Undergraduate Engineering and Built Environment Project Conference 2019

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Final Year Student Research Project Presentations

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Heads of Schools Welcome

A very warm welcome to the University of Southern Queensland, Toowoomba Campus for the 2019 Undergraduate Engineering and Built Environment Project Conference.

The annual Project Conference held on campus in Toowoomba forms the culminating point of your studies in engineering 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 Associate Professor Alexander Kist, Mr Andreas Helwig and the course team for their outstanding work in organising the project conference and activities. We also recognise the efforts of the project examiner, Mr Chris Snook; 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, we would like to welcome you to the Undergraduate Engineering and Built Environment Conference 2019.

The Project Conference, inaugurated in 1998, is being attended by all penultimate and final year engineering and built environment students. This year we are running separate conference for undergraduate, postgraduate and Surveying/Spatial Science/Planning students.

About 250 students are attending the undergraduate conference, 140 students are participating in the postgraduate event and 100 students are coming to the Surveying/Spatial Science/Planning meeting.

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*. 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. We would like to thank the Assistant Examiners Dr Jo Devine, Mr Andreas Helwig, Dr Jason Brown, Dr Ray Malpress, Dr Andreas Nataatmadja and Dr Wijitha Senadeera 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, especially Mrs Melissa Bradey 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.

Associate Professor Alexander A. Kist
Examiner ENG3902 ENG4903
Toowoomba, September 2019

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Improving the prediction of infiltration in crusted soils by measuring the density of the discrete surface seal/crust

Sponsor – Centre for Sustainable Agricultural Systems

Student Name: Cameron Leckie

Bachelor of Engineering (Honours) - Agricultural Engineering

Supervisor: Associate Professor John Bennett, USQ

Keywords: Infiltration, surface crusting, X-ray CT

1. Introduction

Many Australian soils are susceptible to surface crusting. Surface crusts are thin layers with a higher bulk density than the underlying soil. Crusts act as a throttle to infiltration and increase surface runoff.

Traditional soil survey techniques determine bulk density from samples that are many times thicker than surface crusts. This ignores the impact of the crust and is a likely source of error in infiltration and surface runoff modelling. This research project aims to improve the accuracy of infiltration modelling through the measurement of the crust bulk density.

2. Background

Modelling infiltration and surface runoff is of critical importance in many disciplines including agriculture, ecology, environmental engineering and mine-site rehabilitation. As crust bulk density is not normally measured, infiltration can be significantly overestimated leading to model error. Consequential impacts can include inadequate engineering designs and an overestimation of plant available water for agriculture.

3. Methodology

Observed infiltration was obtained from rainfall simulation experiments on soils susceptible to surface crusting a Sodosol and Chromosol . The bulk density of the surface crust was measured using a number of techniques including micro X-ray Computed Tomography CT . Observed infiltration was compared against HYDRUS-1D modelled infiltration to determine whether measuring the density of the surface crust improved model accuracy.

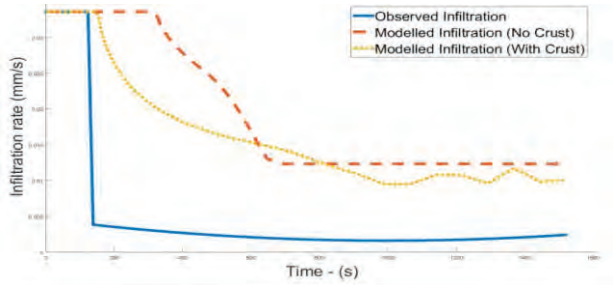

Figure 1 Modelled versus observed infiltration (Sodosol)

4. Key Outcomes

Surface crusts reduced infiltration to a small fraction of applied rainfall. X-ray CT was used to quantify crust thicknesses which averaged ~1 mm. The most accurate method of determining surface crust bulk density was to calibrate X-ray CT results against the traditional soil core ring method. HYDRUS-1D modelling using only soil texture and bulk density data provided a very small improvement in accuracy Figure 1 .

5. Further Work

The incorporation of water retention data into HYDRUS-1D modelling is in progress as is a sensitivity analysis to determine the relative importance of surface crust parameters on the accuracy of infiltration modelling.

6. Conclusions

X-ray CT provides an excellent tool to measure surface crust parameters. Whilst the crust had a major impact on infiltration, measuring its density only marginally improved results using HYDRUS-1D.

Acknowledgements

I would like to thank Associate Professor John Bennett for his guidance and support, Dr Rob Loch from Landloch for the use of the rainfall simulator and Dr Richard Flavel from UNE for support with X-ray CT.

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Construction Project Management – What Knowledge Backgrounds Fit the Mould?

Sponsor – School of Civil Engineering and Surveying

Jacob Cox

Bachelor of Construction (Honours) Construction Management BCNH

Supervisors: Dr Nateque Mahmood, USQ

Keywords: Construction, Management, Project Management Competencies

1. Introduction

Project management is a fundamental part in the construction industry as every construction based project requires the implementation of a project manager or managers. Competency within the project manager role is vital as according to Frank, 2002) the project manager has a direct influence over 34–47% of project success. Further to this, key competencies, skills and knowledge areas have been researched to determine requirements with a plethora of competencies required to operate and meet the time, cost, quality and safety constraints of construction projects. Based on these previous studies, it is clear that project managers play an important role in determining the success of a project.

2. Background

Within the construction industry mid-tier construction companies find themselves with project managers from a variety of backgrounds. The researcher of this project discovered a range of backgrounds, each holding differing strengths and weaknesses. These backgrounds differ from industry trade knowledge to university and tertiary study backgrounds.

3. Methodology

In order to understand which of the knowledge backgrounds best suit the role of the project manager within a mid-tier construction company, surveys will be undertaken by employees of differing positions within a mid-tier construction company in order to synthesis and determine what core competencies are required for the role. From the outcome of these surveys the results will be data analysed to rank the competencies and then paired against knowledge outcomes from differing knowledge backgrounds identified and related to determine which knowledge background fits the mould of the construction project manager.

Figure 1: Generic knowledge areas of project management (Edum-Fotwe and McCaffer, 2000)

4. Key Outcomes

This project intends to assist with the recruitment and assessment of potential project management candidates, and also assist with the identification of current project managers skill/knowledge deficiencies. A preliminary framework will be provided which outlines what project manager competencies are required.

5. Further Work

Due to time restrictions, further investigation should be undertaken into the recruitment process and further refine a framework in which intends to eliminate wrongfully selected candidates. Further work should also be undertaken on the non-tangible criteria associated with working in a management role.

6. Conclusions

This project highlights the key core competencies of a project manager within the construction industry. The requirement to be so diverse in knowledge, competency and skills pertaining to the works being undertaken by mid-tier contractors is the reason why research surrounding this area is imperative to finding and identifying suitable project managers.

Acknowledgements

I would like to thank Dr Nateque Mahmood for his guidance and assistance with the project and also all of those that participated in the surveys and provided invaluable feedback and data.

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The effect of wide centreline treatments on reducing run-off-road-left incidents on rural Queensland highways and support for a review of road shoulder width guidelines

School of Civil Engineering and Surveying

Peter McNamara

Bachelor of Engineering (Honours) Civil

Supervisor: Dr Soma Somasundaraswaran, USQ

Keywords: Road safety, Wide Centreline Treatment WCLT , Run-off-road-left RORL

1. Introduction

This project investigates the effect of wide centreline treatments (WCLT), particularly on run-off-road-left RORL events on lower volume Queensland highways. The project will extend current understanding of the WCLT's effect, enabling comparison with earlier Bruce Highway-based studies to establish whether research into the use of narrower sealed road shoulders with WCLT could be supported.

2. Background

WCLTs have been introduced to a number of major Queensland highways since 2011 with the purpose of reducing the most severe vehicle crash types, the head-on/cross centreline (HOCL) event. They provide up to 1m of lateral separation between opposing traffic flows, as shown in Figure 1, and can be retrofitted to existing road pavements by reallocating road space. As WCLT involve only a combination of paint and audio-tactile line markers they offer an economical safety option.

Previous crash studies on treated Bruce Highway segments have established up to a 33% reduction effect on the target crash type, HOCL Luy, Atabak & Affum, 2018). These studies also found a crash reduction effect of 20% on RORL events, researchers hypothesising that WCLT would negatively affect this crash type. With data from other highways now available, this project builds on previous studies, revealing whether this unexpected effect on RORL events is also seen on lower volume highways.

3. Methodology

Before-and-after statistical analyses are commonly employed to determine a treatment's crash reduction effect. A literature review identified the Empirical Bayes EB) approach as suitably robust and able to account for component effects.

Figure 1 – Wide centreline treatment (Thomason, 2018)

The EB analysis used crash data from both reference and treatment sites. Reference data was used to develop safety performance functions that enabled 'predicted' crash numbers at treatment sites to be calculated. These were compared with the actual crash figures to establish the crash reduction effect, particularly on RORL events.

4. Key Outcomes

This project aims to determine:

- The crash reduction effect and crash modification factors for lower volume Queensland highways.
- The necessity of further investigation of road shoulder widths with WCLT guidelines.

5. Further Work

The completion of the EB analysis will enable comparison of the crash reduction effect with Bruce Highway studies. Should it be verified that WCLT reduce the rate of RORL incidents across all highways, then subsequent investigation into the use of narrower road shoulders with WCLT may be supported.

6. Conclusions

If the positive effect of WCLT on RORL crashes is replicated on lower volume highways this will inform the viability of further investigation into WCLT guidelines and the use of narrower sealed shoulders.

Acknowledgements

Thanks to my supervisor Dr Soma Somasundaraswaran, particularly for his guidance and understanding, and the Department of Transport & Main Roads for project data.

References

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Stressed-Skin Autoclaved Aerated Concrete (AAC) Core Panel

School of Civil Engineering and Surveying

Brendan Shane Matthews

Bachelor of Engineering (Honours) (Civil Engineering)

Supervisors: Mr Gary Elks, USQ

Keywords: Autoclaved Aerated Concrete (AAC), Sandwich Panel, Flexural Investigation

1. Introduction

The sandwich panel concept has been effectively used in areas such as aircraft, automotive vehicles, trains and is even evident in nature through examples such as the human skull (Ashby 2011). With the many desirable characteristics that sandwich panels contain, it is also useful in many building applications.

2. Background

Some core materials currently used in this style of construction, such as foam, possess potential certification and safety issues, resulting from poor flammability and toxicity properties. Autoclaved aerated concrete AAC) is a cellular structured lightweight concrete material with characteristics well suited to the theory behind sandwich panel core materials, whilst addressing the potential risks with existing core materials. This study aims to investigate and design stressed-skin panels with an AAC core using different skin materials, to determine its potential applications in the Australian building industry.

3. Methodology

Initial and subsequent 4-point load testing was undertaken to investigate the options for skin materials, with GFRP and steel compared against a control AAC panel. Analytical methods were then applied to replicate the shear and bending failure loads seen in the tests. Four potential applications were identified; walls, roofs, floors and formwork. The Australian Standards were used to gather the serviceability and ultimate strength criteria conditions. The analytical methods were adapted to suit a more realistic uniformly distributed loading condition and the maximum applied load for each application was found, whilst still satisfying the criteria.

4. Key Outcomes

It was found that when used in conjunction with an AAC core, the steel skinned option was most suitable and recommended skin material. This was due to not only its structural performance, but also it's ability to be more easily integrated into current building systems and client expectations. Analytical methods allow span tables to be produced, which show the limiations of use and the maximum load capacity for each respective span and core thickness combination, refer to Figure 1 for a graphical representation.

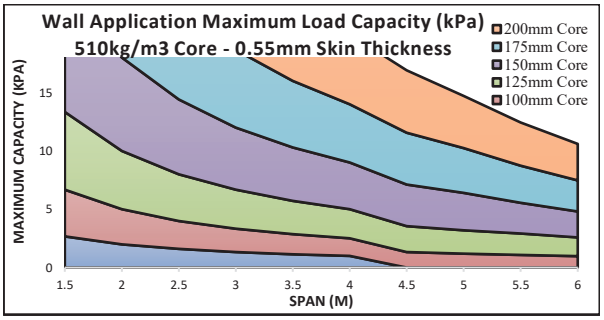

Figure 1 - Preliminary Load Capacity – Wall Application

5. Further Work

Ongoing refinement of the analytical methods is required to finalise the results, and in the future, it would be beneficial to undertake additional testing of steel skinned sandwich panels with an AAC core. More data about the ultimate failure and behaviour of the combined materials would broaden the understanding of the concept. This would solidify the existing knowledge whilst taking the next step towards commercialising the product for the Australian construction market.

6. Conclusions

Ultimately, it was determined that the sandwich system comprising of steel skins separated by an AAC core can be used as a safe and effective structural wall, floor, roof or as part of a formwork system. The span tables provide the load carrying ability of the explored core densities, core thicknesses and the steel skin thicknesses. The variation in criteria from each building application was reflected in the load carrying capacities, highlighting the most important aspects that relate to each application.

Acknowledgements

I would firstly like to thank my supervisor Mr Gary Elks for providing the inspiration and guidance on this topic, along with Associate Professor Allan Manalo for his technical assistance for the analysis. Finally, I would like to thank my immediate family for their great support throughout the project and preceding studies at USQ.

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Redefining the intervention level for upgrading unsealed roads to sealed roads in Rural NSW, main focus, Parkes Shire Council

School of Civil Engineering and Surveying

Joel Cowling

Bachelor of Engineering (Honours) (Civil)

Supervisors: Dr. David Thorpe, USQ

Keywords: Local Road Network, Unsealed Roads, Local Government.

1. Introduction

Rural Councils in NSW have large sealed and unsealed networks with a smaller population per capita meaning there is less money injected into the Council for maintenance of road networks while the same level of service is still expected by members of the community as well as road users. The project aim is to conduct a study on current construction techniques on a whole of life approach (figure 1) and how this could be changed with emerging technologies to produce an asset with a longer service life more efficiently. This will be done by comparing Parkes Shire Council traditional construction techniques vs road reclaimer/rehabilitation techniques to upgrade a road from an unsealed Level of Service (LOS) to a sealed LOS therefore saving on annual maintenance cost and increasing the asset life of pavements.

2. Background

Parkes Shire Council does not have a defined strategy for when to seal an unsealed road, historically, Parkes Shire Council and other rural councils have upgraded pavements from an unsealed standard to a sealed standard ad-hoc or not at all. This is due to the culture & organisational thinking that this method is the most economical. With new technologies reducing construction cost and natural resources beginning to deplete Councils now need to look at other alternatives to increase pavement life.

3. Methodology

Analysis of four locations which have been chosen for testing, each with different characteristics. A cost-benefit analysis system was then created to compare time efficiencies of vehicles traveling on different pavements, safety increases, construction cost converting the data to a numerical value that will assist in the decision-making process for rural Councils.

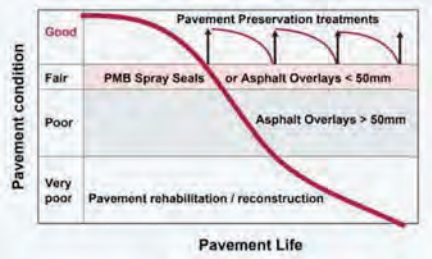

Figure 1 – Pavement Life Cycle with treatment strategies (IPWEA 2018)

4. Key Outcomes

This study will assess the current situation by analysing existing pavements and construction cost to develop criteria for rural Councils to use which will assist in the decision-making process of when to upgrade unsealed roads with the assistance of a Checklist and a Cost Benefit Analysis (CBA).

5. Further Work

Construction of the cost benefit analysis excel spreadsheet is in progress, investigation of the selected sites is ongoing with results to be collated in the near future.

6. Conclusions

It is expected that a system will be constructed which will assist Councils to make educated decisions regarding upgrading roads to a sealed standard.

Acknowledgements

I would like to thank my supervisor Dr. David Thorpe (USQ) for his guidance and contribution towards my dissertation as well as Parkes Shire Council for providing me with the resources to complete my project. I would also like to thank my family who has supported me throughout my research.

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Addressing climate change in the management of road infrastructure through the control of carbon

School of Civil Engineering and Surveying

Daniel Alkhoury

Bachelor of Engineering (Honours) Civil Major

Supervisors: Dr David Thorpe, USQ

Keywords: Carbon offset, Photovoltaic tiles, Road infrastructure design projects

1. Introduction

The impacts of carbon with regards to the development of road infrastructure and the use of the latest available technologies form the basis of the research. The Carbon Gauge tool is used to assess existing road infrastructure design projects. The Carbon Gauge is a tool currently available to measure the carbon equivalent of the greenhouse gas emissions associated with all aspects of the road infrastructure design project life cycle. A Carbon Offset tool is developed which considers the mitigating effects that the use of certain technologies, in this case a photovoltaic tile system, will have in reducing the carbon footprint associated with the same road infrastructure design projects previously assessed using the Carbon Gauge.

2. Background

The research attempts to address one of the many factors associated with climate change. Greenhouse gas emissions are identified as a major contributing factor in the cause of climate change.

3. Methodology

The methodology involves the following steps:

1. Assess existing road design projects for the carbon equivalent of greenhouse gas emissions using the Carbon Gauge tool in terms of its design, construction, operation and maintenance for a period of 50 years.

2. Determine project areas which meet the criteria to implement the photovoltaic systems. This technology is selected as it is at the cutting edge in terms of real world implementation in the near future, although issues related to long term use are yet to be resolved.

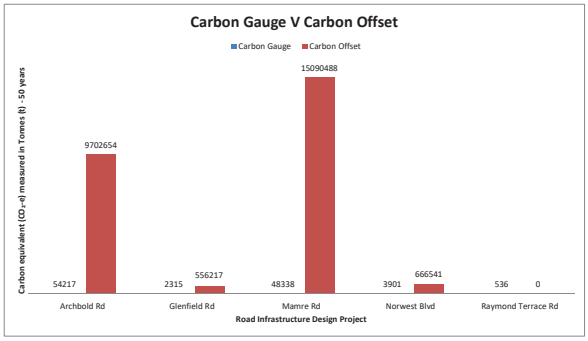

Figure 1 – Carbon Gauge V Carbon Offset overall results

3. Determine the carbon offset from the generated electricity which mitigates electricity generation by traditional means.

4. Key Outcomes

The research project highlights the impact that the consideration of implementing one new technology in road design projects can have on the effects of carbon (Fig 1). Not only is there a potential to offset all the carbon generated by greenhouse gas emissions, in some cases the offset is so great that it could also be used to offset carbon generated by other activities other than that which are related to the road infrastructure.

5. Further Work

A more comprehensive research project is achieved with the incorporation of various technologies.

6. Conclusions

It is demonstrated that there is merit in considering the implementation of modern technology within a road infrastructure design project which can significantly impact how carbon is managed in the transport sector.

Acknowledgements

To my supervisor Dr David Thorpe, it is thanks to your guidance that I was able to submit something which is somewhat coherent.

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CRUSHER DUST-MANSAND REPLACMENT of NATURAL SAND

Sponsor – Construction Science (Vic), Holcim (Vic), Hanson (Vic) and Boral (Vic), School of Civil Engineering and Surveying

Nirbhay Prasad

Bachelor of Engineering (Honours) (Civil)

Supervisor: Dr Sourish Banerjee, USQ

Keywords: Man sand-manufactured sand, crusher dust, workability, concrete, aggregates.

1. Introduction

Today, the demand for concrete and concrete aggregates has increased drastically in Melbourne and in Australia at large. This is causing depletion in sand sources. This project will focus on studying the suitability of recycling crusher dust Manufactured sand), a by-product of quarry operation as a 100% alternative solution in replacing natural sand for concrete production (refer Fig. 1). Properties of natural and man sand will govern the selection and manipulation of sand ratios for the concrete mix designs. In this research the only variable will be man sand ratios with the other factors will remain constant. Experimentally physical properties of the normal concrete and man sand concrete will be compared and adjustments would be made to better the use of man sand.

2. Background

In Victoria natural sand for use of concrete is becoming scare. This is putting pressure on concrete industry for a need to source an alternative source for sand. One possible alternative is the crusher dust which is a by-product of Quarry operation. The current research aims to extend the current use of crusher dust which is a sustainable approach for the environment and in effect, would reduce the cost of sand production/sand mining.

3. Methodology

In this research project I have obtained six different types of samples of man sand from various quarries. Physical properties of natural sand and man sand were determined in accordance with Australian Standards (AS1141 series). Man sand properties having the closest match to the natural sand was selected for this research. Then normal concrete of 50MPa (control experiment) and a series of trial concrete specimens using man were tested in accordance to AS1012 series. Physical properties including shrinkage, water absorption and flowability of man sand concrete were determined at 7 days. Properties after 14, 28, 56 days would be determined in due course. The findings were tabulated and analysed. Past literature were taken into consideration in manipulating the mix ratios for better outcome. Using this adjusted/improved mix ratio, new batches of man sand concrete are to be produced analysed.

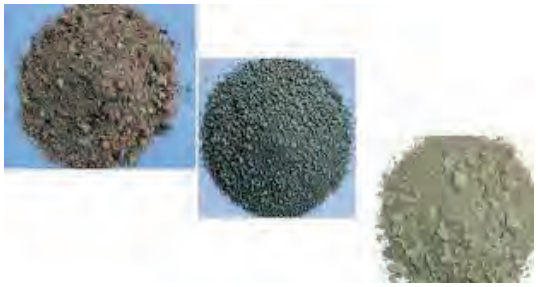

Fig. 1: ***Bottom right-Natural sand, top & middle man sand***
https://www.holcim.com.au/products-and-services/aggregates-quarry-products/sands

4. Key Outcomes

After replacing the natural sand with man sand the properties of concrete changed in both ways, good and bad. The good outcome recorded at 7 days was the increase in compressive strength and not much change in shrinkage. In contrast, increase in permeability and water cement ratio and decrease in workability are the non-desirable outcomes.

5. Further Work

Work in progress to explore workability, permeability and water cement ratio so that man sand concrete can be readily available for use.

6. Conclusions

To conclude at this point of research is that crusher dust as man sand could be a good alternative for natural sand. Preliminary results that indicated that manufactured concrete has better results than normal concrete except for workability. The message to the concrete industry is that the man sand could be a good alternative for natural sand.

Acknowledgements

I would like to acknowledge the following people; Dr S. Banerjee USQ, Supervisor), Mr. S. Mane (Holcim, Technical Manager), Mr. B. Harris (CS, Area Manager)

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Suitability of polyester-based thermoplastic polyurethanes as a fuel resistant asphalt binder in flexible aviation pavement surfaces

School of Civil Engineering and Surveying

Aaron Fiedler

Bachelor of Civil Engineering (Honours)

Supervisor: Dr Andreas Nataatmadja, USQ

Figure 1 – RAAF Darwin Pavement Damage

Keywords: Fuel-resistant binder, polymer-modified binder, aviation pavement.

1. Introduction

Failure of aviation pavement surfaces are predominantly confined to rutting, shearing, cracking bleeding, stripping, ravelling and the breakdown of aggregate (White, 2018 . Aviation pavements are extremely susceptible to failure from petrol, oil and lubricant spills. Development of a fuel-resistant binder, using a polyester-based thermoplastic polyurethane (TPU , has the potential to revolutionise the industry of flexible aviation pavement surfaces.

2. Background

Aviation fuel leaks from aircraft due to component failures and maintenance operations on RAAF bases cause considerable damage as shown in figure 1. This creates capability barriers in the form of restricted pavement operations and possible early structural failure of a surface.

3. Methodology

The Performance-based Airport Asphalt Model Specification 2018), was used for the design of 14mm nominal size mix. TPU pellets were mechanically combined with C320 binder in doses of 3%, 5% and 7% by mass. These polymer-modified binders (PMB) were tested for dynamic viscosity, softening point and fuel resistance. In total 16 asphalt samples were produced using C320 and the PMBs to perform Marshall Stability and Flow and fuel-resistance testing.

4. Key Outcomes

Polyester-based TPU does not incoroporate with C320 to the point of digestion with chosen techniques. This is likely to result in little improvement to fuel-resistance. Adhesion properties of PMB present mixability issues.

5. Further Work

Fuel-resistance testing and reporting is outstanding. Experimentation with advanced incorporation techniques may develop PMBs with a suitable level of digestion.

6. Conclusions

Fuel-resistance testing will provide data on suitability in this arena. Current test results indicate that polyester-based TPU modified binders are prohibitive due to inconsistencies in Marshall Stability and Flow as a result of mixing issues.

7. Acknowledgements

I would like to thank Fulton Hogan Darwin for access to their laboratory and resources. Of special note, Chris Parsonson, whom provided technical guidance throughout the project.

8. References

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Infill Development Impact on the Capacity of Regional Drainage Networks

Sponsor – School of Civil Engineering and Surveying

Mathew Whitby

Bachelor of Engineering (Honours) (Civil)

Supervisor: Dr Rezaul Chowdhury, USQ

Keywords: Stormwater; Drainage; Development

1. Introduction

This dissertation aims to identify the capacity of the existing drainage network in the urban areas of regional towns and the scope for further development in the towns. The research will identify the maximum density of development permissible under current planning law and analyse if the existing drainage network will be able to cope with the potential increase in runoff from the larger percentage of impervious area in the catchment.

2. Background

The capacity of the existing drainage network in the older areas of the townships in Victoria is largely unknown. There are several locations throughout Bass Coast Shire where localised flooding issues are common. There is often no record of the design computations for the drainage assets in these areas. It is believed that the hydraulic capacity of the drains in these areas will not be designed for the intensity of development which is permissible under current planning legislation. Infrastructure may be strained with the shift to a denser urban environment in Bass Coast

3. Methodology

Several study areas (catchments) were chosen based on the potential for infill development. The drainage infrastructure was then modelled in PCSWMM software similar to Paule-Mercado et al (2018) and the results of the pipe flow vs hydraulic capacity have been analysed. The catchment properties are then modified assuming the catchment is developed to its full potential (LGIDA 2019) and any pipes which capacity is now exceeded will be recorded. Several temporal patterns were modelled to accord with Ball et al 2016). See Figure 1 for an example of the PCSWMM model developed. The blue dots are the pits; yellow lines are pipes; and the green polygons are subcatchments.

Figure 1 – PCSWMM model of the Cowes study area

4. Key Outcomes

The hydraulic capacity of the existing drainage network is mostly adequate for the existing level of development. However there are already some areas of insufficient capacity which is concerning, particularly when there is scope for future infill development.

5. Further Work

Modelling of the maximum level of development is yet to be completed. Results will then be compared.

6. Conclusions

Drainage authorities must plan for ongoing infill development due to the strain on the existing drainage network. Although much of the network is adequate for the existing level of development, there are already pipes which have insufficient capacity and future infill development may exacerbate problem areas.

Acknowledgements

I would like to thank Dr. Rezaul Chowdhury for his ongoing guidance for the duration of the project and the staff at Bass Coast Shire Council for their ideas, local knowledge and support.

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Validation of the SCS TR-55 method on Whangarei District Watersheds and Soil Types

Sponsor - School of Civil Engineering and Surveying

Matthew Jacobson

Bachelor of Engineering (Honours) Civil

Supervisors: Dr Rezaul Chowdhury, USQ

Keywords: Peak Runoff, Rainfall, SCS,

1. Introduction

The design of hydraulic structures relies heavily on the estimation of rainfall generated runoff. The TR-55 method is widely used throughout the world to estimate peak runoff during rainfall events. TR-55 was first issued in the United States by the Soil Conservation Service in January 1975, being revised in 1986 (United States Department of Agriculture, 1986). Rainfall excess is calculated using watershed parameters, a normalised rainfall distribution and selected Curve Number CN values. The CN values are more commonly know as runoff coefficients and vary dependant on soil type, ground cover and land use. The method describes four soil categories, giving differing CN values for varying land uses United States Department of Agriculture, 2009).

2. Background

The Whangarei District is located in the Far North of New Zealand, being a sub-tropical coastal region. The Whangarei District Council requires the use of the TR-55 method for the estimation of peak discharge as a basis of design for hydraulic structures. The use of the TR-55 method, particularly the application of the CN curves lacks validation, and therefore is potentially inaccurate for certain design applications. The objectives of the project include a detailed analysis of known rainfall events to determine CN values for the major soil types in the Whangarei District, determine the sensitivity / effect if varying CN values on calculated runoff and gain an understanding of the implications of the require CN values on the design of simple hydraulic structures.

3. Methodology

This research was conducted analytically through the use of recoded rainfall and discharge from three watershed to enable the back analysis of the best fit CN value. Using rainfall data from seven gauges, five rainfall events were isolated with rainfall depths

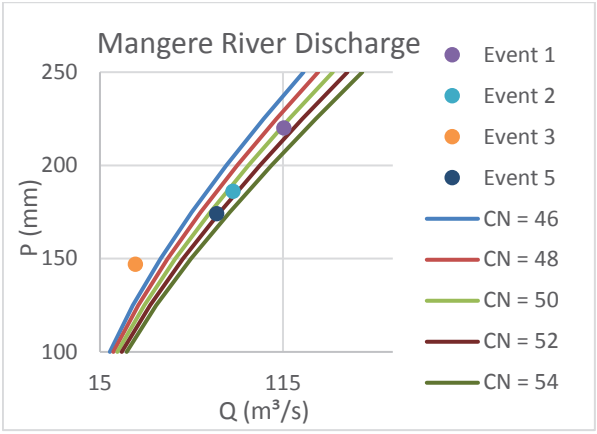

Figure 1 – Mangere At Knights

determined and the corresponding observed peak watershed discharge at the three river gauging station were noted. The measured peak discharge and calculated peak discharge for varying CN values is plotted against rainfall refer Figure 1 allowing the selection of a best fit CN value.

4. Key Outcomes

The methodology has initically produced results which indicate the CN values precribed in TR-55 are not are valid for the Whangarei District watersheds and soil types.

5. Further Work

To aid in the selection of CN values for differing soil types, infiltration testing using a double ring infiltrometer is planned.

6. Conclusions

At this stage it is too early to draw a clear conclusion from the modelling data, however, is it evident that due to the lack of small monitored watershed, the validation is limited to large rainfall events.

Acknowledgements

I would like to thank Dr Rezaul Chowdhury for this input and my colleagues at RS Eng Ltd for their continued support in completing my project research.

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Investigation of alternate processing methods for leachate produced by Toowoomba Waste Management Centre

School of Civil Engineering and Surveying

Courtney Major

Bachelor of Civil Engineering (Honours)

Supervisors: Dr Antoine Trzcinski, USQ

Mr Matt Torr, Toowoomba Regional Council

Keywords: leachate, management, Toowoomba Waste Management Centre

1. Introduction

Landfill is currently the primary disposal method for municipal solid waste (MSW) that is unable to be recycled. In Queensland, 54% of the 11 kilotons of MSW generated, is deposited in landfill, resulting in 6kt of waste buried per year (Pickin et al. 2018). A direct environmental impact caused by landfill is the generation of leachate. Leachate is a contaminated liquid generated by landfills due to rainfall percolating through the waste.

2. Background

The Toowoomba Waste Management Centre (TWMC is a landfill managed by the Toowoomba Regional Council. As existing landfills are closed and rehabilitated across the region, all residual waste will be diverted to TWMC. It is expected that TWMC will service the region for at least another 80 years. Leachate from TWMC is currently diverted to Wetalla Water Reclamation Facility for treatment. There have been concerns however, that due to the discovery of emerging contaminants and increasing levels of regulation, Wetalla may not be a long-term feasible option for treating the leachate. For this reason, a system needs to be installed to manage the leachate produced by TWMC. Many treatment options are available, however they are often specific to the particular lifecycle phase of the leachate.

3. Methodology

Leachate depths and precipitation were collected and analysed to determine the level of contamination and effects of rainfall. Figure 1 shows the variation of pH level over time at Cell A, one of the important factors to consider when selecting a leachate management system. Research was undertaken to find a solution that would suit all relevant types of leachate.

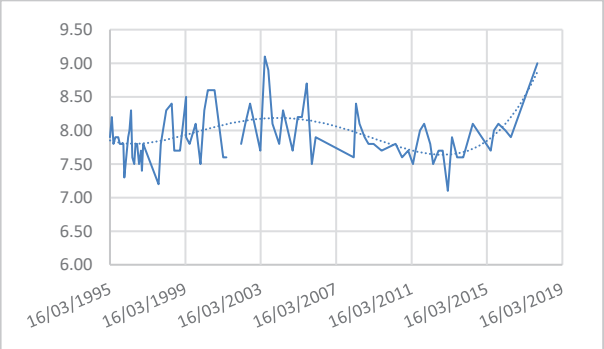

Figure 1 – pH Levels against time in Cell A, TWMC

4. Key Outcomes

Evaporation and membrane bioreactors are the two systems that have been shortlisted that will adequately treat leachate of all ages, be economically viable and sustainable for Toowoomba Regional Council and remain environmentally friendly.

5. Further Work

Additional research is required to determine which of the two options are more suitable for leachate treatment at TWMC. Future studies may then add to these systems to produce a better-quality effluent through further treatment.

6. Conclusions

This project will give data-based advice on the type of system/s that should be employed by Toowoomba Regional Council to adequately manage leachate generated by TWMC.

Acknowledgements

I would like to thank Dr Antoine Trzcinski for being my supervisor, Matt Torr for the support and guidance throughout this project and my colleagues at work for helping me collect data and answering questions.

