



## **Engineering and Built Environment Project Conference 2015**

Toowoomba, Australia  
21-25 September 2015



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

Published by

University of Southern Queensland

Toowoomba Qld 4350

Australia

<http://www.usq.edu.au/>

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## **Heads of Schools Welcome**

*A very warm welcome to the University of Southern Queensland, Toowoomba Campus for the 2015 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.

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 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 2015.

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 570 students attending 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 Dr Badri Basnet 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 2015



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**Patrick Tunnah**

Bachelor of Engineering (Honours) (Civil)  
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Transitioning roadways from high-speed to low-speed environments when approaching Regional Towns in North Queensland

**Aaron Wilson**

Bachelor of Engineering (Civil)  
Establishing a Mix Design Procedure for Geopolymer Concrete

**Ronald Wilson**

Bachelor of Engineering (Civil)  
Redefining Standard Compaction Test to Better Describe the Usage of Cotton Picking Machines on Australian Vertosol Soils

**Shane Wynn**

Bachelor of Spatial Science (Surveying)  
The Re-establishment of Deed Boundaries in Areas Adjoining Torrens Title Land

**Z****Shahrukh Zaman**

Masters of Engineering Science (Mechanical)  
Characterization of Swirling Plume Induced By Hot Annular Surface

**Yao Zhou**

Masters of Engineering Science (Civil)  
Analyses of Twin Tunnel Stability Using Strength Reduction Method

# ABSTRACTS





# Benchmarking Asset Management for Electrical Power Distribution Organizations

Sponsor –School of Civil Engineering and Surveying



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**Keywords:** Asset life cycle, ISO 55000, maturity model.

## 1. Introduction

Asset management is a process of attaining, utilization and removal of assets to make the best out of it in terms of cost and output without compromising on risks involved during their whole life cycle (ISO5500:2014). Over the decades, electric power industries are growing rapidly and the management of its assets has become a challenging issue for the industry. Electric power industry consists of mainly three sectors; these are namely, (i) power generation, (ii) power transmission, and (iii) power distribution. The main focus of this research would mainly be on the distribution side for consumers, such as households and manufacturing industries.

## 2. Background

The objectives of this research is to explore the current asset management processes and practice areas, develop a maturity model and finally set a suitable benchmark of asset management practices for electrical power distribution organizations.

## 3. Methodology

A systematic literature review method is adopted for this research where various literatures are used to explore the current practices and gaps in the electrical power distribution sector and also used for benchmarking key process areas of asset management. The methodology is broken down into two parts as follows;

i) *Explorative and unstructured literature review:* An explorative and unstructured literature search on the current asset management systems.

ii) *Framework for systematic literature review:* This part follows a more systematic approach. A clear and unambiguous research method for conducting a systematic literature review, where we use literature as an input.

Key Process Areas
Asset policy
Asset planning
Asset creation and acquisition
Asset disposal
Environmental analysis
Asset operation
Asset maintenance
Asset management information system
Risk management
Contingency planning
Financial planning
Capital expenditure planning
Review of asset management system

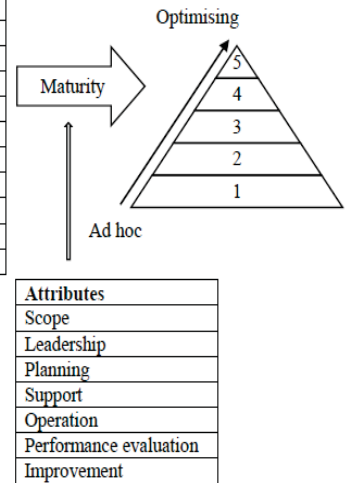


Figure 1. Generalized structural framework of the maturity model.

## 4. Key Outcomes

Based on the systematic literature review, a structural framework (as shown in Figure 1) is developed which includes thirteen key process areas, and seven attributes. Build on this framework, a set of characteristics is defined against the individual level of maturity for each key process area. The attributes are used as reference points in characterising the individual maturity level.

## 5. Further Work

Further work could be implementing this proposed maturity model in real life cases.

## 6. Conclusions

The asset management maturity model can be utilized as a basis for benchmarking and improving asset management in electrical power distribution organizations. It is expected that electrical power distribution organizations can manage their asset management effectively by the implementation of this proposed model and hence deliver a better quality of service to its customers.

## Acknowledgements

I would like to thank both my supervisors for their support and guidance throughout this research.

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# An Investigation into the Testing and Commissioning Requirements of IEC 61850 Station Bus Substations

Sponsor – School of Mechanical and Electrical Engineering



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Supervisors: Dr Tony Ahfock, USQ  
Mr Rob Coggan, Ergon Energy

**Keywords:** Station Bus, GOOSE Message, IEC 61850

## 1. Introduction

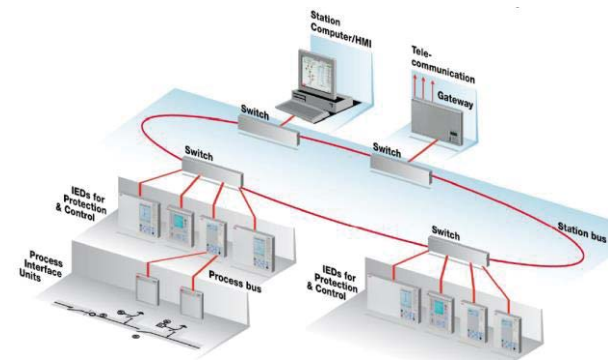
Ergon Energy supplies electricity to 97% of the state of Queensland. The electrical supply industry is under increasing pressure to reduce the operational and capital expenditure for substation infrastructure. The emergence of the new IEC 61850 standard generates a potential to deliver a safe, reliable and effective cost reduction in the way substations are designed and constructed.

## 2. Background

The IEC 61850 Station Bus systems architecture for a substation protection and automation system is based on a horizontal communication concept replicating what conventional copper wiring performed between Intelligent Electronic Devices (IED's). The protection and control applications that were traditionally sent and received across a network of copper cables are now communicated over Ethernet based Local Area Networks (LAN) (Figure 1). On site testing and commissioning plays, a critical role in ensuring that the substation protection schemes meet their intended design and the systems operate as an integrated system prior to operation.

## 3. Methodology

Analysing Ergon Energy's current design standards and philosophies established a connection between current practices and future practices using GOOSE messaging at a station bus level. A potential design of the GOOSE messaging protection functions was implemented using the new technology hardware and software. Identification of potential deviations from the design intent, examination of their possible causes and assessment of their consequences was achieved using a hazard and operability study (HAZOP). This assessment identified the parts of the intended design that required validating or verifying through the testing



**Figure 1 – IEC 61850 Protection & Automation Systems (Brand & Wimmer 2014).**

and commissioning process. A simulated substation and its protection system were developed to assess these findings.

## 4. Key Outcomes

The methods and practices to safely, reliably and efficiently test and commission and place in service a substation using IEC 61850 Station Bus GOOSE messaging.

## 5. Further Work

Additional Laboratory testing using the simulated substation to refine the methods and practices that potentially is used for onsite testing and commissioning.

## 6. Conclusions

The introduction of the Station Bus technology has a significant change in the way a substation protection system is tested and commissioned with substantial changes to current philosophies and practices.

## Acknowledgements

I would like to thank my supervisors Tony Ahfock and Rob Coggan for providing their technical expertise and guidance. I would also like to thank Ergon Energy and Schneider for providing the hardware and software to develop the simulated substation.

## References

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# Investigating the Accuracy of Terrestrial Laser Scanning within a Rail Environment



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(Honours) (Surveying )

Supervisors: Dr Xiaoye Liu, USQ

**Keywords:** laser scanning, calibration, accuracy.

## 1. Introduction

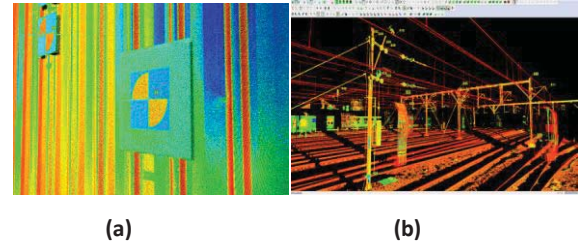
Current survey measurements in NSW are done by a Survey Total Station (STS). This instrument complies with current regulations as it can be calibrated over a baseline - to verify the instruments accuracy. Terrestrial Laser Scanning (TLS) is not a new technology but there is no official legislated procedure to verify its accuracy. This project will investigate the accuracy of TLS by designing and establishing an indoor target network for a self calibration. The data will be analysed to determine if the TLS conforms with Sydney Trains Specifications. A section of rail track will also be scanned and measured by conventional methods as a comparison.

## 2. Background

Sydney Trains recently went through a restructure. This initiated and encouraged innovation and use of advanced technologies to be assessed and introduced to current survey methodology when undertaking survey work on track. Discussion in my workplace of ideas to do survey work on track safely with limited human resources lead me to investigate (TLS) within the rail corridor.

## 3. Methodology

Targets were constructed to use in the indoor calibration room to test the TLS. These targets replicated the rail corridors tones and material. The final targets used in the calibration were manufacturer recommended targets as the scanner would only recognise the algorithm of that particular pattern. These targets were modified by installing a steel pin in the centre to test if the scanner would still scan them. The steel pins represent the coordinated survey marks existing in the rail corridor.



**Figure 1 - (a) Point cloud of Calibration targets (b) Scan of a section of the rail corridor.**

## 4. Key Outcomes

An indoor target calibration room was established. A TLS scanned the calibration targets from three position. The TLS also scanned a section of rail track. The analysis of the data is currently taking place to determine the accuracy of the TLS.

## 5. Further Work

With time permitting it would be great to extract the wires and rails from the point cloud and model them to be able to view the existing track and wire measurements as a spreadsheet.

## 6. Conclusions

Pending my results from the TLS calibration, Scanners will have an enormous use within a rail environment if the calibration results conform with Sydney Trains Specifications. From a safety perspective this is a significant development.

## Acknowledgements

I would like to thank my Supervisor Dr Xiaoye Liu for her support and guidance. My managers and colleagues at Sydney Trains - Survey for their encouragement and support in particular (Graeme, Murray, Gary, Fred and Mick). Thank you to C R Kennedy (John Reddington) and Position Partners (Michael McClelland and Adam Burke) for their time, equipment and software.

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## Study on tribological performance of mild steel under bio lubricant conditions

Sponsor: School of Mechanical and Electrical Engineering



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Supervisors: Dr Belal Yousif

**Keywords:** biolubricant, mild steel ,  
tribology.

### 1. Introduction

In the current era, vegetarian oil is becoming an important resource for fuel and lubrication purposes due to the numerous issues related to the usage of synthetic oils from environmental point of view. In this project, the possibility of vegetarian oils usage as lubricant for different applications is investigated. Different blends of vegetable mixed with synthetic oils are prepared (0-100%). Viscosity of the blends is determined at different temperatures. The newly designed tribology machine at USQ is used at the current study to investigate the wear and frictional performance of the blends at different sliding durations and sliding speeds. Stainless steel counterface is used to be rubbed against mild steel samples. Worn surfaces are examined using scanning electron microscopy (SEM).

### 2. Background

Recently, there is a growing demand for alternative lubricants to replace synthetic lubricants from both economic and environmental perspectives as reported by Balakrishnan et al. (2015). Mobarak et al. (2015) reported that vegetable oils are becoming a promise to tackle the environmental issue related to the lubrications. However, there is a lack of understanding on the wear and frictional behaviour of metals under vegetable lubricants as indicated by the review article by Lawal, Choudhury and Nukman (2012). Accordingly, the current study is motivated to investigate the influence of different operating parameters on the wear and frictional performance of mild steel sliding against stainless steel.

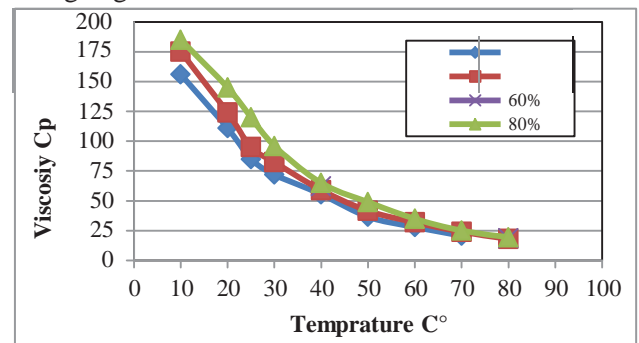
### 3. Methodology

The vegetable oil used in this work is obtained from the super marked as marked as vegetable oil. The specification of the oil is presented in appendix B. to prepare the blends of the lubricants, the vegetable oil should be heated up to 50 °C. at this temperature, the synthetic oil can be poured carefully to the vegetable oil. Electrical mixer at very low speed is used to get uniform mixture. The blends kept for a week to ensure the homogeneity of the mixture. If there is separation in the oil, the blend should be despised. Since, Alotaibi 2014 suggest the usage of such oil in two strokes engine oils, in the current study, fully synthetic catrol oil for two stroke

engines is used as synthetic oil. t By blending fully synthetic oil 2 stroke engine with vegetarian oil. The blend made up in different quantity 20% synthetic, 40% synthetic, 60% synthetic and 80% synthetic mixed with rest of percentage of vegetable oil. After Apply heat up to 50 degree to make the blends well mixed. The viscosity of the prepared blends was measured using a Viscometer at the University of Southern Queensland, Fig. 3.3. Different oil temperatures were considered (20 °C -80 oC). The oil fist put in a small container and then placed in the machine. The temperature set to the maximum and then the viscosity vs. the temperature is recorded

### 4. Key Outcomes

The initial experimental results of the viscosity are presented in **Fig. 1** for different blinds as 20% - 80% synthetic addition. The figure clearly shows that the vegetable oil is very competitive to the synthetic oils despite the addition of the synthetic oils. For the tribological testing, the initial results showed no remarkable different in the wear and frictional behaviours of the mild steel under any blinds of lubricant. In other words, there is high potential of using vegetable oil as lubricant.



**Fig. 1** Viscosity of the prepared blinds (synthetic %) at different temperatures.

### 5. Conclusions and Further Work

There is a high potential of replacing the synthetic oil with vegetable oil whereas there is no remarkably differences in their tribological impact on the mild steel wear and frictional behaviours. However, the oxidization and/or coating mechanisms should be explored in this study for further understating lubricant performance of vegetable oils.

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# Study on the sisal fibres as insulator in building materials.



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Bachelor of civil engineering (honours)

Supervisors: Dr Belal Yousif

**Keywords:** natural fibre, heat conductivity, wall.

## 1. Introduction

In the current era, there is a concern of using synthetic fibres with regards to their impact on the environment since they are non-recyclable or degradable. Moreover, there are several attempts going on to use natural fibres in various engineering applications owing to replace the synthetic fibres with naturals. In this project, the possibility of using natural fibres in building materials is investigated in term of compression strength and heat conductivity. Sisal fibre is selected as reinforced natural fibres for gyprock industrial and commercial wall materials. To gain high interfacial adhesion of the sisal fibres with the gyprock, a study on the optimum chemical treatment concentration is considered in this work. Furthermore, a newly designed heat conductivity setup is developed to study the influence of different volume fractions of glass and/or sisal fibres (0-50 vol.%) on the conductivity of gyprock. Failure mechanisms of the samples after the compressive testing are examined with the aid of the scanning electron microscopy (SEM).

## 2. Background

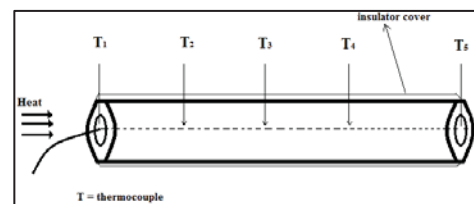
Recently, Berardi and Iannace (2015) reported that the usage of synthetic fibres such fiberglass creates several environmental issues associated with the significant increase of waste disposal sites. In addition, Twidell and Weir (2015) stated that the building sector is a large consumer of resources (materials and energy), highly polluting (emission of carbon dioxide CO<sub>2</sub>), and a generator of residues which in turn it is urgent to promote sustainable building materials to decrease the negative impact on the environment. The usage of natural fibres as biodegradable reinforcements has gained the attention of different engineering sectors. Azwa et al. (2013) published a review article related to the topic and concluded that there is an urgent need to study the impact of such reinforcements on building materials. In the light of the above, the current study is motivated to use sisal fibres in building materials.

## 3. Methodology

Sisal fibres were treated with different concentrations of NaOH (0% to 10%) owing to gain the optimum strength and surface characteristics. Thermal conductivity of different gyprock composite materials based on different content of sisal fibres are studied using a newly designed

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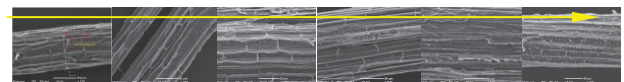
setup, **Fig. 1**. The setup is mainly consists of heat resource (heat gun), insulated tube contains the composites, cooling end and five thermocouples embedded in the centre of the composites at different spaces from the heat resource. In the experimental procedure, the heat supplied by the heat gun and the temperature readings are captured at different durations. The experiments are based on the recent reported work by Benmansour et al. (2014). ASTM C1019 – 14 standards is used for compressive testing of the selected composites.



**Fig.1** Schematic drawing of conductivity measurement

## 4. Key Outcomes

Fig. 2 shows the micrographs of different surfaces of fibres which treated with different NaOH concentrations. 6% NaOH treatment showed the optimum concentration in which the surface of the fibres significantly improved and clean. The initial results of the heat conductivity experiments exhibited that the addition of the natural fibres significantly improves the insulation characteristics of the wall by about 10-30%. However, the compressive strength of the natural fibres composites showed slight reduction in the strength compared to the glass fibres (<10%).



**Fig.2** Sisal fibre micrographs at different NaOH treatment as 0 %, 2%, 4%, 6%, 8 and 10%

## 5. Conclusions and Further Work

The experimental results concluded that the addition of the sisal fibres into gyprock improved the thermal conductivity of the composites; however, there is a slight reduction in the compressive strength. Further study on the flammability of the new composites is required for commercial purposes.

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# Non price factors for contractor hiring in Australian Energy Resources

**Student Name:**

**Siva Kumar Alapati**

Degree: MENS



Supervisors: Dr. David Thorpe, USQ

## Abstract

The aim of the thesis is to bring together the sound literature about the contractors and hiring process the factors considered both price factors and more emphasis on non-cost factors.

### 1. Introduction

A multi-faceted investigation has been ingested which is being explained in several chapters mentioned in later parts.

### 2. Related Background Work

The theoretical existence of various standards, events, methods, factors of contract and subcontract. (Xia, B, et al., 2014)

#### 2.1. Contractor and customer relationship

The magnificence between the customer and the contractor is often stressed, often mentioned to as decreasing performance uncertainty and beyond discussed.

#### 2.2. Project Partnering

Partnering is a more about an attitude with a philosophical approach. It is a structured management process that is efficacious for all sizes of building projects to focus the attention of all the parties on problem solving, without prolonged disputes or litigation (Larson, n.d.)

#### 2.3. Public and Private contracts

The public sector contracts are public service oriented. The private sector projects are privately own public service oriented project and fully privately owned contract. The sections discusses the major strengths and differences of contract types.

#### 2.4. Contract and subcontract hiring process

The contract hiring process differs from type to type and with deference to the scenario.

##### 2.4.1. Private Projects

Private projects fully owned private property.

##### 2.4.2. Public Projects

Public projects are owned by government and tenders are called for both main contract and sub contract hiring. The factor of consideration are lowest cost bid and others.

#### 2.5. Type of Public Projects

The projects are termed as public, semi-public, semi-private and private.

### 3. Contractor hiring process in Power and Energy Projects

The power and energy projects are termed as public and semi-public with respect to its size and necessity. The contract hiring process changes with the project size and character.

### 4. Bidding and rebidding Techniques by AER

The traditional mechanism of bidding and rebidding adapted by AER and other factors incorporated while contractor selection.

### 5. Factors considered in power projects

The traditional factors are tender and bidding mechanism and AER introduced rebidding mechanism for the old contractors. Across the world every project is different.

### 6. Case studies

The public and private projects across the world tend to serve as reference case study in every way. Few of those are discussed.

### 7. Risk Factors

While contractor, customer and sub-contractor process risk is definitely involved and those risks with tentative solutions are to be discussed.

### 8. Non Price factors

The new era selection is about consideration of non-price factors in contractor sections to be hashed out in the segment.

### 9. Price and Non Price factors in Power Projects

The comparison, effects and importance of price and non-price factors.

### 10. Factors suitable in context to AER

The factors considered other than bidding and rebidding by AER and those factors suitable for the selection process.

### 11. Conclusion

The thesis is about discussing the contracts, projects, partnerships and factors considered in selections mainly those involving no cost.

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# Feasibility Assessment of Low Cost Stereo Computer Vision in Clay Target Shooting Coaching.



**Josh Anderson**

BENH - Mechatronic

Supervisor: Dr Tobias Low, USQ

**Keywords:** Stereo Vision Synchronisation Point-Cloud Segmentation 3D

## 1. Introduction

Extracting 3D positional information from images captured using multiple cameras is common in computer vision. The accuracy of these measurements is primarily dependent on camera resolution, calibration and synchronisation.

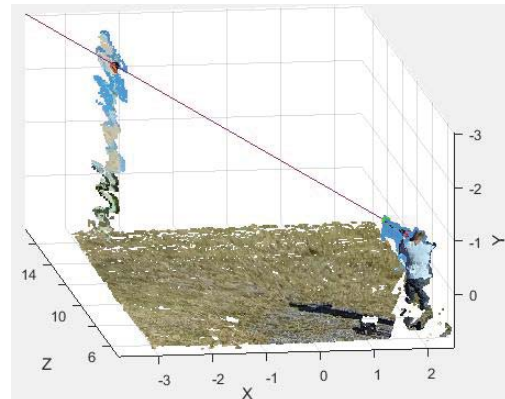
When the feature of interest is moving, camera synchronisation becomes especially important as small movements in the time between the images being captured can translate into large error values.

## 2. Background

Clay target shooting is a sport that has been slow to adopt new technology and coaching techniques have remained largely unchanged in 200 years and are often ineffective. The most widely adopted coaching technology in clay target shooting is gun mounted cameras which require expertise to analyse and time to review. If an automated system can be developed to give feedback on every shot, new shooter improvements could be more rapid and help to retain many of the shooters that leave due to frustration.

## 3. Methodology

The four main areas that the project can be broken down into are research, camera selection, software, and field trials. After completion of a literature review it was identified that synchronisation may become an issue for the dynamic trials. A selection of USB webcams and GoPro cameras were tested for synchronisation, and the test platform for the field trials was developed. Static trials were undertaken to gauge system accuracy with camera synchronisation issue minimised and then dynamic testing was carried out. From each of the trials, code was developed in Matlab to measure then calculate the target position and the shooters aim.



**Figure 1 – 3D scene reconstruction using stereo images to measure gun direction and target location.**

## 4. Key Outcomes

This project has shown that in a static scene, low cost stereo computer vision is able to accurately measure a shooters aim and target position to within 2% (error/shot distance). Figure 1 shows the shooters aim as a line projected toward the target.

## 5. Further Work

The final tasks remaining before project completion is the last round of testing of the system against three experienced coaches. Once this step is complete feasibility can be determined.

## 6. Conclusions

Consumer cameras lack the ability to be accurately synchronised but with high frame rates and awareness of the issue, inaccuracies can be reduced.

## Acknowledgements

Ian Collison and Brisbane Sporting Clays who have made the club facilities available on days normally closed. Chris Worland who helped me setup and record most of my field trials. Dr Tobias Low who has pointed me in the right direction when I have been stuck. Finally I would like to acknowledge the contribution of my wife, Emma Anderson, who without her patience and understanding this wouldn't have been possible.

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# Evaluation of strength characteristics of recycled bituminous pavement materials

Sponsor - School of Civil Engineering and Surveying



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Supervisors: Dr Soma Somasundaraswaran,  
Staff Member, USQ

**Keywords:** RAP, Recycled Asphalt, Hot mix Asphalt.

## Introduction

This research presents a case study to increase the percentage of reclaimed asphalt Pavement (RAP) in asphalt mixture by using existing asphalt and to characterize the quality of such mixture.

Asphalt mixtures containing different percentages of RAP (0%, 15%, 30%, 40%, 50%, 60%) were prepared in laboratory. The mixture without RAP is control mixture, made only with virgin raw materials. Asphalt mixture was prepared in laboratory with highest content of RAP and control mixture. Various tests such as air voids ratio, compacted density, and indirect tensile strength were conducted to finalise the strength and physical characteristics.

## Background

Reclaimed asphalt pavement is source of optimization of natural resources. It is an alternative source of materials, which reduces the use of virgin aggregate. The reduction of virgin materials usage in asphalt mix affects the cost of asphalt pavement. So it is need to develop best practices for increasing the use of reclaimed asphalt pavement in in asphalt pavement mixtures

The key objectives of this project are to determine the effects of variations in RAP material proportion in hot mix asphalt mixture. How an increased percentage of RAP material effects the mechanical properties (resilient modulus) of asphalt materials.

## Methodology

Department of Transport and Main Roads guidelines have been use to prepare the samples and conduct the recommended tests.



Figure 1: Indirect tensile strength (Resilient Modulus Test).

## Further Work

Further analysis to be completed involves the evaluating the effects of air voids on pavement strength and the influence of varying the RAP content on air voids, density, and pavement strength.

## Conclusions

Testing and analysis of the data is still in progress. Early analysis indicates that samples' having an increased RAP proportion's resilient modulus is higher than the virgin asphalt mix, which indicates the higher rutting expectation in high RAP contained material. Preliminary results showed that asphalt mixture containing RAP fulfilled the technical standards and the quality was in most cases similar with asphalt mixture made from virgin materials.

## Acknowledgements

I would like to thank my supervisor Dr Soma Somasundaraswaran for assistance and allowing me access to the required testing equipment. I would also like to thank BORAL Asphalt to provide me required materials in this research.

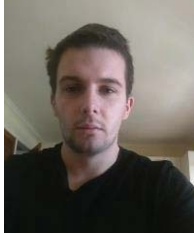
## References

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- Department of Transport and Main Roads specifications (PSTS109) Reclaimed Asphalt.



# Analysis of gait whilst carrying an eccentric load

School of Mechanical and Electrical Engineering



## Robert Ashford

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(Honours) (Mechanical)

Supervisors: Chris Snook, USQ

**Keywords:** Gait, Biomechanics, Walking, Mechanics

## 1. Introduction

The study of gait (walking) is the study of the mechanics of walking. It's been used in injury recovery, sports science, robotics and many other fields.

Since Saunders et al's classic paper in 1953 Gait analysis has been a developing field with new discoveries as well as the advancements and refinements of existing theories.

This research project will focus on how the Gait of healthy adults is affected by them carrying a load which is external and eccentric to their body (in their hand).

## 2. Background

Currently in the workplace beyond the current guidelines for lifting an object unassisted there is little mention of the form of locomotion with which the user could or should use to transport the item.

## 3. Methodology

Testing will involve subjects carrying a weight in one hand while walking on a track or treadmill, with markers on the hips, knees and ankles for the purpose of tracking the relative movement of the body.

Such movements will be compared a control consisting of the same subject with no load.

## 4. Key Outcomes

The main outcome regarding this project will be to examine how – and by how much – an adult's gait is affected by them carrying a load eccentric to their body.

This will involve examining the timeline of the sub-phases of the subject's gait, their spatial gait metrics (such as base, step length and toe angle) as well as "Gait determinants" such as Knee Flexion, Pelvic List and Hip Flexion (among others).

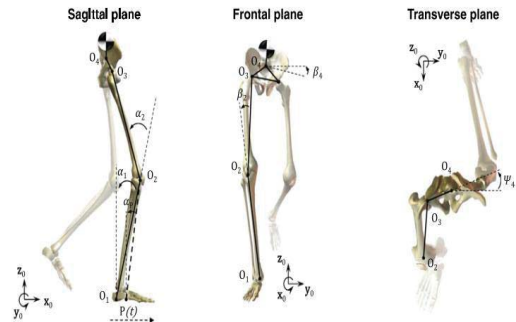


Figure 1 – Gait reference planes (Hayot et al 2013)

Of equal importance will be the asymmetry of those characteristics.

## 5. Further Work

If time and resources permit additional testing may be done using Surface Electromyography (Surface EMG) equipment to examine how the muscles in the body react to the stresses placed upon it.

The physiological effects of carrying an eccentric load won't be examined in this project but the (de-identified) data could be used by a medical professional and/or as the basis of further study.

## 6. Conclusions

As yet no conclusions have been drawn.

Expected conclusions involve a change in the major determinants of Gait, the largest effect being in the asymmetry of the movements of the hips and legs.

## Acknowledgements

I'd like to thank Chris Snook and Dr Albert Chong for their knowledge, enthusiasm and passion surrounding the subject.

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# Investigation on suitability and benefits of using UHMWPE spouts to transfer grain in storage facilities

Sponsor – Downfields Engineering Pvt Ltd



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Master of Engineering Science (Mechanical)

**Supervisors:** Assoc Prof Guangnan Chen,  
USQ

Dr Steven Goh, USQ

**Keywords:** Wear, Spouts, Electric Sander.

UHMWPE: Ultrahigh Molecular Weight Polyethylene

SEM: Scanning Electron Microscope

PSI: Pound per Square Inch

## 1. Introduction

This research proposal investigates the suitability of UHMWPE spouts to transfer grain in storage facilities. Spouts are the tools fitted as connectors between hopper and storage facilities normally used in agricultural practices. There are many uncertainties with the present material of spout and this research addresses the issues and possibilities to overcome the obstructive parameters.

Primary focus of the research is on different materials that are well supported with continuous wear and should not contain any harmful toxics as it will have direct contact with food grains/seeds in the application. Adequate tests are conducted to elect the best material that satisfies all norms of wear function.

## 2. Background

Current research critically evaluates the previous findings and statements of the materials that are better performed under wear operation. There are few uncertainties with current material used for spouts like lifespan of spout, corrosion & wear which are to be addressed by proposed material to replace. This requires extended research of materials and its functions.

## 3. Methodology

Particular arrangement is installed to check the wear rate of materials comparative to one another. An electric sander with 80mm grit size is applied with a pressure of 10 PSI over steel and UHMWPE individually. At regular intervals stop the process, note the material specifications and observe the wear rate and wear pattern using SEM. This results state whether

the proposed material suits the spout better than the existing one or not. 80 mm grit (wood) is selected as it has approximately similar course pattern as of seed abrasion over the spout.



**Figure:** Orbital electric sander with 80 & 100 grit emery papers

## 4. Key Outcomes

To advocate the best material that is more reliable to the function of wear need to be tested with the wear testing equipment/Abrasive Jet machining (AJM). Although there is lack of equipment, a setup has been arranged that resembles the principle of AJM and appropriate tests are conducted based on the principle. Preparation of this replica can be the key outcome from the research.

## 5. Further Work

Experiment results are yet to be finalised, presently working on possible outcomes with the setup. After results are determined further investigation is performed to reduce the complexities with proposed material.

## 6. Conclusions

Appropriate material that is well functioned under high wear operation than the existing type should be determined and suggested. Proposing the material that addresses the current perils could be the key outcome from the investigation.

## Acknowledgements

This is a sponsored project from industry Downfields Engineering Pvt Ltd, I get satisfied cooperation from industry. I would like to thank both supervisors utmost for their unbounded general and technical support. My supervisor has been helpful in all tough phases that I have gone through during research and supported me with his assistance. My co-supervisor has empowered me with technical support that makes me move forward with a hope in success when I faced complications.

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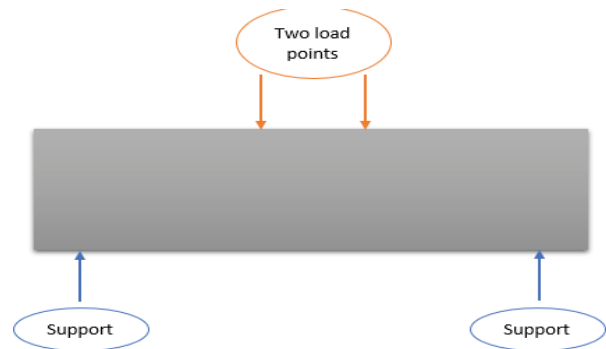
# Study of shear behaviour of geo-polymer concrete beam reinforced with GFRP reinforcement

Sponsor –School of Civil Engineering and Surveying



**Amirahmad Attarnejad**

Master of Engineering Science  
(Civil)



Supervisor: Dr. Allan Manalo, USQ

**Keywords:** Shear behaviour, GFRP reinforcement, Concrete

## 1. Introduction

Traditional reinforced concrete with steel bars and normal concrete is the very common combination of materials for construction purposes which; however, has some disadvantages. Steel bars have corrosion issue especially in marine areas which will be led to loss of strength as well as maintenance costs; in addition, producing cement is not environmentally friendly due to CO<sub>2</sub> emission.

This research aims to investigate the behaviour of geo-polymer concrete beam reinforced with Glass Fibre Reinforced Polymer. The important aspect of this research is that to substitute new materials which can be led to structural and environmental advantages.

## 2. Background

Corrosion is the main problem associated with steel bars. According to Ahmed (2009, p.1), the steel corrosion is an electrochemical process. Not enough studies have been done about the combination of GFRP bars and geo-polymer concrete with different stirrups spacing. So this research has been carried out to determine the effect of these new materials.

## 3. Methodology

Materials which include four beams with GFRP stirrups and one beam with steel stirrups with geo-polymer concrete. To do experimental work, proper preparation is required to achieve better and more accurate results.

After preparation, the test will be done on every single beams. The schematic diagram is shown in figure 1.

## 4. Key Outcomes

According to experimental programme to determine the relationship between applied shear force and deflection and also between flexural strains and

**Figure 1 – Four-point bending test**

different materials and spacing, they all are showing same behaviour; as a result, different spacing does not impact those relationships.

## 5. Further Work

As this research has been carried out just for beams, further studies are needed for columns as well as slabs, so to provide a code for this combination, all aspects of this combination needs to be investigated not only shear behaviour.

## 6. Conclusions

Results showed that different materials and spacing will not affect the relationship of load-deflection as well as load-strain. Moreover, there will be a significant CO<sub>2</sub> gas reduction; as a result, more money will be saved as well as having clearer environment for next generations.

## Acknowledgements

I would like to express my gratitude to Dr. Manalo for his assistance and supervision which led me to the right path wherever I was wrong. Additionally, I appreciate PhD student Ginghamaran who accompany me in testing program.

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# PV Inverter – Voltage Control by Reactive Power

Sponsor - School of Mechanical and Electrical Engineering



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Supervisors: Mr Andreas Helwig and  
Mrs Catherine Hills

**Keywords:** PV Inverter, Voltage regulation.

## 1. Introduction

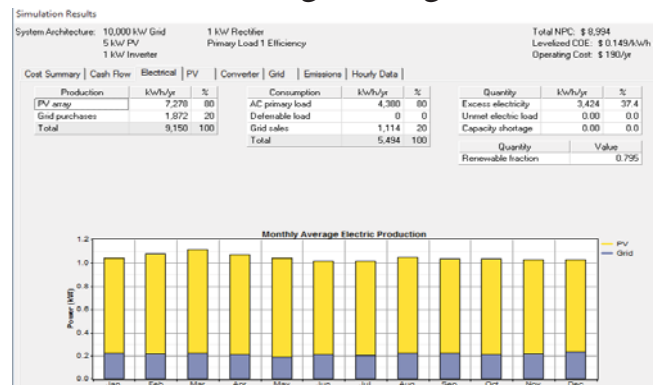
The investigation of the project is aimed to review Photovoltaic (PV) inverter over-voltage problems during peak period solar generation and high local solar penetration rate. The high penetration raise local node voltage value to the maximum and therefore inverters cut-out and turn off export of power.

## 2. Background

Out of the 1.4 billion people of the world who do not have access to electricity, India accounts for about 300 million. Fossil fuels are the main source of energy in India but are not environmental friendly and the national grid often cannot reach the rural areas. The traditional central grid approach to supply electricity to all of India is technically and financially inefficient due to huge capital required. It has a history of insufficient energy generation capacity, age related service reliability issues and construction challenges to connect remote areas. As a result, there is a booming market for renewable energy generation, especially solar PV systems. This includes adequately financed and operated micro grids based on renewable and appropriate resources to overcome challenges facing rural electrification. However, connecting the output of thousands of discrete solar systems to such micro-grids requires overcoming a number of technical challenges. Mismatch of solar energy production to rural load demand daily cycle requires a solution.

## 3. Methodology

The project methodology is initially using HOMER energy to model typical PV systems seasonal response to Indian rural domestic loads to quantify excess solar production that can cause micro-grid voltage rise, and PV inverter cut-out on over voltage. A Simulink model of an inverter is studied and is tested for the best way of voltage regulation aiming to find the best technical



**Figure 1 – HOMER ENERGY simulation result for 5 kW PV with 37% excess energy production over domestic rural consumption.**

and economic way to prevent PV inverter output over-voltage disconnection comparing:

- Reactive power control at the inverter
- Current following control to slide back from maximum power tracking
- Master–slave inverter configurations
- Switchable local deferrable loads to absorb excess demand energy
- Smart communications with the connected weak supply grid to switch on other grid loads

## 4. Key Outcomes

To demonstrate control functions available for inverter configurations, deferrable local loads and begin the process of development of communication protocols suitable to develop SMART-Microgrids in India.

## 5. Further Work

Ongoing development and field testing of power line carrier communications protocols is required in the future to develop the most cost effective hardware to implement SMART-Microgrids in rural India.

## 6. Conclusions

This research project's investigation contributes potential energy saving solutions required for ongoing rural micro-grid development in India.

## Acknowledgements

I would like to acknowledge Andreas Helwig for the actual idea of the project and his and Catherine Hills' guidance and support throughout the project.

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# Finite Element Modelling of Sustainable Hybrid Sandwich Panel under Bending

Sponsor – School of Civil Engineering and Surveying



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Master of Engineering and  
Science (Civil Engineering)

Supervisor: Professor Yan Zhuge

**Keywords:** Finite element modelling (FEM), Hybrid structures, Bending

## 1. Introduction

This research aims to develop a finite element model using Strand 7 to design the bending capacity of different kinds of sandwich composite panels used as structural walls under bending loads in construction. The results from the model will be compared to testing results obtained from the Faculty of Health, Engineering and Science at the University of Southern Queensland.

## 2. Background

Foam core sandwich panels are typically comprised of two high strength face sheets, separated by a polymer foam core bound together to form a panel or sheet which meets both structural and insulation requirements (Briscoe, Mantell and Davidson, 2010). Additionally, the failure mechanisms of the sandwich panel is quite a complex phenomenon as it fails due to failure of one of the materials that comprises the structure (Mamalis, Spentzas, Pentelelis, Manolakos and Ioannides, 2008).

## 3. Methodology

The proposed procedure for the research is outlined as follows:

1. All test results will be obtained from the University of Southern Queensland.
2. Undertake soft core modelling
3. Undertake hard shell modelling
4. Composite section modelling
5. Analysis of the results in Strand7
6. Comparison of the Strand7 results with test results.

## 4. Key Outcomes

By modelling Hybrid Sandwich Panels, it is possible to check how close the testing results are to finite element modelling results. This is done by trying different methods of modelling the sandwich panel in Strand 7 to get closer results to the testing results. Thus, the best modelling method for analysing sandwich panels in Strand 7 is determined.

## 5. Further Work

The modelling of sandwich panel in this program is based on information provided by the University of New South Wales for a specific kind of Hybrid Sandwich Panel (specific materials are used). This information can be used in future to be generalised and come up with modelling methods for any kind of sandwich panel

## 6. Conclusions

This research will develop a finite element model using Strand 7 to design the capacity of different kinds of sandwich composite panels under bending. The results from the model will be compared to testing results obtained from Faculty of Health, Engineering and Science at the University of Southern Queensland.

## Acknowledgements

I thank Professor Yan Zhuge for providing me all the relevant information to be able to complete my project

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# 3D Printing in Construction: embryonic fad or industry gamechanger?

Sponsor – School of Civil Engineering and Surveying



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Supervisors: Dr Steven Goh, USQ

**Keywords:** 3D printing, construction, paradigm shifts

## 1. Introduction

The construction industry is an important one, so much so that it is often used as a vital sign for a nation's well-being. Yet, the construction industry faces many challenges, perhaps the most pressing being the ability to stem the tide of the global housing crisis: providing suitable housing for the world's 7 billion (and growing) people worldwide. Furthermore, such challenges must be done in a way that is both sustainable and safe, a way that current accepted methods of construction have struggled to do. There is clear and growing pressure for the construction industry to innovate and arguably this will be the only way in which it can meet the construction challenges of the future.

## 2. Background

3D printing, or additive manufacturing, is one such innovation that may help the industry to overcome some of its challenges. Indeed, due to its successes in the aerospace and medical areas it is believed by some to be a possible game-changer in the area of construction: drastically decreasing build times, reducing costs and providing a safer more sustainable construction process and product (Koshnevis 2004). Yet despite the promises of 3D print technology in construction and its potential to revolutionise the industry not much is known about it. Is it just a fad? How well developed is the technology? Will it or perhaps even *can* it, change what and how things are done in construction?

## 3. Methodology

This project seeks to contribute to the knowledge of 3D printing in the area of construction in two important ways. Firstly, it endeavors to provide the first

comprehensive review of 3D print technology and how it is used in the field of construction. Additionally, it identifies the research and development currently occurring in construction and related fields. Secondly, by employing a Kuhnian approach (1962) to paradigm shifts, and relying on metaphor theory (Lakoff & Johnson 1980) coupled with discourse analysis it explores ways in which 3D print technology might revolutionise the construction industry.

## 4. Key Outcomes

Results of the review reveal a significant number of proven and developing 3D print technologies are being used in the realm of construction. These technologies use a wide variety of materials from traditional concrete and steel to more exotic materials such as silk and salt. Furthermore, these technologies are being used to produce an increasingly wide range of civil structures: from buildings and bridges to fantastic, architectural proof of concept pavilions (see Figure 1 above). Initial results of the discourse analysis suggest that such technologies may act as a catalyst in changing the dominant world-view of construction as machine (popularized with the systemic approach and mass production in the 1920s) to those that are more organic (agile and evolutionary) and cultural (craft based).

## 5. Further Work

Results are preliminary only, further analysis needs to be conducted and finalised.

## 6. Conclusions

The review suggests that 3D printing in construction has moved beyond the purely embryonic 'fad' stage to what could arguably be called the beginnings of a new industry. Perhaps even more significantly however, the results suggest that 3D printing truly does have the ability to be paradigm shifting: challenging some of the most fundamental assumptions we hold about our built environment and opening a whole new set of possibilities in the construction world.

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## EFFECT OF TIME INTERVAL VARIATIONS ON RTK DERIVED DISTANCES

School of Civil Engineering and Surveying



**Vincent Bein**

Bachelor of Spatial Science  
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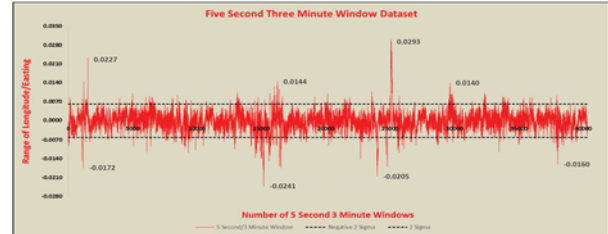


Figure 1 – 5 Seconds Averaged/3 Minute Windowed

Supervisors: Associate Professor Peter  
Gibbins, USQ

**Keywords:** GNSS, RTK, Derived Distances.

### 1. Introduction

Real-time kinematic (RTK) Global Navigation Satellite Systems (GNSS) has been used for cadastral surveying since its inception in 1994. RTK has limitations and capabilities for cadastral surveying (Gibbins & Zahl 2014). Previous research (Janssen, Haasdyk & McElroy 2012) and anecdotal evidence (Spatial Policy of Department of Natural Resources and Mines. *Cadastral Survey Requirements* 2015, Version 7.0) state that when using RTK to obtain a derived distance by observing two points too closely together in time has an effect on the accuracy of the RTK derived distance. The current survey standards require a minimum of 30 minutes elapse before reoccupation of the same points for the purpose of deriving a distance (not measured) between two common points. What effect does time interval variations have on RTK derived distances?

### 2. Methodology

A large amount of RTK GNSS data was collected by utilising the USQ 'Ananga' CORS Site which is located on level 7 of Z-Block. A zero-distance baseline was adopted for the processing strategy and a mathematical model was developed to reduce the data using Microsoft Excel.

Residuals were calculated by differencing the collected epochs of data from the absolute zero distance value baseline. A predetermined number of single epochs of data were averaged and then windowed, also, at varying time intervals. The 95% confidence interval was calculated and then both were plotted on the same graph to visually demonstrate the behaviour of the results. Please see Figure 1.

### 3. Key Outcomes

To achieve an empirical answer on what effect time interval variations has on RTK derived distances.

### 4. Further Work

Further research is required to ascertain if any changes occur to this research as new satellite constellations are introduced and Network RTK (NRTK) areas are expanded across Australia.

### 5. Conclusions

It was found that there is no significant change in the accuracy of an RTK derived line as time between observing the same two points is varied. Therefore, waiting a predetermined time before re-observation of the same points to derive an RTK distance, as suggested by previous research, does not affect the accuracy or precision of an RTK derived distance.

### Acknowledgements

I would like to express my sincere gratitude to Professor Gibbins who has provided me with guidance, encouragement and has always kept my spirits up all through my candidature at the University of Southern Queensland.

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# The use of low-cost photogrammetry techniques to create an accurate model of a human skull.



School of Civil Engineering and Surveying

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(Honours) (Surveying)

Supervisor: Dr Albert Chong, USQ

**Keywords:** Close Range Photogrammetry, Low-Cost Camera, 3D Modelling, Human Skull

## 1. Introduction

There has been increasing interest in low-cost close range photogrammetry techniques for use in a variety of applications. The use of these techniques in medicine, forensic science, architecture, engineering, archaeology and anthropology to record, measure and monitor objects and sites has been growing in recent years. Close range photogrammetry has been particularly investigated and preferred for human body mapping due to being non-contact, non-invasive, accurate, and inexpensive and data is re-measurable.

## 2. Background

Skulls have been traditionally measured using callipers and tape in anthropological study, which is subject to observer error. Close range photogrammetry can be used to perform more accurate measurements and retain a digital copy of the skull, which can be re-used for a number of purposes.

## 3. Methodology

The process for 3D modelling using close range photogrammetry includes camera calibration to determine the camera's internal parameters, photographing the object within a control target frame, and processing the data with photogrammetry software. The model can then be exported to other software, such as a CAD program, if necessary.

## 4. Key Outcomes

Three camera calibrations using two cameras (both Nikon S3700s) were performed to assess differences in the camera parameters and quality of the calibration. The quality of the calibrations varied and the best calibration results was selected for use in the project.

A control target frame was constructed from simple materials and used during the image acquisition. A number of sets of photographs were taken from different angles and processed using Photomodeler software. A number of problems have occurred using the software to



**Image 1 – Model Skull being photographed with target control frame**

generate a Dense Surface Model (DSM), which could be attributed to lighting, surface texture of the skull, target configuration and camera angles.

## 5. Further Work

A number of different strategies are being trialled to overcome the issues mentioned above, such as changing the lighting, dusting the skull with talc powder and experimenting with different camera angles and target configurations.

## 6. Conclusions

Achieving a high precision camera calibration and producing a high-accuracy 3D model were more difficult than anticipated. There are a number of factors which can result in a poor quality models. However, the results show that photogrammetry can be utilised in the capture of accurate 3D skull model using low-cost cameras efficiently. The research was successful.

## Acknowledgements

I would like to thank Dr Albert Chong immensely for his support and assistance during this project, and acknowledge SSSI for their support this year.

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# Vehicle Energy Systems

Sponsor – School of Mechanical and Electrical Engineering



## Andrew Bellars

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Supervisors: Dr Ray Malpress, USQ

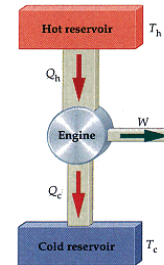


Figure 1 – Heat flow Diagram

## 1. Introduction

Waste heat from exhaust gases and cooling systems of internal combustion engines can be an important heat source to provide additional power and improve engine overall efficiency. Almost  $\frac{3}{4}$  of the heat generated by fuel in an internal combustion engine is either released into the exhaust system or dissipated by the cooling system. With energy sustainability at the forefront of social concerns there is a pressing need to develop technologies that more efficiently use our finite fossil fuel reserves. This project focuses mainly on the design of an exhaust gas heat thermal generator but also considers and suggests other potential areas of thermal waste recycling in an automotive context.

## 2. Background

In order to extract power from a heat engine that operates on a cycle. Heat has to flow between a hot and a cold source. It is unavoidable that some heat will have to be released into the exhaust system (figure 1). Developments in thermal electric generator technology (TEG) has made converting low temperature, low quality waste thermal energy directly into electrical power a promising prospect. Previously ignored waste thermal energy could potentially be recycled and used for numerous applications.

## 3. Methodology

A design of an Exhaust gas thermal electric generator is proposed. A computer simulation using CFD software ANSYS 16.1 is conducted to estimate the expected performance of the system. State of the art thermal electric generator technology is analysed and investigated. A unique new class of thermoelectric module using the Seebeck effect is available through Thermal Electronics Corporation (BiTe-PbTe hybrid). This component is used in the proposed design of the exhaust gas TEG.

## 4. Key Outcomes

It is proposed that the TEG output be used to charge the vehicle battery and thereby replacing the conventional vehicle charging system. Additionally due to the continuous nature of the electrical power output it is proposed that electrical power also be utilised to power a hydrogen generation unit. This would allow a controlled amount of hydrogen back into the engine under light throttle and lean burn conditions. Thereby improving fuel economy and thermal efficiency under these conditions.

## 5. Further work

The proposed exhaust gas TEG configuration is only a design in principle and has not been optimised or tested for maximum performance.

## 6. Conclusions

The TEG design presented is a suitable substitute for a conventional charging system. Additionally there appears to be extensive fuel economy and emissions benefits in electrolysis driven hydrogen-hydrocarbon fuel co-combustion.

## Acknowledgements

I would like to acknowledge Dr Ray Malpress for his assistance and guidance in the preparation of this dissertation as well as assistance with CFD modelling.

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# Use of Fibre-Optic (FBG) Sensors in Structural Health Monitoring – High Grade Reinforced Concrete Beams



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Supervisors: Dr Jayantha Epaarachchi, USQ  
Dr Sourish Banerjee, USQ

**Keywords:** Structural Health Monitoring

## 1. Introduction

Due to natural disasters such as fires, floods and terrorist activities some critical civil infrastructures are exposed to extreme loading conditions and/or extreme temperatures. After such exposure these structures may become unsafe for general use. Currently there are limited mechanisms to evaluate the integrity of these structures after such disasters. Fibre Bragg Grating (FBG) Sensors could be used as an in-situ sensing system to review the structural health of these damaged structures.

## 2. Background

There has been limited research regarding the embedding of FBG Sensors within a concrete structure. If a design can be made to ensure the movement of the FBG Sensors coincide with the movement of the concrete structure, this is a technique that can be utilised for monitoring structural health and integrity of concrete worldwide. The utilisation of this technique would, however, depend on necessity and affordability.

## 3. Methodology

A reinforced concrete beam was chosen as the structure to be analysed. The structure was analysed whilst curing, whilst subjected to fire, and whilst subjected to a three point bending test. Three dimensional static and thermal models of the beam were created in Abaqus/CAE. These models were used to determine the locations of the most critical stresses, strains and temperatures. Fibre-Optic Sensors, thermocouples and strain gauges were then placed throughout the beam



**Figure 1 – Protective FBG Sensor Encasing Successfully Bonded to Concrete**

structure accordingly as measuring devices. A method of encasing the FBG Sensor in a way that it is adequately protected and bonded with the concrete was determined.

## 4. Key Outcomes

The reliability of the FBG Sensor data was compared with the thermocouple and strain gauge data, as well as with the data from the three dimensional models. The unique FBG Sensor encasing method tested is ideal as the sensor is in fact encased in the same concrete that the FBG Sensor was embedded in.

## 5. Further Work

Only replicas of the sensor wire have been embedded in the beam with this unique concrete encasing. Further work would include the embedding of an actual FBG Sensor encased with this technique.

## 6. Conclusions

If encased appropriately FBG Sensors are a viable method for in-situ structural health monitoring of concrete structures. My concrete encasing technique could be an ideal method for industry.

## Acknowledgements

I would like to acknowledge the assistance and contribution of all that have aided the development of this dissertation. A special thank-you to my supervisors Jayantha Epaarachchi and Sourish Banerjee who have been invaluable throughout the duration of this project.

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# An investigation on the properties of Epoxy-based Polymer Concrete

School of Civil Engineering and Surveying



**Amy Beutel**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Allan Manalo, USQ

**Keywords:** Epoxy resin, Polymer Concrete, Coarse Aggregate.

## 1. Introduction

Normal concrete is known to be weak in tensile, brittle and is less durable. This disadvantages can be solve by using polymer concrete. Polymer concrete is a “concrete in which the binder is an organic polymer; a construction and structural material that is a solidified mixture of macro molecular substance with a mineral aggregate” (Technologie, 2009). With such improved qualities, polymer concrete is becoming a fast growing area of research. However, there is still very limited studies conducted on epoxy based polymer concrete, which is the focused of the current project

## 2. Background

Polymer Concrete is progressing in leaps and bounds, however this type of concrete is still more expensive than the normal concrete. In order to minimise cost, aggregates can be added to the epoxy-based resin. However, there is very limited studies conducted on this area. This project aims at understanding the effect of adding aggregates on the physical and mechanical properties of epoxy based polymer concrete

## 3. Methodology

To achieve the project objectives, this project was conducted in three stages:

Stage 1: Determination of appropriate resin to filler mix

Seven cylindrical specimens with varying resin to filler ratio (0 to 60%) and 30% of course aggregates by volume were mixed. The cylinders were cut and visually inspected to determine the mix that will dispersed the course aggregates evenly within the mix.

Stage 2: Characterisation of epoxy based polymer with varying amount of course aggregates

The appropriate epoxy matrix determined from Stage 1 were added with aggregates from 0 to 30% by

volume. Characterisation of the compressive, flexural and splitting properties were then conducted

Stage 3: Development of empirical equation

The results of the extensive characterisation in Stage 2 will be analysed to develop an empirical equation that will describe the mechanical properties of epoxy based polymer concrete.

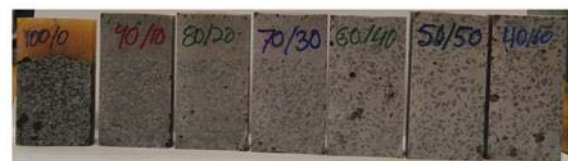


Figure 1 - Study 1 Consistency Check

## 4. Key Outcomes

The key outcomes of this project up to date are the following:

- Epoxy to filler ratio of 40:60 gives a consistent mix with minimal voids% as shown in Figure 1.
- Preliminary analysis indicates that there the addition of coarse aggregates has no significant effect on the mechanical properties of epoxy based polymer concrete

## 5. Further Work

Detailed analysis of Stage 2 is still being conducted. Once this is completed, the empirical equation for epoxy based polymer concrete can be established

## 6. Conclusions

Preliminary results indicated that the addition of coarse aggregates does not decrease the mechanical properties of epoxy-based polymer concrete suggesting that this is a good way to lessen the cost of this type of concrete.

## Acknowledgements

I would like to thank my supervisor and Md Wahid Ferdous for their guidance in this project.

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# Evaluation of the performance of two different global satellite navigation systems, Trimble's CenterPoint RTX and a conventional RTK system

School of Civil Engineering and Surveying



**Richard Boylan**

Bachelor of Spatial Science  
(Honours) (Surveying)

Supervisor: Dr Zhenyu Zhang, USQ

**Keywords:** RTX, RTK, GNSS

## 1. Introduction

Trimble RTX (Real Time eXtended) technology was first introduced in mid-2011. The aim of this project is to test the accuracies that can be achieved from comparing the new RTX solution to a conventional RTK solution on known SCIMS marks as determined by the LPI NSW.

## 2. Background

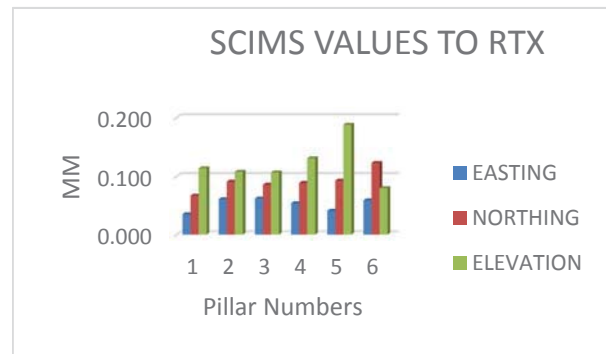
As this technology is relatively new in regards to whole GNSS industry actual field testing has been limited, therefore I feel it is a worthy and important concept to compare field results against stated accuracies in equipment whitepapers. This project gave me more appreciation for all the elements involved getting fixed solution using GNSS technology.

## 3. Methodology

The Methodology for this project involves applying a literature review to establish what testing of this technology has been conducted. From this I conducted two sets of field tests to derive results and analyse this data from which I could make conclusions and recommendations. The results from my second tests can be seen in Figure 1.

## 4. Key Outcomes

Trimble CenterPoint RTX is quoted as having an accuracy of Horizontal 40 mm Vertical 90 mm RTX convergence time for specified precisions 30 minutes or less. I found my RTX results did not fall within these quoted accuracies while my RTK results were closer to stated accuracies of Horizontal 8 mm + 1 ppm RMS, Vertical 15 mm + 1 ppm RMS. The reasons for not achieving the results within these parameters are discussed within the project.



## 5. Further Work

As new models become available for satellite corrections it would be interesting to conduct testing on new accuracies. Also if the augmentation network extends and becomes available worldwide it would be good to test the accuracies and initialisation times within this network.

## 6. Conclusions

The key outcome to this project is that while this new technology is progressing rapidly the accuracies and initialisation times are not at the point yet where the technology is ready for the surveying industry although this technology is more than capable for the agricultural industry.

## Acknowledgements

I would like to thank my supervisor Dr. Zhenyu Zhang for supervising me throughout this project and I would like to thank my family for their patience throughout this project. The equipment to conduct these tests was provided by Ultimate Positioning Group who I would like to thank for their time and support.

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# The Effect of Fibres on the Properties of Concrete with Oil Contaminated Sand

School of Civil Engineering and Surveying



**Ashleigh Braden**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Allan Manalo, USQ  
Dr Weena Lokuge, USQ

**Keywords:** Concrete, Crude-Oil, Fibres

## 1. Introduction

Today, petroleum hydrocarbon (PHC) contaminated sand contributes to a significant fraction of waste materials in the environment. Various methods exist for the treatment PHC-polluted sand, however, most solutions are unsustainable. Several researches have been conducted to determine the feasibility on the use of crude oil impacted sand (COIS) in concrete and noted a reduction in compressive strength. The introduction of fibres is offered as a solution to modify and enhance the mechanical properties and behaviour of oil impacted concrete.

## 2. Background

The worldwide energy consumption projected to increase by more than 40% by 2035. With increasing oil production due to high demand, sand contamination has become a problem. The use of these waste materials in concrete would contribute towards a cleaner environment. A better understanding on the properties of this emerging material is however needed to provide useful information and evaluate their beneficial use in engineering and construction. This is the main focus of the current study.

## 3. Methodology

A three stage testing program was employed. Stage 1 tested specimens containing 0%-20% (by weight of sand) oil contaminated sand under compressive loading to investigate the effects of oil contamination on concrete properties and determine the extent of oil contamination that is still viable for use in construction. Stage 2 investigated the compressive and flexural properties of concrete selected from Stage 1 with four

different types of fibres (Figure 1). Stage 3 tested the concrete with different dosages of the best performing fibre from Stage 2 to determine the optimum dosage rate in concrete selected from Stage 1.



**Figure 1: Fibre Types**

## 4. Key Outcomes

Some key results of the study are the following:

- Up to 10% oil contamination was deemed suitable for use in construction as higher oil content caused unfavourable physical properties and considerable loss in strength.
- Steel fibre was the best among the fibres considered to enhance the mechanical properties of concrete with 10% oil contamination.
- Increasing the amount of steel fibres did not greatly improve the strength of concrete with 10% oil contamination.

## 5. Further Work

Further analysis is required to support findings and the optimum steel fibre dosage needs to be determined.

## 6. Conclusions

Oil contaminated sand greatly affects both the physical and mechanical properties of concrete. The fibres investigated did not have a significant impact on 10% oil contaminated concrete's properties.

## Acknowledgements

I would like to thank my supervisors and Rajab Abousnina for their ongoing support and advice.

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# The Impact of the Construction Management Process on Lifecycle Asset Management



**Nathan Brown**

Bachelor of Construction (Honours) (Management)

Supervisors: Dr David Thorpe, USQ

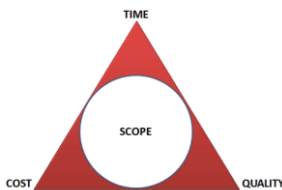
**Keywords:** Iron Triangle, Asset Lifecycle, Project Management Body of Knowledge.

## 1. Introduction

The research project that is being undertaken involves a review of the current available literature relating to the projects topic. This is being done to identify the gaps within the literature. Furthermore, the project will investigate into how other relevant professionals within the industry, such as project managers and engineers, view the issue of how the construction management process impacts upon the lifecycle asset management, as well as their opinion on the gaps in literature, highlighted earlier in the project.

## 2. Background

One of the potential outcomes includes the project formulating a basis document for other professionals in the industry to use when enquiring into how their construction management process will impact their assets lifecycle management. Seen as the project is reviewing available literature and key areas of importance to the topic, such as the principles of the “Iron Triangle” (an example diagram for which can be seen in Figure 1), the project will include in its review detailed information on these principles, helping inform industry professionals that may be unbeknown to these principles.



**Figure 1: Iron Triangle (HPA 2015)**

## 3. Methodology

To summarise the projects methodology, the project was divided up into four phases; the research phase, survey discharge phase, survey collection phase, and finally the write-up phase. Due to complications with the project surveys, the project is still currently in the survey discharge

phase, as the surveys are still waiting on ethics committee approval.

## 4. Key Outcomes

Although the project will assist in formulating a basis document for other industry professionals to refer to, the project will also identify what a re-designed Iron Triangle could look like. Furthermore, the project will also highlight what industry professionals believe an asset lifecycle incorporates. Finally, the most beneficial key outcome for the project to accomplish is to formulate an answer to the topic question itself, ‘The Impact of the Construction Management Process on Lifecycle Asset Management’. To date, the project has identified possible re-designed Iron Triangle’s and the different asset lifecycle’s through its literature review, but at this present time is unavailable to draw conclusions as survey results have not been received yet. These outcomes will be unique as the available literature revealed that there are a number of different re-designed Iron Triangle ideas and asset lifecycles, this provides inconsistency between the application of these theories. The projects methodology was applied to help achieve these outcomes as the project has been completed by following the different phases laid out by the projects methodology.

## 5. Further Work

As previously mentioned, the project is still in its survey discharge phase due to complications with releasing the surveys. This leaves two phases of the project to go; the survey collection phase and the write-up phase. There is also some minor work to be done to the literature review as there are some smaller areas of interest, such as sustainability, that are going to be looked into.

## 6. Conclusions

As the project is not yet complete conclusions are difficult to formulate. The key message that should be taken away from the project upon completion is the result from the key outcome of the project, which to reiterate is to formulate a result of what is the impact of the construction management process on lifecycle asset management.

## Acknowledgements

Special thanks would go out to my supervisor, Dr David Thorpe, for his support and guidance throughout this project, as well as making time for contact meetings. Finally, I would like to thank Ebbesen & Hope (2013) and Ec Harris (2014) for their Iron Triangle and Asset Lifecycle examples as I have used those as my base examples for these principles.

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- Ec Harris (2014), *The Asset Life Cycle*.

# Recycled Rubber Access Cover Riser

Townsville City Council



**Michael Browne**

Bachelor of Engineering (Civil)

Supervisors: 1. Dr Kazem Ghabraie, USQ  
2. Mr Michael Matthews, TCC

**Keywords:** Recycled Rubber, Access Cover, Riser

## 1. Introduction

The aim of this project is to design a recycled rubber access cover riser (RAC) for raising existing stormwater and sewer covers during asphalt overlays. The RAC will predominantly be installed in road carriageways and will be subject to AS 3996 Class D loadings. The riser will be a permanent, low cost and non-destructive alternative to cover removal and replacement treatments. This is a research project that is focused on product development.

## 2. Background

Townsville City Council's (TCC) Construction unit delivers an annual asphalt overlay programme which is worth \$9.0 million. An ancillary activity of asphalt overlays is stormwater and sewer access cover (AC) rising. The existing cast iron AC must be removed and reinstated to the new road surface level being the thickness of the overlay. Traditionally this treatment is by destructive removal of the existing AC and installation of a new circular cast iron AC to the finished surface level. TCC spent approximately \$70,000.00 raising AC in their 2014/2015 programme.

## 3. Methodology

The design methodology was to investigate the problems and opportunities for AC treatments including TCC existing procedures and costs. Furthermore, the structural and material design standards (AS 3996 and AS 5100) were researched. Then design and modelling was undertaken including material and structural analysis using AutoCAD and Strand7. Detailed design drawings, assembly drawings and cost estimates will be produced for reporting.

## 4. Key Outcomes

There are similar products available on the market however all have limitations. An inspection of TCC current AC raising treatment was conducted and the cost was \$3500.00 to \$8930.00 per manhole. KN Rubber produces a commercially available recycled rubber material that is the Symar Load Bearing Pad. Analysis was performed using non-linear Mooney-

Stretch, $\lambda_U$	Nominal Stress, $S_u$ (Mpa)	k = 1					
		Eq. 8	Eq. 9	Eq. 8	$C_1$	$C_2$	$C_c$
0.864	-2	-0.9486	-1.0975	-0.9486	-0.8999	-1.0411	1.8972
0.776	-4	-1.7709	-2.2826	-1.7709	-3.1362	-4.0424	7.0838
0.713	-6	-2.5034	-3.5092	-2.5034	-6.2668	-8.7849	15.0202
0.664	-8	-3.2087	-4.8326	-3.2087	-10.2958	-15.5064	25.6696
0.624	-10	-3.8943	-6.2440	-3.8943	-15.1653	-24.3156	38.9426
0.591	-12	-4.5474	-7.6965	-4.5474	-20.6791	-34.9993	54.5691
0.504	-20	-6.8522	-13.5848	-6.8522	-46.9524	-93.0854	137.0437
0.391	-40	-12.3343	-31.5856	-12.3343	-152.1349	-389.5857	493.3719
0.322	-60	-18.6380	-57.8709	-18.6380	-347.3733	-1078.5949	1118.2772
0.276	-80	-25.7127	-93.1788	-25.7127	-661.1406	-2395.8735	2057.0124
					-1264.0443	-4045.8291	3948.8877

**Table 1 – Calculation of Mooney-Rivlin Coefficients**

Rivlin theory and KN Rubber material data. Refer to Table 1. There will be two products both 1000.0 mm diameter, in two thicknesses of 31.75 mm and 50.8 mm which will be suitable for DG10 30.0 mm and DG14 50.0 mm asphalt overlays. To date preliminary modelling using Strand7 satisfies AS 3996 Access Covers and Grates requirements.

