of white cotton seed (WCS). WCS is the by product of the cotton ginning process and is rich with nutrients and a very viable feed for drought effected livestock. Due to its physical makeup, there are only a limited number of ways to handle the product and feed it out to livestock. These include manual labour or the use of agricultural machinery. However, the availability of automated machines for this process are hard to come by and expensive to purchase. These remarks prompt current research into the availability of existing devices and whether these current devices can adequately and successfully complete the task of feeding out WCS to livestock in an automated fashion.

### 3. Methodology

This project evaluated the existing systems available in the industry today and sought out to identify a prototype design that could be improved to adequately handle WCS in its raw form. Figure 1 shows a design discovered that has been the potential for modifications to be implemented on.

### 4. Key Outcomes

The key outcomes so far from this project include an extensive literature review of all the existing systems being utilised currently and their applicability to this problem. The research has helped develop suitable design specifications and key parameters for the device and give excellent guidelines for a final concept design. A detailed analysis into the existing designs has been undertaken to find and determine the best suited answer to the problem which has led the project into a possible solution.

### 5. Further Work

At this stage of the project, the work is focused on drafting the conceptual sketch. A completed 3D model of the prototype will then be created via an appropriate software package including appropriate dimensions and costing reports.

### 6. Conclusions

Through the extensive research into existing systems and the construction of some key design guidelines, the project will produce a prototype design that will be ready for testing in the field and also have the potential for viable commercial production.

### Acknowledgements

I would like to thank my supervision Guangnan Chen for his excellent contribution towards my progress on this research project. Two other individuals that have been very insightful into this particular industry include Mark Moore and Denis Wooldridge. They have been excellent local producers that have given excellent remarks towards this project.

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# Evaluation of issues for small and medium-sized enterprises in the use of advanced and green engineering materials

School of Civil Engineering and Surveying



**Christopher J. B. Wright**

Bachelor of Engineering with Honours in Civil Engineering

Supervisor: Dr David Thorpe, USQ

**Keywords:** *Advanced and Green Engineering Materials, Material issues, SME issues.*

## 1. Introduction

This research is to evaluate issues for Small and Medium Enterprise's (SME) in the use of advanced and green engineering materials. Universities, and other developers and manufactures of advanced and green engineering materials, can benefit from the knowledge of issues experienced by SME's with the selection and use of their product.

## 2. Background

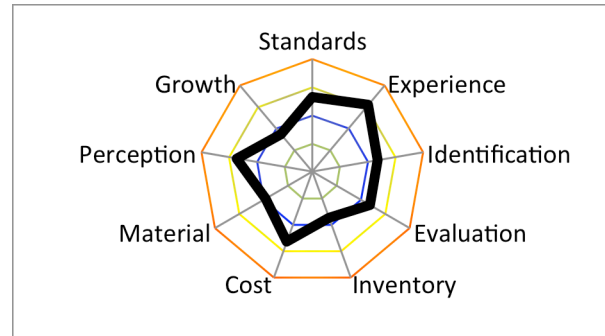
The research, design and innovation involved in creating advanced and green materials can take sizable resources and investment to develop. SME's play a large part in the construction market and therefore their adoption of new materials can be crucial to the success of advanced and green engineering material products.

## 3. Methodology

Identify from literature, a range of advanced and green engineering materials and issues with the use of advanced and green engineering materials. Produce, with approval of the Human Research Ethics Committee (HREC), a survey for SME firms in the construction industry. Distribute the survey, evaluate responses from survey participants, selecting up to five suitable materials for further investigation, and develop conclusions.

## 4. Key Outcomes

Literature provided starting basis for issues to investigate. The general issues with use of advanced and green engineering materials have identified experience as the most prevalent issue, Figure 1. The issue of experience is closely followed by perception, standards and codes, and cost as issues to affect a



**Figure 1 – Initial results of general issues for SME's with advanced and green engineering materials**

firm's use of advanced and green engineering materials.

## 5. Further Work

The collection of survey data is still underway. The final evaluation of data will look further at specific issues relating to five materials. Further research into how to improve standards and codes; alter perception; and improve experience could prove beneficial for the uptake of advanced and green engineering materials by SME's.

## 6. Conclusions

The general issues identified for the use of advanced and green engineering material, experience, standards and codes, and perception all affect demand for a material. Methods to reduce these issues will inturn increase the perceived value, lowering the issue of cost.

## Acknowledgements

I would like to thank; Jessica Barrell, for proof reading and always asking, what do you mean; and Dr David Thorpe, for providing guidance throughout the process. I found books by Spiegel & Meadows (1999) and RSMears (2002) instrumental in the formation of ideas of issues affecting SME in the selection of engineering materials.

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# INVESTIGATION OF HYBRID BRIDGE DECKS AND GIRDERS



**Ding XIAO**

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Supervisors: Prof Thiru Aravinthan, USQ

**Keywords:** Fiber reinforced polymers, hybrid FRP, bridge deck.

## 1. Introduction

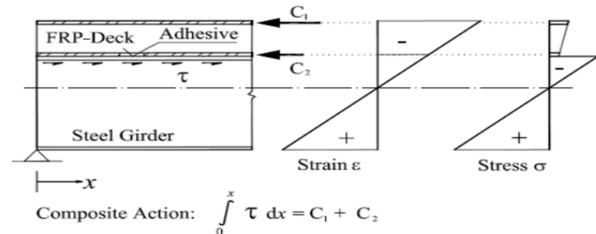
Fiber reinforced polymer (FRP) - advances in high-performance structural materials - made great revolutionary approach in the construction industry, which are increasingly applied for strengthening and repair applications. The project details the investigation of the behaviour of hybrid FRP bridge girder and decks.