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The use of geopolymers for stabilising expansive soils

School of Civil Engineering and Surveying

Dylan Daley

Bachelor of Engineering Honours

Supervisor: Dr Andreas Nataatmadja, USQ

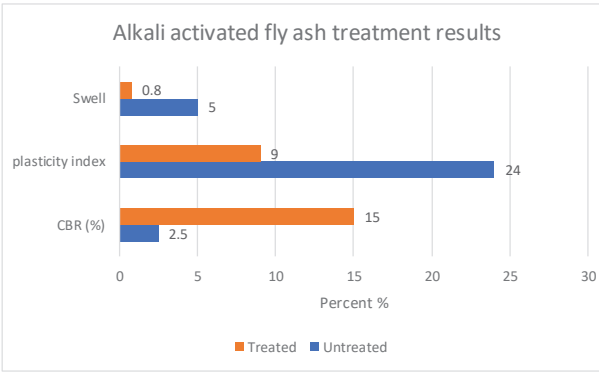

Figure 1- Comparison of treated and untreated soil

Keywords: *Stabilisation, Expansive soil, geopolymer*

1. Introduction

Expansive soils are common throughout the world and especially in South East Queensland. Expansive soils pose a risk to pavements and structures built on them. Expansive soils shrink and expand as the moisture content changes, resulting in excessive cracking and movement. This movement is hard to predict as expansive soils react non elastically, so their behaviour is difficult to predict.

Various stabilisation options are available, each with varying performance, cost and application constraints. Geopolymer stabilisation has several advantages, namely in cost and sustainability.

2. Background

Stabilisation of expansive soils is important as it offers reliable performance of soils and reduced maintenance costs of infrastructure. Current stabilisation methods usually employ the addition of lime or cement powder to soils. These materials have a high carbon cost and are expensive to produce. Fly ash stabilisation has the advantage of being relatively cheap and environmentally friendly, as fly ash is a waste product.

3. Methodology

Research was conducted to determine the most effective tests to identify expansive soils. After this was determined, previous research was examined, and efficient treatment options were found.

The soils were then tested to determine the natural properties, which gave a baseline to compare with after the treated soil was tested. All tests were conducted in accordance with relevant Australian standards.

4. Key Outcomes

The research found that fly ash geopolymers can greatly increase the bearing capacity and performance of soils identified as expansive. As the diagram above illustrates, there was a significant improvement in soaked bearing capacity, as well as a favorable reduction in vertical swell and plasticity index.

5. Further Work

A cost analysis of fly ash stabilisation compared to contemporary methods needs to be conducted to determine if it is economically viable.

6. Conclusions

This project was successful in showing that mechanical improvements could be made using the fly ash geopolymers. The practical applications for this technique could be investigated further, hopefully leading to the reduction of carbon costs involved with soil stabilisation.

7. Acknowledgements

The author would like to thank Dr Andreas Nataatmadja for providing this research topic and constant guidance throughout the research process. Special thanks also to the technical staff at USQ Toowoomba, Daniel Eising and Piumika Ariyadasa. Without their support and help the research would not have been possible.

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Comparison of land vs floating evaporation pans to measure evaporation from dairy farm effluent ponds in the Waikato Region, New Zealand.

School of Civil Engineering and Surveying

Jack Wass

Bachelor of Engineering (Honours) (Civil Engineering)

Supervisor: Miss Justine Baillie, USQ

Keywords: Evaporation Estimation, Floating Pan, Seepage losses.

1. Introduction

Effluent retention ponds are widely used on New Zealand farms to contain effluent for re-use or treatment. A form of mass balance analysis is used in an attempt to estimate the seepage losses of these structures and their resulting compliance with regulations. This method accounts for all inflows and outflows and relies most heavily on the estimation of the evaporation losses. This project focused on researching, constructing, and testing a floating evaporation pan to determine if this could provide better evaporation estimates than the land-based version currently in use throughout the industry.

2. Background

A fail result means the pond must be relined which is costly and heavily disruptive. An incorrect pass result means that local water sources and environments could become contaminated with pollutants. Historically these tests have hinged on the use of a range of land-based evaporation pans. Current research has demonstrated that floating evaporation pans have several advantages over their more common land-based counterparts Masoner et al. (2008). However, there has been no research into their use on small effluent ponds like those in New Zealand.

3. Methodology

This project was undertaken by following these main steps: **1)** Evaporation pans and their influencing factors were researched to inform the custom pan and test design for this application. **2)** The pan was trialled alongside an existing land based version at a range of representative testing sites. Data was collected from both pans in conjunction with that from the wider mass balance analysis. **3)** The results were analysed and impact on the final seepage estimates were determined.

Figure 1 - A floating evaporation pan (Masoner et al. 2008)

4. Key Outcomes

The key outcomes of this project will be the evaporation estimates and the analysis of the effect on overall seepage estimates. The methodology was specifically set up to provide for direct comprison of the results from the same effleunt ponds over the same period.

5. Further Work

Additional testing will continue to provide more data comparing the evaporation pan estimates. Furthermore, supplementary research is recommended to investigate the coefficients used to convert the pan estimates to actual pond evaporation.

6. Conclusions

It is anticipated that the floating evaporation pan will more accurately mimic pond conditions and ultimately produce more accurate evaporation estimates than its land based counterpart. Following these findings, it is expected that this project will recommend the adoption of a floating evaporation pan in place of a land-based version.

Acknowledgements

I would like to thank my employer and sponsor, WSP-Opus, as well as my supervisor for her ongoing guidance.

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The Effect of GFRP Bar Diameter on the Compressive Behaviour of Hollow Circular Concrete Columns with Hollow Composite Section

School of Civil Engineering and Surveying

Liam Anderson

Bachelor of Engineering (Civil) (Honours)

Supervisors:
Dr Allan Manalo
Mr Omar AlAjarameh

Keywords: GFRP, CRS, Reinforced Concrete, Hollow Circular Column, Axial Capacity, Confinement.

1. Introduction

Glass Fibre Reinforced Polymer GFRP is a composite material with emerging popularity as a replacement for steel in reinforced concrete structures, due to its higher strength, better corrosion resistant properties, and more compatible modulus of elasticity with concrete than steel. This study aims to investigate experimentally the interaction of GFRP bars and a proprietary GFRP hollow composite reinforcing system CRS) on the compressive behaviour of hollow concrete columns.

2. Background

Currently there is no Australian Standard for GFRP-reinforced concrete structures, and the research into GFRP bars in circular hollow concrete columns is ongoing AlAjarmeh et al., 2019). It has been shown that hollow columns with internal steel confinement display enhanced concrete strength, greater ductility and yield strength due to the triaxial confinement of the concrete, compared to columns without internal confinement (Han et al, 2010). This provides an opportunity to test hollow circular columns with GFRP bar reinforcement and CRS as internal confinement.

3. Methodology

A total of four 4) hollow concrete columns of 1m in height, 250mm outer diameter with 65mm inner hollow core were prepared using 34.4MPa concrete and tested under concentric axial load. All samples were laterally reinforced with a 9.5mm GFRP spiral at 50mm pitch, three samples S1, S2, S3) were reinforced vertically with both CRS and 6 GFRP bars of varying size (13mm, 16mm, and 19mm . The control sample S4) was reinforced vertically with CRS only.

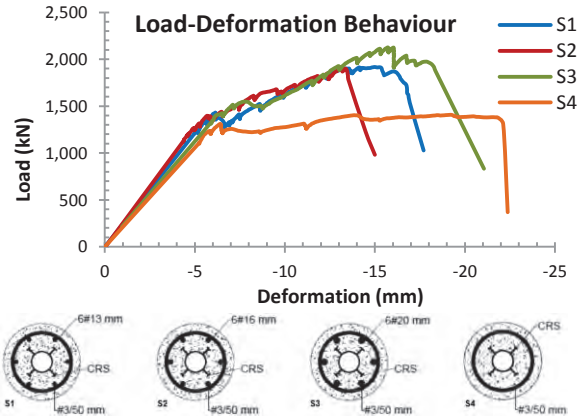

Figure 1- Test Samples & Load-Deflection Behaviour

4. Key Outcomes & Further Work

All samples exhibited linear-elastic behaviour until their initial peak load at which point the cover concrete spalled, exposing the spirals. The samples S1 to S3) continued to support increasing load, failing due to local stress at the end of the column rather than failure of the reinforcement. Figure 1 contrasts these to sample S4, which deformed significantly prior to spiral reinforcement failure. Further work includes examination of the test data, including comparison to theoretical analysis.

5. Conclusions

An increase in bar diameter may increase axial strength, and the use of GFRP bars in combination with CRS as internal confinement significantly increases load carrying capacity after the initial peak load. Future work should include measures to prevent local failure.

Acknowledgements

I would like to thank the technical staff at the Centre for Future Materials at USQ, my supervisors for support and assistance, and V-Rod Australia and CRS for providing the reinforcement materials.

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Effects of preparation method and sieve sizes on clay geotechnical properties

School of Civil Engineering and Surveying

Meelis Liias

Bachelor of Civil Engineering (Honours)

Supervisors: Dr Ali Mirzaghorbanali

Keywords: Clay sample, preparation method, sieve size, geotechnical testing

1. Introduction

Melbourne is experiencing rapid road network and infrastructure expansion into clay dominated areas. Contractors are required to perform quality testing on clay materials, assuring that they are suitable for pavement subgrade. California Bearing Ratio CBR) is one of the most used pavement material quality tests performed in Australia. These materials often do not satisfy CBR requirements, thus, local road authority (VicRoads) requires a number of soil testing campaigns to ensure the designed bearing capacity. While CBR test minimum particle size is governed by 19mm sieve, clay grains can be broken down into much smaller pieces as shown in Figure 1. Breaking down material into smaller sizes, costs extra resources and time. This research is intended to investigate the problem by using different preparation sieve sizes and its effect on CBR, permeability and Uniaxial Compressive Strength (UCS) values.

2. Background

Clays with high plasticity are often avoided as subgrade because of their low bearing capacity and high swelling behaviour. Effects of sieve sizes on clay material consistency are not well understood and often regarded as a trivial factor. Because of the large surface areas of fine grained soils, surface forces significantly influence their behaviour. Soil laboratories tend to dry out the clay material prior to testing, easing preparation process. This can yield erroneous data on geotechnical properties. This project is intended to investigate clay samples geotechnical behaviour, prepared following various preparation methods. Sample preparation recommendations will be drawn based on the experimental results.

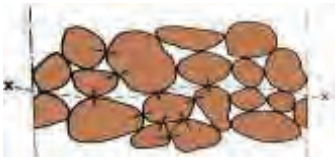

Fig. 1 – Clusters of clay

3. Methodology

The methodology is based on Australian Standard 1289-Testing of Soils for engineering Purposes. Testing is performed in NATA accredited soil laboratory to ensure accurate and industry oriented methodology. Three Samples will be prepared to cover the range between clays with low plasticity to high plasticity values. In order to provide information about the nature of different sieve sizes in material preparation, a series of laboratory tests including Plasticity Index, Particle Size Distribution, Density, CBR, Permeability and UCS will be conducted.

4. Key Outcomes

This research study will provide a set of recommendation for clay samples preparation for various geotechnical properties determination such as CBR, UCS and permeability tests.

5. Further Work

Samples collection and preparation are ongoing. Once samples are prepared, testing campaigns will be carried out based on accredited standards. Collected data will be critically analysed and recommendations for sample preparation will be drawn.

6. Conclusions

Geotechnical properties of clay samples are influenced by preparation methods. In this context, CBR, permeability and UCS values are affected by sieve opening diameter through which clay particles are disintegrated prior to testing.

7. Acknowledgements

I would like to thank my supervisor Dr Ali Mirzaghorbanali for his prompt response and instruction.

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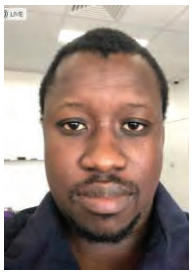
Flexural behaviour of Graphene-reinforced concrete beams

School of Civil Engineering and Surveying



Pako Maruping

Bachelor of Engineering

(Honours) (Civil)

Supervisors: Dr Weena Lokuge

Professor Karu Karunasena

Keywords: Graphene, Flexural and Compressive strength

1. Introduction

Researchers have been looking into ways of making concrete stronger and more durable to reduce the amount of concrete needed. While fibre reinforced polymers and other materials have been widely researched, minimal research has been conducted on graphene reinforced concrete. In this research, we intend to evaluate the effectiveness of graphene as an additive that increases the strength and durability of concrete.

2. Background

Graphene has incredible mechanical properties as compared to other material. The strength of its 0.142 Nm-long carbon bonds, is the strongest material ever discovered, with an ultimate tensile strength of 130 GPa, compared to 0.4GPa for A36 structural steel (Shamsaei, 2018 . Graphene contains elastic properties that enable it to retain its original size after strain. It is these fantastic properties that we hope to harness and improve the properties of concrete in this research.

3. Methodology

This research is conducted experimentally with concrete mixed with 0.05%, 0.1% and 1% (by weight of cement of graphene. The experiments and tests are done as per the Australian standards. The beams for flexural tests are 150mmW x 150mmH x 500mmL with only the bottom layer of the beam having graphene (20mm and 40mm , and the cylinders for modulus of elasticity, compressive and indirect tensile tests are 100mmD x 200mmH graphene reinforced concrete specimens.

4. Key Outcomes

A comprehesive literature review and detailed review of the Australian standards has been conducted that enabled the methodology and experimental design to be concluded. Experimental work is yet to be concluded.

Figure 1 – Flexural and Compression tests

5. Further Work

Tests are yet to be completed for flexural and modulus of elasticity, compressive and indirect tensile tests as shown in figure 1, will have a specific loads per minute load applied until failure occurs then the final reading and the type of failure for both compressive and tensile tests will be recorded. Furthermore, analysis and evaluation of the results will the conducted, to compare with existing theoretical work.

6. Conclusions

Having control samples moulded the same way as the graphene concrete moulds will give us a direct result comparison, and a way to determine whether graphene introduced to concrete improves the mechanical properties of concrete, and at what percentage does this improvement become optimised.

Acknowledgements

I would like to thank my supervisors, Dr Weena Lokuge and Professor Karu Karunasena for their guidance throughout the project. I would also like to the thank Graphene Manufacturing Group for providing the graphene used on this project.

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The development of a systematic framework to guide the inspection, maintenance, rehabilitation and remediation process of a levee.

School of Civil Engineering and Surveying

Scott Douglas

Bachelor of Engineering (Civil Engineering) (Honours) Bachelor of Business (Management and Leadership) (BEHB).

Supervisors: Dr Jo Devine, USQ

Keywords: Levee, visual inspection, earthen embankment.

1. Introduction

Billions of dollars are spent each year on levee construction, maintenance, repair and improvement throughout the world. Rural Queensland in particular, has experienced the deterioration of engineered earthen embankment component of levees which has been attributed to prolonged drought conditions. Relevantly, local councils are faced with the difficult challenge of prioritising the repair and maintenance of levees with limited budgets. This project aims to optimise current practices by developing a systematic framework to guide the inspection, maintenance, and rehabilitation process of a levee subjected to the unique climatic conditions of rural Queensland.

2. Background

This research was motivated by a real case study, where a condition assessment of the Warrego River Levee exposed significant deterioration, as illustrated in Figure 1 (O'Brien, 2016). This research expands upon international best practice to provide a framework which concentrates on the issues relevant to levees in rural Queensland.

3. Methodology

An extensive literature review of international best practice was conducted and informed by the case study experience to develop a systematic framework (CIRIA, 2013; Institute of of Public Works Engineering Australasia, 2015). Additionally it applies the framework to a real case study to test its practicability.

Figure 1 – A typical sinkhole on the levee crest

4. Key Outcomes

This project provides a documented visual inspection program with specific focus on the earthen embankment of a levee subjected to drought conditions and provides a logical methodology for prioritising maintenance, rehabilitation and remediation works.

5. Further Work

The next stage of this project involves the visual inspection and data collection process of the case study to review and analysis the ongoing condition.

6. Conclusions

This project presents a systematic framework for the inspection, maintenance, rehabilitation and remediation process specifically for a levee in rural Queensland.

Acknowledgements

I would like to express my sincere gratitude and appreciation to Dr Jo Devine for her continual support and guidance of my dissertation. This would not have been possible without her involvement.

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Development of an Asset Prioritisation Framework for Gympie Regional Council's Water and Sewerage Assets

Sponsor – Gympie Regional Council, School of Civil Engineering and Surveying

Tim Wood

Bachelor of Engineering (Honours) (Civil Engineering)

Supervisors: Dr Jo Devine, USQ

Keywords: Asset, Risk, Prioritisation

1. Introduction

An asset prioritisation framework systematically identifies assets with high probability and consequence of failure and ranks them in order of criticality. This allows an organisation to make informed asset investment decisions in terms of maintenance activities, operations optimisation and capital expenditure (Park et al. 2010 . This dissertation aims to develop a framework and model for water and sewerage infrastructure assets specific to Gympie Regional Council (GRC .

2. Background

At GRC asset expenditure budgets are currently developed by a small team of experienced professionals. While this approach has generally been suitable in the past there is no documented framework methodology to support these. GRC has recognised the need to implement strategies to assist with decision making and provide documented supporting evidence. An asset prioritisation framework is an approach that should help GRC to optimise budget spending on critical assets and increased efficiency of maintenance activities Olsen 2015).

3. Methodology

An extensive literature review was performed to inform the project. To begin, all water and sewerage assets were categorised. Asset failure modes and consequences for each asset type were identified from which a mix of qualitative and quantitative criteria (see Figure 1) were developed. A consequence severity score was applied to each assessment criteria and weightings developed. The Analytical Hierarchy Process was used to derive a comparative consequence score. Risk of asset failure was determined based on an assets failure mode and field condition rating. A criticality tool in the form of a spreadsheet was developed to semi-automatically process over 50,000 assets. The tool combines the calculated overall consequence and probability scores to determine overall asset criticality, allowing ranking and prioritisation for capital works and maintenance planning.

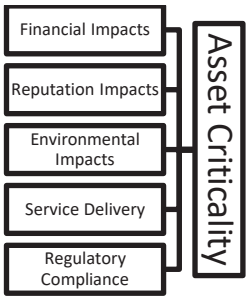

Figure 1 –Asset Criticality Analysis Summary Criteria

4. Key Outcomes

The key outcomes of the study so far are:

- The development of a theoretically founded criticality analysis framework and a spreadsheet tool for implementation of the framework.
- Identification and AHP based weighting of asset failure mode consequences and calculation of failure probability based on asset condition data.
- First draft overall asset criticality results determined.

5. Further Work

Remaining work includes fine-tuning and finalisation of the framework and spreadsheet, development of asset data collection programs and presentation to GRC.

6. Conclusions

The framework will assist GRC with making informed decisions regarding asset expenditure, supported by comprehensive data and documentation.

Acknowledgements

I would like to thank Gympie Regional Council for providing the data required for this project, Jo Devine for guiding the development of my dissertation, and my wife for supporting me through years of part-time study.

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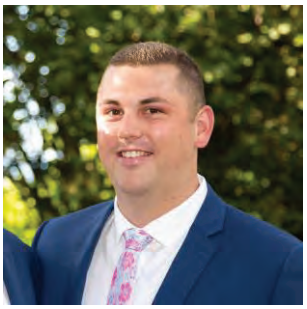
Developing a model for the utilisation of auxiliary through lanes at signalised intersections

School of Civil Engineering and Surveying

Nicholas Browne



Bachelor of Engineering (Honours) (Civil)

Supervisors: Dr Soma Somasundaraswaran, USQ

Keywords: Auxiliary through lane, traffic signal capacity, lane utilisation.

1. Introduction

Additional through lanes are quite often added at traffic signals to increase their capacity, these are known as auxiliary through lanes ATLs , shown in Fig. 1. The amount of traffic that uses these lanes relative to the adjacent continuous through lanes the lane utilisation is often quite low. This research project aims to develop a model for predicting the utilisation of these lanes.

2. Background

The capacity of intersections is often the limiting factor in determining the capacity of a road. Being able to accurately predict this capacity at the planning stage is critical in determining the success or longevity of a potential project. Where ATLs are proposed, the utilisation of these lanes is a key variable in determining the capacity of an intersection. Previous research by Karma et al (2010) has indicated that the length of these lanes may be used to determine their utilisation, but to date no relationship between these two values has been determined. This project intends to build on this research to develop a relationship between ATL length and utilisation, as well as including other variables that may improve the model accuracy.

3. Methodology

57 case study intersection approaches were selected across Australia. The ATL utilisation for each site was determined and key variables were collected, including ATL length, degree of saturation and traffic signal timing parameters. Multiple linear regression methodology was implemented to determine the relationship between different combinations of these variables. The strongest of these will then be used to compare the model to other methods of ATL prediction identified in the literature review.

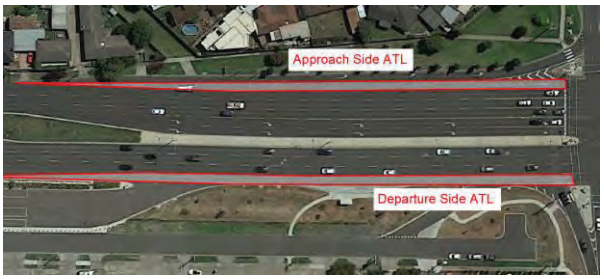


Figure 1 – Auxiliary Through Lane Diagram (Google Maps, 2018)

4. Key Outcomes

The study found that the relationship between single variables and the ATL utilisation were quite weak. However, when variables are combined using multiple regression a moderately strong relationship can be developed. The variables combined to give the strongest relationship were the number of lanes, cycle time, degree of saturation and ATL length in that order of importance.

5. Further Work

The relationship developed as part of this study will be tested against other prediction methods to determine if it improves accuracy in this field.

6. Conclusions

The study has developed a moderately strong relationship for predicting ATL utilisation.

Acknowledgements

The Department of State Growth TAS), Main Roads (WA and VicRoads have provided crucial data. Dr Soma Somasundaraswaran has been instrumental in shaping the project.

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Advanced Numerical Simulation of Rock Joints Load Transfer Mechanisms

School of Civil Engineering and Surveying

Niraj Nitesh Kumar

Bachelor of Engineering (Honours) Major Civil Engineering

Supervisors: Dr Ali Mirzaghorbanali

Keywords: Rock joints, shear strength, normal stress roughness value, numerical simulations

1. Introduction

Joints in a rock mass have a significant effect on the shear strength and deformation properties of the rock mass. Many experimental research projects have been conducted in the last decades on the rock joints using the traditional direct shear apparatus under constant normal load (CNL), where the normal stress acting on the joint is assumed to be constant during the shearing process. Number of research studies have been devoted to shear strength of rock joints under constant normal stiffness conditions CNS) where the dilation is not freely permitted during shearing. Despite the significant number of studies in this area and to the best of authors' knowledge, there is no complete and efficient numerical studies to investigate the shear load transfer mechanisms of rock.

2. Background

Rock mechanics deals with the mechanical properties of rocks and techniques required for the design of rock structures. In many rock engineering projects involving slopes and underground excavations, it is important to consider the effects of discontinuities on the rock mass behaviour as this is relevant to where the stability of infrastructure is influenced by the shear behaviour of a single joint or multiple discontinuity in the surrounding rocks. The overall strength of a discontinuous or jointed rock mass is controlled not by the strength of the intact rock, but instead by the relatively weak shear strengths of the discontinuities. Accurately determining the shear strength of these discontinuities is of critical importance to the design of safe and economical excavations within a fractured rock mass.

3. Methodology

The study is conducted using two dimensional Universal Distinct Element Code (UDEC). Data used in this research is based on literature review (past studies) and are digitised. Subsequently, the collected data sets are simulated numerically in the development of an incremental constitutive model for the shear behaviour of rock joints.

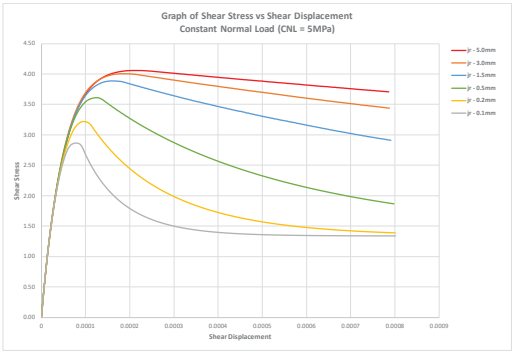

Fig. 1 – Shear Stress vs Shear Displacement

4. Key Outcomes

UDEC simulates large deformation within joints and discountinuties. In this context and as part of this research study, a general subroutine programe is being developed, enabling the software to simulate shear behaviour of rock joints for various field consitions Fig. 1). The subroutine programe will be incorporated for further geotechnical implementations such as slope stability and tunneling technology.

5. Further Work

Further works will be carried out to investigate the effects of roughness values, normal stress, stiffness conditions, shearing rate, sample size, loading cycles and types of constitutive model on shear load transfer mechanisms of rock joints.

6. Conclusions

It is concluded that the shear strength of rock joints is a function of roughness value, normal stress and loading cycles. In addition, the shear strength value is significantly influenced by the boundary conditions.

Acknowledgements

My heartfelt appreciation to my supervisors, to whom this thesis is dedicated.

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Rolling Shear Properties of F2 Hybrid Pine used in Cross Laminated Timber CLT)

Sponsor – School of Civil Engineering and Surveying

Cameron Andrews

Bachelor of Engineering (Honours) (Civil Engineering)

Supervisor: Professor Karu Karunasena and Rebecca Cherry, USQ

Keywords: Cross Laminated Timber (CLT), rolling shear properties, two plate shear test.

1. Introduction

Cross Laminated Timber CLT) is achieved by laying timber panels perpendicular to the adjacent layer typically with a glue adhesive and then pressed vertically and horizontally under a hydraulic press. Used as a structural member for construction purposes, the governing factor for failure in CLT when loaded in out of plane bending can be given by the induced stresses in either axes exceeding the orientations strength. This is a critical factor for the shear strength as this cross layer is the weak point for the CLT member. These shear stresses which cause shear strains in the radial-tangential plane are referred to as the rolling shear stresses.

2. Background

The demand is on the rise for CLT being used in multi-storey buildings due to its eco-friendly and cost effective solution. As the F2 hybrid is reaching maturity in Queensland and New South Wales plantations, investigation needs to be carried out to determine the suitability of the F2 hybrid being able to fulfil the role as feedstock for the manufacturing plant. It is important to characterise the quality of this softwood being used as feedstock. With no publically available studies specific to the F2 hybrid in question being investigated, this study will investigate the critical performance for CLT regarding rolling shear properties.

3. Methodology

The scope of this study consist of experimental, theoretical and FEM components. The experimental component investigates the rolling shear properties of the F2 hybrid timber used as CLT through the design, construction and two plate shear testing of the 39 specimens. Influencing parameters are investigated that focus on growth ring orientation, growth ring width, location of the pith, geometry, clear wood and knotted wood. The theoretical component aims to interpret the behaviour response of the F2 hybrid used as CLT and the governing strength and stiffness properties obtained. The FEM component analyses the CLT under the experimental loading response to validate the data obtained, in particular strain propagation and influence using Strand7 software.

Figure 1. Two plate shear test set-up

4. Key Outcomes

Currently, results have been compiled for each specimen batch and a range of rolling shear strength and modulus values have been achieved including different modes of failure ranging between glue, shear and plate.

Key distinctions from the influence of knot size have been observed to reduce the rolling shear strength for the F2 hybrid CLT specimns. Further investigation is still underway to determine the influence of the other parameters.

5. Further Work

Regarding rolling shear performance, further investigation against existing timber feedstock used for CLT would be highly valued as a performance assessment tool for benchmarking its use in the industry.

6. Conclusions

Preliminary results from the experimental study has highlighted that dependent on the knot influence, values achieved for rolling shear strength and modulus are within tolerance against theoretical values for other types of timber specified for use as CLT.

Acknowledgements

PhD student Rebecca Cherry for procurement of materials, testing configurations and professional input.

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Cooling of high temperature bore water using thermoelectric generated power

Sponsor - School of Civil Engineering and Surveying

Sean Finnerty

Bachelor of Engineering

(Honours)(Civil)

Supervisor: Dr Andrew Wandel, USQ

Keywords: Great Artesian Basin, Thermoelectric, Bore water

1. Introduction

This research project investigates solutions to the problem of high temperature bore water in the Great Artesian Basin of Australia. In particular, the use of thermoelectric generators to harness the energy contained within the hot water. The harnessed energy can then be used to assist cooling of the water.

Proposed designs need to address several key criteria due to the harsh nature of the Australian environment. Designs must be able to withstand windy, dusty conditions with high temperatures and low humidity. The temperature, pH and hardness of the water must also be considered in the design.

2. Background

The Great Artesian Basin is one of the largest groundwater basins in the world and has been used extensively to help develop inland Australia. Early water use was extremely wasteful with up to 95% of water outflow being lost to evaporation and seepage. This has led to a drop in the water level of the basin and has had a dramatic effect on some of the natural springs within the basin.

3. Methodology

This project is research based, using information gathered from various sources including local and state government, and the department of meteorology. Calculations are based on theory and previous observations only and provide mainly qualitative results.

One of the configurations investigated was to run the hot bore water down through a copper coil being cooled by fan-driven air. The power for the fans is generated by a thermoelectric generator attached to the hot water inlet pipe Figure 1). The cooled water can then be stored for use.

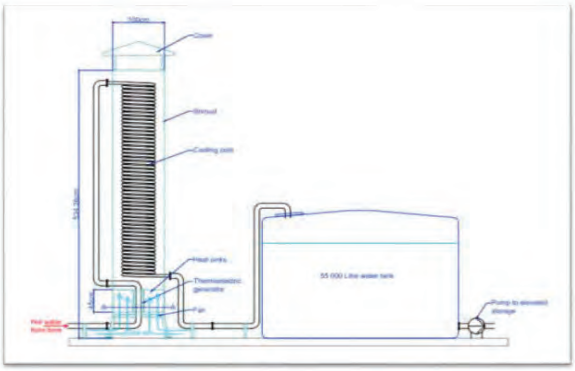

Figure 1 Proposed cooling system

4. Key Outcomes

The report proposes 2 possible systems that can be used to address the problem. These proposals are robust and practical using previously developed technology.

5. Further Work

As this project is purely research based the next step would be to verify results through experimentation and develop a working model. Further development and implementation could be derived from the working model.

6. Conclusions

Assisted cooling is theoretically a viable option, however further experimentation is required to ascertain the practicability of the system.

Acknowledgements

I would like to thank Dr Andrew Wandel for the guidance, mentorship and feedback that was of utmost importance in completing this project. Also my family for support and understanding.

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FEASIBILITY OF IMPROVING CYCLE INFRASTRUCTURE IN FORTITUDE VALLEY BRISBANE

Sponsor - School of Civil Engineering and Surveying

Geoffrey Blundstone

Bachelor of Engineering (Honours) (Civil Engineering)

Supervisors: Dr Jo Devine, USQ

Keywords: Feasibility, Cycle, Infrastructure

1. Introduction

In the project the feasibility of improving the cycle infrastructure in Fortitude Valley is investigated. The effect of such an upgrade on existing traffic flow is explored quantitatively. Several alternative design solutions, with varying focus criteria are investigated. The alternative designs focus predominantly on minimising traffic flow disturbance while increasing rider safety, connectivity and sustainability.

2. Background

Fortitude Valley is part of the inner city of Brisbane and is a central hub for many office blocks and high-density employment, attracting a significant number of cyclist commuters to the area. Existing cycle networks linking Fortitude Valley to the outer suburbs do not effectively connect the cyclist to their destination. The cyclist is forced to integrate with vehicles when entering Fortitude Valley and must share traffic lanes with cars and heavy vehicles, both of which are stressful and dangerous to the cyclist.

3. Methodology

A suitable network connectivity route was established using collected cyclist movement data. A traffic model of the proposed network was developed using data collected on key signalised intersections along the route. The model was based on existing vehicle movement data and existing signal phasing data. This was used to establish a base line efficiency of the traffic network. The Department of Transport and Main Roads Technical Note 128 (2015) was referenced to establish three design solutions for the network upgrade. The options include varying implementations of the design standards from most desirable solution to a minimum treatment solution. The design solutions were applied to the traffic model and the effects to traffic flows level of service) of the key intersections along the route were observed. A high-level cost estimate comparison for the design solutions was also completed.

	Multi-Criteria Assessment		
	Option 1 Full Treatment	Option 2 Hybrid Solution	Option 3 Do Minimum
Traffic Performance	15/30	20/30	30/30
Economic	10/30	15/30	30/30
Rider Safety	20/20	10/20	5/20
Engineering	20/20	10/20	5/20
Social			
Total	**75/100**	**70/100**	**71/100**

Figure 1 – Multi-Criteria Assessment

4. Key Outcomes

Each option was assessed against multiple criteria (Figure 1) to establish a preferred solution. A comment was then derived relating to the feasibility of the preferred solution as an option to improving cycle infrastructure in Fortitude Valley, Brisbane.

5. Further Work

Benefits can be gained by further developing the design model of the cycle path to better understand the impacts at all intersections throughout the project area against the earlier stated criteria Figure 1 .

Conclusions

A preferred design solution was identified which has an acceptable minimal impact on existing traffic performance of the network, is economically feasible, improves cyclist safety, adheres to relevant design standards and has a positive social benefit to the community.