## 5. Further Work

The remaining project work is mainly finalisation of the detailed design and modelling. Design reporting is currently partially complete. Material testing is required to confirm material properties used in the current design.

## 6. Conclusions

The aim of this project is to design a recycled rubber access cover riser for raising existing stormwater and sewer covers during asphalt overlays. Design and modelling was performed in Strand7. There is an opportunity to develop a simple and cost effective treatment for raising stormwater and sewer manhole AC. This research will ultimately present a product that can be used by municipal companies for treating these services during asphalt works.

## Acknowledgements

Thank you to Nick Sabatini from KN Rubber for providing material property data for their range of Symar Load Bearing Pads. Thank you to the Townsville City Council for providing treatment information, approval to conduct inspections and costing data for its current AC treatment.

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# Design and Refinement of a Mechanical Lift System for a Two-Wheeled Tractor

School of Mechanical and Electrical Engineering



**Amy Brumpton**

Bachelor of Engineering  
(Honours) (Mechanical)



Figure 1 – Two wheeled tractor

Supervisors: Dr Guangnan Chen, USQ  
Mr Jeff Esdaile, Agricultural  
Consultant

**Keywords:** Design, third world countries, lift system

## 1. Introduction

Third world countries rely on farming as a source of income. A tractor that is cheap and reliable would be a great advancement for farming within third world countries, which is why a two wheeled tractor has been designed and prototypes made.

It is the aim of this project to develop a reliable and cheap lift system for the farming implement that is attached to the two wheeled tractor, to make it more user friendly. Various lift systems will be compared and a final design will be decided and may be used as a prototype on the two wheeled tractor.

## 2. Background

Within third world countries, four wheel tractors are too expensive for farmers to buy, relying instead on animals pulling their farming implements. A two wheel tractor was thought up and designed, so that a cheap alternative to a tractor was available to the farmers in these countries. Initially, the tractor was quite primitive and the person was made to walk behind the tractor so as to control it. The two wheeled tractor has been improved upon over the years; however, a reliable and inexpensive lift system is still to be found.

## 3. Methodology

A literature review was conducted so as to show an understanding of basic farming practices and to analyse the various lift systems that are available and look at the advantages and disadvantages of each system. A lift system design that is found to be suitable will be reviewed by the project sponsor and then refined. The refined design will then be drawn up within SolidWorks and an analysis made on this design. The design modification considerations such as cost, design life and user requirements will also be analysed.

## 4. Key Outcomes

The required outcome is to find a reliable lift system that is inexpensive to produce and maintain. It has been found that a lift system that includes any form of hydraulics would be too difficult to maintain within third world countries, and could be very expensive to fix if it breaks. A lift system that includes some sort of clutch is still being looked at, however it is not a priority as it can be very expensive to produce.

## 5. Further Work

Further refinement of the lift design and the SolidWorks drawing and Finite Element Analysis of the completed system are still underway.

## 6. Conclusions

I am still to have the design reviewed by the project sponsor, however, it has been concluded that a manual lift system that is helped by mechanical implements such as sprockets that will gear down the amount of effort needed to lift the tines, will be top priority for a prototype lift system.

## Acknowledgements

I would like to thank Dr Guangnan Chen for his helpful guidance and his expertise in the agricultural areas of this project. I would also like to thank the project sponsor Mr Jeff Esdaile for giving me the opportunity to do this project and his vast knowledge on anything agricultural.

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# Designing and Building a Quest-Based User Interface for Remotely Accessible Experiments for Science Education in Schools

School of Mechanical and Electrical Engineering



**Ryan Burtenshaw**

Bachelor of Engineering (Honours)  
(Computer Systems)

Supervisor: Dr Alexander Kist, USQ

**Keywords:** Remote Access Laboratories, Software Development, STEM Learning, Active Learning

## Introduction

As the world becomes more dependent and centred around technology and the sciences connected to it, it is imperative that Australia's input into this ever-changing stream grow as well, to help shape the course of future technologies and developments across all areas.

To this end, the Remote Assistant Laboratories (RAL), located at USQ, have sought to create a user interface for many pre-existing and future experiments in an effort to provide students of all ages with access to activities that provide academic merit and encourage interest in Science, Technology, Engineering and Mathematics (STEM) subjects, by providing a system that actively engages them while imparting knowledge.

## Background

A recent review of Australia's higher education department, showed a distinct drop in the number of students following through to tertiary education and higher learning. This correlates to a lack of interest in these subjects, or an understanding of them which does not encourage further learning or thinking on the students behalf. By engaging these students in a more active learning style rather than a traditional, 'stand and teach' methods it is hoped that more will see the benefits or pursuing a career in STEM fields.

## Methodology

This interface, known as the User Centered Activity System (UCAS), was built using a developmental method called Agile, which focuses on constructing each defined user task as a 'module'. This allows testing of each function before they are assembled together as the final product.

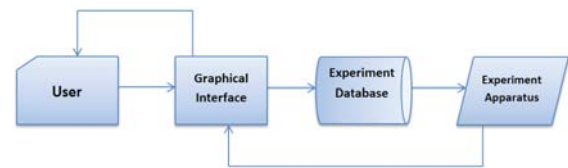


Figure 1 – User Access Flowchart

## Key Outcomes

Key outcomes of the project were addressed in the current release of the UCAS, giving the user access to pre-existing activities, these functions serve as a base for a future expansion of the system that will allow users to contribute, share and develop community engagement.

## Further Work

The development of the RAL and the associated user interface is ongoing, dedicated members of staff and students at USQ will continue to expand the experience and depth of learning both through hands-on help and by user feedback.

## Conclusions

The need for education, especially higher level education is growing by the day, as the collective understanding of science and technology expand exponentially. The creation of this interface will facilitate comprehension and create interest in STEM fields, allowing users of any skill to participate and contribute to physical and virtual experiments, and the activities associated with them, in a self-driven and active learning environment.

## Acknowledgements

Many thanks to Dr. Alexander Kist, along with RAL team, for offering assistance, guidance and encouragement throughout the process this project has followed.

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# Road Safety Barrier Treatment Selection

Sponsor – Harrison Infrastructure Group



**Victor Burtenshaw**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Mr Ron Ayers, USQ

Mr Tony Gallagher, Harrison  
Infrastructure Group

**Keywords:** Road, Safety, Barrier

## 1. Introduction

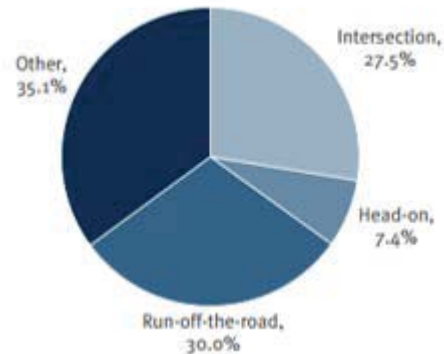
The purpose behind this project is to provide research, modelling and analysis of safety barriers to assist in the identification of the most appropriate road safety barrier treatment, especially for levels 3-6. This project will consider a safety barrier's function and capability in the containment of heavy vehicles and provide advice on the justification for a specific barrier based on performance characteristics in relation to traffic volumes, speed, angle of incident, contextual road geometry and traffic composition.

## 2. Background

There has been a significant increase in the traffic composition of heavy vehicles on our roads and this research project is intended to conduct investigations and analyses into when and how to use the different testing levels in determining the appropriate safety barrier treatment. There is a shortage in the technical data. For example, data surrounding whether a Test Level 4 (TL4) safety barrier will contain a semi-trailer or B-double and will there be a reduction in the severity of the accident. Also, in relation to heavy vehicles, when do you use TL5 or TL6 and under what conditions.

## 3. Methodology

1. Literature review – barrier type and selection
2. Site selection and investigation
3. Crash Data Analysis – relating to barrier type and placement
4. Roadside Hazard & Road Safety Barrier analysis
5. Consultation - range of key stakeholders
6. Model Development
7. Second Site Selection and Trial
8. Quantifying and Cost Comparison



**Figure 1: Serious casualties as a result of crashes by crash type - 2008-2012**

Source: TMR: Road Safety Action Plan 2013-2015

## 4. Key Outcomes

The identification and description of the types of safety barriers currently available along with their testing levels. A review and site application of current hazard assessment procedures in determining the need for a barrier and selecting an appropriate type of barrier.

## 5. Conclusions

This project aims to develop a set of recommendations for the appropriate selection and placement of current safety barriers in limiting fatal or serious injuries in run-off-road crashes, especially in relation to heavy vehicles.

## Acknowledgements

I would like to acknowledge Mr Ron Ayers (USQ supervisor) for his invaluable experience and patience.

I would also like to acknowledge Mr Tony Gallagher's support and sponsorship of me over the last 12 months.

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# Asset Management Framework for NSW Local Government

Sponsor – Cabonne Council, NSW



**Michael Butler**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr David Thorpe, USQ

**Keywords:** Asset Management, Local Government, Framework

## 1. Introduction

Modern societies rely heavily on engineering infrastructure to underpin the fabric of society for transport, communication, water supply or waste disposal. Effective management of this infrastructure is essential to ensure sustainability in an environment of scarce global resources and limited economic means. In Australia, the majority of infrastructure assets are managed and maintained by the Local Government. This study reviews the currently recommended best practice within Australia and will then be used to propose a simplified framework that can be used by a NSW Local Government Organisation to implement a best practice framework or benchmark current practice.

## 2. Background

The International Infrastructure Management Manual (IIMM) states that the objective of asset management is “to meet a required level of service, in the most cost effective manner, through the management of assets for present and future customers.” The Local Government delivers services to the local community utilising public funds, thus both understanding the level of service required by the community and responsibly using funds to achieve that is the highest priority. The NSW State Government currently has a particular focus on sustainable, fit-for-purpose local government systems generating a greater demand for Local Governments to thoroughly understand their infrastructure and manage it appropriately.

## 3. Methodology

This study has reviewed the currently endorsed best practice methodology at the national level through recommendations by the Institute of Public Works Engineers Australia (IPWEA). Each states requirements have then been reviewed and case studies of government entities within NSW are underway. The findings of the research and case studies will be used to



**Figure 1 – IP&R Framework (2012)**

generate a framework for local government, with trials being undertaken should time permit.

## 4. Key Outcomes

The key outcome of this project is a framework that is easily understandable and usable to adopt best asset management practice within a local government organisation, or to benchmark existing practice against.

## 5. Further Work

This study is in the process of undertaking case studies; once completed, the framework will be developed and, if time permits, trialled within Cabonne Council.

## 6. Conclusions

Local Government Engineers are responsible for the efficient and effective management of public infrastructure. Sustainable management is key to meeting community objectives, and requires a robust framework to ensure continuity in the long term between council terms and staff turnover.

## Acknowledgements

The support and access to information provided by the Cabonne Council Engineering Department has been invaluable in the undertaking of this study. The openness and willingness of other Government Organisations has increased the quality and scope of this study

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# An Analysis of Kinetic Energy Recovery Systems and their potential for contemporary Internal Combustion Engine powered vehicles

School of Mechanical and Electrical Engineering



**Steven Carlin**

Bachelor of Engineering  
(Honours) (Mechanical)

Supervisor: Dr Ray Malpress, USQ

**Keywords:** Kinetic Energy Recovery, Regenerative Braking, Vehicle

## 1. Introduction

Kinetic energy recovery (or regenerative braking) is the concept of recovering energy that would otherwise be dissipated into the atmosphere, from a vehicle under braking conditions. This energy can be stored for later use and in most cases it utilised to accelerate the vehicle again when required. An effective system can have both economic and environmental advantages by increasing vehicle performance and efficiency.

This project aims to explore the potential role of kinetic energy recovery systems in the future, and if possible, develop and cost effective, feasible system for Internal Combustion Engine powered vehicles which can be easily implemented and potentially retrofitted to existing light commercial vehicles.

## 2. Background

Whether we like it or not, we live in a society dominated by vehicles. Oil shortages are expected to occur within the next 50 years and with no source of energy technologically viable to take its place, it is necessary to make vehicles more efficient to conserve energy. Kinetic Energy Recovery can reduce fuel consumption and reduce emissions.

Electric hybrid vehicles are the most commonly used kinetic energy recovery solution. These vehicles are effective for small, low energy applications, but not so much for larger applications, where more kinetic energy is available to be recovered. Research suggests that electrical systems are not effective for applications that require not only high energy density, but also power density.

There have been many mechanical technologies that have been of both commercial and academic interest in recent times. Flywheel, hydraulic and compressed gas have been the most prominent technologies.

## 3. Methodology

A literature review of current mechanical kinetic energy recovery systems was carried out. Both theoretical and practical examples were reviewed focussing on feasibility, cost-effectiveness and ease of implementation. Specific design requirements and constraints were developed for eligible vehicles and the technologies were analysed from a retrofit stance. A technology was chosen and a system was designed to suit current light commercial vehicles. The fuel savings are to be modelled based on simulation and a cost benefit analysis is to be performed to assess to overall viability of the technology for existing light commercial vehicles.

## 4. Key Outcomes

The literature review was completed and revealed that flywheel technology holds the most potential of the technologies researched. The available braking energy under typical braking events was determined and the theory of operation was developed. A suitable flywheel system was designed to meet the specifications developed earlier in the project and transmission options were explored.

## 5. Further Work

Completion of the modelling of the regenerative braking system is still required. The functionality of this system will then be simulated using Matlab and existing drive cycles to assess the fuel saving potential of the technology.

There are further opportunities for optimisation of the current design and quantifying the environmental benefits of the technology. Testing is also an area that could use further work to establish failure behaviours.

## 6. Conclusions

Flywheel based regenerative braking for light commercial vehicles appears to be a conceptually viable technology. Further simulations and system cost calculations will be required before a final cost-benefit assessment can be made and a payback period can be established.

## Acknowledgements

I would like to thank Dr. Ray Malpress for his support and guidance throughout this project.

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# Stability of Square and Rectangular Tunnel in Undrained Clay

Sponsor –School of Civil Engineering and Surveying

## Student Name



Master of Engineering Science  
(Structural)

Supervisors: Dr Jim Shiau,  
USQ

**Keywords:** *Stability, Tunnel, Factor of Safety, Undrained Clay, FLAC*

## 1. Introduction

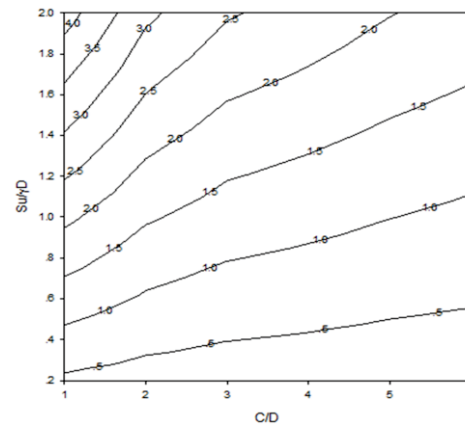
This paper investigates the stability of square and wide rectangular tunnel in undrained clay. A strength reduction technique and the difference program FLAC are used to determine the factor of safety. Results from the FLAC are compared with rigorous upper and lower bound analysis. The model is shown accurately, design charts are presented for a wide range of practical scenarios using dimensionless.

## 2. Background

The tunnel is a kind of underground engineering structure and it is also a kind of form that people make full use of underground space. As the development of city construction, the growing demand from increased urbanization and population has led to a trend of moving the civil infrastructure underground. With limited scope for changing above ground, there is an increasingly common solution for this limitation, which is to move transport and infrastructure underground by using tunnels. With the development of science and people demands, we can combine the theory and practice to use in tunnel.

## 3. Methodology

Tunnel is a complex phenomenon and soil mechanics also has been a complex and uncertain discipline. With the development of computer technique, the shear strength reduction methodology is used to solve the problem in this research. The shear strength of the material is reduced until the limiting condition is found. The factor of safety for cases is computed through finite difference code by the computer program FLAC. Rigorous lower and upper bound technique proposed by Lysmer (1970), Anderheggen and Knopfel (1972) is one of reliable methods used in geotechnical engineering.



## 4. Key Outcomes

I learn to use strength reduction method to investigate the stability of different tunnels and compare with rigorous upper and lower bound analysis. I learn the program and how to use this program to get the solutions, and produce comprehensive stability charts tunnels.

## 5. Further Work

In the future, I will apply the strength reduction technique to the stability analyses of twin circular tunnels, and create stability charts for practical design uses under different material properties.

## 6. Conclusions

Stability of tunnels was investigated in this paper using a factor of safety approach. The results from both a finite difference method and a rigorous upper and lower bound limit analysis were very promising. The factor of safety provides direct information and understanding of tunnel stability.

## Acknowledgements

Appreciation is given to Mathew Sams and Brian Lamb from USQ Tunnelling Research Group led by Dr. Jim Shiau who developed the FISH codes for square and rectangular tunnels making this project possible.

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## COMPARISON OF CONCRETE PAVEMENT WITH ASPHALT PAVEMENT USING FINITE ELEMENT METHOD



**SAJEEL  
CHERAKADAVATH**

Master in Engineering Science  
Civil Engineering

Supervisors: Dr.HABIB ALEHOSSEIN, USQ

**Keywords:** concrete pavement, asphalt pavement, finite element method

### 1. Introduction

Previously, design and analysis of pavements had been gave employing flexible characteristics of pavement layers. So it is larger to substitute design and analysis of pavements alongside fast and influential multimedia encompassing finite element. The finite element method need less computational manipulation and extra suitable for constant environments. So in this discover of numerical 3D modelling of concrete pavement and asphalt pavement was gave to computer program code "Abaqus". Several supplementary methods of 2D modelling were applied for determination of the stress and strain in pavement. In the end the consequence of 3D modelling are contrasted amid both concrete pavement and asphalt pavement. The analogy displays good correspondence even though the 3D modelling gives consequence somewhat lower than 2D method in stress.

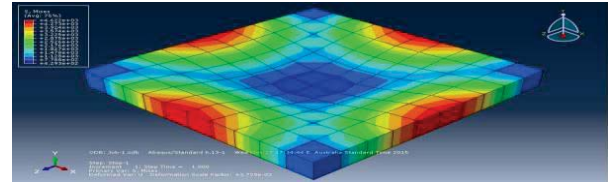
### 2. Background

Rigid pavement system consist Portland cement concrete slabs, finite in length and width over one or more foundation. Then it is subjected to wheel load it develop bending stress and distributes the load over the foundation. Response of this slab is controlled by joint. The response and effectiveness of joint are considered in design and analysis of rigid pavement. A pavement is described as a moderately stable crust constructed above the soil for the intention of supporting and allocating the wheel loads and gives an adequate wearing surface. The flexible pavements encompass of wearing surface built above a base course and they rest on compacted sub grade. The flexible pavements are able to challenge merely very small tensile stresses.

### 3. Methodology

In abaqus software, a solid foundation was utilized, which is extra realistic even though this modelling needs extra recollection for the resolution. The solid foundation is extra realistic than the fluid foundation, because the deflection in each nodal point depends not merely on the force in this node but also of the force in all the supplementary nodes. Abaqus gives more element type which are usefull for pavement analysis. An infinite element model can be used to model the infinite boundary in horizontal and vertical directions

in pavement system. It includes material models like linear elastic, viscoelastic, hypoelastic and elastoplastic models. Is also calculate values of stress and strain



### 4. Key Outcomes

I have gone through most of literature regarding finite element analysis and Abaqus software. As a first step I have made simple modelling of pavement with 1 metre \* 1 metre\* 10cm dimension with all four sides are fixed. I have applied load of 720Kpa.

### 5. Further Work

In future I will analysis both concrete and asphalt pavement with all layer and its stress, strain and displacement distribution are analysed using FEA code Abaqus and hence prove that concrete pavement is much better than asphalt pavement

### 6. Conclusions

Using the software ABAQUS for the design features like traffic related factors the analysis of pavement performance of present roadway and finding total traffic carrying capacity of the existing pavement. From the above work we come to conclusion we can see that concrete pavement is much more efficient than asphalt pavement in aspect of performance and life time maintenances. Varied test indicates that parabolic variation of tire pressure which is constant only within the center region of contact area. Implication of stress strain behavior in the design phase of flexible pavement is quite massive work. Further study on the effect of moving loads and asphalt viscoelasticity is warranted.

### 7. Acknowledgements

This research was carried out under the principal supervision of Dr. HABIB ALEHOSSEIN. I thank him for his supervision, advice, expertise that has helped me from the very early stages of this project.

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# FINITE ELEMENT ANALYSIS OF A NEWLY DEVELOPED HYBRID NATURAL FIBRE SANDWICH WALL PANEL LOADED WITH IN-PLANE SHEAR LOADING



**Shane Collier**

Bachelor of Civil Engineering

Supervisor: Assoc. Prof. Yan Zhuge, USQ.

*Keywords: composite stress FEM*

## 1. Introduction

This project will test newly developed sandwich wall panels with finite element modelling in Strand7. The models will be tested using a diagonal placement with tension load applied.

## 2. Background

With the rapid expansion of sandwich panels continuously increasing it is important to test and analyse the capabilities of these new hybrid models. This project will aim to test the engineering properties of these panels under tension load. From there suitable uses can be identified and recommended.

## 3. Methodology

The methodology used in this project was to create a 2D model, validate it with the results of Dr. Fajrin's project and then create a 3D model for further testing. Problems in the 2D model such as de-bonding were overcome via the use of laminates within Strand7 as opposed to layered plates.

## 4. Key Outcomes

The key outcomes of this project is to create and test a 3D non-linear model in Strand7. A key task in order to achieve this was the development of the 2D model which required a lot of planning and alteration. Both models offer advantages and disadvantages and are necessary for the completion of this project.

## 5. Further Work

Possible further work includes further testing of different aspects of the 2D and 3D models. Such as compression or bending analysis or even a parametric study to determine the optimal configuration of layers and thicknesses.

## 6. Conclusions

Testing is still in development however a key achievement in this point in time is the 2D model development and methods to overcome the obstacles faced as well as the current 3D non-linear model.

## Acknowledgements

I would like to thank Assoc. Prof. Yan Zhuge for her continued support and aid in the completion of this thesis. Her help is of paramount importance and the guidance she gives is also irreplaceable. My family for their patience, understanding and ongoing support in my life choices.

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# Production of semi-real time media-GIS contents of natural disasters using MODIS satellite data

School of Civil Engineering and Surveying



## David Connell

Bachelor of Spatial Science  
(Honours) (Surveying)

**Supervisors:** Dr Kithsiri  
Perera, USQ

School of Civil Engineering  
and Surveying



**Figure 1** NASA Worldview - MODIS Image of Tasmania from 6th Jan 2013 showing fire and thermal anomalies(NASA Worldview 2015)

**Keywords:** MODIS, disaster, media-GIS

## 1. Introduction

During the event of a natural disaster, information in the media can provide great assistance to the public. It is important that the information being provided to the public is easy to understand and accurate. Visual representation of a natural disaster is an effective method of providing information that is easily accessible and able to be understood by the general public.

## 2. Background

Natural disasters have a devastating impact on the world. The effects are felt through the loss of life, deterioration of physical and mental health and the damage to infrastructure, housing, business and finance.

The media has a responsibility to provide information to the public that is accurate and timely. There is a danger of misinterpretation of information leading to misleading outcomes as a result of cultural, language, educational, geographic and access barriers. However, the audience, regardless of these barriers, has a right to be provided with information that is accessible and able to be understood. Effective use of imagery, including appropriate levels of MODIS satellite imagery, assists in achieving this goal.

Media-GIS contents are currently not used in sufficient quantity by the media to effectively exploit their full potential benefit to the provision of public information and disaster management response. The requirement for spatially accurate satellite imagery that is cost-effective and accessible, whilst maintaining accuracy and an ability to be understood by the general public can be viably met by MODIS satellite imagery.

## 3. Methodology

This dissertation uses MODIS imagery to produce media-GIS contents to evaluate two recent natural disasters. In doing so, the study aims to prove the effectiveness of MODIS satellite data for the use in

media-GIS contents against more traditional reporting methods.

## 4. Key Outcomes

The key outcomes of this project is to analyse the potential uses of MODIS imagery in the media and to develop processing techniques and quality assurance criteria to ensure accuracy and quality of results.

## 5. Further Work

Further work would be valuable in researching methods of 'streamlining' the processing of the imagery such as automated systems or potential media specific services.

## 6. Conclusions

Effective use of MODIS imagery will assist the media and governments to disseminate relevant information regarding disaster events to the public allowing for a timelier mobilisation of disaster response and promotion of public behaviour that supports safety and positive outcomes.

## Acknowledgements

This research was carried out with the assistance and supervision of Dr. Kithsiri Perera. Special thanks goes to my wife and child for their patience.

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# ONSITE DETENTION & THE CUMMULATIVE EFFECTS



**Garth Cook**

Bachelor of Engineering (Civil)

Supervisor: Dr Ian Brodie, USQ

**Keywords:** OSD, DRAINS, Stormwater

## 1. Introduction

Over the past few decades there has been a significant push to at the very least limit flooding caused by new developments to pre-development conditions. Previously little regards was given to the increased runoff that new developments produced.

On-site detention (OSD) has been employed by many local governments seeking to return the runoff flows to near existing conditions.

## 2. Background

On-site detention is the creation of stormwater storage devices to attenuate the peak flow rates generally to pre-developed state (or less). Detention devices are designed to store runoff for longer storm events and gradually release water between storm peaks thus reducing the peak flow rates. Depending on the OSD method used to calculate the storage volume this volume can vary drastically between methods.

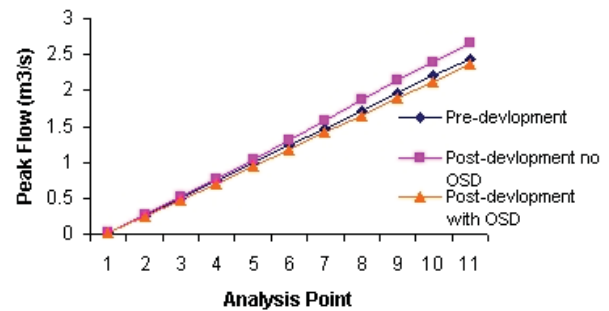
As these calculations are carried out on an individual basis (i.e. one allotment/dwelling) the cumulative effects of all the on-site detention storage devices within a particular catchment may not be taken into consideration.

This research project seeks to determine the cumulative effects of OSD strategies within typical urban development scenarios and to provide guidance to which OSD methods provide adequate reductions in flow when cumulative effects throughout a catchment are considered.

## 3. Methodology

Different OSD calculation methods have been used to determine the storage volume necessary and the permissible site discharge for a single allotment.

Using "DRAINS", the modelling of a typical urban development with individual on-site detention devices in each allotment was carried out.



**Figure 1. ARI 5 Year & Rational Method for OSD**

The flows from varying development states were then compared. This was carried out for each OSD method used.

## 4. Key Outcomes

While not all the modelling has been completed at the time of writing this extract the following preliminary outcomes are noted:

- Storage volume varies greatly across the different OSD methods and strategies currently in use.
- OSD effectiveness varies with different methods.

## 5. Further Work

Stormwater modelling is a time consuming process and although this research paper concentrates on an urban development of a particular size and shape it would advantageous to carry out modelling to identify what other catchment factors attribute to an increase in flow. i.e. a rectangular versus a circular catchment.

## 6. Conclusions

Reducing runoff from developments is of growing importance, especially in a world increasingly focused on environmental impacts. "DRAINS" modelling has found that regardless of the OSD method used that it generally reduces the peak flows. However the effectiveness & efficiency varies between each method.

## Acknowledgements

I would like to acknowledge my supervisor Dr Ian Brodie and most importantly thank my wife and children for the support over the past years.

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# SENSOR PLATFORM FOR MONITORING CONVEYOR BELT ROLLERS

School of Mechanical and Electrical Engineering



## David Cooper

Bachelor of Engineering  
(Honours) (Mechatronic)

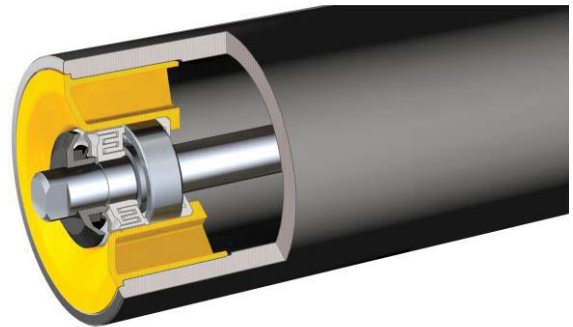


Figure 1 - Cutaway of a Typical Roller (Rulmeca Group, 2013)

Supervisor: Dr John Billingsley, USQ

**Keywords:** sensor, conveyor, roller, wireless.

## 1. Introduction

Many industrial operations, such as mines, factories and processing plants, use conveyor belts to transport material. Conveyor systems can offer efficient, high volume transport of materials over significant distances, sometimes up to tens of kilometres. The belt rollers, which support the belt, are typically spaced about one metre apart, and can number in the hundreds or more.

By integrating a self-powered, wireless sensing platform within a conveyor belt roller, this project will enable better health monitoring and maintenance procedures of conveyor systems.

## 2. Background

The only moving parts within each roller, the bearings, are known to fail. A study of bearings in electrical motors found that bearing failure was the cause of 41% of all break downs. Bearing failure can cause the roller to seize, resulting in efficiency loss, belt wear, noise, and fire hazard from increased friction.

Current inspection techniques rely primarily on visual/manual methods, however, some acoustic and temperature sensing systems are available. Physical access to conveyor belts is often difficult and dangerous, so the remotely monitored system proposed would reduce the risk to maintenance personnel.

## 3. Methodology

The parameters used to determine the health of bearings were found to be (primarily) bearing temperature, rotational speed and vibration signature.

With these parameters in mind, off-the-shelf components were used to build a Roller Sensor Platform (RSP). The RSP is designed to fit within a roller, mounted to the stationary axle depicted in Figure 1. Using a mock-up of a single conveyor roller, the RSP's measurements will be validated using commercial test equipment.

## 4. Key Outcomes

While full evaluation of the sensor platform is yet to be carried out, significant investigation has been completed into bearing health monitoring techniques, as well as wireless sensing. The RSP has been designed and assembled.

## 5. Further Work

Assembly of the test setup is required, so that the sensor platform's performance can be measured. In future, larger scale testing needs to occur, e.g. using 10 – 20 sensor platforms. Software processing of the data generated would also provide a more valuable system, which could alert operators to developing problems.

## 6. Conclusions

Real-time data from bearing sensors can provide better insight into their state of wear and expected lifetime.

Prior to full testing of the Roller Sensor Platform, the main outcome of the project is to demonstrate the application of modern, low-cost technology to long standing problems.

## Acknowledgements

For providing valuable advice and direction I'd like to thank Professor Billingsley, for her patience and reassurance I'd like to thank my wife, and for being great sounding boards I'd like to thank my work colleagues.

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# Development of a Raspberry Pi Based SDI-12 Sensor Environmental Data Logger

Sponsor – School of Mechanical and Electrical Engineering



**James Coppock**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Dr Leslie Bowtell, USQ

Mrs Catherine Hills, USQ

**Keywords:** Software Development; SDI-12 Protocol; Environmental Data Acquisition

## 1. Introduction

The project aim is to develop a logger for environmental monitoring. The logger is based on a Raspberry Pi personal computer. The Raspberry Pi is a small computer, incorporating a 40 pin general purpose input output (GPIO) header for connecting to digital peripherals. SDI-12 sensors are a smart sensor that uses the SDI-12 protocol (SDI-12 Support Group, 2015). SDI-12 is an abbreviation of Serial Data Interface at 1200 Baud. SDI-12 is not strictly plug-and-play so configuration of the logger channels is required through a human machine interface (HMI).

## 2. Background

There are many sensing network implementations each with advantages and disadvantages for a specific application class. SDI-12 provides a cost effective means of environmental data acquisition (EDA). There are unlimited applications for sensor networks and some of which are critical to an industry or of ethical importance. Applications include sustainable living, education, research and food production.

## 3. Methodology

The first task was an assessment of the Raspberry Pi hardware and operating system and the SDI-12 protocol. The key elements of the project are; the development of the hardware interface, specifying a configuration file format, design and implementation of software module for the SDI-12 protocol interface and developing a HMI. The program is written in C++ and is being developed organically. The process of software development is

iterative and extensive with a series of experiments that develop an expanding body of knowledge.

## 4. Key Outcomes

Hardware is required to level shift the outgoing and incoming SDI-12 bus communications. Both the transmit and receive GPIO pins are connected to pins of a SN74HC244 octal buffer and line driver with three state outputs and separate output enable pins. The hardware interface is shown in Figure 1. The SDI-12 bus is 0-5V and the Raspberry Pi pins are 0-3.3V Results from testings show that that a GPIO pins can be used for SDI-12.

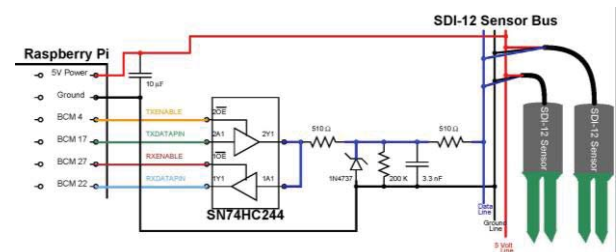


Figure 1 - Schematic of Hardware Interface

## 5. Further Work

The SDI-12 module developed, while functional, has only a subset of the features that a market ready device will need. Future work includes adding control outputs for automation an example application is providing inputs to a building management system. A graphical user interface will also add to its marketability.

## 6. Conclusions

The Raspberry Pi is a powerful computer with useful features to manage a program (or thread) that can be leveraged to interface with the outside world. The Linux kernel allows an interrupt to be detected on any GPIO input as a rising or falling edge transition and the main program can continue to run while waiting for an interrupt. The Raspberry Pi has many advantages over microcontrollers but it is not a true real time system.

## Acknowledgements

I'd like to thank the director of ICT International Peter Cull who has helped with the resources. I must thank my supervisors Dr Leslie Bowtell and Catherine Hills for their wisdom and guidance.

## References

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## Project-Low.-189

# Making Garfield Smarter

Sponsor –School of Mechanical and Electrical Engineering



**Mitchell Corcoran**

Bachelor of Engineering  
(Mechatronic Engineering)

Supervisors: Dr Tobias Low, USQ

**Keywords:** machine vision, robot, interaction

### 1. Introduction

This project is to make Garfield, the articulated robotic arm smarter by external sensors. Machine vision has been chosen which will allow Garfield to perceive the surrounding environment. The aim of this project is to research the currently technology of machine vision and implement a system that can detect and track the human workers within the working environment and determine if the distance between the worker and Garfield is safe where Garfield will continue you operate.

### 2. Background

Current industrial articulated robots are limited with the human robot interaction. This system aims at bringing the two closer for efficient applications. This project is building on from current technology dealing with machine vision. Mechatronics is dealing with programming and mechanical objects.

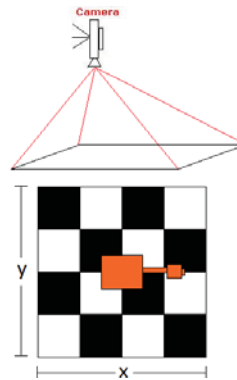
### 3. Methodology

The main methodology is implementing the computer vision video footage into a coordinate system that can relate the positioning of the human worker to a relative position to Garfield. This is the key task within this project since without a coordinate system; Garfield would not be able to determine the relative distance. As you can see in figure 1.1, the camera's image will

contain the coordinate of the work environment which contains Garfield.

### 4. Key Outcomes

The camera positing has been determined, the positioning is key since it needs to be able to obtain all the required information in a fashion that the data is easily manipulated for analysis. The code has been completed that detects the human workers within the work environment and tracks the location and provides the appropriate x and y coordinates.



**Figure 1 Garfield coordinate system**

### 5. Further Work

Once this project is completed, further research can be put into specific tasks that require human robotic interactions.

### 6. Conclusions

In conclusion, using machine vision can allow for humans and robots to work within the same environment but adjustments have to be made such as reducing the speed of the robot.

### Acknowledgements

I would like to express my sincere thanks to Tobias Low for the advice and time spent helping me on this project.

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Zhengyou, Z. (2012). "Microsoft Kinect Sensor and Its Effect." [MultiMedia, IEEE 19\(2\)](#): 4-10.



# COMPARING DIFFERENT HEATING METHODS FOR DETERMINATION OF MOISTURE CONTENT IN SOILS

School of Civil Engineering and Surveying



**Adam Cormick**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Kazem Ghabraie, USQ

**Keywords:** Microwave, Drying, Soils.

## 1. Introduction

This research project aims to compare the results achieved when conducting moisture testing of soil samples by drying the samples with a microwave oven as compared to the results achieved when the samples are dried using the standard method using a convection oven.

## 2. Background

In the civil construction industry it is often necessary to test soil samples for moisture content when conducting many standard soil tests including density tests, California Bearing Ratio (CBR) tests and quality tests such as Plasticity Index (PI) and grading. The standard method for drying the soil samples to obtain the soil moisture content is to dry the samples in a convection oven for approximately 24 hours. If microwave drying is suitable for use the results could be obtained in a much shorter time period as the drying time required should be approximately 30 minutes or less depending on the material and sample size.

## 3. Methodology

Initially the methodology involved researching available research papers and current industry standards regarding the use of microwave drying. The next stage was to formulate a test methodology that will be used to compare the results of the microwave dried test samples against those dried using the standard oven method, which as it is the accepted industry standard is considered to produce the correct results.

The types of clay to be tested are Kaolinite, Montmorillonite and Illite which are to be tested across a range of moisture contents. To attempt to find a limit at which these materials are no longer suitable for microwave drying the samples will vary in percentage

of clay from 0 to 100%. The clay will be mixed with silts to compare the effects of silt on the accuracy of microwave drying.

## 4. Key Outcomes

So far key outcomes include the completion of a review of current literature on microwave drying of soil samples including both literature from Australia as well as international material. Testing is expected to be concluded prior to the project conference and a comparison of results will be included in the presentation.

## 5. Further Work

Testing is still to be completed and reported on and this will be finished during this project. Further work after this project could include the comparison of samples containing various quantities of sands and aggregates as these types of materials are commonly encountered.

## 6. Conclusions

Test results have not yet been finalised therefore no conclusions have yet been reached. I am confident given the literature that was reviewed from previous studies that the use of microwave drying of silt/clay samples will be acceptable for the majority of samples however this remains to be proven during the testing.

## Acknowledgements

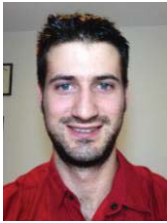
I would like to thank Dr Kazem Ghabraie for his patience, support and assistance during this project. I would also like to thank the staff of the Roads and Maritime Services NSW Ballina Soils Testing Laboratory for the use of their laboratory and assistance with the testing of samples.

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# Green IT - Dynamic Network Topologies

School of Mechanical and Electrical Engineering



**Daniel Costantini**

Bachelor of Engineering (Honours)  
(Computer Systems)

Supervisors: Dr Alexander Kist, USQ

**Keywords:** Green IT, dynamic networks, Linux, MPLS, Raspberry Pi

## 1. Introduction

There have been many different techniques investigated to reduce the power consumption of networks and/or network devices. The work of Aldraho and Kist (2011) presents one such concept that forces the behaviour and topology of the devices and the network to react dynamically in response to traffic demands. The concept's implementation in physical devices, as opposed to simulated or virtualised devices, is investigated in this project.

## 2. Background

The environmental and economic impacts of energy consumption and the resultant carbon footprint is an important consideration in modern engineering, particularly for the Information and Communication Technology (ICT) sector (Webb 2008). A 2012 estimate of global carbon emissions placed the contribution of the ICT sector at 2% of the total (Koenigsmayr & Neubauer 2015). Simulations of the project focus' dynamic topology mechanism have placed the theoretical average reduction in power consumption in the range of 30-50% (Aldraho & Kist, 2011).

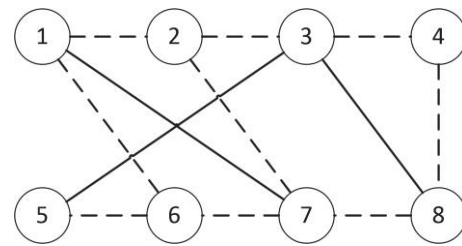
## 3. Methodology

A test network of eight network devices, based on an Australian Telstra network and shown in Figure 1, will be used to compare power measurements of the dynamic network topology mechanism against a baseline using OSPF.

Agile development methods have been embraced to incrementally develop the software implementation of the dynamic topology mechanism and for the network device baseline software build used to run it. Information has been gained through research, both of published literature and of content generated by the Linux community, and by experimentation with software packages and Linux kernels

## 4. Key Outcomes

Each network device is a Raspberry Pi model 1B+ computer running Linux Raspbian 4.1.4, and is capable of processing network traffic using OSPF and



**Figure 1 – Test network**

MultiProtocol Label Switching (MPLS). Two suites of software are instrumental to the devices' operation: Quagga, and OpenVswitch

Configuration of the network devices uses a simple program that reads from a local file that is updated by a central controller. The controller uses another program to construct a traffic matrix using data sampled by each device, and updates each device's configuration file based on the analysis of this traffic matrix.

## 5. Further Work

This project, like most of the current ICT power consumption reduction work, does not consider the network's resilience to device and link failure. Also, as this project is aimed at the physical implementation and real-world power reduction measurements, the optimisation algorithm is not considered. Further work in these areas could produce a robust, fully functional system.

## 6. Conclusions

If the power consumption reductions in the physical system are comparable to the simulated model, further investigation could lead to the widespread deployment of this concept in core networks. This would reduce financial and environmental costs of ICT.

## Acknowledgements

My supervisor, Dr. Alexander Kist, has provided concise and illuminating guidance throughout the project; my friends and family have been vital to the maintenance of my sanity as welcome distractions and eager sounding boards; the Linux community has been a valuable and functionally infinite resource.

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# Key Infrastructure Review (Newcastle NSW)

## Vulnerability to a Tsunami



**Greg Couch**

Bachelor of Engineering (Civil)

Supervisors: Trevor Drysdale , USQ

**Keywords:** Tsunami, Inundation, Newcastle LGA

### 1. Introduction

The location of a city's major infrastructure is a key factor in the resulting impact and available response to a significant environmental event. Prediction and modelling allows for additional disaster and response planning improving a city's resilience to such events.

The primary aim of this project is to determine the Newcastle Local Government Area's (LGA) vulnerability to a tsunami event by undertaking tsunami modelling and identifying the major infrastructure located within the inundation zone.

### 2. Background

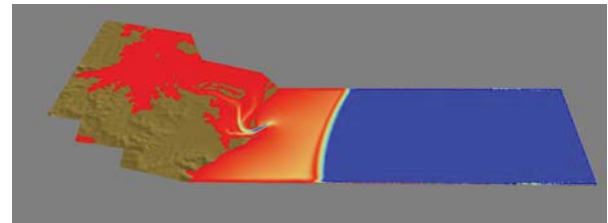
The south-east Australian coastline has been identified as being at significant risk of tsunami from the potential earthquake generators located off the coast. The large population density along the coastline has led to significant infrastructure development within areas susceptible to tsunami inundation. Newcastle has a historically high population density and major industrial zones, around its coastal, port and river areas. Overlaying a city's key infrastructure locations with detailed tsunami simulation modelling will identify the city's vulnerability to inundation.

### 3. Methodology

There were three major task areas to this project. The first involved a detailed literature review examining the current research into the potential tsunami generation (size and speed) from offshore subduction zones.

The second involved detailed tsunami coastal strike and inundation modelling. The Geoscience Australia / Australian National University backed hydrodynamic modelling software ANUGA was used to develop a detailed tsunami model of the Newcastle LGA along with a combination of LIDAR and bathometric survey data.

Thirdly the key infrastructure including arterial roadways, rail networks, electricity networks, trunk water and sewer mains, telecommunication lines, emergency services (police, fire, ambulance, etc.) and



**Figure 1: Newcastle Tsunami Model Screen Short (ANUGA)**

schools were identified within the inundation zone. The potential impact of the tsunami inundation was reviewed.

### 4. Key Outcomes

Inundation modelling detailed significant impact to Newcastle's key infrastructure. Arterial roads and the rail network were cut. The electrical, communications, water and sewer networks are heavily inundated potentially causing large scale damage.

The emergency services suffer inundation and damage with police, fire, ambulance and SES stations affected. The Port of Newcastle is subjected to major inundation and damage. The main Council headquarters are also located within the inundation zone along with a number of schools.

### 5. Further Work

Further work would include detailed assessment into the current condition of infrastructure within the inundation zone and completing an item specific review of potential damage or impact caused by the violent tsunami inundation. Detailed risk assessment of the likelihood of the tsunami event could also be undertaken.

### 6. Conclusions

The theoretical modelling suggests that significant impact to key infrastructure will be caused by such a tsunami event. These results could be used to further develop existing design and development requirements for current and future infrastructure being constructed within the inundation zone.

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# Soil Nitrogen Supply Rates during a Cotton Season

Sponsors – National Centre for Engineering in Agriculture (NCEA) & Cotton Australia



## Constance Coverdale

Bachelor of Engineering (Honours)  
(Environmental)



Figure 1: Extracting gas samples and maintaining soil moisture levels

Supervisors: Dr Alice Melland, NCEA

Dr Diogenes Antille, NCEA

**Keywords:** soil nitrogen potential, mineralisation, urea

## 1. Introduction

As one of the primary nutrients required for optimum plant growth and yield, nitrogen is becoming an increasingly costly input for cotton enterprises. This research investigated the potential soil nitrogen supply of a typical cotton soil (black Vertosol) with and without two fertiliser types - Urea and ENTEC Urea (controlled release fertiliser) over a simulated cotton growing season. The nitrate emissions over the same period were measured to quantify potential nitrogen losses and atmospheric impact.

## 2. Background

With farmers aiming to maintain the highest yield per hectare every season, the soil requires a high mass of plant-available nutrients to continuously fulfil these demands. Previous research in the area of nitrogen use efficiency has determined the varying plant requirements over a typical cotton season, resulting in a more optimum level of fertiliser application. However, the mineralisation process that occurs within the soil (conversion of organic to inorganic nitrogen), volatilisation and leaching processes will greatly determine how much nitrogen a plant actually utilises.

## 3. Methodology

A laboratory based, aerobic soil incubation procedure was used to analyse nitrogen mineralisation rates and gaseous emissions. After determining the initial soil characteristics, four replicates of a single, high application rate of two nitrogen fertiliser types and an unfertilised control were prepared for incubation. Soil was incubated for 60 days at a constant temperature of 25°C, with soil moisture levels being maintained at >75% field capacity (see Figure 1). Soil samples taken at various intervals were extracted using a 2M KCl procedure, and analysed using Hach Dr2700 spectrophotometer methods to determine ammonia and

nitrate concentrations. Gas samples were also taken at various intervals (see Figure 1) and analysed for nitrous oxide, carbon dioxide and methane concentrations using a gas chromatograph.

## 4. Key Outcomes

From soil ammonium and gas emission analyses completed to date, it is evident that Urea and ENTEC Urea exhibit different nitrogen release characteristics over a 60 period with this pattern also reflected in gaseous emission data trends.

## 5. Further Work

Work still to be completed includes analysing for soil nitrate, statistical analyses, comparison of aerobic and anaerobic mineralisation methods and comparing the soil nitrogen potential supply with actual cotton plant demands over a typical season.

## 6. Conclusions

Evidence has been found that the nitrogen release characteristics of the two nitrogen fertilisers differ greatly over a typical cotton season. The controlled release fertiliser (ENTEC Urea) delayed the delivery of mineral nitrogen to the soil-plant system, as expected. This reduces the potential for gaseous or leaching loss soon after application. Fertiliser types can therefore be managed to match the nitrogen demands of cotton over time and reduce nitrogen losses.

## Acknowledgements

I would like to sincerely thank my project supervisors for their support and expert advice and Dr Alla Marchuk who spent time conducting the necessary gas analyses.

## References

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## Real-world comparisons between target-based and targetless point-cloud registration in FARO Scene, Trimble RealWorks and Autodesk Recap



### Raymond Cox

Bachelor of Spatial Science (Surveying)

Supervisor: Zhenyu Zhang, USQ

**Keywords:** point cloud, registration, target-less, laser scanning, TLS

### 1. Introduction

This research project seeks to vigorously test and compare the accuracy of point-cloud registration between target-based and targetless processing methodologies across three point-cloud software packages—Faro SCENE, Trimble RealWorks and Autodesk Recap. The project is largely field-work based and experimental in nature using six real-world survey scanning scenarios—1) a heritage façade survey, 2) a quarry plant survey, 3) an indoor floorplan survey, 4) a tunnel survey, 5) a commercial roof survey, and 6) a wharf monitor survey—to compare target-based and targetless point cloud registration methods as well as evaluate the effectiveness of targetless registration for data extraction.

### 2. Background

With recent improvements to point cloud processing software, encouragement has been given by software manufacturers and retailers to register individual point clouds without isolated targets. Manufacturer test trials and online tutorials show examples of targetless point cloud registration in action. However, it is believed by the author that these examples, using only a handful of scans in beneficial scanning environments, do not necessarily take into account varied, real-world survey conditions that often take multiple scans to effectively measure. Previous initial testing of a simple floor plan survey by the author gave differing results between targetless and target-based registration methods using the same data set. In both cases the registration passed the software’s quality control but the results of the targetless methodology differed in the order of 0.1m horizontally and 0.6m vertically from the target-based, total station supported registration.

REGISTRATION METHOD		SCENE TB	SCENE TL	TRW TB	TRW TL	RECAP TB	RECAP TL
Point ID	Deltas						
T1	Δ E	-0.005	-0.002	-0.003	-0.018	-0.003	-0.002
	Δ N	-0.007	-0.023	-0.013	-0.008	-0.005	0.005
	Δ RL	0.002	0.002	0.003	0.099	0.001	0.009
T2	Δ E	-0.008	-0.011	-0.006	-0.022	-0.002	0.013
	Δ N	0.007	0.062	0.004	-0.010	0.004	0.018
	Δ RL	0.012	0.832	-0.009	0.004	0.004	0.096

Figure 1 – Commercial Roof registration results (Part)

### 3. Methodology

A control survey will be undertaken using traditional total-station measurements of isolated key scanning targets within the scanning area to form a base datum. The scanning data will be processed through the software packages listed above by identifying the targets and registering the point cloud as normal. The relative points will be compared to the control survey. The identical (pre-edited) raw scan FLS files will then be re-processed through each software. The targets within the scans (minus the isolated control stations that need to remain for comparisons) will be cut away and a targetless registration attempted for all survey areas utilizing as far as possible the software’s default targetless registration settings. The results will be compared to the control survey as well as to the target-based registered point cloud. The comparisons will be like for like using identical survey files.

### 4. Further Work

Research into developing better targetless registration algorithms that seek to minimize cloud to cloud vertical distortion would be beneficial to targetless software development/enhancement.

### 5. Conclusions

Targetless point cloud registration has its limitations in accurately portraying certain real-world conditions especially in regard to vertical displacement. Though possibly suited to some surveying scenarios—particularly indoor ones—vigorous quality control and traditional check measurements should be used to support user confidence of the data obtained

### Acknowledgements

Zhenyu Zhang for his supervision of this project

### References

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# Understanding the driving forces for Class A Site Classifications in residential subdivisions within Western Australia

## Damian Cronin

Bachelor of Engineering (Honours) (Civil)



Supervisor: Dr Jim Shiau, USQ

**Keywords:** Site classification, footing slab, builders, developers, Western Australia.

### 1. Introduction

This research project aims to understand the driving forces for Class A site classifications for greenfield residential subdivisions in Western Australia (WA). The purpose of this study is to understand why Class A sites are perceived to be constantly demanded by local government, developers, buyers and builders alike and explores the cost and environmental implications of developing Class A sites.

### 2. Background

Developers are constantly under pressure to provide affordable housing that also provides the most efficient and cost effective build option for potential land buyers. Although Class A sites are the most desirable option for buyers because they provide the cheapest house slab construction, they can be expensive for the developer to construct and the act of importing clean fill sand and dumping in-situ soil off-site is not sustainable to the environment.

### 3. Methodology

The methodology for researching this topic included a literature review of current development standards and guidelines, engagement with developers, builders and potential buyers to understand each of their drivers in regards to site classifications when developing, buying

or building residential lots, a cost/benefit analysis of development constructions and footing slabs costs for each site classification, and researching major fill sources and their expected lifespan.

### 4. Key Outcomes

The key outcomes revealed to date is the prejudice within the development standards and guidelines towards satisfying the building industry in terms of ease of construction. These documents also mandate clean fill sand as a fill material and encourage over-excavation of clay sites to raise the site classification, rather than using in-situ site materials and incorporating higher strength slabs or alternative building solutions as an alternative to achieving Class A sites.

### 5. Further Work

Further work still required to be undertaken is to receive real and tested footing slab costs from builders to accurately undertake the cost/benefit analysis of development and build options for differing site classifications. Lifespans of major fill sources also remain to be confirmed and may be an approximate figure based on current and project extraction rates that are subject to change in the future.

### 6. Conclusions

What are the key conclusions of your project? What is the key achievement or outcome? Did you solve anything? What key message do you want the readers to take away?

### Acknowledgements

I would like to thank both LandCorp for providing real construction data to undertake my cost/benefit analysis and the Master Builders (WA) association for facilitating discussion and engagement with local builders.

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Institute of Public Works Engineering Australia 2012, *Local Government Guidelines for Subdivisional Development*, Edition 2.2, Institute of Public Works Engineering Australia (WA Division Inc.), Perth.  
<http://www.planning.wa.gov.au/publications>

# Modelling the behaviour of floodways subjected to flood loadings

School of Civil Engineering and Surveying



**Shane Cummings**

Bachelor of Engineering  
(Civil)

Supervisors: Professor Karu Karunasena

Dr Weena Lokuge

Dr Buddhi Wahalathantri

**Keywords:** Strand7, floodway, bridge loadings.

## 1. Introduction

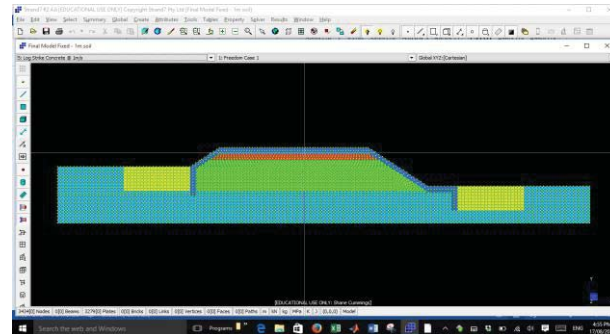
Research shows extreme flood events have an adverse effect on current floodway structures, with many failing to withstand such events. Currently, floodway design guidelines fail to consider drag, debris and lifting forces. This research will utilise the AS 5100.2-2004 bridge loadings to investigate the significance of such loadings using 2D Strand7 Finite Element Analysis (FEA). The aim is to identify the most critical or vulnerable areas of floodway structures and in doing so identify improvements for future design.

## 2. Background

Currently there are no Australian Standards to ensure the safe and effective design of floodways, only guidelines. Floodways damaged in extreme flood events are merely restored to replicate their preceding inadequate design. Consequently, many restored floodways were re-damaged in the wake of the 2013 Queensland flood event, presenting the LVRC with another restoration cost of around \$8m. One example was the East Haldon floodways, restored post 2010/11 flood event costing \$1,418,841, only to sustain approximately \$1m damages in 2013. This reoccurrence, highlights deficiencies in current floodway design throughout this region and Australia.

## 3. Methodology

A case study into the Left Hand Branch Road (LHBR) floodway in the Lockyer Valley was the prime focus for the 2D Strand7 FEA. Limitations in the availability of flood data at this location meant a parametric study was required. Ultimate state design for bridges were considered based upon a range of water velocities and depths with different loading combinations analysed.



**Figure 1 – Floodway Model**

The resultant stresses are then recorded and compared to the compressive and tensile characteristic strength of the concrete floodway. These areas of concentrated stresses will highlight areas of vulnerability.

## 4. Key Outcomes

To date, the AS 5100.2-2004 bridge loadings have been determined and a number of water and velocity loadings have been calculated. The floodway appears to withstand individually applied loads, however shows vulnerability under some combined loading conditions.

## 5. Further Work

Additional loading combinations require Strand7 analysis, with the results to be compared with identical models created using Abaqus FEA.

## 6. Conclusions

Whilst this research is in its infancy, the FEA conducted on the LHBR floodway confirms current guidelines should consider debris, drag and lifting forces when designing floodways as they can have significant impact when combined loadings are present.

## Acknowledgements

I would like to acknowledge the feedback and support I have received from Professor Karu Karunasena, Dr Weena Lokuge and Dr Buddhi Wahalathantri throughout this project, their guidance has been invaluable.

## References

LVRC 2014a, *Submission to the Australian Government Productivity Commission Inquiry into Natural Disaster Funding Arrangements*, <[http://www.pc.gov.au/\\_\\_data/assets/pdf\\_file/0015/138021/sub108-disaster-funding.pdf](http://www.pc.gov.au/__data/assets/pdf_file/0015/138021/sub108-disaster-funding.pdf)>.



# Optimized Scheduling of Water Distribution System Operation to Reduce Energy Demand

Sponsor – Rous County Council, School of Civil Engineering and Surveying USQ



## Samuel Curran

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Les Bowtell, USQ

**Keywords:** Energy, Optimization, Water Distribution Network

## 1. Introduction

This project investigates options to reduce energy costs of the water supply system owned and operated by Rous County Council. The focus of this project is on controlling the reservoir filling schedule of the water distribution network (WDN) to enable the high energy demand Water Treatment Plant (WTP) to take advantage of Time of Use (TOU) electricity metering.

## 2. Background

Energy costs for the Rous County Council water supply system have increased significantly over recent years. There is a drive within Council to reduce our energy costs.

Rous County Council have recently implemented a SCADA system to control the WDN. There are proprietary systems available that interact with SCADA to optimize WDN operation to reduce energy costs however these are costly to implement. This project proposes to use the existing SCADA functionality to implement an optimized reservoir fill schedule with minimal cost to the organisation.

## 3. Methodology

To determine the existing energy demand and usage patterns of the WTP in the water supply system an energy audit was conducted. The results of the energy audit combined with investigations into the WTP and water distribution system operation determined the viability of the project.

The WDN, schematically shown in Figure 1, was modelled in Excel and H2OMAP to determine the required reservoir fill control rules to optimize WTP energy usage patterns.

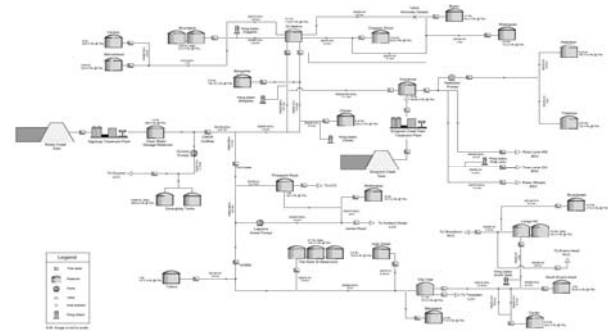


Figure 1 – Water Distribution Network

## 4. Key Outcomes

Modelling of the Rous County Council water distribution network indicates the proposed SCADA controls will achieve the project objective of reducing energy costs.

Projected energy cost savings from implementing the optimized reservoir fill schedule for Rous County Council are approximately 10% of Council's total energy costs.

## 5. Further Work

Implementation of the optimized schedule will require minor capital works to be undertaken to install additional control functionality at key sites. These sites have been identified and upgrade costs estimated for submission into Council's budget process.

## 6. Conclusions

The project objective was achieved using the existing SCADA system controls on the Rous County Council water distribution network which demonstrates that optimization of water distribution networks can be achieved using existing functionality.

## Acknowledgements

Dr Les Bowtell for his guidance and enthusiasm for the project.

## References

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# Design of a Small Wind Turbine for a Rural Area in Australia

Sponsor – School of Mechanical Engineering and Surveying



**Dayne Patrick Davey**

Masters of Engineering Science  
(Mechanical)

Supervisors: Dr Jayantha Epaarachchi, USQ

**Keywords:** Design, Renewable Energy, Wind Power, Composite Materials, Economical.

## 1. Introduction

The main objective of this thesis is to design a small wind turbine for rural parts of Australia mainly for farm use. The wind turbine will be able to produce a power of ~1Kw and all parts are commercially available and composite materials.

The wind turbine designed will be economically feasible and will be a simpler one than the existing designs. Since it is used in farms specifically, it will be easy to erect and bring down.

## 2. Background

Renewable Energy is the future and the more clean way of producing Energy. Wind Energy is a type of Renewable energy and has a great future not only in Australia but worldwide. Farming is one of Australia's main economic source and with the use of wind turbines on farms it can reduce the amount of electricity used from other sources. This design is simpler and economically feasible.

## 3. Methodology

There are various designs of wind turbines (Wind mills) found all over the world, some of which are complex and some of which are simple in construction. At first all designs were considered and a research was made on the best suited design based on various criteria like location, need, power required, wind velocities etc. Once all these criteria are met it also be noted it should be effective and cost efficient compared to the existing designs.

5 kW WIND GENERATOR SPECIFICATION	
GENERAL FEATURES	
Rated Output and Rated Wind Speed	5 kW at 10.5 m/s
Cut-in Wind Speed	3.0 m/s
Survival Wind Speed	50 m/s without lowering
Total Weight of Turbine & Tower	≤ 1.3 tonne
IEC Turbine Class	3
ROTOR	
Number of blades & Diameter	2, 6.0 m
Swept Area	19.64 m <sup>2</sup>
Blade Material	Vacuum infused fibre glass reinforced epoxy
Rotor Position	Upwind
Airfoil	SF7062
Tip Speed Ratio	8.0
Rotor Speed at Rated Output	320 rpm
Over Speed Control	Microprocessor control of generator & electro-mechanical brake
Yaw System	Passive regulation by tail fin
DRIVE TRAIN	
Generator	Fan cooled 4 pole, 3 phase induction generator
Generator Output Voltage	60 - 600 V AC
Generator Frequency	30 to 70 Hz
Gearbox	8.15:1 helical inline gearbox
Brake	Electro-mechanical disk brake behind generator
Brake Torque	40 Nm at generator
Brake Power Consumption	40 W maximum, 10 W average
CONTROLLER / INVERTER	
Control System	Microprocessor controlled power point tracking for maximum efficiency for wind speed below 10 m/s. Stall governing for power reduction at higher wind speeds.
DC Output Voltage	DC 24V, 48V or other as specified by customer
AC Inverter Output	110V, 50 Hz, 220V, 240V (both 50 Hz) as specified by customer
TOWER	
First Option: 18 m hinged tower	Needs crane for installation. Turbine can be raised & lowered manually.
Second Option: 16 m Tower hinged at base can be assembled with hand winch	Turbine can be raised and lowered with a hand winch

Figure 1 – Design of a similar Wind Turbine

## 4. Key Outcomes

Researching contextual designs of various existing wind turbine designs.

Make various decisions like, material selection, dimensions, location, etc. based on the necessity.

Hopefully design a small wind turbine assembly of all parts like the rotor, hub, drive system and the tower.

## 5. Further Work

Based on where this project now, there is a lot of work in the future. Either we can identify manufactures for the various parts or with suitable sponsors' a model of a wind turbine can be built.

## 6. Conclusions

By the end of this thesis we should have a well-designed wind turbine which can be ready to manufacture and used on farms all across Australia. Additionally it will be cost efficient and easy to use.

## Acknowledgements

I would like to thank my Supervisor Dr Jayantha Epaarachchi for guiding me throughout my journey and helping me make my thesis a success.

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## Traffic Management and Control on Roadwork Sites using Intelligent Transport Systems



### Wade Davey

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Prof. Ron  
Ayers, USQ

**Keywords:** ITS (Intelligent

Transport Systems), Roadworks Safety, Traffic Management

### 1. Introduction

Occupational health and safety is increasingly present in all industry however is foremost regarded with construction works on roads. Traffic controllers and workers alike consistently put themselves at risk and somewhat put their safety in the hands of the travelling public, day in, day out. This project aims to evaluate traffic management and control using innovative control devices such as the increasingly popular Intelligent Transport Systems (ITS) in temporary environments to reduce exposure to worksite personnel and effectively and safely manage traffic at road work sites within Australia.

### 2. Background

Intelligent transport systems have been developed to increase the efficiency and safety of our roads in their permanent alignment and could be used to do the same during the construction phase. There have been numerous incidents involving vehicle and human collisions causing serious injury or death to traffic controllers and workman on site, but to mitigate these incidents there seems to be a push for more flashing lights, more signage, more spotters and more traffic controllers. Why not take a different approach and control or manage traffic with less people on the road, less distraction and more concise and accurate signage that has the ability to be controlled remotely, as would be the case by utilising ITS.

### 3. Methodology

In evaluating the aspects of traffic control and traffic management both a qualitative and quantitative approach was taken. An in depth literature review was essential to understand how traffic management operates within Queensland and Australia and what standards govern this. To gain further appreciation of the subject two surveys were developed, one aimed at the general public and one aimed at personnel directly involved in the planning or implementation of traffic management at roadworks. After evaluating the results of both surveys, a series of trials were developed based on the answers and feedback received. The use of newly developed speed radar signage aided by support from the local police station allowed the trials to run smoothly generating a plethora of useful data.



Figure 1.1 – Speed radar sign trials.

### 4. Key Outcomes

In the literature review it was identified that there is a lack in quality statistics relating to accidents and incidents at roadwork sites within Australia. As this information is vital to my research and future research I have engaged with Workplace Health and Safety QLD in an attempt to close this gap and produce some noteworthy statistics. The trials which were conducted have also produced relevant statistics for an active worksite and gives us a clearer picture of how drivers are behaving when travelling through roadworks sites. Although the statistics are still in the process of being collated it was seen that enforcement, above all, plays a key role in reducing speeds.

### 5. Further Work

Useful data has been gathered for one type of road in the network and so for completeness, a critical evaluation needs to be carried out on various other roads.

### 6. Conclusions

An in depth literature review revealed a lack of quality statistics for accidents/incidents on roadworks sites and the process of closing this gap is currently in progress. The two surveys developed show a clear view of the public opinion of roadworks sites which is contrasted to the views held by the industry. The trials have revealed interesting data on the speed selection of vehicles through roadworks and are in the process of being evaluated.

### Acknowledgements

I would like to thank my current Employer Bielby Holdings for supplying the relevant traffic control devices for the trials. I would also like to thank the Cooroy Police Station for supplying officers to assist in the trial process.

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# D-VAR<sup>®</sup> STATCOM

## DC bus and switching strategy analysis

Sponsor – School of Mechanical and Electrical Engineering



**Daniel de Freitas Pessoa**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Dr Tony Ahfock, USQ

Mentor: Dr Andrew Hewitt, Ergon Energy

**Keywords:** STATCOM, IGBT switching,

### 1. Introduction

Static Synchronous Compensators (STATCOMs) are employed to dynamically provide electricity networks with reactive power support. While there has been much research on STATCOM operational characteristics detailed operational information is often highly protected by manufacturers to protect hard earned intellectual property. This project will provide an analysis of the IGBT switching strategy techniques used by American Super Conductor in the D-VAR<sup>®</sup> STATCOM to provide a better understanding of the D-VAR<sup>®</sup> operation and to propose answers as to why fluctuations in the DC bus voltage might occur.