## 2. Background

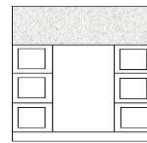
The hybrid structures have increased their market in the recent years, but the lack of knowledge of their behavior and the lack of standards or design codes have limited their application. And also, many technical problems related to the structural design of bridges with pultruded FRP decks have still not been solved/ investigated, or at least only partially, this includes the connection between the main steel girders and FRP deck which mostly is designed as a non-composite action, leading toward economical deficiencies.

## 3. Methodology

By literature studies of FRP bridge deck and girder. Since each fibre composite design is new and unique, and lack of specific design standards and codes, all strength calculations were performed with standard theory. The hybrid FRP bridge concrete deck design is based on reinforced concrete theories.



**Figure 2** - Principle of the composite action between steel girders and FRP bridge decks (Gurtler, 2004).



**Figure 1** - Complete Hybrid Concrete-FRP Bridge Section (Prasser 2005)

## 4. Key Outcomes

The project gives a better understanding of the behaviour of FRP bridge deck, composite behaviour of girder with FRP bridge deck and connection between girder and deck.

## 5. Further Work

Further analyse hybrid FRP bridge girder and deck using numerical FEM model and analytical equations based on the experimental data/study.

## 6. Conclusions

The project seeks to analyse the behaviour of hybrid FRP bridge girder and deck gave promising results that leads to more and further investigation needed in that field.

## Acknowledgements

I would like to acknowledge my supervisor Prof Thiru Aravinthan for his guidance through this project.

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# Investigation of Tunnel Lining in Soft Ground

School of Civil Engineering and Surveying



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Bachelor of Engineering (Civil)

Supervisor: Dr Jim Shiau, USQ

**Keywords:** Structural forces, analytical modelling and numerical modelling

## 1. Introduction

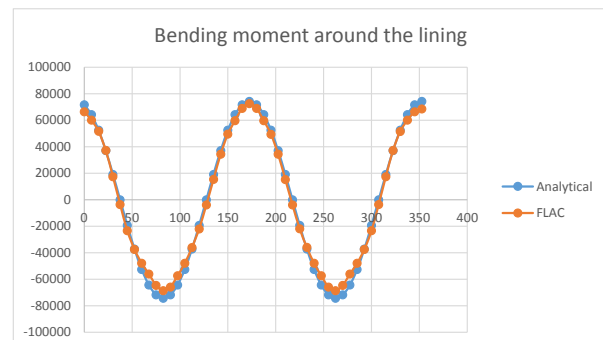
An increasing number of tunnels have been constructed worldwide due to urbanization and industrial purposes. In the past few decades, tunnel boring machines (TBM) have been used to overcome most undesirable geotechnical conditions. In tunnel construction, the tunnelling failure mechanism and ground surface are main aspects to be emphasized, especially in soft ground such as sand and clay. This is to ensure the safety of tunnel construction and contingency planning, as well as to minimize the associated impact on surrounding infrastructure. Tunnelling failure mechanism depends on tunnel stability, and the sufficient internal supporting pressure is provided by tunnel lining design.

## 2. Background

Current study of tunnel lining design is limited to the assumption that the stress pattern in the soil around the tunnel has not been disturbed. However, in reality the tunnelling lining is installed when the stress patterns have redistributed from the tunnelling process. Hence the assumption will lead to inaccurate structural forces of the lining. And the tunnel lining is designed by analytical method or numerical modelling without sufficient detailing.

## 3. Methodology

This paper uses a force relaxation technique and the finite difference program, FLAC, to estimate the tunnel lining internal forces by simulating tunnelling process, both in sand and clay. A number of numerical models are simulated with different parameters, including tunnel depth to diameter ratios ( $C/D$ ), friction angle of



**Figure 1 – Bending Moment Distribution of Lining**

sand, cohesion of clay, different stage of relaxation, Poisson ratio and failure criterion. The numerical model is validated by analytical method, and results of sand and clay models were carefully compared.

## 4. Key Outcomes

This is the key section of your abstract that highlights your achievements and your work. Ideally this includes some of the tasks you have identified in the project specifications. What are the key outcomes that you have achieved so far? Why are they interesting and/or unique? How did you apply your methodology to achieve these outcomes?

## 5. Further Work

Investigate the tunnel lining in  $C/\phi$  soil which has cohesion and friction angle. Twin tunnels, multi layered ground.

## 6. Conclusions

The numerical model has been successfully validated by the analytical method, and by taking account of the tunnelling process, FLAC gives less conservative results. Sand and clay have different stress distribution patterns which should be considered by tunnelling engineers.

## Acknowledgements

I would like to thank Dr Jim Shiau for his time and assistance in the methodology of numerical modelling.

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