Acknowledgements

I would like to thank my supervisor Jo Devine and my colleagues and friends for their sincere encouragement and support, aiding with direction and motivation at critical times.

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Road Link flooding strategy for Low Volume Rural Roads with budgetary constraints considered.

Sponsor - School of Civil Engineering and Surveying

Steven Carr

Bachelor of Civil Engineering Honours

Supervisors: Dr David Thorpe, USQ

Keywords: Floodway's, Economic benefits, Strategic upgrades.

1. Introduction

Within Transport and Main Roads Queensland many design briefs specifically state that all culverts and drainage infrastructure must be capable of Q20 or higher flows. Whilst such a blanket approach may be appropriate in high volume urban environments, low volume rural roads have budgetary constraints and applying such an approach to these sites may not be appropriate from a financial standpoint. The research looks specifically at all things cost to better understand how floodway's with small culverts compare financially to Q20 capable drainage infrastructure.

2. Background

One of the greatest challenges on rural roads is low funding allocations and making the best usage of these funds to improve and maintain road networks. By better understanding if upgrading existing drainage has a positive cost benefit engineers can better understand how to allocate costs to better deal with drainage infrastructure. Although evidence of large-scale costings exercises for floodway's and culverts have been undertaken on urban and highway networks, specific data needs to be appropriately analysed in a rural setting. This will help to get a better understanding of real costings and if upgrading this infrastructure is beneficial to the community and regional authorities.

3. Methodology

Three specific case study sites have been chosen along the Peninsula and Gulf Developmental roads which will be used in order to better understand the costs of Q20 culvert installation vs floodway's with small culverts. A comprehensive costings exercise is undertaken to better understand not only construction costs but lifecycle cost of each option. This is undertaken by firstly using the Rational Method along with HEC-RAS (Hydraulics software) to understand the hydrological specifics of each site. Design software 12d and AutoCAD is then used to create designs along with schedule of rates for costing comparison. Economic and social costs and benefits were then incorporated to help with determination as to which specific structure is more appropriate in such a rural environment.

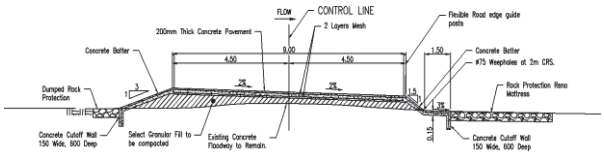

Figure 1 – Typical Floodway Design for costings

4. Further Work

A better understanding of the economic impacts to the communities by undertaking further discussions with local shops, transport companies and community members. Along with this better understanding of the catchments themselves by installing flood gauges, undertaking more survey. Finally, by constructing a floodway with small culverts to better understand how these would function long term on a rural network and if they have an impact on time of closure.

5. Conclusions

The key conclusions show that although cheaper to install, floodway's can have a negative effect on the economic and social aspects of small rural communities. However, what the study shows is that if other location on the rural network currently flood for a similar time period then the premise of upgrading only one piece of infrastructure can be non-beneficial and can create a large strain on small rural roads annual finances.

Acknowledgements

Firstly, I would like to thank my wife for her support over the years of study. I would also like to thank my Lecturer Dr David Thorpe who has provided me with sound advice in my project. Lastly, I wish to thank some of the staff within TMR Far Northern Queensland for data and advice.

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Performance Evaluation of GFRP Reinforced Railway Sleepers

Sponsor - School of Civil Engineering and Surveying

Jacob Verrall

Bachelor of Engineering Honours (Civil)

Supervisors: Associate Professor Allan Manalo, USQ.

Keywords: Railway sleepers, Glass fibre reinforcement (GFRP), Polymer concrete, Performance testing

1. Introduction

In the next 5 years, Queensland Rail aims to replace 130000 in-track timber sleepers per year with alternative composite sleepers. This research project focused on designing a new composite sleeper concept made from polymer concrete reinforced with glass fibre reinforced polymer (GFRP) for narrow gauge track applications. The adequacy of this new concept in lieu to traditional concrete was investigated. Destructive and non-destructive testing was then performed to evaluate the sleepers flexural, shear and deflection capacity as required by Queensland Rail.

2. Background

As the popularity of rail continues to arise, great strain is being placed on Australia's ageing rail network. Concrete railway sleepers have since become more favourable than their timber counterparts as they have a significantly longer design life. However, traditional concrete sleepers are still susceptible to premature failure as moisture can reach and corrode the sleeper's internal reinforcement via concrete cracking (Andersson et al., 2013). Fibre composites have since emerged as they non-corrosive alternative to steel. Meanwhile, Ferdous et. al. 2016) suggests that polymer concrete could be used to significantly improve the durability of railway sleepers.

Methodology

Two finite element models using beam on elastic foundation theory was created in Strand 7 to determine the maximum bending moment and shear force acting on a sleeper. Appropriate reinforcement was then designed and two sleepers were manufactured; one made from Portland concrete refer to figure 1) and the other from Epoxy based polymer concrete. The sleepers were then subjected to a four-point bend test to evaluate their structural performance and determine the suitability of GFRP reinforcement and polymer concrete.

Figure 1 – Casting a Portland concrete railway sleeper designed with GFRP bars

3. Results and Observations

At this time, further data analysis is required to before commenting on the overall performance of both sleepers. Initial testing suggests the Polymer concrete sleeper designed with a Portland concrete core is feasible.

4. Further Work

Destructive testing will be conducted to evaluate the ultimate capacity of the manufactured sleepers.

5. Conclusions

Initial results proved that GFRP reinforcement can be used to manufacture railway sleepers. Meanwhile, the use of polymer concrete helped to reduce the degree of cracking but with an increased sleeper deflection.

Acknowledgements

I would like to acknowledge and thank the efforts of my supervisor over the duration of my research project. Secondly, I would like to thank my family who have always supported me throughout my studies at USQ.

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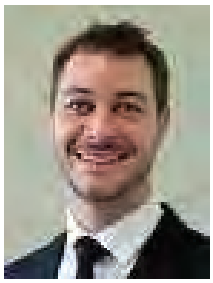
Sewer inflow and infiltration for catchments with high rainfall and aging infrastructure.

Sponsor - School of Civil Engineering and Surveying



Rhys Keily

Bachelor of Civil Engineering

Supervisors: Dr Vasantha Aravinthan, USQ

Keywords: Sewer, Inflow, Infiltration

1. Introduction

As traditional gravity sewer systems age, they become less efficient due to an increase in Inflow and Infiltration (I/I) of stormwater and groundwater into the system.

Far North Queensland Region Of Councils (FNQROC 2017) has its own sewer guidelines, specifically tailored to the regions locality and climate. The sewer guideline has a crude blanket value for estimating the I/I component of the sewage flows.

This dissertation compares different sewage flow estimation techniques used in Australia and worldwide to implement an improved estimation technique for Far North Queensland which takes into account the locality, rainfall, ground water and ageing infrastructure in a holistic approach.

2. Background

The project explores methods to adequately identify and quantify I/I then determine the implication it has on a sewerage network.

The township of Gordonvale was used as a case study, as it experiences large peaks in sewage flows due to high annual rainfall and the ageing sewerage infrastructure. This dissertation investigates the cause and effect of I/I and how it can be better estimated specifically for the case studies region.

3. Methodology

Local council's geographic information system, rainfall, groundwater and historic CCTV data were all used gain an extensive understanding of the current sewerage network and its performance. The researched sewage flow estimation methods were all implemented for comparison against historic sewage flow data for the Gordonvale catchment to develop a customised hydraulic model.

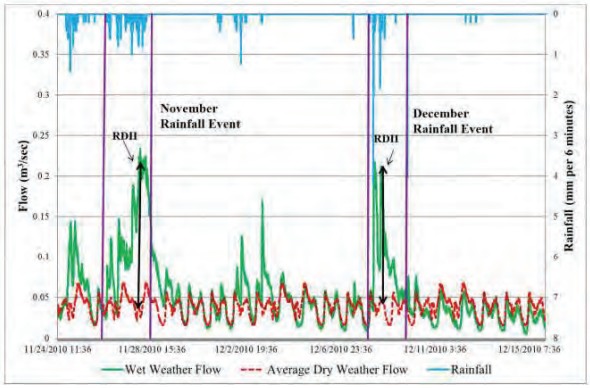


Figure 1 – Sewerage catchment performance (Nasrin et al.)

4. Key Outcomes

The customised hydraulic model was developed to identify the influence of ground water infiltrating the network and rainfall derived inflow. It was also used to predict sewage flows with greater accuracy than the current methods used, similar to Figure 1.

5. Further Work

Further analysis of the network is required to refine the hydraulic model for greater accuracy. A cost benefit analysis will be prepared based on typical sewer remediation methods currently used to reduce I/I.

6. Conclusions

The current sewage estimation method the region adopts does not reflect actual flow data. The customised hydraulic model that was developed identifies areas of concern and better estimates sewage flows without the need for adopting blanket estimation values.

Acknowledgements

I would like to thank Dr. Aravinthan for providing guidance and encouragement on a complex topic. Also, Cairns Regional Council for providing historic data for the case study catchment.

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Evaluation of Issues in Using Advanced and Sustainable Engineering Materials

Sponsor – School of Civil Engineering and Surveying

Jacob Tan

B. Engineering Civil Honours

Supervisors: David Thorpe, USQ

Keywords: Composite Materials, Cross-Laminated Timber, Geopolymer.

1. Introduction

For decades advanced engineering materials have been promising to expand and transform the engineering design and construction field. Materials such as fibre composites, geopolymers and cross laminated timbers boasting to impact the sustainability, economical cost, environmental resilience and energy management of the built environment. However, their take up by industry leaders has not been nearly as rapid as anticipated. This project aims to uncover and expand the factors behind this, such as; high initial cost, financial risk of using unproven technologies, lack of design standards and training.

2. Background

The construction industry is considered to be one of the major contributor to global greenhouse gas emissions with research conducted in the United Kingdom estimating that the construction industry is attributing to approximately 50% of greenhouse gases Akan, Dhavale, Sarkis, 2017). Therefore it is detrimental that sustainable materials and practices be implemented into the construction industry.

3. Methodology

The methodology used for this research project involves a thorough literature review into the following advanced engineering materials: Carbon Fibre Reinforcing Polymers, Cross-laminated timber and Geopolymers used in-lieu of cement in concrete. Findings from the literature review were then summarised and tabulated in report format. A questionnaire was then designed and distributed to focus on issues that have impacted the take-off of Advanced Engineering materials – particularly in the North West NSW region. Results from the questionnaire will be summarised and tabulated. Finally, results will be critically analysed to understand and define the factors that have been influencing the take-off of advanced engineering materials.

4. Key Outcomes

Although the questionaire has not been distributed, so exact impacts in the North West NSW are still unknown, previous research conducted and collated suggest that financial risk, material durability and lack of design standards have hindered the take up in the past.

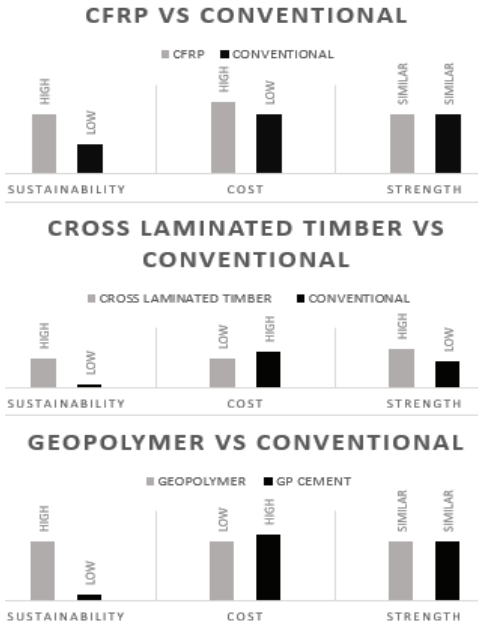

Figure 1: Comparison of Advanced Engineering Materials

5. Further Work

From this point, I have completed up to 'part 3.5' and still aim to complete the rest of the tasks as above. From here I will be obtaining and summarising data from the questionnaire.

6. Conclusions

Due to the timeline and staging of this project, it is hard to exactly pinpoint the outcome from the questionnaire. However from review of previous literature, results suggest that there are generally misconceptions about cost and durability that hinder the take-up. Access to training may increase the use in the future.

Acknowledgements

I would like to thank my supervisor David Thorpe for his ongoing help and direction.

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Investigation into the effects of Stormwater Attenuation within the lower third of a catchment.

Sponsor - School of Civil Engineering and Surveying

Jayden Karaka

Bachelor of Engineering (Civil)

Supervisors: Dr Malcolm Gillies, USQ

Keywords: One-third, attenuation, Drains

1. Introduction

This project will attempt to examine the validity of the 'one-third' rule by modelling a catchment in Toowoomba, Queensland in three sections and varying the detention between them. This project also aims to compare the leading software programs DRAINS and MUSIC to see if MUSIC can be utilised as an effective runoff-routing assessment tool for planning purposes.

2. Background

The planning and design guidelines of urban stormwater systems within Queensland is undertaken in accordance with The Queensland Urban Drainage Manual (QUDM). QUDM states that when designing detention systems to control downstream flooding, it is important to consider the issue of coincident flood peaks. This issue occurs when the peak runoff from a development is delayed or extended and causes this runoff to arrive at a critical location at the same time as flows arriving from the upper catchment. The simple 'one third rule' was developed in response to this issue. This rule stated that stormwater detention systems may not be appropriate within the lower third of a catchment.

3. Methodology

Catchment parameters will be formulated and then split into three separate catchments approximately equal in area. The catchments will be entered into DRAINS and MUSIC and linked allowing for a detention tank to be modelled at the outlet of each catchment (refer Figure 1 for example models . Multiple scenarios will then be modelled in both programs with the results then compared to see what effect stormwater attenuation in the lower third catchment has on stormwater quantity and quality. The MUSIC results can then be compared to the DRAINS results.

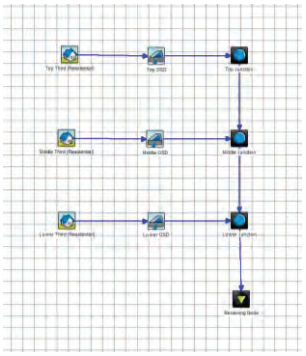

Figure 1 – example MUSIC and DRAINS models

4. Key Outcomes

The key outcomes of this project are to determine the effect on stormwater quality and quantity in waterways by implementing stormwater attenuation devices within the upper, middle and lower thirds of a catchment. Then assessing the effectiveness of MUSIC in modelling stormwater attenuation and make recommendations on the use of MUSIC for stormwater attenuation analysis.

5. Further Work

The DRAINS and MUSIC models require further work to be completed and to ensure comparability with results then collated and analysed.

6. Conclusions

Initial modelling indicates that attenuation within the lower third of the catchment does not reduce the peak stormwater discharge from the total catchment. Further catchment scenarios will need to be completed.

Acknowledgements

I would like to thank my supervisor, Dr Malcolm Gillies for providing guidance throughout the project.

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Estimation of peak flow in Queensland using Quantile Regression Technique and ARR 2016

Sponsor - School of Civil Engineering and Surveying

Samuel Walker

Bachelor of Engineering (Honours)

Majoring in Civil Engineering

Supervisors: Dr Rezaul Chowdhury, USQ
Mr Carlos Gonzalez, Transport and Main Roads

Keywords: Peak discharge, Quantile Regression Technique, ARR 2016

1. Introduction

Design flood estimation for small and medium sized catchments is required for the design of culverts, small to medium sized bridges, causeways and other engineering projects. Palmen Weeks 2011 developed a set of empirical equations for ungauged catchments in Queensland. The aim of this project is to update these models to align with the new 2019 ARR and 2016 Design Rainfalls. The equations only require rainfall intensity and catchment area to estimate peak discharge.

2. Background

Empirical models QRT, for example) are correlated to a particular set of data, they require updates when more data or improved methods are available. Australian Rainfall and Runoff has published 2019 version superseding the industry standard 1987 version. In addition, 1987 rainfall intensity-frequency-duration tables are also out-of-date and will no longer be available, replaced by 2016 version.

3. Methodology

A number of gauged streams where selected with catchments less than 1000km^2 and over 50 years of record. Rating curves for these sites where reviewed and suspect sites investigated and revised. The stream record was analysed and Annual Maximum Series extracted. Flood Frequency Analysis was completed with various distributions and the best fit selected. The estimated flood quantiles for standard AEP events where then be correlated with catchment areas and ARR 2016 design rainfall intensities 72 hour, 2% AEP event) using regression techniques. Alternative intensities where trialled to improve the model. Final testing of the model and comparison against common industry methods was completed.

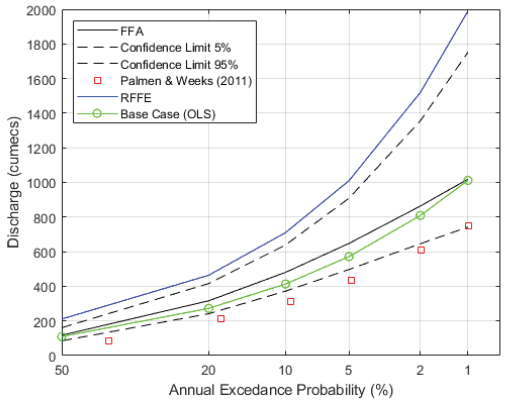

Figure 1 – Comparison of Models for Gauge 146010A.

4. Key Outcomes

The rating curves of a number of stream gauge sites have been reviewed, which will provide more accurate estimation of stream flow. Preliminary regression (green in Figure 1) with a small number of sites provides good accuracy.

5. Further Work

A suggested improvement is to include additional parameters into the model, such as catchment shape or stream slope. A high number of sites used where located along the eastern coast, an assessment of regional areas would be beneficial.

6. Conclusions

The final model will be valuable for use in hydrology field. As a simple, quick hand calculation it can be used to check complex models and verify assumptions are correct, as well as for preliminary design and planning projects.

Acknowledgements

I would like to thank Carlos Gonzalez for providing training and assistance in many aspects of this project; my supervisor, Rezaul Chowdhury, for guidance throughout; and Transport and Main Roads for providing support and resources to complete this project

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Investigating the Structural Behaviour of Graphene-Epoxy Coated Timber members

Sponsor - School of Civil Engineering and Surveying

Thuong Phan

Bachelor of Engineering (Honour)

Supervisors:

Professor Karu Karunasena

Dr Weena Lokuge

Keywords: Experimental analysis, Finite element modelling, timber reinforced with graphene-epoxy

1. Introduction

The use of graphene-epoxy nanocomposites as a reinforcement method to increase the structural capacity of existing structure is receiving considerable attention recently. This newly approach is hoped to achieve a cost effective and simple approach in fixing problems relating to deteriorated timber structures such as bridges and residential buildings André & Kliger 2009).

The objectives of this project are:

- Compare the structural behaviour (bending and buckling) of the reinforced timber member to a non-reinforced timber member

- Validate the results through finite element analysis software (Strand7)

- Determine the effectiveness of the results

2. Background

As the use of graphene nanocomposites continue to increase, its required to develop further experimental and literature knowledge on the material. This project would help contribute to the research materials on the effective uses of fibre composites, which would improve the civil infrastructure market (Wang et al. 2011).

3. Methodology

For the purpose of this research, the experiment would be conducted on a timber beam with no strengthening system and be tested using the four-point bending method. The results obtain from the non-reinforced timber deflection will be compared against the reinforced timber beam with graphene-epoxy nanocomposites coating. These results are then compared with the FEM using strand7 (shown in figure 1) output to validate the FEM numerical model.

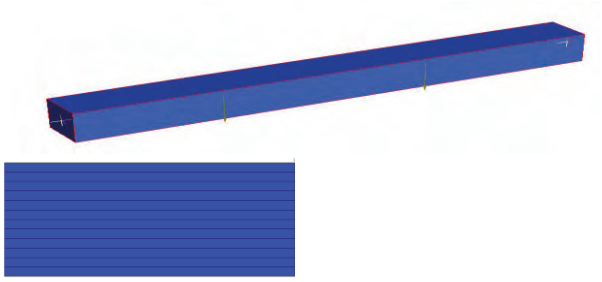

Figure 1 – Strand7 FEM model

4. Key Outcomes

The anticipated outcome will provide advantages for future modelling and improved knowledge on the uses of graphene nanocomposites as an enhancement material.

The expected outcome of this project includes:

- Improve knowledge on the use of graphene nanocomposites as a new type of enhancement strategies

- Deflection of the reinforced timber member would be less compared to the non-reinforced timber members.

5. Further Work

Further research can be conducted on the vibration and wind loading analysis of the graphene-epoxy coated timber members.

6. Conclusions

This project focus on the structural behaviour of the timber member that are reinforced with graphene nanocomposites coating. The benefit of this experiment and model analysis on the timber enhanced with graphene nanocomposites would provide a more accurate results that can potentially use in the future to simulate the real world events.

Acknowledgements

Special thanks to Professor Karu Karunasena Dr Weena Lokuge for supervising this project.

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Geopolymer Mixture Design for Road Subbase

Sponsor - School of Civil Engineering and Surveying

Bowden Grayson

Bachelor of Engineering Hon

Major: Civil Engineering

Supervisors: Dr Andreas Nataatmadja, USQ

Keywords: Geopolymer, Fly Ash, Mortar, Low-Strength Concrete

1. Introduction

As the Australian residential footprint expands, so does the need for more road construction. By being able to develop a low strength geopolymer concrete subbase mixture, can not only help environmental impacts of the current CO_2 emissions but also construction costs for heavier based road pavements.

2. Background

The function of a road subbase is to provide support to the pavement layers constructed on top of it for long-term use. The primary objective of the road subbase is to limit joint deflection and pavement faulting or failing. Figure 1 illustrates the road pavement cross section.

The purpose of this research has two parts:

1. Develop a Fly Ash based geopolymer mortar that ensures the equivalent strength characteristics of Ordinary Portland Cement (OPC .
2. Use the developed Geopolymer mortar as the binding agent to the proposed Fly Ash based Geopolymer Concrete (GPC mix, which eliminates the use for OPC and results in a similar strength.

The current research gap is due to lack of development in low strength concretes for pavement use.

3. Methodology

Regarding part one an extensive literature review was developed to provide relevant information regarding the use and environmental impacts of OPC and the benefits of GPC. Geopolymer concrete has a lower environmental impact, resulting in approximately 85% less CO_2 emissions.

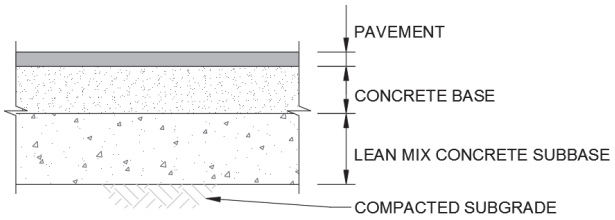

Figure 1 – Road Pavement Cross Section

Part two used a research and experimental approach to test, compare and determine a geopolymer mortar that can replace the use of Portland cement mortar in a Lean Mix Concrete Subbase. The compressive and flexural strengths tests of concrete specimens will be determined in the lab.

4. Key Outcomes

The proposed mortar and concrete mix calculations have been prepared for sampling and testing. The main outcome regarding the overall strength is still to be determined. The results will be analysed once the required concrete curing has been concluded.

5. Further Work

Further studies required would be to conduct testing on the drying shrinkage, rate of gain of strength and compare autogenous and drying shrinkage of the designed concrete mixture.

6. Conclusions

There is evidence that there is lack of detailed research investigations regarding low strength GPC road subbases. Previous researched guidelines have given this research project a solid foundation to conduct concrete mix designs and concrete testing, to identify low strength GPC with high percentages of recycled by products to help reduce environmental impacts

7. Acknowledgements

I would like to thank Andreas Nataatmadja for supervising me though this research and his continued support and advice. I would also like to thank all lab technicians for their help with the sampling and testing of the proposed concrete mixtures

8. References

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Stormwater Harvesting at USQ Ipswich

Sponsor – School of Civil Engineering and Surveying

Luke Badart

Bachelor of Engineering Honours (Civil)

Supervisor:

Rezaul Chowdhury, USQ

Keywords: Stormwater Harvesting, Continuous Rainfall Runoff Modelling, Storage Behaviour Analysis, Reservoir Performance.

1. Introduction

This project aims to determine whether the Ipswich USQ Campus could benefit from utilising more local water resources through stormwater harvesting. A combination of rainfall runoff modelling, storage behaviour analysis and cost benefit analysis will be undertaken to determine the potential viability of stormwater harvesting methods at the USQ Ipswich Campus.

2. Background

Integrated urban water management principals are being increasingly adopted with the aim of reducing pressure and reliance on water infrastructure and damage to waterways Mitchell 2001). These goals are generally achieved through reduction in demand of potable supply, supplementing where possible with alternate water sources and reducing stormwater volumes entering waterways. Harvesting stormwater and rainwater is being more frequently adopted as a solution to achieve these goals (Mitchell 2001).

USQ currently employs water saving methods on their campuses such as; reusing air-conditioner condensate, efficient fixtures and harvesting rainwater and stormwater on some campuses USQ 2014).

3. Methodology

Initial work involves examining current water use on USQ Ipswich campus and determining potential harvesting areas based on the existing stormwater layout. Rainfall runoff modelling will then be used to simulate daily runoff volumes produced by the campus available to be harvested through a potential stormwater harvesting scheme. The rainfall runoff modelling process will be undertaken based on modelling software package named 'Aquacycle' (Mitchell 2001). Aquacycle was produced to model the urban water cycle, the model structure is shown in figure 1.

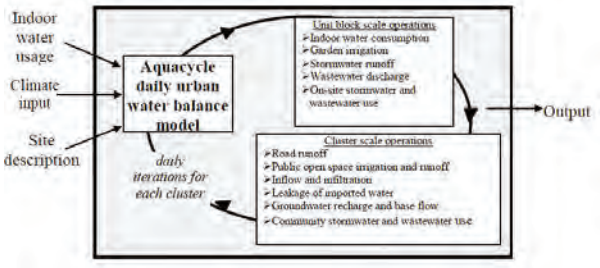

Figure 1: Model Structure of Aquacycle (Mitchell 2005)

A range of demand scenarios will be forecasted for non-potable water use on the campus for input into storage behaviour analysis. Using simulated runoff and forecasted demand volumes storage behaviour analysis is then undertaken to determine the performance of stormwater harvesting stores for varying configurations and locations.

Economic analysis will then be undertaken to determine the most viable outcome and to ultimately determine the plausibility of any new water harvesting scheme at the Ipswich USQ Campus.

4. Further Work

There are many avenues of further work for this project especially in the area of Water Sensitive Urban Design stormwater treatment methods and modelling off site impacts associated with stormwater harvesting at the Ipswich USQ Campus.

5. Conclusions

Results are still being processed at the present stage to determine a reservoir size, location and configuration which is potentially viable for the Ipswich campus.

Acknowledgements

I would like to thank Rezaul Chowdhury for supervising my project and my friends and family for their support.

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The Effect of Reinforcement Ratio on the Behaviour of GFRP-reinforced Concrete Columns with Hollow Composite Reinforcing Section

Sponsor - School of Civil Engineering and Surveying

Michael Ng

Bachelor of Engineering (Honours) (Civil)

Supervisors: Dr Allan Manalo
Mr Omar AlAjarmeh

Keywords: GFRP, HCRS, Hollow Columns

1. Introduction

Hollow concrete columns are structurally efficient construction system due to their high strength-to-mass ratio (AlAjarmeh et al. 2019). However, corrosion of steel reinforcing bars in concrete is a major problem which causes deterioration in concrete. To address this issue, glass fibre reinforced polymer (GFRP) bars are now being used as alternative to the conventional steel bars. This research aims to investigate the effect of the amount of GFRP bar by changing the bar number on the behaviour of concrete columns with hollow composite reinforcing section (HCRS) when subjected to axial compressive loading.

2. Background

GFRP bars offer many advantages over steel bars, such as, corrosion resistance, superior tensile strength and light weight. The use of HCRS provides inner radial confinement for hollow concrete columns hence potentially can improve the stiffness and ductility. It is important therefore to understand on how critical design parameters such as the amount of reinforcement affects the overall behaviour of RC columns reinforced with GFRP bars and HCRS.

3. Methodology

This research was conducted experimentally through the compressive tests of six (6) hollow concrete columns of 250mm in diameter and 1m height. Figure 1 indicates the reinforcement for the tested columns (denote "T") as well as the controlled columns (denote "C"). The reinforcement ratio (ρ) for tested columns 4*15.9mm, 6*15.9mm and 8*15.9mm were 1.74%, 2.6% and 3.47% respectively.

4. Key Outcomes

Figure 2 indicates a number of key outcomes of this project are as follows:

- The failure mode of hollow columns changed from brittle to ductile as the reinforcement ratio increased.

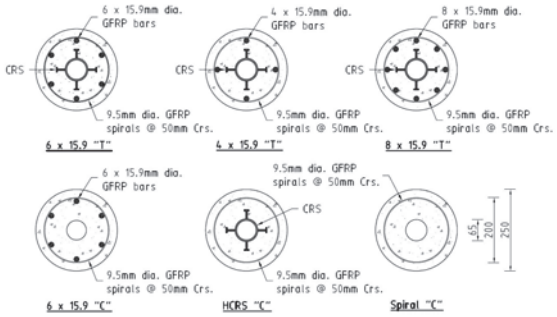

Figure 1 : Cross section of tested and controlled columns

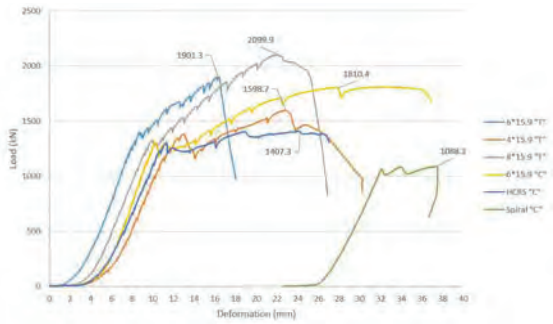

Figure 2 : Load-deformation behaviour of hollow columns

- Reinforcing hollow column with GFRP bars and HCRS increase significantly the capacity of hollow column.
- The ductility or the area under the load-deformation curve of a hollow column with HCRS increased by 30% compared to the column without HCRS.
- Increasing the reinforcement ratio from 1.74% to 3.47% increase the capacity of the column by 31%.

5. Further Work

Theoretical evaluation of the capacity of HCRS will be conducted to verify the experimental results and predict the load capacity of GFRP-reinforced hollow columns.

6. Conclusions

Preliminary analysis suggested that by increasing the reinforcement ratio, both the axial load capacity and the ductility of the hollow concrete columns have increased.

Acknowledgements

I would like to thank V-Rod Australia for supplying the GFRP bars and HCRS.

References

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AN INVESTIGATION INTO THE REDUCTION OF ONGOING MAINTENANCE COSTS BY SEALING FULL-WIDTH ON TWO-WAY, RURAL ROADS

Sponsor - School of Civil Engineering and Surveying

Samuel Robertson

Bachelor of Engineering (Honours) (Civil)

Supervisors: Dr David Thorpe, USQ

Keywords: Rural road maintenance, bitumen seal width, whole-of-life cost

1. Introduction

Roads are an essential part of a developed country, so it is important to ensure existing networks are maintained to an expected level of service. However, road construction and maintenance is an expensive exercise, with over $23.8 billion was spent on Australian road infrastructure in the 2015-16 financial year alone (BITRE 2017). With an ever-growing population it is essential for road authorities to try and stretch this funding as far as possible.

2. Background

It is widely stated that sealing the road shoulders can reduce ongoing maintenance, but it is unclear as to exactly what extent. To measure this, a theoretical analysis has been conducted to compare maintenance costs for both unsealed and sealed shoulders over the life expectancy of the road pavement.

The objective of this report is to determine the feasibility of spending additional money upfront to fund a wider seal to save money in the long term due to reduction in unsealed shoulder maintenance.

3. Methodology

Using first principles, a cost per kilometre was determined for certain activities related to shoulder maintenance. This was then applied to a range of five categories for maintenance frequency, enabling a comparison to be made between sealed and unsealed shoulders. The results of this comparison were then be projected over the life of the road to determine if sealing full width would reduce maintenance cost and by how much.

Figure 1 (left) – An unsealed road shoulder with edge deterioration and drop-off; Figure 2 (right) – A road shoulder that has been sealed full width. (Road Safety Toolkit 2010)

4. Key Outcomes

The results of this analysis are intended to assist road authorities in providing effective design and whole-of-life cost strategies when approaching similar situations. By doing so, this will enable funding to be used more strategically enabling it to go further.

5. Further Work

The next logical step for this research would be to undertake a case study comparing accurate historic maintenance data to the results put forward in this report.

6. Conclusions

Whilst there are many variables which play a role in road shoulder maintenance, this analysis applies a simplistic approach to predict, as accurately as possible, the effects on maintenance costs by sealing full width. The results of this study bridge a gap identified in the literature and provides a simplistic and informative approach for road users to consider.

Acknowledgements

I would like to thank my supervisor David Thorpe for his guidance and Western Downs Regional Council for providing data that made this analysis possible.