### 2. Background

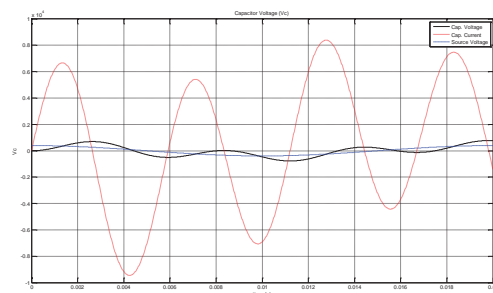
In 2012 ERGON Energy commissioned its first STATCOM system into the sub-transmission network at St George Queensland. In the first year of operation of the D-VAR<sup>®</sup>, ERGON Energy experienced a number of trip events which either removed the D-VAR<sup>®</sup> from service or restricted its output capability. The investigations that followed from the trip events highlighted the limited understanding that ERGON had on how the STATCOM operated and prevented ERGON to critically assess some of the operational aspects of its unit.

### 3. Methodology

The studies performed in this thesis will be based on numerical modelling and the application of power electronic principles. SimPowerSystems models and MATLAB<sup>®</sup> models were developed and are used to assist in the analysis of the D-VAR<sup>®</sup> STATCOM. To further assist in this process, a number of equations will be derived from first principles.

### 4. Key Outcomes

A better understanding on how the IGBT switching strategy assists in building and maintaining the correct voltage levels in the DC bus and its response to a transient in the system. As depicted below, we see the by switching a sinusoidal signal at 90° phase angle the DC bus capacitors will, theoretically, be passively charged to a value of around 1.77 times the peak value of the input voltage.



**Figure 1 – Capacitor transient response to sinusoidal signal switching**

### 5. Further Work

Further investigation on a complete 3 phase system and confirm if the same principles apply considering the findings of this project.

### 6. Conclusions

Passive charge of the DC bus can be achieved to a voltage level much greater than the RMS value of the input signal, while, making it important piece of information when designing a STATCOM ensuring the correct capacitor voltage rating is chosen (interim conclusion).

### Acknowledgements

I would like to thank first and foremost, my wife Catherine and my 2 beautiful kids, Holly and Ryan for all the support and understanding in the last 7 years of our life. Also, Dr Tony Ahfock and Dr. Andrew Hewitt for all the teachings and help during this project.

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# Understanding the barriers to innovation for people employed in engineering

Sponsor –School of Civil Engineering and Surveying



**Nicholas Debritz**

Bachelor of Engineering (Civil)

Supervisors: Dr Habib Alehossein, USQ

Dr Tara Newman, USQ

**Keywords:** Engineering, Innovation, Barriers

## 1. Introduction

Many industries essential to the economic growth of the country, such as construction, mining, telecommunication and manufacturing require a significant engineering competency.

By eliminating barriers to innovation in industries relevant to engineering, it is possible to increase productivity, improve the longer term sustainability of organisations, thereby contributing to the economic growth of nations.

## 2. Background

Extensive research has been carried out by various organisations to understand what key barriers impact a nation's and organisation's ability to innovate and remain competitive on the global stage. However, little information is available to understand the areas which need attention within organisation to facilitate and enable incremental innovation for people employed in engineering.

## 3. Methodology

A conceptual innovation framework developed by the Australian Commission of Public Service was used to develop a survey for people employed in engineering (see Figure 1). The survey contained 32 questions aimed at understanding what key areas hinder people's ability to innovate within engineering workplaces.

The survey was completed by 21 people employed in civil engineering related roles for an Australian Local Government organisation. The qualitative data identified those areas in greatest need of attention within this workplace.

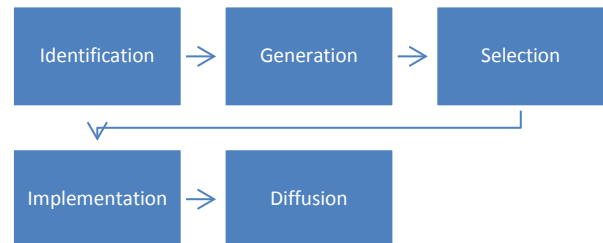


Figure 1 – Conceptual innovation framework

## 4. Key Outcomes

The research found that more than half of respondents believed that 26 of 32 key areas required attention to facilitate and enable incremental engineering innovation within their workplace.

## 5. Further Work

Further work will be carried out to understand how the organisation can address these areas in need of attention identified in the survey.

## 6. Conclusions

The research identified key areas which the Australian Local Government organisation can address to provide a suitable workplace environment which facilitates and enables engineering innovation. Failing to address these issues may negatively impact the longer term sustainability of the organisation by impacting its ability to innovate, remain competitive, and provide value to the community.

## Acknowledgements

I would like to thank Dr Alehossein and Dr Newman who were helpful in guiding my research activities. I would also like to thank the survey participants, and the organisations which provided me valuable insight into their research and development activities.

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# Development of Internal Combustion Engines: To predict Knock in Homogenous Charge Compression Ignition.

Sponsor –School of Mechanical Engineering



**Kaustubh S. Deshmukh**

Master of Engineering Science (Mechanical)

Supervisors: Dr Andrew  
Wandel, USQ

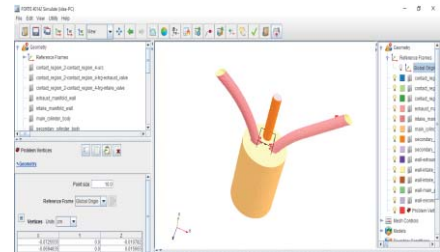


Figure 1 – Single Cylinder Engine prototype inside Forte

**Keywords:** knocking, efficiency, Homogenous Charge Compression Ignition Engine.

## 1. Introduction

The Homogenous Charge Compression Ignition Engine technology is the combination of both the Spark Ignition and Compression Ignition engines. Homogenous Charge Compression Ignition (HCCI) engines are used in order to have a better control over the combustion in terms of efficiency and output from combustion of fuel. Alike, Spark Ignition and Compression Ignition engines, Homogenous Charge Compression Ignition Engine also have an anomaly in knocking, and this research project will be aimed at developing a parametric model for this new genre of combustion engine in order to predict knocking.

## 2. Background

The advantage of Control Auto Ignition Engines over the present day SI (spark ignition) and DI (diesel injection) engines is that it has the positive combination of both the engines, as it delivers with great fuel economy like diesel engine and has ability to produce low emissions as in SI engine. In order to achieve very high compression ratio which assist auto ignition, lean charge of air fuel mixture will be used, though studies have shown that it may be tricky to achieve controlled auto ignition and cold start, or control emission, and also control heat release rate at high load operation and prevent knocking. Predicting knock in order to achieve the higher compression ratio which is necessary for auto ignition is the objective of my project.

## 3. Methodology

I will be carrying out the experiments in order to simulate combustion inside the control auto ignition engine prototype, whose geometry has been adopted from an existing experiment. I have modelled the engine based on the available specifications using Ansys design modeller. I will be using Forte to carry out the combustion modelling, as shown in figure 1.

## 4. Key Outcomes

I have been able to identify the Engine specimen and experiment that I can use to compare. I have completed the modelling of the engine using Ansys, since I required a water-tight geometry.

## 5. Further Work

The tasks that need to be worked upon is carrying out the combustion modelling for complete combustion and knocking and compare them to existing results.

## 6. Conclusions

My experiments will set up the methodology for carrying out the future experiments in order to predict knocking for SI engine set up

## Acknowledgements

My mighty thanks to my supervisor Dr Andrew Wandel. I am very grateful to him for helping me keep scaling the walls all the way and believing in my abilities.

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# Own Identification of contributing factors for the success of toll roads in Australia under Public Private Partnerships

School of Civil Engineering and Surveying



**Luke Diffin**

Bachelor of Engineering (Civil)

Supervisors: Dr Steven Goh, USQ  
School of Mechanical and  
Electrical Engineering

**Keywords:** PPP, Toll roads, Critical success factors

## 1. Introduction

This project aims to identify the contributing factors for the successful delivery and operation of toll road projects in Australia under the Public Private Partnerships (PPP) model.

Success of PPPs in Australia is varied when measured against Government, Community, Market and Industry interests. Some projects have failed financially while still having a positive impact on the community. Other projects have failed to reach delivery stage as result of community objections.

The holistic success of PPP toll roads is ultimately determined by the needs of major project participants being satisfied in an unbiased equilibrium manner.

## 2. Background

In Australia, Public Private Partnerships (PPPs) have been established as a common method for governments to deliver major road infrastructure projects.

PPP toll roads delivered in Sydney Brisbane and Melbourne have had varying degrees of financial success however there are other vitally important factors to be considered. Tollways directly contribute to travel time savings, vehicle operating cost savings, reduced accidents and vehicle emissions and can make a contribution to overall economic performance of a city. Therefore these pieces of infrastructure contribute to society as a whole and not just the investors who provide capital for the projects.

Even with recent financial failings of PPP toll roads, Governments within Australia are still actively pursuing

the PPP model to deliver road infrastructure. Lessons must be learnt from past failures to ensure the successful delivery and operation of future projects. Overall success will be a result of finding a balance between the needs of Government, Private Sector and Society

## 3. Methodology

The methodology to undertake this project consists of reviewing a representative sample of case study projects to identify those factors which contributed to their success or detriment. The frame work for evaluating success will be based on the factors identified from the literature review and additional factors particular to toll roads in Australia as determined by the case studies.

The framework will be validated by cross referencing the selected case studies and finding common factors contributing to success (or failure). The majority of the data used to analyse the case studies will be qualitative with supporting quantitative information incorporated where applicable.

## 4. Key Outcomes

Upon completion of the case study review, a comprehensive framework comprising of critical success factors, particularly applicable to PPP toll road projects in Australia, will be established.

## 5. Further Work

Work to be undertaken for this project involves the analysis of the collected data for the case studies and validation of the framework. A gap analysis will be completed before recommendations are made.

## 6. Conclusions

Conclusions for this project are yet to be determined.

## Acknowledgements

I would like to thank Dr Stephen Goh (USQ supervisor) and my wife for ongoing support.

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# Sliding Deck Development

Sponsor – Syngineering



## Peter Doljanin

Bachelor of Engineering  
Mechanical

Supervisors: Mr Paul Baker, USQ

Mr Shane Matthews,  
Director at Syngineering

**Keywords:** Process, concept development, design.

## 1. Introduction

This project is a subproject of a complete safety system. It involves developing a sliding deck design to bridge a gap of 200-400 mm, taking into consideration the working environment and its variances. The end client and environment dictate that this needs to be an automated action, and it must also conform to the following constraints:

- extend and retract
- fit in a void 50mm in height,
- be light weight
- be supported as depicted Figure 2.

## 2. Background

This project came to Syngineering as a joint development between Syngineering and Salita. As this project is currently in the patent process, certain aspects of this project are confidential. This presentation will be about some of the key struggles that have arisen throughout the product development cycle.

## 3. Methodology

The overall project documents the design and build of an innovative new system. The core methodology of the design will be based on the design process developed within the Syngineering Group. Involved within this process are constant consultations with:

- the end client,
- supplier/manufacturer,
- experienced engineers.

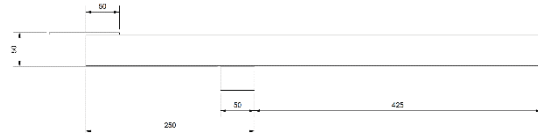


Figure 1: Typical Dimensions



Figure 2: Typical Supports



Figure 3: Typical Load

## 4. Key Outcomes

Key outcomes from this project are to be able to: develop innovative new designs, use new materials which are foreign to the industry and develop conceptual models which are not necessarily functional.

## 5. Further Work

The remaining tasks to this project are to finalise the design and formulate an appropriate test method. This method will need to conform to the relevant Australian standards and maintain the design is within the initial design envelope.

## 6. Conclusions

Key conclusions gained from the process are

- designs are easily modified before production starts,
- fabricator involvement aided the design process
- constant client consultation aided the project progression.

## Acknowledgements

I would like to acknowledge Syngineering (sponsor) and Salita (end client) for the help and support they have given me and the time I have required to learn new process and make errors and mistakes. Also the staff at USQ who have helped through this process as it is not the most standard of projects.

# Generating a gridded annual mean rainfall (1996-2014) map of Bhutan: Assessing Spatial Interpolation Techniques in GIS

School of Civil Engineering and Surveying

**Tshencho Dorji**

Master of Engineering  
Science (GIS)



Supervisor: Professor Armando A. Apan,  
USQ

**Keywords:** Rainfall, Geostatistics Analyst, Geographic Information System

## 1. Introduction

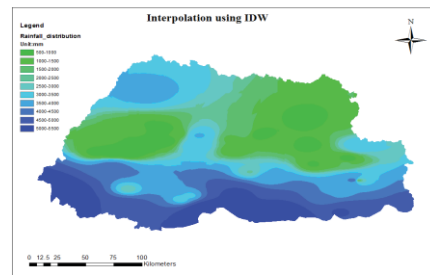
Rainfall or precipitation is an important element of the climate system which is crucial for life on the earth, as too much or too less of it can cause disaster. Thus, accurate rainfall maps are required for water resource management, hydrological and ecological modelling, recharge assessment, and irrigation scheduling, hydropower planning and climate change studies. This research aims to examine an appropriate interpolation method to generate a gridded annual mean rainfall map of Bhutan.

## 2. Background

Selection of an appropriate interpolation method is a main issue because the interpolation methods are dependent on the availability of data, distribution of rain gauges, topography of the place and atmospheric condition. This study focused in selecting the most suitable method to generate a gridded mean annual rainfall for Bhutan by comparing IDW, Spline and Kriging methods. To perform this task, integrated Geographic Information System with geostatistical tools of ArcGIS 10.2 of ESRI was selected. The digital elevation model (DEM, 30mx30m) of Bhutan was incorporated with interpolation methods to establish the relationship between the variation of gridded rainfall and elevation.

## 3. Methodology

The daily rainfall data from 83 meteorological stations in Bhutan were investigated and 63 stations were selected after a thorough check for data continuity and range. The Geostatistical Analyst integrated with the ESRI ArcGIS was employed as this constitutes both deterministic and stochastic methods for advance data analysis and modelling of rainfall. The inverse distance weighting method and the spline (with tension) and kriging methods were compared. The cross-validation



**Figure: Preliminary grid rainfall map**

and validation were carried out to evaluate the quality of the interpolation.

## 4. Key Outcomes

The geostatistical analyst provided a robust platform for comparison of the three interpolation methods. The exploratory data analysis of rainfall data showed the presence of trend and deviation of data from normality. From the comparison of cross-validation results of IDW and spline, the IDW method provided better interpolation. The global trends and data was transformed for interpolation using kriging.

## 5. Further Work

The three kriging methods: Ordinary, simple and universal kriging will be employed to interpolate the rainfall data and the three methods will be compared through cross-validation to select the better one. The IDW and selected kriging method will be compared. The method with better accuracy will be selected to generate the final gridded map and incorporate DEM data to establish correlation between elevation and rainfall variation.

## 6. Conclusions

There is no general methodology to model rainfall and methods have to be scrutinized depending on various aspects of the area of interest. Rainfall is unevenly distributed in Bhutan and it is worth to establish relationship between rainfall and elevation.

## Acknowledgements

My profound gratitude to Professor Armando (GIS) for his unconditional support and guidance.

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# Numerical Modelling of Complex-Structure Fluids



**Aditya Duddu**

Master of Engineering Science  
(Mechanical)

Supervisors: Prof Nam Mai-Duy, USQ

**Keywords:** Complex fluids, Dissipative Particle Dynamics, Fluid mechanics

## 1. Introduction

Complex Structure fluids are fluids where material properties are dependent on their microscale and mesoscale structures. Some of the complex fluids which we encounter in day to day life are Colloidal suspensions like Paints, Inks, Gels, Foam, Liquid crystal, Soup, Blood and emulsions etc. In mineral processing Industries these type of fluids are very common. Understanding the Rheological properties of these fluids is required for proper design of the Process, Piping orifices, Tanks, Agitators and insulation etc. It involves different stimulation techniques based on the size of the particulate (micro, macro and mesoscopic methods).

## 2. Background

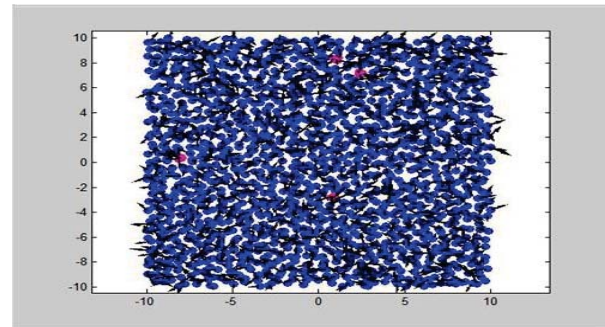
This research project is concerned with the use of numerical methods to predict the mechanics behaviour and the bulk properties of complex structure fluids such as paints, inks gels, blood, and emulsions etc. The analysis of complex fluids cannot be done using conventional methods and requires numerical modelling. The numerical modelling methods presently are divided into three broad categories.

- Molecular Dynamics –( Micro Scale)
- Dissipative Particle Dynamics –(Meso Between Micro & Macro)
- Navier-Stokes Discretization Methods -- (Macro Scale)

Dissipative Particle Dynamics is a mesoscale simulation technique that is widely recommended for simulation of complex fluids. This method simulates the fluid in the range between microscopic and macroscopic particulate size.

## 3. Methodology

Data of industrial flow processes involving complex-structure fluids is collected from the web and library



**Figure 1 – DPD particle modelling**

resources. Numerical techniques for simulating complex fluid systems (micro, meso and macroscopic methods) is reviewed including their strengths and weaknesses. Theoretical aspects and formulations of Dissipative particle Dynamics (DPD) is studied and applied to analyse some complex fluid systems including particulate suspensions.

## 4. Key Outcomes

The Data of industrial flow processes involving complex structure fluids is collected and is being analysed using DPD suspension software. The key outcomes will be a proper numerical methodology for studying properties complex structure fluids.

## 5. Further Work

Tests are to be performed on various complex fluids using the DPD suspension software through which we get the value of viscosity, volume fraction – viscosity curve plot. With these results we can determine the properties of the complex structure fluid.

## 6. Conclusions

By applying numerical methods on complex fluids, the properties of the fluid is determined, which is helpful for industries for proper design process.

## Acknowledgements

I would like to thank my supervisor, Professor Nam Mai-Duy for guiding me throughout the project. I also would like to thank faculty and fellow students for supporting me.

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# Power System Asset Planning and Risk Management Focusing on Ageing Infrastructure

Sponsor – School of Mechanical and Electrical Engineering

## Jaison Duma

Master of Engineering Science  
(Electrical/Electronic)



Supervisors: Dr David Thorpe, USQ

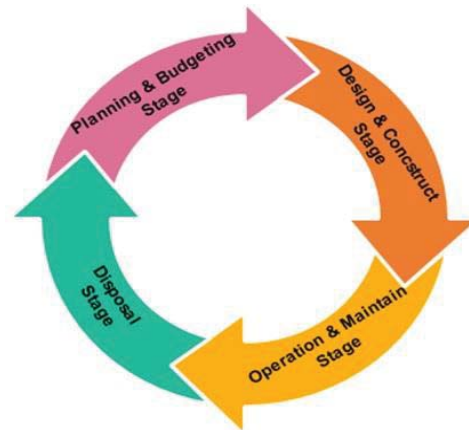


Figure 1 – Asset Life Cycle Stages

**Keywords:** Asset Planning, Power System, Ageing Infrastructure

## 1. Introduction

Electricity has become an essential part of modern life and is used in many different areas for different purposes. In an Electrical Power System physical assets include generating, transmission, distribution/supply assets, and generating and distribution assets maybe located hundreds of kilometres apart.

The project investigated the concept of asset planning and risk management in ageing electrical power systems, with the view of maximising the availability and maintainability hence the reliability of electricity supply. These assets are managed to supply electricity (for human satisfaction) reliably at minimum cost to the power utility.

## 2. Background

Electricity energy consumption has been steadily growing throughout the world due to economic activity as well as population growth. In Zimbabwe the increased consumption of electricity has not been matched on the generation side and the country is supplied by ageing infrastructure, some built more than 70 years ago. The project aims to create a draft asset management plan template for a power generating facility.

## 3. Methodology

Research was carried out on components of an electrical power system and life cycle of physical assets as shown in Figure 1. Asset management standards, as well as risk management were researched as part of literature review.

## 4. Key Outcomes

The key outcome for the project was to produce a draft asset management plan for a power station and complete an academic dissertation, and this was partially achieved.

## 5. Conclusions

Asset planning and risk management should be part of physical assets if the assets are to provide reliable services. For ageing assets the focus should be put on the operation and maintenance stage. Minimisation of cost while maximising the availability of the assets will satisfy all stakeholders.

## Acknowledgements

I would like to acknowledge David Thorpe for the support and guidance during the preparation of the project.

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# Investigations into the Effect of Contaminants on Permeable Concrete Effectiveness during its Life Cycle

Sponsor – School of Civil Engineering and Surveying



**John Eaton**  
Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Yan Zhuge, USQ  
Mrs Krishna Mishra

**Keywords:** Clogging, Porosity & Permeability

## 1. Introduction

This project explores both the positive and negative implications of using Permeable Concrete (PC) in new construction developments. Permeable concrete in theory should address problems with urbanisation of land around cities as they expand. Issues associated with high density of impervious areas are of major concern to the underground aquifers drying up, where the water should be intended to filter through natural ground replenishing the aquifers, instead turns into stormwater runoff.

The integration of pervious concrete into new housing developments around Toowoomba or any city should be encouraged by planning sections of local government to consider new developments that PC be incorporated for use on roads, driveways and footpaths.

## 2. Background

From further investigation on PC its main flaw is clogging from turbidity and is perceived as the major reason why permeable concrete does not have widespread use. This report is aimed at developing an understanding for what influences clogging of the pores/voids in PC which ultimately leads to permeability reduction.

## 3. Methodology

Four samples of permeable concrete were batched up in the USQ labs with the only change between each sample was percentage of aggregate of 9.5mm and 4.75mm stone. Each sample was tested first with fresh water then re-tested with local stormwater using the falling head permeability test apparatus. Please see Figure 1 for an example.



**Figure 1:** A picture depicting the *Falling Head Test Apparatus*

## 4. Key Outcomes

Many research have been conducted on permeable concrete but generally have not focused exactly on its weakest point, clogging. My only concern with this project is on the topic of PC clogging. Results revealed that the denser the sample, or lower the porosity, increased the likelihood of clogging. Others have proved PC has the necessary requirements to be used as low volume pavement.

## 5. Further Work

More laboratory testing is required as high porosity samples tested did not clog as expected using stormwater. The lower porosity samples started to clog with the stormwater. As this is only small scale testing in the laboratory I would like to do a carpark or full scale subdivision and monitor the results over time.

## 6. Conclusions

Results indicated the negative implications of clogging on permeable concrete. Vigorous testing to develop a solution and preventative approach to clogging is crucial for the life cycle of permeable concrete.

## Acknowledgements

I would like to thank and express gratitude towards my supervisor and family for their assistance and support.

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# Investigation of the relationship between speed and separation width for head-on crashes in New South Wales

School of Civil Engineering and Surveying



**Jonathan Epselis**

Bachelor of Engineering (Civil)

Supervisor: Mr. Trevor Drydale, USQ

**Keywords:** Head-on crash, speed, separation width

## 1. Introduction

Of all the types of crashes, head-on/cross-over collisions are most severe and result in a far higher percentage of deaths due to the physical forces at work when one vehicle is struck by another.

Speeding is regarded as one of the principal contributing factors in road crashes. Once a crash occurs, the outcome of the crash for the vehicle occupants is related to the amount of kinetic energy applied to them.

Medians and/or separation between opposing carriageways aim to reduce the incidence and severity of head-on and crossover crashes

This report will aim to investigate the trends and establish a correlation between head-on crashes, posted speed and separation width.

## 2. Background

Due to the high volumes of traffic using New South Wales roads, particularly in urban areas, when a vehicle leaves the carriageway in which it is travelling and crosses the median into the opposing carriageway, there is a high probability of a collision with one or more oncoming vehicles.

Many years ago when the majority of NSW roads were being constructed, it was not anticipated that they would be required to cater for such high volume of traffic. To increase their capacity and reduce traffic congestion, lanes have been added to many existing roads. Often due to properties abutting the road corridor and utilities located adjacent to the carriageway, these addition lanes were commonly created in existing medians, often resulting in minimal separation between opposing carriageways.

## 3. Methodology

There have been a number of report analyses prepared on road safety and the relationship of crash rates and their severity. The research into head-on crashes and their affect on crash rates depends on valid and reliable methods to produce accurate results.

The model for most of the literature in this dissertation has been the use of historical 'Crashlink' crash data, with the combination Road Brower software and aerial imagery. This is the most preferred method for highlighting the correlation between head-on crashes and other contributing factors such as speed and separation width.

## 4. Key Outcomes

The research project to date has reviewed literature and proposed a methodology to analyse head on crashes with respect to speed and separation width. The review has proved that speed and separation is not extensively considered in current design theory. Analysis of the data to indicate causes and identify trends remains.

## 5. Further Work

Analysis of the collected crash data is required to discuss the relationship between head-on crashes, speed and separation width.

## 6. Conclusions

The research is expected to highlight trends between certain speeds and separation widths to distinguish a 'safer' width for specific speed environments.

## Acknowledgements

I would like to thank my supervisor Mr. Trevor Drysdale for taking on the project and providing guidance. Also special thanks to Roads and Maritime Services and my expert colleagues in the Road Design Engineering Section who gave me comprehensive knowledge and experience.

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# EVALUATION OF PHOTOGRAMMETRIC MEASUREMENTS OBTAINED USING IMAGING ROVERS AND IMAGING THEODOLITES

School of Civil Engineering and Surveying



**Jesse Evans**

Bachelor of Spatial Science  
(Honours) (Surveying)

Supervisors: Dr Xiaoye Liu, USQ

**Keywords:** Imaging Total Station, Terrestrial Photogrammetry, V10 Rover

## 1. Introduction

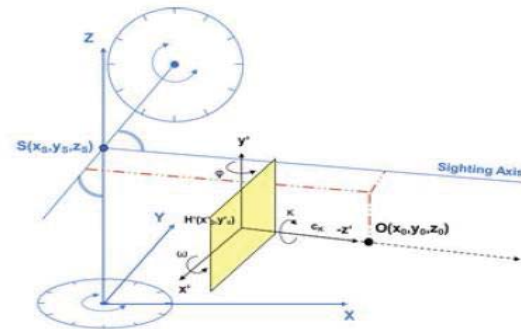
Recent improvements in electronics has allowed instrument manufactures to incorporate new digital technologies into traditional surveying equipment. Digital cameras have been integrated with electronic theodolites to streamline the photogrammetry process that allows measurements to be taken of objects using a pair of photographs. An imaging rover has also been created that allows 360 degree panorama photos to be taken from a flexible pogo platform. With the addition of advanced software, terrestrial photogrammetry is now an alternate option of data collection for the modern industry professional.

## 2. Background

There are great benefits in using this new technology. The saying 'a picture is worth a thousand words' is certainly true with imaging theodolites/rovers as a pair of photos can potentially generate large point clouds of data. Complex work sites can be efficiently surveyed with minimal field time. However there are always concerns with the accuracy of measurements when using new equipment. The aim of the project is to clarify information for the use of imaging theodolites/rovers under real world conditions and guide users on the appropriate operation of the equipment.

## 3. Methodology

The project began by researching commercially available equipment (hardware and software) to gain an understanding of adopted industry standards. An appropriate field testing method was then designed and



**Figure 1 - Model of a camera independent of the optical telescope (Trimble 2012).**

carried out to determine the extents of useable data. After analysis recommendations can be made for the reliable use of the imaging technology.

## 4. Key Outcomes

The key outcome for the project is to determine parameters that will provide for correct operation of the technology, delivering reliable measurements.

## 5. Further Work

Final analysis of field observations and recommendations are still to be completed. Following on from this project, it would be interesting to compare point clouds generated between photogrammetry and laser scanning technologies.

## 6. Conclusions

Terrestrial photogrammetry has great potential to capture huge amounts of data through the use of imaging technologies. Correct operation and understanding of limitations will be critical to measurement accuracy.

## Acknowledgements

I would like to thank my supervisor Xiaoye Liu for her guidance. I would also like to thank my employer, Mosel Steed Surveyors for allowing the use of an S6 imaging theodolite and access to their facilities throughout the project. Ultimate Positioning Group- Adelaide was also generous in providing access to a V10 imaging rover.

## References

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# Investigation of seepage in water supply distribution channels in St George, Queensland

Sponsor – School of Civil Engineering and Surveying



**Melissa Fairley**

Bachelor of Engineering  
(Honours) Major Environmental  
Engineering

Supervisor: Dr Malcolm Gillies

**Keywords:** seepage, channel, irrigation.

## 1. Focus of the Study

This study measured the seepage losses in 9 kilometres of a 99 kilometres agricultural channel water supply system constructed in St George, Queensland during the 1950s and 1970s.

The results of the study were compared to the seepage losses measured in other Australian studies. The expected seepage loss was 0.015 metres per day.

## 2. Background

The annual loss of water in storage due to evaporation and seepage is estimated to exceed several thousand gigalitres representing billions of dollars lost to the Australian economy. There is a need for water-saving measures and a structured approach to assess water loss in earthen supply channels.

The St George Irrigation Area (SGIA) is the only supplemented irrigation system in south west Queensland and it is a major contributor to the fibre (mainly cotton lint) produced in Australia.

## 3. Methodology

The field measurement installation sites were selected based on soil types, the nature of the use and the likelihood of a shutdown period.

The ponding test method was used to calculate the daily seepage losses through the bed and walls of the earthen channel supply system at three field sites. Absolute pressure transducers installed in three isolated channel sections with contrasting soil types measured the rate of drop of the free water surface in the supply channel. The daily seepage loss rate was calculated by subtracting the daily evaporation from the rate of drop of the free water surface. Finally, the geometry of the channel sections was used to estimate the annual seepage loss.



**Figure 1 – The water levels measured by the pressure transducers in Channel B2/2, St George were manually calibrated**

## 4. Key Outcomes

- Reviewed Australian channel seepage loss studies
- Measured seepage losses in earthen channels and estimated potential annual water savings

## 5. Conclusions and Further Work

The ponding test is a simple structured approach used to assess water loss to seepage in earthen supply channels.

The estimated seepage loss during May 2015 in the B2/2 Channel (29 megalitres per day capacity) was 0.008 metres per day  $\pm$  0.002 (95%).

The experimental results of this study should be replicated to confirm the estimated seepage losses are a true representation of annual seepage losses during varying environmental conditions.

## Acknowledgements

Queensland Department of Natural Resources and Mines, R Krebs (dec'd), J Weller, J Schultz, J McLean, M Gillies.

## References

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# Investigation the dynamic properties and energy absorption capability of Engineered Cementitious Composite (ECC)

Sponsor – School of Civil Engineering and Surveying



**WEI FAN**

Master of Engineering Science Major Structural Engineering

Supervisors: Assoc Prof Yan Zhuge, USQ

**Keywords:** ECC; Mix Design; High strain rate test; Indentation test

## 1. Introduction

Engineered cementitious composite (ECC) is a kind of material which was based on cement and containing a mix of fly ash, sand, PVA fibres, water and chemical adhesives. ECC is a family of high performance fibre reinforced cementitious composites, with randomly distributed short discrete fibres, known for its superior mechanical properties like enhanced tensile strength and ultimate strain capability. Compared with the conventional concrete material and regular fibre reinforced concrete, it has significantly improved tensile strain hardening capacity.

## 2. Background

In order to fulfil the need of protecting people from either the adverse effect of natural force or violent attacks by other enemies, the new developed material ECC has been driven. PVA fibre is the main one used in the design. It has small diameters and low product strain hardening when compared to other fibres. The research project aims to develop a new type of ECC with improved impact resistance.

## 3. Methodology

Compression test, flexure test and indentation test have been conducted in this project. The compression test was using cylinder specimens (200x100). The flexural beam (350x100x20) were tested by three kinds of different strain rates in order to compare the results under different strain rates and the disc specimens is for indentation test for hardness.



Figure 1 – Flexure test

## 4. Key Outcomes

As the 350x100x20 size beam tested by the 1mm/min rate, I get the curve from different strain rates which mean the concrete is ductile. The different specimens have also affected the test results of the strain capability.. The more loads you add the more strength it gets, which means that it is the ductile concrete we want.

## 5. Further Work

I have completed nine groups of mix designs so far. In order to achieve a high level of research I think I have to find out more mechanical properties of ECC and developed a mathematical model from my indentation test.

## 6. Conclusions

This study has explored experimentally the mechanical properties of a new ECC reinforced with 1.5% PVA and 0.5% steel fibres, forced by 2% PVA for comparison. It is found that the flexure strength increases three times for ECC compared to normal concrete.

## Acknowledgements

I would like to thank my supervisor Prof Zhuge who led me on the project step by step and my peer Ali who gives me much guidance. And I would also like to thank lab staff Daniel and Piumika for helping me with the test.

## References

- Chen, Y. Fracture of Hybrid Micro fiber Reinforced Cement Composites, chapter 43, pp. 1-8.
- Hu, W & Xiang, J. (2013), 'Experimental research on the mechanical properties of PVA fiber reinforced concrete',

# Evaluation of Signalised Intersections in NSW with Right Turn Filters

University of Southern Queensland – School of Civil Engineering and Surveying



**Daniel Farrugia**

Bachelor of Engineering  
(Honours) – Major Civil  
Engineering

Supervisors: Dr Soma Somasundaraswaran,  
USQ

**Keywords:** Road Safety, Right Turn Filter and  
Signalisation.

## 1. Introduction

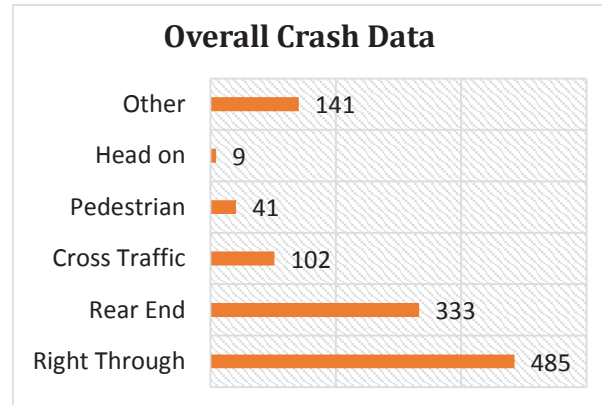
The use of right turn filtering at signalised intersections allows the through movement of the major road to operate with greater green time. This improves intersection efficiency, although allows a conflict point between opposing traffic flows. Signalised intersections with right turn filtering enabled generally results in a higher occurrence of right through crashes.

## 2. Background

The NSW Traffic Signal Design guide (2010) outlines the requirements for right turn filtering to be enabled. However, this document does not give evidence of the research undertaken to form these guidelines. This research aims to confirm the guide is correct and assess other factors which may contribute to right through crashes at filtered signalised intersections.

## 3. Methodology

The analysis examines 147 approaches from 77 signalised intersections with right turn filtering enabled. All sites selected are located within the Sydney, Newcastle or Wollongong regions and have a reported right through crash history in the 2014 calendar year. Crash data for each approach was acquired from Crash Link database for the 2009 – 2013 calendar years. Analysis has been undertaken on approach speed, traffic volumes, number of opposing through lanes, available gap sight distance, age and sex of driver turning right, and other physical factor which may contribute to a higher crash rate at signalised intersections with filters.



## 4. Key Outcomes

The major outcome of the project is to determine attributes of signalised intersections that contribute to a high rate of opposed right turn crash. This is expected to allow current and future signalised intersections to be accessed to identify if the intersection will have a greater occurrence of crashes as a result of right turn filters being implemented.

## 5. Further Work

At this point in time research is still ongoing, although it has been determined that a cost and benefit analysis should be undertaken to determine the approach speed that results in an undesirable cost to society.

## 6. Conclusions

At this point in time it has been determined that more research is required into approach speed for filters, the day of the week has not impact on right through crash rate and young drivers are at most risk.

## Acknowledgements

I would like to acknowledge my Partner Jade Patterson and son Lachlan Farrugia for their love and support though this degree. Also my current employer the NSW RMS for their assistance in undertaking this research. Finally my supervisor Dr Soma Somasundaraswaran for his support on this research project.

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- Roads and Maritime Services. (2010). *RTA Traffic Signal Design*, 3.
- Austrroads Ltd. (2013). *Guide to Traffic Management: Part 6 – Intersections, Interchanges and Crossings*, 2.
- Austrroads Ltd. (2010). *Guide to Road Design: Part 4A – Unsignalised and Signalised Intersections*, 2.

# Machine Vision and Sensing With an Android

Sponsor – School of Mechanical and Electrical Engineering



## Shaun Field

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Prof. John Billingsley,

**Keywords:** Machine Vision, Android, Image Processing, Row Detection

## 1. Introduction

With the continually decreasing numbers of skilled farmers and the ever increasing necessity for agricultural production there is always a great need to increase productivity and efficiency on farms. Vehicle automation has been one of the key ways to do this in the recent past. This project investigates the concept of developing an automated vehicle guidance system using the Android mobile platform.

The Android platform has specifications for an array of sensors that can be used in vehicle guidance applications. This project researches the capability of these sensors being used for vehicle guidance. Particular focus is made on machine vision techniques that use the camera as the main sensor for vehicle automation.

## 2. Background

Machine vision has been used for the automation of farming vehicles for a number of years now however setting up vehicles for this type of automation requires specific technical skills and multiple pieces of expensive equipment. This project aims to lower the cost and complexity of installing a machine vision device on a farming vehicle by testing the feasibility of machine vision on an easily installable and inexpensive mobile device.

## 3. Methodology

A literature review was conducted to see what methods for farm vehicle automation are currently used. This review primarily focussed on current machine vision techniques and their effectiveness as well as the ability of the Android SDK to perform these machine vision tasks. Several short programs were then written in Android code to identify some key aspects of the Android SDK. Code was then written to access the video stream as a byte array of pixel values that were



Figure 1 – Crop row identification from an Android device

then used to identify rows of crops. Figure 1 shows a modified crop row image captured from the Android device.

## 4. Key Outcomes

This project identifies the capabilities of an Android device being used for farm vehicle automation. The project has shown that an Android device can identify crop rows based on the greenness of the image pixel. Further development of Android based machine vision could dramatically reducing the cost and complexity of setting up alternative automated vehicle guidance systems.

## 5. Further Work

While this project has shown that an Android device is capable of identifying crop rows it is still a long way from being field tested. Future work for this project would involve the Android system deducing steering demands from the camera image and then outputting a signal to an actuator that controls the vehicle. All of these devices would then need to be field tested.

## 6. Conclusions

This project showed that an Android system is capable of identifying rows of crops and that it has potential to be used in vehicle automation in the future.

## Acknowledgements

I would like to thank Prof. John Billingsley for helping me complete this project and introducing me to the world of machine vision.

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- Billingsley, J & Schoenfisch, M 1997, 'The successful development of a vision guidance system for agriculture', *Computers and Electronics in Agriculture*, vol. 16, no. 2, pp. 147-63.
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# AN ASSESSMENT OF RURAL ROAD NETWORK RESILIENCE AS CRITICAL INFRASTRUCTURE FOR COAL SEAM GAS DEVELOPMENT IN REGIONAL QUEENSLAND

Sponsor – Western Downs Regional Council

## Sam Fitzgerald

Bachelor of Engineering Honours (Civil)



Supervisors: Trevor Drysdale, USQ  
Brandon & Associates,  
Western Downs Regional  
Council

**Keywords:** Infrastructure, Resilience, Network

## 1. Introduction

This dissertation investigates the resilience to flooding of the local road network in the Wandoan Region of Queensland, Australia and the expected economic impacts on local CSG developments as a result of this level of resilience. This project also evaluates the increased resilience to the network as a result of planned road upgrades and provides an analysis of these upgrades in terms of the cost, and expected savings offered by the increased level of resilience.

## 2. Background

The local infrastructure networks in these areas of development often consist of a pavement and formation only. This existing asset class leaves these roads and associated road networks vulnerable flood events, with these roads often suffering significant damage and requiring a substantial amount of repair work be undertaken before the road is returned to the regular level of service. As a result these networks are

extremely vulnerable to damage and disruption during flood events.

## 3. Methodology

The assessment of the local road network in the Wandoan area was completed using the existing NIRA (Omer, et al., 2013) framework to quantify the resilience in terms of cost due to network disruption. The modelling of the actual disruptions themselves was undertaken using historic scenarios of the 2011 event.

## 4. Key Outcomes

This project has highlighted the vulnerability of traditional trunk infrastructure networks to disruption in the event of disruptions on the main arterial links in the network.

## 5. Further Work

There are multiple further topics for investigation including congestion, alternative travel paths, and standardised evaluation of hazard effects.

## 6. Conclusions

This investigation provided insight into the vulnerabilities both of rural road networks and of the individual road assets to disruption during flood events as well as quantifying the cost to road users in an event.

## Acknowledgements

USQ for the support and assistance provided over the course of my degree, in, in particular Trevor Drysdale for the valuable feedback provided during this project to date. I would also like to acknowledge WDRC for the use of flood and asset data.

## References

Omer, M., Mostashari, A. & Nilchiani, R., 2013. *Assessing Resilience in a Regional Road-based Transportation Network*. International Journal of Industrial and Systems Engineering, 13(4), pp. 389-408.



# Thermally Insulated Structural Sandwich Panels for Roofing Applications

Sponsors: Buchanan's Advanced Composites  
School of Civil Engineering and Surveying



**Mr Aiden Flannery**

Bachelor of Engineering (Civil)

Supervisors: Dr Sourish Banerjee, USQ

Mr Norman Watt, Buchanan's  
Advanced Composites

**Keywords:** fibre composite, sandwich panel, roofing

## 1. Introduction

The viability of using fibre composite sandwich panels for roofing applications forms the primary investigation of this research project. The flexural strength and thermal insulation are of main focus however fire resistance, cost effectiveness and lifespan are also investigated.

## 2. Background

The market for modular housing and infrastructure is growing remarkably quickly. The increasing cost of labour and the demand for energy efficient, long lasting buildings are some of the driving factors for this movement. Fibre cement panels with corrugated steel shells have been on the forefront of the quick build industry for some time. This project investigates the viability of fibreglass sandwich panels for this application.

## 3. Methodology

A literature review was conducted on the design methods, requirements and applications of fibre composite technology in the civil infrastructure industry. Based on these findings, the theoretical properties of the materials were calculated and used to design a set of sample panels. The modular roofing concept design is shown in figure 1. The panels will be tested in bending and shear by use of a three point bending test. Results from the tests will then compared with the theoretical properties and used for a finite element analysis to confirm the structural integrity of the design. Along with the strength, the thermal insulation was checked for conformance with current Australian standards and local requirements.

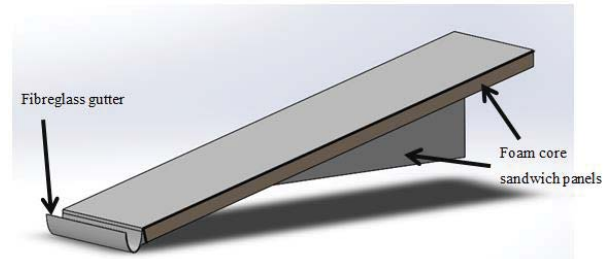


Figure 1 – Modular Roof Concept

## 4. Key Outcomes

The flexural testing is underway with results expected to support the theoretical properties calculated. At this stage, the validity of the design cannot be determined, however based on the theoretical results the panels will satisfy the strength, serviceability and thermal insulation requirements determined in accordance with relevant Australian Standards.

## 5. Further Work

The analysis and comparison of test results with the theoretical properties of the material is yet to be completed. An FEA will be conducted based on these results to confirm the design. Time permitting; a detailed cost analysis of the design in comparison to traditional roofing will be completed.

## 6. Conclusions

At this stage of the investigation, it is not clear whether fibreglass sandwich panels will pose as a viable roofing material. Upon positive results, the panels will be subject to further development with the aim of producing the modular roofing design on a large scale.

## Acknowledgements

I would like to thank BAC and in particular Norman Watt for the supply of materials and continued support throughout this project. I would also like to thank Dr Sourish Banerjee for his guidance and Wayne Crowell for his assistance in the testing laboratories.

## References

Howard, A. G. (1969). *Analysis and Design of Structural Sandwich Panels*. Rushcutters Bay: Pergamon Press.



# Object-Oriented Image Analysis of Cotton Cropping Areas in the Macintyre Valley Using Satellite Imagery

School of Civil Engineering and Surveying

## Desmond J Fleming



Bachelor of Spatial Science  
(Honours) (Surveying)

Supervisors: Prof. Armando A. Apan, USQ

**Keywords:** Remote Sensing,  
Segmentation, Object-Oriented.

## 1. Introduction

The segmentation process of extraction of polygons using software such as ENVI on satellite imagery to produce object based data is becoming more apparent. The technique is impressive on large areas, extracting information which can be processed for whatever purpose, with export options allowing compatibility for use in other software packages. The research is to use Landsat 7 imagery with its multispectral bands, applying the object-oriented technology through ENVI software and acquiring an image data set for cotton area estimates and possible infield crop analysis if time permits.

## 2. Background

The application of object-oriented technology analyses the object space rather than the pixel space. Converting images into multiple objects refers to image segmentation, where polygons created from object shapes are able to be interpreted. The aim is to test the object-oriented phenomena on cotton crops from satellite imagery.

## 3. Methodology

The methodology of an object-oriented image analysis is to group pixels with similar spatial response using predefined sets of rules and apply pixel-based image techniques to extract features relevant to the applied use (Navulur 2007 p.1). The application of different rule sets in ENVI will be applied to the Landsat 7 imagery obtained and results shown of the effectiveness of cotton field data extraction.

## 4. Key Outcomes

The validation of the segmentation concept, utilising ENVI parameters and classification algorithms available in the software in the extraction process.

## 5. Further Work

Object-oriented phenomena of data extraction of cotton fields is one small example of the software's capabilities in which can be applied to any desired piece of object information that can be identified from an image. Therefore further work in this area is unlimited.

## 6. Conclusions

The ability to extract object-oriented polygons of interest from a satellite image and be able to utilise this information in other software packages represents the increased potential of information data collection.

## Acknowledgements

I would like to thank Dr Glenn Campbell for his guidance in the initial idea of the object-oriented concept. Also I would like to thank my supervisor Prof. Armando A. Apan for his fresh approach and assistance in my endeavours into the object-oriented phenomena.

## References

Navulur, K, 2007, *Multispectral Image Analysis Using the Object-Oriented Paradigm*, CRC Press, Boca Raton, p. 1.

LandsatLook Viewer 2015, LandsatLook Viewer image of property "Eukabilla", viewed 21 March 2015, <http://landsat.usgs.gov/LandsatLookImages.php>

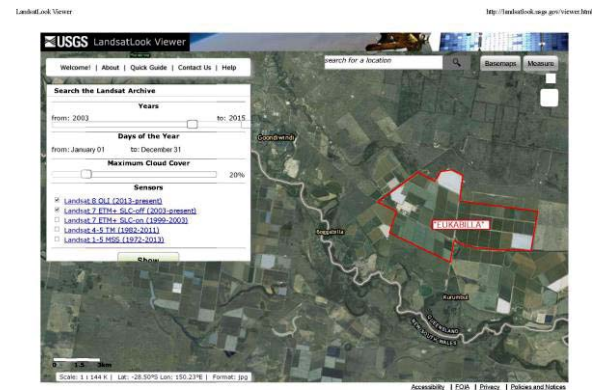


Figure 1 – LandsatLook Viewer Image property "Eukabilla"

## Effect of Environmental Surroundings on Accuracy And Precision of Total Station Measurements Sponsor – School of Civil Engineering and Surveying



### Joseph Ford

Bachelor of Spatial Science  
(Surveying)

Supervisors: Zahra Gharineiat,  
USQ

Keywords: EDM Measurement, Reflection, Surveying Interference.

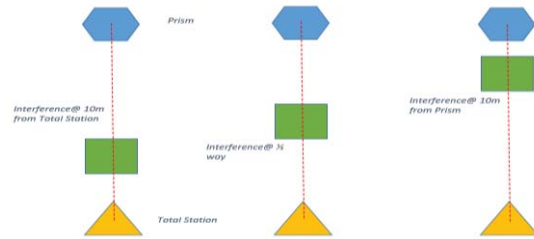
1. Introduction - The aims of this project is to investigate the effects of environmental surroundings, on the accuracy and precision of total station measurements, more specifically, whether the background or foreground objects have an influence when measuring to the desired target.

2. Background - As surveying practice takes place outside of laboratory conditions there are a multitude of influencing factors that contribute to the reliability of the data collected in the field. A few objects have previously been identified in creating erroneous measurements, but limited studies have been undertaken as to identify their effect.

3. Methodology - To test for the effect of these objects, 3 experiments were created; urban retro-reflective and non-reflective interference and water background interference. The experiments were completed using a range of prisms commonly used in day to day surveying practice - Super Prism, 360 prism, and Direct Reflex. For these a range was created and measured without interference, the desired object to be tested was then added and the measurements were recorded again. An example of experiments 2 and 3 can be seen in Figure 1.

4. Key Outcomes - The findings from the practical experiments have shown that the interference provides either minimal errors with regards to the true distance measurements or extremely large errors that can easily be identified as gross errors in the field. The results from the testing of measuring with glass as an interfering object can be seen in Figure 2. This shows the effect of the glass with the target being the Trimble Super Prism, with the glass being placed at 10m from the instrument, 1/2 way and 10m from the target. As shown in Figure 2 the errors caused by the glass are relatively small and most probably would not be easily noticed in the field or data review methods.

5. Further Work/ Conclusion - The projected tasks have been completed the results have indicated that the [Figure 2 Trimble 5600 - Interference of Glass \(Super Prism\)](#).



**Figure 1 Experiment 2/3 -Example of interference placement for each station**

reflective interference of the objects have not had a dramatic effect. A few issues have been revealed through examining the results and it would be interesting to investigate their effect, e.g. the effect of partially covered prisms.

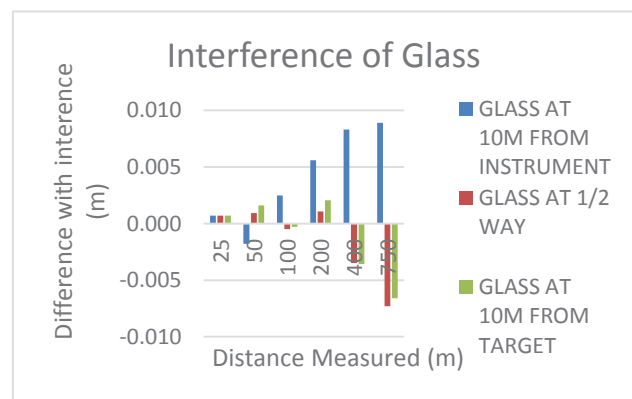
6. Acknowledgements - I would like to thank Zahra Gharineiat for her help and guidance throughout this project, my father Robert Ford, for help with the field practicals and Murray and Associates for supplying survey equipment and insight into the project.

#### References

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Steyn, N. (2009). Automated methods of precise surveying using robotic total stations and retro reflective tape targets, University of KwaZulu-Natal, Durban, retrieved May 25, 2015, <http://geomatics.ukzn.ac.za/Uploads/0090ba64-939c-4057-bfcf-1f107a284e93/STEYN.pdf>

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# Vulnerability of Bridges in Extreme Flood Events Based on Element Failure

School of Civil Engineering and Surveying



**Carl Fraser**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Karu Karunasena, USQ  
Dr Weena Lokuge, USQ

**Keywords:** Natural disasters, bridges, structural vulnerability

## 1. Introduction

The aim of this project is to investigate the effects of flooding on bridge infrastructure, particularly in the Lockyer Valley Region. The vulnerability can be determined from structural modelling of the bridge and this can be used to identify which bridge infrastructure may be in need of remedial work to make them less vulnerable to damage from future flooding.

## 2. Background

The 2011 and 2013 floods had a devastating impact on the Lockyer Valley community as a whole. A number of bridges were severely damaged creating a costly repair bill. As bridges are critical infrastructures, limited access or closure can impact on emergency services and other disaster relief services as they are not able to reach isolated communities. Vulnerability of a structure is defined as how susceptible it is to damage from an extreme event or the level of consequence that resulted from a hazard.

## 3. Methodology

The Finite Element software package, Strand 7, was used to model the bridge under applied flood loads. A simple bridge was used first to gain preliminary results and also to gain an understanding of how the model will work. A case study bridge in the Lockyer Valley, located near Gatton, crossing Tenthill Creek was then chosen. A simplified version of this bridge is to be modelled in Strand 7.

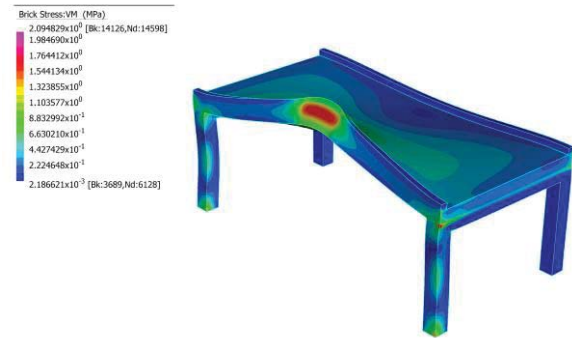


Figure 1 – Simple bridge – stresses from log impact

## 4. Key Outcomes

The load capacity of the simple bridge has been calculated and work on calculating the vulnerability indices is currently underway. The capacity was found by gradually increasing the flood load in Strand 7 until the stresses exceeded the material strength. To simulate cracking a small element with a lower modulus of elasticity was added to the centre of the girder. This simulates a log or shipping container impacting the bridge.

## 5. Further Work

The case study bridge is still required to be modelled in Strand 7. Due to time requirements further modelling of scour will not be completed.

## 6. Conclusions

Preliminary results indicate that bridge element failure does lower the bridge load capacity and is therefore vulnerable to flooding.

## Acknowledgements

I would like to thank my supervisors Dr Weena Lokuge and Dr Karu Karunasena for their guidance throughout my project and also Dr Buddhi Wahalathantri for his input.

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# Optimisation of a Side Tipper Bin

School of Mechanical and Electrical Engineering



## Lee Gardner

Bachelor of Engineering  
(Honours) (Mechanical)



Figure 1 – Side Tipper Bin

Supervisors: Mr Chris Snook, USQ

Mr Darren Black, Haulmark  
Trailers Australia

**Keywords:** Finite Element Analysis, Tipper,  
Manufacture

## 1. Introduction

This project is a feasibility project based around the manufacture of a side tipper bin similar to that shown in Figure 1. These bins are used in agriculture and mining applications.

## 2. Background

Haulmark trailers have built their products based around conservative hand calculations and rules of thumb. These rules have survived the test of time with the company now in business for approximately 50 years. Over the last 10 years, due to technological advancements, such as the use of FEA, there has been an opportunity to streamline some of those products. This falls in line with my background in steelwork and machinery manufacture.

## 3. Methodology

A Finite Element Analysis (FEA) model of the side tipper bin was created to allow virtual testing of the current design compared to a new concept designed in Autodesk Inventor. Two sets of configurations of the side tipper bin were set up and analysed. The results are currently being reviewed and the new design is being optimised for manufacturing efficiency and fabricated weight loss.

## 4. Key Outcomes

To date the current design has been reviewed and is now being used as a benchmark from which to measure the new design. As a result of the requirement to reduce manufacturing costs, time has been spent developing a new bin design that is easier to

manufacture, as well as being lighter with a lower COG (whilst mounted on the trailer). In applying FEA to review the structure, a reduction in both manufacturing time, by a target of 12.5% and weight is indicated while still maintaining a very robust design that will stand the test of time.

## 5. Further Work

The final design analysis results need to be reviewed and detailed in the report. The next step, which is outside of the project scope, is to build and test a full tipper bin. At a large cost, this was something that was not part of the project budget.

## 6. Conclusions

In conclusion, my project has developed a more efficiently manufactured product that meets the benchmark set by the original product. A better solution is not always to make something thicker if it's failing, or to simply add a gusset or a brace in areas of high stress. True improvement is gained by approaching the problem holistically and tracing it back to the source, which may not be where the product has failed.

## Acknowledgements

I acknowledge the assistance of my supervisor, Mr Chris Snook, USQ, for providing the ANSYS software. I would also like to thank Darren P. Black for sharing more than 25 years worth of trailer building experience. I would like to thank my wife and son for supporting me through this process for the last 8 years.

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- ANSYS Workbench (Version 15) (2013)



# Soil pore blockage as influence by intensive livestock effluent with specific focus on colloids



**Timothy Colin George**

Bachelor of Engineering  
(Honours) (Environmental)

Supervisors: Dr John McLean Bennett, USQ

**Keywords:** livestock, effluent, pore-blockage

## 1. Introduction

This research looks at the effect that thickness of compacted *in-situ* soil liners for secondary livestock effluent retention ponds has on reduction of beneath pond seepage following on from research done by Bennett and Warren (2015) which looked specifically at the role that suspended particulates play in pore blockage within the soil. The key addition is the focus on the role liner thickness plays on where these particles are retained within the soil liner. The current governing equation for this process is Darcy's law of hydraulic conductivity which states that as long as the ratio of hydraulic head (water depth) to filter depth (soil liner thickness) remains the same there should be no difference between the seepage rates. This research will also seek to compare the seepage rates and determine whether the results comply with Darcy's law.

## 2. Background

Mitigation of groundwater pollution is a key theme concerning the intensive livestock industry in Australia and New Zealand. By-product effluent is currently dealt with through retention in imported clay or rubber membrane lined ponds. Liners are employed to reduce pond permeability and hence reduce beneath pond seepage to meet requirements set by regulatory bodies. However the use of such technology is costly, and hence my research looks at an aspect of a possible alternative method: compacting the *in-situ* soil and relying on pore blockage mechanisms to reduce seepage. This thinking follows on directly from studies completed by Bennett and Warren (2015) who isolated filtration of micro suspended particulate as being the main reason for sealing effluent ponds when using parameters likely to be employed in Australia and New Zealand. A knowledge gap exists as to the effect that increasing liner thickness with increasing retained effluent depth. If it is found that there is no effect on seepage reduction my research may benefit industry through cost reduction.

## 3. Methodology

Varying scales of the dimensions recommended by governing bodies where utilised and an apparatus was constructed to simulate these scales in an enclosed environment. Simulated liners were constructed from 2 distinct soil types and then compacted. To isolate the particulate component, a purely chemical replicate of the effluent solution was added to some of the replicates. Resulting rate of liquid emerging was recorded and later graphed to determine the change over time. Later columns were dismantled and sectioned so that particulate distribution tests could be performed. Refer to figure 1 for apparatus.

## 4. Key Outcomes

There is not enough data yet collected to be able to discuss any key outcomes.

## 5. Further Work

Further collection of leaching data is required. Soil sample physical and chemical analyses to classify them. Analysis of soil core particulate distribution. Some cores will have to be prematurely terminated to be able to harvest the above data within the project timeframe.

## 6. Conclusions

There is as of yet not enough data to be able to draw any solid conclusions that are any more than speculation.

## Acknowledgements

Jemima Wixted and Peter George for helping with construction of the apparatus. Dr John McLean Bennett for providing the fundamental idea that made this project possible.

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# INVESTIGATION INTO THE ECONOMICAL FEASIBILITY OF GRID-TIED PHOTOVOLTAIC PANELS AND STORAGE SYSTEMS

School of Mechanical and Electrical Engineering

## Sharon Graham



Bachelor of Engineering  
(Honours) - Electrical and  
Electronic

Supervisors: Mr Andreas Helwig, USQ

**Keywords:** Batteries, Grid-tied Photovoltaics, Storage feasibility

### 1. Introduction

With a perceived increase in discussion and acceptance of environmental concerns such as carbon emissions and global warming, sustainable and renewable energy sources have become a topic for great discussion and increased research. A big question surrounding these energy sources is how best to store the energy generated by these 'clean' energy sources. This project is an investigation into battery technologies for use as storage in an Australian domestic grid-tied photovoltaic installation.

### 2. Background

Photovoltaic Panels have been described as one of the cleanest energy sources currently available (Kumar Sahu, 2015). A limitation of this technology is its availability during hours of direct sunlight only resulting in a customer's reliance on grid-supplied energy outside daylight hours. This project aims to provide recommendations on battery technologies for use in domestic installations based on safety, environmental and economic considerations as well as provide insight into the costs surrounding these technologies with consideration of current and future Australian tariffs.

### 3. Methodology

The methodology applied in this project included data collection of a Queensland domestic installation, data collation, data analysis using HOMER software (see Figure 1) and investigation into developing a 'smart' switchboard such that a domestic load can be switched to further reduce reliance on grid-supplied energy.

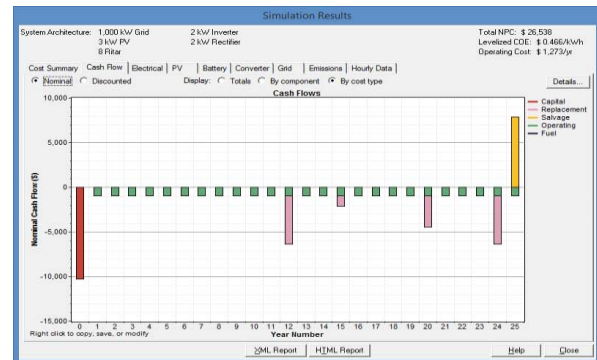


Figure 1 – HOMER analysis of Ritar Lead-acid batteries

### 4. Key Outcomes

The literature review identified a lack of discussion of various battery technologies in current Australian Standards and a large variation in predicted future tariffs in Australian states. Several battery technologies and Australian tariffs were used in HOMER analyses to provide an indication of required tariff and installation costs to achieve economic feasibility. The methodology applied could be used to analyse any domestic installation.

### 5. Further Work

The winter analysis is to be completed in HOMER as the required battery capacity has increased. The 'smart' switchboard concept design still requires further investigation and development. Future projects could attempt implementation and improvement of this design and completion of a prototype.

### 6. Conclusions

Initial analysis suggests significant decreases in technology capital costs will be required along with increases in tariff prices in order to make battery storage a feasible option in domestic installations.

### Acknowledgements

I wish to thank Mr. Andreas Helwig for his knowledge, assistance and guidance throughout this project.

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Kumar Sahu, B 2015, 'A study on global solar PV energy developments and policies with special focus on the top ten solar PV power producing countries', *Renewable and Sustainable Energy Reviews*, vol. 43, no. 0, pp. 511-36

# Uniformity Performance of Non-Standard Overlapped Centre Pivot & Lateral Move Sprinklers



**Matthew Green**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Joseph Foley

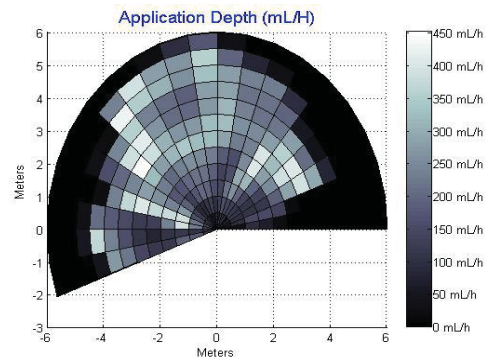


Figure 1 – Results plot example

**Keywords:** Irrigation, Uniformity, Irrigation sprinklers

## 1. Introduction

This research project looks at the uniformity of part-circle irrigation sprinklers commonly used around Australia on lateral move and centre pivot irrigation machines. There is little knowledge of the actual performance characteristics of these devices and as a result it is difficult to gain maximum efficiency around the towers where these devices are commonly used. This project aims to assess the uniformity characteristics of these device and make recommendations to how they can be more effectively implemented.

## 2. Background

A major issue for irrigation machines particularly in the first years of operation is wheel bogging and rutting, which develops from water running into the wheel tracks of the irrigator. A method to reduce this is to use part-circle sprinklers around the towers, but as there is little research in the area. Often up to a 10% reduction of crop yield can result from the reduced application around the towers (Senninger Irrigation Inc., 2010).

## 3. Methodology

Testing involved two sprinkler models and five 3TN nozzles per sprinkler. Each sprinkler and nozzle set was tested at two pressure settings. The tests involved 200+ individual catch cans to record the application of water. Figure 1 shows an example of the data. In total 16 tests were carried out under laboratory conditions, eliminating environmental effects on the tests.

## 4. Key Outcomes

Results from testing have unveiled some very interesting patterns, indicating low uniformity but solid consistency in the shape of application and where the water is applied by volume. Analysis of the results have allowed for a set of recommendations to be developed for the implementation of these devices on irrigators in the field.

## 5. Further Work

Recommendations will be made for the implementation of these devices, as the results are analysed in more depth the recommendations will become more specific and provide a higher quality of application.

## 6. Conclusions

The purpose of this project was to shed light onto the performance of part-circle irrigation sprinklers, through the work done the industry will have a greater understanding of these devices.

## Acknowledgements

There have been several people who have been very helpful throughout this project. Daniel Eising and Jonathon Maskall, during the testing stage of the project, and Dr Joseph Foley as my facilitator has provided invaluable direction and advice.

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# Determining the suitability of GPS as a measurement tool within the crane industry

School of Civil Engineering and Surveying



## Jonn Grimmond

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Zhenyu Zhang, USQ

**Keywords:** GPS, Measurement, Construction

## 1. Introduction

Accurate job planning is curial to the safety of any construction job especially in construction environments where works encroach on public areas. This dissertation was undertaken to determine if there is a suitable method of measurement utilising the global positioning system (GPS) that could be implemented in the crane industry.

## 2. Background

Crane stability is based on the working radius of the crane and as such is pivotal to safe and efficient job planning within the construction industry. This fact combined with the fact that job planning within the “taxi hire” crane industry is generally conducted by non-technical personnel such as crane drivers or supervisors has lead, in my belief, to the requirement of a method of accurate distance measurement to be developed.

## 3. Methodology

To determine a simple and accurate method of measurement three locations were surveyed using a dual frequency GPS receiver to allow for data post processing and accurate location of these points. The positions were also surveyed using traditional methods to confirm location. After establishing this base line additional GPS receivers were used to survey this location to determine if any units could locate the points within a metre of their true location.

## 4. Key Outcomes

It has been shown from this study, that post processing can be used effectively to measure distances in the Ad-hoc construction environment in areas of good sky visibility.



Figure 1 – Visual GPS location output

## 5. Further Work

Ongoing field trials from different types of GPS receivers. This will aid in determining if additional channels or technology can improve location accuracy.

## 6. Conclusions

Post processing is an accurate means of georeferencing when used with good sky visibility. ‘Urban canyons’ or areas of high multipath still create ambiguities that effect accuracy even when the data is post processed. For readily available receivers to be used with any accuracy in the southern hemisphere research into space based augmentation would need to be undertaken.

## Acknowledgements

Dr Zhenyu Zhang, for giving me confidence to undertaking a task that I thought was outside my discipline. The initial inspiration for my dissertation came for the John Hopkins Applied Physic laboratory and their cutting edge work on the transit system and the development of the first Global positioning system. Lastly I need to thank Chriss Veness (2015) who I have followed through the internet which has enabled me to develop a solid understanding of Latitude and Longitude calculations and the application of mathematics to a spheroid.

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# Millimetre Wave Mobile Communications For 5G Cellular Networks



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Gudimetla**

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Supervisors: Associate Prof Wei Xiang,  
USQ

**Keywords:** Millimetre waves, LTE technology

## 1. Introduction

With every passing year the evolution of telecom technology has improved from 1st generation to 2.5 generation directly and from 3rd generation to now towards 5th Generation. Every upgrade of new generation realized the mobile users experience a fresh sight and as well-educated users to become accustomed to the change in devices.