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Improved theory for the design of high-speed roundabouts to suit heavy vehicles

Sponsor - School of Civil Engineering and Surveying

Mark Tomarchio

Bachelor of Engineering (Honours) (Civil)

Supervisors: Dr Soma Somasundaraswaran, USQ

Keywords: roundabouts, heavy vehicles, side friction

1. Introduction

All roundabouts are effectively a series of "reverse curves" that vehicles are required to negotiate. These curves limit the speeds that can be achieved by vehicles through the roundabout, which is the predominant reason that this form of intersection control is often considered the safest. However, there are significant differences between the performance and capabilities of cars and heavy vehicles. This research project investigates the differences in roundabout geometry required to safely cater for heavy vehicles as well as cars, and aims to improve the design standards and guidance for designers of such roundabouts.

2. Background

Roundabout usage as a form of intersection control is becoming more common every day, and they are increasingly being used in high speed areas on major roads, with a wide variety of traffic composition, including heavy vehicles. This is in contrast to their more traditional usage in low speed urban environments, which the commonly available standards and guidelines currently reflect. It is important that roundabout designers understand the differences between truck and car capabilities if they are to ensure safe and effective geometry for both vehicle types.

3. Methodology

A case study of an actual roundabout with perceived heavy vehicle issues was carried out. An as-constructed 3D model of the roundabout was obtained, speed data collected and analysis of car vs truck speeds performed. The travelled path of a semi-trailer through the roundabout was analysed via video, and simulated using Autoturn software. 12D software was then used to model and measure the actual radii and crossfalls that the vehicle encountered.

4. Key Outcomes

Combined with the speed data, the side friction being generated by the vehicles and the rate of rotation of crossfalls could then be calculated and compared to relevant design standards. Refer Table 1 for a summary of car vs truck speeds and side friction (f) values.

Location	Travelled Path Radius (m)	Crossfall (%)	All Vehicle Classes (1-12)		Heavy Vehicles (Austroads Classes 3-12)	
			Speed (km/h)	Side Friction (f)	Speed (km/h)	Side Friction (f)
1	207.3	2.956	78.12	0.202	74.88	0.183
2	105.2	-3.000	66.70	0.303	63.46	0.271
3	57.0	1.662	55.08	0.402	51.84	0.355
4	42.9	-3.050	55.71	0.539	52.47	0.475
5	140.0	-3.000	63.72	0.198	60.48	0.176

Table 1 – Cars vs Heavy Vehicles Calculated Side Friction

5. Further Work

Further development of examples of recommended treatments is required. Further possible work beyond the reaches of this project could involve increasing the number of case studies performed on actual roundabouts to further confirm the findings, and trialling and evaluating some of the recommended treatments.

6. Conclusions

Cars can tolerate a much higher value of side friction at roundabouts than trucks. Additionally, a cars margin for error re side friction is much higher than a trucks, ie, if a car generates side friction in excess of what it can tolerate, it will typically slide, whereas a truck will typically roll. Therefore, trucks need to negotiate roundabouts at significantly lower speeds than cars, and unique geometric considerations need to be made to facilitate this.

Acknowledgements

Thank you to Dr Soma, my colleagues and mentors at GHD, and the various data contributors who supplied the necessary information for the case study.

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Lot Infiltration Trenches Impacts on Water Quality

Sponsor - School of Civil Engineering and Surveying

Aidan Train

Bachelor of Civil Engineering Honours

Supervisor: Mrs Justine Baillie, USQ

Keywords: EPA SWMM, Model Conceptualisation, Catchment Pollutant, Source Control, WSUD

1. Introduction

The project aims to address growing need for more advanced modelling and conceptualisation of urban subdivision. Specifically, modelling software, EPA SWMM will be employed to compare traditional, catchment scale water treatment measures – detention basins with source control WSUD measures – infiltration trenches.

2. Background

This extends upon hydraulics and hydrology studies undertaken as part of my civil major. It provides an opportunity for me to understand the application of a software which is unfamiliar to me, by applying theories and concepts, creating the model in a bottom up approach. QGIS software was used for spatial analysis and to aid in the conceptualisation of many of the parameters. This program hopes to serve a proof of concept regarding using an EPA SWMM to model the performance of WSUD measure, in addition to answering the question as to whether source control is more economical than measures at the other end of the hierarchy.

3. Methodology

To undertake the modelling, relevant data needed to be obtained. Prior to this, extensive research into literature and previous SWMM models was conducted so that key parameters were understood. Firstly, a QGIS project was created and DEM data was analysed. Lot boundaries were digitised to represent subcatchments and the DEM data allow for the drainage flow paths to be verified, along with the selected outlet. Zonal statistics was used to analyse the slope of each lot, ascertain the area, and prepare all spatially dependent and linked inputs in a format that was more user friendly than the EPA SWMM interface. Excel processing was conducted to ensure the QGIS exports could be directly copied into excel. Figure 1 shows the export which was made from QGIS.

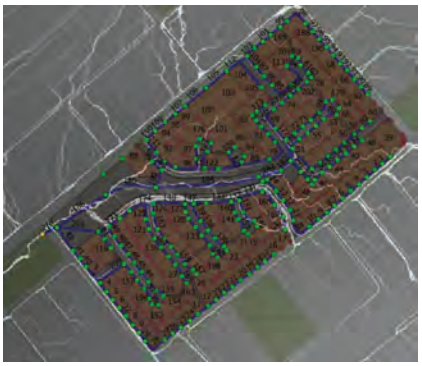

Figure 1 – QGIS Catchment Conceptualisation

4. Key Outcomes

Catchment conceptualisation has been completed, though some refinements may be necessary. The model has been able to simulate rainfall through the catchment.

5. Further Work

The model must now be given an appropriate rainfall input. A detention basin scenario must be designed based upon the infiltration trench source control measure. Performance will then be assessed as $ per equivalent pollutant unit treated.

6. Conclusions

EPA SWMM is demonstrated to be applicable to an urban subdivision in Toowoomba, with QGIS able to allow for simplification in the preparation of all spatially varied parameters

Acknowledgements

Thanks to my partner, my parents and my supervisor, the support of whom, has made the progress to date possible.

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Effects of Climate Change and Land Use on Rainfall and Management of Flooding in an Urban Coastal Catchment

Sponsor – Knobel Engineers, School of Civil Engineering and Surveying

Erin Way

Bachelor of Engineering (Honours) (Civil)

Supervisors: Dr Antoine Trzcinski, USQ

Mr Blake Stephens, Knobel Engineers

Keywords: Climate Change, Urban Development, Flooding

1. Introduction

Extreme and unpredictable rainfall events occur regularly within Australia and the likelihood of these occurring more regularly may increase as a result of climate change.

This dissertation investigates whether the occurrence of severe rainfall events based on estimated climatic condition changes on the Gold Coast have increased and determines whether these severe rainfall events have increased the rainfall intensity. Sea-level rise and increased flood levels will be analysed along with storm surge and how this correlates with climate change.

2. Background

There is an increased likelihood of severe rainfall events that are affecting urban coastal development drainage systems due to climate change. These rainfall events are unexpected and have the potential to have a large impact on urban areas. Future predicted rainfall intensities have a high possibility of increasing due to climate changes and it is critical to understand these changes as it can result in increases to the risks of flooding.

3. Methodology

The Currumbin Creek catchment has been chosen for this analysis due to the area being a low-lying, high-density area with a large increase in population. An increase in population follows a need for development, subsequently a change in land use and enhanced climate change factors.

An analysis will be conducted on rainfall events using QGIS and TUFLOW modelling software. Data will be obtained from available online datasets that are input into the software programs. A number of scenarios will be modelled applying climate change factors, increased impervious ground cover and increased sea-levels.

Figure 1: Currumbin Creek Catchment

4. Key Outcomes

Based on the expected outcome that the subject catchment is highly inundated during an extreme rainfall event, a flood management outcome will provide mitigation options such as lot based attenuative structures/infiltration trenches/rainwater tanks, regional detention basins.

5. Further Work

Ensure that the lot-based water sensitive urban design devices are capable to hold the inflow of rainwater.

6. Conclusions

It is predicted that with an increase in population and change in land-use will result in higher flood levels due to reduced infiltration and higher volume of runoff. Higher flood levels increase the risk of safety for the urbanised area in question. It is essential that flood management is a major requirement when developing an adjacent major river or a coastal area.

7. Acknowledgements

I would like to thank my supervisor Antoine Trzcinski for his guidance and prompt response throughout my research and also my on-site supervisor Blake Stephens for his expertise within this field of study. Furthermore, I would like to thank my family and friends for their on-going support and encouragement.

8. References

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Effect of short fibres on the mechanical properties of particulate-filled polymeric resin

Sponsor – School of Civil Engineering and Surveying

Luke Fitch

Bachelor of Engineering (Civil) (Honours)

Supervisors:

Dr Allan Manalo

Dr Wahid Ferdous

Keywords: Short fibre reinforcing, particulate-filled polymeric resin, railway sleeper, fibre composite.

1. Introduction

This project evaluates the mechanical properties of particulate-filled resin with different types and dosages of short polymer-based fibres. Unlike hardwood sleeper, a fibre reinforced epoxy sleeper will not be inclined to common drawbacks such fungal attacks and infestations by termites.(Ferdous and Manalo, 2014). This study aims to provide a solution to the current challenges addressing the production of a low-cost particulate-filled resin matrix with strength characteristics comparable to that of hardwood. The epoxy mixture will be kept constant all throughout the tests with the main goal of analysing the effect of adding short fibres on the properties of the polymer matrix.

2. Background

In the present time, railway sleepers are manufactured predominantly from timber, steel and concrete. These traditional materials respectively possess suboptimal characteristics leaving them susceptible to failure. Hardwood is by far the most common type of sleeper used in railway industry. However, they are vulnerable to splitting, fungal decay and termite attack. The problems of these sleepers can have negative implications in the service such as train derailments and high maintenance costs for replacement. As years goes by, the demand of hardwood is increasing, and therefore depleting the resources resulting in more expensive and a less viable sleeper material.

3. Methodology

Three fibre types ReoShore 45, Econo-Net and a mix of Forta Ferro and Econo-Net) were added at three dosages to a particulate filled epoxy resin system. The selected dosages by weight of fibre with respect to the mix is 0.5%, 1.0% and 1.5%. For each fibre dosage, 50mm diameter by 100mm long cylinders were produced to evaluate the compressive strength. In addition, 25mm x 25mm x 250mm rectangular beams were tested for flexural strength. At least three replicates were prepared and tested for each sample type.

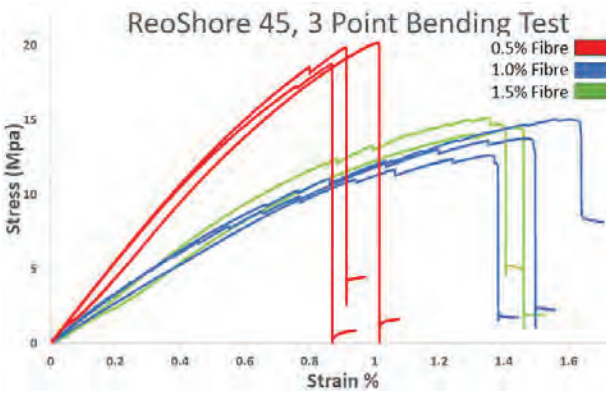

Figure 1 – Reo Sure 45 fibre stress strain graph

4. Key Outcomes and Further Work

Figure one shows the results for the ReoShore 45 fibres. The highest strength for both 3point bending and compressive strength was achived at the lowest dosage tested. For the fibres and dosages tested; it was found that incresing the dosage lead to a decrease in strength for both tests. The effect of other fibre types is still being analysed. There is a potential to produce higher strength by testing lower dosages than looked at by this study.

5. Conclusions

The Econo-Net and the mix of Forta Ferro and Econo-Net fibre types were wider than the ReoShore 45 fibres and made the samples weaker by causing more disruption of the epoxy matrix. By incresing the dosage of the fibres tested, more and more matix interuption occurs and results in a weaker structure.

Acknowledgements

I would like to thank the technical staff at the P11 laboratory for their assistance ensuring the project is competed safely. I would also like to thank my supervisors; Dr Allan Manalo and Dr Wahid Ferdous for their guidance.

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Conflict of Interest: The Dual-Role Superintendent / Lead Designer in Construct Only Contracts

Sponsor - School of Civil Engineering and Surveying

Alexander Swift

Bachelor of Construction Hons

Supervisors: Dr Nateque Mahmood, USQ

Mr Alastair Oxbrough, HFW

Keywords: Superintendent, contract, standard.

1. Introduction

The role of the Superintendent in construction contracts has long been the subject of dispute between contracted parties. This role is further conflicted when the Superintendent is also responsible for design and design management. The project aims to outline the challenges faced in this regard under current standard form contracts and how the Superintendent role impacts commercial construct only contracts.

2. Background

Australian Standard form contracts AS2124 & AS4000 and their D&C variants represent 70% of contracts used in Sharkey's 2014 sample study. The role of the Superintendent under AS contracts has not evolved for over two decades, despite major evolutions in the commercial construction industry. As the industry becomes more automated and administrative resources become more stressed, there needs to be more trust and cooperation in the contract administrative body.

3. Methodology

Through a series of questions and case studies, quantitative analysis will be compiled and assessed to understand: if there is an industry-wide perceived bias; where and what the bias is; how this bias can impact a project; and what can be done to improve this situation, contractually.

4. Key Outcomes

At the time of this abstract, the questionnaire has not yet been finalised. However, based on early indications the industry is definitely responsive to some changes, in particular the inclusion of an 'independent assessor' who performs the valuing, assessing and certification roles generally speaking). There remains a role for the superintendent, that of the 'principal's agent' – who performs all the functions that would be traditionally imposed on them as representative of the principal. In particular, it is important to get equitable coverage of respondents from Contractors, Consultants and Principals (*see Figure 1* .

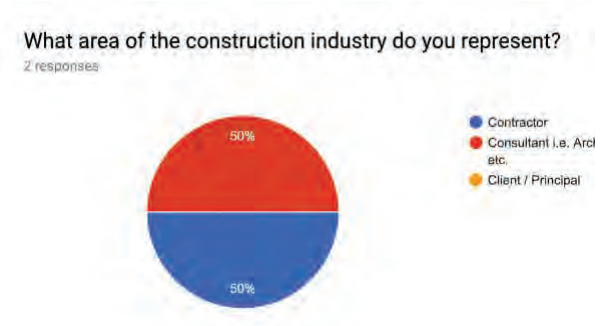

Figure 1 – Industry Representation

5. Further Work

Final quantification of the questionnaire and case studies in order to capture a true reflection of industry opinions and compilation and assessment of the results in line with the project objectives.

6. Conclusions

The intended conclusion is for a majority acceptance of the amended role of the superintendent under standard form contracts. The benefit of which would be increased trust between contracted parties, leading towards a more harmonious and less adversarial environment and ultimately a more cost-effective final product.

Acknowledgements

I would like to thank Dr Nateque Mahmood for his support thus far, and my external supervisor Alastair for the opportunities and support he has provided me. Of course, my wife Isobel and daughter Evie, for their patience, encouragement and understanding throughout.

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Exploring the impact of the Building Industry Fairness (Security of Payments) Act 2017 (Qld) on the Commercial Construction Industry

Sponsor - School of Civil Engineering and Surveying

Jordan Martin

Bachelor of Construction (Honours) (Construction Management)

Supervisors: Dr Amirhossein Heravi, USQ

Figure 1 – Who does the BIF Act really affect?

Keywords: Legislation, Government, Construction Law

1. Introduction

The Building Industry Fairness (Security of Payment) Act 2017 (Qld) was introduced to both private and public sector projects throughout 2018, and the change has been one of some controversy in industry. This dissertation delves into the legislation change effecting how payment claims are handled in the commercial construction industry, and uses industry feedback to predict the outcomes of the legislation moving forward, as well as evaluating it.

2. Background

The legislation was brought about by the Labour Government off the back of an election promise, a promise to improve the payment process to subcontractors, and give them more security and rights around payment for work performed. The process of drafting and implementing the new legislation to support this promise was evidently rushed, and has meant a number of amendments, as well as concerns from bug players in the industry. The change brings into effect tighter timeframes around payment claims, project bank accounts (PBA's) and more power of prosecution and torts to the Queensland Building and Construction Commission (QBCC).

3. Methodology

Adopting a mixed method approach, the methodology consisted of a qualitative method, by way of interviewing industry professionals, and a quantitative method by way of survey to a broader number of professionals. The interview incorporated a series of open-ended questions to both gauge the professionals understanding of the legislation, as well as their honest, uncensored opinion. The survey used a series of multiple choice and number scale questions to develop more measure around importance and costs, off the back of the results of the interviews which highlighted key areas using theoretical saturation.

4. Key Outcomes

The project was embarked on to raise a better understanding of how the legislation change has worked, and how it has effected the industry. The aim was to create an understanding of the Building Industry Fairness (Security of Payment) Act 2017 (Qld), how it has been rolled out, and how it will affect the industry. As cost is a unit that everyone understands, the project aims to identify cost effects, as well as area for improvement, feedback on the roll out, a thorough understanding of the legislation to abolish ambiguities in beliefs.

5. Further Work

The survey is yet to be closed out, however there is much more that could be done to both understand the legislation and educate the industry. More substantial feedback, beyond the scope of this project, would provide far more sway for political action.

6. Conclusions

PBA's seem to be an ineffective measure that will be costly to smaller contractors with many ongoing projects, which may even cause them to go out of business. The legislation relies on honest reporting of breaches to prosecute, and therefore dishonest contractors may continue to be dishonest regardless of the legislation, making it muchly pointless. Contractors have no issue with more constraints around payments, but believe that under the current legislation it is not working as it should.

Acknowledgements

I would like to thank Nateque Mahmood for his supervision up until leaving USQ, and Amirhossein Heravi for taking over thereafter.

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Building Industry Fairness (Security of Payment) Act 2017 (Qld)

Utilising a Mobile Device to Aid in Early Diagnosis of Corneal Abnormalities

Sponsor - School of Mechanical and Electrical Engineering

Sean Thomson

Bachelor of Engineering (Honours) – Electrical and Electronic.

Supervisor: John Leis, USQ
Advisor: Dr Srujana Sahebjada, CERA

Keywords: Corneal Dystrophy, Keratoconus, Pentacam, Digital Image Processing, Machine Learning.

1. Introduction

The cornea is the clear front surface of the eye that allows light to enter and provides up to 75% of the eyes focusing power. There are many conditions that can affect the cornea (Remington, 2011 . The condition that this project will target is a corneal dystrophy disorder called Keratoconus (KCN). The hypothesis is that an image taken from a mobile device can be reconstructed into a corneal topographic image and can be utilised for quick automatic diagnosis of abnormalities. This diagnosis would be without the need for an extensive review from an ophthalmologist or specialised imaging equipment.

2. Background

Many methods have been presented to correct KCN to reduce the progression. However, diagnosing KCN currently relies on the use of specialised topographic cameras and then careful analysis by an experienced ophthalmologist Laveric & Valentin 2019**).** While this project will focus on KCN diagnosis, it is hoped that it could be expanded to many corneal abnormalities in the future. It would be advantageous if any medical professional could give a preliminary diagnosis and begin treatment or get specialised care for their patient.

3. Methodology

A database of topographic corneal images from an OCULUS Pentacam was obtained from the Centre for Eye Research Australia (CERA . The database includes severe to mild KCN and non-KCN control images. Data pre-processing algorithms and neural networks were created to differentiate between a patient with and without KCN. Some pre-processing techniques employed included data augmentation, normalising inputs, and dimensionality reduction. The neural networks techniques and complexity were varied one at a time to find the most effective model convergence. Figure 1 shows an example of inputs and network convergence.

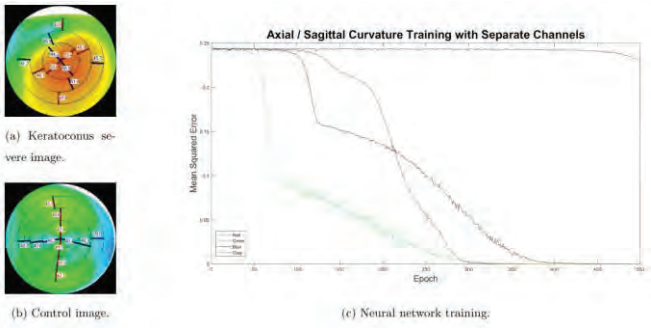

Fig. 1 - Axial / sagittal curvature image examples post processing and model training comparing RGB channels and gray scale.

4. Key Outcomes

The neural network training has shown that with the pre-processing techniques used, the image maps will converge on at least one of the dimensions. This should lead to successful results when the final model is created using the optimum dimensions for each map.

5. Further Work

Following on from here robust classifier should be created utilising significantly larger databases and tested on images from varying equipment. Then investigations in combining these with current mobile topographic technology could be achieved. Finally, if successful this can be expanded to other cornea abnormalities.

6. Conclusions

This project demonstrates that the automatic diagnosis of KCN is feasible from Pentacam images and can be executed on a mobile device. However, significantly more data will be required to use these techniques for patient diagnosis and other abnormalities.

Acknowledgements

I would like to thank John Leis for being my supervisor and offering guidance when required. I would also like to thank Dr Srujana Sahebjada and CERA for their ophthalmologist guidance and data. Lastly, I would like to thank my partner Karen Zaunscherb for her help in developing the topic and ongoing support.

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Applied Machine Intelligence From Diverse Data Sources For Financial Market Prediction and Analysis

Sponsor - School of Mechanical and Electrical Engineering

Cameron Beaman

Bachelor of Electrical & Electronic Engineering
& Bachelor of Business Leadership and Finance

Supervisor: Mark Phythian

Keywords: Quantitative Finance, Machine Learning, Neural Networks, Cloud Computing, Financial Time Series

1. Introduction

Attempts to forecast financial markets has long been the ultimate goal of financial traders. Financial markets can be described as a stochastic system. This project identifies financial markets as a time series prediction and analysis problem where, given enough information and computation, accurate mathematical predictions can occur. Given the highly computational nature of this project, machine learning agents are applied in a cloud based computation environment to provide an ideal solution.

2. Background

The Efficient Market Hypothesis effectively surmises that all information about a given financial market is known to all market participants, concluding that financial markets are random in nature, thus statistical advantage cannot be achieved. However, the above theory by Fama (1969) does not account for external factors. In this case, diverse data sources such as heliophysics and terrestrial climate data. Zhang (2019) identifies that classical algorithms such as the (ARMIA) Autoregressive Integrated Moving Average model perform well in linear time, however, these classical models degrade when applied to non linear data. This indicates that machine learning frameworks have the capability to improve overall model performance. This effectively makes any financial market a time series prediction problem.

3. Methodology

Machine learning models have established methodologies that advocate high performance when compared to traditional methods. This project predicates that terrestrial earth is a closed system, thus all probable outcomes can be simulated given enough information. Model prediction is aided by machine learning applications from diverse multidimensional data sources in conjunction with robust cloud computing to identify market opportunities from unlikely parameters.

A key methodology is the build and application of deep reinforcement learning to financial markets (see Fig.1). Reinforcement learning in this context is three-fold; a policy dictates how the neural network makes decisions, a reward function dictates positive and negative behaviour, and a value function dictates long term goals. In this instance the neural network will learn to optimise a strategy that can be measured by overall performance.

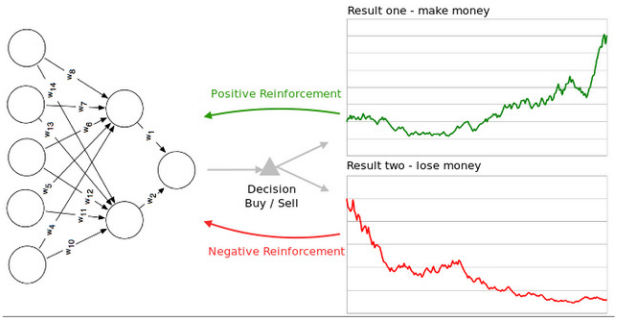

Fig 1: Reinforcement learning applied to a neural network can be either negatively or positivity reinforced to achieve goals. (Reed, 2019)

4. Key Outcomes

This project will provide a detailed investigation of current machine learning methodologies and how they relate to financial time series. Additionally, this project will compare traditional forecasting methods and practices, provide a detailed review of neural network architectures and model training methodology. It will provide an empirical comparison of machine learning models and algorithms for financial time series forecasting. Finally, a critical assessment of model performance on different data sets will be provided.

5. Further Work

This work is the application of financial time series modelling, machine learning and econophysics. This work could be furthered by new methodologies identified by Gonclaves (2015) who applies quantum theory to economics and finance, indicating that quantum artificial neural networks represent a new way to build, model and simulate financial markets. Additionally, quantum logic and gauge theory has a wide range of applications within the quantitative finance domain.

6. Conclusions

It is predicated that a correlation between agricultural stocks, heliophysics and terrestrial climate exist. Additionally, machine learning models are anticipated to outperform traditional methods and the introduction of multidimensional data will enhance market prediction.

Acknowledgements

I would like to thank my supervisor Mr Mark Phythian, my family and friends for their continued help and support and most importantly inspiration from Richard Feynman, who's quote " *Study hard what interests you the most in the most undisciplined, irreverent and original manner possible*" will always resonate with me.

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Applying Systems Engineering Approaches to the Management of Electrical Engineering Projects

Sponsor – School of Mechanical and Electrical Engineering

Darius Nooriafshar

Bachelor of Engineering (Honours)
(Electrical and Electronic Engineering)

Supervisors: Associate Professor Tony Ahfock, USQ

Associate Professor David Thorpe, USQ

Keywords: Systems engineering, systems thinking, project management.

1. Introduction

This research study aims to find a connection between systems engineering and project management in an electrical engineering environment. Electrical engineering projects are unique in nature as they generally involve many complicated sub systems that are required to interact with each other. Hence, a holistic or systems project management approach may be suitable.

2. Background

Modern electrical projects should not be viewed as static but rather as dynamic systems. Hence, traditional project management methods and approaches may not be appropriate. An emerging method in project management is the application of systems engineering which considers the relationships between various parts of a given system. Locatelli, Mancini and Romano (2014), found that there is a connection between systems engineering and project management. Therefore, the purpose of this study is to build on the well-established literature and develop a suitable systems engineering model for the management of electrical engineering projects.

3. Methodology

A critical review of the literature led to the identification of a knowledge gap. An in-depth interview instrument was devised and five senior key domain experts were selected based on a number of criteria for interviewing. The results from the conducted interviews were analysed manually by theme. The identified recurring themes were used in conjunction with the existing project management models in order to develop a proposed model refined for electrical projects.

Figure 1 – Connection between systems engineering and project management. (Reproduced from Van Gemert, 2013)

4. Key Outcomes

The results obtained from the in-depth interviews agree with the conducted literature review. A systems engineering model appears to be a suitable method for the management of electrical engineering projects. There is a strong connection between systems engineering and project management (figure 1).

5. Further Work

Suggested further work would be to verify the proposed model by applying it to a real-world electrical engineering project.

6. Conclusions

The domain experts and literature agree that the application of systems engineering approaches to the management of electrical engineering projects has the potential to improve the outcome and success rates.

Acknowledgements

I thank Associate Professors Tony Ahfock and David Thorpe for their guidance and support throughout this research project.

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Electrical Control System and Inverter Development for a 10kW Wind Turbine

Sponsor – School of Mechanical and Electrical Engineering

Bradley Paton

Bachelor of Engineering Honours (Electrical and Electronic)

Supervisors: Dr Leslie Bowtell, USQ

Prof Peter Schuble, USQ

Keywords: Small Wind Turbine, Control System, Invertor.

1. Introduction

This project aims to improve the existing control system of an operational Camira Energy 10kW wind turbine by implementing a refined control system, such as a fuzzy controller in conjunction with a Maximum Power Point Tracking algorithm. This will replace the existing table lookup control system and converter. Safety improvements will provide additional protection features within the operational objectives to prevent the turbine overspeed, and investigate a new approach for power conversion from the Permanent Magnet Synchronous Generator (PMSG) to the Power Grid.

2. Background

Due to the environmental impacts of fossil fuels, renewable energy sources are being investigated and implemented to provide an alternative power source. Wind power generation is one source which has gained momentum. This project extends the existing knowledge of large-scale wind turbine control and safety functions and applies this knowledge to small wind turbines.

3. Methodology

A literature review was conducted to determine the current practices and research within the PMSG wind generation systems, as well as a component and system breakdown of the existing Camira Energy 10kW wind turbine. I then assessed control systems to be implemented to the existing wind turbine and investigated safety features to prevent the overspeed of the Camira Energy 10kW wind turbine during generation trips and with the event of excessive wind speed. Simulations were then conducted on the chosen control system using Matlab/Simulink, and the results presented over the various transient and steady state operating conditions.

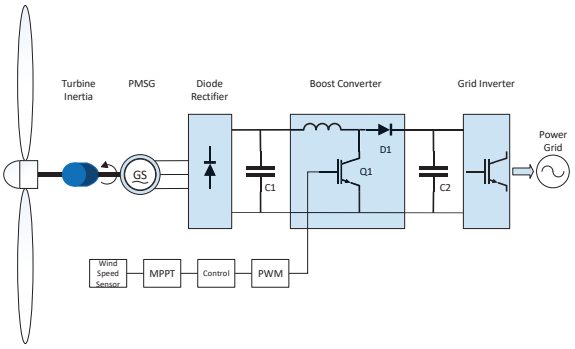

Figure 1 – Wind Turbine DC/DC Converter

4. Key Outcomes

The system which provides the best performance based on a cost criteria, and without the requirements to install additional sensor hardware, is the DC/DC Boost converter as shown in Figure 1, controlled from an open loop control system with an input from a wind speed sensor and a maximum Power Point Tracking algorithm based on the wind turbine tip speed ratio.

5. Further Work

Further work for this project will continue with the bench testing of the control system to fine tune system parameters and prove the simulated results, and then proceed to a hardware upgrade and real time field testing.

6. Conclusions

This project is continuing work to determine a cost-effective method to improve the performance of the Camira Energy 10kW wind turbine and export the generated power via grid connected inverters.

Acknowledgements

I would like to acknowledge Dr Leslie Bowtell for the guidance and advice throughout the course of this project and to Prof Peter Schuble for making this project available for development.

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Optimization of a SNCR/LN NOx Reduction System using Model Predictive Control

Sponsor - School of Mechanical and Electrical Engineering

Grant Johnston

Bachelor of Engineering (Honours) Electrical and Electronic Engineering

Supervisors: Dr Les Bowtell, USQ

Mr Russ Anderson, Covanta

Keywords: MPC, SNCR, NOx, and DCS.

1. Introduction

An increase in public awareness has pushed governments to tighten regulations surrounding environmental emissions limits. Existing plants are required meet new regulations, which involves the implementation of new technologies. These process changes are very costly for older facilities to both implement and maintain. Application of one such system at a Metro Vancouver Waste to Energy WTE) facility utilized a Low NOx^{tm} (LN) and Selected Non-Catalytic Reduction (SNCR) to reduce the plants NOx output. This project, completed in 2013, did not performed well due to a requirement for the Operator to manually balance the LN and SNCR systems. This resulted in roughly 35% more Ammonia used with potential savings of $ 39,249.87/yearly. This project provided the feasibility and configuration of Model Predictive Control (MPC) to maximize the performance of these two systems, which resulted in a design to reduce the overall operational cost of the system, as shown in Figure 1 – MPC Control Region.

2. Background

Advanced Process Control is slowly being adopted into Industry and the ability to showcase the benefits is required before funding is provided as most smaller facilities are cautious to these new technologies.

3. Methodology

The Methodology of this project was structured as a Front-End Engineering Design project. The project involved a performance analysis, cost-benefit analysis, design work, and proof of concept configuration.

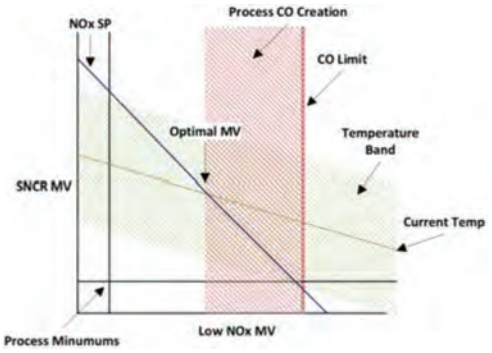

Figure 1 – MPC Control Region

A detailed evaluation of the original control strategy was performed to determine its limitations and constraints. A cost-benefit study to show the benefits of an optimized system was conducted. Design documents were created to provide a base for the modifications that would be required to implement the new control strategy. A digital twin of the sites DCS was created and used as a development system for the new control strategy. The MPC controller was configured using standard function block programming and added to the HMI. To create the prediction model for the MPC controller, a training dataset was selected from the facilities historical data. This model was verified against a test set of data, and performance evaluation was conducted on the model.

4. Key Outcomes

The LN and SNCR system was analyzed. A new control strategy was designed and configured ustilizing MPC to provide the most optimial balance between the LN and SCNR system.

5. Further Work

Online implementation of the designed MPC controller along with refinement of the prediction model would be beneficial. Additionally, temperature control strategies need to be investigated.

6. Conclusions

Utilizing MPC would result in higher utilization of LN and a decrease Ammonia usage while maintaining both CO and NOx. These changes would see a reduction in operating cost and provide payback with the costs recovered within the first year of operation.

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Feasibility of Remote Earth Monitoring for SWER Systems

Sponsor – School of Mechanical and Electrical Engineering

Amy Ferrari

Bachelor of Engineering
(Honours)
(Electrical and Electronic)

Supervisors: Assoc. Prof. Tony Ahfock, USQ
Mr David Bell, Energy Queensland

Keywords: Single Wire Earth Return (SWER), Earthing, Ground, Simulink, Simscape

1. Introduction

Single Wire Earth Return SWER) is engineering brilliance in its elegant simplicity. The design involves one high voltage conductor with the mass of earth acting as the path for the return current and as a protective measure to dissipate fault currents. The connection between the earthing conductors and ground is an integral component of the SWER distribution system and it is essential for electricity providers to maintain reliable low resistance connections. This research project will develop a method for the remote monitoring of SWER earths through system models verified against field test results.

2. Background

SWER power distribution systems were developed in the 1920's and implemented in Queensland in 1959. SWER originated from the need to supply sparsely populated rural areas with small individual load densities in a cost effective manner. Failure of earth connections can present safety hazards to humans and livestock from increases in step and touch potentials. Due to the non-homogenous nature of soil it is important to understand the key factors of inductance, and site characteristics of electrode specifications. Previous earthing studies have provided instantaneous earth resistance and resistivity readings; there is no engineering evidence that has been found to demonstrate remote continuous monitoring of SWER earth connections.

3. Methodology

SWER systems were investigated from advantages to disadvantages, influence of emerging technologies and the future of SWER schemes, construction techniques, and current earth testing practises. Equivalent base SWER and two clamp test circuit models were developed using Simulink/Simscape. The test circuit was induced on the secondary winding of the base model and the filtered results extracted. The LV earth circuit results were analysed against HV and LV voltage references to establish variations to base line thresholds.

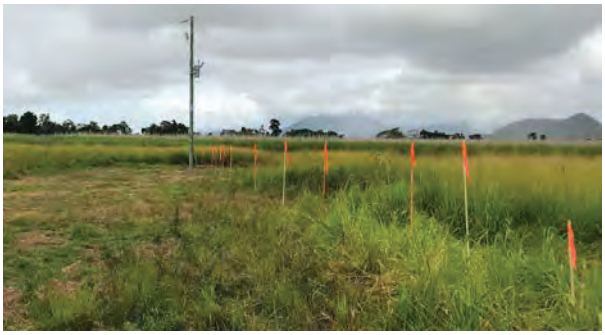

Figure 1 – Field Testing

4. Key Outcomes

A Simulink/Simscape test model has been developed that theoretically verifies a test method for online SWER earth monitoring. Manufacturer functional specifications and test site recommendations have been established for confidential company release.

5. Further Work

The test site for the stretch target has been built; test equipment manufacture is currently underway. Trials and onsite results will be available at the end of the year.

6. Conclusions

The project modelling has proven online monitoring of SWER earthing is possible. Results from the onsite trials will provide fundamental understanding of the behaviour of SWER earthing and potentially influence the business behaviour and decision making.

Acknowledgements

Associate Professor Tony Ahfock and Mr David Bell for providing guidance and input.

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Condition Monitoring using a Low Power Wide Area Network based on LoRaWAN

Sponsor – School of Electrical and Electronic Engineering

Jonathon Ball

Bachelor of Engineering (Honours)

Maj, Electrical and Electronic Engineering

Supervisors: Associate Professor, Alexander Kist, USQ

Mr Dylan Willis, Aurizon

Keywords: IoT, Condition Monitoring, LoRaWAN

1. Introduction

The Internet of Things (IoT) offers opportunity for the reliable collection of data. Low power wide area networks (LPWANs) offer the establishment of IoT networks and devices with low power budgets. Some LPWANS like LoRaWAN also offer long distance connections, suitable to remote and widespread operating environments (Karima & Atkinson 2013).

This project investigates the rollout of a LoRaWAN network and the development of a compatible data collection device to enable condition monitoring of critical track circuit devices in Aurizon's Network.

2. Background

When track circuits fail they prevent the safe running of trains, can delay road vehicles at level crossings and cost considerable amounts in lost revenue while they are repaired. Aurizon relies on a large number of EBI Track 200 track circuit devices known to fail during their operational lifetime. Prior research has shown that majority of nuisance failures can be predicted and prevented through condition monitoring of these devices (Rose 2009). Due to the geographically diverse roll-out of these track circuits, traditional computer-based serial communications is not possible. Aurizon requires a solution to remotely gather the available diagnostic information from these devices.

3. Methodology

Initial market research was undertaken to determine if an existing solution was available on the market that could be used to connect to an EBI Track 200 device and LoRaWAN. When no device could be found a Systems Engineering approach was undertaken to develop a device capable of reporting back condition information of EBI Track 200 devices over LoRaWAN.

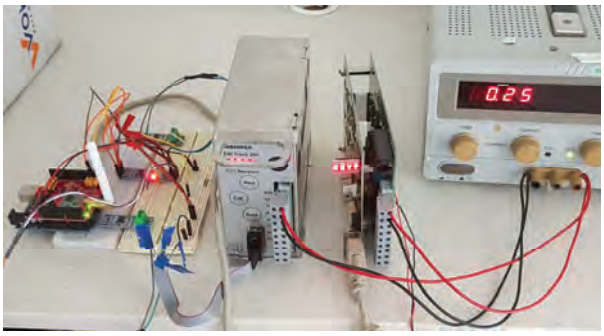

Figure 1 – Proof of concept system in operation

4. Key Outcomes

A proof of concept device was built using an Arduino Uno capable of connecting via RS-485 serial connections and collecting condition data of multiple units see Figure 1. This collected data is then broadcast over a private LoRaWAN network.

5. Further Work

Due to circumstances that arose over the course of the project some key requirements remain open. This includes using battery powered end devices that would operate in a local power outage, developing a private LoRaWAN network connected to Aurizon's internal data network and performing field testing on active receivers.

6. Conclusions

A proof of concept device was developed that enables EBI Track 200 track circuits to have their condition reported across a private LoRaWAN network for centralised monitoring and alerting. This data will allow for the implementation of proactive maintenance activities to reduce nuisance failures and improve the availability of train paths.

Acknowledgements

I would like to thank my partner Alyssa Robinson for always supporting me and Dylan Willis for providing key resources and mentorship.

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Low-investment EMI pre-compliance for COTS technology insertion into submarine combat systems

Sponsor – School of Mechanical and Electrical Engineering

Luciano Colagiuri

Bachelor of Engineering (Honours)

Electrical and Electronic

Supervisor: Dr Andrew Maxwell, USQ

Keywords: *EMI, COTS, MIL-STD-461G*

1. Introduction

A modern submarine's combat system is largely dependent on commercial off the shelf (COTS computer technology as a means of cheaply adopting the latest, high-performance, commercially developed and qualified systems to maintain capability (Guertin Miller 1998 . COTS technology is not normally designed for military use, nor is it necessarily compliant to military standards for electromagnetic interference (EMI), such as MIL-STD-461G.

A gap analysis, based on a comparison of commercial and military EMI standards, showed that there is no guarantee of COTS EMI compliance. For example, Figure 1 illustrates a frequency coverage gap between typical commercial and the predominant military requirements for electric field emissions.

2. Background

Formal compliance testing at a certified test house is prohibitively expensive due to the highly controlled, calibrated and specialist nature of such facilities. It is normally only used for final qualification testing prior to acceptance of new designs into service. In order to reduce the risk of a compliance failure, pre-compliance testing should take place prior to and even during system design. Evidently, a need exists for a low-investment and practical test protocol to verify the EMI performance of such COTS equipment against the applicable military EMI standards.

3. Methodology

Background research was undertaken into the historical development of current commercial and military EMI standards, the trend and motivation for the use of COTS in the defence environment, as well as the mechanisms and theory of EMI design as applied to the submarine. This research was critical in the development of a gap analysis procedure as well as the development of low-cost and practical alternatives to formal EMI testing with simplified tests as pre-compliance test protocols.

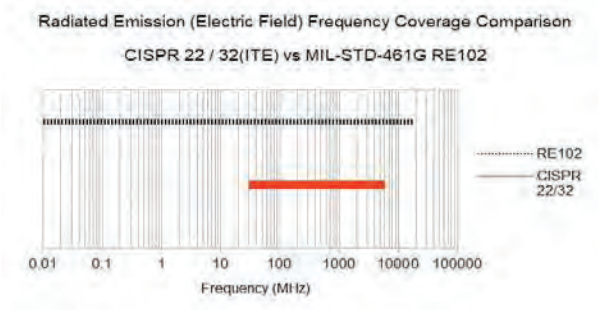

Figure 1 – Frequency coverage gap between CISPR 22/32 and MIL-STD-461G RE102 radiated electric field requirements.

4. Key Outcomes

A clear understanding of commercial non-compliance to the military EMI standard. The design of test hardware and calibration techniques with the use of general test equipment to undertake practical EMI pre-compliance tests readily in a typical development laboratory facility.

5. Further Work

Due to resource and time limitations, radiated emissions test design was limited to a span of 1GHz. Further work is needed to expand the project out to the full 18GHz military span of interest. Comparisons of experimental results against certified test house results would be most useful to ultimately prove or disprove this concept.

6. Conclusions

While COTS computer technology is generally sought after to provide low-cost and high capability to defence, commercial EMI standards do not comply with military requirements. It is necessary and eminently possible to undertake low-cost and practical pre-compliance testing as part of a product or system design.

Acknowledgements

I would like to thank my father, Agostino, and my colleagues John Macleod and Steve Saunders.

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Optimised renewable generator schemes to improve the utilisation of network assets while maintaining safe operation of primary plant in accordance with the National Electricity Rules

Sponsor - School of Mechanical and Electrical Engineering

Michael Elsasser

Bachelors of Engineering (Honours) (Electric/Electronic)

Supervisors: Associate Prof. Tony Ahfock, USQ

Mr Greg Caldwell, Energy Queensland

Keywords: Optimisation, National Electricity Rules, Renewable Generation.

1. Introduction

Energy Queensland has identified a problem which results in underutilised assets. According to the National Electricity Rules (NER) generators are required to meet specific continuous generating conditions which results in generator connected lines which are rated to carry more current than that supplied under unity / standard conditions. This dissertation aims to create a control system which will allow generators to supply power at the limit of their generator connected lines.

2. Background

Because of its popularity and the recent evolution of renewable technology, the number of large-scale renewable generators is on the rise. Limiting the capacity of these renewable generators could be detrimental to the future of the Energy Queensland network. Because of this Energy Queensland has opted to find a solution which allows generators to operate above agreed supply limits and output power according to their generator connected lines.

3. Methodology

MATLAB was used to analyse historical data to understand the extent to which assets are underutilised and to identify any areas which may need to be specifically monitored (e.g. Power Factor, Voltage) refer to figure 1 for an example. These monitoring systems would be implemented in the control system. After a thorough analysis of historical data, a control system was designed which would ensure safe operation of both generator plant as well as Energy Queensland assets. This control system was designed according to Energy Queensland specifications and in accordance with energy Queensland's SCADA systems.

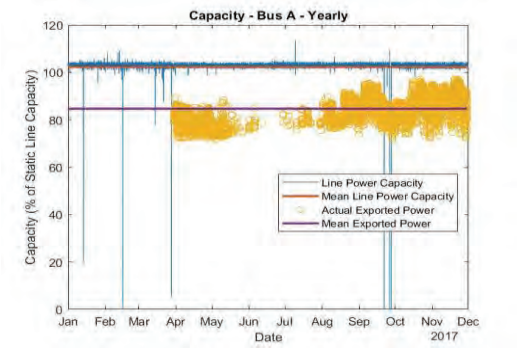

Figure 1 – Available us capacity on bus A using yearly dataset

4. Key Outcomes

The potential outcome of the dissertation is the implementation of the designed control system which would allow large scale renewable generators to supply power to the limits of their generator connected lines.

5. Further Work

Further work includes the design of a control system which will allow scheduled and semi scheduled generators so supply to connected line limits.

6. Conclusions

The key outcome of this project was the development of a functional control system which may be used as a guide for similar systems in the future.

Acknowledgements

I want to thank my academic and industry supervisors, Dr Tony Ahfock and Mr Greg Caldwell. I would also like to thank my family and friends who have supported me through this endeavour.

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Impact of Largescale PV Penetration on Network with a View of Replacing Synchronous Generators

Sponsor - School of Mechanical and Electrical Engineering

Mkululi Mpofu

BENH Electrical and Electronic Engineering

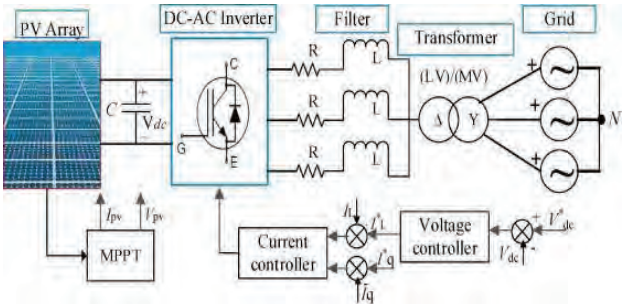

Figure 1 : Grid-Connected PV System (*Al-Shetwi et al, 2018*)

Supervisors: Associate Prof. Tony Ahfock, USQ

Keywords: Intermittency, Uncontrollability, Stability

1. Introduction

The world is shifting away from use of fossil fuels for generation of electricity as these are attributed to excessive production of carbon dioxide, a gas that is widely accepted to be linked to global warming. Solar energy has become synonymous with environmentally friendly source of energy as it is seen as a significant contributor to global warming reduction. This has led to large penetration of solar energy into electricity networks as some world governments are targeting 100% solar generated power by as early as 2030. However, there has been insufficient research on optimal solar penetration levels given the intermittent and uncontrollable nature of solar energy generation thus setting up a stage for this research project.

2. Background

The impact of high penetration of solar on networks is investigated through modelling of a real-life grid connected solar system. The project aims to produce outcomes that will help in preventing black outs in case there is a cut-off point beyond which network stability gets compromised.

3. Methodology

The project starts with an extensive research on literature relating to the impact of high solar Photovoltaic (PV) penetration on electricity networks. A simple model of an electricity network is developed as shown in figure 1. The model comprises of Solar array with varying irradiance and/or temperature, DC-DC boost converter to facilitate Maximum Power Point Tracking MPPT) capability, DC-AC Inverter, Point of Common Coupling (PCC), Step-up Transformer and grid system with conventional synchronous generators.

4. Key Outcomes

The model is simulated with MPPT algorithms used to control output from PV cells. Voltage and frequency recovery times are recorded and compared with grid code values as solar generation is varied from zero to 100% penetration.

5. Further Work

Simulation results are yet to be accumulated and analysed. Further investigation should include batteries.

6. Conclusions

Inverter control systems seem to match those of synchronous generators but are slower in recovery to system disturbances and this might call for revision of standards on fault ride through capabilities and grid codes.

Acknowledgements

I would like to thank Andrew Hewitt, Tony Ahfock and USQ staff for their valued support and guidance towards the success of this project. I would also like to thank my workmates, my wife and our two sons for their support.

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Home based solar power grid system monitoring and maintenance study

Sponsor - School of Mechanical and Electrical Engineering

Stephen Souproanuck
Bachelor of Engineering - Electrical and Electronics Engineering

Supervisor: Dr P Wen, USQ

Keywords: Performance and maintenance assessment.

1. Introduction

There are significant numbers of homes with rooftop solar systems. The homeowners are expecting the performance outlined by the installer at the time of installation. These systems are rarely maintained or checked for performance. Homeowners may be unaware that the output of the system will degrade over time without adequate maintenance or even with maintenance.

The aim of the project is to investigate the lifespan of a typical rooftop solar system. Determine the typical lifespan of the system and the main components. It aims to identify expected performance of the system over time and the required maintenance to achieve this.

2. Background

According to the Clean Energy Council, the number of homes with rooftop solar system have passed 2 million and continuing. The average sizes of the systems are continuing to increase year on year as costs come down. These solar systems provide homeowners with their own power source that can either be used as it is generated or sold back into the grid. Homeowners are installing these systems to counter increased energy prices and promises by installers of short payback periods and a long life of 20 – 25 years.

With the focus on installing new systems, what consideration is given for maintaining these systems that are expected to last for 25 years? Are these systems continuing to provide the output of power as it was designed or are they underperforming?

3. Methodology

The project method was to gather research about individual solar components and systems as well as test reports and endurance studies. This research was assessed and applied to the home rooftop solar system, to determine typical failure modes and requirements to minimise these failures.

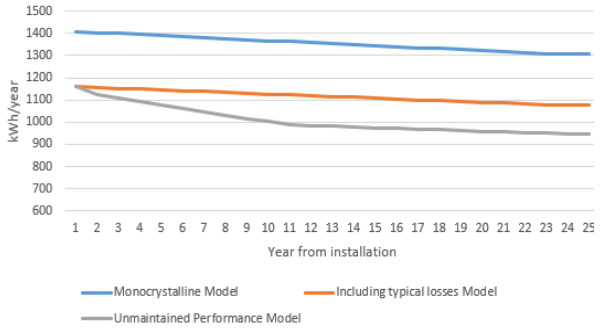

Figure 1 – Potential Output of 1kW system over time

4. Key Outcomes

The main outcomes if the project has been to identify the main causes of system failures and reduced performance for home rooftop solar systems. In additional to this, predicting current and future performance of systems with and without maintenance as shown in Figure 1.

5. Further Work

Extension of home rooftop solar systems with battery backup and assistance. Currently the number of these systems are small but expected to increase with their reduced cost and low feed in tariffs. This has not yet been addressed in detail.

6. Conclusions

The project has identified several failure points for rooftop solar systems. However, the main benefit of this project has been to identify the effects of unmaintained systems and the improvements that can be made by a small amount of maintenance.

Acknowledgements

I would like to acknowledge USQ for making high grade qualifications available to working students and the flexibility they have shown.

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Investigation of PV inverter auto-changeover from grid-connection to local power supply in emergencies

Sponsor: – School of Mechanical and Electrical Engineering

Makenote Tshuma

Bachelor of Engineering (Honours) – (Electrical and Electronic)

Supervisors: Dr Les Bowtell, USQ

Keywords: Grid-tied inverter (GTI), auto-changeover, battery storage, anti-islanding.

1. Introduction

This project investigated the ways of maintaining power supply to some of the residential final circuits in case of grid outages. It focused on the possibility of modifying a grid-tied inverter that can remain connected to the grid if normal grid electricity is available, but change-over to disconnect from grid and supply the selected essential local loads only when the grid power is interrupted.

2. Background

The existing literature indicate that there are different types of PV inverters. The grid-tied inverter has got anti-islanding protection that prevents it from remaining connected when there is a grid failure (Arya J. & Saini L.M. 2015).

A properly configured solar inverter can benefit both the consumers and the utility company by improving the power supply reliability, reducing transmission losses (Nge et al 2011), and the consumption of energy from the grid – hence reduced energy bills.

3. Methodology

In depth knowledge was obtained from various literature reviews, including different types of inverter protection methods, and the associated governing standards. A block diagram for the modified GTI and 'pilot' inverter was drawn (Figure 1), followed by Simulink modelling and simulation. The changeover detection and control circuitry was also designed, prototype built and simulated, with the algorithym code done, using Arduino IDE and breadboard components.

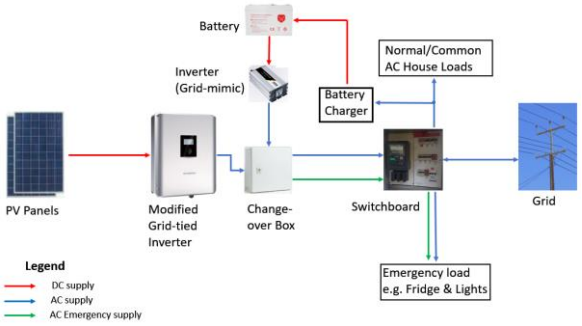

Figure 1 – Block diagram showing modified grid-tied inverter incorporating changeover circuitry box

4. Key Outcomes

Although the Simulink modelling results indicated that the grid-tied inverter can be paralleled with a pilot inverter to supply essential load during grid failure, the hardware prototype results proved otherwise. The 600W pilot inverter could not absorb the GTI output power and caused voltage instability resulting in the GTI tripping.

5. Further Work

Modelling on the Simulink require double checking and the consistence of the building blocks verified. Further investigations on cheaper means of using the PV energy via a PV inverter when a grid fails is required.

6. Conclusions

The existing grid-tied inverter could not be synchronised with a pilot inverter to supply essential load during emergency. However, there is still an available option of using a hybrid inverter with a battery bank, if the price of the battery becomes affordable to many.

Acknowledgements

I would like to acknowledge and thank Dr Les Bowtell, (USQ supervisor) for his guidance, assistance and advice; and my family for support and encouragement.

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Design of a Brushless DC drive for unmanned aerial vehicles UAVs)

Sponsor –School of Mechanical and Electrical Engineering

Student Name: Faisal Alharbi

Degree: Bachelor of Engineering (Honours)

Supervisors: Dr Paul, USQ

Keywords: Unmanned Aerial vehicles, BLDC, control.

1. Introduction

Unmanned aerial vehicles (UAVs) are adopted as an efficient, fast and relatively cheap vehicle in a variety of applications including military missions, surveillance, transportation, photography, filming, etc. UAVs have been designed and manufactured in various different types and sizes. The key component of UAVs is the propulsion system, which is usually comprised of an electrical motor driven by a rechargeable battery. From various types of electrical motors, BLDC motors provide the best performance in terms of reliability, size and efficiency. In this project, a BLDC-based propulsion system will be designed for light-weight UAVs.

2. Background

BLDC motors favour high efficiency, compact size and light weight. In contrast with the conventional DC and AC motors, BLDC motors require a special current control (driver) circuitry to operate. Figure 1 depicts the structure of a BLDC drive. An inverter is used to convert the DC voltage of the batteries to a pulsating voltage, which is applied to the three-phase winding of the motor. The speed and torque of the motor is controlled by a digital controller through adjusting the pulse widths of the inverter output voltages.

The cost and dynamic performance of a BLDC drive system is mainly dependent on the design of the driver circuit its control system. The manoeuvring of UAVs is directly dependent on the BLDC drive system, which must follow the speed control commands accurately and with a fast dynamic response. In addition, the energy efficiency of the BLDC drive is of paramount importance as the battery lifetime and hence the maximum flight time depends on it.

3. Methodology

The first step of the project is selecting a suitable BLDC motor for the UAV and designing the BLDC drive hardware. Next, the mathematical model of the BLDC drive, control system and UAV is derived and the model is implemented using a simulating software. The simulation setup will then be used as a basis for designing the control parameters to achieve the optimum dynamic performance.

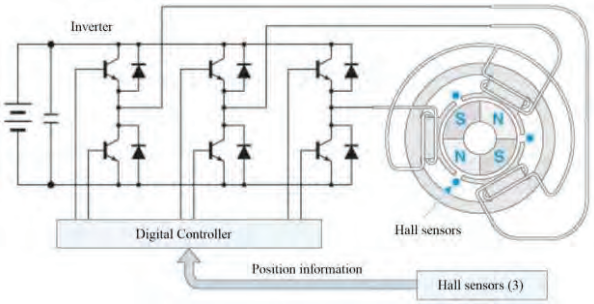

Figure 1 – Structure of BLDC drive

4. Key Outcomes

Up to this stage, the mathematical model of the BLDC drive, the digital control system and the UAV is developed. The mathematical model of the UAV relates the resultant torque of the four BLDC motors with the acceleration of the UAV in three dimensional space. The BLDC drive model expresses the resultant torque of each motor to the speed control command. The controller determines the speed control command of each motor such that the UAV travels in the specified trajectory.

5. Further Work

The next stage of the project is to implement the model in MATLAB. The model will then be analysed to study the sensitivity of the system on the control parameters. The analysis results will then be used to design the controller to optimize the dynamics.

6. Conclusions

High performance quadcopter UAVs utilize BLDC motors as the means of propulsion to realize the desirable dynamics and energy efficiency. In this project, the modelling, analysis and design of BLDC-based UAVs is carried out.

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Off-grid Solar Power Design and Battery Storage Optimisation

Sponsor – School of Mechanical and Electrical Engineering

Jason Hooper

Bachelor of Engineering (Honours) majoring in Electrical & Electronic Engineering.

Supervisor: Professor Paul Wen, USQ

Keywords: Off-grid systems, solar battery backup, renewable resource optimisation, BESS, LCOE, SRES.

1. Introduction

Home based solar power generation is a popular and effective choice amongst residential homes to decrease costs and utilise clean energy. Rising costs with electricity have intensified discussion in the solar battery market over the years. In this project, detailed simulations have been used to simulate loads / components used, in order to analyse and optimise the best system.

2. Background

In Australia there is no clear analysis for individual residential renewable solar systems that analyse the choice of the PV panel s), inverter(s), and Battery Energy Storage System s) BESS) used. With ever increasing pressure on the government to provide a national electricity plan, and concern for the supply and resilience of transmission / distribution networks (Abbot, M & Cohen B 2018 p.70), now is the best time to analyse solar PV systems with battery backup for off-grid capability. This project will expand upon the lack of modifying components, tariffs used and manual dispatch mode for batteries in past papers Li, J 2018 p.1247), as well optimise for the total system, in which will be done across 5 locations on varying load profile sizes in accordance to energy usage data.

3. Methodology

Research is conducted from utilising popular solar system components and requires extensive simulation work to generate data to compare between legible systems and load profiles. In order to perform a detailed optimisation, the models will be constructed using HOMER Pro® and NREL's SAM software. System sizes simulated will be: 3.3 kW, 6.6 kW and 13.0 kW respectively. As noted in Figure 1, 3D models will be used to perform 3D shade analysis through NREL's SAM software. Levelized Cost of Electricity LCOE , Renewable Fraction, Payback period and Capital Cost are used to determine the best system per location.

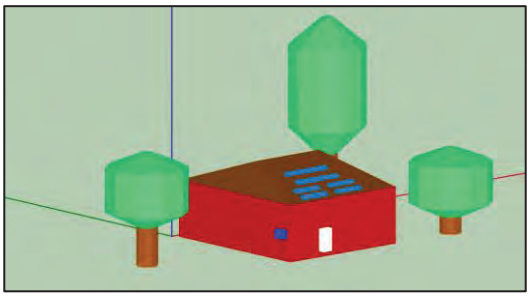

Figure 1. – 3D model for Location 1: Brisbane.

4. Key Outcomes

The key outcomes for this project are as follows, the simulations allows for a thorough optimisation, in which shows that often the largest PV size isn't the most cost effective. In addition, existing technology has a better cost per kWh, compared to newer technology Tesla Powerwall 2 v. Enphase AC battery .

5. Further Work

Further work can be performed on the environmental impacts of the components used in the systems compared to a traditional grid connection. This may also include a universal pricing database for components used and obtaining and testing an optimised system to validate the simulation results and for additional analysis.

6. Conclusions

This project has achieved the objectives to optimise all possible locations and load profiles, battery life extension / throughput was essential to reducing LCOE and a clear advantage was found for residential homes to install batteries in the current market, before the Small-scale Renewable Scheme SRES) ceases in 2030.

Acknowledgements

I would like to thank my family for continued support, as well as Professor Paul Wen for guidance throughout this research project.

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COMPUTER MODEL FOR SENSOR-LESS DAYLIGHT HARVESTING

School of Mechanical and Electrical Engineering

Juan Montes

Bachelor of Engineering (Honours).

Major in Electrical and Electronic Engineering

Supervisors: Dr John Leis, USQ

Keywords: daylight harvesting, computer modelling, average daylight factor, sensor-less daylight harvesting.

1. Introduction

Lighting equates to approximately 30% of the total energy consumption of commercial buildings. Daylight harvesting (DH) uses natural light to offset artificial lighting and reduce the overall energy cost.

This project focus is on a new innovative daylight harvesting method called Sensor-less Daylight Harvesting (SDH). This report outlines the feasibility of a simulation tool using MATLAB software, by which SDH benefits and innovation can be seen and recorded to allow commercial building owners to maximise costs during the design phase of a building project and retrofit options for existing buildings.

2. Background

With many nations, including Australia, focused on minimising energy consumption and relying more heavily on renewable energy and energy efficiency, daylight harvesting continues to be a focus of study. However, as building regulations and policies in most countries have not been updated with current research findings, assessing daylight conditions has adhered to somewhat old-fashioned methods.

3. Methodology

A mixed approached was implemented to complete the dissertation work, both qualitative and quantitative research methodologies were implemented. Research into existing mathematical equations and daylighting systems and proven comparative results in academia were studied. In addition, site sampling was carried out to validate the programme coded.

Programming using MATLAB to create the simulated computer model to work with the system LCS was achieved. Figure 1 shows a diagram of the SDH system architecture implemented.

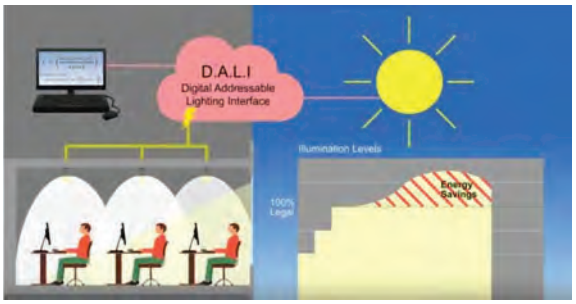

Figure 1 – SDH system architecture

4. Key Outcomes

This report outlines how building owners can gain the ability to assess SDH as a viable daylight harvesting system for new design buildings and retrofit projects.

5. Further Work

A simulated computer model for sensor-less daylight harvesting is achievable and requires further development to accurately compensate for the variables covered during site calibration.

6. Conclusions

DH is beneficial for occupants, building owners, and is a viable way to reduce energy consumption in commercial buildings. The computer simulated model is a valuable tool to assess the return on investment and overall benefits of SDH as a system.

Acknowledgements

Thank you to my wife Rani who made it possible to spend numerous hours researching and fine tuning my work. Brenden Harris who mentored me through the whole process, and Dr John Leis whose guidance and insights were extremely valuable to the project.

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Estimation of Soil Moisture and Nitrogen Stress Using Plant Growth Statistics

Sponsor – School of Mechanical and Electrical Engineering

Glenn McCorquodale

Bachelor of Engineering Honours (Electrical and Electronics)

Supervisor: Dr Alison McCarthy, USQ-CAE

Keywords: Automation, soil moisture, nitrogen.

1. Introduction

Water resources are under constant allocation pressure between the needs of agriculture, populations and the environment. In broadacre cropping, agronomists and growers manually assess plant growth and soil status and conduct soil sampling to identify crop stresses and determine irrigation and nitrogen requirements. However, these measurements and data analysis are time consuming and labour-intensive over large areas. Existing research has identified the potential for growth rates to determine moisture and nitrogen stress independently, without focussing on situations with both moisture and nitrogen stress. This research project aims to determine the viability of using plant growth statistics as a proxy for soil moisture and available nitrogen estimation (Skirycz & Inze, 2010).

2. Methodology

A field trial was conducted to: i) identify most sensitive plant parameters; ii) develop automated data analysis algorithms for extracting irrigation and nitrogen responses; and iii) conceptualising fully automated data collection and analysis system. Two cereal crops oats and barley) were grown from seed in large drums under controlled conditions with sandy soil. Three irrigation regimes and three nitrogen application rates were used in a total of nine drums. Irrigation up to the soil's field capacity was applied when the three different target recharge points were reached. Nitrogen was applied at alternate irrigation events at the recommended full rate, ½ the full rate and ¼ of the full rate.

The maximum height of each plant and the soil moisture at three depths 90mm, 300mm and 600mm was recorded daily. Data analysis techniques were investigated for extracting irrigation and nitrogen responses from the plant measurements. Candidate approaches included regression analysis and statistical machine learning approaches.

3. Results and Discussion

Manual observations of the plant growth data indicate that the average daily growth aligned with water availability in a number of settings Figure 1). With other contributing factors accounted for, it is expected that in reasonable growing conditions, measurable growth statistics can assist with appropriate re-irrigation application responses. It was also noted that several unrelated conditions also impact growth concurrently. Sensitivity to temperature and root depth appear to have a role in plant growth progression (Fan et al, 2016).

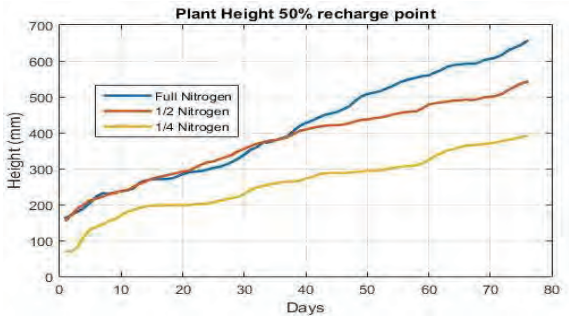

Figure 1 – Plant Height v Nitrogen Application Level

4. Conclusions

A trial was been conducted to assess if plant growth responses can be used to determined combined irrigation and fertiliser stress responses for oats and barley. This has indicated that daily plant height is responsive to these stresses. A proof-of-concept data analysis system has been conceptualised. Further work is required to automate the data collection method and evaluate approach under broader irrigation and fertiliser treatments, climates and crops.