## 2. Background

The generation evolution of telecommunication starts from 0G, 1G, 2G, 3G (present), 4G (upcoming), 5G (future) version every each version is developed step by step process 0G offers radio wireless transmission technology. This is the way the engineering science is evolving and our culture also plays an important role in this tremendous growth in a friendly mode. First generation of wireless telecommunication technology the network contains many cells. The second generation mobile communication system is a technical advancement for first generation. The 3<sup>rd</sup> generation mobile communication is a super extension with the introduction of MMS mechanisms. The 4<sup>th</sup> generation technology is termed as the 20<sup>th</sup> century mobile technology which the present day technology is allowing multiple access simultaneously.

## 3. Methodology

The two technologies are different concepts and architectural. The transition of technology leads to MWT operation to provide very high rates compared to two different microwave systems. The gains exceed the 10x spectrum increase because of the enhanced signal power and reduced interference thanks to the directional beamforming at both transmitter and

receiver. The next anticipated mobile communication technology is expected to follow out the millimetre wave engineering. The need of the 5th generation is to allow multi-platform approach and multiple network technology.

## 4. Key Outcomes

From the experiments it was understood that tinted glass and brick pillars have high penetration losses of 40.1 dB and 28.3 dB. Which shows that building penetration for outdoor transmitters is difficult. The penetration loss for non-tinted glass and dry wall is only 3.6 dB and 6.8 dB respectively. This connects mobile station to base station and base station to base station too.

## 5. Conclusions

The 5G Millimeter Wave Technology mobile network offers very high data rates as compared to the current 4G LTE networks. Along with the high data rates 5G Millimeter Wave Technology also offers low power consumption in mobile devices and also supports ubiquitous computing wherein the user is connected to many access technologies simultaneously like WiFi or 5G Millimeter Wave Technology networks and the user can thus move from the range of one access technology to another without loss of internet access.

## Acknowledgements

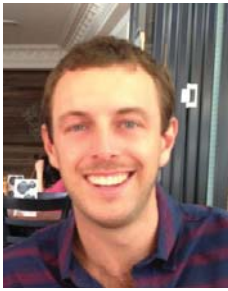
I would like to thank University of Southern Queensland and my supervisor Associate Professor Wei Xiang for supporting me in finishing this project.

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## Own Mechanism for solving disputes over retaining walls near property boundaries



**Craig Ross Hancock**  
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(Honours) (Surveying)



Image 1 – Sample image of retaining wall on property boundary

Supervisor: Shane Simmons, Civil Engineering and Surveying USQ

**Keywords:** retaining wall, dispute, boundary

### 1. Introduction

This project aims to investigate the current legislation relating to retaining walls which are on or near common property boundaries in each State of Australia and create a mechanism that can be used which will provide ways of overcoming disputes that arise between adjoining owners over retaining wall rights and responsibilities.

### 2. Background

The property rights of land owners consist of a mixture of rights, obligations and duties. A property owner is entitled to the full benefit of the enjoyment of his/her land and it is because of this that boundary disputes can arise when these rights are impinged upon. Australia's current legislation has little information available when it comes to issues arising from retaining walls on or near property boundaries. Questions in relation to the ownership of the retaining wall and respective responsibilities of adjoining land owners can arise and cause neighbouring disputes. The current legislation of most Australian States describe retaining walls in a negative way by saying what a retaining wall is not (i.e. a fence...does not include a retaining wall – *Dividing Fence Act 1991 NSW*) but does not give much information on the property owners rights and responsibilities relating to the wall. This project will build on the current legislation in Australia by also considering how legislation is applied in Australian court cases and also how other countries legislation relates to retaining walls on or near property boundaries.

### 3. Methodology

The phases of research within this project consist of firstly, reviewing the current Australian legislation that applies to aspects relating to retaining walls and boundaries, comparing the research to find commonalities and differences between each State and recording observations. The second phase consists of reviewing general land laws that can relate to boundaries and the retaining of land. The third phase consists of searching and reviewing Australian court cases which most relate to this issue, creating a summary and observations which will aid in the creation of the boundary dispute mechanism. The final phase is searching and reviewing dispute methods and legislation from other countries regarding boundary retaining walls. All the information

gathered from these phases will then be used to create a mechanism for overcoming boundary disputes involving retaining walls on or near property boundaries in Australia.

### 4. Key Outcomes

From observing the process and outcomes of several court cases involving retaining wall disputes and how specific legislation are applied in a court of law as well as information from New Zealand and UK legislation, some key factors that will contribute to the outcome of the mechanism will include; firstly that there is a general lack of knowledge by property owners when it comes to their rights and responsibilities as land owners and that this needs to be the starting point for any boundary dispute mechanism. Secondly, communication between neighbours is essential as a number of disputes arise from undertaking work when an adjoining neighbour is unaware or does not give consent. Thirdly, the purpose of a retaining wall will be the defining factor for the mechanism. This is because knowing the purpose to which the retaining wall serves on or along a property boundary will determine how it is to be treated in relation to the rights and responsibilities of property owners. It is interesting to note that some law case studies have treated retaining walls as boundary fences while others have judged them as an encroaching structure. The individual benefits that arise from a retaining wall will also be a contributing factor to the mechanism.

### 5. Further Work

Tasks that still need to be completed include taking these key outcomes and creating the mechanism. Also exploring the general land laws that relate to boundaries and the retaining of land that affect freehold properties in Australia.

### 6. Conclusions

Although the mechanism for solving disputes over retaining walls near property boundaries has not yet been completed one key conclusion is that if a retaining wall serves the purpose of a boundary fence then fencing legislation should be applied to the situation to overcome the dispute.

### Acknowledgements

I would like to thank Shane Simmons for his input and supervision in the progression of the dissertation and his guidance in helping me pursue this particular topic.

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- Dividing Fences Act 1991*(NSW) (Austl.)
- Conveyancing Act 1919* (NSW) (Austl.)



# Exploring the Suitability of LandXML in EARL Project for 3D Cadastre Development in Queensland

School of Civil Engineering and Surveying

## Robert Hancock



Bachelor of Spatial Science  
(Honours) (Surveying)

Supervisor: Dr Dev Paudyal,  
USQ

**Keywords:** LandXML, 3D cadastral, DCDB

## 1. Introduction

With rapid growth of urban environments including the increasing complexity of infrastructures, there is an urgent need to develop more innovative and efficient land administration systems. Many countries around the world, including Australia, are now developing and implementing three dimensional (3D) cadastral frameworks to address these situations, but capturing and registering these rights within existing systems brings considerable challenges. In Australia, the existing approach of registering 3D rights and storing partial geometry in the database does not support 3D functionalities such as 3D validation, query, visualisation and manipulation. The DCDB does not store 3D, and there is no automated validation, and no digital lodgement of 3D yet (Karki, 2013).

## 2. Background

The Intergovernmental Committee on Surveying and Mapping (ICSM) has endorsed LandXML as the national standard for digital lodgement of cadastral plans (Sudarshan KARKI, 2011). LandXML is an extensible mark-up language (XML) package which can be used for exchanging spatial information. In Queensland, surveying information is captured digitally using tools built in-house, called a Surveying Information Processing (SIP) tool which is based on LandXML and is used to electronically capture paper based cadastral plans.

## 3. Methodology

The LandXML has been widely adopted within the spatial industry. The research will identify relevant information on the performance of LandXML on 3D cadastre within EARL project. Limitations of 3D modelling within EARL will be determined.

## 4. Key Outcomes

The use of LandXML is expected by the industry to be the standard “vehicle” in which the data will be transferred and stored. However, the required capabilities of LandXML in 3D Cadastre have not been fully tested within the scope of EARL system.

## 5. Further Work

Some of the standards for LandXML that have been put in place by the Open Geo Spatial Consortium (OGC) are particular to the five levels of multi-scale modelling.

## 6. Conclusions

It is expected that this project will explore the suitability of LandXML within EARL project in Queensland and therefore improve the exchange of spatial data between surveyors and DNRM through digital lodgement.

## 7. Acknowledgements

Dr Dev Paudyal (USQ) for helping me formulate the idea and supervision. Staff at DERM, in particular, Chris Mcalister and Sudarshan Karki.

## 8. References

Karki, S. (2013). *3D CADASTRE IMPLEMENTATION ISSUES IN AUSTRALIA*. (Master of Spatial Science Research), UNIVERSITY OF SOUTHERN QUEENSLAND.

# Design of a Low Drag Caravan

School of Mechanical and Electrical Engineering



## Matthew David Hillocks

Bachelor of Engineering  
(Mechanical) and Business  
(Human Resource Management)

Supervisor: Dr Ruth Mossad, USQ

**Keywords:** Aerodynamics, Fluid Mechanics, Drag, Computational Fluid Dynamics, Fluid Flow, Caravan

## 1. Introduction

The project being undertaken involves the background research, design, analysis and refinement of a normal, everyday caravan in order to better towing vehicles' fuel consumption, and aid in reducing the wear and tear on vehicle drivetrain and powertrain components due to increased loading due to the increase of power required to tow a less aerodynamic caravan. This was undertaken using theoretical computer simulation, in order to gain an easily repeatable result, with the ability to iterate between small modifications of the design quickly and easily.

With the nature of three-dimensional design, it becomes very easy to identify and fix flaws in a design quickly, and efficiently, and the ultimate target of this project is to do exactly that.

## 2. Background

Research into aerodynamics of caravans has showed several key failings in design. The primary failing in caravan design is in the area of aerodynamics. Too many caravans are poorly designed, with form over function in mind. This leads to incredibly high drag forces acting on the tow vehicle, increasing both wear and tear and fuel usage. This project aims to remedy this with a visually appealing, low drag caravan.

## 3. Methodology

In order to solve the problem, it was first realised there was a need to research into the various methods of doing so. Computational Fluid Dynamics, or CFD, was decided on as the deciding factor. This enables real time wind-flow analysis, with drag forces able to be calculated in real-time throughout iterations of the design. Additional aims for the project included design and manufacture of a wind tunnel prototype, via CNC

machining and hand finishing, with the use of Buckingham's Pi Theorem to solve the problem to give a realistic scale.

## 4. Key Outcomes

Key outcomes include design of a caravan with significantly reduced drag, by creation and subsequent modification of a design via CFD.

## 5. Further Work

Further work includes final completion of various modelling tasks for towing vehicles, and subsequent CFD testing in various wind-speed situations. If time allows with the project, a prototype part will be designed and CNC machined on 3-axis routers at BAC Technologies, and finished to a similar grade of a brand new caravan. The aim is to test this in a wind tunnel at simulated speeds, accounting for scale.

## 6. Conclusions

The final outcome of the project is that the design remained still quite visually appealing, however did also significantly reduce drag forces with the use of a much more aerodynamic design. Reductions of 30-50% are expected.

## Acknowledgements

First and foremost, thanks to Ruth Mossad, my supervisor. Secondly, to Norman Ross Watt, my employer at BAC Technologies for both the knowledge imparted in composites and for the freedom of using the equipment needed on my days off work. Acknowledgement also goes to Briskey (2013) for his work in a similar subject, to Liu, Tu and Yeoh (2008) for their work in making CFD understandable, and to Guillou for his work in flow studies around high-speed trains. Finally, the biggest acknowledgement is to my family, without them I wouldn't have had the drive to get involved with mechanical engineering and to ultimately be at this point.

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# Investigate gripping effectiveness of a fluid capillary actuator adapted to a parallel finger robotic end effector

Sponsor – School of Civil Engineering and Surveying



**Raymond Ho**

Master of Engineering Science  
(Mechanical)

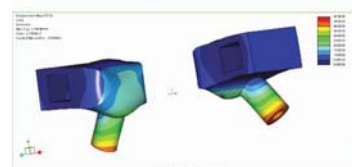


Figure 1 - fluid capillary actuator

Supervisor: Dr Tobias Low, USQ

**Keywords:** robotic gripper finger, tactile, slip

## 1. Introduction

This research project investigates the use of a low cost fluid capillary actuator (FCA) to improve the gripping ability of an industry standard two finger robotic end effector. Gripper effectiveness is determined by comparative testing. These results are expected to show increased handling performance by measuring the imposed end effector force, acceleration capacity, grasping sensitivity and applied surface stress.

## 2. Background

There are many types of single degree of freedom robotic grippers which populate the materials handling industry. A critical feature for a robotic hand is moving the target piece from point to point by grasping positively with just the right amount of force without it slipping or deforming the component. Li (1983) states “when shapes and sizes of an object are known, a simple non articulating device is used”. These units are normally low cost basic devices having a predetermined force setting with the ability for limited and well-known applications. Johnson (1984) in his U.S. patent for a pneumatic gripping force control acknowledged the need for a low-cost and effective sensor as “the systems in use today tend to be rather complex and costly”. This report proposes that adapting a low-cost, simple compliant actuator with the transfer fluid communicating force disturbances to a pressure transducer will enhance gripper control manipulation without the need for complex and expensive tactile sensors.

## 3. Methodology

The gripping performance is measured by conducting a number of functional tests. These comparative tests measure the applied gripper force using a piezoelectric strain gauge in conjunction with a fluid pressure sensor

then plotting the force profile as the object travels along a predefined path. Also the rate of applied force is measured which shows how delicate is the grasping touch and included is an estimation of the amount of contact surface stress. It is required for testing to design a novel hyper-elastic FCA using parametric modelling and simulation for rapid prototyping manufacture.

## 4. Key Outcomes

A key finding of this investigation will prove that a low-cost basic actuator system will provide grasping performance and diagnostic capability as a viable performance alternative to complex and expensive electronic tactile sensory systems.

## 5. Further Work

For this project to be completely successful it is necessary to design and build a control system to automate the FCA. A significant benefit would be to research whether detection of object slippage via fluid wave propagation is possible.

## 6. Conclusions

This report demonstrates whether an increased gripping performance can be achieved with a simple low cost FCA providing enhanced functional flexibility for basic parallel finger grippers. It will also imply that fluid can potentially be used as a medium to detect mechanical system information than has been previously considered.

## Acknowledgements

I would like to thank Dr Tobias Low for his support and guidance on ways of exploring this project.

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# Mechanical Properties of a Mycelia Matrix Composite with Timber Sawdust as added substrate

School of Civil Engineering and Surveying



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Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Sourish Banerjee, USQ

**Keywords:** Mycelia, Bio-composite, Fungi, Substrate, Mechanical Properties

## 1. Introduction

This project aims to explore the current implementation of bio-composites in industry as well as researching and testing the structural properties of bio-composite material mycelium with wood fibre substrate.

## 2. Background

So far conventional materials take up so much of the market that it appears other smart materials such as advanced composites could provide a much more effective solution to certain projects. The three giants; steel, plastic and concrete also leave a large carbon footprint from cradle to grave. This project takes the important approach of looking into the options with cradle to cradle products including those that are ecologically friendly, especially the composites with a mycelium matrix that can break down once its intended use has been fulfilled.

## 3. Methodology

This project was carried out in a three prong approach; firstly to investigate with a literature review; the major contributions made towards structural mycelium composites. The second step included selecting the materials to use and involved procuring the different ingredients, a growing phase, and personal observations. Wood fibres and sawdust were selected at this point based on a known technique used within the literature, but also due to environmentally friendly aspects. Finally, the last step involves the physical testing of the samples to determine certain mechanical properties and behaviours and comparing these with the properties of other materials.

## 4. Key Outcomes

To determine the extent of current research in the field of mycelium composites and to identify the most adequate testing procedures for such a material. The most important project outcome will arise from the

mechanical testing results including; compressive, flexural, tensile strength, and density, and then making observations and conclusions based on the empirical data then graphing it on a comparative basis. Key outcomes achieved so far include; narrowing down the relevant literature in this highly experimental field, selecting and implementing materials such as the wood fibre substrate, and also applying current testing standards that would be relevant to this composite.

## 5. Further Work

Remaining tasks include testing the samples and deducing any conclusions. Also a feasibility study is yet to be done which will include the advantages and disadvantages of mycelium biocomposite bricks compared with conventional materials. An aspect that I wanted to address within this study was to experiment with different types of species of fungi, but due to the unavailability of this material, it never became feasible to test. This study will end with the above outcomes, but further research could prove beneficial and could include addition experimentation investigating the effects of differing types of reinforcement materials.

## 6. Conclusions

Mycelium is still a highly unknown material in the structural industry and much more work will need to be done by industry professionals to ensure progress in the nascent field of bio-composites. Also the mycelium itself is a fragile material to work with, as the material needs very specific conditions to grow. This was a definite learning curve within the project. From the study, I would like the readers to take away this; working with such an interesting and esoteric material has both advantages and challenges, and it should be tackled by those who possess three qualities; passion for the material, past knowledge in the field of mycology, and proper equipment to grow and test such a material. This study carried out will benefit those in the future including its useful results to compare and contrast with.

## Acknowledgements

I would like to thank Dr Sourish Banerjee for his unrelenting support and advice throughout this study.

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# Remote Management of Safety Systems in Power Utility Installations

Sponsor – Ergon Energy



**Paul Hohenhaus**

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Supervisors: Dr Les Bowtell, USQ

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**Keywords:** Configuration, Protection, IEDs, Remote

## 1. Introduction

Within the power industry protection schemes that are designed to protect electrical plant and the public from power system events can be described as safety systems. Today Protection schemes consist of Intelligent Electronic Devices (IEDs) which are software dependant and require configuration files to apply predetermined thresholds and logic to detect and operate in response to power system disturbances.

The focus of this dissertation is to objectively assess the systems, processes and design criteria that will facilitate remote management of selected protection IEDs employed to protect Ergon Energy's distribution network.

## 2. Background

Power utilities are under increasing pressure to provide a cost effective, reliable and safe power network. To accommodate these expectations efficiencies in existing infrastructure and operating techniques warrant continual examination. Infrastructure providing remote connectivity to IEDs already exists, however the changing of protection functions remotely has been avoided over concerns of a change in verification methods. Owing to the number installed and the geographic diversity a request for a remote change will be inevitable. The question is can a protection setting be changed remotely as safely as in person?

## 3. Methodology

Both qualitative and quantitative methodologies were used to understand current practices and design new processes. Techniques included customer surveys and data mining using SQL. Figure 1 is a sample of qualitative data collected by internal surveys used to assess the effectiveness of existing configuration

processes. Laboratory testing on protection devices was also undertaken to assess the challenges associated with remote configuration delivery.

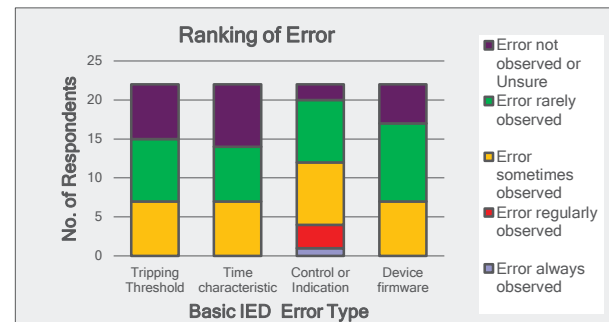


Figure 1: Ranking of Configuration errors

## 4. Key Outcomes

The perception surveys identified existing processes may not be robust enough to ensure a configuration file would be delivered free of error. During the development of a proposed verification method for remote configuration delivery a pre-existing anomaly was found with a Basic IED under test. This was found not to impede the IED's operation but did effect the verification of a successful configuration delivery.

## 5. Further Work

Further laboratory testing is required to assess how the Basic IED responds to remote delivery of a configuration file and the impacts on system integrity and to extend into more complicated IEDs.

## 6. Conclusions

A remote change of a Basic IED protection function requires controlled and definitive processes that identifies the why, how, when and who. It is imperative that the process of IED remote configuration changes is fault tolerant and a thorough knowledge of the intended IED responses and network protection implications during the remote delivery is essential to achieve this outcome.

## Acknowledgements

Dr Les Bowtell (USQ)

Mr Robert Coggan (Ergon Energy Corporation)

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## A Comparison of the Limitations and Accuracy of both Obstructed Prism and Obstructed Non-Prism Measurements



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(Honours) (Surveying)

Supervisors: Mr Dev Raj Paudyal, USQ

**Keywords:** Reflectorless, Prism, Obstruction

### 1. Introduction

The aim of this project is to compare and contrast through field based testing, both the limitations and accuracies of obstructed prism based (both manual pointing and ATR based) and obstructed non-prism based field measurements and to be able to derive the reliability as well as the repeatability of such measurements. The instruments being tested in this project include the Trimble S6, Leica TPS1100 and Topcon DS200 Total Stations.

### 2. Background

Prism based and non-prism based measurements represent the two general forms of distance measurement that a surveyor will use in conjunction with a total station in the field. Throughout a surveyor's day-to-day survey duties in the field, whether it is on a busy construction site or traversing a residential block, they will at some point or another encounter an obstruction of sorts that will prohibit them from being able to record a clean measurement. Without the ability to record an obstruction free measurement, there always exists the possibility that there will be some distortion or inaccuracies in the recorded data. For this reason it is important that an investigation be undertaken in order to evaluate the accuracy, reliability and repeatability of both prism based and non-prism based measurements when reading through obstructions.

### 3. Methodology

The methodology employed called for a range of instruments (Leica 1100, Trimble S6 and Topcon DS200) to be tested through a series of obstructions (Light Vegetation, Medium Vegetation, Heavy Vegetation, Builders Fence Cloth, Glass, Wet Target/Instrument, Dusty Target/Instrument) over a range of distances (10m, 20m, 40m, 80m, 120m, 160m). For each distance, the obstructions were tested at different intervals (close to the instrument, halfway and close to the target, with the exception of the wet and dusty lens and target tests.



Figure 1 – Tested Instruments (Leica 1100, Trimble S6, Topcon DS200)

### 4. Key Outcomes

At this present stage, the field testing is not yet completed. Upon completion and analysis of all of the acquired data, It will be able to be determined what obstructions can be read through successfully with little or no dilution in the data and what obstructions cause unacceptable compromise of the recorded data. From this analysis, a series of suggestive guidelines for reading through obstructions will be able to be created and used at least in my place of work.

### 5. Further Work

The tasks that remain in this project include the finalisation and analysis of the field testing as well as the remainder of the report itself. Future work for the testing of prism based and non-prism based measurements through obstruction could include more physical obstructions as well as include more weather based obstructions including rain and fog as they were unable to be tested during this project due to time constraints.

### 6. Conclusions

The key conclusions for this project will not be what instrument works better rather what the consensus amongst the instruments was and what of the tested scenarios yield acceptable and repeatable data.

### Acknowledgements

I acknowledge and thank the following people/ organisations for their input and assistance with this project.

Dev Raj Paudyal – Project Supervisor

Byrne Surveyors – Equipment Use

Daniel Maher – Assistance in Testing of Equipment

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R. Höglund & P. Large, (2005). *Direct Reflex EDM Technology For The Surveyor And Civil Engineer*: Trimble Survey, Westminster, Colorado, USA

## SPATIAL MODULATION CONCEPT FOR MASSIVE MU-MIMO SYSTEMS

Sponsor – UNIVERSITY OF SOUTHERN QUEENSLAND, TOOWOOMBA CAMPUS



INUMPUDI LAVA KUMAR Power Engineering

**Supervisor:** WEI XIANG, USQ, ASSISTANT PROFESSOR**Keywords:** sub channel method, zero padding method.

## 1. Introduction

This paper presents the concept of spatial modulation (SM) technique used in MU MIMO system. The SM is to use the index of antenna at any time instant either transmitting or receiving depending upon the SM scheme applied. The main idea introduced here is the sub channel index which in turn corresponds to the precoding matrix used in the Base station in order to convey extra useful information. Two methods are proposed such as Sub Channel and Zero Padding method. The aim here is to explore the above mentioned methods in order to reduce the inter antenna interference in order to alleviate the Bits error degradations.

## 2. Background

This section explains the research question which is laid out in the introduction Spatial Modulation is used in Massive MIMO system as a transmission technique since it offers better spectral efficiency and high data transmission with reduced Inter Antenna Interference and Bits per error. According to [1] it is said that Massive MIMO system in fourth generation (LTE) the use of 8x8 system has been standardized. It is believed that Massive MIMO system will be standardized in 5G cellular system to improve higher data rate. Spatial Modulation is a technique in which the information is carried by both the index of antenna and the symbol transmitted through this antenna, hence by introduction of spatial modulation in Massive MIMO this could be achieved.

## 3. Methodology

The two methods are discussed in this section the results are formulated by Matlab and presented in form of graph. We consider a downlink massive MU MIMO system **Sub-channel Method:** In this method the User's sub-channel for additional data transmission, by gathering the rows of user channel matrices into a multiuser precoding matrix used in the Base station transmitter (BSTx). This method eliminates fading in the channels but it causes Inter antenna interference there by Zero padding method is introduced. **Zero-padding method:** In Zero-padding technique all the receiving antennas receive zeros except the active antenna. Making the transmission simple and the channel fading is totally cancelled. As usual the multi user interference on the received data by precoding using the zero padding technique in the channel matrix.

## 4. Key Outcomes

All the simulations are to be carried out in QPSK and 16-QAM formats. By comparing the simulation and analytical results we obtain that both match closely especially with high SNR. All the four figures are explained detailed and outcomes are the BER performance. It is noted that BER decreases as the number

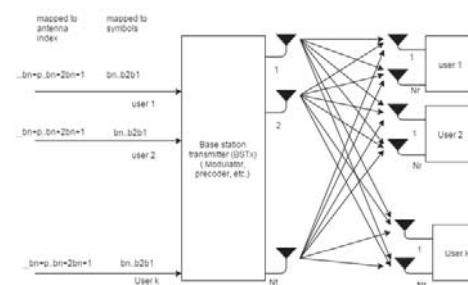


Figure (1) SM for Multiuser MIMO systems

receiving antennas increase. The main outcome is multi-antenna is not used for diversity but used in MUSM. (ML) detection is applied where the errors in the receiving end sides have been obtained. Zero-padding technique gives better BER performance even in the increase receiving antennas per users. All the above simulations work has been shown in QPSK. It is noted that the performance of both the methods in 16-QAM. Where the increase in the constellation or high users doesn't affect the BER performance in Zero-padding.

## 5. Further Work

The SM-MIMO performance can be studied for higher order modulations. Other Decoding techniques can be explored to reduce the complexity of ML. Quadrature based spatial modulation (QSM) & Differential spatial modulation (DSM) can be incorporated for more data rates. OFDM based SM-MIMO can be studied.

## 6. Conclusions

From the result BER performance for those methods are studied and experimented. From sub channel method the BER performance decreases with an increase in the users services by BSTx or number of receiving end antennas. In the Zero-padding technique increase in the number of users doesn't affect BER performance because all the multiuser interference gets cancelled totally.

## 7. Acknowledgements

I would like to thank my supervisor Dr.WEI XIANG for his constant assistance towards me in this research project. The success of this project is because of the endless knowledge of Dr. Wei on various concepts regarding the project, for which I am grateful to him.

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# Evaluating The Differences and Accuracies Between GNSS Applications Using PPP.

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**Keywords:** GNSS; PPP; GPS; GLONASS; Beidou; Galileo

## 1. Introduction

The aim of project is to provide relevant technical information on the performance and accuracies of standalone versus combined GNSS systems, testing whether these combinations achieve quicker convergence, accuracy and reliability compared with the use of a single GNSS system.

GNSS are satellite navigation systems with global coverage. There are several systems in operation today ranging from the United States NAVSTAR Global Positioning System (GPS), Russian GLONASS, Chinese Beidou-2 and the European Union's Galileo. GNSS have three segments including satellites, ground system and user equipment that are used to pinpoint the geographic location of a user's receiver anywhere in the world.

## 2. Background

GNSS have come a long way, being used throughout various commercial, residential, and a host of other industries. The surveying and mapping industries have been revolutionised by the use of GNSS. It is imperative that professionals within the survey and mapping industries have a good understanding of GNSS systems, including their accuracies and precisions.

## 3. Methodology

Equipment utilised include two Trimble R10 GNSS receivers utilising Trimble Access version 2015 Firmware 3.0.2. Each trig station for this study was occupied for a period of 24 hours at an observation epoch of 30 seconds remaining consistent with recommendations done in previous studies, providing consistent comparable data. Occupations will be undertaken on two separate dates for each site to test



**Figure 1 – Base Station observing on Cromer Trig Station**

repeatability. Observations at each site will be taken simultaneously ultimately ensuring the isolation of effects of error.

## 4. Key Outcomes

Evaluate and analyse the accuracies and performance between GNSS systems using the PPP technique with emphasis on the function and performance of single systems compared with combined GNSS systems. Evaluation of physical aspects of GNSS systems including signal structures, frequency bands, signal strengths, availability and a host of other physical configurations.

## 5. Further Work

Further work required includes field observations, converting and reducing raw field data to Rinex file for online data processing, data analysis and comparison and finally conclusions.

## 6. Conclusions

Through literature review and research it is expected that a clear understanding of GNSS process and functionality, and the performance of standalone versus combined GNSS are achieved. It is imperative that professionals within the survey and mapping industries gain a basic understanding of GNSS systems, including their accuracies and precisions.

## Acknowledgements

I would like to take this opportunity to thank my family, Project supervisor Dr Zhenyu Zhang and Ultimate Positioning Group for providing equipment and software support.

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# Investigation of Optimal Inspection Methods for “Girth Weld” certification for Subsea Pipeline Installation

Sponsor – School of Mechanical and Electrical Engineering



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Bachelor of Engineering  
(Mechanical Engineering)

Supervisor: Dr. Jayantha Epaarachchi, USQ

**Keywords:** NDT, Inspection, Subsea Installation, Girth weld, AUT and Radiography.

## 1. Introduction

The study of Optimal Inspection Methods for “Girth Weld” certification in Subsea Pipeline Installation focuses on the requirements for girth weld inspection and certification for and the relevant the industry specifications, codes and standards.

## 2. Background

There are many NDT methods that are used for welding inspection, however for offshore girth welds, only radiography testing (RT) and automated ultrasonic testing (AUT) are used for girth weld quality control and certification.

A significant factor in determining the duration and cost of a welding and inspection sequence is that the value is only applicable with confidence to the particular vessel and welding contractor used and can vary significantly if the same sequence is applied on a different installation vessel.

There is therefore a need to understand which methods are the optimum for a task and the criteria for selection of the optimum methods. Selection of inspection and testing methods has to take into consideration health and safety risks, equipment availability, time and financing constraints.

## 3. Methodology

A review of literature and relevant industry codes and standards to gain an understanding of the materials, manufacturing methods, installation methods, welding and inspection methods used for offshore pipeline installations in the Oil and Gas industry. The review identifies best practices and defines selection criteria for pipeline welding and NDT methods for different pipeline sizes. The selection criteria are used in a case study based upon an example project taken from industry.

## 4. Key Outcomes

Two inspection methods are considered applicable: Ultrasonic Testing (AUT) and Radiography Testing

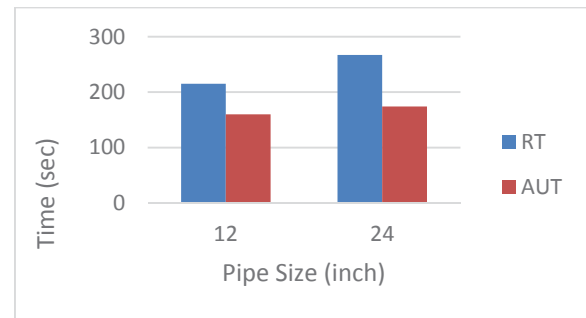


Figure 1 – NDT Cycle Time

(RT). RT provides two techniques; conventional RT and real-time RT and can be used for all pipe sizes. Pipes with OD 12inches or greater use the single wall single image technique. Pipes with OD below 12 inches uses the double wall single image technique. AUT provides a comprehensive inspection result but requires a lengthy qualification and validation process. AUT is used for pipes that are 6 inch OD or greater. AUT is a faster process than RT.

## 5. Further Work

Pipe tensile load during installation remains incomplete for the project, however the results would not add to the report.

## 6. Conclusions

There are two NDT methods that are used for inspection of girth welds during offshore pipeline installation; Radiography and AUT. Selection of the NDT method is based on the design and operating conditions and size wall thickness of the pipeline.

## Acknowledgements

I would you like to thank my Supervisor Dr. Jayantha Epaarachchi, my friend Anthony Shaw for his guidance and encouragements. Lastly to my wife Amy for her unconditional love and support throughout this journey.

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# Launceston’s Combined Drainage System – Investigation and Strategy Development

TasWater



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(Civil)

Supervisors: Dr Vasanthadevi Aravinthan,  
USQ

Mr Andrew Truscott, TasWater

**Keywords:** Combined Drainage, Combined Sewer Overflows, Discharge Frequency, Discharge Volume

### 1. Introduction

TasWater operates a combined drainage system that services the greater part of the city of Launceston. The operation of the combined drainage system is of interest to the local community and a number of key stakeholders who are concerned that the design principles, age and performance of the combined drainage system is causing degradation of the receiving waters into which treated effluent and combined sewer overflows (CSO) are discharged.

### 2. Background

The Launceston Combined Drainage System is the last combined system of note within Australia and is an ongoing cause of community concern due to perceived impacts on the health of the local receiving waters.

Due to ongoing stakeholder concern and limited data for CSO events and system performance TasWater is seeking to understand how the combined drainage system performs.

The performance will be measured against recognised service levels to help educate the community about the combined drainage system and to develop capital and operational programs of work to address deficiencies in the system.

### 3. Methodology

The research will investigate the management of combined drainage systems internationally in terms of performance standards and levels of service. This information will then be applied to derived quantitative data to understand the overall performance of the system and identify areas of deficiency for either operational or capital improvement.

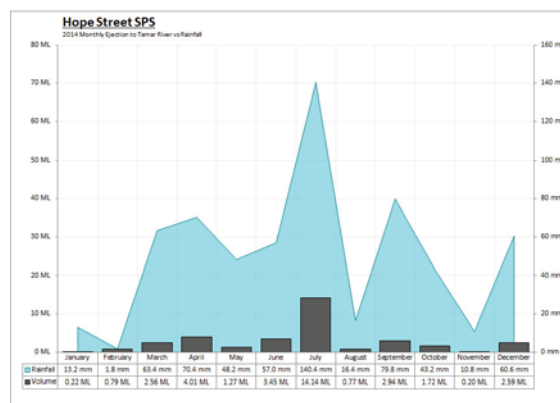


Figure 1 – Hope Street SPS CSO Discharge to River

### 4. Key Outcomes

The key outcomes of the project will be to understand the total volume of CSO discharged from the combined drainage system, the frequency of CSO events, understanding trigger rainfall events and the potential pollutant load of CSO. This information will be used to develop a strategy to minimise CSO events and impacts and to educate stakeholders about the combined drainage system.

### 5. Further Work

Development of a strategy for the combined drainage system that will aim to reduce the volume, frequency and potential impact of CSO events where it is identified that they are causing environmental harm.

### 6. Conclusions

Conclusions will be used to inform the development of a capital and operational works program for the combined drainage system. The conclusions will also be used for stakeholder information and education.

### Acknowledgements

I would like to thank my employer TasWater for their support of the project. I would also like to thank my supervisor Dr Vasanthadevi Aravinthan for her guidance and support.

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# Demand Management Storage Project (DMSP) – An Application of Grid Scale Battery Energy Storage Systems

Sponsor – Powercor Australia, School of Mechanical and Electrical Engineering



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Bachelor of Engineering (Power)

Supervisors: Assoc Prof Tony Ahfock, USQ  
Mr Anil Singh, Powercor Inc.

**Keywords:** batteries, battery energy storage system, peak shaving, distribution construction deferral, energy time shifting, dynamic battery charging/discharging model

## 1. Introduction

Grid scale BESS (battery energy storage system) has been identified as one of the key technologies in the utility network of the future. There are significant benefits associated with their ability to store energy. This research focuses on using economic models to evaluate grid scale BESS benefits and to sum them up into value propositions.

## 2. Background

DMSP project is planning to install one of the largest BESS systems at a 22kV distribution feeder in Australia. According to (Eyer & Corey, 2010) guide, energy storage systems could have 17 electric grid related applications which across 5 categories: electrical supply, ancillary services, grid system, end user/utility customer and renewable integration. Among all the applications, the DMSP project focuses on using grid scale BESS for energy time shifting, distribution construction deferral, voltage support and frequency support applications.

## 3. Methodology

In order to quantify the economic feasibility of the BESS system, the data models need to be created to reflect the distribution system, energy market and BESS system. With the data models, methods need to be found out about how to simulate electrical and economic performance of the battery energy storage system and quantify these performances into market value.

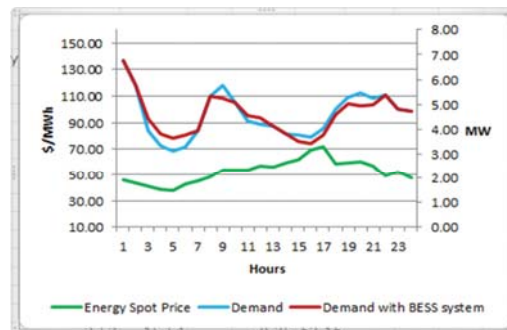


Figure 1 – A Typical BESS Charge/Discharge Curve

## 4. Key Outcomes

After the study of previous researches, a Dynamic battery charging/discharging method (Ciadea, Orr, Emanuel, & Zhang, 2013) was adopted and modified to optimize BESS charge and discharge routines. With this method, the demand curves with BESS system can be simulated and used for quantity analysis.

## 5. Further Work

For the next stage, the research will focus on the development of an optimal predicating method to predicate the demand and electricity price.

## 6. Conclusions

The research shows that BESS can bring positive benefits for combined energy storage applications. The potentials of using BESS systems in Australian utility network shall be extended specially with the system costs decreased in the future.

## Acknowledgements

Special thanks to my family for their endless supports. Thanks also to Ming Yang and Rahul Kulkarni of Powercor Inc. who provided valuable suggestions and supports to this research. This research is sponsored by electricity distribution company Powercor Inc.

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# The Behaviour of Bridges Subjected to Flood Loadings Based on Different Design Standards

Sponsor – School of Civil Engineering and Surveying



**Bradley Jordan**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Weena Lokuge, USQ  
Dr Karu Karunasena, USQ

**Keywords:** Flood Loads, Bridge, Bridge Design Standards

## 1. Introduction

Australia is a country of draughts and flooding rains. The need to design bridges to withstand flood and debris loads has long been recognised in Australia with the current and previous bridge design codes providing guidance. This projects seeks to investigate how well the current Australian standards perform, compared to other standards from around the world.

## 2. Background

The Lockyer Valley experiences highly variable and unpredictable rainfall; droughts are experienced regularly however there have been some extreme flooding events, the worst of which occurred in November 2008 and January 2011. As a result, about 85% of council-owned bridges were either completely gone or partially destroyed (Maesele 2011). This calls for immediate attention to the way in which bridges are being designed against flooding.

## 3. Methodology

The different Bridge Design Standards that will be used are AS5100,2004, BA 59/94, AASHTO, 2012 and the Indian Code of Practice, 2014. The main forces that were identified in a flooding event are drag force, lift force and moments on piers and superstructures. The simulation of the flood loadings on the identified bridge models will be performed using the Strand7 software package. Strand7 is a Finite Element Analysis (FEA) software product developed by Strand 7 Pty. Ltd. The results that will be compared are stress and deflection.

Tenthil Bridge, located in Gatton will be used as the main simulation bridge in this project.

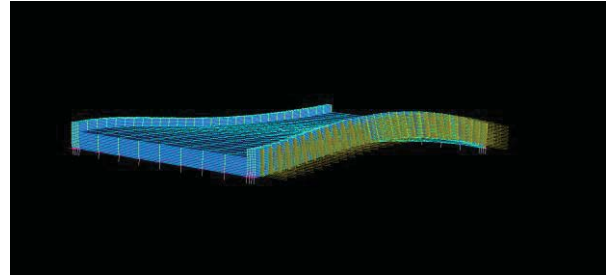


Figure 1 - A simple bridge deck subjected to a flood loading

## 4. Key Outcomes

The key outcome of this project will determine if the Australian Bridge Design Standards perform well compared to other standards from around the world and if improvements could be made to the current standards.

## 5. Further Work

The main task of modelling Tenthill Bridge subjected to flood loadings is still to be performed. After this is done, a comparison will be performed on the different design standards and conclusions will be drawn as to which bridge design standards provide to safest flood loads and if the Australian Standards could be improved.

## 6. Conclusions

The key conclusions of this project will be how well the Australian Bridge Design Standards perform when subjected to flood loadings, compared to different standards from around the world and if improvements can be made.

## Acknowledgements

I would like to acknowledge my supervisors Weena Lokuge and Karu Karunasena for their constant guidance and support throughout this project. I would also like to acknowledge Buddhi Wahalathantri, a post-doctoral research fellow student at Springfield campus. This project would not be possible without their guidance and support.

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# Axial Flux Permanent Magnet Coreless Machine

Sponsor - School of Mechanical and Electrical Engineering



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Bachelor of Engineering  
(Electrical & Electronic)

Supervisor: Andreas Helwig, USQ

**Keywords:** Axial flux, coreless, wind generation, permanent magnet, cogging torque.

## 1. Introduction

Axial Flux Permanent Magnet (AFPM) machines are becoming increasingly popular due to the appearance of second generation rare earth permanent magnets (Neodymium Iron Boron – NdFeB) and advances in modern technology.

This project investigates the performance of coreless internal rotor AFPM machine with minimum cogging torque suitable for a small wind turbine.

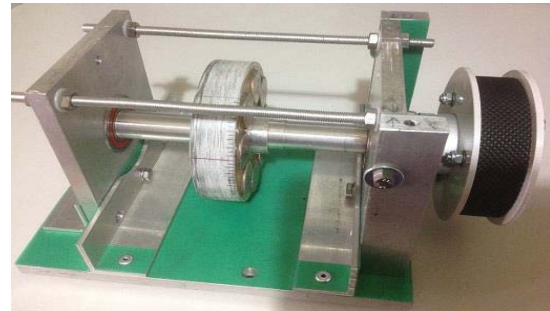
## 2. Background

The coreless AFPM structures with minimum cogging torque are essential for many applications set to address pollution and green energy production. This includes hub motors of electrical vehicles and electrical bicycles, and wind turbines.

Specifically, the coreless AFPM structures with minimum cogging torque are critical for wind generators to allow operating in low wind areas, which are the typical areas of operation of small turbines. However, at the moment the low power generation units are significantly more expensive per kilowatt than their high power counterparts. The continuing research to minimise the cost of materials, to increase efficiency, to simplify technology and availability of manufacturing methods would ultimately result in more small wind turbine units used. The benefits are twofold: green energy production and an affordable access to electricity to those in need of it.

## 3. Methodology

The existing topology of AFPM machines and corresponding advantages and disadvantages of various known configurations are investigated in the literature. The chosen configuration is single internal rotor -



**Figure 1 – AFPM Prototype Rotor**

double stator. A prototype was designed and built based on available materials and desired minimum cogging torque (Figure 1). An 8 pole rotor prototype was complemented with three stator types for comparison: blank, coreless ribbon wire winding and coreless ribbon wire winding with magnetic powder composite backing.

## 4. Key Outcomes

Objectives achieved so far: understanding of the internal rotor AFPM design limitations; prototype is built ready for testing.

## 5. Further Work

Results for the project are not yet finalised. The use of the constructed machine as a motor can be investigated. Further research into generator use could include building additional stator types or inclusion of additional rotor discs for magnetic flux path completion.

## 6. Conclusions

This research project's investigation into the minimum cogging torque contributes to advancing understanding of AFPM coreless technology performance.

## Acknowledgements

I would like to acknowledge Andreas Helwig for the actual idea of the project and his guidance and support throughout the whole duration of the project.

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# Investigating ethanol production potential from Sugarcane processing wastes; fermenting of pre-treated bagasse with ultrasound/chemicals

School of Mechanical and Electrical Engineering



## Manoj Kumar K

Master of Engineering Science  
(Electrical/Electronic)

Supervisors: Dr Ihsan Hamawand, NCEA  
Dr Les Bowtell, USQ

**Keywords:** Bagasse, acid and base, ultrasound, bio-ethanol, fermentation, pre-treatment, yeast.

### 1. Introduction

In this research low cost ethanol is produced using sugarcane bagasse with efficient pre-treatment methods; they are chemicals (acid, base) and ultrasound. Then the Pre-treated bagasse is fermented with yeast called *Saccharomyces Cerevisiae*. It has many advantages for ethanol production from biomass: it is an efficient ethanol producer from glucose, they don't require oxygen during fermentation.

### 2. Background

There are many researches undergoing within Australia for increasing the ethanol production using various methods from bagasse. The Australian sugar industries burn wet bagasse to meet their heat and energy requirements, There are many technologies exist, but no known commercial operation for the conversion of bagasse to ethanol is known to exist at present. So the research is required to increase the production of ethanol from bagasse.

### 3. Methodology

**Pre-treatment:** is required to alter the physical and chemical structure of the biomass, which enhances the efficiency of fermentation and increase the ethanol yield. Acid treatment breaks the bond between lignin and Hemicellulose and solubilises the Hemicellulose, which increase the efficiency. In this project, the dilute acid H<sub>2</sub>SO<sub>4</sub> will be used to treat lignocelluloses materials (Njoku, S, 2013). Ultrasound pre-treatment

Ultrasound produces sonochemical and mechanoacoustic effects which affects the chemical and physical structure of lignocelluloses. Fermentation is the process of converting the sugar to ethanol. (Alvira, P, 2009)

### 4. Key Outcomes:

The Bagasse was pre-treated with the various methods like acid, base and ultrasound which are identified in the previous studies and research and some of the modifications and gaps in the research are fulfilled in this project.

### 5. Further Work

In future many pre-treatments methods can be combined together for treatment purpose, to produce the maximum ethanol production. Fermentation of the bagasse can be done for 6-12 days to get the high ethanol yield.

### 6. Conclusions

This project demonstrates that more effective and economical delignification of bagasse can be done by ultrasound and chemical pre-treatment. Combination of acid and ultrasound together which results in higher ethanol production. The objectives of the project are achieved successfully.

### Acknowledgements

I would like to thank the University of Southern Queensland, for providing me with the facilities to conduct my research. I would like to thank my supervisor Dr. Ihsan Hamawand and Les Bowtell, they are excellent supervisors. Their guidance and advice were very valuable for the accomplishment of this thesis.

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## Development of ultra-high performance, fibre reinforced ductile concrete

Sponsor – School of Civil Engineering and Surveying, Potter Industries



Bachelor of Engineering (Civil)

Supervisors: Dr Yan Zhuge, USQ

**Keywords:** PVA Fibres, Lightweight Engineered Cementitious Composite

### Introduction

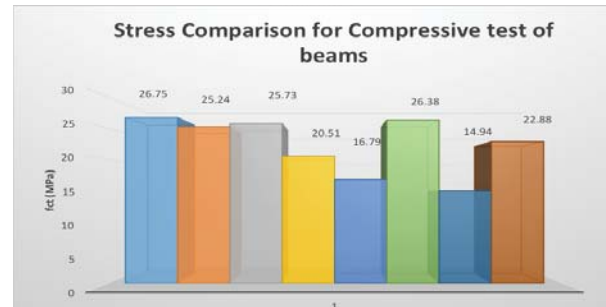
An extensive research has been carried out in order to increase the concrete tensile strength and other characteristics that are suitable for the modern aesthetics and evolving architecture. This research investigates the development of new Lightweight ultra high performance concrete by the use of PVA fibres and Lightweight microsphere as an additive.

### 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 strength exhibited by such is not as high as that of conventional reinforced concrete, however the addition of PVA fibres increases the tensile strength and undergoes strain-hardening properties.

### Methodology

Lightweight ECC mix designs with randomly dispersed uncoated PVA fibre and hollow glass microspheres were created and test specimens were prepared. Mix designs were also prepared by using fly ash and steel fibres. The specimens were exposed to compression,



tests were analysed in order to assess if there was an increase in compressive strength, flexural strength and whether strain hardening was achieved. Key Outcomes With the addition of PVA fibres and along with microsphere additive, it negatively impacts on the fibre matrix, whereas a potential of strain hardening has been observed. There is an increase in compressive strength observed.

### 1. Further Work

Detailed analysis and further testing on samples with fly ash and steel fibres is still not finished. Further research with PVA and Steel fibres need to be conducted.

### 2. Conclusions

The fundamental property of the specimens is to achieve the strain hardening properties.

### Acknowledgements

I would like to thank my husband Gursalamat for his all time support and understanding me during this time. Sincere thanks to my supervisor Dr Yan Zhuge for her support. Thanking to PHD student alor and Gurpreet Kaur for sharing information.

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# Two and Three Dimensional Numerical Investigation into Sinkhole Formation

Sponsor –School of Civil Engineering and Surveying



**Anthony Keightley**

Bachelor of Engineering  
(Honours) (Civil)

Supervisor: Dr Jim Shiau, USQ

**Keywords:** Sinkhole, Stability, Trapdoor, Modelling,

## 1. Introduction

This paper focuses on investigating sinkholes through research, 2D numerical modelling and then finally 3D modelling. Applying previously learnt civil and geotechnical engineering knowledge, researching relevant literature and previous sinkhole collapses, the investigation continues on the work by B. Lamb.

The generation of idealised 2D and 3D models describing the sinkhole phenomena adds to the current understanding of sinkhole mechanics.

## 2. Background

Sinkholes are depressions or shafts formed at a soil surface due to changes in the soil and or rock beneath. A number of numerical models have been investigated over time in an attempt to understand sinkhole formation.

This paper offers a continuation of the trapdoor method of modelling sinkhole overburden stability. This method uses the strength reduction method to find the stability of a sinkhole case with reference to its factor of safety caused due to its self-weight ( $\gamma$ ).

## 3. Methodology

As a numerical modelling project, the methodology used has been based on research and utilising FLAC software. This modelling has been restricted to sinkholes where the overburden consists of cohesive soil using a Greenfield scenario. Numerous sinkhole simulations have been conducted with differing depth to cavity width ratios. The simulations are analysed using a strength reduction method, which allows for the determination of a factor of safety of each simulation.

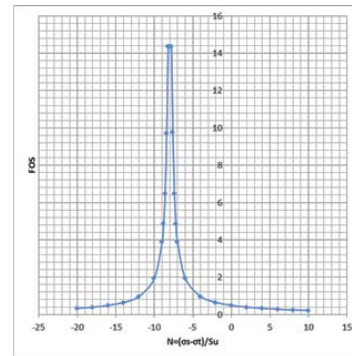


Figure 1: Stability Number versus Factor of Safety

## 4. Key Outcomes

From the data gathered to date, it is possible in the trapdoor scenario to determine a state of equilibrium where the self-weight of the overburdening soil is balanced with the ratio of external forces. Figure 1 demonstrates a situation where the optimal stability point is achieved making the overburden soil seem weightless. Soils with lower cohesion require a greater stability number to achieve this point of equilibrium whereas there is a direct proportion between the depth of the trapdoor and the stability number at these points of equilibrium.

## 5. Further Work

Extending the modelling using FLAC 3D will further the understanding of sinkhole behaviour.

## 6. Conclusions

By completing these simulations with altered overburden depth to cavity roof width ratios, the sinkhole mechanics has been more precisely explained.

## Acknowledgements

I would like to acknowledge Mr Brian Lamb for his consent allowing the further development of his initial work in this area. I also thank Dr Jim Shiau for his guidance throughout this project.

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# Using a sprinkler infiltrometer and the GAML model to predict moving sprinkler performance in the field



**Simon Kelderman**

B. Engineering (Agricultural) +  
B. Business (Supply Chain)

Supervisor: Dr Joseph Foley, USQ

**Keywords:** Green-Ampt, Mein-Larson, sprinkler, infiltration.

## 1. Introduction

The infiltration of water through the soil surface is an important process for many disciplines, including the irrigation of agricultural soils. Reducing or preventing runoff from the soil surface is desirable from economic, agronomic and environmental perspectives and infiltration models that predict the potential runoff from soils under irrigation can be useful to this end.

## 2. Background

Mein and Larson (1971) adapted the famous Green-Ampt equation (the 'GAML model') to remove the requirement for ponded conditions, making it useful for modelling infiltration under rainfall or sprinkler irrigation. However, there was still an impractical requirement that the rainfall or sprinkler irrigation rate be constant throughout the event. Chu (1987) proposed a graphical method that allowed for a variable application rate. Chu (1986) also proposed another graphical method to determine the Green-Ampt equation parameters for a field soil but only under a constant sprinkler application rate.

## 3. Methodology

Matlab is used to encode and adapt Chu's graphical methods for processing of field data under a sprinkler infiltrometer. This is used to determine the infiltration capacity function for an in-situ field soil and then to estimate the runoff from a set of moving overlapped sprinklers.

A novel sprinkler infiltrometer concept is used. Very particular set-up configurations will give sprinkler application profiles that feature sections of constant application rate. When located appropriately in the field relative to a test plot the set-up may be used in lieu of a specialised infiltrometer.



**Figure 1: Makeshift mobile sprinkler rig used for model evaluation.**

## 4. Key Outcomes

Desktop testing of the adapted Chu models against published infiltration data has produced reasonable results (within 5% of observed). Laboratory tests of sprinkler configurations have been completed and have identified several configurations that suit the purpose of a sprinkler infiltrometer.

## 5. Further Work

Field tests using the makeshift sprinkler infiltrometer and moving sprinkler rig (Figure 1) over prepared soil plots are underway and need to be completed.

## 6. Conclusions

The sprinkler infiltrometer idea used is novel but cumbersome and highly subject to wind interference in the field. It remains to be seen how well the predictions of the adapted Chu methods perform against field data.

## Acknowledgements

My thanks goes especially to Dr Joseph Foley, not only for supervising this project but also for sharing his knowledge and experience on the subject of irrigation science, both in the classroom and out. Also, thanks to Brad Oleksyn at DPI for the loan of various pieces of equipment (complete with resident redbacks 😊).

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# THE USE OF THE HILBERT-HAUNG TRANSFORM FOR DYNAMIC RESPONSE TESTING OF THE STRUCTURAL HEALTH OF FIBRE COMPOSITE S.H.S.

School of Mechanical and Electrical Engineering



**James Lyle Kerr**

Bachelor of Engineering  
(Honours) (Mechanical)

Supervisors: Dr Jayantha Epaarachchi, USQ

**Keywords:** Dynamic response, Hilbert transform, empirical mode decomposition

## 1. Introduction

The purpose of this research endeavour was to apply new advances in mathematical signal analysis to the dynamic response monitoring of fibre composites. Advanced materials such as fibre composites are becoming more popular because of their wide variety of achievable properties, however because of their non-uniform material properties, conventional methods of testing their structural integrity is quite difficult.

In this paper, a new transformation method is applied known as the Hilbert-Huang transform. This is the most recent innovation in signal analysis as it is a highly accurate method for keeping both frequency and time data from a non-linear and non-stationary signal.

## 2. Background

Much like the behaviour of fluids, the world of solid materials is still loosely understood. As we build our homes, vehicles etc. from such materials understanding is paramount to the correct use and safety of users. For years scientists and engineers have worked tirelessly to perfect our methods for ensuring the safety of the things we build and use, but of late due to the environmental instability, growing populations and their structures required, and the increased complexity of new material, we have witnessed, the intent becomes stronger.

## 3. Methodology

A S.H.S glass fibre resin reinforced beam was simply supported at both ends. The beam was fitted with accelerometers to measure the induced acceleration. An oscillatory force was introduced by use of a force hammer. The accelerometer was connected to the LMS data acquisition system which recorded the response and the force data. This data was then numerically analysed by use of the Matlab script produced by the researcher.

The script performed a series of tasks. Firstly in order to perform the Hilbert-Huang transform, the acceleration

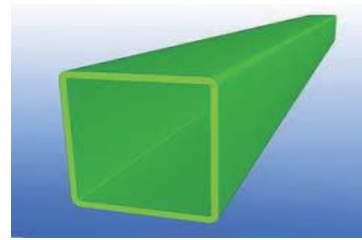


Figure 1 – SHS glass fibre composite beam model

data needed to be double integrated yielding displacement data. This could then undergo the steps entailed by the transform. This involved the empirical mode decomposition, which decomposes the original signal into a series of base signals known as intrinsic mode functions (IMF) which are then subtracted from the original signal. Once the original signal became monocomponent, the IMFs could be analysed simultaneously by the Hilbert transformation giving frequency data. The final step is to include this frequency data from each node into frequency response functions which are used to build a flexibility matrix.

The flexibility matrix results can then analysed for anomalies that signify the location and severity of damage.

## 4. Key Outcomes

It is hoped that this will yield more accurate results indicating location and severity of damage than the frequency response function analysis conducted by use of Fourier transforms and other forms of wavelet analysis.

## 5. Further Work

Suggested further research includes

- Perform the same analysis using a non-stationary oscillatory vibrating force
- Perform the same analysis with a laser Doppler vibrometer instead of accelerometers as sensory apparatus

## 6. Conclusions

As the research was not completed at the time of writing this abstract conclusion are still not prepared for this document.

## Acknowledgements

I owe great thanks to my mentor and supervisor Jayantha as he has aided me not only in my project but also with advice and consolation during my time studying at USQ.

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# LiDAR for DEM Generation and Hydrologic Modelling



**Glen Kilpatrick**

Bachelor of Spatial Science  
(Honours) (Surveying)

Supervisors: Dr Xiaoye Liu, USQ

**Keywords:** LiDAR, Terrain Analysis, Hydrologic Modelling

## 1. Introduction

Recent natural disasters in Queensland and Australia that have influenced authorities' preparation and response to such events such as the floods of January 10 2011 in Toowoomba. Digital Elevation Models (DEM) and hydrologic models support understanding of flood flow characteristics and therefore preparation and response to flood hazards. Airborne LiDAR data is a present topic of interest. This project work focuses on the utility of LiDAR for hydrologic analysis and other related applications.

## 2. Background

Airborne LiDAR data has evolved over the last decade and has proven to be suitable data source for flood modelling applications. The catastrophic floods of January 10 2011 in Toowoomba have affected the Toowoomba community and area and the hydrologic properties its significant catchments are of interest. LiDAR data has been utilised to analyse East Creek in this project work.

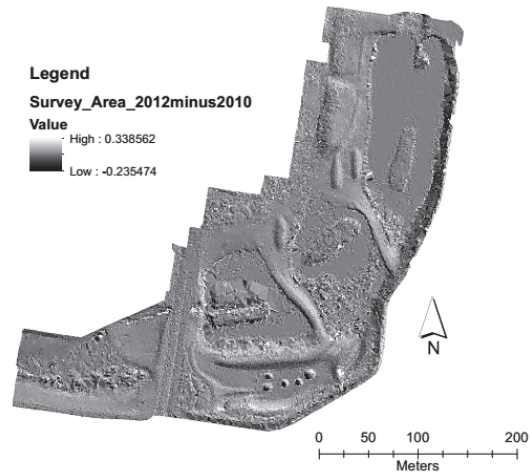
## 3. Methodology

Analysis was done for the entire East Creek catchment and for a small section along East Creek in Rangeville, Toowoomba. Appropriate LiDAR datasets from 2010 and 2012 were utilised. ArcMap software with Arc Hydro extension was utilised to generate hydrologic outputs for East Creek catchment and results were compared. A field survey was also completed over the small study area, separate DEMs were created and results were compared. Flood surface delineation was also compared between datasets.

## 4. Key Outcomes

Comparisons of hydrologic outputs over East Creek catchments reveal that LiDAR data point distribution, accuracy and derived DEM resolution all effect these outputs. DEM dataset comparisons over the smaller area indicated that LiDAR data performed well except

in acute relief, thick vegetation and trees. It was also found that these characteristics influenced flood extents generated at a small level.



**Figure 1 - Difference raster comparing elevations from 2012 LiDAR data against 2010 LiDAR over small study area on East Creek**

## 5. Further Work

Further detailed analysis of hydrologic outputs using parameter variations and LiDAR error analysis is expected. The project work highlights areas of interest and potential future research such as hydrologic analysis in medium relief urban areas, automated terrain change detection with LiDAR data. Hydraulic model generation software is of value.

## 6. Conclusions

The results have shown that LiDAR data capture systems are high accuracy and high resolution. With good understanding, modelling and filtering of errors hydrologic, hydraulic modelling and terrain change analysis can be improved.

## Acknowledgements

I acknowledge Dr Xiaoye Liu for her knowledge, experience and help and Chris Power for assistance with field work.

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# Combining Sub-Surface Scanning with Machine Vision;

## A Feasibility Study for Abattoir Quality Control

Sponsor – School of Mechanical and Electrical Engineering



**Brett Kington**

Bachelor of Engineering (Mechanical)

Supervisors: Mr Chris Snook, USQ

Prof. John Billingsley, USQ

**Keywords:** X-Ray, Machine, Vision.

### 1. Introduction

This project studies different mature sub surface medical imaging technologies and analyses the feasibility of combining the output of the most suitable of these with a machine vision system in order to automatically conduct quality control processes, specifically in the end-stage processing of a beef abattoir.

### 2. Background

Sub-surface scanning for medical application is mature and widespread, yet application of these technologies to industrial processes has been relatively slow to attain broad acceptance. One industrial process which relies heavily on quality control in the end stages of production is beef production. Foreign contamination occurs within the product stream and existing manual methods of detection are susceptible to failure due to human error. Recent research has investigated the use of various scanning technologies for both intrinsic and extrinsic quality control and machine vision has been utilised to analyse extrinsic qualities of product, including meats. These two technologies have yet to be combined for the purpose of QC. Further to this, the high cost and complexity of 3D imaging technologies preclude their use in many industrial processes. By analysing the positional shift of contaminants relative to a datum a depth dimension can be realised. This provides the ability to track contaminants in three dimensions using simple (and relatively inexpensive) two dimensional technologies.

### 3. Methodology

An extensive literature review was conducted, involving medical imaging technologies and machine vision advances. A structured selection process was employed in order to choose the most viable medical imaging technology.

An experimental test rig was designed and built. Image capture; object filtering and pattern recognition systems are still being developed.

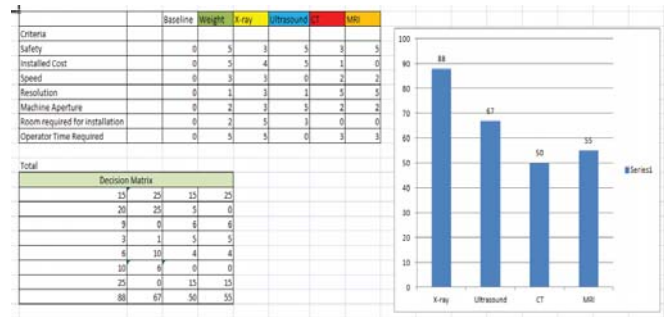


Figure 1 – Pugh Matrix of selection criteria.

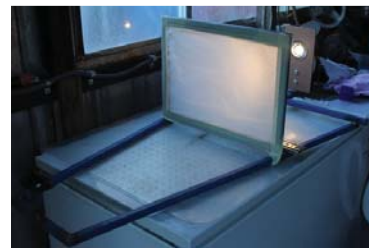


Figure 2 – Experimental test bed using point light source and diffuser screen.

### 4. Key Outcomes

The project has demonstrated that combining x-ray scanning, especially when using a single fixed source coupled with a single fixed pickup, with machine vision, is feasible for development into a system for quality control in an abattoir. Further to this, foreign contaminants can be located not only in the x-y plane, but through comparative positioning, in the z axis as well.

### 5. Further Work

The experimental phase of the project is still underway. There have been difficulties converting the captured images into a form that can be processed to the degree that accurate shape recognition can be achieved.

### 6. Conclusions

Traditional x-ray imaging can be an invaluable tool in final stage quality control. Its combination with machine vision heralds exciting possibilities for the future in industrial quality control processes.

### Acknowledgements

I would like to thank Mr Chris Snook for his direction and Professor John Billingsley for sharing his immense subject knowledge and for keeping me on track.

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 Billingsley, J. (ed) 2000, *Mechatronics and Machine Vision*, Research Studies Press Ltd, Hertfordshire, England.



# Maximum Power Tracking for Photo Voltaic / Co-gen supply Design

Sponsor – School of Mechanical and Electrical Engineering



**Chris KIRBY**

Bachelor of Engineering,  
Electrical / Electronic.

Supervisors: Catherine HILLS, USQ

**Keywords:** Photovoltaic, Matlab, Efficiency.

## 1. Introduction

Advancements in photovoltaic technology have enabled the development of small scale electrical generating systems, commonly seen in residential areas. This project aims to identify the factors which lead to reduced energy yields, providing solar installers with a set of guidelines to optimise system efficiency.

## 2. Background

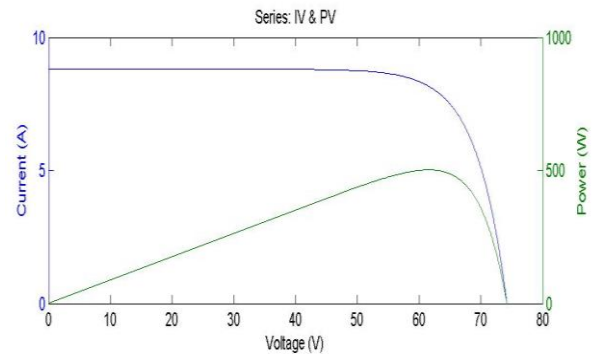
The rated capacity of photovoltaic systems installed throughout Australia is in excess of 4GW (Parkinson, 2014). Parameters for panel installation set the tilt angle equal to the location degree of latitude. Optimisation of the panel installation criteria and system configuration provide the possibility of efficiency improvements. Installation parameters could permit installation in configurations which are not currently being implemented.

## 3. Methodology

A simple IV curve model using Matlab has been developed to assess the effect of various external influences on the power generated within a small scale photovoltaic system. Homer energy will be used to identify the optimum tilt angle for a range of azimuth angles. Further modelling will be conducted using Homer energy to identify the optimum installation parameters, and provide a set of optimised parameters for system installation.

## 4. Key Outcomes

Modelling of various system configurations and analysis of the data produced assists in the determination of optimised installation parameters. System output efficiency is affected by various external factors



**Figure 1 – Photovoltaic IV curve at standard test condition.**

including panel shading, temperature, light intensity, panel specifications and installation configurations, with the potential effect ranging from negligible through to near complete loss. Repeating the system modelling while changing one parameter value provided an insight into the effect of the particular parameter.

## 5. Further Work

Future work of this project includes a generic analysis of potential financial savings and environmental benefit for reworking existing solar installations throughout Australia, including a feasibility study of such work.

## 6. Conclusions

The current approach to the installation of solar systems may not provide optimal output. Refining the installation parameters can lead to a higher energy yield and reduced reliance on fossil fuel systems, with minimal impact on current installation process and cost.

## Acknowledgements

I would like to thank the following people: my wife, Gemma, for support throughout my studies; Catherine Hills, supervisor, for assistance and guidance with researching and writing of this project; Andreas Helwig for information and assistance in selecting a project topic; Wayne Cheary for listening to ideas and providing suggestions for avenues of research.

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# Project Management Maturity in Local Government

Sponsor – School of Civil Engineering and Surveying



**Nathan Koenig** BEng (Hons)

Supervisors: Dr Nateque Mahmood, USQ  
Mr Kent Boyd, PSC

**Keywords:** Local government, project management, maturity model, PMBOK

## 1. Introduction

This paper examines the current project management maturity of the local government (LG) sector. The research provides an initial benchmark of Councils' project management (PM) practices and defines common strengths and weaknesses. By investigating the current practices of councils, the objective of this research is to provide a method of performance measurement and provide suggestions by which councils can make the quantum leap into standardised and optimised project delivery.

## 2. Background

LG across NSW once again faces the threat of forced amalgamations under the NSW state government's 'Fit for the Future' reforms package. A future of reduced financial assistance from the state government has challenged the sector to improve their performance. For many councils, this is a paradigm shift from an ad hoc approach, toward organisational project management maturity. At this juncture, councils must focus on improving business practices to deliver services sustainably; project management is one discipline to improve business function. No measures on project management performance are currently conducted in the sector. Measures of maturity offer the ability to compare councils and set benchmarks for their performance improvement.

## 3. Methodology

The research was conducted by reviewing and modifying existing maturity models from industry PM frameworks and creating a questionnaire that could be

conducted by participant self-assessment. The assessment was distributed via email and conducted using SurveyMonkey. Assessment was carried out in comparison to established maturity indicators in the 9 Knowledge Areas of PMBOK4. Maturity ratings ranging from Level-1 (Ad-hoc) to Level-5 (Optimised) formed quantitative data for analysis

## 4. Key Outcomes

The results of the survey have highlighted clearly that councils adopting a framework for project management consistently rate higher maturity indicators for PMBOK Knowledge Areas. Those councils with greater resourcing in project managers also demonstrate much greater maturity in project delivery. This extends to metropolitan councils when compared to rural councils; outperforming them on all measures.

## 5. Further Work

The results of the study indicate the need for deeper investigation into the structure and governance of LG to assess the challenges and barriers to achieve higher maturity levels. This initial benchmarking provides a basis for future studies for long-term trend analysis to explore service and financial metrics in correlation with improvement in PM maturity.

## 6. Conclusions

Critically, the results of the research show the LG sector rates just over 2 out of 5 for maturity, indicating that competitive practices are not widely adopted. Organisations with a Project Management Office score more mature overall having implemented and supported standardised systems and integrated them into business operations. Continued measurement and support of PM improvement may be included in ongoing annual reports to ensure a continued push for maturity in the sector.

## Acknowledgements

The student would like to thank the guidance of his supervisor Dr N. Mahmood and the participation of project officers across the local government sector.

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# Optimisation of off-highway truck fuel consumption through mine haul road design

School of Mechanical and Electrical Engineering



**Kristy Kubler**

Bachelor of Engineering  
(Honours) (Mechanical)

Supervisors: Dr Paul Baker, USQ  
Mr Trent Knack, New Hope Group

**Keywords:** optimisation, off-highway trucks, fuel consumption

## 1. Introduction

In the open cut mining environment, off-highway trucks are used to carry material along haul roads to different locations within the mine. Haul roads can change rapidly as mining progresses and access to different areas is required.

Diesel is a key consumable for mining operations, so it is imperative to understand the relationship between haul road design and fuel consumption. This would allow engineers and mine planners to design haul roads in a way that will minimise diesel consumption.

## 2. Background

Although condition monitoring has been used on mining equipment for many years, data collected is not always used in a proactive manner. This project aims to combine data from multiple sources in order to quantify variations in fuel consumption across an open cut mine environment.

## 3. Methodology

After researching mine design and operational factors that impact fuel consumption, a data collection programme was used to obtain truck data from a coal mine. GPS data (Figure 1) was combined with data from a fuel meter and truck condition monitoring data. This was used to identify different scenarios within the mine such as ramps, intersections and truck queuing. These different scenarios were further analysed in order to understand the quantity of fuel consumed depending on certain variables.

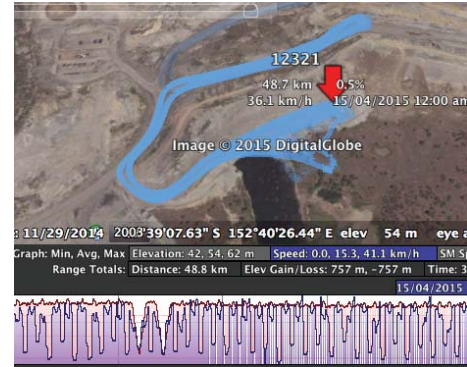


Figure 1 – Truck GPS data with speed and elevation profiles

## 4. Key Outcomes

MATLAB programs were written, allowing GPS and fuel consumption data to be combined with condition monitoring data from the truck's computer. This allows truck performance to be reviewed within the context of the operating environment at that moment.

Combining this data made it possible to quantify fuel consumption in different scenarios. For example, variations in fuel consumption across different ramp gradients.

## 5. Further Work

Continued data collection and analysis may allow identification of additional haul road scenarios. In future, bringing other truck models into the study would provide a more complete picture of fuel consumption at this operation.

## 6. Conclusions

Quantifying fuel consumption allows engineers and mine planners to make better-informed decisions based on anticipated costs and benefits when designing roads and scheduling material extraction.

## Acknowledgements

Mr Trent Knack and Mr Paul Hutchins for their support and assistance with data collection. Dr Paul Baker for his guidance and feedback.

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# Progress towards sustainable road construction – An investigation into the Roads and Maritime Services of NSW and Sustainability Rating Tools (SRTs)

School of Civil Engineering and Surveying



**Alexander  
Labrosse**

Bachelor of Engineering  
(Honours)

Major-Civil Engineering

Supervisors: Dr David Thorpe, USQ

**Keywords:** *Sustainability Rating Tool, road construction, management*

## 1. Introduction

This research project seeks to identify current industry wide trends towards sustainability within road construction, with specific focus on the Roads and Maritime Services (RMS) of NSW. The concept of a Sustainability Rating Tool (SRT) will be examined, in order to determine if an organisation-specific system can be developed and to identify the benefits of implementing such systems.

## 2. Background

The roads and transportation industry is within a period of major change, where integration of sustainability considerations in new projects is becoming more prevalent. The RMS is the NSW state government agency responsible for developing and maintaining the roads network, with around a \$3Billion annual capital works program. Finding methods to improve efficiencies is an important area, hence why SRTs are being investigated.

## 3. Methodology

This project involves three stages; Stage 1 involves analysis of the RMS organisation, and comparison of the progress made with other road construction agencies. This involves a comprehensive investigation into all current and past processes and initiatives related to sustainability, with a particular focus on the construction stage of road development.

Stage 2 of the project involves development of an SRT specifically for construction. This involves analysis, and adaptation of certain facets from current SRTs, as

well as keep points of importance from the analysis conducted in Stage 1.

Stage 3 of the project involves implementing the SRT to a current RMS project to gauge potential feasibility and effectiveness and to suggest improvements.

## 4. Key Outcomes

The main outcome from the project will be an SRT tailored for RMS road construction, which will be able to be utilised for certain construction projects. A succinct review of the road construction practice from the RMS will also be provided, with a comprehensive discussion on the findings.

## 5. Further Work

Sustainable road construction is an area with many directions yet to be explored. With respect to the project; if the SRT developed is to be truly effective, additional trials and development will be necessary in order to ensure it is effective and functions as intended, not simply as an additional administration process.

## 6. Conclusions

There is positive evidence that SRTs are beneficial in benchmarking sustainable practice as well as being useful as a management tool. RMS shows evidence of several initiatives toward sustainability in the past, however there is a lack of specific action towards improving sustainable road construction.

## Acknowledgements

I would like to thank my supervisor David Thorpe for having interest in a common area and providing guidance early on when structuring the project.

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# Energy Efficiency Improvement in Coal Fired Power Plant through Operational Optimisation

Sponsor – Stanwell Corporation – Tarong Power Station



**Jason Lang**

Bachelor of Engineering  
(Electrical/ Electronic)

Supervisor: Catherine Hills, USQ

**Keywords:** Energy Efficiency, Auxiliary Power, Coal-Fired, MATLAB®

## 1. Introduction

Stanwell Corporation operates an energy generation portfolio of 4100MW. Tarong Power Station (TPS) is a 1500MW coal fired station located in Queensland.

One of the major cost influences in the production of power in coal-fired power plant is auxiliary power consumption. It is the auxiliary power consumption within TPS that is the focus of this project.

## 2. Background

Auxiliary energy is the power used by devices directly associated with electricity generation. This usage is broadly understood and metered at a high level at TPS.

This project aims to first profile auxiliary energy consumption and then suggests operational methods that could result in a reduction in consumption. Accepted changes can be implemented through modification of the control system logic without capital investment.

## 3. Methodology

To understand the plant energy usage two primary methods were employed. Firstly energy tracking logic has been developed in the plant Siemens T3000 Distributed Control System. Secondly energy models of one full unit have been created in MATLAB, primarily utilising Simulink. These models have been confirmed against the plant energy metering.

## 4. Key Outcomes

The tracking logic and the MATLAB model have demonstrated the key link between plant load factor and energy efficiency. Figure 1 demonstrates the link between the auxiliary energy requirements at various

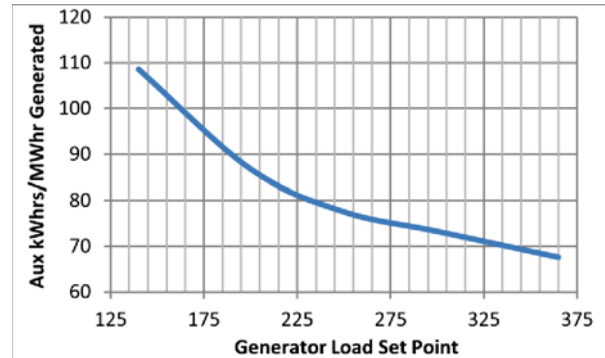


Figure 1 – Auxiliary Energy Reduces as Load Factor Improves

load factors. The project outcomes show that the current operational practices of the station show room for energy efficiency improvement.

## 5. Further Work

The next stage of the project is the additional testing of identified energy reduction options. Testing will be carried out through use of the created MATLAB models. These options then will be risk assessed for potential future implementation on generating plant.

## 6. Conclusions

The T3000 energy tracking logic created will give the plant owners the ability to monitor and address energy usage now and into the future. That plant load factor has a considerable influence on the overall energy efficiency of TPS. Findings indicate that energy reduction can be achieved without major capital investment.

## Acknowledgements

I would like to acknowledge the support and assistance of Catherine Hills, USQ. Also thanks to Stanwell Corporation for granting plant access to make this project possible. Finally I would like to thank my wife and daughter for their ongoing support.

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# Characterisation of the Physical and Mechanical Properties of Bamboo Fibre Cement Bonded Composites

Sponsor – School of Civil Engineering and Surveying



**Daniel Lee**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Allan Manalo, USQ

Prof Karu Karunasena, USQ

**Keywords:** Bamboo, fibre composite, concrete bonded

## 1. Introduction

Bamboo is a natural composite material with a high strength-to-weight ratio making it useful in building and construction. The fibres can be extracted and combined with other materials to produce a viable building material, even as an alternative to timber and steel.

This research project investigates the physical and mechanical properties of bamboo-fibre cement-bonded composites and explores the potential uses for the product in the engineering and construction industry.

## 2. Background

Natural fibres are an abundant and highly accessible resource and are a major reason for an emerging interest in clean sustainable technology. They have numerous advantages over many conventional materials, in that they are environmentally friendly, fully bio-degradable, not-toxic, non-abrasive, and cheap.

For thousands of years bamboo has been used as a construction material in China and India, and it isn't until very recently that the fibres were considered potentially useful as an amalgamated building material after separation from the culm.

## 3. Methodology

Five boards were constructed utilising five separate fibre-to-cement ratios. The procedures involved testing and analysing the behaviour of the boards in a variety of situations and environments. The mechanical testing consisted of subjecting the samples to static bending, short beam shear and water absorption experiments.

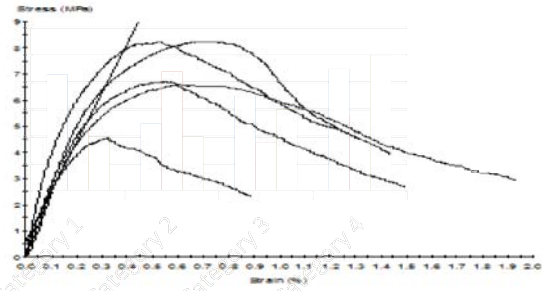


Figure 1 – Stress vs Strain for Static Bending Group 6

The deflection, stress, strain and thickness swelling of the samples were recorded and analysed.

Figure 1 details a stress vs strain plot for the 1:6 ratio sample group.

## 4. Key Outcomes

The results of the testing show that, with appropriate preparation and fabrication, bamboo-fibre cement-bonded composites can be a viable construction material, particularly when utilised as wall and ceiling panels.

## 5. Further Work

Further work that could potentially be undertaken involves the exploration of chemical additives to assist with the binding process between the bamboo fibres and the cement mixture. Furthermore, additional testing could be considered to investigate further physical capabilities of the material and its uses.

## 6. Conclusions

At this current point in the investigation it can be construed that the behaviour of the BCBC fluctuates not only under loading variances but with specimens within the same sample set. This is due to the minute differences in thickness, consistency and structural integrity of the material, however when optimum conditions are met the results are quite promising.

## Acknowledgements

I would like to thank and acknowledge Dr Allan Manalo for his support and guidance throughout this research project. I would also like to thank Professor Karu Karunasena and Mohammad Hizam Rusmi for their assistance during the course of the project.

# Research into Prefabricated Modular Construction and an Investigation into Incorporating Bathroom Pods into a High-rise Building Project



## Bryden Leeson

Bachelor of Construction (Civil)

Supervisors: Dr David Thorpe, USQ

**Keywords:** Prefabrication, offsite, lean construction and bathroom pods

### 1. Introduction

This research project aims to research past and present prefabricated modular construction techniques and processes and also investigate issues around incorporating bathroom pods into a high-rise building project.

### 2. Background

Prefabrication has proven to be an overwhelming success in the automobile, shipbuilding and aerospace industries. Advancement in technology has increased efficiencies in construction time, material usage and more ergonomic work processes. This project aims to investigate and explore the feasibility of incorporating prefabricated components, specifically bathroom pods, into a high-rise building project. Research into past and present prefabricated construction components and technologies will also be discussed in a literature review.

### 3. Methodology

A methodology has been formulated to investigate incorporating a prefabricated bathroom, in lieu of traditional in-situ bathroom construction, whilst meeting budget, program and quality objectives.

Three key investigations will be developed and evaluated to determine if these objectives can be achieved including:

- Identification of accurate scopes of work
- Establishment of a detailed Bill of Quantities
- Development of finishes cycle programmes



Figure 1 – Inside a Bathroom Pod

### 4. Key Outcomes

Detailed research and workshops have identified clear delineation between the scopes of works between the bathroom pod manufacturer and the following trades required to fit off and connect services to the pod.

The establishment and population of a detailed Bill of Quantities has also allowed a feasibility study to be carried out with respect to overall cost of prefabricated bathroom pods verse traditional in-situ bathroom construction.

### 5. Further Work

Further investigation into the potential reduction on project's program is to be completed, evaluated and analysed prior to submission of dissertation.

### 6. Conclusions

The key conclusion when determining whether to adopt a prefabricated building component is consideration and planning early in the project life-cycle. Early selection of prefabrication as the preferred construction method encourages the client, design and engineering consultants and contractors to work collaboratively to realise a prefabricated solution to a given construction context.

### Acknowledgements

Thanks and appreciation is owed and due to my project supervisor, Dr. David Thorpe, employer Brookfield Multiplex in particular Glenn Robinson, architect Lucien Fender and Interpod Offsite's Stuart Light.

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## THE FEASIBILITY OF USING CONSTRUCTED WETLAND SYSTEMS FOR URBAN WASTEWATER

Sponsor - School of Civil Engineering and Surveying

Yvette Lieschke-Mercer



Bachelor of Engineering (Civil)



Figure 1 – Bathurst Waste Water Treatment Works

Supervisors: Dr Thomas Banhazi, USQ

Dr Elad Dafny, USQ

**Keywords:** Constructed Wetlands, Effluent Polishing, Floating Treatment Wetlands

### 1. Introduction

Constructed treatment wetlands are used globally to treat stormwater and wastewater for the effective removal of nutrients and pollutants. This technology is a proven method for water treatment and is gaining greater momentum in its application in Australia. The technology allows for reductions in construction and ongoing capital costs. In addition, this technology can reduce the need for chemical treatment of waste water management systems.

### 2. Background

Treatment wetlands are a passive system capable of treating primary and secondary effluent, however predominantly they have been employed to treat wastewater beyond the secondary level, often referred to as effluent polishing (Kadlec, 1996). Treatment wetlands are more commonly applied to the treatment of stormwater runoff however are also effective for treating human wastewater, industrial, mining and agricultural effluent. The reuse and reclamation of treated waste water is gaining momentum especially in countries where water is or is becoming more of a scarce and expensive resource.

### 3. Methodology

Investigation into the feasibility of a passive treatment system was undertaken for a large urban population to determine if civil costs, operational costs and EPA load based license fees have the potential to be reduced. Specifically the comparison of the efficacy of two types of constructed wetland systems was undertaken. A traditional and a floating treatment wetland (FTW) were compared, as part of the treatment process for

municipal wastewater to meet discharge limits and to determine which type of wetland has greater viability with regard to its actual footprint, land availability and also treatment efficiency. The Constructed Wetlands Manual (DLWC, 1998), as well as sizing methodology put forward by Reed et al (Reed, 1995) were utilised to determine wetland surface area.

### 4. Key Outcomes

Floating treatment wetlands appear to be the most feasible option in terms of land footprint, treatment efficiency and also enabling the retrofitting of existing structures.

### 5. Further Work

Further work to include engineering design and reporting the costs of constructing and/or retrofitting a new treatment system and comparing these to the current capital costs.

### 6. Conclusions

Constructed wetlands, in their various forms, are a viable alternative for wastewater treatment and effluent polishing.

### Acknowledgements

I would like to thank Martin Haege who has been a valuable mentor and provided useful assistance.

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# Suitability Assessment of a Heavy Air Lift Vehicle In-Flight Shutdown Rate for Extended Range Operations

School of Mechanical and Electrical Engineering



**Steven Lightly**  
Bachelor of Engineering  
(Mechanical)

Supervisors: Dr Ray Malpress, USQ

**Keywords:** In-Flight Shutdown, Extended Range Operations, Heavy Air Lift Vehicle

## 1. Introduction

Military aircraft are increasingly required to have multiple capabilities, roles and functions. Heavy Air Lift Vehicles (HALV) are often required to conduct both military-specific functions in addition to the passenger-carrying flights typical of commercial carriers.

Where passenger flights are conducted more than 60 minutes from a suitable aerodrome, they are referred to as Extended Range Operations (EROPS) and are subject to specific regulations and the highest standards of safety and reliability within the aviation industry, including the requirement to maintain an In-Flight Shutdown (IFSD) rate less than 0.02/1000 engine hours.

## 2. Background

The operational flight characteristics of the HALV vary significantly from the commercial aircraft upon which EROPS targets are based. As such, thermal and mechanical loading of the propulsion systems can be expected to diverge from that which is typical of an EROPS passenger-carrier. Therefore a suitability assessment of the HALV IFSD rate must be conducted to ensure an equivalent level of reliability is maintained.

## 3. Methodology

HALV flight profiles have been subject to both numerical and statistical analysis including MATLAB processing of raw flight data. The resulting database includes various key indicators that have been utilised to conduct a comparative analysis of flight profiles. Utilising the MATLAB processed engine data, as depicted in Figure 1, the cumulative effect of transient mechanical and thermal values can be assessed as it relates to performance variations.

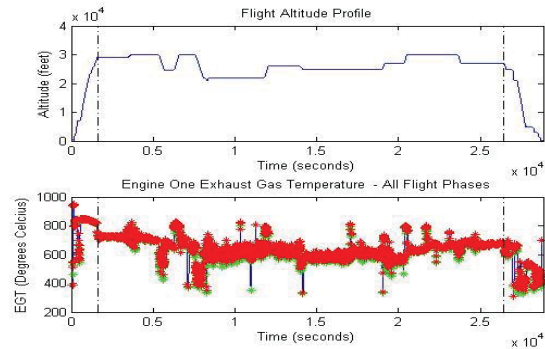


Figure 1 – HALV Military Specific Flight Profile

## 4. Key Outcomes

The primary objective of this research was to ascertain and investigate all relevant factors that differentiate the operation of the HALV from a commercial operator. Whilst the analysis of flight profiles was only one factor that was considered in the derivation of the HALV IFSD rate it is significant to note that these results also have significant implications relating to asset management.

## 5. Further Work

Due to a limited historical database further research is required to quantify existing MATLAB results, in addition to further analysis into the optimal use of HALV simulators as a means for maximising asset life.

## 6. Conclusions

Increased thermal and mechanical loading of the HALV propulsion system during military flight profiles is significant. The HALV IFSD rate does require adjustment according to the various operational factors that differentiate the HALV from commercial carriers. Minimisation of certain flight profiles can significantly increase the propulsion system through-life reliability.

## Acknowledgements

My sincerest gratitude to Dr. Ray Malpress of USQ for providing his time, engineering expertise, project management guidance, feedback and support.

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## Creating a performance management system for contractors to assess subcontractors



**Nicholas Linman**

Bachelor of Construction (Management)

Supervisor: Dr Vasantha Abeysekera

**Keywords:** subcontractor, performance management, principle contractor

### 1. Introduction

This research project seeks to investigate the creation of a functional performance management system that principle contractors can use to assess subcontractors.

The performance management system will be based on an extensive literature review that has been undertaken and applied to the use of construction subcontractors. The literature review identified a data analysis technique that can use previous performance to provide an estimated prediction of the future performance of subcontractors.

The use of such a system could help principle contractors with their procurement strategies for subcontracted work. Other benefits include better quality outcomes on projects due to higher performing subcontractors, subcontractor strategic partnering or marrying retentions with subcontractors' performance.

### 2. Background

Up to 90% of the works is subcontracted within the construction industry, so it is important to develop a functional subcontractor performance management system to select the most appropriate subcontractors for the application.

### 3. Methodology

An extensive literature review was undertaken to provide the most relevant data that was used as the basis for the subcontractor performance management system.

A detailed process flowchart was then formulated that can be used as a template that can be customised to suit the specific requirements of a principle contractors organisation.

A case study is also undertaken to test the performance management system and its effectiveness within a real world application. Out of 51 performance management indicators that were identified, a principle contractor's organisation identified their top 10 performance management indicators as seen in figure 1.

Rank	No	Name	RII
1	21	Honesty and Reliability	0.9077
2	51	Commitment Reliability (e.g. Keeping their word)	0.8769
3	15	Quality	0.8769
4	20	Adherence to Construction Program	0.8769
5	2	Level of Understanding of Scope	0.8769
6	24	Cooperativeness with main contractor	0.8462
7	43	Successful past projects	0.8462
8	8	Communication	0.8462
9	9	Financial Capacity	0.8462
10	10	Technical Capability	0.8462

Figure 1. Top 10 Performance management indicators as selected from principle contractor within the case study.

### 4. Key Outcomes

The major outcomes that this research project hopes to fulfill are:

1. Understanding the relevant literature for the design of a subcontractor performance management system
2. Develop a guideline for the design of a subcontractor performance management system
3. Use the guideline and literature research to establish the relevance of the proposed subcontractor performance management system within the industry.

### 5. Further Work

Further work is recommended to evolve the system further. Automating the data analysis and integration into a functional database would make the performance management system more user friendly and would ensure that the system is used effectively within a principle contractor's organisation.

### 6. Conclusions

The literature review was quite extensive and the information obtained has integrated into a functional performance management system that appears to be fit for purpose. Based on the case study that is undertaken, the performance management system is effective and appears to fulfill the specification requirements as prepared at the beginning of the project.

### Acknowledgements

Thanks to Dr Vasantha Abeysekera for helping shape the performance management system and mentoring me throughout the research project process.

Thanks also to all participants who participated in the case study.

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# Design a Modified Planetary Reduction for Optimum Performance

Sponsor – Evolution Drill Rigs



**Graham Little**

Bachelor of Engineering  
(Honours) (Mechanical)



Figure 1- Completed Planetary Gear Set.

Supervisor: Dr Canh-Dung Tran

**Keywords:** Optimum, Planetary, Compact, Minimum Weight gear.

## 1. Introduction

Planetary gearing is a well-established method of achieving high reduction ratios and torque transmission while maintaining a relatively small power dense package size. The project basis is the redesign and optimization off an existing reducer. This reducer is part of an exploration drilling rigs low gear train. The difficulty was to achieve a smaller physical envelope, maintain the current output torque and increased the planetary reduction ratio. The measure of performance is a minimum weight gear set which can achieve the specified design life and fit within a reduced space envelope.

## 2. Background

There has been a significant amount of research into high efficiency in gearing including planetary arrangements. However existing research studies do not provide a method for a complete design of a planetary system to achieve an optimum performance. Planetary gear sets involve both internal and external meshes which requires a different approach to design when compared to external gear trains.

## 3. Methodology

The project start point was the determination of a duty specification and the selection of AGMA standards as the basis for the gear rating. A literature review was undertaken to identify existing knowledge and methodology applicable to minimum weight gear design. A design method and Matlab programme was developed to accept preliminary inputs, estimate the minimum geometric size and calculate the data to assess suitability. FEA was used to verify calculated design stresses and assembly stiffness. The manufactured gear set is shown, figure 1.

## 4. Key Outcomes

A gear set was developed with a rating of 8 years as required by the sponsor. The assembly outside diameter and depth was reduced. The gear reduction ratio was increased to 7.5:1 while achieving an increase in pitting resistance. A program was developed to assist with future designs. FEA was used to prove acceptable tooth flank contact to full torque. The reducer was manufactured, tested and implemented as part of a gearbox into the field.

## 5. Further Work

FEA analysis comparison between frictionless and frictional tooth contact has not been completed at this time. The comparison of results for calculated and FEA analysis also needs to be completed.

## 6. Conclusions

There is a lot of flexibility in gear and planetary design, however it is important to closely define the duty and expected design life as a starting point. FEA techniques play an important part in design verification and assembly stiffness.

## Acknowledgements

I would like to thank my supervisor Dr Canh-Dung Tran for his support during the project and advice in the preparation of the dissertation.

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# Condition Monitoring of Rotating Machinery

## - Vibration Analysis

Sponsor – Faculty of Engineering and Surveying



**Richard Little**  
Bachelor of Engineering  
Mechanical

Supervisors: Mr Robert Fulcher, USQ

**Keywords:** Vibration Training Program

### 1. Introduction

The aim of condition monitoring is to detect defective machine components and allow timely repair before failure and secondary damage occurring. This project, in particular, covers the condition monitoring techniques applicable to rotating machinery and vibration analysis.

### 2. Background

Vibration analysis is a specialised role and equipment owners often have a limited understanding of it. Practicing technicians also benefit from better understanding fundamental principles and ongoing training. Key to improving outcomes of CM programs is improving knowledge and understanding.

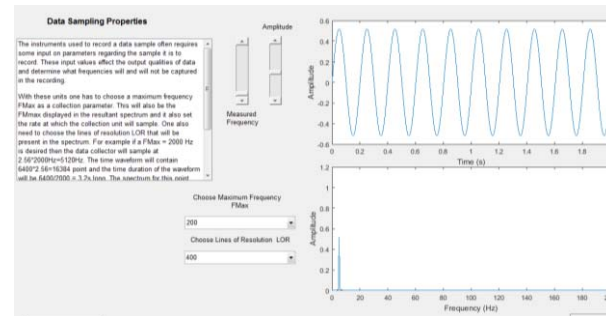
### 3. Methodology

Utilising overall project specifications, a schedule, flow and Gantt charts, decision trees, listing activities with diagrams and milestones ensured the orderly development of the project.

Researching condition monitoring practices and standards applicable to rotating machinery led to developing required outcomes, software specifications and user requirements for a virtual training package prior to writing the Matlab program.

### 4. Key Outcomes

Development of a vibration training program in line with ISO 18436-2 requirements and industry recognised practices for personnel conducting and utilising vibration condition monitoring. The program currently covers level 1 and level 2 concepts. It is a



**Figure 1 – A level 1 concept - adjustable data collection parameters - resultant waveform and spectrum.**

program that is easy to use, familiarising the user with fundamental concepts and readily detectable faults.

### 5. Further Work

Addition of level 3 components and improving the animation of concepts would be beneficial. The constraint on time will limit the level of complexity in fault modelling.

### Conclusions

The key aspect of the project specification, the development of a training and awareness tool based on industry practices and expectations, is displayed in the training program. It is a tool that can help technicians and plant owners better understand and implement vibration condition monitoring and improve outcomes thus reducing costly unplanned plant outages.

### Acknowledgements

I would like to thank my supervisor Mr Bob Fulcher for guidance and feedback on work throughout the project and a work colleague Mr Phil Carroll for ideas and interest in my project.

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# PLC Based Discrete Step Single Phase Voltage Regulator for Rural SWER Applications

Sponsor – School of Mechanical and Electrical Engineering



**Shufen LIU**

Master of Engineering Science

Major Electrical & Electronic Engineering

Supervisors: Dr Leslie Bowtell, USQ

**Keywords:** SWER, Low Voltage Regulator, PLC, Matlab

## 1. Introduction

In the past few decades the rural load demand for SWER network is increasing with 3% average per year for agricultural irrigation systems, farm automation equipment and refrigeration units. However, that increases of load demand over time has resulted voltage variation even sags during peak load period, which has impacted on electronic equipment and at grid system as whole.

The objective of this project is to research a new simplified low voltage (LV) regulator by using PLC to improve line regulation and significantly delay the system upgrades.

## 2. Background

Single wire earth return (SWER) or single wire ground return is a single transmission line to provide a single-phase power from the grid to remote areas at low cost. Around 70% of Ergon Energy's powerlines are classified as non-urban, with approximately 65,000km of the network being SWER lines. However, with the load demand has increased quickly the voltage sag problem during peak load period are often be found in SWER networks, especially for the lines over 100km. Traditional methods to solve the voltage problem was expensive and time-consuming. So it is significant for us to find a new method to improve the quality of SWER line and cost less.

## 3. Methodology

The basic method is to add a LV regulator behind the Customer Step-down transformer to make sure the output RMS voltage maintain in  $\pm 5\%$ . It includes a toroidal transformer, Triacs groups, customer RMS voltage detection system and PLC control system. Its control strategy is that PLC according the customer RMS voltage at customer node to choose suitable taps of toroidal transformer to change the load voltage within  $240\text{ V} \pm 5\%$ .

## 4. Key Outcomes

- a. LV customer voltage regulator scheme research and design.
- b. RMS voltage detection circuit design, debug and results analysis.
- c. PLC control program design, debug and results check.
- d. Modeling and simulating the LV voltage regulator.

## 5. Further Work

- a. The output power, power factor and load current should take into account with the LV voltage regulator.
- b. The tap change delay time TD should check with real SWER power line.

## 6. Conclusions

This project researches a boost/buck LV voltage regulator to improve the voltage quality on the SWER line with low cost and long use life. The LV voltage places beside the customer step-down transform and it can quick detect the customer voltage drop and control the tap change action.

## Acknowledgements

I must give my most appreciate to my project supervisor Dr Leslie Bowtell for his valuable guidance and help in my master project process. Special mention is to Mr Andreas Helwig for his patiently explain and help.

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# Evaluation of Strength Characteristics of Foamed-asphalt Mixtures with RAP Materials

Sponsor – School of Civil Engineering and Surveying



**Dinesh Liyanage**

Master of Engineering Science  
(Civil)

Supervisors: Dr Soma Somasundaraswaran,  
Staff Member, USQ

**Keywords:** Foamed asphalt, RAP materials, Resilient modulus

## 1. Introduction

The aim of this research project was to investigate the strength characteristics of Asphalt samples with various percentages of Reclaimed Asphalt Pavement (RAP) materials by using foamed bitumen as a binding agent. The results were also compared with current standards specified by AUSTROADS.

## 2. Background

Stabilisation can be defined as a process by which the intrinsic properties of a pavement material are altered by the addition of a stabilisation binding agents to meet performance expectations in its operating, geological and climatic environment.

Foamed bitumen is a mixture of air, water and hot bitumen. This foamed state of bitumen is ideal for mixing with fine materials because its large surface area bonds to fine particles.

The lack of a standardized mix design method for pavement construction in Australia gives this study significance. The confidence in the implementation of foamed bitumen stabilisation process in the field can be increased by reducing the uncertainty in laboratory mix designs.

## 3. Methodology

The methodology includes the samples preparations by using materials considering Aggregate Pericles Size Distribution (PSD) as well as Compaction (OMC and MDD) tests. The different percentages of RAP material were mixed with new aggregate and were stabilized with foamed bitumen. Next, the foamed asphalt mixtures were compacted into specimens using gyrator compactor followed by curing in oven. The following tests were done on prepared samples according to the guidelines of Australian standards as the indirect

strength (ITS) and indirect tensile resilient modulus (ITM<sub>R</sub>).

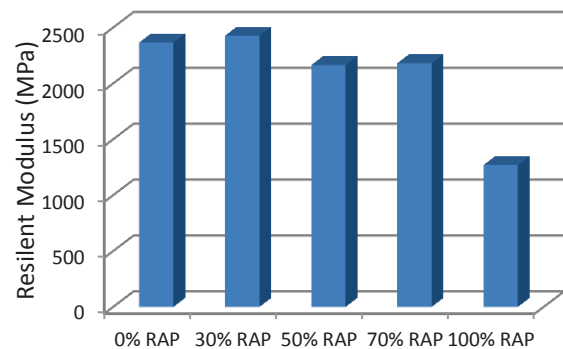


Figure 1 - ITM test results for various RAP percentage

## 4. Key Outcomes

The Resilient Modulus of samples with different % of RAP material (Figure 1) obtained by ITM test showed that samples containing 70% of RAP material can be used to construct pavement which is comparable to the AUSTROADS specifications.

## 5. Further Work

The next step of this research project will be the implementation of new sample mix in trial sites for performance to determine whether superior performance and lower maintenance is possible using the foamed bitumen stabilisation method compared to other more conventional stabilisation treatments.

## 6. Conclusions

The hypothesis of this research project is proved as the strength characteristic tests showed positive results as compared with AUSTROADS standards. The overall aim of the project is achieved by providing the efficient mix design for Foamed-asphalt for construction of pavement in Australia.

## Acknowledgements

I would like to thank Dr Soma Somasundaraswaran, for the patient guidance, encouragement and advice he has provided throughout my time as his student. I also like thank BORAL Asphalt to provide the required materials.

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# Stability of Undrained Tunnels

Sponsor – School of Civil Engineering and Surveying



**Jay Lobwein**

Bachelor of Engineering (Civil)

Supervisor: Dr Jim Shiau, USQ

**Keywords:** Tunnels, Undrained Clay, Design Chart

## 1. Introduction

Subsurface infrastructures are becoming more important with the growing demand of transportation systems in major cities around the world. Tunnel construction is a key focus in the advancement of underground construction. There are number of different tunnel designs evolving based on construction techniques, soil settlement and tunnel stability.

## 2. Background

Many research studies have been conducted in the field of tunnel stability for different types of soils and geometries. The majority of the studies were based on a stability number for undrained clay. This stability number was commonly formulated by increasing the uniform surcharge pressure, whilst setting the internal tunnel pressure to zero, in an active collapse mechanism. Basing the stability number on dimensionless parameters, stability design charts were produced for preliminary design.

This study will ignore the surcharge and internal tunnel pressures and induce collapse in a greenfield situation for various tunnel geometries for undrained clay, similar to common slope stability analyses.

## 2. Methodology

Computer based 2D models using Optum G2 were completed for circular, heading and twin circular tunnels in tresca material. Optum G2 is a finite-element software package used for strength and deformation analysis of geotechnical boundary value problems. Each tunnel geometry was analysed using limit analysis and strength reduction techniques by inducing a state of collapse by amplifying the gravity and undrained shear strength of the soil, respectively.

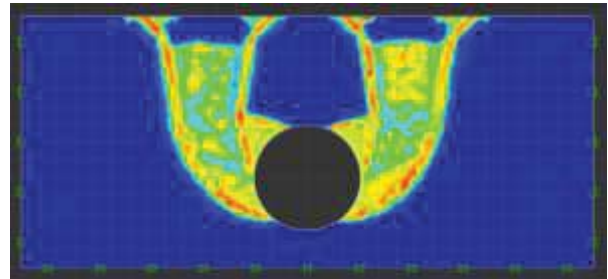


Figure 1 – Plastic dissipation of a shallow circular tunnel

## 3. Key Outcomes

A new Factor of Safety (FoS) function was developed based on depth, strength and spacing dimensionless parameters. Subsequently, new stability design charts were constructed for each tunnel geometry based on a unit FoS. Graphing of shallow, medium and deep tunnelling were also completed with an increasing FoS.

## 4. Further Work

The plasticity, shear strain rate, principle elemental stresses and displacement vectors are to be completely analysed and compared for the three tunnel headings. Comparison of the shallow, medium and deep design stability charts are to be concluded.

## 5. Conclusions

The new stability design charts can help practising engineers with preliminary tunnel design construction of shallow, medium and deep tunnels in undrained clay.

## Acknowledgements

Dr Jim Shiau for his knowledge, expertise and guidance during this research project. Furthermore, I would like to thank my family for their ongoing support and understanding.

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# Piecewise Adaptive Controller Design For Position Control of Magnetic Levitation System

Sponsor – School of Mechanical and Electrical Engineering



## Ryan Lucas

Bachelor of Engineering Honours (Instrumentation and Control)

Supervisor: A/Professor Paul Wen, USQ

**Keywords:** Magnetic Levitation, Adaptive Control, Nonlinear Control, Piecewise Modelling

## 1. Introduction

Magnetic Levitation is a complex physical phenomenon, gaining increasing popularity for use in public transportation systems such as trains and trams. This project investigates the nonlinear dynamics of such a system and develops a suitable control strategy for position control.

## 2. Background

Magnetic levitation is a nonlinear phenomenon, and hence precise position control is no trivial task. Traditional linear control theory can no longer be applied, and so other means must be investigated. Whilst the number of nonlinear control techniques is almost endless, adaptive control is one of the most common.

## 3. Methodology

Educational Control Products have developed an apparatus that simulates the magnetic levitation principle. The Model 730 system (see Figure 1) was used as the basis of testing and simulation. The system parameters were first determined experimentally to yield a suitable dynamic expression. System linearization techniques were then studied and the most appropriate implemented accordingly. A PID control algorithm was then developed and implemented as a basis of comparison and suitability, after which an adaptive control strategy can be applied.

## 4. Key Outcomes

This is the key section of your abstract that highlights Key outcomes achieved in the project thus far include: a thorough understanding of magnetic levitation

systems, an appreciation of nonlinear control and the techniques available, linearization of a complex dynamical system around a suitable operating point, implementation and optimisation of a PID control



Figure 1 – Model 730 Apparatus

algorithm using the MATLAB control toolbox and the selection (there are many) of an appropriate adaptive control strategy.

## 5. Further Work

Before completion, the final adaptive control strategy must be proposed and/or tested. This project studies the SISO operation of the Model 730 instrument, further work could incorporate the MIMO operation, and a controller designed accordingly.

## 6. Conclusions

By applying adaptive control techniques to a nonlinear problem of this nature, this project seeks to provide a framework for future studies in precision nonlinear position control systems, with the potential for development and use in industrial applications.

## Acknowledgements

A big thankyou to my supervisor, A/Professor Paul Wen for passing on his knowledge, wisdom and enthusiasm for this topic, as well as my family and friends for all their support throughout this journey.

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# Industrial Wireless Network Mapping

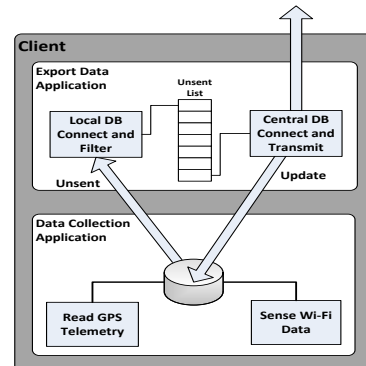
School of Mechanical and Electrical Engineering



**Glenn Lumsden**

Bachelor of Engineering (Honours)  
(Computer Systems)

Supervisors: Dr Alexander Kist, USQ



**Figure 1 - Client Application**

**Keywords:** Wireless, Networking, GPS

## 1. Introduction

Wireless network mapping is the process of displaying quality and performance information related to wireless access points over a relational map. Business systems utilising wireless technologies demand sufficient coverage and performance of their networks under all conditions. To reduce negative business impacts, early detection of emerging deficiencies is required. This project aims to develop a system that can provide client based outdoor Wi-Fi information for live analysis and display.

## 2. Background

Whilst commercial Wi-Fi mapping software exists, some use information from the access points (AP) to estimate the coverage and other quality factors. Whilst this can be live information it does not provide suitable information about the network as seen by clients on the network. Others methods employ a technique known as war-driving that maps GPS and Wi-Fi data at a client level but only producing a snap shot in time. This project is developing software allowing clients on a wireless network to report Wi-Fi and GPS information back to a centrally located server for live analysis and reporting.

## 3. Methodology

The project employed researching existing techniques and coding for gathering GPS telemetry and Wi-Fi data. Database systems were also researched. Using agile software development techniques, starting with a system model as shown in Figure 1, the trial system was incrementally built, testing each additional function.

## 4. Key Outcomes

Research provided access to code and methods that have been tested and critiqued. The system has been conceptualised and alternative programming languages and database programs have been compared. A trial system has been designed and tested to retrieve available Wi-Fi information with GPS telemetry, storing the data in a local database. A remote/central database has been developed and tested in conjunction with the client application.

## 5. Further Work

Multiple client testing is yet to be achieved in a real world setting. As an extension to the project, progress will continue on the ability to display and filter the data.

## 6. Conclusions

The trial system has succeeded in providing live client based Wi-Fi information allowing data collection to occur on a central server. Further work will address client based outdoor wireless network reporting.

## Acknowledgements

Firstly, I need to thank my wife, Jenn, for her support with all my studies. Thanks also to my manager, Anthony Goodger, for his support with this project, Dr Alexander Kist for his guidance and introducing me to DreamSpark.com and fellow student Jason Lang.

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# Optimisation of Multicore Processor and GPU for use in Embedded systems

Sponsor – National Centre for Engineering in Agriculture.



**Chloe Mansell**

Bachelor of Engineering  
(Honours) (Computer  
Systems)



Figure 1 – ODROID XU3 Development Board

Supervisors: Mr Stephen Rees, USQ

**Keywords:** Embedded Systems, Optimisation, ODROID XU3

## 1. Introduction

The advancement of technology has been continuing at a rate predicted by Moore's Law half a century ago. Continued advancements including the decrease in the size of integrated circuit components allowing more components on a single chip has decreased the cost of processors and greatly improved performance including clock speeds and power efficiency.

We are now seeing the slowing of Moore's Law as advancement's in Integrated Circuits approach physical limitations. This slowing has contributed in the birth of multicore processors and parallel processing to allow for continued increase in processing power. As the cost of multicore processors and development boards become lower this will allow multicore processors to become more of a viable option for use in embedded systems.

This dissertation will investigate the use of multicore processors and Graphics Processing Unit to execute optimised embedded system algorithms.

## 2. Background

Optimisation of an embedded system algorithm can be aided with a comprehensive understanding of different architectures of current processors including Central Processing Unit, Single Instruction Stream Multiple Data Stream, Digital Signal Processor, Floating Point Unit, Programmable logic device and Graphics Processing Unit alongside an understanding of how they function.

## 3. Methodology

Software will be developed, demonstrating three typical machine vision embedded system algorithms. The three software programs will be optimised using software optimisation techniques found to be advantageous in the current literature. The three optimised algorithms will be executed through an individual Arm A7 and A15 core as well as execution through the Exynos 5422 processor scheduled by the GCC compiler. The three algorithms will be optimised to be executed using the Neon unit, Floating Point Unit and the Graphics Processing Unit independently.

## 4. Key Outcomes

This project aims to record and compare execution speeds of three algorithms optimised and executed on separate hardware components available on the ODROID XU3 development board as discussed in the methodology.

## 5. Conclusions

Upon successful completion this dissertation will be able to demonstrate to the best optimisation techniques for the increase in execution speed of three typical machine vision embedded system algorithm's executed on a current development board comprising multicore processors and GPU.

## Acknowledgements

I would like to thank my project supervisor Stephen Rees for his continued guidance and support throughout this project.

# Remote Identification of Overhead Conductor Material

School of Mechanical and Electrical Engineering



**Scott Marsh**

Bachelor of Engineering  
(Power)

Supervisors: Dr Les Bowtell, USQ

Mr Dave Shephard, Ergon  
Energy

**Keywords:** Spectral Remote Conductor

## 1. Introduction

A percentage of conductor material and size of overhead distribution and sub transmission line is unknown by the owner e.g. Ergon Energy. The identification of this conductor is presently performed by experienced eye from the ground and/or diameter testing using insulated equipment both of which are extremely costly.

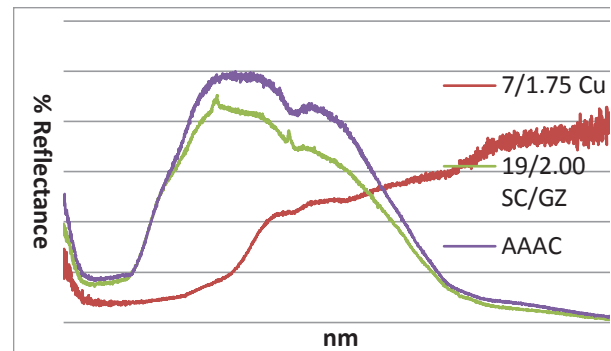
This project researches the suitability of spectroscopy to identify the conductors commonly used in overhead networks with a view to incorporating the technology into the workflow of the various LiDAR survey aircraft already overflying the entire Ergon Energy network each year collecting geo-spatial information.

## 2. Background

Previous attempts to identify conductors such as copper in coastal areas were unsuccessful due to costs in the tens of millions of dollars. Dramatically reduced income and a less labour intensive, more automated approach to conductor identification is required. Using spectral reflectance curves to identify materials has been used reliably in the medical, mineral exploration, astrophysics and military fields for some time and has the potential to reliably identify conductor materials in a cost effective manner.

## 3. Methodology

The suitability of image spectroscopy to identifying conductors was initially proven using a consumer digital SLR, a combination of lenses and Fourier analysis using Matlab. After the concept was proven at a high level, a commercial spectrometer was used under laboratory conditions at the USQ to research the



**Figure 1 – Typical results of copper, steel and aluminium conductors**

reliability and repeatability of the technology to identify a range of overhead conductors commonly used in the Ergon Energy network under a known light source.

## 4. Key Outcomes

Copper showed a significantly different response than the other conductors while steel and aluminium conductors showed moderate similarities under laboratory conditions and a stable known light source. The identification of aluminium covered steel reinforced (ACSR) was entirely dependent on the placement of the steel re-enforcing strand in the cable lay due to the spectrometer requiring a direct light path from the material. Research into identification from above is ongoing.

## 5. Further Work

Research into conductor identification from above is ongoing.

## 6. Conclusions

Spectroscopy is a suitable technology for the remote identification of most conductors. For ACSR with an internal steel core, spectroscopy and conductor diameter analysis would need to be used in conjunction.

## Acknowledgements

I would like to thank Mr Dave Shephard, Dr Les Bowtell, and Mr Paul Hohenhaus for their ongoing support.

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# EXPLORE EVAPORATION MITIGATION MEASUREMENT TECHNIQUES



**Jonathon Maskall**

Bachelor of Engineering  
(Honours) (Civil)



**Figure 1: GRAPHTEC midi LOGGER GL220**

Supervisors: Dr Pam Pittaway, USQ

Dr Joseph Foley, USQ

**Keywords:** storage evaporation, monolayers, surface film.

## 1. Introduction

This project seeks to investigate novel evaporation mitigation performance measurement techniques for stored irrigation water using the existing USQ Ag-Plot evaporation research facilities. The aim is to understand the performance of a monolayer and the impacts of a warm and cold surface film on evaporation. The hypothesis is that the warm surface film will create a thermally stable water body which resists diffusion, thus causing the monolayer to have limited potential for evaporation reduction.

## 2. Background

There has been much research to suggest that monolayer products provide a genuine cost effective solution for reducing evaporative losses from water storage facilities. However previously developed products have had considerable limitations, the poor durability and longevity of the product has seen it significantly impacted by wind, water disturbance and solar radiation. What's more some improvement in durability and longevity are continually being discovered, however other factors operating at the interfacial boundary layer have rarely been investigated. The significance of this research project is to investigate the resistance to evaporative loss that exists at the air-water interface.

## 3. Methodology

In conducting this research project two water troughs were used as storage facilities. Difficulties were experienced in designing a floating apparatus which was essential for spacing and protecting thermocouples used to analyse the subsurface water temperature. The data logger shown in figure 1 was used to record

temperature variations at half hour intervals. The evaporative losses in the tanks were measured twice daily over the test duration. Some forecasting was necessary to schedule when to conduct the field trials; light winds and clam dry conditions experienced during the winter months are considered optimal for collecting the most accurate data.

## 4. Key Outcomes

While testing is still underway, initial data would suggest that the stated hypothesis is indeed supported. Further field trials will hopefully continue to reinforce this theory, while providing an increased understanding of the characteristics of a surface film.

## 5. Further Work

From here I need to finalise field testing; once a sufficient quantity of data has been collected, analysis of the data will be undertaken with weather station data included as part of the analysis process.

## 6. Conclusions

The project looks to examine the resistances to evaporative loss that exist at the air-water interface with the focus on making a contribution towards improvements in water management within the agricultural industry.

## Acknowledgements

I would like to thank my supervisors, Dr Pam Pittaway for her guidance and expert knowledge in evaporative research and Dr Joseph Foley for his direction and support. I would also like to thank Terry Byrne for invaluable assistance with the design and assembly of the testing apparatus.

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# Investigating Development Potential for Pumped Hydro Energy Storage & Water Security in Northern & Eastern Australia



**Matt Mason**

Bachelor of Power Engineering

Supervisors: Mr Andreas Helwig, USQ

**Keywords:** Hydropower, Australia, Energy Storage,

## Introduction

This project was intended to research the economic and technical feasibility of a Pumped Hydro Energy Storage (PHES) System in Queensland. The benefits of this scheme would include:

- Improved water security across Queensland.
- Times shifting Capability and ancillary support to the NEM
- Increased support for renewable energy penetration into the NEM's current generation profile.

## Background

There are multiple pressures on Queensland and NEM infrastructure currently to provide stable access to the essential services of both water and electricity.

Due to Australia's naturally erratic weather patterns and the increasing pressures associated with climate change; water security is fast becoming an issue of state and national concern.

Also due to increased uptake in renewable electricity generation to meet Australia's Renewable Energy Target; there are infrastructural developments needed to ensure electricity security. The main renewable energies that are being implemented are wind power and solar power. Due to the temporal and spatial variability and also ancillary stresses associated with these technologies; Australia will need to start considering energy storage options.

## Methodology

The methodology used to research the technological and economic feasibility of this proposal has been listed as follows:

1. Extensive research was conducted to ascertain realistic cost projections of implanting all the associated infrastructure of the proposed PHES scheme.
2. The most appropriate sites in QLD were chosen on the basis of proximity to Stable water sources and proximity to the NEM network. This was done using GIS Google Earth software and mapping overlay techniques
3. The technical capabilities of these sites were then modelled using Homer Software.
4. The technical capabilities of the PHES system 's benefits were then quantified in economic terms and considered in the context of current electrical market analysis and predicted short term future trends. These costs were used to test the feasibility of the project against the modelling results.

## Key Outcomes

Identifying the technical need for this infrastructure, and also identifying the costs of the problems associated with current and predicted future infrastructural strains associated with not implementing this system.

This research project has provided an overall analysis of a PHES system as a significant national asset to provide a solution for increasingly significant water and electricity security issues in eastern Australia

This research vicariously assists researching similar schemes in other locations.

## Further Work

While this research project has primarily focused on energy storage as a means of solving national electricity and water security issues, it also lays the ground work for energy storage as an investment in nationally produced renewable energy as an export product.

As solar energy technology follows trends of increasing efficiency and decreasing costs; Australia's vast potential for solar resources becomes increasingly viable. There is increasing potential for Australia to profitably export energy to South East Asia via a High Voltage DC link.

Energy storage is an indispensable key element in such a scheme.

## Conclusions

The undertaking of this project suggests the system would have a long payback period but would also provide long term stability to water and electrical security in the Queensland and NEM regions.

While the scope of this proposed system is significant, and would require a much greater analysis to justify the costs involved; this project has outlined the overall feasibility of this system.

This project has also been equally as useful in its exploration of the problems, as it has been in its proposed solution to them. As there are multiple solutions to many of these infrastructural strains, perhaps the more important first step is having a developed understanding of the problems.

The intention of this research project has been to illuminate the current context of Eastern Australia's water and energy security issues and increase the awareness of these as a national security issues. It has also been to illustrate that there are long term solutions to these issues that would provide ongoing benefit for generations to come.

## Acknowledgements

I would like to thank my supervisor Andreas Helwig for giving me the opportunity to undertake this project and also for providing guidance throughout its development.

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*Power System Adequacy Report 2013, Australian Electricity Market Operator (AEMO) Mansfield QLD*, viewed 2<sup>nd</sup> April 2015, <http://www.aemo.com.au/Electricity/Resources/Reports-and-Documents/Power-System-Adequacy>



# Wastewater Treatment by Coagulation and Anaerobic Digestion Processes and the Potential of Bioenergy Production

School of Civil Engineering and Surveying



Butho Masuku  
Master of Engineering Science  
(Environmental Engineering)

Supervisors: Dr. Friederike Eberhard, USQ  
Professor Jochen Bundschuh,  
USQ

**Keywords:** Abattoir wastewater, coagulation, co-digestion, biogas production

## 1. Introduction

There are many approaches in the treatment and disposal of abattoir wastewater from the beef industry. Abattoir wastewater has a high content of solids, organic matter and nutrients, and anaerobic treatment processes are ideal for abattoir wastewater because of their capability to reduce pollution in land and waterways. The covered anaerobic ponds have an advantage over other treatment methods in regards to the amount of biogas produced which is one of the main by-products of wastewater treatment and it is used to augment electricity as a source of energy in the abattoir. Physical and chemical treatment methods of abattoir wastewater do not result in 100% treatment and if used as pre-treatment methods for anaerobic digestion, the toxicity of chemicals impact negatively on the anaerobic digestion process.

## 2. Background

Research in Australian beef abattoirs has determined that in the covered anaerobic digester fats, oils and grease form at the top of the digester and are not involved in the reactions that produce biogas. Previous research into coagulation of abattoir wastewater recommended chemicals that are environmentally friendly or have no impact on biological processes. Examples of these chemicals are iron based coagulants such as ferrous oxide, ferrous sulphate and chitosan as a coagulant aid. This research investigates biogas production of blood water by coagulation and anaerobic digestion processes.

## 3. Methodology

A laboratory scale experiment was set up to investigate biogas production through a combination of coagulation and anaerobic digestion processes.

The wastewater sample was pre-treated by coagulation with ferric oxide and a combination of ferric oxide and chitosan as a coagulant aid. The supernatant solution from the coagulation was then co-digested with an inoculum in an anaerobic digester (reactor). An inoculum to substrate ratio of 2:1 based on volatile solids was used and biogas production is assessed using 500 ml Wheaton bottles connected to 1L tedlar bags.

## 4. Key Outcomes

Results from the coagulation effect show a trend of varying pH values and NPOC results with coagulant dosages. This will definitely have an effect on the biogas production since microbial activity is dependent on pH.

## 5. Further Work

It is recommended that sludge from the coagulation process is mechanically and thermally treated and later co-digested.

## 6. Conclusions

On completion of the study, the bioenergy potential of combining the coagulation supernatant from the abattoir waste water and the anaerobic waste water from the Pittsworth water treatment plant will be discussed. In addition, the optimum coagulant doses for biogas production will be determined.

## Acknowledgements

I am grateful to God the Almighty for the strength to be able to carry out this research. I would like to thank and appreciate my supervisors Dr. Friederike Eberhard, Professor Jochen Bundschuh and Dr. Ihsan Hamawand for the support and guidance in the execution of this project.

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# The Identification of all Rights, Obligations and Restrictions on Freehold Land in South Australia

School of Engineering and Built Environment



**Brad Mattsson**

Bachelor of Spatial Science  
(Surveying)

Supervisor: Dr Glenn Campbell

**Keywords:** Rights, Obligations, Restrictions

## 1. Introduction

The rights, obligations and restrictions (RORs) on a parcel of land are of critical importance. They can vary in nature depending on classification, perspective and benefits or hindrances (both to the land, the owner and the surrounding community).

Finding out where RORs apply, who they apply to, the reasoning behind their creation and if and how they can be changed are of critical interest to both land owners and the general public.

## 2. Background

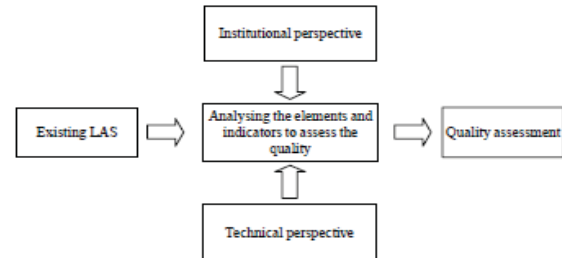
The land administration system must be a dynamic tool capable of managing the ever changing needs of society. The system must be capable of upholding the RORs as they relate to competing rights of individuals and communities. As with any object or thing there will be disagreements and the land administration system and society must have a precedent and set of rules and outcomes to avoid conflicts between members of society.

As land and property rights develop over time the number and range of RORs associated with land parcels is predicted to continually increase. For the future sustainability and efficiency of land markets property rights must be 'clear, searchable and definable in location' (Lyons et al, 2002).

## 3. Methodology

This project has been broken down into three distinct stages as outlined below:

1. Compile a detailed review of relevant literature pertaining to RORs and current land administration trends.
2. Adapt Temple's typology to the current South Australian system and complete case studies to discover any RORs existing over the chosen parcels of land.



**Figure 1** – Framework for assessing the quality of a LAS (Ali et al, 2013).

3. Analyse the results and detail the impediments to identifying the RORs using Temple's typology.

## 4. Key Outcomes

Research the history of RORs and land administration problems.

Research the history of South Australian property law.

Adapt Temple's typology to suit the South Australian land system.

Apply this system to locate existing RORs on freehold parcels of land.

## 5. Further Work

Multiple case studies over South Australian properties using the adapted typology to identify RORs and any impediments occurred.

## 6. Conclusions

Anticipated conclusions include identifying impediments to efficient land right searching in relation to existing RORs.

## Acknowledgements

I would like to thank my family and friends for their support throughout my time at USQ.

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# Measuring the Impacts of Varying Design and Documentation Quality in Construction Projects

School of Civil Engineering and Surveying



**Jessica McFarlane**

Bachelor of Engineering  
(Honours) (Civil)

Supervisor: Mr Paul Tilley, USQ

**Keywords:** Design and Documentation; Performance Quantification, Benchmarking

## 1. Introduction

In today's competitive construction market, there is a need for industry participants to benchmark not only their own performance, but also the performance of those companies with whom they work. Ideally, the design and documentation provided for construction projects would be complete, precise and unambiguous, but this is rarely the case.

Through a combination of research and case studies, this project will identify the common factors attributing to poor design and documentation quality, and utilise them to develop a method of quantification of design and documentation quality, to be applied to further Case Studies.

## 2. Background

While quality assurance has become a major factor in most construction businesses, literature and anecdotal evidence suggests that generally design and documentation quality is still severely lacking.

Utilising existing quantification methods as a base, such as the *Quantification of the RFI Process* method (Mohamed, et al., 1999) and applying the latest industry knowledge, it is possible to develop methods for the measurement of design and documentation quality and in doing so provide an assessment of how varying quality can impact the efficiency of the construction process.

## 3. Methodology

The methodology undertaken to complete this project was developed by answering a series of research questions which provided suitable guidelines. The

process involved data collection, validation, correlation and utilisation. Research, combined with the collected data was used to develop a mathematical relationship based model, with the inclusion of extra performance criteria. The final step is the validation of the model, which will occur through application to a project Case Study.

## 4. Key Outcomes

There are three major milestones within this project, the first to complete research and an initial case study to identify the common causes and impacts of design and documentation deficiencies. This milestone has been reached, and work is being completed towards reaching the second milestone – the development of a method for measuring design and documentation quality. The mathematical method is mainly Excel based, and is in the final stages of development.

## 5. Further Work

The final milestone is to apply the measurement method to a second Case Study, to both validate it and identify points for improvement. It is aimed that this application will provide an in depth assessment of how varying quality can impact the efficiency of the construction process. If time permits, I would like to develop an interactive online based form, in place of an Excel Spreadsheet.

## 6. Conclusions

Provided the validation of the developed model is successful, the quantification method of design and documentation quality will hopefully provide construction industry professionals with a means of quantifying documentation performance, with the aim of ongoing improvement and meeting benchmarks.

## Acknowledgements

I would like to thank my supervisor Mr Paul Tilley for the guidance, technical expertise, and patience that he has exerted towards this project. I acknowledge and thank Toowoomba Regional Council for access to their facilities, employees and data. I cannot thank my family and friends enough for their support.

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# Monitoring and Removal of Natural Organic Matter (NOM) from Toowoomba Water Sources

Sponsor – School of Civil Engineering and Surveying



**Jamie McIntyre**

Bachelor of Engineering (Honours) (Environmental) / Bachelor of Science (Environment and Sustainability)

Supervisor: Dr Vasantha Aravinthan, USQ

**Keywords:** water quality, organic matter, enhanced coagulation

## 1. Introduction

This project aims to monitor the amount of natural organic matter in the water sources of Toowoomba and investigate the removal of this by enhanced coagulation. The contribution of this project will include identifying the organic carbon concentrations in the water sources of Toowoomba, which have not previously been measured, and determining the optimum dosage of alum added as a coagulant for maximum organic carbon removal.

## 2. Background

Natural organic matter is present in all water sources and is potentially problematic for drinking water purposes. Organic matter reacts with disinfectants used in the water treatment process and forms harmful disinfectant by-products. This is not regulated in Australia. In the United States, it is a requirement that if any source water measures a concentration of greater than 2.0 mg/L of total organic carbon, a water treatment plant is required to practice enhanced coagulation. In the absence of Australian regulations, measurements obtained during the course of this project are compared to the US regulations.

## 3. Methodology

Water samples were collected from the Japanese Gardens and three water sources at the Mt Kynoch Water Treatment Plant. Standard methods were used to take measurements of pH, turbidity, alkalinity,  $UV_{254}$  absorption, dissolved organic carbon, iron and selected anions. Jar testing is the method used to simulate removal of DOC by enhanced coagulation.

## 4. Key Outcomes

The water quality characteristics of the four water sources have been identified. The primary findings of the dissolved organic carbon concentrations are shown in Figure 1. This represents the key outcome of monitoring the amount of organic matter in the water sources. A secondary key

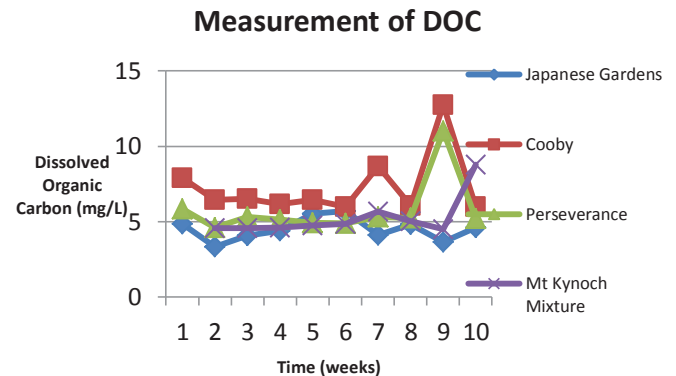


Figure 1 – Dissolved Organic Carbon Measurements

outcome is to perform the jar testing to investigate how the organic matter is removed with increasing coagulant dosages.

## 5. Further Work

Tasks remaining to be completed for this project include the jar testing for three of the water sources and the measurement of the trihalomethane formation potential of raw and treated waters. The obtained results are to be analysed.

## 6. Conclusions

The dissolved organic carbon concentrations of the water sources were all consistently greater than 2.0 mg/L for the duration of the monitoring period. Enhanced coagulation is recommended for the treatment of Toowoomba's water sources.

## Acknowledgements

I would like to thank my supervisor, Dr Vasantha Aravinthan, as well as Friederike Eberhard and Raed Ahmed Mahmood for all of their guidance and assistance.

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# Development of a New Type of Concrete Headwall – Stage One: Fiber Dose Rate

Sponsor – Humes TM



**Lincoln McKay**

Bachelor of Engineering (Honours)  
(Civil)

Supervisors: Dr Yan Zhuge, USQ

*Keywords: concrete, fiber, reinforcement*

## 1. Introduction

For an extended period the vast majority of civil construction projects have utilised standard steel reinforced concrete. This arrangement provides concrete with added strength and ductility, a characteristic that unreinforced concrete does not have on its own. Fiber reinforcement is a material that has been around for a while but is yet to be widely adopted by the industry. In recent times however, there has been a lot of interest as there are many benefits that they bring to a concrete product and the research surrounding different types and hybrid mixes has gathered momentum. An interesting side note about fiber reinforcement is its ability to add an almost unbelievable ductility to concrete from a particular type (PVA) of fiber.

## 2. Background

Many of the precast concrete companies are investing in the research of fibers for use in their precast products. This is valuable as it carries considerable economic benefit as it reduces a lot of the labour involved with using steel reinforcement cages. It is also important as strength characteristics vary depending on the concrete mix used, which is why it is important to utilise Humes' specific super plasticised mix to ensure the company receives the correct research data. Humes have identified that headwalls would currently be the best product to incorporate fiber reinforcement, but as they supply The Department of Transport and Mainroads, this is not an options as it has to be created to a specification supplied by them. For a change to happen, the strength characteristics of fiber reinforcement has to be calculated and compared to that of standard steel reinforced concrete. If these characteristics match or exceed then a change to the Mains Roads specification could see the incorporation of fiber reinforcement.

## 3. Methodology

Multiple specimens with varying fiber dose rates were cast into cylinders and beams for testing. These specimens will be loading in flexure as well as compression to give an adequate quantity of results for strength comparisons. The testing will take place after 24 hours to determine early strength characteristics to see if the product can be removed from the mould and left resting to reach full strength. A final strength comparison is also needed after the specimen is left to cure for 28 days (the optimal timeframe for max strength). A small theoretical analysis will also be employed to validate or dismiss the data obtained through testing, although this may prove difficult as there is no standard set of equations for fiber reinforcement, given its random nature.

## 4. Key Outcomes

It is hoped that the strength characteristics of fiber inclusion to Humes concrete mix will exceed that of the use of steel rebar in the same mix. This data can then be used to prepare a full scale headwall using fiber reinforcement for testing. It is then hoped that if the data acquired is promising, Humes will invest further into the research of fibers to include an option for all of their concrete products.

## 5. Further Work

After completion of the current research the optimal dose rate of fibers could be utilised in many different types of concrete structures (in particular a headwall). The product could then be modelled using a computer software package to see points of failure and to identify if the inclusion of fibers is a viable option using a full scale concrete product. Lastly, a full scale product could then be constructed and tested to support the above computer modelling.

## 6. Conclusions

YET TO BE CONCLUDED, FURTHER TESTING REQUIRED

## Acknowledgements

Firstly, I would like to thank Brett Beaver. Brett offered assistance whenever needed and was an incredible help throughout the project. Dr Yan Zhuge, who is my supervisor. Thank you Yan for the assistance when required. Lastly I would like to thank Humes for their involvement.