Acknowledgements

I would like to thank the Centre for Engineering in Agriculture for providing the research project and Dr Alison McCarthy for her guidance during the study. The support and patience shown by my family is greatly appreciated.

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Developing a model for sustainable IT infrastructure in a rural setting in Northern India

Sponsor - School of Mechanical and Electrical Engineering

Arman Mohajer
Bachelor of Engineering (Honours) (Computer Systems
Bachelor of IT Applied Computer Science)

Supervisors: A/Prof Alexander Kist, USQ

Keywords: rural computing, digital divide, systems engineering

1. Introduction

Although the rapid development of information technology and its widespread presence has opened the doors to immense global potentialities, implementation of technology does not suit a 'one size fits all' approach. There are several factors and considerations that impact the success of implementation projects, especially in rural settings, ranging from socio-cultural to economic and logistical. This project aims to identify a few key factors that may assist in developing a suitable system for computing in a block of villages in Northern India.

2. Background

Many projects have been previously undertaken to address a growing digital and social divide between rural and urban areas, by providing low-cost access to computing systems and other forms of technology. However, ample research has indicated that access to technology is only the first level of this divide, and for it to be bridged, usage of technology and the outcomes of such usage need to also be considered Warschauer Matuchniak 2010). The focus of this project therefore is to move beyond a generalised system, and instead develop a suitable system based on the local needs and requirements of the Kakori block of villages in India that does not limit the usage to certain pre-determined forms.

3. Methodology

This project follows a systems engineering approach whilst considering additional social and cultural factors throughout the requirements analysis. Weighted Decision Matrices are then developed alongside selection criteria as part of the High-level design. This criteria is used to determine key components of the detailed system design and can also be modified for use in future system development projects in other areas.

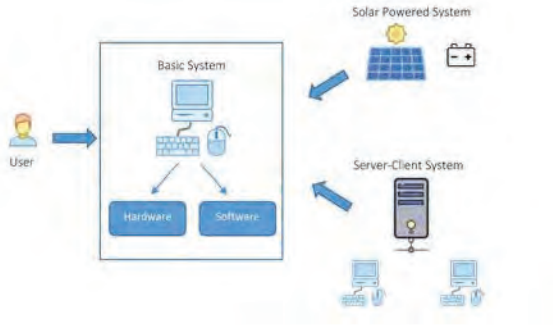

Figure 1 – System Architecture Diagram

4. Key Outcomes

This project collates and expands on existing research to identify factors that influence the sustainable implementation of technology in rural areas. Furthermore, the methodology used in this dissertation may provide an innovative framework for system development that is more coherent with local needs and values.

5. Further Work

Future research guided by the findings of this project could further examine the influence of technology on local values and the role usage plays in this regard. As the scope of this project was limited to a basic system design (Figure 1), further work could incorporate more system components to extend the usability and suitability of the system for the local reality.

6. Conclusions

In addition to the system design developed in this project, the design process this dissertation followed is also able to be replicated and further expounded on in future projects.

Acknowledgements

A great deal of gratitude goes to Assoc. Prof. Alexander Kist for his help and guidance as needed, and to the Foundation for Advancement of Science for assisting with the logistics involved in testing the initial implementations of the project.

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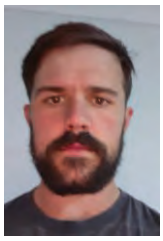
Harmony Analysis in A'Capella Singing

Sponsor - School of Mechanical and Electrical Engineering



Jarred Oliver

Bachelor of Electrical & Electronic Engineering

Supervisors: Mr Mark Phythian, USQ

Keywords: Linear Predictive Coding LPC ; Cepstral Analysis; Pitch Period; Note recognition;

1. Introduction

Today, people everywhere are using speech processing algorithms every day. The more obvious examples are the likes of Apples Siri artificial intelligence that uses algorithms similar, to what is presented in this project for voice recognition. Speech processing still has many disadvantages particularly in multi-speaker environments or areas with high background noise.

These algorithms form the basis for singing processing. Singing uses the same organs as speech to develop the required pitch and rhythm. In A' Capella singing the singers tune their voices to each other rather than to instruments. The chromatic scale is 12 equally tempered tones, the subset of these tones is known as the diatonic scale which consist of 7 tones in key, while the other 5 are out of key (Brattico et al, 2006)

2. Background

Singing contains large amounts of information such as emotion, pitch, melody and language. Most research into singing processing has centred around singing with musical accompaniment, particularly removing singing from non-singing segments. In the past these adapted methods have had moderately good results Muller et al, 2011 .

Methods used for processing include Linear Predicitve coding, Cepstral Analysis, HMM, and wavelets to detect signing traits from music.

This project will be utilising these techniques to developa training system to detect pitch, melody, harmony and timbre in A'capella singing and provide the end user with feedback on all traits.

3. Methodology

To develop an effective system for analysing the vocals of A 'Capella singers, the accuracy of speech analysis algorithms needed to be tested. LPC shown in figure 1), AMDF and Cepstral analysis methods were chosen for the test. Each method was tested against a single frequency from note A2 to A6, then against tracks of known frequencies and finally against a live A 'Capella track composed of multiple singers.

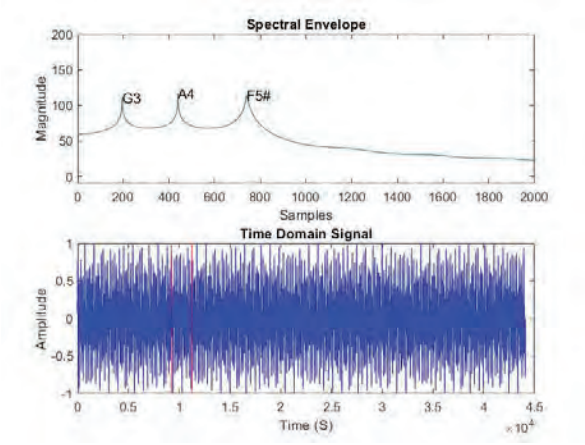


Figure 1 – LPC Spectral Envelope & Time domain signal

4. Further Work

Future work will involve testing the possibilities of implementing signal separation of multiple singers to test. This will allow for improvement in accuracy when looking for traits such as harmony timbre.

5. Conclusions

LPC and Cepstral analysis provide the best results with multiple notes, with some results proving these methods can provide accuracy within 1%. LPC takes the longest computation time at 0.0143 S for a single frequency (averaged across multiple samples) and AMDF providing the faster results with a decrease in accuracy.

6. Acknowledgements

I would like to thank my supervisor Mark Phythian, who's provided invaluable insight and knowledge throughout this project.

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Smart model/package for home base solar power grid system design

Sponsor - School of Mechanical and Electrical Engineering

David Armstrong

Bachelor of Engineering (Electrical/Electronic) Honours

Supervisors: Dr Paul Wen, USQ

Keywords: Solar Home System, Photovoltaic, Battery storage.

1. Introduction

The increasing cost of electricity, environmental sustainability and an increased awareness and understanding of global warming is a driving force pushing homeowners towards home based renewable energy sources.

The main objective of this research was to develop a user friendly program that would assist in choosing a solar home system to meet their needs.

2. Background

While solar home systems are not a new concept, technological advancement over the past 10 -15 years (Erdinc, O Uzunoglu, M, 2012) have greatly reduced the cost of the component of the system while greatly increasing their lifespan. This combination plus a more climate conscious society have added to the uptake of these technologies Liu, H, Azuatalam, D, Chapman, AC & Verbič, G, 2019).

3. Methodology

The first step in this research was to gain and extensive knowledge of all the key concepts related to this topic. main results. Once sufficient knowledge was gained the next step was to collect as much data as possible about the location, household, loads and S.H.S components as can be seen in Figure 1. From here models were developed to see manually what the program should produce. Further performance and economic optimisation were performed. Finally, a user friendly MS Excel program was developed.

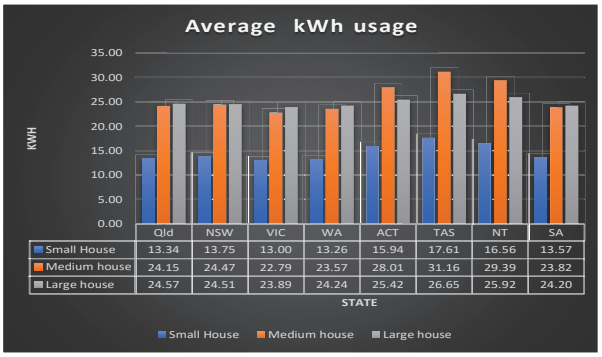

Figure 1 - User data

4. Key Outcomes

The key outcomes of this research are to better understand what the average load requirement are for different home sizes using this data to build a dataset based program to aid in the selection of a S.H.S. for residential use

5. Further Work

The research project has had its focus on residential systems, future work could include commercial and industrial focuses and incorporating different battery technologies.

6. Conclusions

Once the final program has been completed the user will have at their disposal an assist to help in their decision making of a very important investment.

Acknowledgements

I would like to thank my supervisor Dr Paul Wen for his guidance and support throughout this research project. I would also like to thank my wife and young family for allowing me to complete my years of study.

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Design and Implementation of coreless axial-flux machine for use in wind-turbine applications

Sponsor - School of Mechanical and Electrical Engineering

Brent Weedon

Bachelor of Engineering (Honours), Electrical and Electronic.

Supervisors: Mr. Andreas Helwig, USQ

Figure 1 – Axial Flux Generator Model

Keywords: Axial-Flux, Coreless, Wind-Turbine

1. Introduction

In many economies' energy production is a major point for debate. For major economies the cost of large-scale generation systems can be accommodated, this cannot be said for smaller 3rd world countries. As such small-scale generation systems must be developed to improve quality of life, education, employment and health. Madagascar is one such economy. Kaliyev et al. 2017)

To provide a robust, reliable and renewable energy system, small scale wind turbine must be investigated and improved as solar or hydroelectricity cannot be solely dependable. It is therefore the aim of this project to investigate and develop a wind turbine electric generator that can operate in conditions that are not suitable for large scale wind turbines, whilst also considering manufacturing methods which may reduce equipment and manufacturing costs.

2. Background

Axial-Flux machines have been researched as far back as 1831 my Michael Faraday Patterson et al., 2009). The major impact on their success has primarily been due to the unavailability of cost-effective, powerful magnets. Due to recent development in magnetic technologies the field is again able to progress. One example of a modern variant is the electric motor used to power the Toyota Prius.

3. Methodology

A design has been produced in accordance with the scope, design limitations and available resourcing. This design was then interrogated to produce an estimated performance to which a subsequent prototype can be evaluated against. The prototype will be evaluated for electrical performance, appropriateness of manufacturing methods and cost effectiveness. Time permitting, a comparison against an existing system for relative system performance data will provide real-world conclusions. Figure 1 demonstrates the prototype model.

4. Key Outcomes

The key developments up to this point have been the development of components by additive manufacturing techniques that allow for a safe and modular assembly system. Energy output estimates are appropriate for low wind speed areas.

5. Further Work

Expanding on this work would include investigation into using PCB printed windings as a supplement to coils in the Stator. In line with the goals to produce a wind turbine to low economic nations.

6. Conclusions

At time of writing this abstract the major conclusion is that affordable and appropriate manifesting methods are available using 3-D printing and normal manufacturing methods that can be easily adapted to suit low budget outcomes.

Acknowledgements

Appreciation must be given to Andreas Helwig for his ongoing guidance. Additionally, John McCleverly for assistance with component manufacture.

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Optimisation for the Positioning of the Proposed Eurobodalla Southern Storage Future Water Treatment Plant

Sponsor - School of Civil Engineering and Surveying

Brent Parker

Bachelor of Engineering (Honours) (Environmental)

Supervisors: Mrs Justine Baillie, USQ

Keywords: Water Supply, Pumping Stations, Head loss

1. Introduction

The aim of this project is to research, develop and implement a hydraulic model to optimise the position of the proposed Eurobodalla Southern Storage ESS future Water Treatment Plant (WTP .

Water Pumping Stations WPS) are required to transfer water from low to higher elevations or maintain service pressure. WPS increase water pressure within a pipeline using a pump to achieve a static lift, while overcoming any head losses.

WPS have capital construction and ongoing operational costs that are dependent on the size and duration of the pumping requirements of the water supply system. Alternatively, water can be transferred by potential energy from stored water located at a higher elevation to delivery point.

2. Background

The Eurobodalla Shire Council ESC) is located on the NSW South Coast and responsible for a water supply scheme that provides over 3,000 ML per year of potable water to the major townships of Batemans Bay, Moruya, Narooma and other surrounding villages.

A new water storage is required by 2023 for integration into the existing scheme to satisfy water demand forecasts with the ESS identified as the preferred option. Later upgrades include the provision of a future WTP for construction no earlier than 2030 and an increase in storage capacity to meet the long term water supply.

3. Methodology

This included a literature review on the configuration considerations that have a significant impact on capital and operational costs within a water supply system.

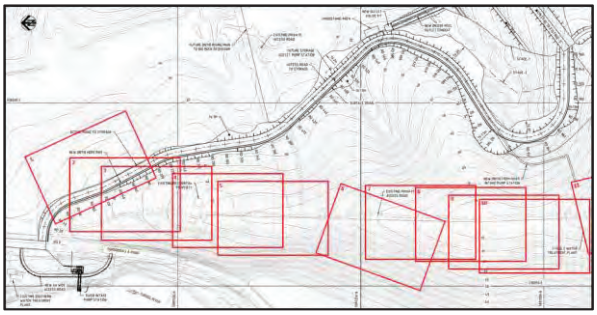

Figure 1 – Possible positions for future WTP (Adapted from SMEC 2016)

Next, a hydraulic model was developed to determine, evaluate and compare the spatial differences between the key infrastructure items within the water supply system for further financial analysis.

4. Key Outcomes

The future WTP was modelled in 11 different positions shown in Figure 1. The model was limited by site constraints and accounted for the operational water levels of proposed and existing infrastructure. Pumping requirements were identified for each scenario to meet future water demands.

5. Further Work

The capital and operational costs for each scenario are still to be determined for further analysis using Net Present Value (NPV) to identify the optimal position.

6. Conclusions

From the preliminary investigations, it is anticipated that the optimal position shall be identified. In addition, the working model and evaluation framework may be utilised for other optimisation studies.

Acknowledgements

I would like to thank my supervisor Mrs Justine Ballie for always providing timely advice and guidance, ESC for allowing me access to relevant resources, and my family for their ongoing support and patience.

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An Alternative Proprietary Water Quality Treatment Methodology and its Effect on Efficiency and Capital Costs.

Sponsor - School of Civil Engineering and Surveying

Michael Colnan

Bachelor of Engineering (Honours) Environmental Major

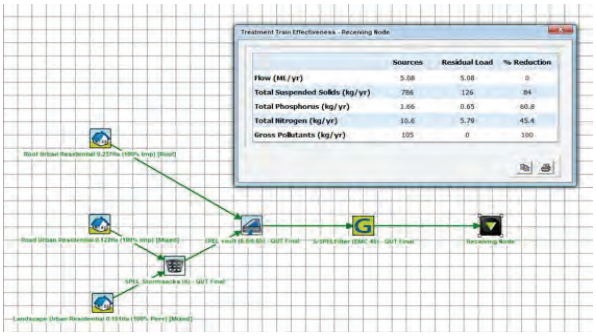

Figure 1 – Conceptual Treatment Train

Supervisors: Dr Steven Goh, USQ

Keywords: Water Sensitive Urban Design (WSUD) Water Quality Treatment, Stormwater Management.

1. Introduction

National and State Government mandated stormwater quality treatment objectives, combined with the increasing value of developable land in urban areas, has resulted in the adoption of proprietary water quality treatment devices in lieu of traditional biological treatment. Traditional biological treatment devices are relatively cheap to install and maintain but require a significant land allocation. For high density urbanised areas like city centres, this can result in inefficient use of land and can contribute to urban sprawl.

Proprietary water quality treatment devices may be located below ground for no significant loss of developable area. They are also typically more expensive to install and maintain.

2. Background

Proprietary treatment devices may be housed in a tank or manhole and consist of rechargeable cartridges containing a filter media designed to capture soluble and particulate pollutants and adsorb materials such as dissolved metals in stormwater runoff SPEL Environmental 2016). The cartridges are particularly sensitive to high velocity stormwater flows and treatment efficiencies are limited by the rate of inflow to the device.

3. Methodology

It is proposed to provide upstream capture and controlled inflow of stormwater runoff from an urbanised catchment to a proprietary treatment device. Computer software modelling will be used to determine the minimum size of the device in order to achieve statutory water quality objectives. Refer to Figure 1 for the conceptual layout of the model.

4. Key Outcomes

Preliminary modelling indicates that, by capturing and controlling inflow to proprietary devices, a reduction in the overall size of the system is achieved. It is theoretically possible to direct 100% of treatment flows through a small treatment device however, by treating a a large volume of stormwater within a smaller device, it is expected that aditioanl maintenance of the system will be required. A life cycle cost analysis will be undertaken to determine if the methodology is economically feasible.

5. Further Work

Future work could involve optimising the size of the filter cartridges to extend the maintenance intervals and reduce operational costs of the water quality treatment system.

6. Conclusions

The results of the modelling and life cycle costing are yet to be determined. A key achievement of this project would be demonstrating that an overall reduction in the capital cost of proprietary treatment devices is possible.

Acknowledgements

I would like to thank my supervisor, Dr Steven Goh for his time and insight. I would also like to thank my employer, Walsh Consulting Engineers, for affording me the time and resources to complete my major project.

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Improving the timing and application of preventative chemicals for the control of disease through automation

Sponsor - School of Mechanical and Electrical Engineering

Benjamin Teys

Bachelor of Engineering (Mechanical Engineering)

Supervisors:

Dr Wijitha Senadeera, USQ
Mr Vince Fernon and Mr Brian Mullany, Grove Estate Wines

Keywords: automation, preventative chemicals and ideal mixture.

1. Introduction

In Australia the season for fresh grapes typically runs from November to May. The vine experiences three of the four seasons thus leaving it open to many diseases which can significantly reduce the yield of the vineyard. There are opportune times to apply certain preventative chemicals to reduce the chance of infection. The processes for treating crops are labour intensive thus constituting one of the biggest expenses of the business. By automating such processes human intervention will be reduced thus increasing efficiencies and consistency in chemical application across the crop.

2. Background

The biggest problems encountered with growing grapes at Grove Estate Wines are the timing and application of chemicals for the control of disease. There are a number of factors which can hinder application such as adverse weather conditions, machinery and equipment problems as well as labour and chemical shortages. The current equipment at the vineyard is unable to regulate the release of chemical to achieve optimal crop coverage. This project will assist to identify opportunities to build efficiency in chemical application and improve the likelihood of vines producing optimum yields.

3. Methodology

Interviews with industry experts and internet research were conducted to gather information on: current limitations associated with chemical application; available equipment; optimal concentration of chemicals relative to the crops; and relative risks which contribute to the chance of diseases developing. Data analysis and theories of fluid dynamics were used to determine optimal methods for chemical dispersion.

Figure 1 - Grape Downy mildew infection on a grape bunch showing infected berries with white down and resistant healthy green berries

4. Key Outcomes

Proposed improvements to equipment stand to enhance the chemical application resulting in efficiencies in material use and labour as well as reduced revenue losses associated with infected crops. By critically analysing variables contributing to optimal crop coverage, automation can be applied to achieve a more consistent and effective result.

5. Further Work

Further work is required in fabrication, implementation and testing of the design. The performance of this design will need to be reviewed as a future project.

6. Conclusions

Adverse weather conditions have a major impact on the ability of grape growers to apply necessary concentrations of chemical to their crops within critical time periods. A solution for this issue is vital to the success of their business. The use of automation shows promise in optimising crop coverage as well as improving labour and material efficiencies.

Acknowledgements

Thanks to Wiji for his invaluable feedback and Brian and Vince for sharing their industry knowledge.

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Pacific Island Operating Environment Impact upon a PV inverter Component Performance, LCA and reliability in Hybrid Power system.

Sponsor - School of Mechanical and Electrical Engineering

Ziemingka Iborito Karotu

Bachelor of Engineering Honours, (Mechanical)

Supervisor: Mr Andreas Helwig, USQ

Keywords: *Renewable Energy, Climate Change, LCA*

1. Introduction

This project develops and uses of a hybrid system in the tropical regions in the Pacific Island region Kiribati). This will implement the use of Creo Simulation and HOMER software to find the impacts of changing weather and the LCA for a Hybrid (PV) Power system.

2. Background

Electricity is needed in the Republic of Kiribati Islands which has a population of 110000 (COP23 2018). The first new hybrid renewable system has been produced by IRINA (2017) based at the capital of Tarawa. Hence there is not much known in the long term how it would physically perform against changing climatic conditions in the region. This project investigation is to predict possible climate impacts on a hybrid renewable system in the tropics, and possible climate change effects, such as temperature rise shown in figure 1.

3. Methodology

The methodology utilised to address the problem is the use of a flowchart method that includes sensitive models, Homer Software Sizing , Creo Simulation Modelling) and LCA.

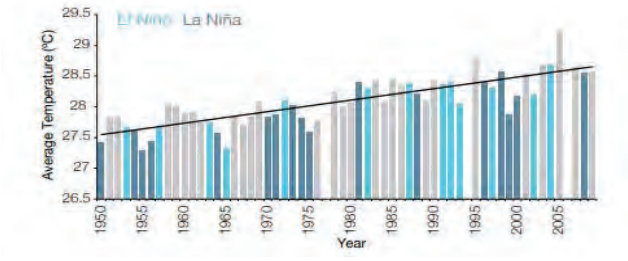

Figure 1 – Change in temperature from 1950s to 2019 shows a gradually increase. Key factor for impacts on the physical desgn and performance of the PV panels. (Source: Australian Government 2019

4. Key Outcomes

Report critical review of previous relevant academics and meteorological data on future climate change outcomes. Software model HOMER, Creo) to evaluate life cycle trends by sensitivity studies of impacting factors. The research is supportive towards Kiribati Islands and other tropical countries within the Pacific region. The outcomes of the Creo and HOMER modelling provides specific guidance for tropical island applications' specifications needed to ensure maximum life of hybrid renewable energy systems.

5. Further Work

Designing of a power micro off grid system to compare the storage, costs and life expectancy with the produced design. With more given time this would be attainable.

6. Conclusions

For a 25-30 life expectancy, a case study of sizing and optimal hybrid renewable energy generation system design is provided. In addition, impacts caused by climate change wind impact, saline atmosphere corrosion and humidity on electrical PCB boards and connections) are defined. The thesis is a small portion for a suitable solution for climate change impacts on island power supplies. Overall, electricity is a necessity, hence quantifying future climate change impacts for renewable energy component to improve design specifications for application in the harsh tropical island environs is a priority outcome.

Acknowledgements

The Research was effective with the help from University of Southern Queensland Engineering Faculty Software and the guidance of the supervisor. Referencing work had used APA referencing style produced by the University website.

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Testing Australian commercially available biodiesel properties, combustion, performance and emission characteristics

Sponsor - School of Mechanical and Electrical Engineering

Huseen Alaoud

Bachelor of Engineering (Mechanical)

Supervisor: Dr Saddam Hussen Al-Lwayzy, University of Southern Queensland

Keywords: Biodiesel, diesel engine, performance.

1. Introduction

Diesel engines are used in the wide range of applications ranging from powering electrical generators to transportation. The emissions produced by the diesel engine are degrading the quality of natural environment and have negative impact on it. There is a worldwide trend to find out alternative fuels which will have reduced emissions and be environmentally friendly. The petroleum reserves are depleting with the passage of time and also their prices are increasingly day by day. (A. Sydbom et al, 2001).

Using Australian commercially available biodiesel might increase the performance of the engine and combustion characteristics. This project aims to investigate experimentally the performance and combustion characteristics of diesel engine fueled with blends of biodiesel and diesel with different percentages of Australian commercially available biodiesel.

2. Background

Biodiesel is usually obtained from various types of oils like vegetable oil, palm oil, rapeseed oil and rice bran oil. It is produced by a chemical process known as transesterification. Transesterification reaction is shown in figure 1. Researches have proved that blends of biodiesel with additive fuel are compatible with the diesel engine and can be used in engine without modifications or with little modification (S. Imtenan et al, 2014).

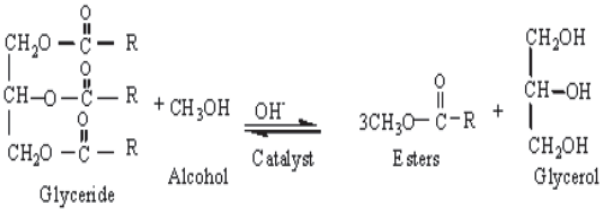

Figure 1: Transesterification reaction

3. Methodology

Biodiesel blends will be prepared in different percentages of biodiesel and diesel and experiments will be performed on the engine setup available in P7 USQ. Blends that will be prepared and tested include B20 (20% biodiesel and 80% diesel), B50 (50% biodiesel and 50% diesel) and B100 (100% biodiesel). Performance and emission characteristics of diesel engine will be compared for these blends against the standard diesel fuel for engine speed of 1800 rpm, 2000 rpm, 2600 rpm, 2900 rpm and 3800 rpm.

4. Key Outcomes

Till now progress report has been completed in which literature survey indicates that biodiesel blends improve the engine performance and emission characteristics.

5. Further Work

Experimentation on engine setup, collecting results and drawing conclusion is remaining in this project.

6. Conclusions

Expected conclusion is that adding Australian commercially available biodiesel will improve engine performance and combustion characteristics of diesel engine.

Acknowledgements

University of Southern Queensland is acknowledged for providing full support in using engine test facility. Also, I would like to thank Dr Saddam Hussen Al-Lwayzy for his supervision, expertise, guidance and support in conducting work.

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Investigation of Wear Characteristics and Mechanism of SBR Under Dry and Wet Conditions

Sponsor - School Mechanical and Electrical Engineering

Student Name: Nawaf Alharbi

Bachelor of engineering (Honours) (Mechanical)

Supervisors: Dr Belal yousif, USQ

Keywords: Wear, Mechanisms of SBR, Abrasion.

1. Introduction

For performance evaluation of elastic materials, wear characteristics and rubber abrasion are among most significant properties. Depending upon the materials systems, several factors can impact the abrasive characteristics of rubber material like base polymer type, contact parameters, or physical conditions. Currently, there is limited information available for these characteristics of SBR under wet and dry conditions. In this work, the tribology and wear mechanisms of rubber-based compounds would be investigated under controlled lab conditions.

2. Background

In this study, various methods should be applied in terms of abrasive tests to investigate the wear and abrasion mechanisms of SBR materials under controlled conditions. Through distinct abrasion tests, different fundamental mechanisms of wear would be explored and segregated.

3. Methodology

Wear mechanisms would be investigated through application of distinct working conditions like sliding values, connected loads, contact conditions, sliding speeds, contact instrument, and elastic microstructure. For analysis of wear characteristics, a number of tribological mechanism assemblies have been structured. Through the application of hard conditions like speeding and sliding, high frictional temperatures would result disintegration conditions for the material. During the project, resources like Ring-on-block Testing Machine, SEM Machine, and X-Ray Diffraction Machine would be utilized. Following composition would be utilized for conducting the experiments.

The composite formulation (Unit: parts per hundred rubber; phr).

Ingredient	Content (phr)
Rubber	100.0
Carbon black	50.0
Zinc oxide	5.0
Stearic acid	2.0
Dioctyl phthalate	10
Sulfur	1.5
N-Cyclohexyl-2-benzothiazolylsulfenamide	2.0

Figure 1 - Sample Composition

4. Key Outcomes

Key outcomes for this study are the data on wear and rubbing characteristics of SBR under real-time working conditions. Understanding these mechanisms would aid in enhancing the resistance against friction, wear, abrasion, and wet skid resistance.

5. Further Work

For comparative analysis, future studies can be made on materials like nitrile butadiene under dry and wet sliding conditions. Moreover, further studies can also be made under wet conditions through varied lubrication conditions.

6. Conclusions

SBR servers as the main component of tires threads utilized for automobiles. Results would indicate the effects on load on wear and friction properties of SBR materials. This data would provide the base for wear theory of SBR.

Acknowledgements

I acknowledge the help and guidance provided by my supervisor throughout this project.

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Chemically Bonded Excavator Bucket Redesign

Sponsor – School of Mechanical and Electrical Engineering

Mr Craig Wright

Bachelor of Engineering

(Honours) (Mechanical)

Supervisors: Assoc Prof Jayantha Epaarachchi, USQ

Keywords: Excavator Buckets, Chemical Bonding, Construction.

1. Introduction

This dissertation aims to investigate manufacturing efficiencies achievable by chemically bonding excavator buckets. The main obstacle remaining for the manufacturing of excavator buckets is the lengthy process of welding required, not only to fabricate the main structure but also attach all ancillary equipment required to the Bucket. This process has changed little since the inception of current welding techniques, disadvantaging countries that require workforce pay rates far above foreign competitors.

2. Background

Excavator buckets play a key role in mining, agricultural and construction industries worldwide. Their size ranges from a few hundred kilos to over 50 tonnes and have a multitude of uses. An excavator bucket is required to be robust in nature, with the bucket experiencing near totality of the digging forces during its intended operation. The emergence of Computer Numerical Control (CNC) cutting tools has dramatically decreasing cutting time while increasing tolerance accuracy, reducing manufacturing time.

3. Methodology

The project employs qualitative market research on current sales of excavator machinery, research on bucket construction standards including each segments role within construction and a risk assessment. The project employs quantitative research calculating the typical loading conditions and expected digging forces; performs a detailed analysis of appropriate adhesives and their performance. A bonding agent was selected a 3D model was created; this model was subjected to Finite Element Analysis (FEA , please refer Figure 1, and changes were documented as required.

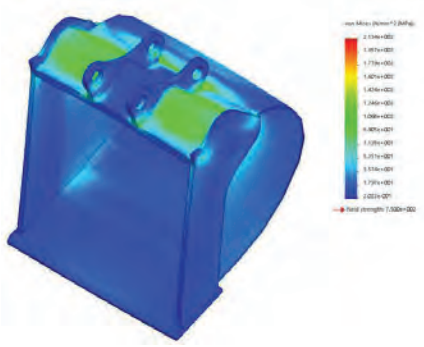

Figure 1 - Adhesive bucket design performance

4. Key Outcomes

Quantitative analysis indicates an all adhesive bucket is inefficient, but a combined weld/adhesive construction may result in a faster, cost-effective approach. The scope of this dissertation has been achieved and FEA provided a satisfactory, innovative model that is feasible.

5. Further Work

A simulation of the loading effects placed on the skin of the bucket through analysis of soil densities and the bucket volume is advantageous. The construction of a scaled prototype and testing of a sourced adhesive for failure is anticipated with collaboration by a sponsoring party.

6. Conclusions

The combination of the skin and attachments epoxied in place with the main lip welded may yield an agreeable solution to allow for an alternate, efficient approach to bucket construction. This is especially true for flat-lying wear-resisting components that will have little loading stress from ground engagement tools.

Acknowledgements

The author would like to thank Assoc Prof Jayantha Epaarachchi, the supervisor of the project, for his time and guidance.

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INVESTIGATION INTO THE INFLUENCE OF THE DOUBLE VACUUM BAGGING PROCESS ON CO-CURED SCARF REPAIRS

Sponsor- School of Mechanical and Electrical Engineering, Centre for Future Materials, Defence Science and Technology Group

Riley Mitchell

Bachelor of Engineering Honours (Mechanical Engineering)

Supervisors: Dr Xuesen Zeng
Prof. Peter Schubel

Industry: Dr Paul Callus, Defence Science and Technology Group

Keywords: Double vacuum bagging (DVB), pressure mapping, scarf repair

1. Introduction

Sustainment and through life costs of military vehicles are often substantially greater than acquisition costs, and as such, efforts to improve reliability and minimise costs are significant. Regarding composite structures, scarf repairs are often used to restore strength to a damaged component, with a shifting focus to out-of-autoclave processes to reduce cost. This project aims to identify the influence of double vacuum bagging (DVB) processes on improved repairs while minimising costs.

2. Background

DVB co-cured scarf repairs have been identified as a successful alternative to traditional hard-patch, autoclave repairs [1], however, this process was conducted in multiple stages. To reduce time, cost, and material requirements, this project investigates single stage co-curing, and whether the presence of a caul plate influences the quality of the repair.

3. Methodology

Soft patch adherends were co-cured onto a parent panel under SVB or DVB conditions , with or without a caul plate. Pre-cure pressure mapping was conducted to determine if any relationship between pressure distribution and bond quality existed, before tensile testing was conducted. The co-cured tests were then compared against baseline parent-to-parent (hard patch) specimens, to determine if they are viable alternatives.

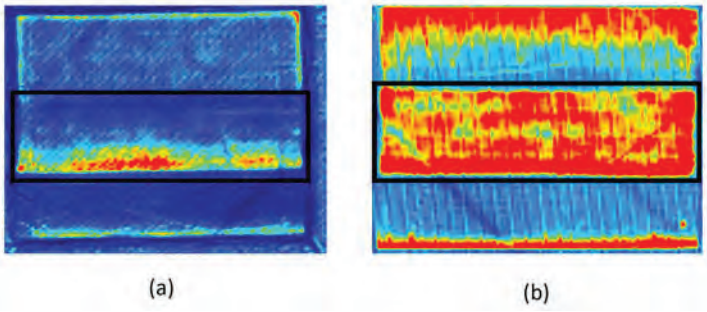

Figure 1 – Pressure distribution in a soft patch (a) with an overlap and no caul plate and (b) with a caul plate.