# Recyclable Disposable Helmet Design

School of Mechanical and Electrical Engineering



**Samuel Robert  
McQuade**

Bachelor of Engineering  
(Honours) (Mechanical)

Supervisor: Dr Ray Malpress, USQ

**Keywords:** Recyclable Material, Disposable  
Helmet, Brisbane CityCycle

## 1 Introduction

The Brisbane CityCycle (bike rental scheme) was implemented in 2010 this scheme in its short lifespan as currently used and disposed of or is in current use of a total of 2000 helmets, which are all destined for landfill. This has created a need for a cheaply produced helmet which can be implemented into the scheme with the same safety rating which is currently being used, which can also be recycled. The implementation of the proposed helmet will not only reduce the landfill which the scheme is currently creating, but also open a door for future works into recycled materials for head protection innovations, and this is why the proposal of a paper pulp recyclable disposable helmet is put forward.

## 2 Background

The Brisbane City Cycle Scheme was introduced to reduce inner city congestion and to endorse the public into being active and healthy. Throughout the lifespan of the scheme the council has implemented free to use helmets with the bikes. It is stated that within the first 1500 helmets 70% were reported destroyed or stolen. To introduce a recyclable disposable helmet destruction or theft of the helmets would not leave the council at a loss as the material used (Recycled News Paper) is readily available and with the possibility of the helmets being reused within the process the resources will always be accessible.

## 3 Methodology

The methodology utilised has been referred to as the Scientific Method. The method of conducting experimentations which is based off the prediction of a theory within a topic and to observe the outcome and analyse the results. The experiments which has

been used to determine the outcome of the helmets performance is in accordance with the Australian New Zealand Standards outline for Impact Energy Absorption, and Load Distribution

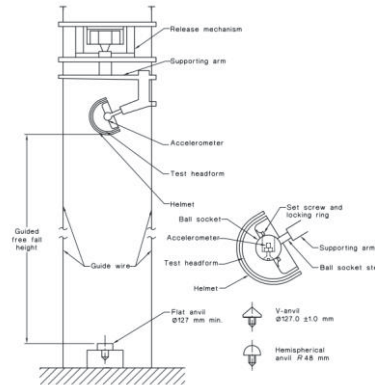


Figure 1, Typical Apparatus for impact energy attenuation test (Standard 2007)

## 4 Key Outcomes

To produce a helmet made from recycled material which meet the required Australian New Zealand Standards which could possibly be introduced into various bicycle rental schemes. To determine that paper pulp is a suitable substitute for the current material used, (EPS). This together will determine if the possibility of a disposable helmet made from paper pulp is a suitable and safe alternative to the current helmets on the market.

## 5 Future Work

To test the helmet proposed to the two Australian standards and to analyse the results. If the design passes the outline criteria the following steps is to tests for the remaining standards outlined. Also to go get the helmet design certified with an Australian Standard sticker which will allow the helmet to be sold and used within Australia.

## 6 Conclusion

Final conclusion of this dissertation is at this point unclear yet the material testing of paper pulp has outlined that the material is a suitable replacement.

## 7 References

Standard, ANZ 2007, *Methods of testing protective helmets* Method 3.1: Determination of impact energy attenuation - Helmet drop test  
<<http://www.saiglobal.com/PDFTemp/osu-2015-04-02/6760248451/2512.3.1-2007.pdf>

# Feasibility Investigation of the Implementation of Raised Speed Limits on 'M' Class Motorways in Rural Environments

School of Civil Engineering and Surveying



**Thomas Meadows**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Soma  
Somasundarasawaran, USQ

**Keywords:** Motorway, Standards, feasibility

## 1. Introduction

The comparison of Australia's infrastructure design standards to world leaders is important to ensure the world's best practice is upheld, especially on the freeway networks. This will ensure Australia's economic growth can continue without the need for constant investment in remedial works.

## 2. Background

Australia is currently experiencing its highest population growth of the past 40 years with much of this concentrated in major cities. As a result, faster and more efficient freeway network is required to allow the transport of goods. This report will identify if an increase of motorway speed limits is a feasible solution to improve the efficiency of the network and cater for the demands of the growing population.

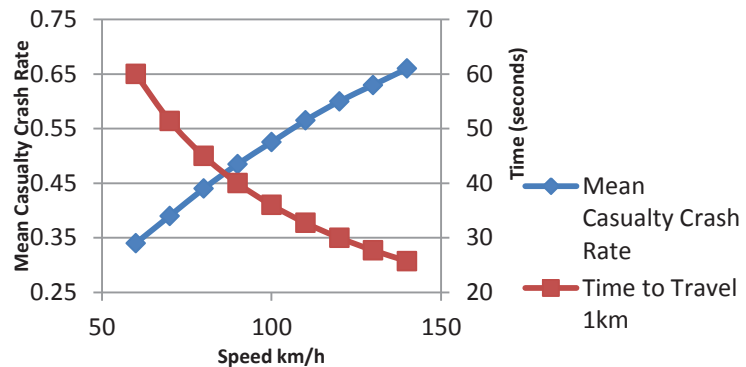
## 3. Methodology

The standards utilised in the design of freeways in Australia were examined and values and methods of analysis compared, with similarities denoted.

Various costs, such as cost of construction, cost association of crashes and additional emissions, and benefits such as, travel time savings and reduction of accidents were calculated. These values were compared to understand if the increase in speed limit resulted in a substantial economic benefit.

## 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



**Figure 1 – Casualty Crash Rate and Travel Time vs. Speed**  
unique? How did you apply your methodology to achieve these outcomes?

## 5. Further Work

Further research into the topic could include:

- Difference in driver education and behaviour
- Investigation into the currency of values used in standards

## 6. Conclusions

Based on the studies undertaken in other countries, such as Wilnot and Khanal (1998), speed limit increases does not result in an equal increase of median speeds, however smaller dispersion of speed often result, leading to lower crash rate. Studies such as Son, Fontaine and Park (2009) show that an appropriate speed limit can increase driver satisfaction, speed limit compliance and reduce speed disparity.

Examination of the standards of Australia and international sites identify that the common principle of determining geometric features are held common, however the values used in the formulas vary greatly.

## Acknowledgements

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

## References

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# Power Law flood frequency analysis of selected Queensland stream gauges

Sponsor –School of Civil Engineering and Surveying



## Denika Moes

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Ian Brodie, USQ

**Keywords:** Flood Frequency Analysis, Power-Law, Log-Pearson

## 1. Introduction

Floods are one of the worst natural disasters and each year can cause millions of dollars of damage and the loss of human lives. Conventional flood frequency analysis methods have been criticized for their failure in extreme flood predictions. This project aims to investigate the suitability of the Power Law statistical model as a preferred method to estimate flood frequency.

## 2. Background

Accurate and reliable predictions of flood events are extremely important to the civic society, especially since Queensland has the highest average annual actual damages due to flood. Determining a more accurate flood frequency analysis procedure will reduce costs associated with construction and maintenance of infrastructure in the long term. A floodplain map created using the predicted discharges from the Power Law model will help with the awareness and readiness of communities in flood events.

## 3. Methodology

Data was collected for a number of Queensland stream gauges from a number of sources. This historical data used to create an annual flood data series and a partial flood data series. Using these data series, a Log-Pearson 3 distribution and an exponential regression model was created as per the Australian Rainfall and Runoff guideline. These models were compared with a Power Law relationship also created from the historical data by the use of 'goodness of fit' tests. Figure 1 shows one of the stream gauge station's fitted models with their predicted peak discharges fitted to different flood recurrence intervals.

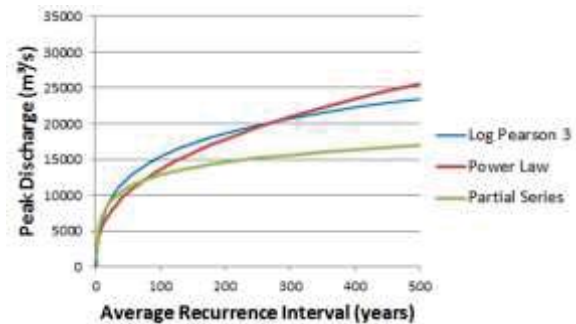


Figure 1 – Model predicted peak discharge for Herbert River at Abergowrie fitted to the average recurrence intervals

## 4. Key Outcomes

To date, the three types of frequency models of been created for ten Queensland stream gauge stations and R-Squared and Chi-Squared 'goodness of fit' tests have been applied. Early results indicate that the Log-Pearson distribution generally fit to the historical flood records better, while the Power Law relationship provides a more conservative peak discharge prediction for the rarer flood events.

## 5. Further Work

Work to be completed for this project is the finalisation of the analysis and results and trends to be reported. Further work could be completed to compare the Power Law predictions of extreme events against the Generalised Extreme Value models.

## 6. Conclusions

This study looks at the accuracy of the conventional flood frequency analysis methods used in Australia and compares that to the accuracy of a Power Law relationship. Accurate and reliable predictions of flood events will reduce the costs of construction and maintenance of infrastructure in the long term

## Acknowledgements

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

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- Malamud, B., & Turcotte, D., (2006). The Applicability of Power-Law Frequency Statistics to Floods. Journal of Hydrology, 322, 168-180.



# Finite Element Analysis of Fillet Welded Joint

Sponsor – School of Mechanical and Electrical Engineering



**Rafiqul Islam  
Mohammed**

Bachelor of Engineering  
(Mechanical)

Supervisors: Mr Chris Snook, USQ

**Keywords:** Finite elements analysis, FEA on welding, Fillet welded joint.

## 1. Introduction

Welding is the most commonly used process for permanent joining of machine parts and structures. Welding joints are prone to be fatigue cracking due to residual stress concentration. This research project aim is to use finite element analysis tools to define normal stress and fatigue life of the fillet welded joints and compare with the experiment results, which can validate the finite element analysis results on particular applications.

The research outcome will help designer to characterise the behaviour of fillet welded joints and estimate strength of welded structural component under dynamic loads.

## 2. Background

Fatigue failure is quite often occurred in mobile plants, bridges and transport equipment. If the designer can predict behaviour of the structure before its operations it can save from damaging equipment as well as lives of people.



Figure 1: Fatigue Damage of structure ("Leap Australia," 2014)

The use of finite element analysis is to achieve design requirement and more sustainable equipment for the society.

## 3. Methodology

The model of the fillet welded joint is made from 250 grade structural steel and welded as a cross section. In the physical experiment we have done tensile test of the material to compare with the result of FEA. Finite element analysis tools, ANSYS is used to analyse the same profile as tested in the lab. The geometry of the heat effected zone are defined from the previous literature and applies different material property on heat effected zone due to rapid heating and cooling.

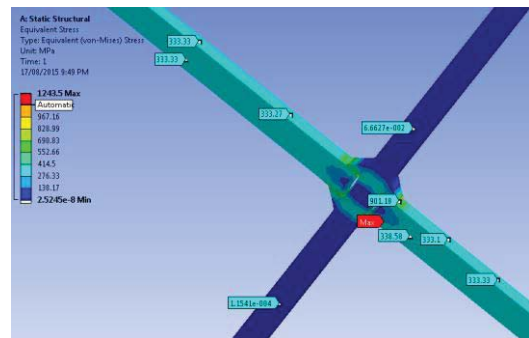


Figure 2: Finite element analysis result

## 4. Key Outcomes

This study provides an in-depth understanding of the behaviour of fillet welded joint under cyclic loading. The comparison of the test results with the finite element analysis will also give an indication about the assessment capability of the analysis tools for this type of joint

## 5. Further Work

Further investigation required on the experiment for a fatigue test with full penetration welding joints and in the simulation required to apply heat on the weldment according to welding procedure.

## 6. Conclusion

The investigation has been found tensile stress is very close between experiment and FEA with less than 7-8% error. Similar way we can conclude fatigue analysis also has accuracy with 7-8% error.

## Acknowledgements

I would like to acknowledge Mr. Chris Snook for his supports and comments. Many thanks to Mr Chris Galligan who has done very well welding for the project and special thanks to Dr. Ray Malpress for his tips to use ANSYS.

## References

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# Bond Behaviour of Steel Reinforcement to Concrete with Oil Contaminated Sand

School of Civil Engineering and Surveying



**Zaffar Mohammed**

Bachelor of Engineering  
(Civil)

Supervisors: Dr Allan Manalo, USQ

**Keywords:** Bond-slip, steel-concrete interface, bond, oil contamination, pull-out test, bond strength

## 1. Introduction

Leakage during exploration, production and transportation of oil is considered a significant issue worldwide (CSIRO, 2013). This pollution affects almost all natural resources such as soil/sand within the surrounding areas. Remediation of sand contaminated with oil is very expensive.

The idea of reusing oil-contaminated sand as a civil engineering construction material and in the manufacturing of concrete is considered an innovative solution to a growing problem. However, much research is still needed to explore the potential use and identify critical issues in this application.

## 2. Background

Reinforced concrete structures work on the basis that steel and concrete form adequate bond to composite act with each other and safely carry the desired loads. Without this fundamental theory, the design of reinforced concrete structures using oil contaminated sand may present a significant challenge. It is therefore imperative to thoroughly understand the effects of oil contaminated sand on the concrete steel bond to further evaluate the suitable use of this material in civil engineering and construction.

## 3. Methodology

The focus of this research is to study the effects of light crude oil contamination on the bond strength between concrete and steel reinforcement. Mineral w2.5 motorcycle fork and suspension oil was used to contaminate the fine sand at 1%, 2%, 6%, 10% and 20% by mass of dry sand. Concrete at a mix ratio of 1:3:3, with a water/cement ratio of 0.5 was then prepared. Normal strength steel of 16 mm diameter was embedded in the concrete and pulled out. Separate specimens were also prepared and tested to determine the compressive and tensile strength of concrete.

## 4. Key Outcomes

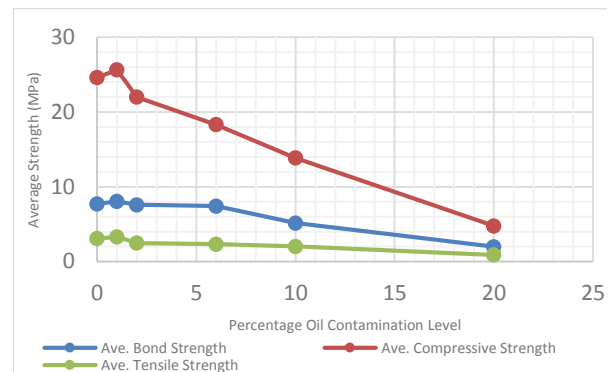


Figure 1: Graph of average bond, compressive and tensile strengths versus percentage contamination level

It was found from this study that the level of oil contamination have a significant effect on the compressive, tensile and bond strength properties of concrete as shown in Figure 1.

## 5. Further Work

Pull-out testing with different types of oil contaminated concrete, i.e. varying oil viscosity and API number can be conducted.

## 6. Conclusions

The following conclusions are drawn from the study:

- The 1% oil contaminated sand gives higher compressive, tensile and bond strengths than the control sample and the 2% and 6% contaminated samples are relatively close to the control samples.
- Therefore the oil contaminated sand up to 6% can be used to manufacture concrete and can be applied in design with an acceptable factor of safety.

## Acknowledgements

I would like to thank, my supervisor, Dr Allan Manalo for his advice and guidance, Mr Rajab Abousnina for his advice on my project, and my family for their support.

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# Manipulation of Remote Experiments through Gesture Recognition

School of Mechanical and Electrical Engineering



**Peter Moore**

Bachelor of Engineering  
(Computer Systems)

Supervisors: Dr Alexander Kist, USQ

**Keywords:** Matlab, Server-based, LEGO EV3

## 1. Introduction

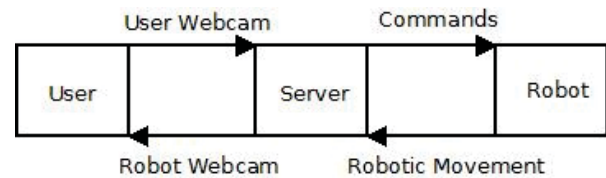
This project involves the remote manipulation of an experiment through gesture recognition. This is to be done using a web camera device and internet connection on the users end connecting to a server based system that hosts the remote connection through to Matlab, which performs the processing tasks and sends movement commands to an experiment (LEGO EV3 robot).

## 2. Background

This project assists remote users in manipulating remote experiments using only a computer, internet connection and web camera device. The implications of this development allow for increased interactivity in projects based upon remote access, such as the Remote Access Labs (RAL) project currently being developed at USQ. This project extends upon knowledge of computer vision and using relatively common devices, creates a hand gesture based interaction system for user and computer. As far as state of the art developments in this area, the Xbox Kinect could be considered as a commercial grade version of this project, using a camera input and providing output dependant on user movement.

## 3. Methodology

The initial skeleton solution of the project was to get the user web camera stream and periodically process the live stream and compare against previously acquired user hand data. Considering the use of Matlab software in this project, a server based system would allow users to access without having their own copy of Matlab. The user would have to upload a web camera stream with which images can be extracted, processed and compared to previously stored hand data. The use of a minimum comparison rate minimised the chance for any non-gesture or blurry pictures to become false positives in the comparison process. After the image is successfully recognised as a hand gesture, a LEGO EV3 add on for Matlab allows for dynamic programming to issue the commands to a LEGO EV3 robot used as the output for this experiment.



## 4. Key Outcomes

An obvious key outcome for this project is gesture recognition at a feasibly high rate of correct analysis, which has been achieved through image capture, processing and correlation to best fit of other previously stored images with a minimum comparison rate required to dissuade incorrect analysis. Low cost impact is achieved through the use of devices common to most homes in this era of technology. A future goal to be achieved is precise robotic control, which shall be managed by setting the movement duration after a successful command input equal to the interval between image checks on the webcam, possibly with a buffer to allow for lag.

## 5. Further Work

The tasks remaining on this project include the implementation of the robotic control and rigorous testing of its integration into the project. Ongoing research into scholarly articles related to this project will also continue for the duration of this project.

## 6. Conclusions

This key achievement of this project is the creation of a system that interprets human hand gestures from a remote location and converts them into robotic movement at a central hub. The creation of this software permits for further implementation in remote experiment control, which will allow users who are otherwise unable to access the experimental equipment to have the opportunity to learn how their inputs will affect real systems in real time.

## Acknowledgements

I would like to thank Dr. Alexander Kist for providing feedback on ideas for the project and inviting me to a remote access laboratories conference to allow further insight into the possible implementations of research in this area.

## References

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<<http://enprints.usq.edu.au/21691/>>

# CREATING A SIMPLIFIED MODEL OF THE ALKALI-SILICA REACTION IN CONCRETE BY UTILISING FINITE ELEMENT MODELLING TECHNIQUES

School of Civil Engineering and Surveying



**Robert Murdoch**

Bachelor of Engineering (Civil)

Supervisors: Assoc. Prof Yan Zhuge, USQ

**Keywords:** Finite Element Modelling, Concrete, Alkalai Silica Reaction.

## 1. Introduction

This dissertation involves using finite element software to construct a simplified model of the ASR effect on in-situ structures with the view to giving practicing engineers a tool which they can use to estimate the strength of an affected structure.

An added element of complexity exists in the fact that, of the variety of FEM programs available, Strand7 is not typically set up to deal with this type of problem.

## 2. Background

In Queensland alone there have been 105 bridges found to be affected by the deleterious effects of the Alkalai Silica Reaction (ASR). Depending on the effects it can be appropriate to repair and maintain an existing piece of damaged infrastructure or, alternately, demolish and construct a replacement.

## 3. Methodology

The first step was to understand ASR and how it affects concrete. Time was also allocated to study how ASR was modelled previously and how FEA could be used to model this process. The next step was to try to replicate the experiments conducted previously using the Strand7 FEM program. This was done in several stages, the first being a model of unaffected concrete (See Figure 1), then internal stresses and fracture lines were introduced to simulate advanced ASR effect and finally a 3D model was created.

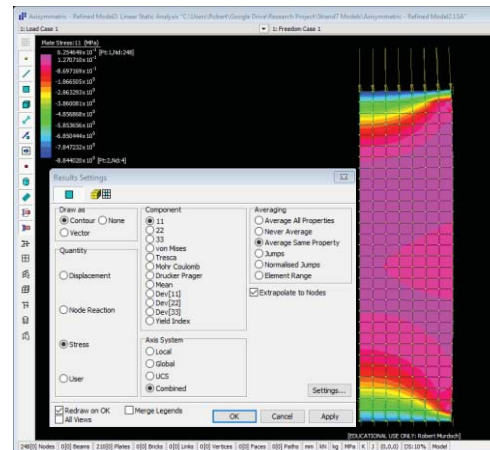


Figure 1 - Concrete Cylinder Compression Test

## 4. Key Outcomes

The model being developed is intended to replicate the deleterious effects of ASR on concrete structures. Ultimately this would be able to be used to create a simplified approach to modelling ASR affected structures.

## 5. Further Work

Further refinement of this method is needed to make it useful for practicable purposes. It is important to gauge the accuracy of this model in various conditions and establish the error bounds.

## 6. Conclusions

This is a problem has proved to be a very challenging task. The current model is not sufficient to be used but with more work it appears possible to get a functioning model.

## Acknowledgements

I would like to thank my supervisor, Yan Zhuge, for her patience and help over the year.

## References

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# Dynamic Conductor Ratings: Annealing Properties of Homogenous Conductors across Varying Climatic Conditions

Sponsor – Ergon Energy Corporation Ltd. (EECL)



**Ryan Murphy**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisors: Mr Andreas Helwig, USQ  
Mr Greg Caldwell, EECL

**Keywords:** Dynamic Ratings, Climatic Conditions, Sub-transmission/Distribution Power lines.

## 1. Introduction

Currently, the Australian Standard (A.S. 7000:2010) prescribes the methodology employed by the IEC standard (IEC TR 61597 1995) for calculating the load ratings of overhead conductors. This project aims to investigate whether or not this is more superior to that of the previous guideline provided by Electricity Supply Association of Australia (ESAA D(b)5-1988) and to provide the ability to uprate a sub-transmission line based upon real time data.

## 2. Background

Correct conductor ratings are vital in maintaining a safe and operational network. To ensure the conductor doesn't fail, a steady state formula is used to approximate the available load which can be transmitted. This formula is known as the 'Heat Balance Equation' (HBE). A critical analysis will help identify which equation is more superior. With additional testing against real time measured data, it is hopeful that an additional level of confidence will be provided to EECL to rate its overhead network across varying climatic terrain.

## 3. Methodology

Analysing the variant HBEs allows for differences to be identified. To quantify such differences MATLAB code has been written to show the percentage change in available current ratings as per each varying component. Following this, a comparative assessment is performed against real time values from sub-transmission power lines. From the test of real time values against formulated values, the conductor may be able to be subjected to dynamic ratings. An asset management analysis is also required as to identify the cost benefits to EECL of such implementations.

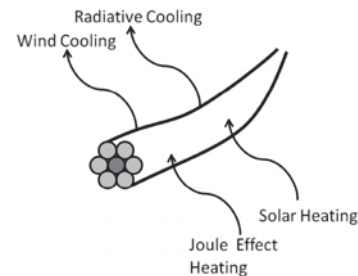


Figure 1 – Heat Balance Equation – Model

## 4. Key Outcomes

Objectives achieved to date include: thorough understanding of the HBE; application of heat transfer theory for thermal modelling; construction and evaluation of models using MATLAB, (ESAA D(b)5, A.S. 7000 and CIGRE working document 207). Identification of the preferred HBE and modelled MATLAB plots of real time data vs steady state data based on the ESAA D(b)5 and A.S. 7000.

## 5. Further Work

An investigation into uprating a sub-transmission/distribution line based upon known real time data, is in progress. To quantify the benefits of uprating, a cost savings analysis is to be undertaken.

## 6. Conclusions

This project has the potential to provide additional confidence to plant rating engineers when it comes to uprating power lines. By conducting weather analysis and monitoring the conductor temperature, this practice could be implemented more frequently.

## Acknowledgements

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

## References

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# Sustainability in construction and management of low volume roads in India

**Subashree M N**



MENS

Supervisors: Supervisors: Dr David thorpe, USQ and Dr Ian craig, USQ

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

## 1. Introduction

Low to medium traffic volumes are roads that have relatively low vehicles per day that is from 400 to 800 and usually with low speed limit of 50kms max in India. We can find these types of roads mostly in rural areas or in few residential areas, the low to medium traffic roads are mostly used by local traffic and very few connecting traffic. The main aim of my project is to bring in a considerable low volume road management plan, which will benefit the people and the local government. The main objective of this plan is spending less money and getting more benefits of it. With the new possible steps and sustainability ideas we can construct the best low to medium traffic volume road with good drainage.

## 2. Background

The low to medium volume traffic roads in the India are mostly found in the outskirts of every district. They are generally used by local traffic that is people who reside by there or the connecting traffic that use those type roads to go somewhere else. The low to medium traffic volume roads are an important factor for any transportation of goods, farm-to-market access roads, roads connecting communities, and roads for logging or mining are significant parts of any transportation system. They are necessary to serve the public in rural areas, to improve the flow of goods and services, to help promote development, public health and education, as well as to aid in land and resource management.

## 2. Methodology

My project mainly focuses on drainage and environmental factors and health issues due to improper Indian drainage systems. Which should be very carefully constructed is the drainage, the drainage system should be of high priority in Indian road construction, as many problems come at later stages. These problems could be avoided when careful consideration is given at the first stage of construction itself. Catch Water Ditch (Intercept Drain) it is a flat-bottomed excavation or ditch located above a cut slope that is designed to intercept, collect and drain away surface runoff water before it goes over the cut slope, to protect the cut slope and roadway from erosion.

## Key Outcomes

Cost friendly and very fast when compared to other drainage construction. The benefits of intercept drain are it is less disruptive; it involves less time in construction, safer when compared to steep excavations. Survey and design time could be saved, as it does not need detailed survey and detailed design. Therefore we can save some cost and money in this.

## Further Work

How researches on different drainages and how it works are still remaining and needs few more research.

## Conclusions

A good pavement design is a very important and useful design for reducing cost and reducing the environmental impacts, it will also help in future research of low to medium traffic volume roads. The trenchless drainage is a sustainable drainage system which is suitable for low to medium traffic volumes.

## Acknowledgements

I would love to thank Dr david Thorpe and Dr ian craig for Their support and dr karunasena also for his support for the Project.

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# A REVIEW OF WARRANTS FOR TRAFFIC BARRIERS IN DIVIDED CARRIAGEWAY MEDIANS

School of Civil Engineering and Surveying



## Lachlan Nash

Bachelor of Engineering  
(Honours) (Civil)

Supervisor: Mr Trevor Drysdale, USQ

**Keywords:** guidelines; contributing factors; median barrier; divided carriageway; dual carriageway; Pacific Highway; benefit/cost ratio; questionnaire; cross-median crashes.

## 1. Introduction

Cross-median crashes on high-speed divided carriageways frequently result in severe injuries and fatalities. Previous studies have mainly focused on contributory factors such as median width and average daily traffic. Some researchers have studied how cross-sectional elements and geometry of the road can influence the frequency of median related head-on crashes. The aim of this project is to review warrants for traffic barriers for suitability on high-speed divided carriageway medians, specifically for the Pacific Highway.

## 2. Background

A lot of existing research relies on crash history. For new alignments, there is no crash history and dealing with a high-speed, high-standard alignment, with the majority of obstacles removed from the clear zone can be challenging. Also, not all the relevant factors may have been considered for a warrant for median crash barrier. This research project will focus on median barrier warrants for two specific sites on the Sapphire to Woolgoolga Pacific Highway Upgrade opened in July 2014. Some road designers consider that a median barrier is warranted at these two locations and some consider it is not warranted.

## 3. Methodology

The study had access to experienced road designers. The assessment method consists of: a questionnaire, comparisons of design and as-built road, risk factor analysis and a benefit/cost analysis.



Figure 1, above, is one of the specific site locations, it has alignment, interchange, and median slope factors, as well as the standard contributing factors.

## 4. Key Outcomes

The study has produced consistent views of factors to take into consideration from experienced independent specialist road designers. These road designers considered the presence of multiple risk factors to compound the overall risk.

## 5. Further Work

To finalise this study, more detail consideration is required of the geometry of the sample sites, risk factors and benefit/cost analysis.

## 6. Conclusions

There are many factors that are currently not considered in determining the warrant for median barriers. Factors such as horizontal alignment and median slope can be considered in addition to standard design factors.

## Acknowledgements

I would like to thank Mr Michael Bulmer, the Pacific Highway Design Manager and also Mr Trevor Drysdale, the USQ supervisor for their assistance.

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# Human Detection using Cascade Classifier and Local Binary Patterns technique

Sponsor – School of Mechanical and Electrical Engineering



Sean O'keeffe  
Bachelor of Engineering (Honours)  
(Electrical/Electronic)

Supervisor: Mr Tobias Low, USQ

**Keywords:** Object detection, Cascade classifier, Local Binary Pattern (LBP)

## 1. Introduction

The use of human detection systems via an image processing system has been implemented in a variety of fields including security, pedestrian recognition systems and sporting environments to name a few.

Various research has been conducted in order to further refine image processing techniques and ultimately create image processing algorithms that are accurate, robust and can operate effectively within a number of environmental elements including varied lighting, camera angles and occlusions that may occur within a real world situation.

The application of this research project is to provide an effective static human detection system by completing image processing techniques of images taken by an autonomous quadcopter with a pre-determined route.

## 2. Background

A cascade classifier system was used to provide trained examples using a tiered level approach in which positive (human within a scene) images are compared and evaluated against negative (image not containing a human) images, resulting in classifier evaluation files being generated.

Local Binary Patterns (LBP) technique was used within the image processing to describe and analyse the local spatial structure of an image. An LBP approach compares the pixel intensities of the centre pixel with its eight surrounding pixels (Ahonen, Hadid & Pietikainen (2006)). This comparison assists in determining any large changes in the image for example the pixel difference between the boundary of a human figure and a grassy field. A major advantage of LBP classifiers is the speed at which they can be trained and acceptable accuracy ranges.

## 3. Methodology

A Raspberry Pi with on board 5 megapixel camera using a sports mode setting was used to acquire 5000 'positive' images of people in various positions, rotations and background environments. Within the images, a region of interest was specified to detail only the person within the image. A further 15,000 'negative' images were created in order to provide the classifier with examples of scenes which did not contain a human.

The C++ algorithm was used with OpenCV libraries in order to train the classifier to provide an effective training samples



**Figure 1.** Example of human detected in scene (image zoom at 50%)

in which a further C++ program was used in order to detect a human within the static scene.

## 4. Key Outcomes

Test results to date indicate a detection rate of 69.50% (sample size of 250 images). In comparison Buljan (2008) using a Haar classifier indicates results of 92% successful detection.

Correct	Incorrect	False Positive	Detection Rate
178	35	37	71.20%

**Table 1.** Detection results to date.

A Haar classifier would further improve my results however due to the computational costs of training the classifier, if time permits I will train a Haar classifier to compare the two.

## 5. Further Work

The remaining tasks required for this project is to further train the classifier to provide an efficient, real time classifier. Further development of my C++/Open CV program is required in order to provide positional information (GPS coordinates) when a person is detected within the scene. The on-board APM flight module and GPS unit will be used to provide this information.

## 6. Conclusions

This project provides evidence that an object detection system can be achieved using a cascade classifier adopting the LBP technique within an autonomous flight device such as a quadcopter. Further work is required to improve accuracy and robustness of the system in order to provide a reliable human detection system for security purposes.

## Acknowledgements

Thank you to Tobias Low, Michael Simpson and family and friends that provided the image samples used in training.

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# Development and Execution of Asset Criticality and Maintenance Framework: A Case Study of Water and Wastewater Infrastructure at Toowoomba Regional Council

Sponsor – Toowoomba Regional Council



**Campbell Olsen**

Bachelor of Engineering Honours (Civil)

Supervisors: Dr Nateque Mahmood, USQ

Mr Phil McEwan, Toowoomba Regional Council

**Keywords:** Asset, Criticality, Infrastructure

## 1. Introduction

Asset criticality is an important tool in the development of asset maintenance and renewal strategies. By identifying critical assets and critical failure modes, organisations can target and refine investigative activities, maintenance plans, and capital expenditure plans at the critical areas (NAMS, 2011, pp. 2-95). This dissertation aims to provide the documented research, methodologies and models required for the Water Infrastructure Services (WIS) Branch at Toowoomba Regional Council (TRC) to perform an asset criticality analysis on its entire asset base.

## 2. Background

The prioritisation of asset maintenance and renewal at TRC is currently performed at the discretion of skilled technicians. Although this approach has proven satisfactory for numerous years, there is no formal methodology to justify these decisions. TRC has recognised the need to implement methodologies to assist technicians to make informed decisions. Criticality and maintenance framework must be developed to ensure funding and resources are invested in assets that will return the greatest benefit to TRC in line with core business values and objectives.

## 3. Methodology

Firstly, major asset groups were extracted from the WIS asset register. Typical failure modes and consequences were analysed for each asset group and a mixture of quantitative and qualitative assessment criteria were developed. Severity scores were assigned to the criteria and weightings were derived using pairwise comparisons. A semi-automated criticality assessment calculator was then developed to enable



**Figure 1 – Burst Water Main (Associated Press, 2014)**

rapid processing of asset data and provide an overall asset criticality ranking.

## 4. Key Outcomes

Criticality assessment criteria have been successfully developed and a draft criticality calculator has been established. There seems to be a correlation between the criticality assessment criteria and TRC's level of asset management maturity. As more detailed asset data becomes available, the assessment criteria tend to shift from purely qualitative to semi-quantitative.

## 5. Further Work

The next step is to identify the extent of the case study and gather data from GIS and various field studies. Once data is obtained, the criticality assessment tool will be applied and the results will be analysed.

## 6. Conclusions

Additional work needs to be conducted before any significant conclusions can be made.

## Acknowledgements

I would like to thank TRC and Mr Phil McEwan for providing me with the opportunity to undertake this project. In addition, I would like to thank Dr Nateque Mahmood for his ongoing support and guidance.

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# Failure analysis of bridges during cyclone Marcia in Queensland



**Pathirana Thilini Nisansala**

Bachelor of Engineering Supervisors:

Dr Weena Lokuge, USQ

Prof. Karu Karunasena, USQ

*Key Words: Bridges, Cyclones, fault Tree Method, Resilience*

## 1. Background

Over the years, North Queensland has experienced numerous natural disasters including severe tropical cyclones which have caused devastating impacts on properties and livelihoods. Cyclones have caused significant damages to road infrastructure such as bridges and culverts which leaves towns isolated for weeks. Understanding the response of these structures against catastrophic winds and storm surge is important to improve their resilience as well as planning the emergency response for existing bridges and culverts in severe weather events. The majority of available literature is only limited to responses of suspension bridges in United States against hurricane forces. This study aims at comprehending the most probable failure mechanism for bridges that were damaged by cyclone Marcia in which will be useful in improving the resilience of future bridges and developing predictive models for emergency planning in cyclonic events.

## 2. Materials and Methods

A case study will be conducted on the bridges that were affected by the cyclone Marcia, and data such as level of damage, specifications (material used in these structures, type of structure), age, annual average daily traffic, heavy vehicles and inspection data (physical condition of the bridge structure) before and after the cyclone will be collected and analyzed (e.g. Overall Structural Condition Index-OSCI) (Rashidi and Gibson 2011).

This case study will further analyzes the failure criteria/ mode of failure of different types of bridges. The relationship between the collected data and the failure of the specific bridge of interest will be analyzed using fault tree method (Setunge et al. 2015).

## 3. Key Outcomes

Inspection data for 90 damaged bridges were collected and inserted into a database. A fault tree was constructed for the most damaged bridges.

## 4. Further Work

Based on the availability of structural specification data of the bridges and culverts a predictive model can be developed to understand their resilience against wind loads and vertical and horizontal forces that would act on the structure in a cyclonic event.

## 5. Conclusion

No conclusion could be drawn up on since the study is still on progress.

## 6. Acknowledgements

I sincerely acknowledge the guidance and support given by my supervisor, Dr. Weena Lokuge (USQ), and Dr. Suntharawadiwel (CQU).

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# Building Information Modelling: An explorative study

School of Civil Engineering and Surveying



## Melanie Patterson

Bachelor of Construction  
(Honours) (Management)

Supervisors: Dr Vasantha Abeysekera, USQ

**Keywords:** BIM, Design & Build

## 1. Introduction

The use of the design and build (D&B) method is an advantageous method of construction due to benefits such as reduced construction timeframes and improved coordination. D&B projects however are not without their challenges for the contractor, such as increased financial risks, responsibility for all design and potential delays if the design and construction phases are overlapped too far.

## 2. Background

Building information modelling (BIM) is not a new phenomenon. A key advantage to the use of the BIM 3D model is the ability for the model to be used as an object database which includes specific information for each element in the building.

The use of 4D BIM (Time) technologies on projects enables the project team to utilise the 3D BIM model in conjunction with the project schedule, in order to optimise and refine the schedule. The schedule can be visualised through a simulation of the construction sequence while still in the design phase improving the constructability review process.

5D BIM (Cost) technologies allow the 3D BIM model and 4D BIM to be used in the estimating and cost review of a project. A key advantage to the use of 5D BIM is that costs for the project are able to be reviewed in a significantly shorter timeframe.

A number of research studies have been undertaken on the benefits of the use of 4D and 5D BIM technologies on construction projects; however no significant research has been completed on the use of 4D and 5D BIM technologies on medium scale D&B projects.

## 3. Methodology

A survey was undertaken with industry colleagues in order to augment the concerns identified in the literature review. A historical case study on a completed D&B project was undertaken to identify specific problems encountered during the project.

A pilot case study was completed using BIM technologies Autodesk Revit, Autodesk Navisworks Manage and Exactal CostX. The aim of the case study was to understand the technologies prior to implementing the software on a larger project. The BIM technologies are then applied to a D&B project to resolve the value in overcoming problems encountered.

## 4. Key Outcomes

The pilot case study identified an advantage in using 5D BIM tools to produce estimates from the BIM model. The use of Autodesk Navisworks, enabled the project schedule to be sequenced, however due to the simple design model the advantages were not as obvious as the 5D tools.

## 5. Further Work

The results of the final case study in to the use of 4D and 5D BIM tools on a D&B project is still underway. The results of the case study must still be analysed to determine the value of utilising these technologies.

## 6. Conclusions

The final results of the research project are not yet complete. The study has identified that there are advantages to the adoption of 4D and 5D BIM tools on construction projects.

## Acknowledgements

My supervisor, Dr Vasantha Abeysekera, for his guidance and support throughout the project.

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# An evaluation of traffic calming devices for major highways passing through rural Australian Communities

Roads and Maritime Service



**Gregory Paul**

Bachelor of Engineering (Civil)

Supervisors: Dr Soma Somasundaraswaran ,  
USQ

**Keywords:** Traffic Calming, Safety, Effectiveness

## 1. Introduction

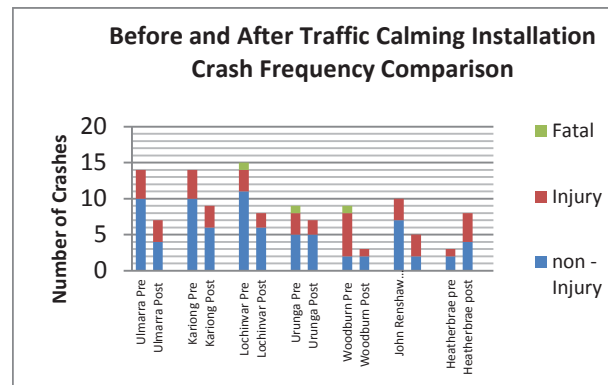
Traffic calming is any engineering measure to help mediate driver behaviour. In the last decade vast technological advancements have been made in the engineering field to moderate driver behaviour. However, these engineering features have not been tested for efficiency and effectiveness in Australia. This research project aims to ascertain whether these low cost solutions offer viable safety benefits to warrant their inclusion in the Australian road network.

## 2. Background

Rural townships are overrepresented in the Australian crash statistics. This can be attributed to many factors predominantly fatigue and speed. This project is important as it analyses low cost engineering solutions to help improve driver safety through rural towns. Much work has occurred overseas to study the effectiveness of traffic calming but little in the Australian Road environment.

## 3. Methodology

The methodology was planned in a two phase system. The first involved an analysis of the before and after crash data at sites of known traffic calming devices. This enables a fair indication of the improvements to safety after installation. The second involved an analysis of traffic speeds over a length before and after the traffic calming device through rural communities. This was completed by recording driver speed at regular intervals and plotting these over time. This showed the relationships of drivers as they passed through traffic calming devices.



## 4. Key Outcomes

The before and after crash analysis shows that fatigue has the most prominent reoccurrence in the crashes involved throughout rural communities. The speed analysis showed that whilst speeding is not the overarching problem driver behaviour can be improved through low cost engineering means. This will improve road user safety as well as to improve the networks efficiency.

## 5. Further Work

Further work needs to be completed in the analysis of the effectiveness of traffic calming devices and the effect a varying AADT will have on their effectiveness.

## 6. Conclusions

Speed is not a major factor in crashes through rural communities. Instead it appears crashes occur due to a combination of the inability of drivers to recognise variations in driving environment and the influence of fatigue on driver reactions.

Traffic calming has the potential to help mediate driver behaviour and increase driver awareness; this will improve the safety of motorists through rural communities and reduce the number of traffic incidences thus improving the network.

## Acknowledgements

I would like to thank my supervisor Soma as well as my employer the RMS. I would also like to acknowledge the works of Roper (2006) and Hallmark (2011).

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# MANAGEMENT OF LOW TRAFFIC VOLUME ROADS IN THE SCENIC RIM REGIONAL COUNCIL AREA

Sponsor – Scenic Rim Regional Council



**Krystin Peach**

Krystin Peach - BEngHons (Civil)

Supervisors: Dr David Thorpe, USQ

Chris Gray, SRRC

**Keywords:** low volume roads sustainability

## 1. Introduction

Low volume roads play an important role in regional areas, conveying residents to economic centres, employment and school to name but a few. If not maintained to an acceptable service level, the region will suffer financially and socially. As the Scenic Rim Regional Council is a sparsely populated area with a low rate base, providing the necessary funds to maintain this network is an ongoing issue.

## 2. Background

Since early 2011, the area has suffered two declared natural flooding disasters. These have caused Council staff and budget to be diverted from regular scheduled activities with a focus on reconstruction. This work has recently been completed in June 2015 therefore maintenance operations are due to return to regular schedule. This dissertation is a review of the current low volume road situation in the Scenic Rim Regional Council area, with a view to consolidate and build on the current sustainability of the network. This includes a check of all associated documentation and modelling data, a review of current hierarchies and road conditions, and an analysis of long term sustainability.

## 3. Methodology

Inspections were carried out in five diverse geographical areas in the region to ascertain whether the maintenance practices and applied hierarchy were being applied appropriately to provide an appropriate level of service. Current maintenance related documentation was reviewed and future prediction procedures assessed.

## 4. Key Outcomes

The major findings and outcomes from the research are as follows:

1. Practices over the last four years at Scenic Rim Regional Council have been greatly affected by the two declared flood events (2011 and 2013).
2. Council has a comprehensive set of documents in place with regards to inspections, maintenance and management protocols of these roads however the actual success on the implementation of these documents is variable and the documents themselves rarely reviewed.
3. The road classification hierarchy at Scenic Rim Regional Council requires reviewing. Currently, roads with the same hierarchy currently do not always provide a similar level of service.
4. Changes to external factors such as the MUTCD & Austroads impact heavily on the maintenance budget.
5. Historical data collection and data confidence is a major issue with some vital data not being available and other data not being accurately logged.
6. The current level of service currently identified by allocated hierarchy may not be maintainable into the future due to the low rate base and ever increasing costs associated with maintaining such an extensive network.

## 5. Further Work

As a result of the findings from this research, a program to re-assess the hierarchy and service levels of all roads in the region is proposed. To do this, a traffic count on all roads without existing data will be required. This will allow for a more detailed analysis of whether Scenic Rim Regional Council are able to maintain this level of service.

## 6. Conclusions

The conclusion from this research is that extensive follow up work is required to ensure sustainability of the road network into the future. The road network is currently considered. Along with the review of all road hierarchies in the area, the documents which have been developed need to be implemented and monitored. Due to the natural flooding crises this has not been the case in the past four years.

## Acknowledgements

Many thanks to my supervisor, Mr David Thorpe and my fellow staff members, Mr Chris Gray, Mr Justin Shera, Mr Josh Canaris and Mr Rick Hotz who have provided guidance and professional advice throughout this project.

# Feasibility of Improved Traffic Flow on Cohoe Street, Toowoomba by Coordination of Intersection Signals

Sponsor – Department of Transport and Main Roads



**Kelly Pearson**

Bachelor of Engineering (Civil)

Supervisors: Professor Ron Ayers, USQ

**Keywords:** Traffic Modelling, SIDRA Intersection, road network capacity

## 1. Introduction

The increasing population of Australia is placing higher demands on the road network. For many regions road transportation is the only economically viable option for freight and connectivity. It is imperative that the network is maintained to a level that satisfies the needs and expectations of Australian communities. This project aims to investigate and improve traffic flow on Cohoe Street, Toowoomba.

## 2. Background

Toowoomba is located approximately 125 Kilometers West of Brisbane, Australia. Cohoe Street is a section of the Warrego Highway that is a designated Heavy Vehicle Route. Cohoe Street is located within a residential and commercial area and as such has large traffic volumes with a high percentage being Heavy Vehicles.

## 3. Methodology

The Department of Transport and Main Roads conducted detailed traffic counts for each intersection being investigated. These counts provided a breakdown of the traffic composition including both the AM and PM peak hours.

SIDRA models were developed for each intersection using the PM peak volumes as these represent the worst case scenario. A standard two percent compound traffic growth rate along with a 15 year design life were employed for each model.

A range of options will be investigated to determine the optimal solution taking into account not only the functionality of the intersections but the social, safety and environmental implications as well.



Figure 1 – Cohoe Street, Toowoomba

## 4. Key Outcomes

The key outcomes to date are the identification that the intersection of James Street and Cohoe Street will reach a Level of Service D in five years. All movements from the Eastern leg of Herries Street are currently operating at a Level of Service F, although the planned traffic signal installation will potentially improve this result. Tourist Road will be operating at a level of service D in seven years. Subsequently each site will require upgrading/reconfiguring in the near future.

## 5. Further Work

The focus for the final portion of the project will be on optimising and evaluating potential solutions to improve the operational capacity of the road link.

## 6. Conclusions

Results from the analysis have highlighted that within the next five to ten years all of the intersections investigated will reach or exceed the acceptable level of service.

Improving the capacity of the intersections investigated is a complex issue due to the constrained road reserve and traffic composition.

## Acknowledgements

I would like to thank my Supervisor Ron Ayers for his support and guidance throughout the project and my colleagues at the Department of Transport and Main Roads for their continued support.

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# Investigating Electronic Distance Measurement Equipment (EDME) Calibration

Sponsor – Moreton Bay Regional Council



## Rhys Pescod

Bachelor of Spatial Science  
(Surveying)

Supervisor: Dr Glenn Campbell, USQ

**Keywords:** Calibration, Baseline & EDME.

## 1. Introduction

The reliability and accuracy of Electronic Distance Measurement Equipment (EDME), like any equipment, is critical. To determine these factors, EDME is calibrated on government maintained baselines, identifying any existing errors in the instrument so that they may be adjusted.

It is hypothesised that the current design of calibration baselines can be improved upon to better align with the specifications and calibration of modern EDME. Through research and implementation this hypothesis is tested and alternate EDME calibration baseline designs is proposed.

## 2. Background

The Department of Natural Resources and Mines (DNRM) is the authority appointed for the verification of length. DNRM provides and maintains EDME Baselines throughout the state for the purpose of calibrating Surveying equipment. Current baselines are based on addressing three types of error found in all EDME: constant, scale and cyclic errors. If it is established that cyclic error is not required to be addressed in all equipment (more commonly modern EDME), an alternate design may provide more efficient and sustainable baselines, without compromising the accuracy of the calibration process.

## 3. Methodology

The viability and accuracy of an alternate calibration baseline design will be tested by performing a calibration using a currently established calibration baseline followed by a series of three separate reductions. Each consequent reduction will be performed using fewer of the observation baselines.

The resulting three reductions will be compared against the initial calibration to calculate and determine if any inaccuracies or discrepancies exist.

## 4. Key Outcomes

It has been determined through research and reduction processes that cyclic error is non-existent in modern day instruments and therefore not required to be taken into account for baseline design. It is on this basis that the baseline design can focus on addressing the other two errors of scale error and constant error.

## 5. Further Work

It is still to be determined whether using fewer baselines decreases the accuracy of the calibration. Reductions will be compared and conclusions drawn on the basis of that data.

## 6. Conclusions

At this stage in the project it is clear that cyclic error is not a consideration in baseline design for modern day instruments. EDME can be calibrated over baselines with fewer pillars but is yet to be determined the effect it has on the accuracy of the baseline calibration.

## Acknowledgements

I would like to thank my supervisor Dr Glenn Campbell for his guidance and support. Also I would like to acknowledge Gregory Williams and Colin Moorhead for their advice and assistance throughout the course of the project.

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# Investigation into the implementation of renewable energy sources in rural communities

School of Civil Engineering and Surveying



## Joshua Phillips

Bachelor of Engineering  
(Civil)

Supervisors: Dr Steven Goh, USQ  
Dr Ian Craig, USQ

**Keywords:** Renewable energy, feasibility, modelling

### 1. Introduction

The field of renewable energy is undergoing rapid innovation. This project looks at introducing renewables to smaller communities and develops a simplified model to assess the feasibility of different supply scenarios using a time-variable simulation. Suggested scenarios include a decentralised network with some integration of centralised power generation.

### 2. Background

Australia is still at work in implementation of renewables and must investigate methods of implementation to a greater extent. Developing a simple feasibility simulation and framework is of importance for private and public bodies assessing renewable applications by allowing a quick and inexpensive method of assessing future supply options.

### 3. Methodology

A program was written in MATLAB that identifies the key elements of expense in both the supply and demand cycle of electricity generation. Using data attained from third party sources the model simulates the introduction of renewables into a community over  $n$  number of years. See Figure 1 for basic framework design.

### 4. Key Outcomes

The project was able to identify a possible framework for the introduction of renewables into a community. Through the modelling process, it is possible to quickly identify options that are feasible and options that are likely to remain unfeasible. The project identified some scenarios of implementation for a town in South-East Queensland for which decentralisation and reduced grid-dependence was identified as having a positive impact on sustainability and feasibility.

### 5. Further Work

The model currently simulates only in terms of economic feasibility; however, further work is required

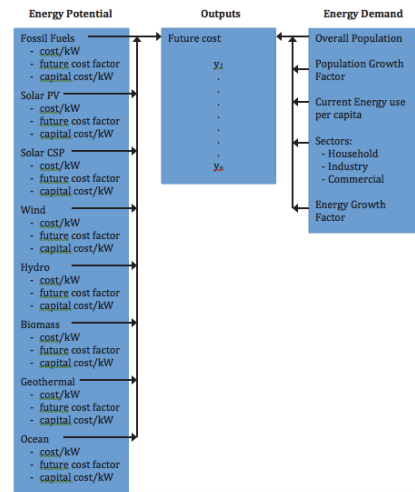


Figure 1 – Basic framework design

to prove the environmental feasibility (emissions reductions) of each option. Addition of a carbon price would be possible with a hybrid of the economic and environmental simulations. Furthermore, the simulation can be improved to provide an optimum model for towns.

### 6. Conclusions

The project provides a quick test to assess the feasibility of renewables into the future. Using a case study, the simulation was proven to be a useful resource for government bodies and companies looking to invest and identifies the value of a full feasibility study.

### Acknowledgements

Thank you to Dr Steven Goh for your encouragement and drive to succeed in this project, as well as your critical insight into developing the model. Thanks also to Dr Ian Craig for your enthusiasm for renewables that contributed to my own passion in this area.

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# Investigation into the Delamination of Composite Laminates on Aircraft Rudders due to Fluid Ingress and Icing.

Sponsor – School of Mechanical and Electrical Engineering



Samuel Pike

Bachelor of Engineering  
(Honours) (Mechanical)

Supervisor: Dr Jayantha Epaarachchi,  
USQ

*Keywords:* Rudder, Composite, Fatigue

## 1. Introduction

This project investigates how fluid ingress and icing causes delaminations into composite aircraft rudder laminates. The use of optical, strain and FBG sensor data were utilised to determine crack propagation of a rudder composite laminates through fatigue loading of a few test samples.

## 2. Background

Since the early 90's the use of composite materials in the aircraft industry has doubled due to the increasing price of oil, increased airline traffic and changing attitudes about the environment. This has led to fibre composites moving from military fighters to civilian airlines. Fibre composite aircraft structure fatigue limits are hard to predict due to the relative short time these structures have been in operation, leading to uncertainty of how fibre composite structure will perform after years of sustained fatigue loading through flight operations.

## 3. Methodology

Utilising FEA modelling, tensile and flexure testing the material properties of a rudder GRFP laminate were determined.

These properties enabled FEA modelling of the rudder laminate. Subsequently, two 12ply fibre composite samples were then made for tensile and 3 point bending tests. Testing was then carried out to determine the amount of crack propagation for a given number of cycles collected from optical, strain and FBG sensor data collection methods.

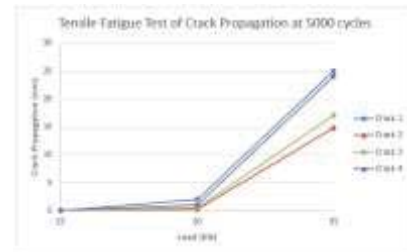


Figure 1: Tensile Fatigue Test of Crack Propagation

## 4. Key outcomes

The accumulated data from the optical, strain and FBG sensor data was compared with the initial FEA models. The results seem to suggest that the ice inside a composite laminate will start cracking the laminate up to 20% earlier than the original material properties.

## 5. Further Work

Further work could look into a finer range of applied loads for tensile and 3 point bending tests of ice infused laminates.

## 6. Conclusions

Fluid ingress through icing does cause a substantial weakening of the composite laminate as a result of the embedded FBG sensor capturing the stress/strain concentrations due to the ice formation.

## Acknowledgements

I would like to acknowledge the love and patience of my wife over the last 5 years of study. A special thank-you to my supervisor Jayantha Epaarachchi and PhD student Ayad Kakei who have been invaluable throughout the duration of this project.

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# Analysing Geotechnical Aspects of Concrete Pipe Culverts

School of Civil Engineering and Surveying



**Simon Porter**

Bachelor of Engineering  
(Honours) (Civil)

Supervisor: Dr Kazem Ghabraie, USQ

**Keywords:** Geotechnical, Culvert, Backfill

## 1. Introduction

Culverts are integral roadway structures that provide a passage for water to move through a road corridor. They also have alternative functions as wildlife and fish passages and potentially pedestrian, cyclist and vehicular access ways. The structures are designed to withstand vehicular and soil loading as well as provide adequate flood resistance and limit the potential ingress of water into the pavement and bedding.

## 2. Background

This project was specifically developed due to the practical benefits of an improved understanding of culvert-soil interactions in industry. It is recognised that there are large potential for failures when constructing subsurface structures that alter the existing ground conditions and are subject to surface loading. In particular pipe construction methods have significant effects on the potential loads and movement of the soil around culvert structures. Therefore, an understanding of design practices and assumptions are necessary to ensure that the design meets the infield construction methods.

## 3. Methodology

The project utilised Finite Element Method (FEM) software in order to assess the effects of changed backfill materials and trench conditions upon culvert loading and the backfill materials response to loading. Research into current understanding around this area was also undertaken in order to analyse and compare the different analysis methods for the soil-structure interaction. This interaction was then another factor that was assessed within the FEM comparison. A summary of the results for the change in deflection across material types and trench depths for linear elastic analysis is shown in Figure 1.

## 4. Key Outcomes

The key findings of this project show that there is little effect upon the structural capacity of the pipe through changing granular material types but deflections can be significantly affected. The case of using aggregate backfill also unexpectedly led to improved structural performance in many cases as well as reduced deflections. The findings for the comparison of analysis methods will be discussed within the report.

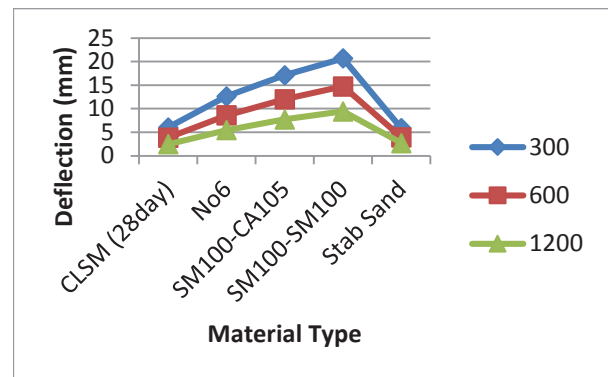


Figure 1: Material Surface Deflections

## 5. Further Work

The work remaining within this project involves continued assessment of different culvert design scenarios and a comparison of FEM analysis results. Current alternative culvert installations are also required to be analysed to determine if the current designs have sufficient safety factors and meet current standards.

## 6. Conclusions

The key outcomes of the project will report on the structural adequacy of varying backfill materials and the key differences across soil models and what this means for current design practices.

## Acknowledgements

I would like to acknowledge the contribution the Roads and Maritime Services which has exposed me to the challenges of culvert construction in the field and developed the idea for this research. The assistance of my supervisor Kazem Ghabraie and the help of colleagues, friends and family throughout my research was also extremely valuable and I thank them for this help.

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# Sustainable Road Development and Management

## David Price

Bachelor of Construction (Honours) (Management)

Supervisors: Dr David Thorpe USQ



**Keywords:** Sustainable, Road Development, Road Management.

### 1. Introduction

Over the years there has been a shift in the construction industry to now give significant importance to sustainable practices and construction. Therefore this dissertation will explore and analyse current management and development utilised in the road industry. With this knowledge gathered it will be desired that sustainability has progressed and adapted to now have a positive influence on the road industry.

### 2. Background

Early investigation into the topic of sustainable road development and management reveals that sustainability is researched to a fairly great extent; however it is often neglected by organisation for various reasons such as cost, time and quality presumptions.

### 3. Methodology

The methodology that was employed to analyse the current sustainable road development and management practices was to conduct two site tours on roads currently being construction in the south east Queensland. I received qualitative results which will allow me to analyse sustainable practices often used in the road industry. The final site tour will be selected by evaluating the sustainable practices being employed which aims to reveal that sustainable management and development practices can often have a benefit outcome on the project.

### 4. Key Outcomes

The key outcomes for this project are to analyse and evaluate three road projects and to critically review their sustainable practices and how it affected their project. This is currently being achieved as two of the three site tours reveals certain sustainable practices have influenced the project in a positive manner. This is an interesting point as it common misconception that sustainability is expensive and time consuming.

### 5. Further Work

The tasks remaining for me to complete this dissertation is conducting my final site tour and determining the positive and or negative aspects of sustainability in relation to the final site. If time permits, this dissertation will investigate outside Australia to determine the situation in other countries.

### 6. Conclusions

The key message that can be taken away from this dissertation will be that sustainability can have meaningful impact upon the road industry and should always be on engineers and professionals minds.

### Acknowledgements

I would like to thank Thiess constructions for allowing me to conduct a site tour on their project up in Redcliffe. This was particularly useful as it allowed me to get the required information for this dissertation and revealed important aspects of sustainability. I would also like to thank my supervisor who is continually guiding and shaping my dissertation.

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# An Investigative Study of Road Construction Contract Variations

Sponsor – Qld Dept. of Transport and Main Roads (TMR)



**Alan Purvis**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr David Thorpe, USQ

**Keywords:** Construction Contracts, Variations, Scope Changes.

## 1. Introduction

TMR have a tight target on construction cost over-runs of 5% however anecdotal evidence suggests the average cost over-run is closer to 20%. Therefore the better understanding of a project prior to contract award will result in a more accurate design and cost estimates avoiding costly variations to the contract and ultimately meeting the target cost over-run limit.

## 2. Background

The aim of this research project is to assist with that understanding and to provide recommendations to minimise the likelihood of a particular type of variation occurring in the future.

## 3. Methodology

This research project specifically examines Road Construction Contracts (RCC) and entails a state wide quantitative analysis into current and recent RCCs. A literature review examines previous research into the root causes of road construction variations. Historical variation data has been collected from the sample contracts and reasons why variations commonly arise established.

A survey of project delivery practitioners has also been undertaken to assess the level of understanding of the root causes of RCC variations among TMR personnel.

## 4. Key Outcomes

From the 111 contracts sampled there were 529 variations in total which combined with the survey results provide the research outcomes.

An example is that that on average all contracts sampled had a variation ratio of 24.2% of the original contract value. Another revealing statistic is that contracts with original values less than \$10M had an average variation

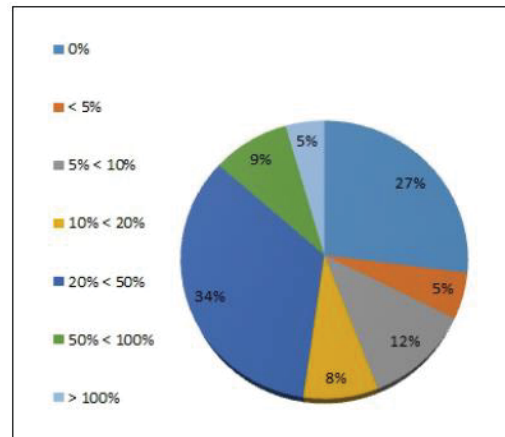


Figure 1 - Frequency of Differing Levels of Variation Ratios

ratio greater than the all contracts average and those contracts with original values greater than \$10M had variation ratio less than the all contracts average.

## 5. Further Work

Further work is required to consider the implications of the variations for future improvement of estimating and delivery of RCCs.

## 6. Conclusions

This research project provides a better understanding of the root causes of RCC variations and offers recommendations to minimise the likelihood of these variations occurring in the future.

## Acknowledgements

I would like to acknowledge the support I have received from TMR and my USQ supervisor Dr David Thorpe for the assistance and direction required to complete this project.

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# Modelling and analysis of multi-junction photovoltaic cells for conversion efficiency improvement

School of Mechanical and Electrical Engineering



**Xueyu Qi**

Master of Engineering Science

(Electrical/Electronic)

Supervisors: Dr Narottam Das, USQ

**Keywords:** Multi-junction solar cell, double diode model, MPPT, GaAs, Matlab/Simulink, conversion efficiency

## 1. Introduction

This project objects to model and analyse multi-junction photovoltaic cells to improve conversion efficiency of GaAs type solar panel. Matlab/Simulink tool is used to simulate models of solar cell. From the simulation results, it was found that the double diode model is more accurate than the single diode model. Hence, the double diode model is used to simulate multi-junction solar cells. And multi-junction solar cell (MJSC) is investigated to obtain its maximum performance compare to the conventional silicon solar cell. MATLAB/Simulink modelled results show that MJSC cell can provide almost triple maximum power compared to silicon solar cells. Maximum power point tracker (MPPT) has also been performed to improve the conversion efficiency of the PV systems. The MPPT is able to assist the PV cells to attain more power efficiently and deliver electricity to the grid. Consequently, MJSC power generation increases considerably and the conversion efficiency increases of the PV systems.

## 2. Background

Solar cell is a popular sustainable energy generator that is able to convert the sun-light as renewable energy into DC current. With the assistance of solar cell, there is a high possibility of decrement in demand on fossil fuels as energy sources. However, the performance of silicon solar cells these days are still far from the satisfaction. In recent years, new tandem solar cell is widely used in high technique applications such as

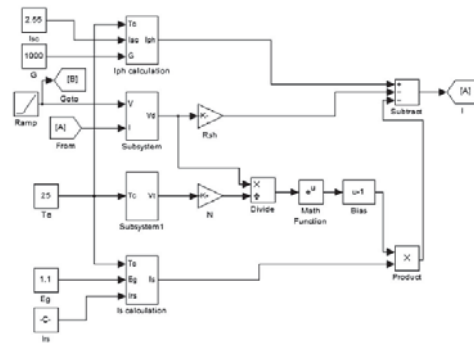


Figure 1 – Simulation of triple lays MJSC in Simulink

satellite and aircraft because of its higher conversion efficiency. It is expected to be the best device for converting solar energy into electricity.

## 3. Methodology

In the modelling, Matlab/Simulink helps to setup double diode model of MJSC and compares it to single diode model in theory. By analysis of the conversion efficiency, MPPT method is used to seek an optimum in adjustment of factors affecting solar cell.

## 4. Key Outcomes

Double diode model is considered as a better simulation of real condition of solar cell. And MJSC has been approved to be improved by adjustment of affected factors such as junction materials, fabrication and working temperature. Apparently, MJSC could be operated in an optimistic high conversion efficiency.

## 5. Further Work

In next steps, optimization of thermoelectric generator will be designed by basing on the previous results of tandem cells.

## 6. Conclusions

MJSC will be the bright future in the renewable energy industry.

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# Controller Area Network Bus to Modbus Network Bridge

School of Mechanical and Electrical Engineering/Gas Detection Australia Pty Ltd



## Matthew Quinton

Bachelor of Engineering  
(Honours) (Electrical and  
Electronic Engineering)

Supervisors: Mr Mark Phythian, USQ  
Mr James Boucher & Mr Chris  
Kelly, Gas Detection Australia

**Keywords:** CAN, Modbus, network bridge, BMS

## 1. Introduction

Controller Area Network (CAN) bus and Modbus are two common network protocols with several differences and it is not possible to directly interface devices using them together. The aim of this project is to design a bridge to allow existing or new CAN and Modbus devices to communicate with each other. The bridge handles the data exchange accounting for the key protocol differences such as speed and packet composition.

## 2. Background

Gas Detection Australia (GDA) design and manufacture gas detection products that are sometimes required to interface with Building Management Systems (BMS). Some BMS utilise the CAN protocol for low level communications devices. Current GDA products do not support CAN but some operate a Modbus ASCII interface. Network bridges are not a new concept but to the writer's knowledge, none of the existing research or products meets the requirements of GDA.

## 3. Methodology

A literature review was conducted to examine research previously conducted on this topic. Existing commercial products were also considered. From here a logical overview of the bridge was developed and can be seen in Figure 1.

The bridge required both hardware and software design. Hardware was addressed and developed as one circuit. The software was designed using data flow diagrams and flow charts to trace out the flow of data

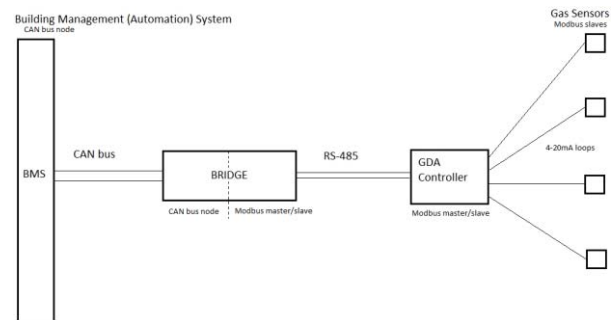


Figure 1 – Bridge logical overview

and the structure of the code. Coding was completed using the 'C' language.

## 4. Key Outcomes

The key outcome of this project was to reconcile the differences of the two protocols. Using the data flow diagrams I was able to trace out the logical flow of data through both network interfaces. At the time of writing, development of the software for this process was not complete but is anticipated in the near future.

## 5. Further Work

The major aspects remaining including finalising the software implementation including the use of hardware interrupts to ensure incoming data is not lost during microprocessor execution. Beyond that, documentation for the bridge is to be produced.

## 6. Conclusions

The key conclusion is that the concept is feasible and while not complete, it is expected that the bridge will fulfil the requirements of the specification.

## Acknowledgements

I would like to thank Mr Mark Boucher, Gas Detection Australia, in particular James Boucher and Chris Kelly for their time and expertise on this project.

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# Sustainable construction waste management in building environment

Sponsor – School of Civil Engineering and Surveying

## Abdolsaheb (Ebi) Rahimi

Master of Engineering Science (Civil)



Supervisor: Dr David Thorpe, USQ

**Keywords:** Sustainability, Management, and Construction Waste

### 1. Introduction

The construction industry is one of the main industries in the world, which is growing rapidly. The industry generates employment opportunities and economic growth through creating foreign and local investment opportunities (M. Agung, 2009). In spite of these contributions in nations economic, it has some drawbacks such as environmental pollution and degradation (Johnson & David, 2008). This research aims to find out the main sources and factors which cause construction waste, the cost of these wastes, how to minimize them, and evaluate the environmental impacts.

### 2. Background

Construction waste is one of the single largest waste stream which is estimated approximately 50 percent of all materials used worldwide. Construction is a vital connection to infrastructure and growth of industry all around the world. Building roads, bridges, housing and other constructed facilities play an important role in shaping society's future. A large number of building materials and components use large amounts of non renewable sources of energy, as well as resources that are in danger of depletion, such as timber, sand, and crushed stone (Bossink & Brouwers, 1996)

### 3. Methodology

Considering the timeline and the other limitations of the project, complex method of open-end method and closed-end method has been used to design the questionnaire. Therefore multiple choice questionnaire has been designed in order to which can be simply filled within thirty minutes, to ascertain the extent of construction waste. There are two kinds questions in

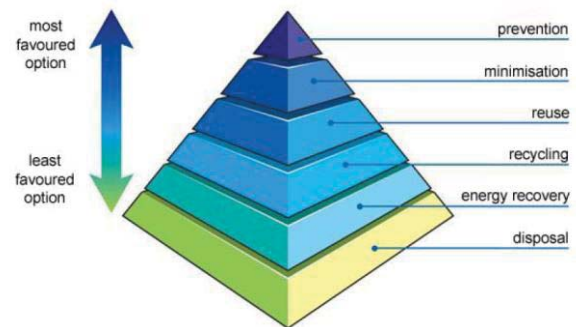


Figure 1 – Waste Hierarchy (Price & Joseph, 2000)

which participants can express their opinions regarding the other factors leading to construction wastes.

### 4. Key Outcomes

The propose of this study is to raise awareness for construction companies and contractors to find some critical factors that contribute to produce construction waste and leads to increase the costs of projects. Identifying these factors can assist the firms to minimize their waste and reduce construction costs and environmental impacts as well.

### 5. Further Work

After getting Ethic Committee Approval I need to collect the data, analyse them and draw conclusion and recommendations. Regardless of the delay, I am confident that I will finish all the remaining tasks by the time.

### 6. Conclusions

The conclusion would be identifying some key factors leading to construction wastes, which can be prevented. By doing so, costs, environmental drawback and waste of time and energy in construction sites can be reduced.

### Acknowledgements

I would like to thank to my supervisor Dr David Thorpe who have been kind and supportive from first stages of my research project.

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# How to Mitigate the Effects of Scour on Bridge Piers Through the Use of Combined Countermeasures

School of Civil Engineering and Surveying



**Andrew Raleigh**

Bachelor of Engineering (Civil)

Supervisors: Dr Joseph Foley, USQ

## *Countermeasures to mitigate scour around bridge piers*

### 1. Introduction

Bridges have been built for a millennium providing an essential link for transportation. Bridge failures due to scour particularly during flood events have caused major destruction resulting in financial hardship and emotional despair. Scour is the removal of existing sediment due to a change in velocity of the flow and or restriction in the flow path. This can cause the structural integrity of the bridge pier to be undermined resulting in bridge failure. This research project aims to show the reduction of scour around bridge piers through the use of effective and combined countermeasures.

### 2. Background

This research is of vital importance to ensure the safety of bridges, especially during flood events, when this infrastructure may provide the main route for evacuation. Events such as bridge failure have a huge economic and personal impact on both the community and government. The latest research suggests the use of combined countermeasures as a cost effective mechanism to reduce the effects of scour around bridge piers. This project will further expand knowledge around the effectiveness of combined countermeasures in comparison to the performance of a bridge pier without any countermeasure. Research shows the use of combined countermeasures generally saw a higher efficiency in the reduction of scour and therefore improved longevity of the bridge.

### 3. Methodology

Three models of bridge piers were built, the first a control model, then two more featuring different combined countermeasures. One countermeasure employs three collars, the other uses a plate attached to the pier. These models were placed individually into the large ag flume at the University's Toowoomba Campus and using a FARO Scan Station the volume of scour was measured for each one. The volume of scour will then be compared against the control model to understand if any reduction in scour was achieved. The tests will be completed keeping the height and velocity of the water at a constant. Control tests conducted to date showed the effect of scour after only 15 mins of water running at a steady flow. Figure 1 above shows how quickly scour can occur if a pier is not protected.



### 4. Key Outcomes

Theoretical analysis showed that combined countermeasures in the optimum configuration are more effective than a single countermeasure in the reduction of scour. Results are not yet finalised to determine the effectiveness of the chosen combined countermeasures.

### 5. Further Work

The countermeasures are currently being tested. These results will then be modelled in FARO Scene showing their efficiency in the reduction of scour. Testing could be completed at varying heights and velocities to provide more in depth analysis of the scour process and different bedding materials could be modelled.

### 6. Conclusions

Conclusions are yet to be drawn but from the literature review it is apparent that combined countermeasures can be very effective. Proving which countermeasures are the most effective both in the initial cost of construction and the ongoing maintenance varies according to the type of river bed, size of the river, velocity and depth of the channel. The use of engineering technology and research can provide innovative and safer structures for use in the modern world.

### Acknowledgements

I would like to sincerely thank Dr Joseph Foley of the National Centre for Engineering in Agriculture for his guidance and leadership. Thanks also to Daniel Eising for his assistance and Chris Power from the Faculty of Health, Engineering and Sciences.

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# A detailed study on the effective use of different size bolts on the telecommunication tower designs

Sponsor – Crown Castle, Australia



**Vipinraj Ramadasan**

Bachelor of Engineering (Honours)  
(Mechatronic)

Supervisors: **Mr. Chris Snook**, USQ

**Mr Faribrooz Niknam**, CCA

**Keywords:** Telecommunication Towers, Structural designs, Fasteners.

## 1. Introduction

The design of towers used in telecommunication networks requires constant upgrade to keep up with the rapidly changing technology and the customer requirements. This research will be based on a study on the effectiveness of using different size fasteners in the design of Telecommunication Towers.

## 2. Background

The structural members of typical towers are fastened using bolts. Some of the existing designs have combined use of variable size diameter bolts connecting these members. But the effectiveness of using different sizes of bolts together is not very evident. The motivation was to study the capability of the existing structure in details and confirm the theoretical capabilities with laboratory tests. Please see Figure-1 for typical tower design.

## 3. Methodology

A literature review was done to understand the structure in detail. To analyse the theoretical calculations with the actual performance of the bolts, a series of laboratory test was carried out. The test would be further analysed by Finite Element Analysis (FEA).

## 4. Key Outcomes

A uniaxial load testing to determine the load bearing capacity of the fasteners was carried out. 3D modelling and FEA analysis of the fasteners and the structural members was done to compare the theoretical and tested results. The findings are expected to provide documentary support for the existing and future designs.



**Figure- 1: Typical arrangement of bolts on towers**

## 5. Further Work

There is a scope for further tests to analysis the different components of the telecommunication towers. The fasteners' test may be further developed by varying the sizes and distance between them and formulate a general equation relating to the load bearing capability, the difference in fastener sizes and distance between the fasteners in Engineering designs.

## 6. Conclusions

The project was approved by Crown Castle and the resource requirement for the laboratory test was identified at University of Technology, Sydney. The specimens for the laboratory test were designed and fabricated. The tests were carried out at UTS. 3D modelling and FEA analysis of the test specimens was done to compare and analyse the results of the test. This project has given a deeper insight into reliability on fasteners in Engineering designs.

## Acknowledgements

I would like to thank Mr. Faribrooz Niknam, Senior Structural Engineer, Crown Castle and Mr. Chris Snook, Lecturer and Discipline Group Leader, USQ for their support and guidance throughout this project.

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## An Investigation of Aluminium (Nano)/Fibre/Epoxy Hybrid Composite System

Sponsor – School of Mechanical and Electrical Engineering



**NAME:** DEEPAK VENKATESH NANJAPPAN RAMANUJAM

### **SUPERVISORS:**

Dr. Jayantha Epaarachchi  
Senior Lecturer (Mechanical Engineering)

**Keywords:** Composite, Hybrid Composites, Properties, Nano-Powders

### **1. Introduction**

Glass fibre reinforced polymer (GFRP) composites are widely used in automotive and aerospace industries because of its light weight, good wear resisting property and for its low cost. The aim of this project is to investigate the mechanical properties such as tensile strength, flexural strength, impact strength, hardness and electrical conductivity of the E-glass fibre reinforced epoxy composites with filler materials. The filler materials play a vital role in composites, so it has to be selected carefully to achieve required mechanical and other properties of the composite. Aluminum is a lighter material and has comparatively good mechanical properties. This project is proposed to investigate the behaviour of aluminium Nano powders (filler material) in E-glass fibre reinforced epoxy composites through laboratory sample testing.

### **2. Background:**

Glass fibers reinforced in polymers have received considerable attention during the last century. Studies conducted during the last decade reveal that adding small amounts of foreign particles (like clay or silica) of Nano size significantly improves the engineering properties of the polymers. Glass fiber reinforced plastic (GFRP) composite material was developed to meet the requirements of the industry for high strength materials with low weight. The advantages of GFRP material include savings in weight, improvement in strength and decreased cost of material and fabrication. The uniform dispersion of Nano fillers in the polymer matrices is a general prerequisite for achieving desired mechanical and physical characteristics

### **3. Methodology:**

Initially, test samples were fabricated with neat resin and the fillers (aluminium Nano powder) to see the behavior of the aluminium Nano powder by testing its mechanical properties and electrical conductivity. Research was conducted into the different chemicals that were to be used and inductions were organized so that the risks and safety was understood. Once the research into the chemicals was completed the amount of epoxy, hardener, and aluminium Nano powders were calculated. Specimens with 0.5% of aluminium Nano powders were fabricated as follows. The epoxy resin was poured in a plastic container which weighed 164 grams. The proportion of epoxy and hardener is 1:4 ratio, so 41 grams of hardener was kept in another container. 0.5% of aluminium Nano powder was calculated with the total weight of epoxy and the hardener, which is 10.25 grams. The aluminium Nano powders were added slowly in smaller amounts to the resin and stirred simultaneously in the container. The mixture was mixed in the container for 15 mins and then the hardener was added and mixed for couple of minutes and the mixture was transferred to a mechanical blender and was mixed thoroughly for 10 minutes. Now the mixture is poured into the tensile and the flexural molds. The air bubbles were removed using a needle and was allowed to cure for 3 days at room temperature. The test specimens were post cured in the oven for four hours at 60 degrees. Then the specimens are removed from the molds. My project is so far at this stage. The fabricated specimens will undergo tensile, flexural, impact, hardness and electrical conductivity and will be compared with the predetermined results of neat resin.



Figure1: Tensile mold

The test specimens were post cured in the oven for four hours at 60 degrees. Then the specimens are removed from the molds.

My project is so far at this stage. The fabricated specimens will undergo tensile, flexural, impact, hardness and electrical conductivity and will be compared with the predetermined results of neat resin. The GFRP hybrid composites will be manufactured by hand layup method with 3 layers of GFWM; consisting of bottom, intermediate and top layers of GFWM. Initially a releasing agent will be spread over a flat mold to enable easy removal of the manufactured GFRP. Above this releasing agent layer, a thin layer of the Nano AIO<sub>2</sub> mixed epoxy resin will be applied. Reinforcement in the form of GFWM cut as per the mold size will be then placed at the surface of mold. The Nano AIO<sub>2</sub> mixed epoxy resin will be then poured onto the surface of GFWM already placed in the mold and it is uniformly spread with the help of a brush. A roller will be moved with a mild pressure on the GFWM-Nano AIO<sub>2</sub> mixed epoxy resin layer to remove any air trapped. Again a thin layer of Nano AIO<sub>2</sub> mixed epoxy resin will be applied. The next layer of GFWM will be then placed above. The process is repeated for each layer of Nano AIO<sub>2</sub> mixed epoxy resin and GFWM, till the three layers of GFWM are stacked. Finally a thin layer of the Nano AIO<sub>2</sub> mixed epoxy resin will be applied. A weight will be placed over the manufactured GFRP specimen and the entire setup is left for 24 hours. Thus GFRP specimens with three different Nano AIO<sub>2</sub> particles filler proportions will be manufactured separately. The fabricated specimens will undergo tensile, flexural, impact, hardness and electrical conductivity using the material testing system as per ASTM standards and will be compared with the predetermined results of glass fiber reinforced polymer

### **4. Key Outcomes:**

The specimens were fabricated without fibres using moulds to test the behaviour of the aluminium Nano fillers. The specimens will be tested and be compared with the neat resin.

### **5. Further Work:**

Upon the completion of this project, further background research, testing would be required to validate the use of an alternate material in order to ensure the practicability and durability of the material.

### **6. Conclusions:**

The fabricated material will be tested as per the international standards and will be compared to the predetermined results of the glass fibre reinforced epoxy composites. Depending on the results of the hybrid composite, the material can be assigned for appropriate applications.

### **7. Acknowledgements:**

This project was carried out under the principal supervision of Dr. Jayantha Epaarachchi Senior Lecturer (Mechanical Engineering) at University of Southern Queensland, also my supervisor who provided me a great amount of assistance and support to ensure I successfully complete the project.

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# System Design of a Hydrogen Induction System as a Retrofit Item Compatible with Existing Internal Combustion Engines.



**Kieran Richardson**

Bachelor of Engineering (Honours)  
(Mechanical)

School of Mechanical and Electrical Engineering

Supervisors: Dr Ray Malpress, USQ

**Keywords:** Hydrogen, Internal Combustion, mechanical

## 1. Introduction

This research project aims to investigate the feasibility of converting internal combustion engines to run on hydrogen gas, with minimal modification to the existing platform. A concept was developed to suit the conversion of a LPG/petrol dual fuel Holden 5.0L to operate as a petrol/hydrogen hybrid. Numerical modelling using MATLAB has been used to establish the mechanical performance of the concept compared to petrol and LPG vehicles. A trade study was undertaken to develop the concept and validate against design criteria.

## 2. Background

In a post hydrocarbon economy, renewable transport will be the norm. However, time is required to develop these technologies and the associated infrastructure. The use of existing internal combustion technology with a renewable fuel resource provides short term emission reduction opportunities as a bridging technology until other technology becomes prevalent. The Mazda RX-8 Hydrogen RE and BMW Hydrogen 7 exemplify the state of the art hydrogen internal combustion vehicles currently. This project builds and extends on the knowledge gained from design of machine elements, computational mechanics in design, system design and energy technology courses undertaken within the mechanical engineering discipline.

## 3. Methodology

The MATLAB model builds on existing work from Ferguson that has previously been transcribed into MATLAB. The model allows the thermodynamic work returned from a combustion cycle to be calculated for various fuel types. The model was adapted to allow the comparison of LPG, petrol and hydrogen combustion performance at various rpm ranges for the case study engine specified. In this way the performance of the fuels relative to one another were obtained and the need for further numerical or finite element analysis was

established (ie; varying compression ratios/altering piston design). A trade study was undertaken to compare a variety of design options against criteria established from a requirements analysis.

## 4. Key Outcomes

Preliminary modelling has yielded results that are comparable to the works of Ferguson and performance predictions/expectations, however testing is not yet complete. An extensive literature review has identified key limitations of the concept in regards to available technology, infrastructure and cost, primarily in concerning hydrogen availability and storage. However, these issues remain largely outside the scope of the project.

## 5. Further work

Manufacture and testing of a prototype is also outside the scope of this project due to a range of limiting factors. This is an area where future work could be performed.

## 6. Conclusions

Testing is still underway, meaning no tangible conclusions can be drawn from the data. The model still requires work to produce all of the desired outputs and thus is too early to comment on the validity of the model or the efficiency of the design.

## Acknowledgements

I would like to thank Ray Malpress, my supervisor, for his highly valued input and guidance with technical and conceptual challenges. I would also like to thank Matthew Richardson, my older brother, who has been very helpful in both guidance and motivation. Both Ray and Matthew have been behind my topic selection and I thank them for their support.

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# Automatic Splint to Prevent Self-Injurious-Behaviour (SIB) in Autistic and Brain Injured People.

Sponsor – Own Project



**Mark Richardson**

Bachelor of Engineering (Honours)  
(Instrumentation and Control Engineering)

Supervisor: Dr Andrew Maxwell, USQ

**Keywords:** Automation, Splint, Self-Injurious Behaviour (SIB).

## 1. Introduction

Self-injurious behaviour is a condition which can affect people with severe autism and brain injury. SIB includes head injuries inflicted by self-punching, which can lead to bleeding, bruising and broken cranial bones (Johnny L. Matson, 2010).

Where treatment of the condition is not successful, it is often necessary to apply mechanical restraints to prevent harm. Once restraints are applied, the wearer's freedom and dignity are removed and simple arm related tasks cannot be completed.

## 2. Background

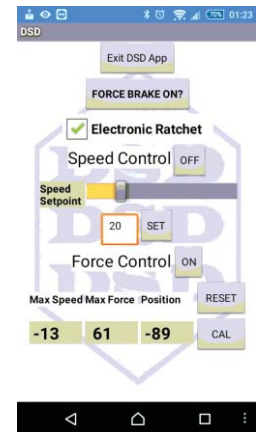
This project addresses the need for a 'smart' splint device. Nothing presently exists which selectively brakes a joint when impact is detected or predicted, but also allows free movement at all other times.

## 3. Methodology

Research was completed to explore existing methods and devices, and to find technologies suitable to incorporate into the Dynamic Splint Device (DSD). The research focused on low cost, easily reproducible parts and open source controllers to allow cheap manufacture. Consultation with an occupational therapist was also sought to help refine the requirements. A solution was then engineered.

## 4. Key Outcomes

A DSD which controls the elbow joint via an electromagnetic brake was developed and workshop tested. Speed and accelerometer sensors were utilised to detect potential impact, and brake the elbow if required. All components are either off the shelf, or printed on a 3D printer. Development of an Android



**Figure 1 – DSD Early Prototype and Android Screenshot**

phone application was also completed to control the device via Bluetooth from a safe distance. The Android application allows adjustment of the speed set-point, calibration of sensors, manual activation, and displays the status of the device. It also records the highest impact force and speed achieved. An electronic ratchet was also developed and incorporated into the DSD to allow the arm to be extended passively to prevent impact from shoulder movements.

## 5. Further Work

The DSD needs to be trialled with people suffering SIB. This will be in conjunction with Occupational Therapists working with the Disabilities Services in Western Australia. Further work will also be required to ensure long term comfort to the users by improving weight, and simplifying the design.

## 6. Conclusions

Once trials on people with SIB are successfully completed, the DSD may eliminate the practice of using standard restraints, and therefore improve the freedom and dignity of many sufferers.

## Acknowledgements

Thankyou friends and family for supporting me during the many hours spent on this project. I would also like to thank my friend and occupational therapist Evan Williams, BHSc (OT) for planting the seed of an idea which will benefit many people with SIB.

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# Use of Biochar Geostructures for Urban Stormwater Water Cleanup



**Giuseppe Rizzo**

Bachelor of Engineering (Civil)

Supervisor: Dr Ian Craig, USQ

**Keywords:** Biochar, Geostructures, Stormwater

## 1. Introduction

Stormwater runoff from urban catchment areas is a leading contributor to water quality pollution which can result in limitations on urban development. Engineering systems used for the treatment of stormwater runoff, use in most cases, non-renewable resources. Biochar or charcoal is a renewable resource and is being investigated as a filtration media for stormwater cleanup.

## 2. Background

Currently engineering systems are available to control the volume of runoff after a storm event from urban catchments and influence the runoff water quality. In these engineered systems the water is not only slowed down, but also, physical, chemical and microbial processes are utilized for the removal of unwanted contaminants. An organic medium being researched for the use of stormwater cleanup is Biochar. Biochar is a form of charcoal produced through the thermochemical conversion of organic materials or biomass. The biomass remaining after pyrolysis is a fine-grained, highly porous material which gives the material large amounts of surface area resulting in a highly adsorbent material.

## 3. Methodology

The use of Biochar for improving stormwater water quality has been growing worldwide with product developers and researchers working to prove, advance science and markets of this emerging material. This thesis has been compiled using research material collated from various sources which provides insight into the use of Biochar geostructures for urban stormwater cleanup. Collectively, the material contained within this thesis represents research already undertaken by other parties; however it will provide information on emerging technologies using biochar.

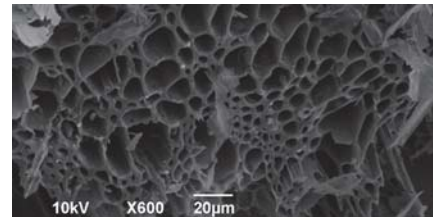


Figure 1 – Biochar Close Up (Source: [www.carbolea.ul.ie](http://www.carbolea.ul.ie) via Biochar Ireland)

## 4. Key Outcomes

Initial trials using biochar as a medium for improving stormwater quality for urban runoff has provided positive results. Additional research is required to determine cost effective, easy maintainable and to monitor performance versus economic considerations for the use of biochar geostructures. Research using enzyme additives to improve biochar performance is emerging.

## 5. Further Work

The next stage is the use of biochar as a medium for different geostructures for urban stormwater water cleanup and record the results of the reduction of heavy metals, herbicides and organics in stormwater.

## 6. Conclusions

The use of Biochar for improving stormwater water quality in urban catchments is in its infancy for practical testing. The different biomass used to create Biochar has an effect on its performance for improving stormwater runoff quality. Research is continuing to evolve to determine whether enzymes can be used to improve the performance of Biochar.

## Acknowledgements

I would like to thank Dr Ian Craig for introducing me to Biochar and for providing guidance and encouragement.

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# Managing field moisture to reduce the soil compaction risk at cotton harvest

Sponsor – Project completed within the NCEA and funded by CRDC



**Stirling Robertson**

Bachelor of Engineering  
(Honours) (Agricultural)

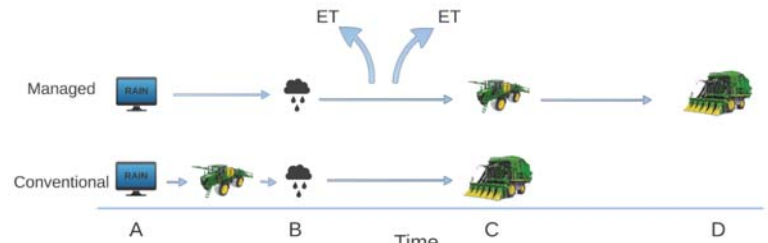


Figure 1: Proposed management strategy versus conventional where time A represents a rainfall event notification, time B represents the time of rainfall event and time C and D represent field operations accordingly. ET represents the soil moisture loss due to evapotranspiration in the proposed strategy.

Supervisors: Dr John McLean Bennett, NCEA, USQ

**Keywords:** Soil compaction, Cotton harvest, moisture management, vertosol.

## 1. Introduction

The 2013/14 and 2014/15 seasons had unseasonal wet finishes in some regions, which caused a tension for farmers in terms of managing pick timing: 1) defoliate prior to rain and risk a wet pick, or 2) defoliate post rain and wait for the field to become trafficable.

This project aims to investigate a novel approach whereby defoliation of the cotton crop is delayed in high-risk weather predictions to allow the crop to dry down soil profiles more rapidly to mitigate potential detrimental compaction effects of harvesting operations.

## 2. Background

Given that more than eighty percent of Australia's cotton crop is picked by the John Deere 7760, the concern for soil compaction has rapidly become a hot topic in the cotton industry since the machine's inception in 2008. Weighing in at more than twice that of the previous basket picker, methods to manage impact on the soil resource are required.

## 3. Methodology

Existing data, and a field experiment located near Aubigny, Qld, were used to investigate the ability for undefoliated cotton plants to dry out the soil moisture profile. The field experiment imposed a defoliant black out via covering adequate green cotton with module tarps during defoliation processes, allowing replicates of defoliated and undefoliated cotton in the same paddock. The proposed management strategy, along with a conventional approach is represented in figure 1 below.

Following the field trials, historical climatic data was used in APSIM in order to develop a modelling exercise that investigated the merit of the approach in managing soil compaction.

## 4. Key Outcomes

This project was developed to provide cotton growers with information that can be used to make viable decisions around the time of field operations to manage soil compaction.

## 5. Further Work

Extending from the work done in this project, further work needs to be completed in order to accurately predict the soil compaction risk under different management strategies and climatic predictions. It is proposed that a model be developed which combines the crop simulation techniques of APSIM and the soil compaction prediction techniques of SoilFlex (Keller et al., 2007).

## 6. Conclusions

Unseasonal rain and cold weather limited the field data, but this was reinforced with existing draw down information. The proposed modelling also provided some guidance on the merit of the suggested approach.

## Acknowledgements

Gratitude must be awarded to my project supervisor, Dr John McLean Bennet for assistance and guidance during the project. A large thank-you must also go out to all of my friends who assisted me during the completion of my field trials.

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# CIRCULAR GEOPOLYMER CONCRETE COLUMNS WITH COMPOSITE REBARS

Sponsor – V-Rod Australia and CEEFC

## Matthew Robertson

Bachelor of Engineering (Honours) (Civil)



Supervisors: Dr Allan Manalo, USQ

**Keywords:** GFRP, Geopolymer, Columns, Behaviour

## 1. Introduction

Reinforced concrete (RC) columns traditionally use Portland cement as a main ingredient for the cement as well as using steel bars for reinforcement. One major problem encountered by RC columns is the corrosion of the reinforcement cages, which results in deterioration of the concrete, loss of serviceability as well as, in extreme cases, failure of the structure. Glass Fibre-Reinforced Polymer reinforcement (GFRP) is a non-corrosive, high strength material that is highly regarded as a possible replacement to steel reinforcement. There is major concern over the amount of  $CO_2$  released by Portland cement during the curing process. Studies have shown that the cement industry is responsible for approximately 6% of  $CO_2$  emissions (McCaffrey, 2002). Geopolymer concrete has been gaining recognition as a suitable replacement to Portland cement as its use minimises carbon dioxide emissions and utilises waste products from industry.

## 2. Background

Although there is a surplus of knowledge on the behaviour of steel reinforced geopolymer concrete, there is no research into the behaviour of geopolymer concrete reinforced with GFRP. Furthermore, there is a large gap into the compressive behaviour of concrete structures reinforced with GFRP bars, which is the main motivation in undertaking this study.

## 3. Methodology

Six circular column specimens of 250mm diameter and 1m height were prepared. Different internal transverse reinforcement types (circular and spiral) and spacing (0, 50, 100, 200) were considered. Geopolymer concrete with a compressive strength of 32MPa was used. The columns were subjected to concentric loading through a 2000kN hydraulic cylinder, as seen below in figure 1. A theoretical analysis was also performed, in order to predict the behaviour of the specimens as well as to compare with the experimental results.



Figure 1. The compression test setup (l) and a tested specimen (r).

## 4. Key Outcomes

When compared to the control specimen, it could be seen that the specimens that were transversally reinforced had an increase in the ultimate load and durability. It has been found that both types of transverse reinforcement is capable of confining a column, however the specimens that were reinforced with spiral ties allowed for a higher strain and compressive deformation. When the spacing of the ties was analysed, it was discovered that a spacing of 100mm resulted in the most strain being placed on the specimen, however the specimens that had a spacing of 50mm were able to withstand higher ultimate loads, when compared to the same type of transverse ties.

## 5. Further Work

This study indicates that GFRP reinforced geopolymer concrete is suitable for use within industry, and therefore the opportunity for further research exists. Recommended work include: the behaviour of rectangular columns, optimal structural configurations as well as geopolymer concrete mixture designs.

## 6. Conclusions

It was observed that despite the behaviour of the specimens being different to what is expected for steel reinforced RC, GFRP reinforced geopolymer concrete has a strength and recorded strain that rivals steel reinforced RC. This is why GFRP reinforced geopolymer concrete is showing a large potential for use within the construction industry as a replacement for steel reinforced Portland cement.

## Acknowledgements

I would like to take this opportunity to thank my supervisor Dr Allan Manalo, for his constant support and guidance throughout this project. I would also like to thank Ghingis Maranan, for his support, along with the CEEFC for the use of their facilities and staff.

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## A study into the behaviour of FRP bolted connections



**Adam Robinson**

Bachelor of Engineering  
(Civil)

Supervisor: Dr Sourish Banerjee

**Keywords:** composite, FRP, connection, joint, FEA, stress

### 1. Introduction

FRP or fibre reinforced polymer has been used in the civil industry since the 1960's mostly in reinforcing or retrofitting. But it has only been in the recent decade that FRP is being used for construction of structures using pultruded sections such as I-beams or hollow sections.

The connection of pultruded sections in structures is critical and often the most important part of the structure. To date only guidelines are given from EUROCOMP (1996) and some pultrusion manufacturers as to recommended geometry for FRP joints with no established standards for connections.

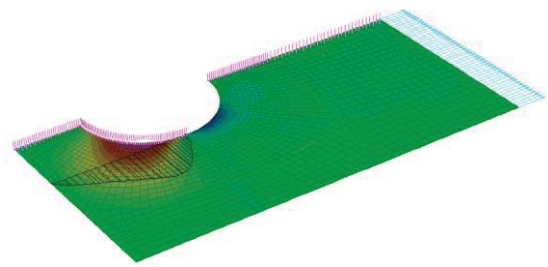
### 2. Background

Previously there has been research into lap-joint failure modes mostly using experimental methods. There has also been research into FEA modelling of connections, particularly Turvey (2007) who has outlined discrepancies with the current EUROCOMP guidelines and recommendations.

This research will focus on the behaviour of single and multi-bolt connections under a tension load using various geometries in order to predict failure modes and the behaviour will be analysed.

### 3. Methodology

The research consisted of both theory and FEA modelling of lap-joints. Theoretical calculations were used to validate the FEA and stress concentrations factors were used to confirm peak stresses on the hole edge. Strand7 was used to model a range of single and multi-bolt lap-joints using a range of geometric parameters suggested by EUROCOMP and previous research. The FEA was confirmed against theory and a study was performed on stress behaviour on critical failure planes. Mottram (2010) and Turvey (2007) was used extensively to compare FEA models and determine analysis schedules. Failure modes such as net-tension, bearing and shear-out (tear-out) are investigated and joint geometry associated with these



**Figure 1 - Shear stress ( $\tau_{xy}$ ) distribution on FRP joint**

failures have been evaluated to determine whether previous research and guidelines are in agreement.

### 4. Key Outcomes

The stress behaviour along the critical failure planes has been investigated and relationships found between various geometric ratios and likely failure modes. Bolt hole edge stress shows movement of shear stress as connections geometry changes and in particular the multi-bolt joint shear stress varies either side of the hole with higher shear and tension on the interior edges of the bolt hole. As a result the research shows good correlation with EUROCOMP and previous research with only the w/d ratio showing difference than that suggested by the guidelines.

### 5. Further Work

Future work could consist of experimental testing in order to determine the strength of connections and joint geometry susceptible to failure and can be used with FEA to compare accuracy.

### 6. Conclusions

The research has shown e/d ratios compare closely to the guidelines however the w/d ratio from the manufacturers and previous research indicated slightly low and the multi-bolt connections showed the same correlation.

### Acknowledgements

Thank you to Dr Sourish Banerjee for his assistance during this research.

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# Machine Vision Calciprill Size Monitoring System

## Sponsor – Omya Australia Pty Ltd



### John Rudge

Bachelor of Engineering  
(Honours) (Electrical/Electronic)

Supervisors: Dr Alison McCarthy, NCEA, USQ

Examiner: Mr Chris Snook, USQ

**Keywords:** Automation, image analysis, real-time processing

### 1. Introduction

Calcium carbonate is widely used as a soil conditioner in agriculture to improve soil pH levels. However, standard calcium tends to compact which requires spreading on the farm using expensive specialised equipment. Omya Australia Pty Ltd recently built a new Granulation Plant located in Bathurst, NSW, that produces prills of calcium carbonate 'Calciprill' that can be spread by a standard super spreader.

Currently the size of the pellets is controlled by an operator within the Granulation Plant visually monitoring the pellets and then manually adjusting control settings. To meet customer and company needs the Granulation Plant must be capable of running unmanned. An automatic measuring system using camera technology and image analysis algorithms would enable the pellet size to be automatically extracted from collected images and control settings to be generated based on the detected pellet size. This research aims to design, implement and test a fully automated, on line particle size measuring system which is non-contact, low maintenance and highly accurate, suitable for use in the Calciprill process.

### 2. Background

Image analysis techniques used for automatic measurement of materials on conveying systems have been the subject of research since the 1980s. In certain processes these systems have replaced the need for mechanical screening hence providing a real time measuring system which is non-contact and low maintenance. In recent times M.Thurley and T.Anderson (2007) developed an online, 3D image analysis system used to measure size distribution of iron ore pellets on a conveying system. The system classifies pellets into sieve size classes between 5 and 16mm and was the first known system to consider specific measuring errors such as the overlapping of particles. The Calciprill size monitoring system also considers these errors and will be the first known measuring system used to control the

prilling process by viewing material on a conveying system.

### 3. Image analysis system and key outcomes

The image analysis system comprises of four main steps. 1). Image acquisition. Before an image can be processed it must first be captured (using suitable hardware and software) with a specific level of detail. The detail level is determined by the application and is critical to ensuring the system can operate as required. For the calciprill size monitoring system a Gocator 312350A imaging system was selected. This imaging system is a 3D camera which has a field of view of 158-365mm, clearance of 300mm and a resolution of 0.30-0.60. 2). Image pre-processing improves the image data by removing unwanted distortion, noise and information. For the calciprill system this step involves identifying all pellets using edge detection algorithms and removing pellets which are partially covered. The removal of partially covered pellets reduces overlapping error. 3). Image Analysis is the process of transforming the raw data in an image into useful information. For the calciprill system this process involves measuring all pellets (which are entirely visible) and determining their size (mm). 4). Image post-processing defines how the information acquired in the previous steps is presented to the end user. Once the pellet sizes have been determined (step 3) the information is tabulated to form a particle size distribution curve (PSD).

### 4. Further Work

The automation infrastructure within the Calciprill Plant has a limited number of input connections to the PLC. A project to increase the number of connections is underway however is not due to be completed before October 2015. Once an input is available the measuring system will be integrated into the plants PLC and used to automatically adjust/control the size of the prill.

### 5. Conclusions

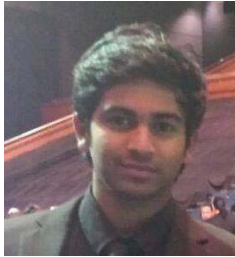
An automated, calciprill size monitoring system has successfully been designed which provides real time feedback and has the potential of being integrated into a PLC system. With further research and algorithm development the system will also be capable of providing weight of particles in each size class. The development of this system will allow the Calciprill Plant to run unmanned increasing the plants efficiencies and can be considered for future calciprill plants.

### Acknowledgements

I would like to take this opportunity to thank Dr Alison McCarthy (Supervisor) for her input and guidance. Omya Australia, in particular Mr David Scott (Former Director of Operations), Mr Neil Tinker (Former Engineering Manager), Mr Rob Tikoft (Director of Operations). Lastly my family in particular my wife Mrs Lauren Rudge.

# Failure Analysis of Total Hip Replacement and the feasibility of Fibre composites as an alternative material

Sponsor – School of Mechanical and Electrical Engineering



**Swapan Sadanala**

Bachelor of Engineering  
Honours (Mechanical)

Supervisor: Dr Steven Goh,  
USQ

**Keywords:** Total hip replacement, failure analysis, material selection, fibre composites.

## 1. Introduction

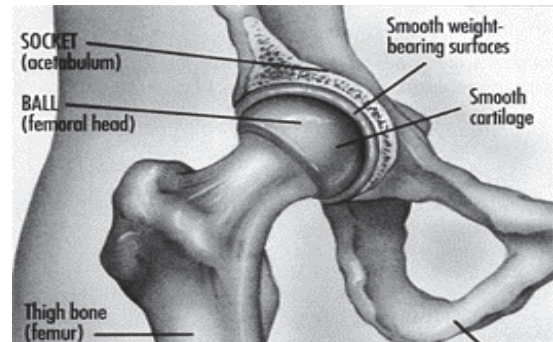
First performed in 1960, total hip replacement (THR) is one of the most successful operations in medicine history. The improvements in joint replacement surgical techniques and technology have tremendously increased the effectiveness of total hip replacement. The primary goal of this project is to investigate the failure of orthopaedic hip implants and the possibility of using fibre reinforced polymer composites as an alternate material based on the performance requirements.

## 2. Background

The hip is one of the largest joints and an essential part of the body. The primary function is to make the legs mobile without reducing the ability to support the weight of human body during both static and dynamic positions. As biomedical engineering continues to advance in the modern age, engineering materials have become more useful despite their other engineering applications. It is evident that the use of these materials is tremendously increasing as the number of medical operations continue to increase every day (AAOS, 2013).

## 3. Methodology

The project initially aims to provide an analysis of the potential causes of failure in Total Hip Replacement (THR) based on an extensive review of literature. Research into the feasibility of using fibre composite as an alternate material used for designing the hip implant and perform a detailed material selection process based on a wide range of selection criteria to identify and compare all the relevant materials. Once the relevant materials were identified, the underlying theory of Finite Element Analysis (FEA) for hip implants was reviewed. A 3D solid model of the hip implant was designed using standard dimensions. The solid model was designed to perform static analysis under normal loading conditions using Creo Simulate. The key outcome of FEA was to obtain results for the hip implant under loading conditions using the relevant materials identified in the material selection process.



**Figure 1 – Total hip replacement (THR)**

The results are then to be studied and analysed in order to justify the materials suggested in the material selection process.

## 4. Key outcomes

In the case of a successful outcome for the project, the use of new material as an alternative option would be justified based on the material selection process and Finite Element Analysis (FEA).

## 5. Further Work

Upon the completion of this project, further background research, testing and waste production would be required to validate the use of an alternate material in order to ensure the practicability and safety of the new implants.

## 6. Conclusions

Throughout the project the different types of implant including their sizes, standards and material properties are to be observed and based on an extensive literature review and finite element analysis, the most suitable prosthesis is to be suggested.

## Acknowledgements

This research project was carried out under the principal supervision of Dr Steven Goh who provided me a great amount of assistance and support to ensure I successfully complete the project.

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# Townhouse Development Using DINCEL Construction System

Sponsor : School of Civil Engineering and Surveying

## Yashar Salehi

Master of Engineering Science (Civil)



Supervisor: Mr Trevor Drysdale

*Keywords:* Development, Dincel, Construction

### 1. Introduction

Land scarcity and population growth are creating a strong demand for urban in-fill development in the major capital cities around the world. According to Queensland treasury, the office of economic and statistical research Queensland's population has been growing quickly and this growth is projected to continue. The medium series projection puts the state's population at approximately 6.6 million people by 2031. By 2056 Queensland's population is projected to be 9.1 million people, double the size of the 2010 estimated resident population. If the housing supply in our major population centres does not keep pace with population growth a housing shortage and an affordability crisis will result. In-fill development also known as urban consolidation is redevelopment within an existing suburb in the form of medium or high density housing. In-fill development addresses both housing supply and affordability. This project is considered as both an implementation and research project.

### 2. Background

This project is very important because it describes how a civil engineer can help the community to overcome the housing problem and also how new technology and new materials such as Dincel can provide a more affordable yet stronger construction system.

### 3. Methodology

The methodology which is employed in this project are 2 software packages (Design it and The SAFE). A series of compression test machineries is also used for the research methodologies of this project.

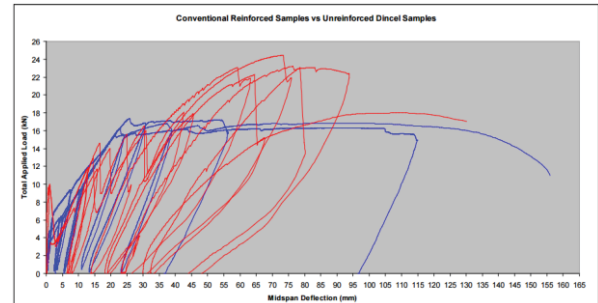


Figure 1 – Total applied load Vs Midspan deflection comparison between Conventional Reinforced Concrete Samples (In blue) and Unreinforced Dincel samples. (In red)

### 4. Key Outcomes

The major outcome of this project is creating a development site which satisfies all the standards with a new construction system called Dincel which is cost effective and unique.

### 5. Further Work

All the main aspects and stages of the development from beginning to the end are introduced and properly discussed. However there are some parts that could be investigated more and described further in detail.

### 6. Conclusions

The key conclusion of this project is completion and delivery of the product (Townhouses) using Dincel and its benefits. The growing need of housing and accommodation is solved and readers can learn how a development is achieved in Australian cities.

### Acknowledgements

I would you like to thank my supervisor Mr Trevor Drysdale who gave me his professional advice and guided me through the whole chapters of this project. I would also like to thank Dincel company with their unconditional support. My dear friend Mr Mark Lieb who was the site manager for this construction site also helped me so much to get a good understanding of how things are done and how to put what I have learnt in to a real practice.

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# Prediction of Timber Bridge Girder Strength and Stiffness Using Stress Wave Analysis.

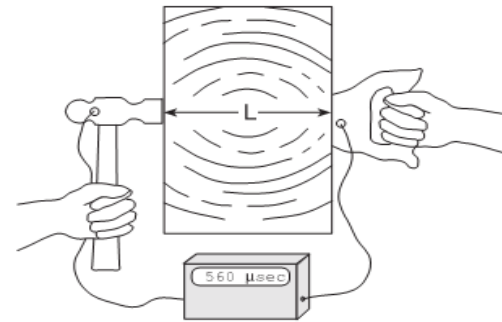
Sponsor –City of Launceston,

School of Civil Engineering and Surveying



**Marcus Salonen**

Bachelor of Engineering (Civil)



**Figure 1 - Schematic of Stress Wave Timer**

Supervisor: Dr Allan Manalo, USQ

**Keywords:** Stress Wave Analysis, Timber Properties, Bridge Structures

## 1. Introduction

This project investigated the use of a new method to measure the remaining strength and stiffness of the existing timber girders from a bridge structure. Stress Wave Timing (SWT), a technology that uses sound wave that travels through the timber and is measured in microseconds shown in Figure 1, was used. This project also investigated the natural properties of timber and the common factors of decay that occur within, and identified the level of decay. Comparison between the measurements from the destructive testing method, finite element analysis Strand 7 and real-life deflection measurements was conducted.

## 2. Background

Currently Australian state and local authorities have many existing timber bridges within their asset portfolio which have been replaced at high costs due to lack of understanding on the property retention of timber. By using a non-destructive technology, a better understanding of the structure and strength properties within the timber and the remaining life can be gained, which is the main focus of this project.

## 3. Methodology

Stress Wave Timing was used to measure the soundness of timber, non-destructively. The structural properties of timber with different levels of simulated decay (by increasing the void within the timber) were then determined by testing up to failure. Simulation of the load and deflection behaviour was implemented using Strand 7 and the results were

compared against the non-destructive and destructive evaluation.

## 4. Key Outcomes

The results showed that SWT can reliably predict the strength and stiffness properties of timber with different levels of decay.

## 5. Further Work

Future studies and works would be to model the bridge structure as a whole frame system to work out the safety load factors using Stress Wave Timing and direct comparison to real life situations.

## 6. Conclusions

The measurements from the Stress Wave Timing can be directly correlated to the remaining strength and stiffness of the existing timber girder. Through this project, a better understanding of the remaining life of timber girder is gained which will be very beneficial for maintenance requirements and inspection routines of timber bridges.

## Acknowledgements

I would like to thank City of Launceston for providing me with the time and resources to achieve the research. I thank my supervisor Dr Allan Manalo for his guidance and my wife Dr Maria Yanotti for her support throughout my studies.

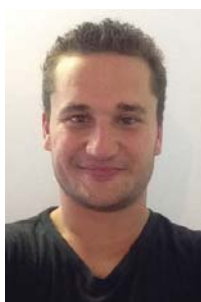
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# Energy Management and Automated Analytics

Sponsor – USQ, HES, School of Mechanical and Electrical Engineering



## Matthew Santarossa

Bachelor of Engineering  
(Electrical/Electronic)

Supervisor: Dr. Narottam Das, USQ

*Keywords:* Awareness, Analytics, Efficiency.

### 1. Introduction

The energy management concept is utilised to provide more information in order to assist energy consumers. It allows these consumers to better understand their electricity consumption in order to reduce their energy costs.

### 2. Background

This project aims to find more innovative and cost efficient methods to deliver the energy management process to engage consumers and reduce their consumption. It will be aimed at lower end consumers who may not consume enough energy to justify investing in a commercialised energy management process.

### 3. Methodology

Based on experimental measurement, energy data was gathered and compiled. The compiled data was then presented in a format that would resonate with the consumer. The analysis phase was vital to the viability of implementing an energy management process. Computer technology was utilised to assist with data analysis. It reduced time and allowed for the potential for scalability. Figure 1 below represents the average daily energy consumption on a monthly basis for the business test site.

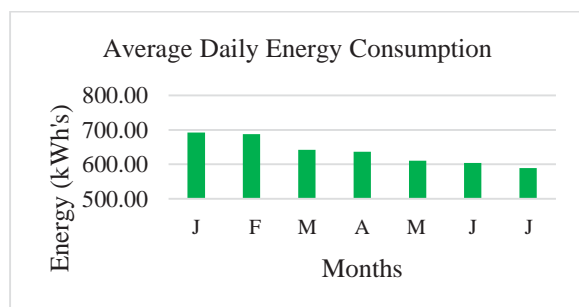


Figure 1 – Average Daily Energy Usage

### 4. Key Outcomes

It became apparent that consumers were more likely to reduce their energy costs if equipped with the correct information. Consumers indicated that they felt more energy conscious from the information they had received than before beginning the energy management process. This leads to more efficient business and household operations as well as long term economic sustainability.

### 5. Further Work

Energy data capturing technology is vastly improving and computer technology has created a dynamic infrastructure to distribute information. This research project can be improved by leveraging from energy capturing devices and tailoring the information for the needs of a standard consumer.

### 6. Conclusions

A standard consumer can save on their energy costs if they are given the correct information. This research project proves the viability of the energy management process and how it can assist a standard energy consumer. It also proves the requirement for more innovative methods to implement the energy management process for the benefits of our society.

### Acknowledgements

I would like to sincerely thank my supervisor Dr. Narottam Das for all of his guidance throughout this project plus the support of my family and friends. I would also like to acknowledge the owners of the test sites for allowing me to use their business and home for the purposes of this project.

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# Flow Measurement Techniques for Large Diameter Low Head Water Pipelines

School of Civil Engineering and Surveying



**Rowan Seccombe**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Joseph Foley, USQ

**Keywords:** Flow metering, large diameter pipes, pressure differential devices

## 1. Introduction

In the advent of the 21<sup>st</sup> century there has been significantly more thought given to the management of water resources in the physical environment. This due to increasing public awareness into water usage and the increased demand on declining water resources. In order to effectively manage this limited resource, effective flow metering devices need to be implemented by the users of the system.

## 2. Background

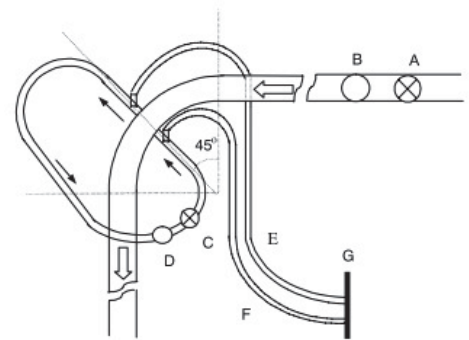
The aim of the research is to investigate methods of measuring flow rate in large diameter, low pressure irrigation pipelines that are economical, practical, accurate and have a low energy lost. There is a need for this investigation as there is a demand in the irrigation industry for a simple effective metering devices that can be readily constructed using tools found in the average farm workshop.

## 3. Methodology

This investigation focused on three techniques of applying pressure differential to meter flow rate. These were the orifice plate meter, the Pitot tube, and the elbow-bypass flow meter. These methods are to be trialled and tested under laboratory conditions to determine if these methods are a viable option to measure irrigation flow.

## 4. Key Outcomes

The flow-meters are assessed based on four main criteria: the cost of the meter both, the practicality of its



**Figure 1: (B. Z. Yuan, 2003)** the drop in pressure it causes and the accuracy of the measurement.

## 5. Further Work

Tasks that still remain is to complete testing of the accuracy of the flow meters which should be completed before the completion of the project.

## 6. Conclusions

The project has concluded so far that the orifice plate flow meter is completely unsuitable for use in large diameter irrigation pipelines due to unacceptable energy loss and limited practicality. The Pitot tube and the elbow are yet to be assessed.

## Acknowledgements

I would like to thank my family, especially my parents and brothers who have supported me constantly. I would also like to thank Dr Joseph Foley for giving me the opportunity to conduct this research. The following sources were invaluable in my research. (Millar, 1996), (B. Z. Yuan, 2003).

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# Project Performance Measures for Civil Construction Projects Associated with Different Procurement Strategies

Sponsor – Gelly Consulting



**Luke Seeney**

Bachelor of Engineering (Civil)

Supervisors: Mr Paul Tilley, USQ

**Keywords:** Procurement, Performance Measurement

## 1. Introduction

This research project investigates performance measures for civil construction projects based on different procurement strategies used in the civil construction industry. The key area of focus is on current performance measures used within the industry, if these are reflective of current industry, practices and procedures, how the industry generally perceives performance measurement, opportunities for the development of new performance measures, whether the industry seeks and encourages innovation and if not, whether this could be achieved through performance measurement.

## 2. Background

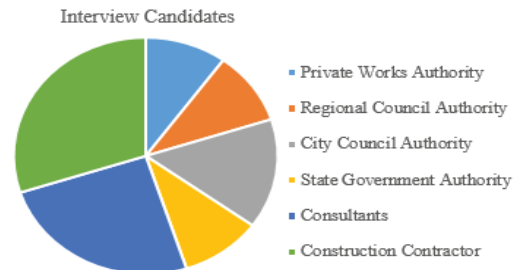
Procurement is a core project element that takes into account the characteristics, risks and circumstances of a project and, through analysis of various options, determines the delivery model and procurement method to be used to deliver the project (Casey and Bamford, 2014).

Casey and Bamford (2014) reveal that the link between the procurement strategy and performance measures comes through the adoption of a price, non-price (qualification based) or combination of the two (value-based procurement) based procurement strategy.

Kagioglou et al. (2001) explains that performance measurement is an integral part of business improvement and that measurement is often seen as the information system at the heart of the performance management process.

## 3. Methodology

This project has utilised semi-structured interviews to engage current industry professionals and gather qualitative data regarding procurement strategies and performance measurement. **Figure 1** shows the breakdown of professionals interviewed, which covers civil construction contractors, private, local and state



**Figure 1 - Sample Diagram**

government works authorities and a number of consultants involved in design and contract administration. This qualitative data has been assessed for common trends and viewpoints related to the research questions.

## 4. Key Outcomes

The research indicates that performance measurement is generally well perceived in the industry but the issue lies in capturing, processing and using this data. The industry does not tend to encourage innovation through performance measurement and due to prescriptive specifications and risk averse government cultures, the industry is stifled when trying to innovate.

## 5. Further Work

Further analysis of data obtained through semi-structured interviews will solidify the findings of this project.

## 6. Conclusions

Procurement strategies and performance measurement has developed significantly over the last 20 years, however there remains issues associated with the measurement of subjective areas of performance and the analysis, storage and use of performance data.

## Acknowledgements

I would like to thank Greg Lerch of Gelly Consulting for his support and assistance, as well as my Supervisor Paul Tilley for his knowledge, guidance and patience as I undertake this project.

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# Update of a calculator for assessing greenhouse gas emissions for agriculture and land management

School of Civil Engineering and Surveying



**Zhiyong Shao**

Master of Engineering Science  
(Environmental)

Supervisors: Prof Guangnan Chen

**Keywords:** Greenhouse gas; Emission; Calculator

## 1. Introduction

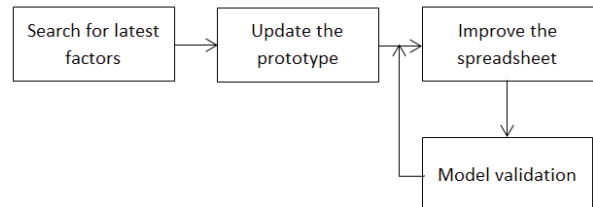
This project aims to develop a reliable and user-friendly greenhouse gas (GHG) emission calculator for Australian farmers and land users. In order to achieve this goal, it is required to further develop the existing calculator prototype, GreenGauge, and update the relevant emission factors. In addition, latest updates should be applied to the actual software based on Microsoft Excel spreadsheet. Besides the calculator itself, a user manual for the final calculator model will also be developed by documenting the emission factors, algorithms and coefficients used in the model. Most of the works included in this project are based on desk-top research and excel programming.

## 2. Background

GHG emission from agriculture and land use account for about 1/4 of the total emission in Australia. However, there are few reliable tools for farmers and land users to estimate and control the emission. The anticipated project outcome is to develop a reliable calculator using the algorithms and emission factors which are approved by Australian Department of the Environment.

## 3. Methodology

This project was started with a literature review of the latest studies about agricultural GHG emissions. Then gaps and scope additions to the prototype calculator have been identified. Reliable algorithms and emission factors are mainly obtained from government standards and reports to enhance reliability. Based on Excel spreadsheets, updates and improvements are being applied.



**Figure 1- Project process diagram**

The updated calculator will be validated by comparing the estimates from the calculator with the results from other existing calculators using similar data input.

## 4. Key Outcomes

A literature review of the latest studies of emissions from agriculture and land management activities has finished. The insufficiencies of GreenGauge model are identified by comparing the methods it used to the latest government reports. The model is currently being converted and updated based on excel spreadsheet. After validating the model, a user manual documenting the emission sources, relevant theoretical algorithms, factors and coefficients referred in GreenGauge will be developed.

## 5. Further Work

The final calculator should be further tested and validated with data measured in the real world.

## 6. Conclusions

The emission factors vary in different seasons and in different areas of the country. For the benefit of developing a user-friendly model, only algorithms and factors for the scenario in Queensland are employed in the model. Theoretically, the model has the potential to estimate emission from other areas by substituting the emission factors.

## Acknowledgements

At this point, I would like to give thanks to my supervisor Professor Guangnan Chen, who has provided me with helpful advises and clear instructions.

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# **Analysis of Evolving River Meander Bends and Flood Plain Using GIS and Field Observations.**

## **A Case Study in Condamine River.**

Sponsor –School of Civil Engineering and Surveying



### **Sudeep Shiwakoti**

Masters of Engineering Science  
(Civil Engineering)

**Supervisor: Dr. Dev Raj Paudyal**

**Keywords:** Meander, Morphology, Sediments

### **Introduction**

Meander bends-(the concave section followed by the convex curve) in the river are the most vulnerable sections where the erosion and deposition occurs consecutively. Therefore, the objective of this research to investigate the meander bends and flood plains in the Condamine River with the intensive study using GIS and data collected from field observations

### **Background**

River regime and its behaviour hold lot of importance from economic and social point of view for the people living around its area. As a matter of fact, lot of research have been done on hydrological, hydro chemical and geological aspects of flood plain, aquifer and catchment area of Condamine plain which are used to construct the conceptual understanding and numerical models. But however, very less study has been done on the meander bends of this river. Hence, this research aimed its sole focus on the meanders of the Condamine River. Thus investigates into the variables contributing to the shifts of meander in this river. For this, spatial data from GIS along with field observation had been used to investigate the factors affecting the widening of meander bends of this river.

### **Methodology**

To find out the variables that are responsible for the widening of meander bends, the intensive study of bends using spatial data from GIS along with field observation and note taking was done. Field observation includes, marking water level, flood plain level, vegetation, and soil sample.

### **Key Outcomes**

The intensive data analysis from GIS and aerial photographs has indicated the direct relationship between the nature of sediments and vegetation pattern around the selected site. However, the careful data collection and observation from site visit will reveal the exact pattern

### **Further Work**

As, river involves complex hydrological, sediment logical and geotechnical variables, such detail investigation on bends acquires more time and lot multiple expertise. As this research solely depends upon the use of Arc GIS and relies on the field observation of selected meanders. Furthermore, the section from North Condamine Branch to Warwick to Killarney of the whole Condamine River has been selected based on the intensive GIS and aerial photographs.

### **Conclusions**

In conclusion, rivers like the Condamine involve very complex hydrological, sediment logical and geotechnical process. It is almost impossible to do river protection work along the thousands miles of river. So a better and accurate model which could incorporate all these parameters and be exactly able to predict the worsening pattern of meander in the river. This way, we could be able to save lot of property and life in many parts of the world where lot of settlement are still in the meander parts of river.

### **Acknowledgements**

My special thanks and appreciation to my supervisor Dr. Dev Raj Paudyal for his guidance and insight whole time during the project

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# Relationship and other advanced contracting process



## Karthik Reddy

Master of Engineering Science  
(Electrical/Electronic)

Supervisors: Dr David Thorpe

Senior lecturer (engineering/  
technology management)

Keywords: electrical contract, e-trade

### 1. Introduction

Contract processes play a vital role in the several business relationships. Despite developing enthusiasm in administration are overseen, the most proficient method uses by the contracts to oversee administrations for shockingly meagre in administration research. The main aim of this thesis is to understand the deeper concepts by using contracts and manage the services in the business relationship. This thesis mainly understands the concepts to manage the service with the contracts

### 2. Background

The contract execution way is fruitful clear and the correspondence is satisfactory in between the foreman and employer. The arrangements and correspondence of plans may offer the opportunity in executing the future things that helps to guarantee the gatherings for creating trust in the program of development. It is a two-ways transform. The action course may have an essential point for the levels of correspondence protects the emerge issues. The contractors understand that it can fit to go "to the top" and liaise straight forward with the top administration. as it will undermine the administrator agreement. Essentially, this is an improper staff on the foreman side to crumble the inner grievances agreement for the execution association director.

### 3. Methodology

The ordinary grouping in completing research work is to characterize issues and learn encompassing truths that can bring about a superior understanding of focused on issues. A scientist can devise her or his own particular workable techniques the extent that a sensible, consistent and persuading clarification can be given to help this methodology. It is the obligation of a scientist to pick a model or a technique that both fits the issue to be unravelled and/or fits other exploration goals, and that will deliver dependable results. Any bit of research must have an expressed extension and constraints, as a

solitary exploration venture can't tackle all issues connected with a given study. A decent bit of exploration ought to finish up with a talk focused around genuine discoveries.

### 4. Key Outcomes

To eliminate the issues found in electrical contracting process and to facilitate further improvements several recommendations can be given to future electrical contracts. These recommendations also help future electrical contracts to improve their efficiency in execution.

### 5. Further Work

Electrical contracting processes should be converted into computerized electronic contracting methodology for easier contracting activities like contract initiation, authoring, approval, and further communication between clients and contractors

### 6. Conclusions

The investigation of electrical and electronic contracts gives a knowledge to the advancement of innovation and the behavioural changes that has occurred at the worldwide level. Usage of any procedure or arrangements has its own troubles. Clients are not utilizing e-trade as there is absence of interpersonal contact. The advancement of all the contracting routines and its execution is observable through the years. As development segment is growing the agreement for distinctive exercises gives an inclination of security the requirement for contracts have expanded on account of the inconveniences included in this part

### Acknowledgements

It is with tremendous gratitude, I acknowledge the kind full support of my project supervisor **Dr. David Thorpe**, for his wilful and persistent guidance in encouraging me throughout accomplishing my thesis.

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# Surveying Applications of Photogrammetric UAVs - *a comparison with conventional Survey techniques*



Sponsor – Land Development Solutions Pty. Ltd

## Curtis Haydon Smeaton

Bachelor of Spatial Science (Honours) (Surveying)

Supervisor: Dr Xiaoye Liu, USQ

**Keywords:** UAVs, Drones, Photogrammetry, Surveying

### 1. Introduction

Unmanned Aerial Vehicles – or Drones is a broad term for a range of aerial vehicles that are not manned. UAVs are capable of capturing ground spatial data by mounting a camera onto the UAV to capture photogrammetric images. These photogrammetric images are able to be geo-referenced using a process called ortho-rectification. From these geo-referenced images spatial data can be obtained and output such as digital elevation models. With the ever increasing access and reduced costs to this type of technology this may become a viable tool for the modern surveyor to increase their efficiency and reduce workplace risks.

### 2. Background

The modern surveyor must continually adapt their field practices to match the most contemporary technologies accessible. In this regard, the following dissertation aims to compare the use of UAVs as a photogrammetric tool for Survey measurement purposes. The aspects tested within this comparison include: precision, accuracy, limitations, and overall operating costs of both conventional trigonometric survey techniques and UAV photogrammetric methods.

### 3. Methodology

Initial research was conducted within the use of UAVs for photogrammetric image capture, methods were developed to determine appropriate flight planning, ground control, and camera settings to ensure a high level of accuracy and precision. Field observations conducted within this dissertation test photogrammetric UAV data in comparison with conventional survey technique data within an active civil construction project. A number of site considerations such as: ground cover, vegetation types & densities, buildings & other vertical structures, water bodies, and colour of objects have been specifically tested for accuracy for comparison of the conventional survey data with the UAV photogrammetric data. Field observation times, office reduction times, overall equipment costs and total project completion costs have also been recorded for both methods to determine a cost-benefit analysis for a number of different types of survey.



Figure 1 – Orthomosaic from UAV photos

### 4. Key Outcomes

Field observations within this dissertation test these specified accuracies, and analyse differences in quoted accuracies. The critical objective for the comparison within this dissertation is to provide quantified evidence for the types of survey work that an unmanned aerial vehicle can be utilised.

### 5. Further Work

Field testing was only conducted using one type of photogrammetric UAV it is recommended that further research be conducted into other UAV models in a similar comparison as tested within this dissertation

### 6. Conclusions

Fixed wing UAVs are capable of providing high precision orthorectified georeferenced 3D photogrammetric models with horizontal accuracies of 20mm and vertical accuracies of 35-50mm. The results from the project show that UAVs are appropriate as a tool for topographic mapping, work as executed surveys, and volume surveys.

### Acknowledgements

I would like to personally thank Ultimate Position Systems Pty Ltd. and Land Development Solutions Pty Ltd. for providing the use of their equipment in this project.

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# SEQ Storm Tide Response to Tropical Cyclone Oswald

Sponsor – BMT WBM



## Mitchell Smith

Bachelor of Engineering (Honours)  
(Environmental)

BSc (Geog)

Supervisors: Dr Jahangir Alam, USQ

Dr Ian Teakle, BMT WBM

Dr Bruce Harper, SEA

**Keywords:** Storm Tide, Tropical Cyclone, Modelling

## 1. Introduction

Although a significant body of work exists, previous storm tide studies within Moreton Bay have consistently underestimated observed tide gauge levels by up to 40%. There remains debate regarding the source of this ‘missing’ contribution which is argued to be resultant from either disturbance of regional oceanic density structure, surface wave-surge interactions or the current parameterisation of wind stress onto the water column. This study investigates the storm tide associated with the passage of *TC Oswald* on the 26-27th of January 2013. A key hypothesis is that the three-dimensional ocean density structure plays an important role in the generation of observed storm surge.

## 2. Background

The ability of coastal models to accurately reproduce observed events is important as they form the basis for coastal and disaster management planning. To predict levels at the coast, external forcing on the ocean such as, astronomical tides, surface winds, atmospheric pressure, waves and ocean density gradients can be represented using mathematical models on a numerical mesh (refer Figure 1) which uses bathymetric survey to represent the ocean floor and coastline.

## 3. Methodology

Firstly the model was calibrated to astronomical tidal levels for the January 2013 period leading up to *TC Oswald*. Following tidal calibration a series of five experimental runs were investigated assessing two and three-dimensional ocean behaviour.

## 4. Key Outcomes

Undertaking storm surge assessments using 3D modelling that accounts for density structure is



**Figure 1 – Numerical Model Domain**

important in capturing offshore eddies associated with the East Australian Current. These eddies result in the setup of ocean water levels on the adjacent coast. This setup is exacerbated by the effects of extreme winds. The modelling has shown that storm surge associated with *TC Oswald* can be matched to **within XX and XX %** with a 2D only and 3D baroclinic model.

## 5. Further Work

This study has used a coarse ocean circulation model HYCOM as boundary conditions. Soon CSIRO will release an updated ocean model for the Australian region and at this time the study should be repeated. It is also proposed to undertake wave modelling to assess the potential for wave setup on storm surge levels.

## 6. Conclusions

It is hoped that through the findings of this study, planning officers will be able to better estimate likely inundation and flood hazards during a TC event, thus improving evacuation response and recovery.

## Acknowledgements

I would like to thank Ian Teakle, Toby Devlin, Matt Barnes, Bruce Harper, Bill Syme and Jahangir Alam for their assistance and understanding throughout the project.

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# Implementing and Industry Best Practice Alarm Management System

Sponsor – School of Mechanical and Electrical Engineering



**Daniel Snelgar**

Bachelor of Engineering  
(Electrical and Electronic)

Supervisor: Catherine Hills, USQ

**Keywords:** Alarms, Alarm Management, Industrial Automation, Process Control

## 1. Introduction

In Industrial Automation Alarms warn operators of abnormal situations that could affect product quality, or lead to hazardous consequences. Poorly managed alarm systems have been identified as contributing factors in major industrial accidents such as the partial nuclear reactor meltdown at Three Mile Island (USA, 1979) and explosions at the Milford Haven Refinery (UK, 1994) and the Longford Gas Plant (Australia, 1998).

Industry groups such as the Engineering Equipment and Material Users Association (EEMUA) and the Abnormal Situation Management Consortium (ASM) lead the early research and the development of the guidelines. The approach to Alarm Management was standardised in the USA with the introduction of ISA-18.2-2009. This standard has now been released as an international standard IEC 62682:2014.

## 2. Background

The adoption of Alarm Management has not been uniform in all industry sectors. Some sites, such as the project site have never employed any form of Alarm Management. The site has been issued with a cooperate directive to adopt an Alarm Management system that is compliant with ISA-18.2-2009. The project site is a large coal fired power station which uses modern computer based Process Control systems.

## 3. Methodology

Key principles of the ISA-18.2-2009 Alarm Management Lifecycle (Figure 1) where adopted. These included the creation of an Alarm Philosophy, a Master Alarm Database and alarm performance reporting tools.