4. Key Outcomes

Adhesion between the parent and adherend were noted to be poor in the specimens cured without a caul plate, with improved cohesive failure noted in the specimens cured with a caul plate [2]. This is reflective of the improved pressure distribution noted between the comparison of Fig. 1a and Fig. 1b. Regarding the DVB co-cured specimens however, this obersvation didn't lead to improved strength, suggesting that the cure cycle used being the dominant factor in bond quality/strength.

5. Further Work

Additional work using dielectric sensors to monitor cure progression within both the prepreg and adhesive would allow for the determination of an optimal cure cycle. Furthermore, 2D and 3D scarf repairs are required to determine strengths representation of in-service repairs.

6. Conclusions

Cure cycle and adhesive quality are the controlling factors, as the pressure distribution achieved with a caul plate did not influence the strength or quality.

Acknowledgements

I would like to thank my supervisors, CFM Technical staff, and DSTG for the support and mentorship throughout this project.

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Drag Force Analysis on Vehicle Roof Accessories

Sponsor - School of Mechanical and Electrical Engineering

Jacob Broad

Bachelor of Engineering Honours

Major: Mechanical

Supervisors: Dr Ahmad Sharifian-Barforoush, USQ

Keywords: Wind tunnel, Drag force analysis, vehicle accessories.

1. Introduction

Two forces oppose a vehicles movement; drag and rolling resistance. The drag force rises exponentially with velocity and as such there has been considerable development into the aerodynamics of vehicles over the last few decades. Aerodynamic testing is generally undertaken on solely the body shape and dismisses external add-ons including roof attachments. Roof racks are becoming increasingly popular for their practicality in transporting large and bulky objects such as camping gear, bicycles, skis and pods. Their presence increases the frontal area of a vehicle and disrupts flow, impacting vehicle performance.

2. Background

Roof racks are most often utilised for extended trips when lots of gear and supplies are needed. It is in these journeys that small changes in the aerodynamics of a vehicle are magnified and can significantly increase fuel usage. A 10% increase in fuel could cost a driver thousands of dollars over the course of a trip. Studies by Hol Agrewale 2019) and Zacharof Fontaras 2016) have confirmed that empty roof racks increase drag by 1-2%. However, there is some discrepancy with the drag caused by objects attached to the racks. This project aims to verify and add knowledge to this area.

3. Methodology

ANSYS Fluent computer software was essential for simulating driving conditions. A vehicle silhouette was created and air was passed over it at varying speeds, gathering data about pressure, velocity, turbulence and drag force. More tests will be undertaken with empty roof racks and full roof racks for comparison. To verify the results, small-scale models will be 3D printed and placed in a wind tunnel in the Engineering block at USQ.

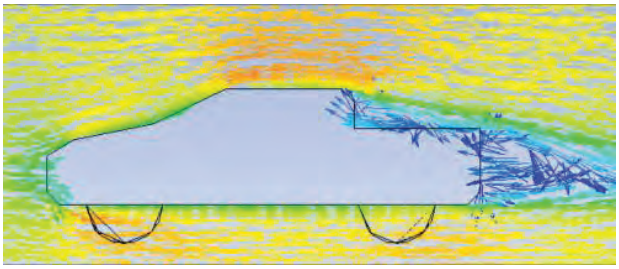

Figure 1 – Velocity vectors over vehicle model

4. Key Outcomes

Preliminary tests have been performed on a vehicle using the ANSYS software. As of yet, the drag of roof attachments has not yet been analysed. The software aids in the visualisation of airflow around the vehicle, as can be seen in Figure 1. The blue swirling patterns signify the recirculation of the turbulent wake, which is one of the factors that causes drag.

5. Further Work

The wind tunnel tests are yet to be undertaken. They can then be compared with the ANSYS software to verify the results. Investigation into reducing the drag created by these bulky objects should be carried out also.

6. Conclusions

The project has not yet confirmed whether roof attachments increase the overall drag of a vehicle or not. These results will ideally determine whether simple methods can reduce this harmful drag and improve fuel economy for adventurous travellers.

Acknowledgements

I would like to thank my supervisor for his input and assistance in my project. I would also like to thank my partner, family and friends for their continued support.

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Restart of a 2D Hypersonic Inlet at Mach 6 using Slot Injection

Sponsor - School of Mechanical & Electrical Engineering

Lachlan Noller

Bachelor of Engineering (Hons) Mechanical

Supervisors: Prof. David Buttsworth
Dr Fabian Zander
Mr Byrenn Birch

Keywords: Hypersonic, Scramjet, CFD, Restart

1. Introduction

This project contributes to the understanding and improvement of scramjet inlet restarting. The proposed restart mechanism uses a suction slot placed at the scramjet inlet throat removing low momentum air induced by Shock Wave / Boundary Layer Interactions swbli's). Size of the recirculation region, initiated by the swbli, is increased due high downstream isolator pressure applied using sonic slot injection which propagates upstream and disgorges at the inlet throat.

2. Background

Unstart in scramjets is a flow phenomenon occurring at the inlet which limits the oxygen delivery of intake air flow to the supersonic combustor, consequently leading to a loss of thrust and vehicle control. For example, the recent X-51A scramjet-powered hypersonic vehicle test flight suffered from inlet unstart (Musielak, 2010 .

Ground based testing and Computational Fluid Dynamics (CFD) assist researchers in the design and optimisation of mechanisms preventing inlet unstart. However, minimal research has been conducted into mechanisms able to restart an inlet once it has unstarted.

3. Methodology

Using oblique shock wave relations, a 2D hypersonic inlet was designed for operation at Mach 5.85. The inlet contraction ratio was set relatively close to the Kantrowitz limit, a criterion which determines the minimum contraction ratio which allows an inlet to self-start. Using this calculated geometry, an experimental model was manufactured to be tested in the TUSQ Hypersonic wind tunnel. The testing will be evaluated using Schlieren visualisation and pressure measurements on the inlet ramp. Eilmer4, a numerical finite volume implementation of compressible Navier Stokes Equations, was used to develop a CFD simulation of the inlet geometry under flow conditions matching experimental testing.

4. Key Outcomes

Both computational and experimental results show that the inlet geometry can self start under the specified flow conditions. Simulations show that the increased pressure applied downstream from the transverse air injection results in high pressure propogation upstream into the inlet throat increasing in boundary layer displacement thickness unstarting the inlet. Stopping the downstream injection a large recirculation region at the inlet throat remains, leaving the inlet unstarted. Applying and removing a Mach 1 transverse slot injection at the location of the separation adds an impulse of air to the flow field pushing through the recirculation region, allowing the inlet to re-enter a started mode of operation.

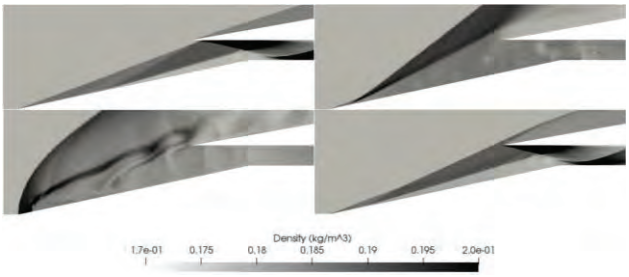

Figure 1 - Simulation Results: Top left self-started inlet, Top right unstarted inlet from Mach 1 isolator transverse injection, Bottom left Mach 1 transverse injection restart mechanism, Bottom right restarted inlet.

5. Further Work

Further experimental work is still required to validate the simulation results and assess if the mechanism is practically feasible. Future work on the project would see an unstart detection closed loop system impliemented used with the proposed restart mechanism. Moreover, a 3D simulation would better improve the accuracy found computational results.

6. Conclusions

This research shows that there is the possibility of practical application of slot injection as means of scramjet restarting. If experimental results show that the restart method does indeed work, the mechanism poses a simple and feasible method of inlet restarting for real-world application.

Acknowledgements

A massive thanks must go to my supervisors: David for your wealth of knowledge in hypersonics and patience answering my endless questions, Fabian for your unwavering support with Eilmer4 and Linux, and Byrenn for your assistance with running the wind tunnel.

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"Methodology to obtain homogeneous temperature distribution across a reverse flow offset barbecue"

Sponsor - School of Mechanical and Electrical Engineering

Matthew Tait

B.E. (Mechanical)

Supervisor:

Dr Khalid Saleh, USQ

Keywords: CFD, Design, Heat Transfer

1. Introduction

The Smoke Commander is a reverse flow offset barbecue that the author has fabricated and sold for recreational slow cooking or smoking of meat and vegetables. Through operation of the product design limitations have been identified resulting in uneven temperature distribution throughout the cooking chamber. This project involves modelling the current design using ANSYS Fluent and trialling different methods to minimise the temperature gradient. Upon identification of a successful method it will be carried out on a physical model and tested for correlation with the simulation.

2. Background

An offset barbecue has the firebox offset from the combustion chamber to prevent radiant heat from the fire burning the outside of the meat and allowing lower quality cuts to be cooked for longer periods of time. The reverse flow design diverts combustion gases to the opposite end of the cooking chamber to the firebox to encourage an even temperature distribution. It is evident from the two installed temperature gauges that a temperature difference of up to 20℃ exists throughout the cooking chamber. The aim of this project is to identify the areas with the greatest temperature gradient and alter the design to minimise the issue. The results from the project can be used for future marketing as proof that this product has a proven design advantage over competitors.

3. Methodology

Initially the operating parameters of the Smoke Commander barbecue had to be ascertained. Four thermocouples were place inside the cooking chamber, one at the exit point from the firebox and one in the flue. The barbecue was kept at a standard average cooking temperature of 135℃ and exhaust flow through the flue was measured. An infra-red camera was used to qualitatively show the temperature distribution from the outside. Figure 1 shows a cooler zone where combustion gases rise when changing direction on the lower left. CFD simulations were performed which will then be carried out in practice and tested for correlation.

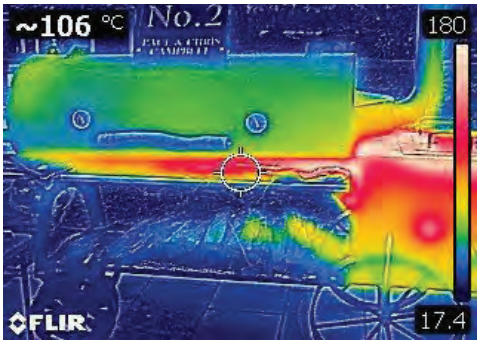

Figure 1 – Temperature distribution captured using an infra-red camera

4. Key Outcomes

The initial temperature distribution has been mapped and a solution has been identified to introduce hot combustion gases into the cooler zone while using turbulence to encourage a more even temperature distribution.

5. Further Work

The CFD simulation and revision is still being undertaken, with further design changes under consideration and a possible design overhaul.

6. Conclusions

The primary aim of this project is to minimise the temperature distribution of the barbecue which has not been carried out in practise yet but is certainly achievable. A secondary aim is to gain exposure to CFD simulation software and the potential uses in industry.

Acknowledgements

I would like to thank Dr Khalid Saleh for his help in providing the instrumentation to carry out the initial testing and advice on how to approach the CFD simulations.

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Conceptual design of the non-assisted wheel chair, for improved functionality and ergonomics for public spaces

Sponsor - School of Mechanical Engineering and Electrical Engineering

Ahamed Asraz Aslam Cassim

Bachelor of Engineering (Honours) (Mechanical)

Supervisor: Dr Steven Goh, USQ

Keywords: Finite Element Analysis (FEA), Wheelchair, Computer Aided Design (CAD)

1. Introduction

This project intends to determine core limitations encountered by non-assisted wheelchair users while navigating public spaces/local environments. Upon identification of core limitations, it aims to investigate current solutions attempting to address the limitations. Further providing a conceptual design that uses a basic wheelchair as a base to address the limitations.

2. Background

Over the coming years it is expected that the global population will reach 9.7 billion by 2050, with an anticipated rise in the aging population globally United Nations, 2015). It's estimated that currently ten percent of the global population live with a form of disability (World Health Organization 2008), which encompasses a significant portion of the global population. Of the ten percent of people's with disabilities, it's estimated that ten percent of them require a wheelchair for mobility (World Health Organization 2008).

As the population grows so will infrastructure, as a result there will be facilities that are out of date, in comparison to relevant standards. Resulting in a spectrum of facilities with a range of access, making it challenging for wheelchair users to navigate their environment. Hindering a wheelchair users access to a barrier free environment and an increased standard of living.

3. Methodology

The design methodology used in the project follows a methodology created by Pahl, Beitz, Feldhusen, Grote. Which requires a review of literature and currently used wheelchair technology. While selecting a location to use as a case study, USQ Residential Colleges facilities were chosen. Further identifying constraints and requirements to consider while creating design concepts. Following conception of designs conduct a feedback loop, evaluating designs against constraints and requirements. Finally, creating CAD models and conducting Finite Element Analysis (FEA) on perceived stress points. Please see Figure 1 for an FEA of the deflection experienced by a conceptual suspension design component.

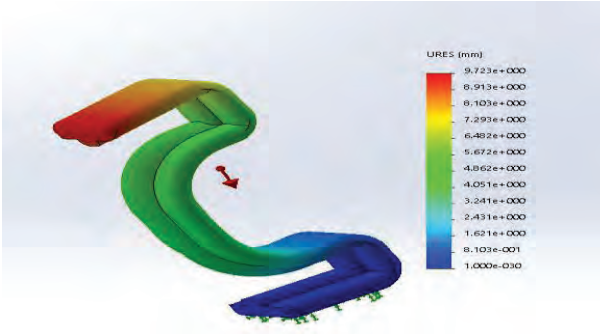

Figure 1 – FEA Analysis of a Concept Suspension Component

4. Key Outcomes

Three designs have been chosen to be modeled using CAD. The chosen designs to be displayed, while presenting data from the FEA. Which include the models reaction to stress, strain and displacement, replicating typical loadings, statically.

5. Further Work

Further iterations of the feedback loop are required before completing final conceptual design models and creating engineering detailed drawings. Ideally, moving forward creation of protypes and conducting testing to compare with results yielded by the FEA. Additionally, dynamic FEA testing would prove necessary.

6. Conclusions

Successfully developing conceptual designs that provide solutions to the limitations identified. Ideally, the designs would be implemented and commence assisting peoples with disabilities.

Acknowledgements

I would like to thank my supervisor, Dr Steven Goh for his guidance throughout this project. I would also like to thank my family and friends for their support during the duration of the project.

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Determining the effectiveness of vortex generators with regards to automotive applications

Sponsor - School of Mechanical and Electrical Engineering

Luke Greenbank

Bachelor of Engineering (Honours)

Mechanical

Supervisors: Dr Ahmad Sharifian-Barforoush, USQ

Keywords: Aerodynamics, vortex generators

1. Introduction

In 2004 Mitsubishi released the Lancer Evolution 8 MR. The press release stated that the inclusion of vortex generators was an innovation in aerodynamics technology. However, there was no quantifiable data included in the press release to go along with these claims. This study investigates the question of whether vortex generators can reduce aerodynamic drag on a vehicle.

2. Background

Engineers are continuously looking at ways of redesigning vehicles to reduce drag, as this is the major contributor to the total resistive force at highway speeds. Any reduction in the drag coefficient of a vehicle will return an improvement in fuel economy. In the past, vortex generators have been investigated on aircraft but infrequently on cars. If these passive aerodynamic devices result in a net improvement in efficiency, they have potential for mainstream implementation.

3. Methodology

This research project included computational and experimental data collection. The latter involved both wind tunnel tests and real-world tests on my own vehicle. The video footage was analysed before and after the installation of vortex generators. Verification of the hypothesis was to be taken from the experimental tests whereas the quantifiable data was to come from the CFD analysis.

4. Key Outcomes

It was discovered that vortex generators impact the downstream airflow characteristics by mixing the high energy of the free stream air with the slow moving boundary layer flow. This results in delaying the separation from the body and reducing drag. However, the real world tests produced inconclusive results due to the high aerodynamic performance of my vehicle which made identifying the benefits challenging.

Figure 1 – Mesh used on the scale vehicle for the CFD tests

5. Further Work

CFD studies are underway and early indications are looking promising (Figure 1). Additional testing of different vortex generators could be performed to understand how design characteristics dictate the overall effectiveness of the device and whether there is an optimal design for a specific application.

6. Conclusions

Vortex generators can reduce aerodynamic drag of a vehicle in theory but ascertaining conclusive results via experimentation can be challenging. From the research completed it is likely that vortex generators need to be specifically designed for each application. Mainstream adoption may not be viable due to the additional research and development R D costs. Also, factors such as the effect on aesthetic appeal for a standard commuter car will need to be considered.

Acknowledgements

Many thanks to my supervisor Dr Ahmad Sharifian-Barforoush and the numerous USQ staff members who went out of their way to help me towards my project.

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An Investigation into the feasibility of micro scale pyrolysis powered by renewable energy

Sponsor - School of Mechanical and Electrical Engineering

Paul Buckley, CPRA

Bachelor of Mechanical Engineering (Honours)

Supervisors: Assoc Prof Andrew Wandel, USQ

Keywords: Pyrolysis, Renewable Energy, Circular Economy

1. Introduction

Rapid technology advancements have led to an acceleration in the rate that waste is generated by 12% per annum Pickin et al., 2018, pg. 9 . In Australia this equates to 67 million tonnes of waste per annum Pickin et al. 2018, pg. 8)

The aim of this project is to examine if pyrolysis on the micro or household scale has the ability to change the perception of waste through restoring its intrinsic value to the homeowner.

2. Background

A significant amount of this waste generated every year is dumped illegally or poorly managed entering waterways and polluting the environment.

Significant amounts of global carbon emissions are generated in the production of fossil fuels, the generation of energy and the collection, storage and management of waste.

One way to counter the negative global impact of consumers is pyrolysis of waste to generate energy and fuels as well as effective management of waste.

3. Methodology

To determine the feasibility of renewable pyrolysis, Chemkin was used to model pyrolysis and determine the energy required process waste. Figure 1 shows the inlet, a plug flow reactor and outlet which combine forming the pyrolysis model. This model used the Creck pyrolysis Reaction mechanism CRECK Modeling, 2014). Its inputs were derived from proximate analysis of municipal solid waste and were combined as a gas mixture of Carbon, Hydrogen and Oxygen for the model.

Figure 1 – Chemkin inlet, plug flow reactor and process outlet

The model results were compared to the daily waste generated for selected dwelling sizes as well as solar energy availability to determine system technical feasibility.

This information was then combined with cost estimates to conduct a cost benefit analysis of the system to the household.

4. Key Outcomes

The key outcome of this project has been the identifiecation through Chemkin modeling of the technical feasabilty of the microscale pyrolysis for the household.

5. Further Work

A consumer investigation should be conducted to determine if the costs are acceptable to the household given the technology benefits and energy savings.

A formal study into the impacts of pyrolysis distributed waste management in society would provide further context on the commercial viability of the process and assist in justification of government subsidies.

6. Conclusions

This project has identified that pyrolysis has potential to provide significant social and environmental benefits while being technically and financially viable in microscale applications.

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Three body abrasion of rubber in mining application under dry contact condition

Sponsor - School of Mechanical and Electrical Engineering

Hamad Almuhaini

Mechanical engineering, BSc

Supervisors: Assoc Prof. Belal Yousif,, USQ

Keywords: Three body abrasion, rubber, mining applications

1. Introduction

Wear is generally defined as the gradual removal or deformation of material at solid surfaces due to mechanical reasons such as erosion (Kovarikova et al., 2009). It occurs in two surfaces named the base body and counter body as soon as they come into contact. Particularly it increases when there is no lubrication between two surfaces which is called dry contact condition. A hard third body due to grit or dirt can be placed between two sliding surfaces and damages one or both of the sliding bodies. This case of wear is called three body abrasion. This project is to investigate three body abrasion of rubbers under dry contact condition.

2. Background

Mining is a processing for finding coal and other solid minerals in the world. Conveyor belt is a main device in mining to transport raw materials. The associated wear and friction in this device imposes some costs together with maintenance for the system. Therefore, designing and selection of a suitable belt for this system is very important for an accurate and long life operation. It is then required to understand and get familiar with the wear mechanism due to its destructive character and its highly occurrence in the belt and rubber during operation.

3. Methodology

The testing machine which is used for the experimental work in this thesis was designed and fabricated by Yousif (2013) at the University of Southern Queensland. Figure 1 shows a schematic of the testing machine.

4. Key Outcomes

On the successful performing this project, it is expected to achieve a complete investigation of three body abrasion mechanism in rubbers under dry contact condition. A sample of rubber will be used to conduct different tests under different wearing loads. The experiemntal data are then collected and analyzed to present a useful discussion for three body abrasion in rubbers.

Figure 1 – Schematic of the testing machine (Yousif, 2013)

5. Further Work

The obtained results from experimental part of this project can be compared with the current results in available literature to check the accuracy of performed tests with the testing machine and to correlate the experimental results from different wear loadings.

6. Conclusions

This project investigated the wearing mechanism of rubber under three body abrasion and dry contact condition. The findings and experimental results in this project will be helpful in selecting or designing components which consists of rubbers or belts particularly in mining applications.

Acknowledgements

I would like to thank my supervisor Dr Belal Yousif for his supports and useful recommendations for this project.

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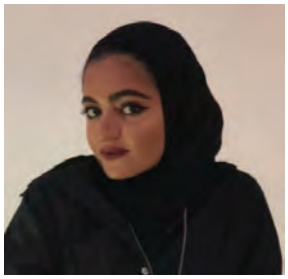
Design a portable wheelchair that can meet the carry-on luggage requirements

Sponsor - School of Mechanical and Electrical Engineering



Danah Alshatti

Bachelor of Engineering (Honours) Mechanical Major

Supervisors: Dr Steven Goh, USQ

Keywords: Mechanical – People with physical disabilities - International Air Transport Association (IATA

1. Introduction

One of the basic problems of portable wheelchairs is that it needs to meet the carry-on requirements of airplane baggage, but most will exceed the carry-on weight and size limit. Even though many people have implored the International Air Transport Association (IATA) to increase the carry-on weight for special circumstances, not much has been done. Elderly people and those with disabilities sometimes need to travel a long distance by air and by implication they need special care and assistance. Most of them require a wheelchair, hence the need to make the wheelchair suitable for air travels.

2. Background

About half of the world's population has disabilities. These conditions are diverse in terms of situation, causes and symptoms such as heart disease, lung problems, mental health, depression, diabetes, cancer and physical disabilities. Physical disability is a condition that affects human flexibility, strength and physical capacity. Examples of physical disability are; upper limbs, spinal bifida, amputation, muscular dystrophy and spinal injury (IMVC 2019). The wheelchair is one of the greatest engineering inventions for patients suffering from various forms of disabilities. Much work has been done in reinventing and making this device more suitable for the users based on their peculiar situations.

3. Methodology

Searching and investigating the weight of the materials and calculating the stresses and strength of the materials what material can handle big weights or can't handle it's well as coming up multiple conceptual designs and analysis these designs and choose the best design to do it in CREO.

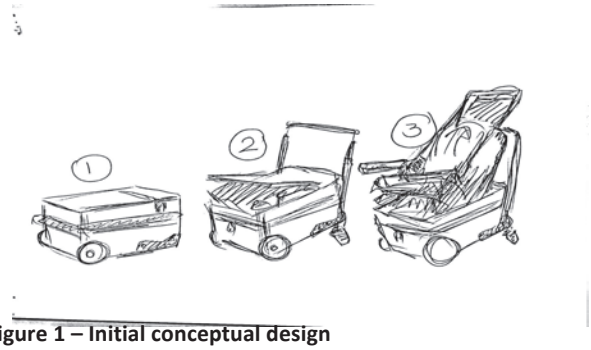


Figure 1 – Initial conceptual design

4. Key Outcomes

The main outcome of this dissertation a design of a lightweight portable foldable wheelchair that can meet the carry-on requirements of airplanes Figure. 1). The design is focused on meeting the needs of the users as well as meeting the carry-on requirements of airplanes. The CREO software is used to model this design.

5. Further Work

Further works include implementing the design from this dissertation and subjecting it to simulation and testing to see the stress, stiffness, strain and elongation of the design with the weight of an actual person.

6. Conclusions

The conceptual design has been able to solve the difficulty that people with disability suffer when travelling by air and having to check in their wheelchairs as check-in luggage, or to hire one at various locations. The light weight and small size means it has other portability benefits other than complying with airline regulations for carry-on luggage.

Acknowledgement

First of all,, I would like to thank my supervisor Dr Steven Goh for always guiding me through the whole project and throughout my years in USQ. Secondly, I would like to thank my family for supporting me through my years in Australia. Lastly, I would like to thank my friends in Australia and Kuwait for their moral support and encouragement.

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Investigating the productivity of double slope solar still with sponge cubes

Sponsor – School of Mechanical and Electrical Engineering

Rimeta Tabwere

Bachelor of Engineering (Honours) – (BENH)

Major– Mechanical Engineering

Supervisors: Dr Ahmad Sharifian, USQ

Keywords: Solar desalination, Passive type double slope solar still.

1. Introduction

Three quarter of the earth surface is covered with water. 97% is ocean salt water and 3% is freshwater. From the 3% freshwater available, less than 1% is readily available for human consumption.

One possible method to address water shortage problem is the use of solar stills at a small scale for small communities in arid areas where cost of transporting freshwater from urban cities may be costly.

2. Background

This project develops from the work of Abu-Hijleh et al (2003) and Lalitha et al 2019) where sponge is used to improve production of solar still. Capillary action of sponge cubes allow sponge to increase free surface area of water, increase evaporation rate and therefore increase productivity. A common method to investigate productivity of solar still with sponge cubes is by comparing with a reference still (identical still without sponge cubes .

3. Methodology

The performance of the double slope solar still with sponge is investigated experimentally for different days and also for the reference solar still. A data logger is used to record temperature of: Water, Glass, Vapor and Ambient. Water and vapor temperature. Measuring Jar is used to measure productivity in terms of ml very low productivity .

4. Key Outcomes

Productivity of solar still with sponge cubes increases by 115 ml compared to solar still without sponge cubes (Fig. 1). Temperature of water also increase when using sponge cubes. However, the initial water temperature of water for solar still without sponge is greater than initial temperature of solar still with sponge.

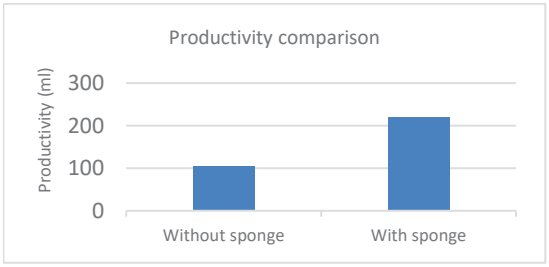

Figure 1 – Solar still productivity comparison

5. Further Work

There is only 1 solar still used and it is required that the climatic condition be similar for different days to allow for exact comparison of without sponge and with sponge solar still. Further work will be more experiment to find similar days to allow for accurate comparison.

6. Conclusions

The use of sponge cubes in the basin of solar still will improve productivity by more than double. This method of improvement does not require any energy source which is considered low cost in terms of no energy usage. In addition, it is simple to implement and does not require any special skills to apply sponge cubes.

Acknowledgements

I would like to first of all thank my supervisor Dr Ahmad Sharifian for the support and direction throughout the progress of my project. I also acknowledge Mr. Ahmed Alkaisi (PhD student USQ) for advice and direction for project. I would also like to thank the technical staff Richard Landers, Terry and Graham Holmes whom have helped with providing equipment and technical assistance for data logging, and Brian Aston who had supervised my experiment at Z4 compound USQ Toowoomba. Last but not least, I would like to thank my family and friends back in Kiribati for their support throughout my studies and the progress of my project.

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Investigating Wave Rotor Performance Characteristics and Design for Air Pumping Applications

Sponsor – School of Mechanical and Electrical Engineering

Liam Channer

Bachelor of Engineering (Hons) -Mechanical

Supervisors: Prof. David Buttsworth, USQ

Keywords: wave rotor, compressible flow, shock waves, expansion waves, air pumping, CFD.

1. Introduction

The wave rotor is a type of turbo machine which manipulates expansion and shock waves to compress gasses. The applications for wave rotors vary from refrigeration to internal combustion engine supercharging. Although wave rotors have been researched for many decades there are still many aspects requiring further investigation.

The focus of this project is to improve the understanding of performance, analysis and design of wave rotors used for air pumping applications. Tasks include: experimental testing, computational fluid dynamics CFD simulation and development of a one-dimensional 1D) mathematical analysis procedure.

2. Background

The wave rotor was first conceived in the 1940s. The only commercialised wave rotor, the 'Comprex' was developed between 1950 and 1970. The Comprex was used as an alternative to a traditional turbo charger for diesel engines, most famously fitted to the Mazda 626.

The isentropic efficiency of shock wave compression is extremely high relative to other compression methods for pressure ratios up to 2.2 Akbari, P., Nalim, R., Mueller, N. 2006). This has generated a lot of research interest in wave rotors for low pressure gain applications. Some of the main players in the field include: NASA, Rolls Royce Allison, Indiana University and Michigan State University.

This project is focused on a pressure exchanger equalising wave rotor PEEWR). PEEWRs are relevant to compressible fluid pumping applications where ejectors are employed. PEEWRs have the potential for 50–75% isentropic efficiency which compares very well against 20 – 30% efficiency for ejectors. See figure 1 for the arrangement of a PEEWR. PEEWR research is limited with Kentfield 1969) the only publication reporting experimental results.

3. Methodology

The experimental testing was carried out by measuring the flow conditions of the device at each port over a range of inlet pressures ratios. The performance data was then processed and mapped using MATLAB. The 1D analysis method was developed using Euler compressible flow equations to analyse the fluid flow in the rotor channels on an *xt* diagram. The CFD methodology was developed using ANSYS Fluent. The model used was inviscid to reduce computational cost and improve correlation with 1D analysis results. The rotor movement was incorporated with a dynamic channel mesh moving past stationary ports.

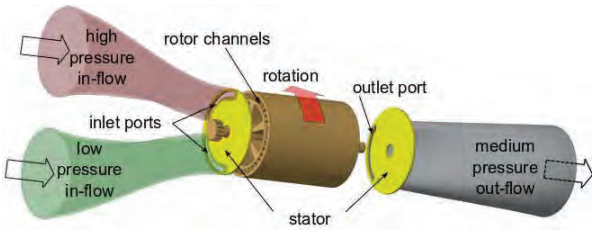

Figure 1 –Pressure exchanger equalising wave rotor (Adapted from Buttsworth, personal communication, 2019)

4. Key Outcomes so far

The 1D analysis method developed simulates the experimental results published by Kentfield 1969) with exceptional accuracy. It also determines the port timing with good correlation to CFD results. The experimental results mapped thus far have the same trend as Kentfield 1969) however, the maximum overall isentropic efficiency achieved is lower than reported by Kentfield 1969) 35% compared to 70%) and predicted by analysis.

5. Further Work

Currently possible causes of the low experimental efficiency are under investigation and ways to improve it are being identified. The scope of further work beyond this project is large. However, further research on the effect of porting geometry and channel size may indicate the low efficacy compared to Kentfield's 1969) results.

6. Conclusions

The experimental results confirm that PEEWRs have definite potential to be a competitive alternative to ejectors. With improved design the efficiency reported by Kentfield 1969) should be achievable. The 1D analysis method developed provides a very go alterative to CFD without the computational cost for analysing PEEWRs.

Acknowledgements

I would like to thank my supervisor Prof. David Buttsworth for his invaluable support and guidance throughout this project. The support from Z4 USQ Workshop has also been important to the success of this project.

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Analysing erosive wear life of rubber panels used in mineral processing plants

Sponsor – School of Mechanical and Electrical Engineering

Mr. Kiran Thundiyil

Bachelor of Engineering (Mechanical)

Supervisors: Dr Belal Yousif
Mr Nigel Kriel, Multotec Pty

Keywords: Erosive wear, Rubber panel, Mining plant wear protection

1. Introduction

Wear protections systems are used to protect plant components used in the production of energy and raw materials, the liners are solutions for effective protection against wear. There is no single lining material that is suitable for every wear application. Most wear liners that perform well in heavy impact applications will generally perform poorly in an abrasive environment. Hard materials such as some castings and ceramics tend to be brittle and are not always suitable for use in high impact environments.

2. Background

The service life of the rubber liner is unpredictable due to nature of the slurry and application environment (Blair Rubber Pty, 2019), current methods of choosing rubber liner thickness and specification is largely based on experience and empirical methods. DEM modelling can provide qualitative indication of the wear patterns, but simulation is extremely time consuming and computer with high processing power is required. The industry standard practice is to choose a nominal thickness liner. Standard size liner for every application is preferred by liner manufacturers as it helps to streamline production and stock management, but it forces the customer to organise maintenance schedule to suit liner replacement cycles.