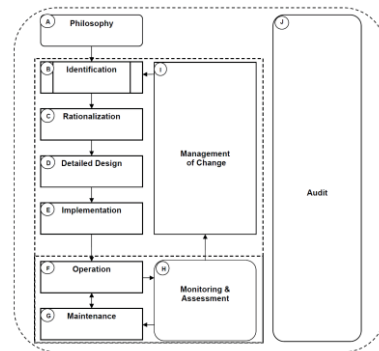


Figure 1 – ISA-18.2-2009 Alarm Management Lifecycle

The project site's alarm performance was benchmarked and the worst performing alarms were investigated. Solutions to eliminate the worst performing alarms were devised and recommended to the project site.

## 4. Key Outcomes

The project site has adopted the Alarm Philosophy into their site procedures. The Alarm Reporting Tool and Alarm Management Database have been deployed to the site and are in use. The current daily alarm rate is an order of magnitude higher than recommended. Investigations of the top alarms have identified improvements which could reduce the current daily alarm rate by 40%.

## 5. Further Work

The recommended improvements need to be implemented, as well as further work to improve the daily alarm rate to a level that is considered manageable. Once the daily alarm rate is under control alarm management focus needs to shift to measuring and reducing Alarm Floods and number of active Standing Alarms.

## 6. Conclusions

The project has shown how to practically implement an Alarm Management system that reflects industry best practice and is compliant with current standards.

## Acknowledgements

I would like to thank my supervisor, Catherine Hills, for providing the guidance to shape this idea into a project.

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# Quantifying the time and cost associated with the request for information (RFI) or technical query (TQ) process - a designers perspective.

Sponsor – School of Civil Engineering and Surveying, USQ



**Peter Sparksman**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Mr Paul Tilly, USQ

**Keywords:** request for information, technical query, construction, designer, construction projects

## 1. Introduction

Within the modern construction industry the 'request for information' (RFI) procedure has become the formal process for the contractor to gain further information from the project designer.

The RFI process begins during a construction project where the contractor encounters a problem or has a question regarding how a certain aspect of the project is to be completed. Once the RFI is created by the contractor it is passed to the project manager or the superintendent so that a solution or formal response can be drafted. It is the efficiency of this process that this research project aims to quantify.

## 2. Background

The entire RFI process from initiation to resolution as can be a lengthy and costly exercise. Although some of the cost is normally absorbed by all parties, this research project aims to quantify the time and cost associated with this process from a designer's perspective.

## 3. Methodology

After thorough analysis of the current process and procedures, the project will first develop a methodology for selecting a group of case study projects.

This involves developing parameters that will determine what case study projects are to be collected. It will then detail the specific project and designer's data that is to be collected.

A model of the costs incurred by the designer during the RFI process on these projects will then be created and combined into a usable database. This data will then be analysed to identify factors that influence both the number of RFI's and associated costs incurred by the designers.

## 4. Key Outcomes

From these identified factors conclusions can be made on how they could be used to identify future high risk projects. Recommendations can then be made on how the number of RFI's and their cost to designers, can be reduced on future projects.

## 5. Further Work

As some of the data collection is still underway at the time of writing, the project database will need to be finalised and results are to be reported. Further work within the topic field would be to gain a further model from a different aspect such as an architect.

## 6. Conclusions

Conclusions from the project will include a detailed data base of the costs incurred by designers in the RFI process and recommendations can then be made on how the number of RFI's and their cost to designers, can be reduced on future projects

## Acknowledgements

I would like to thank Kehoe Myers Consulting Engineers and other local consultants that have contributed to my project and my supervisor Mr Paul Tilly for his ongoing help.

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# Critical Analysis of RCM in an Australian ANSP Context

Airservices & USQ School of Mechanical and Electrical Engineering



**Nicholas Spurry**

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Supervisors: Dr Stephen Goh, USQ  
Mr Daniel Field, Airservices

**Keywords:** RCM, ANSP, Maintenance Engineering

## 1. Introduction

Airservices are Australia's only civil Air Navigation Service Provider (ANSP) and are responsible for providing safe air traffic services within Australian airspace. In order to provide these services, Airservices operate a complex network of aviation specific and more general technology across Australia. In recent years, with a changing economic climate, Airservices have expressed interest in modernising its maintenance practices and identifying potential efficiency gains.

Reliability-Centred Maintenance (RCM) is a structured methodology for developing maintenance regimes that claims to maximise equipment reliability whilst simultaneously minimising maintenance costs. RCM has become commonplace in general industry and it appears to be a promising avenue for Airservices to explore.

## 2. Background

Whilst RCM is published as a number of standards, those standards do not detail the specifics of RCM implementation, leading to significant variations in RCM application. Opinions amongst industry experts also vary on the value of quantitative analysis in maintenance regime development. Concerns have been raised about the validity of the underlying research that the RCM methodology is founded on.

There is no evidence in the literature of widespread adoption of RCM in the ANSP industry. What's more, the Federal Aviation Authority (FAA), the only ANSP known to have publicly acknowledged its intentions to adopt RCM, were investigated by the United States Government Accountability Office (GAO) after union members testified that RCM was unsafe.

## 3. Methodology

The project focused on the development of an example RCM maintenance regime and the demonstration, through reliability modelling, that system performance would be equivalent if not better under an RCM maintenance regime compared with current maintenance regimes.

## 4. Key Outcomes

Due to Airservices unique maintenance practices, it was found that no commercially available modelling packages were suitable and a custom Time-Sequential Monte-Carlo reliability modelling program was developed. An RCM maintenance regime was developed for the VHF Air-Ground Communication System. System performance was modelled using the custom software and compared against current the current maintenance regime.

## 5. Further Work

The bulk of the analysis of the modelling results remains to be completed before conclusions can be finalised. Outside of this project, further analysis is required to ensure that results translate across all systems and a cost-benefit analysis is required to ensure that implementation is economically feasible.

## 6. Conclusions

Key conclusions await the completion of further analysis. Initial results, however, indicate that it is likely that the adoption of RCM in Airservices would facilitate drastic reductions in maintenance actions compared to current maintenance regimes whilst continuing to satisfy operational requirements.

## Acknowledgements

Airservices have been particularly helpful in the completion of this project, providing resources, time, expertise and some funding. Special acknowledgement must be made to Nowlan and Heap (1978) whose original report was a seminal work in the field of Maintenance Engineering and to John Moubray (1997) who significantly expanded on this work in the development of RCM2.

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# A Review on Australian Mine Haul Road Design & Maintenance Procedures



## Anita Strack

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Supervisors: Dr Andreas Nataatmadja, USQ

Mr Peter Foley, WorleyParsons

**Keywords:** Haul Roads, Pavement Structural Design, Deflection / Deformation & CIRCLY

## 1. Introduction

The cost effective design of mining haul roads is critical to the successful operation of all open cut mines within Australian and around the world. These mines rely heavily on the haul road network to transport run of mine (ROM) material. However, haul roads are reportedly under-designed and seldom constructed and maintained to a standard that minimises total cost.

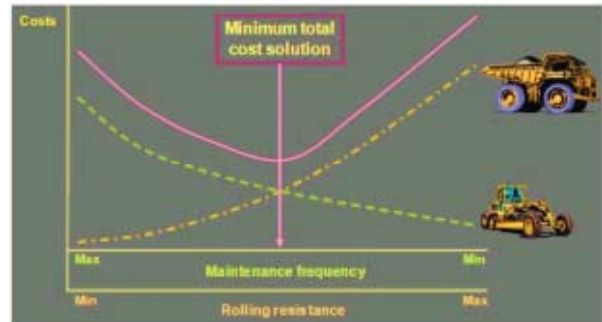
## 2. Background

There are several methods for the design of haul road pavements. They can be designed empirically or mechanistically. Historically Kaufman and Ault's CBR Cover Design Method (Kaufman & Ault, 1977) has been widely used. Design inputs include subgrade CBR and the vehicle wheel loads which are easily obtained. Recently Thompson has developed a mechanistic method which limits the pavement layer vertical compressive strength depending on the life expectancy and volume of traffic. (Thompson, 2011).

Haul road pavement designs are completed onsite with guidance from company specific Haul Road Design Manuals. Typically the pavement is designed using locally won material to reduce costs.

## 3. Methodology

Theoretical methods of Queensland haul road design including pavement design, geometric design and functional design were researched and documented. Using design and as-constructed information obtained from mine sites within Queensland, an analysis was undertaken to determine how different methods of pavement designs presented different configurations. These configurations were verified in CIRCLY to calculate pavement deflection under the vehicle. The



**Figure 1 - Minimisation of Road Maintenance and Vehicle Operating Costs (Thompson, 2011)**

calculated deflection was then applied to calculate rolling resistance and the impact on fuel consumption.

## 4. Key Outcomes

There are a multitude of factors that contribute to calculating rolling resistance. The static deflection data produced by CIRCLY was not suitable to use in determining the component of rolling resistance that can be attributed to pavement configuration. Therefore different methods of pavement design were analysed to determine maximum deflection / deformation under similar load conditions.

## 5. Further Work

Determine a suitable method to calculate dynamic deflection data for heavy mining equipment and establish the relationship with the rolling resistance of heavy vehicles.

## 6. Conclusions

Designing for minimal surface deflection would suggest that the optimal method is to determine cover to subgrade via Ahlvin's method (Ahlvin, 1971) and then to adopt Austroads (Jameson, 2012) sub layering to determine the exact composition of the layers.

## Acknowledgements

WorleyParsons for providing the tools and systems required to undertake this project. Andreas Nataatmadja my research project supervisor for his continued help. Leigh Wardle (Mincad Systems) for the use of CIRCLY 6.0 software (and licence).

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# Optimisation of Wheel-set Usage Through Predictive Management in the Heavy Rail Haulage Industry

School of Mechanical and Electrical Engineering



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(Mechatronic)

Supervisors: Mr Chris Snook, USQ

**Keywords:** Predictive Management, Heavy Rail Haulage Wheelsets, Matlab Model

## 1. Introduction

This project seeks to come up with a model that will predict the number of wheelsets that will have reached the end of life span at **Rio Tinto Iron Ore**. The period of prediction ranges from days up to 10 years because the life expectancy of a heavy rail haulage wheelset is 10 years at this company. Implementation of this project would avert the risk of under or over stocking of wheelsets thus rendering the rail operation economic.

## 2. Background

In the past decade the organisation increased their rail fleet to meet the focused production targets. With wagons in excess of 10 thousand and intention of automation of the rail system, maintenance is seen to be a key factor. With such a fleet the amount of wheelsets handled demand a predictive approach to the needs of the near future.

## 3. Methodology

The first approach was to analyse the wheel set so that terminology and components are known. Material and manufacturing technologies are researched. Wheel set defects are also looked into as this adversely affect the life span of these wheel sets. A model was then developed in Matlab, that keeps track of the wheelsets in service and predict the life span.

## 4. Key Outcomes

Though there is, in the Pilbara region, advanced rail technologies, these are found to be mostly condition monitoring devices. This project plugs the gap that is

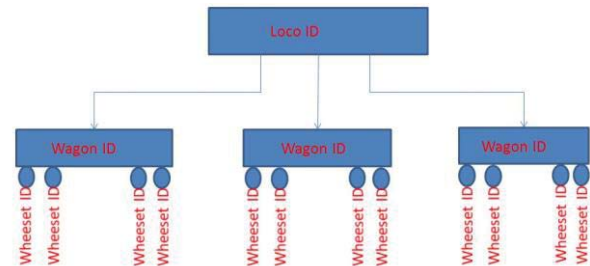


Figure 1 – Schematics of Concept

still open – prediction of the wheelset numbers due for replacement at any time in future up to 10 years.

## 5. Further Work

As it is currently this project has no capability to be implemented on industrial level. Collaboration with IT giants like, IBM, will be sought to take the concept to a level of industrial capability.

## 6. Conclusions

This predictive management can improve maintenance in the heavy Rail industry in that the correct number of wheelsets is available when needed. Otherwise maintenance standards are compromised resulting in a less safe and reliable rail system.

## Acknowledgements

First I would like to thank Professor Chris Snook of The University of Southern Queensland for his guidance throughout my project. My friend, Tim Samanyika Murehwa, did a great job helping me develop skills in **LaTeX** and my thanks go to him as well.

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## Utilization of Waste Cooking Oil as Bio-lubricant: Tribology properties



**Tiss Thomas**

Master Of Engineering Science  
Major: Mechanical

Supervisors: Dr Belal F Yosif, USQ

**Keywords:** Waste cooking oil, Bio lubricant, tribology.

### 1. Introduction

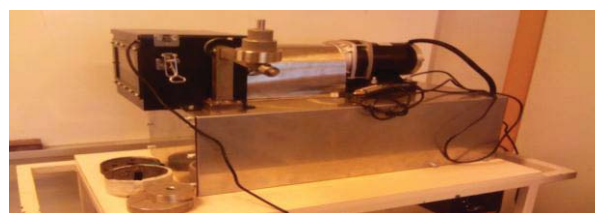
This paper is a review of vegetable oil in lubricant industry. The suitability of vegetable oils as lubricant is mainly influenced by its composition and stabilization towards oxidation. Therefore the modification of vegetable oil structure is necessary to enhance its performance as a better lubricant. The depletion of the world's crude oil reserve, increasing crude oil prices, and issues related to conservation have brought about renewed interest in the use of bio-based materials. However, suitability of the vegetable oils for a specific application either needs chemical modification or may be used as it is with additive blending route in order to get base stocks as per specifications for a particular end use application.

### 2. Background

The continued growing environmental concerns are providing impetus for increased demand and usage of vegetable oil utilization in lubricants from many applications. Of the 5 – 10 million tons of petroleum based oleo chemicals entering the biosphere every year, about 40% comes from spills, industrial and municipal waste, urban runoff, refinery process, and condensations from marine engine exhaust. Meanwhile, vegetable based oil can offer significant environmental advantages

### 3. Methodology

The tribology machine was used to conduct adhesive wear testing under lubricant condition. The first step in the experiments was to prepare the sample and counter face similar to the preparation process explained. Prepare the sample Upload the lever with the required dead weight. Fill in the lubricant set the rotational speed Fix the thermo – imager camera in a proper location Run the machine



### 4. Key Outcomes

This work covers most of international articles published in the area of bio lubricant aiming to address the most recent issues and explore the potential of using waste cooking oil lubricant. Some important points can be drawn from this work. There is a concern from an environmental point of view to find alternative lubricants and an attention is paid by the researchers and vast work is focusing on the possibility of using vegetable oils. The test is to be done using a tribological machine under wet adhesive conditions and compare the results.

### 5. Further Work

If time permits a test will be conducted using fossil lube and bio lube and compare the results and come to a conclusion where bio lube is much more efficient than fossil lube. However, further study is recommended for further work.

### 6. Conclusions

As a conclusion, waste cooking oil can be used as a novel application for lubrication even without the addition of additives. The application of wastes in industries is a wise way to decrease pollution from industries as well as to preserve the environment. At the same time this trend is hoped to further utilize and give added value to wastes by converting waste to wealth.

### 7. Acknowledgements

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

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# Analysis and Design of Telehandler Lifting Jib

McCormack Industries



**Caleb Thompson**

Bachelor of Engineering  
(Mechanical)

Supervisors: Mr Chris Snook, USQ  
Mr Steven Radke, McCormack Industries

**Keywords:** Manufacturing, Machinery, Agriculture

## 1. Introduction

This dissertation aims to detail the process of the design and analysis of a telescopic-handler lifting jib. This project has been sponsored by McCormack Industries, with the intent of implementing the design into their current product range. Outlined in the report are details of the attachment's intended use as well as analysis methodology leading to the design decisions. Product drawings and manufacturing methods are outlined to allow the final design to be commercially produced.

## 2. Background

McCormack Industries desires to expand their product range of industrial and agricultural machinery attachments. Lifting Jibs, primarily used for materials handling have previously been designed specific to the machine of use. This design aims to harness a *base* design with interchangeable attachment lugs that can be adapted to a range of different Telehandler machines. The design also conforms to the relevant Australian Standard Lifting Codes.

## 3. Methodology

An analysis of intended use of the attachment was conducted to allow the design to be functional to its purpose. Furthermore, an assessment of current Telehandler attachment lug variations, between different manufacturers, was conducted to provide a range of dimensional variance between machines. This in turn allowed for design formulation of the rear of the Jib where the interchangeable lugs are to be fitted. Figure 1 details the size variance between the largest and smallest lugs sets being catered for. The design of the main Jib structure was assisted by the use of an

FEA software package. This allowed for rapid design formulation and preliminary strength analysis.

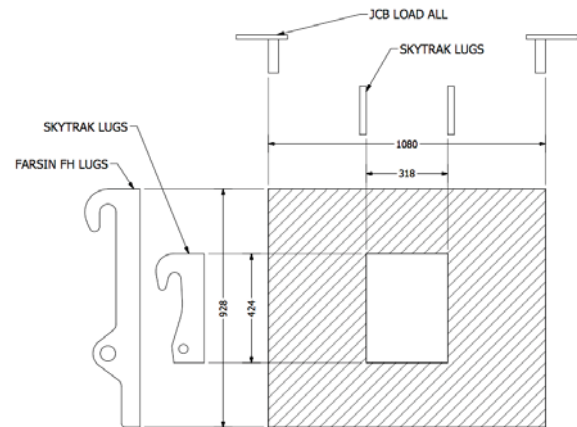


Figure 1 Dimensional Variance of the Attachment Lugs being catered for

## 4. Key Outcomes

After first establishing a rear structure that best accommodates the fitting of various attachment lugs, several design solutions were produced. Of the several preliminary designs produced, a final design was taken and tested, harnessing the combined advantages of the preliminary designs. The preliminary designs were produced with consideration given to visibility, weight, cost, manufacturing complexity, strength and design safety.

## 5. Further Work

Manufacture of the Jib would be useful in validating the design. Manufacture would allow physical testing according to the Australian Standards, and would also validate cost estimations.

## 6. Conclusions

In conclusion, a lifting Jib design has been produced with a focus on safety, usability and commercial viability. The design is unique in allowing for ease of adaptability to various Telehandler machines.

## Acknowledgements

I would like to acknowledge my current employer and industry sponsor McCormack Industries, as well as personally thanking my supervisor Chris Snook for his constant assistance and thorough project guidance.

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# ISOLATED GRID SOLAR-BATTERY SUPPORT FOR SWER

Sponsor – USQ, HES, School of Mechanical and Electrical Engineering



## Philip Timings

Bachelor of Engineering  
(Electrical/Electronic)

Supervisors: Dr Narottam Das, USQ  
Mr Daniel Warne, Ergon Energy

**Keywords:** Single Wire Earth Return (SWER), Solar, Mini-grid.

## 1. Introduction

This research project is to investigate the feasibility of a Battery Energy Storage System (BESS) to both utilise Windorah's excess solar generation to prop up/augment the nearby SWER line and to utilise Single Wire Earth Return (SWER) at low loads to charge the BESS to offset Windorah's peak load diesel consumption.

## 2. Background

Windorah is an outback Queensland town of about 150 people and is supplied distributed electrical prime power by a diesel generation based mini-grid. Due to competitive pricing, high insolation and a burgeoning ethical stance, solar Photovoltaic (PV) generation installations have become an attractive alternative for offsetting the high price of diesel. Unfortunately, with stability and intermittency challenges, the town's mini-grid now has an excess of solar penetration.

Nearby to the town, a SWER feeder, supplied from Queensland's primary electricity grid network, is suffering both high peak loads, and low load voltage issues.

## 3. Methodology

To investigate the potential for this system to be feasible, the project focuses primarily on the load and supply data of two independent systems. This includes measurement trends and records of the SWER line load in order to fully appreciate when the peaks are and their size. An understanding of the solar insolation availability in Windorah is also required, as well as the current PV

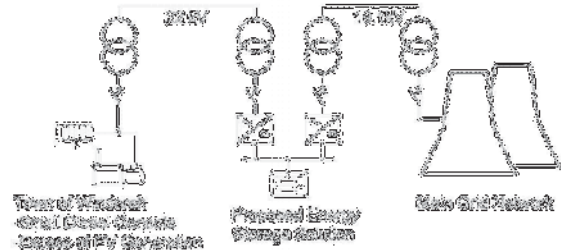


Fig. 1: BESS Interconnection of Mini-grid to the SWER.

single line diagram for the proposed system.

## 4. Key Outcomes

The goal of this project is to understand how the interconnection might be accomplished and what gains (if any) are to be made by such an implementation. Essentially, the low load of the SWER needs to coincide with a load demand from the storage system. Likewise, the abundance of solar should coincide with the peak load on the SWER.

## 5. Further Work

Costs of the primary plant is a substantial factor for the actual implementation and, along with diesel fuel offsets (savings), should be examined to determine economic viability in future.

## 6. Conclusions

The proposed system modelled results demonstrate the technical feasibility of the BESS as an interconnection between two systems.

## Acknowledgements

I would like to thank Dr Narottam Das, USQ for his input and guidance throughout this project and to acknowledge Mr Daniel Warne, Ergon Energy for research support to work on this topic.

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# Effect of Simulated Environmental Conditions on the Properties of Epoxy Based Polymer Resin

## Ashlii Timms



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Bachelor of Business  
(Management and Leadership)

Supervisors: Dr Allan  
Manalo, USQ

**Keywords:** Epoxy, Filler, Durability

## 1. Introduction

Concrete is the most widely used material in structural engineering. However, when exposed to Australia's climate, concrete can suffer stress, shrinkage cracking and deterioration. These harsh environmental conditions include excessive heat, moisture, alkalinity, and high humidity (hygrothermal environment).

Epoxy is a commercially available polymer that has historically been used for crack repair and coating due to its known high strength and durability properties. This project analyses the effect of light-weight particulate filler has on the thermomechanical and durability properties of epoxy resin, with respect to simulated environmental conditions.

## 2. Background

Despite the commercial use of epoxy for its mechanical properties (Lokuge & Aravinthan, 2013), there is a decrease in those properties with increased temperature past the glass transition range (Michels, Widmann, Czaderski, Allahviridzadeh & Motavalli, 2015). Ideally, the epoxy is post-cured to increase the glass transition temperature (Custódio, Broughton & Cruz, 2011). However, this is uneconomical and inconvenient for large concrete structures.

The use of fillers practically reduces the price of epoxy based polymer and has been found to improve the mechanical properties. However, little research has been done to understand the effect of fillers on the temperature sensitivity and durability of epoxy based polymers. This is the main motivation of this study.

## 3. Methodology

The project was divided into two studies. Study 1 was conducted to determine the optimal filler content, with respect to elevated temperature, that had no significant reduction in the compressive strength of the epoxy resin. Compression testing from room temperature to 80°C and physical observations were conducted.

Study 2 aimed at evaluating the six-month durability of the optimal mix selected from Stage 1 at different simulated environmental conditions. The samples were exposed to either air, saltwater, water or hygrothermal environment. Changes in the compressive strength, appearance, dimensions, weight and microscopic structure were observed at pre-set intervals.

## 4. Key Outcomes

From Study 1 the optimal mix was 60% epoxy resin to 40% filler (Figure 1). This optimal mix was used for Study 2. Analysis of the results for Study 2 is on-going.

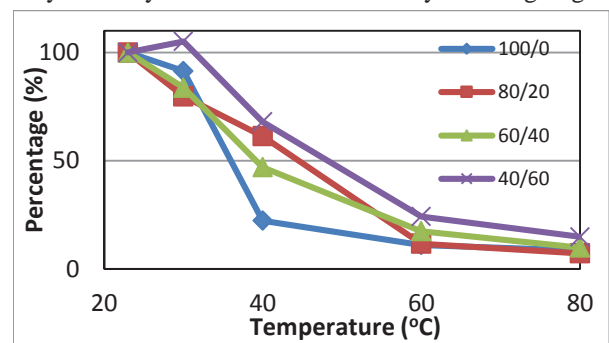


Figure 1 - Compressive Strength Trend Analysis for Resin/Filler Ratio

## 5. Further Work

The measurements and observations for Study 2 had been completed. The results are now being analysed to determine the comparative durability of particulate filled epoxy based resin under different simulated environments. Based on the results from Studies 1 and 2, the conclusions of the study will be drawn.

## Acknowledgements

I would like to thank my supervisor for providing clarification and guidance for the process of the project and Wahid Ferdous for assisting me in the preparation and conduct of experiments.

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# Evaluation of EverFE Software for Designing Australian Concrete Pavements

Sponsor – School of Civil Engineering and Surveying



**Jake Tobler**

Bachelor of Engineering  
(Honours) (Civil)

Supervisors: Dr Andreas Nataatmadja, USQ

**Keywords:** Concrete Pavements, Austroads, EverFE, Rigid Pavements

## 1. Introduction

The design of Australia's rigid pavements (concrete pavements) is outlined in the Austroads Design Guide (2012). The aim of this study is to examine the design guide and identify the potential for implementation of a finite element program, EverFE, to be used in conjunction with the design guide.

## 2. Background

The basis of the methods outlined in the Austroads Design Guide comes from the methods of the Portland Cement Association (PCA), referred to as the PCA method. The PCA method is based on a semi-empirical design procedure involving empirical design charts. This method has been adopted by Austroads with modifications to suit Australian conditions, however some limitations exist. It is also not known if these design charts can continue to be extrapolated into the future if there are changes to traffic loading and conditions.

The aim of this project is to examine these limitations and compare results from Austroads with results developed from EverFE with an objective of potentially using EverFE in conjunction with the current design guide to aid in the development of rigid pavements in the future.

## 3. Methodology

- Describe use of EverFE software in concrete pavement design and review the minimum pavement thickness requirements from Austroads
- Identify parameters required for design (heavy vehicle loading and load location)
- Develop a pavement thickness design using the Austroads Design Guide (2012)

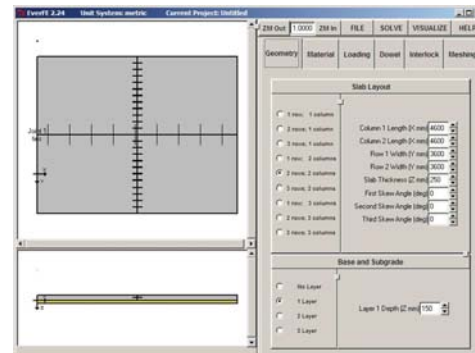


Figure 1 – EverFE user interface

- Perform analysis on the pavement design using EverFE software to determine stress values with input parameters defined
- Conduct a sensitivity analysis on results with the inclusion of temperature gradients

## 4. Key Outcomes

Key outcomes presented of this study will endeavour to provide justification for the implementation of EverFE as a design aid, in conjunction with Austroads Design Guide, in the design of Australian rigid pavements in the future.

## 5. Further Work

Work to be completed in this project includes analysis of pavement stresses using EverFE with the design input parameters identified for finalisation of results.

## 6. Conclusions

The analysis of Austroads and EverFE in this project will provide a basis for the potential incorporation of more advanced analytical techniques to be incorporated into the design of Australia's rigid pavements.

## Acknowledgements

I would like to acknowledge Dr Andreas Nataatmadja for his help and supervision throughout this project.

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# Compact passive stormwater sampling device for use in urban pit drains



## Bryan Triaca

Bachelor of Engineering  
(Honours) (Mechanical)

Supervisor: Dr Ian Brodie, USQ

**Keywords:** Stormwater, sampling, flow-weighted

## 1. Introduction

Stormwater sampling equipment and procedures are frequently required for the purpose of obtaining representative storm water samples that may be analysed in a laboratory. Such testing when properly conducted enables scientist, engineers and relevant authorities to produce reliable storm water quality data that can guide future actions in catchment management.

This project aims to develop and test a proof of concept prototype of a low cost storm water sampling device capable of autonomously capturing a flow-weighted runoff sample when installed in a common urban pit drain.

## 2. Background

Collecting many flow-weighted runoff samples from around an urban catchment can be an expensive and time consuming exercise.

Research of existing sampling systems did not reveal any low cost, compact sampling equipment commercially available or conceptual. The device developed in this project is intended to provide an economical tool for widespread catchment monitoring.

## 3. Methodology

After careful consideration of the performance required from a cost effective stormwater sampling device a prototype was designed and constructed for the purpose of testing. The prototype is a compact gravity driven flow splitter design. Construction was primarily via 3D printing.

The sampling device is to be tested on a purpose built flow simulator that will allow accurate measurement of the devices flow-splitting accuracy.

## 4. Key Outcomes

This project so far has delivered a prototype that is capable of achieving the primary task of capturing a flow-weighted sample of water. Qualitative assessment



**Figure 1 – Sampling device primary flow splitter**

of the device suggests that it is working well. Future quantitative testing will confirm performance.

## 5. Further Work

Further work on this project will be centred on comprehensively testing the device in order to evaluate and where possible improve performance.

If this project were to be continued beyond this year future work would involve continued refinement and eventual commercialisation.

## 6. Conclusions

This project so far has proven that it is possible to construct a low cost, compact stormwater sampling device capable of being installed in a pit drain or similar environment. With further development such devices could prove a useful tool for economically collecting runoff samples in urban environments.

## Acknowledgements

I would like to thank Dr Ian Brodie for providing the initial idea for this project and his ongoing support as my supervisor. I would like to thank my employer Collier and Miller for providing time in which to complete my project and discounted materials.

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# Diversion of Stormwater First Flush: An Alternative Method of Managing Pollution to Urban Waterways

School of Civil Engineering and Surveying



## Patrick Tunnah

Bachelor of Engineering (Honours), Majoring in Civil Engineering

Supervisors: Dr Vasantha Aravinthan, USQ  
Mr Tony Bamford, MWH

**Keywords:** Wastewater, Stormwater, First Flush

## 1. Introduction

This study looks at the diversion of stormwater first flush as an alternative to the containment of wastewater overflows for managing pollution to urban waterways.

The focus area of the study is the Norman Creek Catchment located in Brisbane. The opportunity for stormwater first flush diversions within the catchment, along with the resulting benefits, were identified and reported on.

## 2. Background

A traditional view towards managing urban waterway pollution focused on overflows from wastewater networks. Over time, significant work to improve wastewater networks and meet conveyance capacity or spill frequency targets has reduced overflows. However, unacceptable levels of pollution are still being observed in urban waterways. Further reductions of wastewater overflows potentially have very high costs and may provide little benefit to the waterway.

Urban stormwater runoff is increasingly being recognised as one of the most significant contributors to water pollution (US-EPA, 1997). Additionally, the effects of stormwater pollution can be exacerbated during the initial stages of a storm event, or when small storm events occur after long dry spells, with the rainfall runoff containing a higher pollutant loading (Lee, et al., 2004). These occurrences can be described as “stormwater first flush”. Diversion of stormwater first flush may provide an alternate, cost effective solution to waterway pollution, instead of further reducing wastewater overflows.

## 3. Methodology

Small storm events following extended dry periods were selected from rainfall data, then run through calibrated hydraulic models to determine the capacities in the wastewater network. The stormwater discharges from the catchment will then be determined and the potential to divert into the wastewater network assessed.

## 4. Key Outcomes

From Jan 2013 to July 2015, a total of 23 dry periods consisting of 10+ consecutive days with <0.5mm daily rainfall were identified. 100% of these dry periods were followed by a small storm event (<10mm daily rainfall). The pollutant build up and stormwater discharge associated with these events has the potential to be diverted into the wastewater network for treatment, instead of directly entering the waterway.

## 5. Further Work

The latter stages of this project will require the remaining capacity in the wastewater network during each storm event to be determined. Possible diversion locations within the catchment will then be identified. From there, the amount that can be diverted from the stormwater system to the wastewater system can be assessed.

## 6. Conclusions

Stormwater pollution can pose a greater overall risk to a waterway than sewer overflows. Early work has indicated that there is available capacity in the wastewater network to accept diverted stormwater flows during smaller storm events. A potential solution being the diversion and containment of polluted stormwater may provide far greater benefits than the traditional focus on solely eliminating sewer overflows.

## Acknowledgements

I would like to thank Tony Bamford for his guidance and ongoing advice throughout my dissertation.

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## Examining the ways of defining tidal waterfront boundaries in NSW and QLD and which method is the best to cope with rising Sea Levels.

School of Civil Engineering and Surveying



### Trent Vella

Bachelor of Spatial Science  
(Surveying)

Supervisors: Mr Shane Simmons, USQ  
Mr Simon Geest, Cooper and  
Richards Surveyors

**Keywords:** Waterfront, Boundary, Sea Level Rise

### 1. Introduction

This dissertation was done to find out what way of defining tidal boundaries is best to cope with the problem of rising sea levels in the future. Separate methods in NSW and QLD were used to see how each one will cope with rising sea levels.

### 2. Background

In the future rising sea levels are going to be major problems to people that live in a close vicinity to the water and especially people who live on waterfront properties. It is not known how these rising sea levels will affect landowner's titles and what it will do to their overall areas. This project will find out how rising sea levels will affect this waterfront land in 50-100 years. This is very important as the respective states need to prepare for the consequences.

### 3. Methodology

The first key attribute to find out for this project was the projected rise in sea level over the next 50 and 100 years. There are a plethora of different theories out there on this topic but the one I selected was done by the IPCC(Intergovernmental Panel on Climate Change) as they are the most respected source out there. Below is the table that states their predictions

Component	Year 2050	Year 2100
Sea level rise	30 cm	59 cm
Accelerated ice melt	Included in above value	20 cm
Regional sea level rise variation	10 cm	14 cm
Rounding	-	14 cm
Total	40 cm	90 cm

Table 1-Expected sea level rise

Once this was established calculations could be done to figure out how boundaries in respective states will be affected by the rising sea levels.

### 4. Key Outcomes

Two separate waterfront sites were surveyed and then calculated in terms of establishing the waterfront boundary in both NSW and Qld methods. The types of sites chosen were different, one being quite flat and one being much steeper in topography. If the rising sea level predictions are actually

correct landowners in flat area could lose more than half their land due to inundation. This will cause major issues to land titling and prices of land on waterfront blocks.

### 5. Further Work

An actual comparison between the two types of waterfront boundary definition still has to be calculated so I can come up with what state has the best method to cope with rising sea levels.

### 6. Conclusions

In conclusion rising sea levels in the future are going to prove a major problem for people living on waterfront properties and being able to prepare for this will help us negate the effects. Waterfront boundaries are going to be affected due to rising sea levels and being able to map the changes will help to come up with a solution of the best way to define these boundaries. If the NSW or QLD method is considerably better than the other then that method should be adopted in both states so this future problem can be nullified.

### Acknowledgements

Thanks must be given to my supervisor Shane Simmons for giving me the idea about the project and giving me some useful links to help understand the boundary definition process more. I would also like to thank Simon Geest from Cooper and Richards Surveyors for his passing on his expertise in NSW MHWB boundary definition to help me with this project.

### References

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# Insulated Container Testing & Rating System Development



Thierry-Jacques Vever

Bachelor of Engineering  
(Honours) (Mechanical)

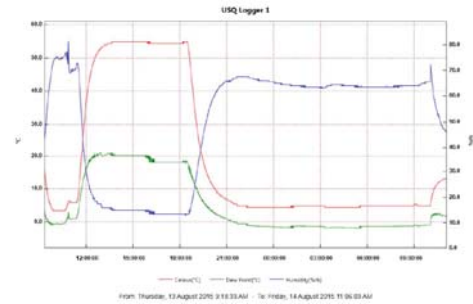


Figure 1 – Temperature curve (red line) for a vessel going from cold, to hot, and back to cold (RH in blue and dew point in green)

Supervisor: Dr Ruth Mossad, USQ

**Keywords:** Heat Transfer, Energy Ratings, Ice Boxes

## 1. Introduction

This research project seeks to develop a cheap, accurate, objective and repeatable rating and testing system for insulated containers (known as eskies, coolers, ice boxes or chilly bins), similar to the star ratings for white goods and plumbing fixtures, whether used for hot or cold items (like pizza pouches).

## 2. Background

Currently there is no uniform rating system for insulated vessels on the market. Whether for the domestic consumer or the insulated shipping container industry, manufacturers carry out their own testing while journalists regularly carry out reviews of coolers on the domestic market, however none of the tests are the same and they tend to be subjective and fraught with risks of inaccuracy due to variables in the tests (such as temperature and quantity of ice used, as well as the issues of ice changing state to water during the tests), or being too application specific such as stock being transported on a particular transport corridor.

## 3. Methodology

By heating and cooling empty test vessels in chambers of differing temperatures (see Figure 1), the heat transfer to and from the air within can be calculated using the vessel's volume and the time taken to reach steady state. Dividing this by the temperature differential creates a single value in W/K for comparison with other vessels.

From this, consumers can learn to interpret which rating is sufficient for their needs, allowing them to purchase an expensive item with confidence, knowing that they have selected the right vessel for the task.

## 4. Key Outcomes

Testing has been carried out on a sample of existing vessels to see how effective this system is. Tests have

also been carried out to determine the effects of relative humidity.

Data from the initial tests show that this testing system is effective in demonstrating an internal temperature change over time in both directions, varying with volume and vessel lining materials.

## 5. Further Work

Tests are also to be carried out for air pressure to determine whether this can skew the results if testing labs are not all at the same atmospheric pressure.

It may also be necessary to develop better chambers which have greater control over temperature, RH and air pressure, to determine with more precision just how much these influence the heat transfer.

The final rating system is still in development, but could either be the conductance, its reciprocal resistance, or something similar to the star ratings mentioned above.

## 6. Conclusions

This project demonstrates that it is possible to introduce a simple, cost-effective, objective, universal testing and rating system for any insulated vessels.

## Acknowledgements

Thanks go to Ruth Mossad (Supervisor), Sandra Cochrane, Vivienne Armati & Marcos Riba (Librarians), and Terry Byrne & Adrian Blokland (Laboratory assistants) for their support, guidance and assistance throughout this project.

## References

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# Planning Support Systems for Complex Infrastructure Development

School of Civil Engineering and Surveying



**Thomas Wager**

Bachelors of Engineering  
(Honours) (Civil Engineering)

Supervisors: Dr N. Mahmood, USQ

**Keywords:** Complex Project Management

## 1. Introduction

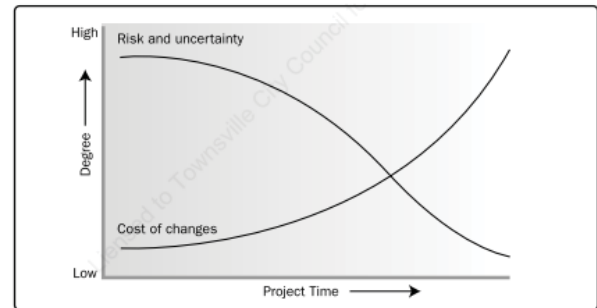
As projects become larger and the complexity faced by engineers to manage those increases, the importance of successful project management techniques has never been greater. In most cases (up to 75 percent of complex projects), the project with budgets greater than \$500 million is considered as complex projects (Engineers Australia, 2014). Engineers Australia (2014) identified that the massive failure rates of complex projects are due to inadequate communication, critical skill and knowledge gaps, or poor conceptual planning as well as "ineffective transfer of lessons learnt between similar projects". All the factors are linked with the effective and efficient decision-making during planning faces of a complex project. The planning support system can assist decision-makers to make decisions under uncertainty. The aim of this thesis is to provide a basis for beginning and experienced engineer's exposure to complex project management methods, and support systems that can be followed.

## 2. Background

As outlined in the introduction, 75% of all complex projects experience a project failure of either schedule or cost overrunning by at least 25%. Complexity of a project may be in the form of uncertainty (Figure 1), a lack of obvious links between cause and effect, personnel, project size, over optimistic estimates or pessimistic attitudes, technical difficulties or trust. The focus of this research is mitigation controls for successfully managing complex projects.

## 3. Methodology

The systemic qualitative literature review is adopted in this research. Systemic review provides a method for researchers to identify, appraise, select and synthesize



**Figure 1 – Cost of Changes vs Project Duration (PMBOK, 2013)**

existing literature. The review processes involve five steps that are outlined and established in the several literature.

## 4. Key Outcomes

Based on the critical review of relevant literature, this research provides a framework for detailed planning support system for managing complex projects. The planning support system is designed to assist the project managers for making better decisions under complex project environment.

## 5. Further Work

The future work will be the implementation of proposed planning support system in real life complex projects.

## 6. Conclusions

There has been a growing interest on the management and decision support systems of complex projects to the project managers, engineers and also to the researchers world-wide. Given the current context, the proposed planning support system for complex projects has the potential to add greater value to the practitioners.

## Acknowledgements

I would like to thank my supervisor Nateque Mahmood for being available and approachable with any issues I have faced.

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# Analysis of the behaviour of composite transom decks for railway bridges

School of Civil Engineering and Surveying



Scott Walker  
Bachelor Engineering (Honours)  
(Civil)

Supervisors: Dr Allan Manalo, USQ

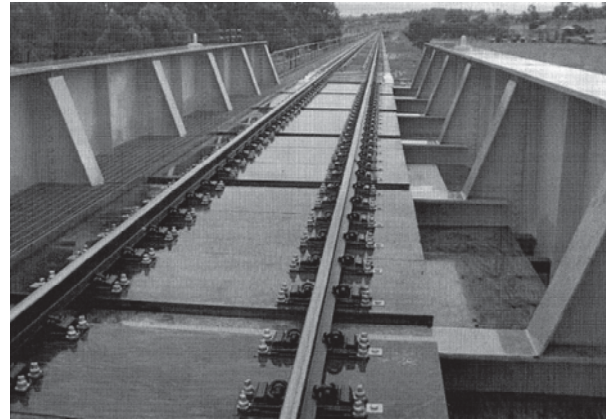
**Keywords:** Composites, Transom, Decks, Analysis, Structural, Bridge, Railway.

## 1. Introduction

Transom decks are an alternative to cross ties for rail bridges. Cross ties are generally larger dimensioned versions of railway sleepers, also known as “transoms”. Transom decks perform the same tasks as transoms, namely, tying the rails at the designated gauge, and transferring the load from the passing train to the structure of the bridge. Transom decks differ to transoms by the simple fact that the deck is a uniform surface and presents as that of a normal road or walking bridge, except with the addition of rails. This project seeks to identify the practicality of fibre composite material fulfilling the role of transom decks in rail bridges.

## 2. Background

Hardwood has been the preferred material for railway sleepers and maintenance work on existing timber sleeper track continues to be provided by hardwoods. Worldwide, there are more than 35 million timber sleepers required to maintain the track quality into a specified level of service. In Australia alone, railway lines require in excess of 2.5 million timber sleepers per year for railway maintenance. Over the past decade, it has been increasingly difficult to get good quality and large section of hardwood timber in quantities to keep up with demand especially in maintaining existing timber-sleeper railway lines. This trend is set to continue and will become critical within the foreseeable future, hence there is an urgent need to develop a sleeper product made from renewable resources.



## 3. Methodology

Research of existing composite fibre technology and its properties will enable an identification of the dimensions and orientation required for a unique composite sandwich panel in the development of a bridge transom deck. Finite element modelling and simulation using strand7 finite element software will be implemented to investigate the overall performance of the composite sandwich transom deck under the wheel loading due to the passing train.

## 4. Key Outcomes

Identification of the orientation and size of the transom deck panel suitable for static and moving train loads. Any benefits or drawbacks of such a system are to be identified.

## 5. Further Work

Develop the strand7 model of loading for the transom deck panel live train load. Potential live testing under expected train wheel loads.

## Acknowledgements

Dr Alan Manalo for his guidance.

## References

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# Improved Cooling System for USQ's Small Scale Icing Wind Tunnel

School of Mechanical and Electrical Engineering



## Rhyan Wall

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(Honours) (Mechanical)

Supervisors: Dr. David Buttsworth, USQ

Dr. Khalid Hashim Saleh, USQ

**Keywords:** Work extraction, expansion based cooling, Design.

## 1. Introduction

This project aims to investigate the feasibility of cooling test air in USQ's small scale Icing Wind Tunnel (IWT) by expanding pressurised air through a work extraction device. The specific device being investigated is a rotary vane air motor, which must be capable of cooling air to below  $-40^{\circ}\text{C}$  to replace the current nitrogen plenum based system being used.

## 2. Background

IWTs are a popular tool used for gathering the bulk of icing simulation data, offering a safe and reliable means to study the effects of ice accretion in repeatable and controlled environments. Typical IWTs flaunt large refrigeration based cooling systems, which are highly costly in operation. USQ's small scale icing wind tunnel has already been adapted to accommodate a nitrogen plenum based cooling system, to gain the necessary amount of cooling at a much lesser expense.

Employing a work extraction device as an alternative system would eliminate several problems with the current system, particularly the large fluctuations in temperature and the introduction of vaporised liquid nitrogen in the air stream.

## 3. Methodology

The project initially aimed to gain an understanding of current IWT cooling systems (particularly the system in question) and their performance characteristics. These specifications provided an overall idea on the performance required of a work extraction device for it to be a viable alternative. Upon review of current devices, a rotary vane air motor was chosen for the study (given theoretical expansion ratios and the envisaged simplicity of analysis). Testing of a commercial air motor served to confirm or disprove

theories about performance, as well as provide data for tuning a theoretical model.

## 4. Key Outcomes

Testing of a 400W DEPRAG air motor proved that commercial variants lack the necessary expansion required, reaching temperature drops of just over  $25^{\circ}\text{C}$ . The data acquired from physical testing shows that the expansion process of a fully loaded system is approximately isentropic in nature. This finding further supported the design and simulation of a purpose built air motor, aimed at maximising work extraction.

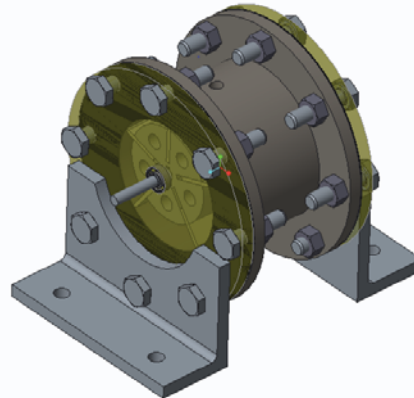


Figure 1 - Specialised Air Motor Design Assembly

## 5. Further Work

Fabrication of a propose built air motor is still possible, however there may not be enough time for testing.

Further opportunities exist to explore the implementation of a reciprocating piston device, which theoretically has an unlimited expansion ratio.

## 6. Conclusions

This thesis has provided a great deal of insight into the capabilities of work extraction devices in providing cooling via expansion. However testing of a rotary vane air motor optimised for expansion capabilities is required to make real conclusions on feasibility.

## Acknowledgements

A special thank you goes to Dr. David Buttsworth, Dr. Khalid Hashim Saleh and Dr. Ray Malpress, whose continued guidance, assistance in lab work and advice has been most appreciated.

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# Quantifying Barometric and Tidal Effects on Groundwater Levels in the Condamine Plain

Sponsor – School of Civil Engineering and Surveying, USQ



**Kieren Ward**

Bachelor of Engineering  
(Honours) (Civil Engineering)

Supervisors: Dr Elad Dafny, USQ

**Keywords:** Groundwater, Frequency analysis, Barometric and Tidal effects.

## 1. Introduction

Groundwater levels in aquifers are known to fluctuate in both the temporal and spatial dimensions in response to processes associated with the input-output balance (e.g. recharge, pumping and evapotranspiration), but also in response to changes in external pressures such as barometric pressure and earth tides.

The primary purpose of this project is to quantify the effects of the external stresses on groundwater levels in bores throughout the Condamine floodplain by conducting frequency analysis on existing hydrographs (time-series of groundwater levels).

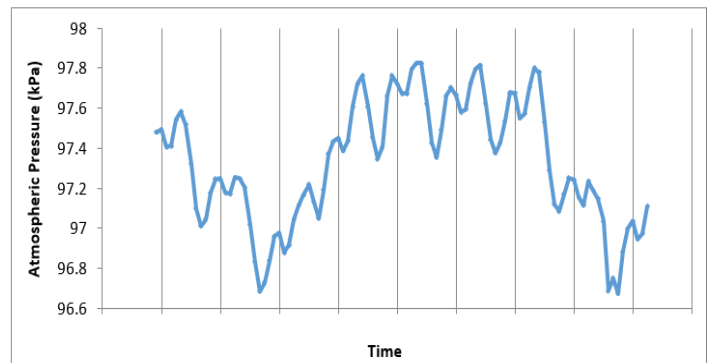
## 2. Background

Important material properties including the elastic properties, porosity and transmissivity of an aquifer are intrinsically related to the aquifer's response to earth tides. Similarly the response of an aquifer to changes in atmospheric pressure is directly related to the degree of confinement of the aquifer as well as the aquifer's hydraulic and storage characteristics.

By quantifying the effects of the barometric and tidal stresses on the groundwater levels of the Condamine River Alluvial Aquifer (CRAA), a path is provided for future hydrologist to calculate important aquifer properties without the need of extensive pumping tests or boring investigations.

## 3. Methodology

The project involved the collection of primary time-series datasets of groundwater levels and barometric pressure from monitoring bores across the Condamine floodplain; an example of the barometric pressure dataset is illustrated in Figure 1. A comprehensive literature review was also required to find appropriate software and mathematical models which would compensate for fluctuations of the groundwater level



**Figure 1 – Atmospheric pressure time-series dataset**

caused by external stresses; and then use these models to perform frequency analysis on the collected datasets.

## 4. Key Outcomes

The project has achieved the following key outcomes: collection of the time-series datasets for groundwater levels, atmospheric pressure and temperature; developed an understanding of the barometric effect and the tidal effect; revealed available methods to compensate for fluctuations of groundwater level caused by external stresses; and performed frequency analysis on the collected datasets.

## 5. Further Work

Further work for this project will include conducting frequency analysis on all the available bore sites within the Condamine floodplain as well as performing statistical and spatial analysis on the results.

## 6. Conclusions

Through frequency analysis on existing time-series datasets the groundwater fluctuations induced by the external stresses on the CRAA have been quantified. Further work can now be conducted to estimate important material / hydraulic properties of the CRAA.

## Acknowledgements

I would sincerely like to thank my project supervisor Dr Elad Dafny for collecting the primary time-series datasets which were essential for the completion of this project, as well as his ongoing support and guidance. I would also like to thank my family for their support.

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# Wastewater Treatment using Tidal Flow Wetlands

School of Civil Engineering and Surveying



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(Civil)

Supervisors: Professor Jochen Bundschuh,  
USQ

**Keywords:** *tidal flow wetlands, wastewater treatment, sustainability*

## 1. Introduction

Tidal flow wetlands for wastewater treatment are one of the emerging intensified wetland systems. They are designed to improve treatment performance by increasing the oxygen supply to the water. In these type wetlands increased oxygen supply is generated by introducing tides into the wetland cells. Increased oxygen supply means these systems can treat water to tertiary standards on much smaller areas than traditional type treatment wetlands. For this project a comparison between tidal flow wetlands, traditional passive wetlands and conventional wastewater treatment plants was undertaken that demonstrates land requirement, construction costs, energy use and treatment performance.

## 2. Background

An increasing demand for more sustainable and environmentally friendly practices and hence stricter discharge standards put pressure on current treatment facilities. Tidal flow wetlands are a promising option for improved wastewater treatment practices.

## 3. Methodology

Following a thorough review of the work of the most important developers and researchers in this field a hypothetical wastewater scenario was developed to be able to compare the performance of a tidal flow wetland to other conventional treatment options. Energy use, land requirement, treatment performance and construction and operating cost were investigated.

## 4. Key Outcomes

Expected outcomes based on research are: Tidal flow wetlands are able to achieve better treatment performance on a much smaller area than traditional type wetlands. They use less energy than conventional wastewater treatment systems while still achieving the same level of treatment. The water quality achieved means wastewater can be recycled for irrigation and in dual reticulation buildings reducing potable water use.

## 5. Further Work

The concept level design and comparison of a hypothetical wastewater treatment situation is currently ongoing.

## 6. Conclusions

Tidal flow wetlands are a promising approach to wastewater treatment and reuse. The real advantage of the system is its ability to reduce nitrogen levels using little energy on a small area. Hence tidal flow wetlands are best suited to wastewater flow low in BOD and TSS, but high in nitrogen.

## Acknowledgements

I would like to thank David Austin for spending the time to answer my many questions over the last months and my partner Graham Peden and my two daughters for their support.

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# Transitioning roadways from high-speed to low-speed environments when approaching Regional Towns in North Queensland



## Jared West

Bachelor of Engineering  
(Honours) Major Civil  
Engineering



Figure 1 – Geographical Study Area

Supervisor: Professor Ron Ayers, USQ

**Keywords:** Transition speed regional

## 1. Introduction

This research project aims to analyse the effectiveness of traffic control devices currently in place to transition motorists from high speed to low speed environments. The target geographical area on the project was North Queensland. Regional Towns such as Ingham, Ayr, Charters Towers and Pentland and their approaches are included in the study.

## 2. Background

There has been a significant amount of research done on transitioning from high-speed to low-speed environments in the past. In particular the US research boards have undertaken significant research. A lack of research in my local area made this project of particular interest to me.

## 3. Methodology

In order to gain an understanding of how well the current devices are performing at transitioning between high and low speed environments I undertook field survey's at multiple locations with a traffic radar gun within the study area. Further to those results I requested all available crash data for the region through the Transport and Main Roads Department.

## 4. Key Outcomes

Findings so far indicate the 85<sup>th</sup> Percentile Speed sampled in all 6 target locations exceed the posted speed limit by greater than 10%, with the highest sampled location providing an 85<sup>th</sup> percentile speed greater than 18% over the posted speed limit. Current analysis of crash data has not indicated anything out of the ordinary, more detailed analysis is required.

## 5. Further Work

Further work includes analysis of environmental and other factors relevant to the region and providing recommendations for changes to existing standards and procedures.

## 6. Conclusions

The project hasn't progressed to the stage where I am in a position to draw definitive conclusions; however my results to date indicate that there is an issue with speed compliance in the region's approaches to regional towns and some action may need to be implemented to provide improvement.

## Acknowledgements

I would like to thank Ron Ayers for the direction he has provided on this project.

## References

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- Manual of Uniform Traffic Control Devices, Part 4 Speed Controls, Queensland Government, 2003



# Establishing a Mix Design Procedure for Geopolymer Concrete

School of Civil Engineering and Surveying



**Aaron Wilson**

Bachelor of Engineering (Civil)

Supervisor: Dr Weena Lokuge, USQ

**Keywords:** geopolymer, fly ash, mix design

## 1. Introduction

The purpose of this project is create a mix design for geopolymer concrete to fill a sustainable void in the construction industry.

## 2. Background

As the population of the world increases so too does the requirement for building materials, in particular ordinary Portland cement (OPC) for the binder in concrete. Geopolymer concrete uses industry by-products as the binder substitute for OPC (Davidovits 1994). Currently, millions of tonnes of these by-products are being disposed of into landfill, whilst OPC is being produced at the highest volumes recorded. With these pozzolanic materials and an alkaline activator we can partially or completely remove the need for OPC in concrete production.

## 3. Methodology

A database was set up containing quantities of materials and tested compressive strengths gained from a literature review. These quantities were then used as inputs for artificial neural networks (ANN) through Matlab, along with the compressive strengths as targets. The neural network then predicted compressive strengths of geopolymer concrete through the use of learning algorithms built into the matlab neural network toolbox. The outputs were then compared to deduce an optimum quantities of materials for 32MPa concrete. Figure 1 indicates the ratios of Hydroxide/Sodium Silicate and that of Alkaline Fluid/Fly Ash required to create various strengths of geopolymer concrete. For 32MPa concrete, use 0.2-0.4 of NaOH/Sodium Silicate and 0.45-0.6 AL/FA.

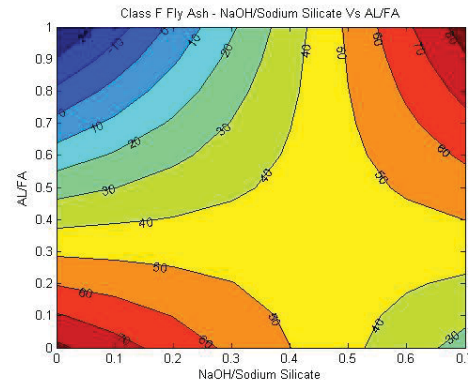


Figure 1 – Class F Fly Ash – NaOH/Sodium Silicate Vs AL/FA.

## 4. Key Outcomes

The use of neural networks for the prediction of compressive strengths of geopolymer concrete is beneficial and can help create a mix design for public use. This will open up the industry to higher usage of geopolymer concrete and in turn a reduction in greenhouse gasses.

## 5. Further Work

Testing of the mix design output from the ANN will need to be performed to compare the results and determine the effectiveness of the research.

To fully cover all possibilities, neural networks should be performed on all available mixes, this is however outside the timeframes of this project.

## 6. Conclusions

The usage of artificial neural networks, along with existing test data, is an efficient and effective way to determine geopolymer concrete compressive strength.

## Acknowledgements

Dr Weena Lokuge for guidance and her continued feedback throughout the year have been invaluable and I am extremely grateful.

I would also like to thank my wife and daughters for their patience and forgiveness of absence during the long hours spent studying.

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# Redefining Standard Compaction Test to Better Describe the Usage of Cotton Picking Machines on Australian Vertosol Soils

Sponsor –National Centre for Engineering in Agriculture (NCEA)



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Supervisors: Dr John Bennett, NCEA

**Keywords:** Vertosol, Compaction, Standard Test

## 1. Introduction

The aim of this project is to investigate the applicability of the standard load used in the uniaxial compression test to describe the impact of large harvesting machines, such as the JD7760, on the soil.

In the past the uniaxial compression test with a load of 200kpa has been used to generate a reference maximum bulk density. This test has been used instead of the proctor test as the proctor test is was seen to generate a load greater than that typically experienced under farm machinery.

However, due to a vast increase in the size and weight of farming machinery it is not uncommon to find soils that have experienced a loading of as much as 600kpa (JD7760). As such there is a need to either redefine the load used in the uniaxial compression test or revert to using the modified proctor test such that the reference compaction generated is representative of that experienced in the field.

## 2. Background

The cotton industry is one of Australia's largest rural exports (Cotton Australia, 2012). One of the most common and difficult to manage issues when farming cotton is compaction (Lipiec & Hatano, 2003). Due to a trend towards increasing vehicle size this is likely to become a greater issue in the future should it not be managed correctly.

## 3. Methodology

In order to achieve the aforementioned aim a review of the pertinent literature has been undertaken. Following this samples were gathered from a variety of sites around South East Queensland.

Following this, Soilflex was used to model the distribution of stresses within the soil during the application of a 600kpa load. (600kpa being taken as the standard load applied by a JD7760).

The results from this analysis will be used to determine a range of applicable loading values. Using these values a series of uniaxial tests will be conducted using a combination of principals derived from articles written by Håkansson (1990) and Suzuki (2013). In addition to this the proctor test will also be undertaken to provide further comparisons.

## 4. Key Outcomes

At the time of writing testing is still to be undertaken on most samples, however this should be well underway at the time of presentation. It is expected that this project will provide an insight into a new reference load to be used in the future.

## 5. Further Work

If time permits a similar process will be undertaken with the proctor test in conjunction with its modelling in SoilFlex.

## Acknowledgements

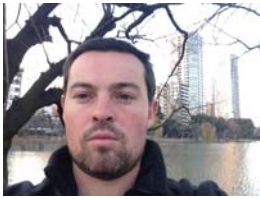
With thanks to Dr John Bennett for his support over the duration of the project.

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# THE RE-ESTABLISHMENT OF DEED BOUNDARIES IN AREAS ADJOINING TORRENS TITLE LAND

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Bachelor of Spatial Science  
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Supervisor: Dr Glenn Campbell, USQ

**Keywords:** Old System Land, Primary Applications, Best Practice Guidelines

## Introduction

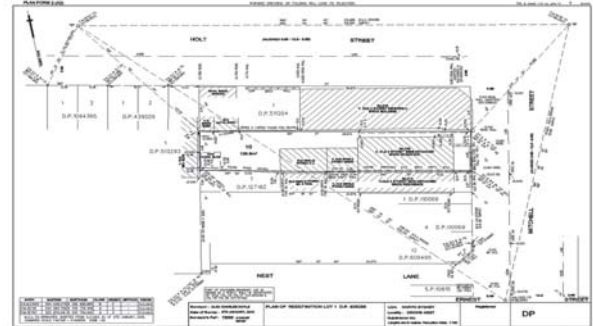
In New South Wales there are two main types of titling systems that operate within the land title office, Old System and Torrens title. Old System titles were in place between 1792 and 1862 and were used to keep a record of government land grants and change of ownership. This system relied on a chain of evidence to prove ownership of land. In 1863 a new system of titling was introduced called Torrens title, which is still in place today. This research project aims to investigate the conversion process of Old System land to Torrens by way of primary applications by private practice and the LPI.

## 1. Background

In New South Wales approximately 1% of land is held under Old System title. There has been an on-going campaign to convert this land to Torrens title, which has benefits for both the state government and private owners. One conversion process is based on a primary application being submitted to the LPI NSW by registered surveyors. This type of conversion is not something that a registered land surveyor does on a common basis. They may only do one every couple of years. A best practice guideline would be a very helpful piece of information for surveyors to use in order to complete the conversion process.

## 2. Methodology

The methodology used for this research paper involves researching the conversion process and finding areas that require more investigating. Deposited plans used for primary applications will be compared to the guidelines to find any flaws with current boundary re- instatement and from there, creating guidelines for surveyors to use in the future.



*FIGURE 1. This picture is of a plan of survey used as part of a primary application. The information on this plan and others like it formed the basis of the research project.*

## 3. Key Outcomes

The key outcomes from the research will include recommendations for other surveyors on how to undertake primary applications when converting the titling of land.

## 4. Further Work

Further work involves compiling the report and concluding the 'Best Practice' guidelines into a format for ease of use.

## 5. Conclusions

The key conclusions of this research paper involve creating a 'Best Practice' guideline for other surveyors to use as part of a primary application.

## Acknowledgements

I would like to thank my supervisor Dr Glenn Campbell, my employers at Johnson Procter Surveyors & Clarke & Dipauli Surveyors and my family and anyone else who has helped me over the past 9 years.

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# Characterization of Swirling Plume Induced By Hot Annular Surface

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(Mechanical)



Supervisors: Dr Ahmed Sharifian, USQ

**Keywords:** *Swirling Flows, Convective Heat transfer, PIV Imaging*

### 1. Introduction

Recent studies show that it is possible to induce a swirling flow without the use of a fan and other mechanical devices. The aim of this study is to characterise the behaviour of side impinged cold fluid flow and raise it from an annular hot surface. The study will be conducted using CFD and experiment approaches. The flows will be ultimately visualized by application of PIV system

### 2. Background

The swirling flow is a complex feature of a flow which is of high interest in industrial applications. Dependant on the application the swirling flow can increase the mixing of fluid, heat transfer or either imparts a centrifugal force.

Consider a hot surface, where cold air is subjected to it. The temperature of the air around the hot surface will increase due to heat transfer, while the surface temperature will drop. Consequently a thin layer of warm air will surround the hot surface and there on heat is transferred to outer air around this layer.

### 3. Methodology

The discussed problem will be approached both computationally and experimentally. Later on the solutions from both the approaches will be compared to validate our exploration in understanding the swirl phenomenon in conjunction with convection.

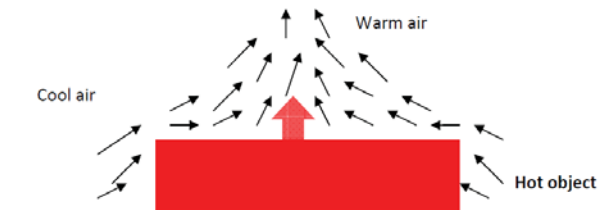


Fig:1 Natural Convection phenomenon (M. Barhami, 2001)

### 4. Key Outcomes

Literture Survey has been performed and significant understanding and insight has been gained to appreciate the phenomenon being explored. The settings and inputs to perform the simulation of the experiment has been identified to carry-out the simulations.

### 5. Further Work

The tasks that are yet to be performed are the experimentation and the simulations which are expected to be conducted by December. The experiment will also be processed using the PIV technique, so as to generate the fluid motion pattern.

### 6. Conclusions

On successful completion of this study we will be gaining immense understanding of the swirling flows and natural convection phenomenon. We will be demonstrating the combined effect of swirling flow in conjunction with natural convection. Procedure to perform a CFD analysis for the swirling flows in conjunction with natural convection process will be established. This study can provide another simple mechanism to generate swirling flow for the industrial and educational application.

### Acknowledgements

I wish to thank my supervisor Mr Sharifain for his immense patience and support to me with this work. My family who has been the driving strength to me during this course can't be thanked enough for motivating me. The Publication of Ruth Mossad(2001) about her study on the convection analysis has been a vital input for me to proceed with my work.

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## ANALYSES OF TWIN TUNNEL STABILITY USING STRENGTH REDUCTION METHOD

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Supervisors: Dr. Jim Shiau, USQ

**Keywords:** Twin tunnel, stability analysis, strength reduction methods, FLAC

### 1. Introduction

This project mainly focus on the investigation of the stability of twin tunnel with consideration of different soil ration, pressure ratio, tunnel spacing, e.g., in undrained clay condition. The strength reduction method adopt by applying FLAC software to simulate different underground tunnel environment and compute their stability. All results are comparable with new castle university published results and our USQ tunnel study group, data shown below are more presentable and evident data picked from big data base. It can be an interesting research to help us in twin tunnel design field.

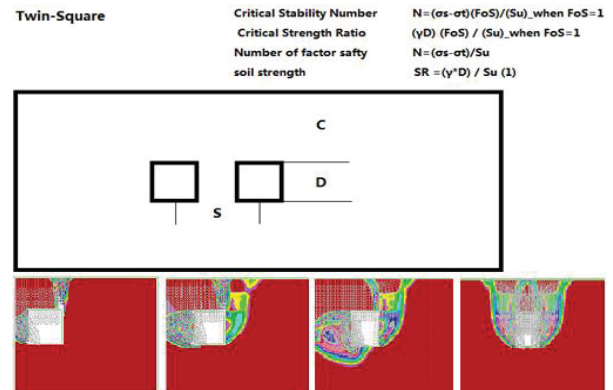
### 2. Background

Following the rapid development of Morden transportation, tunnel as one of the carrier of heavier and heavier transportation are gradually improving as well. Twin tunnel was first proposed in 1944, the western terminus of I-70 was Denver, along the corridor of US 40. The portion across the Rocky Mountains was added to the plans, after lobbying by Colorado officials, following the US 6 corridors, the origins of both the US 40 and US 6 pre-date the U.S. System of numbered highways, using established transcontinental trails.

### 3. Methodology

We have offered a rare method strength reduction method by FLAC in tunnel stability system analysis, our preact are benefit from the rapid development of computers in these years which makes use numerical modelling to deal complex phenomenon like tunnel stability system become possible.

The involve stability number (N) and factor of safety (FOS) was described after 1955 by Bishop, through finite element control we built different type of model with hundred case of each type, through numerical modelling to deal the FOS of every case, then to analysis the effecting of each element.



### 4. Key Outcomes

Through this research I learned to use this method to investigate stability of different geometric problem by using numerical simulation modelling method, I gained more understanding of soil stability relative acknowledge, basic of FISH code, presentation skills, communication skills.

### 5. Further Work

For further works through same method by use finite element control method can compare the advantage and dis advantage of different shapes tunnel in different soil condition. Also I can use strength reduction method to analyses the stability of twin circular tunnels, tall tunnels, wide tunnels. This research could have great divergent development in future.

### 6. Conclusions

The approach of using OFS and FLAC to investigate tunnel stability are useful and success, in design er option it always provides direct information and understanding of twin tunnel stability.

### Acknowledgements

Appreciation wishes to given to all members of USQ Tunnelling Research Group led by Dr. Jim Shiau who developed the FISH codes, and great helps and guidance from my supervisor who making this project possible.

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