3. Methodology

Erosion test was done using sand blasting machine which works in principle with gas blast apparatus as per Arnold & Hutchings 1991.In this method, a stream of erodent particles is accelerated by a compressed air flow pass through a straight cylindrical nozzle to strike the test specimen held at a fixed angle. A fixture was designed to hold 3 test pieces at 75˚,60˚and 45˚ angles simultaneously. 1st test was done for 1-minute duration and the 2nd for 2 minutes. The mass of specimen before and after the test was measured to find the amount of material worn for each of the 6 samples. The mass of erodent consumed for each test were also noted and a graph is plotted as per below figure 1.

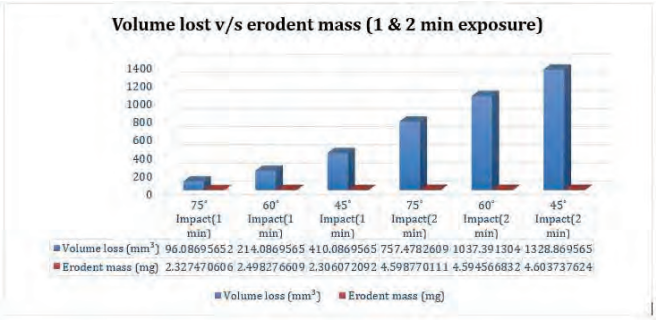

Figure 1. Volume eroded versus erodent mass

4. Key Outcomes

The test pieces were analysed through SEM and huge difference was noticed in the embedment of the abrasives due to variation in impact angles. It was observed that surface roughness increases as angle of impact increases.

5. Further Work

Further study to be done to analyse the effect of variation in temperature, impact velocity, elastic modulus and lubrication on rate of wear.

6. Conclusions

The study concluded that, lower the impact angles, higher the erosion and re-affirmed that application range for rubber panels are within 60˚ to 90˚impact angle.

Acknowledgements

I would like to offer my sincere appreciation to Dr. Belal Yousif for his support and guidance. I would also like to acknowledge the contribution of employees of Multotec Pty Mr. Nigel Kriel & George Gruevski, for their generous support in making this project a reality.

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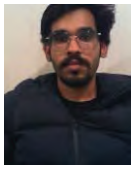
Study the Impact of Wear/ Damage on Various Ceramic Coatings in Mining Machines

Sponsor – School of Mechanical and Electrical Engineering



Hamad Alsaed

Bachelor of Mechanical Engineering

Supervisors: Assoc Prof. Belal Yousaf

Keywords: Ceramic Coatings, Tribo-Tests, Protective Coatings

1. Introduction

In Australia, a variety of challenges are faced by the growing mining industry, like the abrasion wear of mining equipment, which ultimately leads to its loss or failure. A number of coatings, such as ceramic, fused tungsten carbide, graphene, are used for the protection of mining equipment. In this research project, a number of coatings will be analysed for their anti-wear characteristics by using a new Tribo-Test machine developed at USQ. Tests such as BOD (ASTM G99), BOR ASTM G77 , and DSRW ASTM G655 will be performed by using this machine

2. Background

The protective coatings based on metal composite matrix Ni-base with fused tungsten carbide were conventionally used for protecting mining tools against abrasion. However, the limited reserves of tungsten have led to the exploration of its alternatives. The ceramics, such as Al_2O_3, ZrO, TiN and SiC, are the potential candidates for protective coatings because of their excellent anti-wear characteristics.

3. Methodology

The ceramic coatings will be tested for adhesion and abrasion by using the new Tribo-Test available at USQ, as shown in figure 1. The three tests, such as block on disk (ASTM G99), block on ring (ASTM G77 , and dry sand rubber wheel (ASTM G655) will be performed in this study. The different parts of machine are; 1-Counterface, 2-BOR lever, 3-BOD lever, 4.-Three body abrasion hopper, 5-BOD-Specimen, 6-BOR-Specimen, 7-Lubricant container.

4. Key Outcomes

The tests performed in this study will provide a detailed analysis of the performance characteristics of ceramic coatings based on Al_2O_3, ZrO, TiN and SiC. At the place of conventional coatings, nanostructured ceramic coatings e.g. plasma sprayed nanostructured alumina are considered as highly effective against abrasion and wear.

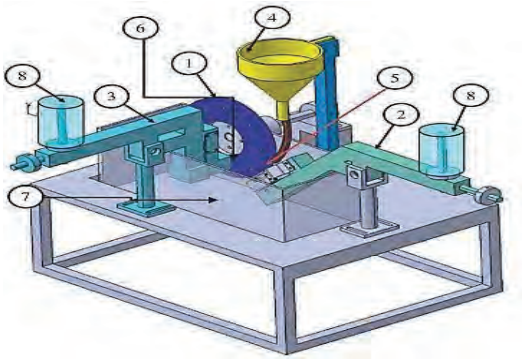


Figure 1 - Sample Diagram

5. Further Work

This project will not consider the development of new or improved coatings based on modern (such as nanostructured materials. However, our recommendations for most effective protective coatings can be helpful for researchers interested in developing such coatings.

6. Conclusions

Based on the results of anti-wear characteristics for different protective coatings, the most suitable coatings will be compared and recommended.

Acknowledgements

I would like to thank my supervisor Belal Yousaf for his support and guidance.

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METHOD AND ANALYSIS OF IGNITOR FOR ROTATING WAVE COMBUSTOR

Sponsor – School of Mechanical and Electrical Engineering

Bismillah Haidari

Bachelor of Mechanical Engineering Honours

Supervisors: David Buttsworth, USQ

Keywords: Detonation, Ignition, Hydrogen

1. Introduction

Detonation is a type of combustion where the shock wave travels in the order of 1000 m/s (Wolanski, 2011). Engines that implement this type of combustion are called detonation engine where the shock wave propagates circumferentially around the annulus. The fuel and air mixture are usually burned in a spate channel called pre-detonator which plays significant role in providing steady detonation wave into the main combustor. The detonation tube consists of a pre-detonator, fuel and air inlet, and spark plug. The efficiency on the design on detonator is dependent on the fuel-air mixture ration, tube dimensions, and the energy from the source (Guirao, Knystautas & Lee, 1989).

The transition from deflagration to detonation is completed inside the pre-detonator and accelerated towards the open end which is tangentially connected to the main combustor (Ma, Zhang, Luan, Yao, Xia & Wang 2017). Rotating Detonation Engine implement direct initiation from energy source where high energy is ignited by spark plug to burn the fuel-air mixture.

2. Background

The project aims to provide an analysis for different method of providing detonation into the combustor. The project to provide alternative solution for wave propagation using square tubes and compare it with conventional circular tubes. Steady wave propagation is the main challenge engineers are facing to implement efficient and sustainable propulsion engines. The project would help to understand the combustion process used in aviation and aerodynamic industries.

3. Methodology

The experiment would be conducted using stainless steel material that can withstand strong shockwaves. The fuel-air mixture is ignited by Arduino-controlled commercial spark plug. A brief and general mechanical analysis will be conducted on Creo Simulate to estimate stress analysis and design improvement of the pre-detonator. The schlieren image will take a picture of the shock wave for square tube through highly explosive resistance glass material. Another experiment will be conducted using circular tube and the results will be compared to see the effect of square tube on steady wave propagation. The below figure shows an exploded view of the square and circular tube.

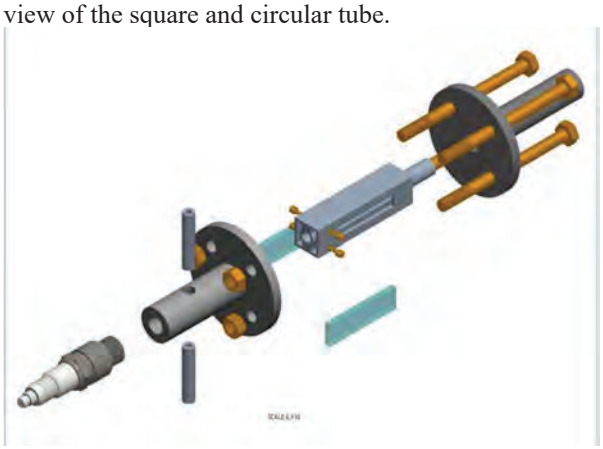

Figure 1. Design of the square and circular tube

4. Key Outcomes

The expected outcome of the project include:

- Improved knowledge on the design of pre-detonator
- Image visulisation of the detonation wave in square tube
- The square tube tend to be less effective in providing stable deotnation due to corners and edges
- The steciometric ratio of 1 for hydrogen-air mixture is more stable

5. Further Work

Further Research can be conducted on the steady wave propagation and design improvement specifically on reducing the geometry of pre-detonator.

6. Conclusions

The focus of the project is to analyse ignitor for rotating wave combustor by visualising the detonation shock front using schlieren image. Detonation wave seems to be more stable in circular detonation tube.

7. Acknowledgement

I would like to thank David Buttsworth and Craig Lobsey

The effectiveness of energy recovery ventilators (ERV) for air-conditioning systems in multi-purpose halls in North Queensland

Sponsor - School of Mechanical and Electrical Engineering

Gene Morgan

Bachelor of Engineering (Honours) (Mechanical)

Supervisors: Dr Andrew Wandel, USQ

Keywords: energy recovery ventilator, air-conditioning

1. Introduction

An energy recovery ventilator ERV) is a device that provides pre-conditioned outside air to a building which is a code requirement by mixing conditioned exhaust air with incoming ambient air using a permeable membrane to transfer energy. When designing air-conditioning systems for multi-purpose halls in tropical climates, large amounts of outside air are required which results in larger required cooling capacities and higher energy costs. Utilization of an ERV is imperative to increase the energy efficiency of a system and to reduce plant size and cost.

2. Background

Typically, heating, ventilation and cooling HVAC) accounts for approximately 40% of an entire building's energy consumption (Department of the Environment and Energy 2013). Increases in the occurrence and severity of hot days over time have elevated the energy costs attributed to air-conditioning systems. These subsequent temperature rises have resulted in a significant reliance on air-conditioning. Therefore, it is important to design energy efficient air conditioning systems which will significantly reduce a building's energy costs.

3. Methodology

The project was based on a multi-purpose hall in Townsville, North Queensland. A quantitative comparison was undertaken for an air-conditioning system with and without an ERV. A heat load simulation was undertaken for both systems using the minimum BCA/NCC Section J requirements for building fabric and glazing. Both air-conditioning systems were then designed and documented using industry design guidelines. The effectiveness was comparatively evaluated by undertaking a building energy analysis and cost analysis of each system.

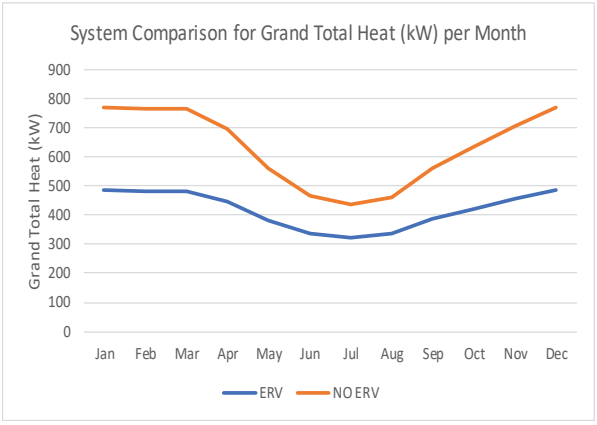

Figure 1 – Preliminary System comparison of GTH (kW)

4. Key Outcomes

It was found that incorporation of an ERV in an air-conditioning system yields a significant reduction in the Grand Total Heat (kW of a multi-purpose hall in North Queensland as seen in Figure 1. It is anticipated this reduction in GTH will see significant cost and energy savings once the analysis has been completed.

5. Further Work

Further studies could apply this dissertation and framework to different climates and applications. Study could be undertaken into the different types of energy recovery ventilators in order to achieve better efficiencies.

6. Conclusions

The aims of this study were to compare the effectiveness of ERV's in the North Queensland region from a performance and cost perspective. This was achieved but at the time of compiling the abstract, results were not finalised.

Acknowledgements

I would like to thank my supervisor Dr. Andrew Wandel for his assistance and guidance throughout this dissertation. A special mention to my partner Caitlin, my parents and family members for their support and patience throughout the project and degree.

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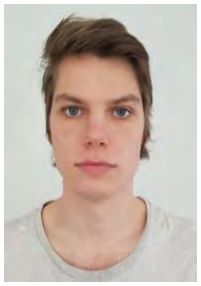
Overall Performance and emission effects of light naphtha additives in a Diesel Engine

Sponsor - School of Mechanical and Electrical Engineering



Marek Eberhard

Bachelor of Mechanical Engineering Honours

Supervisors: Dr Andrew Wandel, USQ

Keywords: Light Naphtha, Diesel Engine, Performance and Emissions

1. Introduction

The current landscape for internal combustion engines (IC) is ever changing to meet new emission regulations imposed by governments to combat the risk of climate change. To reduce the fuel side of these emissions, fuel companies are filtering out more fuel groups than they would have left in previously. This creates surpluses of these fuel groups as they are no longer used as filler fuels (Baker O'Brien Inc. 2016 . The current fuel group that is being increasingly removed to meet emission regulations is the light naphtha group. This project investigates the performance and emission effects of some of these light naphtha fuels if they were isolated and blended with diesel.

2. Background

Limited research has involved using the light naphtha group as an additive in a diesel engine. Ekaab, Hamza Chaichan 2018), investigated the performance and emissions difference between diesel and kerosene. Kerosene is a fuel that contains many hydrocarbons, mainly naphthene's and straight chain alkanes. Their research concluded that while performance and NOx emissions was negatively impacted, Particulate matter, Carbon monoxide and unburnt hydrocarbon levels were reduced considerably.

3. Methodology

Combustion research is a complicated endeavour, with many factors that can cause changes with the results. Each light naphtha diesel blend will be experimentally tested in a single cylinder diesel engine located at USQ, these results will then be used to validate the computer simulation models within the ANSYS Forte Software. The process of validation will then allow further testing to occur within ANSYS Forte with a certain degree of accuracy.

The light naphtha species that were chosen as the fuel additives are: pentane, hexane and cyclohexane. These species were chosen by investigating the most common fuel species within the light naphtha group and the potential effects based on octane number and other parameters.

Table 1. Chosen light naphtha species with properties

Properties	Pentane	Hexane	CylcoHexane	Diesel
Octane	61.7	24.8	83	~20
Boiling Point (°C)	~36	~69	~80	
Abundance in light naphtha group (%	~1.5	~0.5	~.2	

4. Key Outcomes

Investigation into the light naphtha group has resulted in knowledge of which species will be most abundant and therefore most viable if results are promising.

The test engine that will be used has been modelled within ANSYS Forte.

5. Further Work

Further simulations and simulation refinement have to occur, with testing the fuel additives in an engine occurring in the following weeks.

6. Conclusions

While testing is ongoing no clear conclusions can be made. However, while fuels are the leading cause of climate change, they are and will be a significant portion of our energy source for years to come. Therefor ongoing research in the future is vital.

Acknowledgements

I would like to thank Dr Andrew Wandel for always answering my questions when I got stuck.

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The Experimental & Simulation Investigation of the Engine Performance Characteristics of Conventional and Waste Plastic Fuel

Sponsor – School of Mechanical and Electrical Engineering

Abdullah Murad

Bachelor of Mechanical Engineering

Supervisors: Dr.Saddam H.Al-wayzy, USQ

Keywords: Waste plastic biodiesel, Cetane number, recycling

1. Introduction

The recycling of non-biodegradable waste plastic is an attractive option for preventing environmental pollution and conserving fossil fuels. Considering this, the present study will evaluate the engine performance characteristics of Yanmar ln48 by using regular diesel. The results will be compared with the engine performance characteristics of waste plastic diesel fuel WPDF) obtained through ANSYS modelling and simulation.

2. Background

In the present era, the ever increasing greenhouse gas emissions have aggravated the environmental pollution leading to global warming and rapid climatic changes. As a result, along with the exploration of renewable sources, the recycling of existing materials in to new forms/ shapes is also desirable. For example, plastics, an integral part of our daily lives, could be recycled in to valuable products such as biodiesel) at the end of their service life. A feedstock of mixed waste plastics could be treated via pyrolysis to produce waste plastic diesel Fuel (WPDF).

3. Methodology

Due to the difficulties in obtaining the (WPDF) on time, in this project. ANSIS simulation will be used to test the engine performance and emission using conventional diesel fuel and WPDF. The results of the simulation will be validated by performing engine test with diesel fuel only on Yanmar L48N testing stand (fig-1). The experimental data such as fuel consumption, pressure within cylinder during run, and composition of exhaust gas emissions will be collected.

Fig. 1–The Yanmar L48N engine stand, available at USQ

4. Key Outcomes

In this study, the simulation results that will be validated with engine test will indicate the sutability of using the WPDF in diesel engine without modification. Earlier studies have reported that engine running on WPDF give fairly low concentrations of NO_x and CO_x as compared to Diesel. However, this topic is not fully covered.

5. Further Work

Here, the engine performance characteristics studied by using WPDF were limited to simulation and modelling. The experimental study revolved around regular diesel only. However, a more comprehensive study could be conducted through experimental evaluation of WPDF in Yanmar ln48.

6. Conclusions

The WPDF is a renewable fuel that can contribute in reducing environment pollution from waste plastic. The identification of engine performance and emission will enable other researches to further explore the potential usage of 100% WPDF for modern diesel engines without substantial modifications.

Acknowledgements

I would like to thank my supervisor Saddam Al-lwayzy for his support throughout this research.

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Steering System Design to Improve Manoeuvrability of a Multi-Wheel Feed Chute Transporter

Sponsor – Russell Mineral Equipment (RME

Nicole Brunner

Bachelor of Engineering (Honours) – Mechanical

School of Mechanical and Electrical Engineering

Supervisors: Mr Chris Snook, USQ

Mr Brett Salomon, Russell Mineral Equipment

Keywords: Steering system, multi-wheel, independent steering

1. Introduction

Feed chute transporters are used in the grinding mill industry to extract, transport and replace grinding mill feed chutes. In industry today, performance expectations from plant and equipment are steadily increasing. The steering system of Russell Mineral Equipment's Multi-Wheel Feed Chute Transporter has been highlighted as an aspect that would benefit from further development.

This project aims to design a steering solution that improves the manoeuvrability of the RUSSELL Multi-Wheel Feed Chute Transporter.

2. Background

Steering on the current Multi-Wheel Feed Chute Transporter design is achieved through a hydraulic mechanical linkage system. This design creates limitations in the achievable steering angles and thus manoeuvrability. Inefficiencies arise during machine operations around site, slowing down the mill reline. Therefore, it is important that customers are provided with an improved product that will further aid in the servicing of grinding mills.

3. Methodology

From an evaluation on potential solutions developed from relevant literature and discussions with RME to create a high-level project scope, it was proposed that to achieve the functional requirements, independent steering combined with significantly improved steering angles is to be implemented onto the Multi-Wheel Feed Chute Transporter.

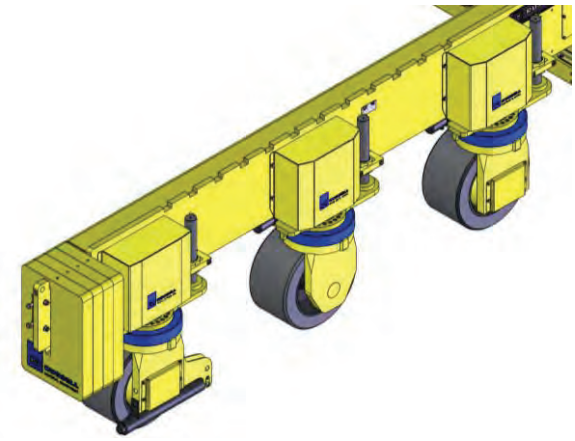

Figure 1 – Independent steering system design on one side of the RUSSELL Multi-Wheel Feed Chute Transporter.

Preliminary design of the system was completed to determine the general layout. The detailed design involved Finite Element Analysis on the wheel assemblies, updates to interfacing stages, hydraulic design, and development of the control strategy.

4. Key Outcomes

An independent steering system, using slew drives at each wheel has been fully designed. See Figure 1. It meets all project requirements and has introduced multiple steering modes, improving the existing design.

5. Further Work

Upon completion of this project, the steering system design with programmable logic control can be introduced onto future production machines at RME.

6. Conclusions

Implementing independent steering onto the Multi-Wheel Feed Chute Transporter has greatly enhanced the steering capabilities and steering modes of the machine.

Acknowledgements

I would like to thank my supervisors, Chris Snook and Brett Salomon for their guidance during this project. Special thanks to my family, friends and Russell Mineral Equipment for all the support throughout my studies.

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Renewable Alternative Fuel for Diesel Engine

Sponsor – School of Mechanical and Electrical Engineering

Talal Yousif

Bachelor of Mechanical engineering

Supervisors: Dr. Saddam Al-wayzy, USQ

Keywords: internal combustion,

1. Introduction

The invention of the internal combustion (IC) engine revolutionized the 19th century. During its discovery, gas was used as the primary source of fuel. Fossil fuel is the most used fuel for most industrial engines, especially diesel engines. However, the high demand for fossil fuel coupled with the adverse environmental impacts of fossil fuel combustion prompts research about alternative fuel with high efficiency, and biodegradable. This study Examine the use of renewable fuel such as Dimethylethe/Dimethylfuran as an alternative fuel for diesel engine.

2. Background

Diesel engines are well suited to heavy machinery, locomotive ships and automobiles. Comparing the efficiency of the diesel engine with the spark ignition (SI engine, the diesel engine has higher thermal efficiency. The use of renewable fuels extracted from waste will contribute in reducing the diesel engines pollution.

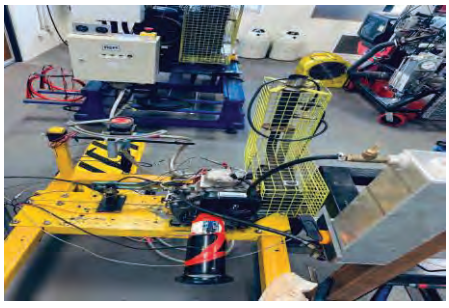

Fig-1: The engine which will be used at USQ.

3. Methodology

The experiment setup will involve engine testing and evaluating the performance of the engine when dimethylether/Dimethylfuran is used. Appropriate sensors will be coupled to the engine to monitor its performance see fig.1). In addition to, the emission characteristics will also be analysed.

4. Key Outcomes

The findings will determine whether dimethylether/Dimethylfuran is a good substitute for petroleum diesel both performance and emission wise.

5. Further works

Future works can attempt to test dimethylether/Dimethylfuran as an alternative for diesel fuel using diesel engines on vehicles and other machines in different blends with diesel fuel.

6. Conclusions

The experiment will confirm whether dimethylether/Dimethylfuran can be adopted as an alternative for fossil fuel, therefore providing a direction for future research and contributing to the existing body of knowledge on alternative energy.

Acknowledgements

I would like to thanks my supervisor Saddam Al-lwayzy for his support and guidance through this project.

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Prevention of Children's Death due to Heatstroke and Hyperthermia when left in cars using Mechatronic Means

Sponsor - School of Mechanical and Electrical Engineering

Mthulisi Mlilo

Mechatronics Engineering

Supervisors: Dr Tobias Low, USQ

Keywords: Hyperthermia, heatstroke, microelectronics, Arduino, Mechatronics

1. Introduction

Death in the cars from hyperthermia and heatstroke has increased since the legislation of airbags. The airbag technology has increased while the death of infants has increased dramatically(Null, 2013). When paralleled to airbags which have by legislation, even without an act dedicated to them specifically, have been elevated to the summit, it behoves those who have determined to dedicate their lives to solve the issues of the current and coming generations.

2. Background

Parents have lost children due to a gap in engineering. Legislation has promoted the airbags but has not done much on children in cars other than implementing the back seat policy. The deaths of children has borne this idea of wanting to use mechatronics means to solve the problem. Parents who are distraught from losing a child face prosecution(Booth, 2010).

3. Methodology

A more convergent methodology approach has been employed to analyse the possible outcomes that encompass this study. Data done by others has been the primary source. Temperature data logging was also employed to understand the problem. As in Fig 1, the system was first used to collect data, and finally it is used to detect and respond to temperature changes.

4. Key Outcomes

The work that has been covered is a fundamental basis. On this platform, I have laid my own reaseach. A system that will alert the emergency services of any sign of life. This is based on sensors that detect motion and carbon dioxide release.

Two LEDs will come on, seconds from each other, indicating the engine and air conditioning start.

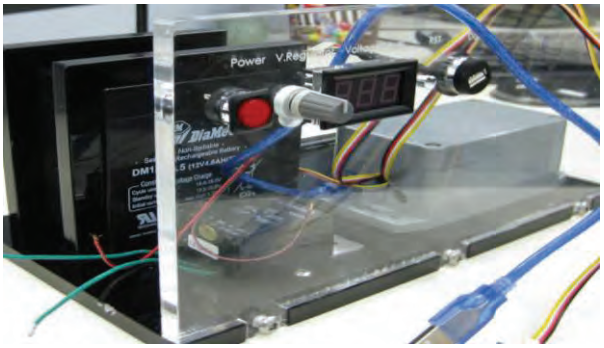

Figure 1 - Childsafe module

Arduino, which is the microchip driving the system communicates with the sensors. When the conditions are met, the system activates and alerts the caregiver and the emergencies, giving the GPS location of the vehicle and the registration.

This will still need to be implemented in real life.

5. Further Work

The integration of this research into the vehicles is to take place. With the hope that this work will one day be patented and then a testing on vehicles will be sought. Carbon dioxide levels remain a bit hard to detect owing to the fact that no life can be left in the vehicle at the moment (having eliminated the risk of heatstroke) to do the actual test, owing to legislation and ethics.

Lobbying the legislation on the implementation of manufacturer solutions.

6. Conclusions

Temperatures in cars rise rapidly during the hot seasons, calling for a vigilant approach to save lives of children. Mechatronics means can however ease this problem, it can be employed in the prevention of losses life of children within the communities.

7. Acknowledgements

I will like to acknowledge Tobias Low, my supervisor for his support and support. I will acknowledge Richard Myors for his support. To colleagues that I would occasionally bump my ideas.

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Single Spatial Sensor Control of Robotic Arms

Sponsor – School of Mechanical and Electrical Engineering,

Damian Easterbrook

Bachelor of Engineering, Mechatronics

Supervisors: Dr Tobias Low, USQ

Keywords: Robotics, Vive, IMU, Robot Arm, Control

1. Introduction

This project has been inspired by two areas. The first is the earth moving industry where large machines roam building and mining sites scooping large volumes of earth using buckets mounted on long robotic arms. The second area is the field of telepresence where humans control robotic devices over a long distance. Of primary importance to this project is the idea that a robotic arm may be controlled through the use of a single sensor system such as an inertial measurement unit (IMU) and such a control system will be superior to current methods.

2. Background

The predominant control method in the industry is the joystick having each axis of the various joysticks control a specified angle in the robotic arm. Other means of control have been explored such as the use of a Phantom device and multiple sensor systems to control the arm.

3. Methodology

The methodology used in this project includes detailed analysis of the kinematic chain of a robotic arm to determine the inverse kinematic model. Three different types of controller are explored, traditional 4 joystick system, the HTC Vive and a single IMU sensor. The IMU sensor is problematic in that errors build up quadratically. A special algorithm was needed to be developed using some assumptions. Figure 1 shows the double integral as it relates to the IMU

4. Key Outcomes

Using the trapezoid method and several assumptions, the double integral problem has been solved with some success. The solution has a unique touch to it matched only by gesture systems seen on mobile phones and the like.

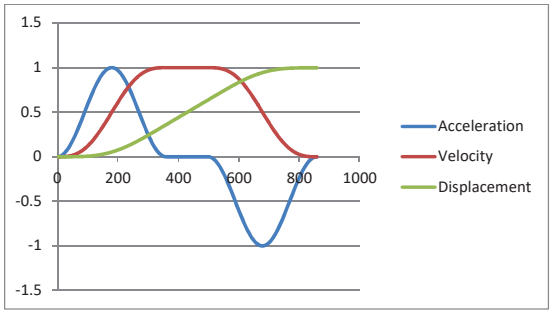

Figure 1 – Idealised double integral problem, X-axis = time

5. Further Work

The principles of this project have been tested in a controlled environment. This technology needs to be applied in actual industry to evaluate how well it would function. With results from Gleeson (2016), a functional telepresence system can be realised.

6. Conclusions

A controller that uses a single IMU to track position and orientation has been developed and tested on a robotic arm. The solution for this achievement required handling of the double integral problem. This was achieved through a number of assumptions about the use of the controller as well as handling of errors in the IMU data.

Acknowledgements

I would like to thank Dr Tobias Low, my supervisor, for his insight into some of the issues encountered. Thanks goes to members of my family such as my mother, partner and children for their support while doing this project. I would also like to acknowledge Gleeson (2016) and Kim et al. (2009) for inspiration.

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Low-Cost Firmness Based Avocado Ripeness Tester

Sponsor - School of Mechanical and Electrical Engineering

Jared Mathews

Bachelor of Engineering
Honours Mechatronic

Supervisor: Dr Craig Lobsey, USQ

Keywords: Food Wastage, Ripeness, Firmness

1. Introduction

In the 2016-2017 financial year, Australia generated 7.7 million tonnes of food waste (ARCADIS, 2019), or just over 300 kilograms per person. As Australia and indeed the world's population grows, society will have to make more efficient use of the limited resources available. Reducing food waste is one way of increasing overall resource efficiency. This project aims to help better manage resources through development of a device capable of providing a quantifiable assessment of fruit ripeness through non destructive testing.

2. Background

Food waste occurs across the chain of supply. The primary production, wholesaling, retail, hospitality and food services, institutions and household sectors together contribute just over 75% of Australia's food waste with the Household and Primary Production sectors contributing most of the waste ARCADIS, 2019). Some of the food waste from each of these sectors is a result of difficulty in managing perishable foods. A range of ripeness evaluation tests exist, each with their drawbacks and none providing a comprehensive picture of fruit ripeness. One of the simplest methods is a firmness test which provides a fair indication of fruit ripeness Llecha, Fructuoso, Valero, Guinjuan, Latorre, Laudo, Blanchar Sala, 2005). Firmness is typically tested using a penetrometer test which destroys the fruit in the process thus limiting the number of fruit that can be tested. A non-destructive firmness testing device using low cost actuators and sensors is proposed.

3. Methodology

A stepper motor coupled with a drive screw and a load cell will be used to measure the force and displacement applied to the fruit to calculate a firmness value (Figure 1). An Arduino Nano will be used to control the stepper motor and interpret the readings from the load cell. The results obtained from the non-destructive firmness testing will be compared to a penetrometer test and an assessment by a human panel.

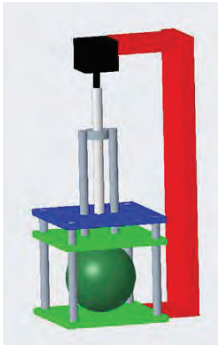

Figure 1 – Basic Experiment Layout

4. Key Outcomes

Once testing is completed, the non destructive firmness testing will be evaluated against the existing destructive firmness testing to determine if the proposed method is feasible for application in the Avocado supply chain.

5. Further Work

To further the information gathered from the system, an RGB spectrometer could be added to allow for a more educated estimate of fruit ripeness. Additionally testing of the system on other varieties of fruit would provide interesting and beneficial results.

6. Conclusions

Food waste is a major problem in today's society. This project aims to make an advancement on current ripeness testing methods, thus making it easier to manage perishable food items and cut down on food waste.

Acknowledgements

I would like to give special thanks to my supervisor Craig Lobsey for his patience and guidance in helping develop this project.

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Collision Avoidance in Motion Control Systems by Real-Time Predictive Interference Detection of 3D Assembly Models

Sponsor - School of Mechanical and Electrical Engineering

Rob Brooker

Bachelor of Engineering (Honours) (Mechatronic)

Supervisors: Tobias Low, USQ

Keywords: collision avoidance, real-time, 3D

1. Introduction

This project attempts to create a method to protect machines from self-collision. By loading a 3D model of the machine into a dedicated processor and passing axis positions and speeds to the processor from the PLC, interference tests are conducted, and if a collision is predicted, a stop signal is sent to the appropriate axis.

2. Background

Existing machines rely on the programmer to prevent collisions by considering every use scenario during development. They manually analyse the structure of the machine to identify combinations of axis positions that can cause a collision

Problems can occur when the analysis misses a potential collision, when a new product is configured with parameters that were not anticipated, or when an operator jogs one axis into another.

3. Methodology

First a method will be found for detecting collisions between 3D model parts. Then an automated process for translating the designed 3D model. Next is the determination of the process structure and hardware requirements. Can the process be real-time, or must it be a run-once program which generates a static rule set? Can the selected method be incorporated within the PLC, or will it require external hardware? Finally, build chosen system architecture, and test, both in simulation environment, and on a real machine.

4. Key Outcomes

Early testing determined that complete 3D models of even simple machines require too much memory for mid-range PLCs to do internal real-time analysis. Automatically generated rules-based analysis is still possible. To conduct real-time analysis, external hardware was required. Figure 1 shows the limitation of real-time processing using a Raspberry-pi3. Models consisting of less than 300,000 triangles can be analysed with a 6ms cycle time. Greater model complexity steeply increases processing time. An EtherCAT fieldbus adapter to retrieve axis positions and speeds from the PLC was added. A freeware physics library was used to reduce development time.

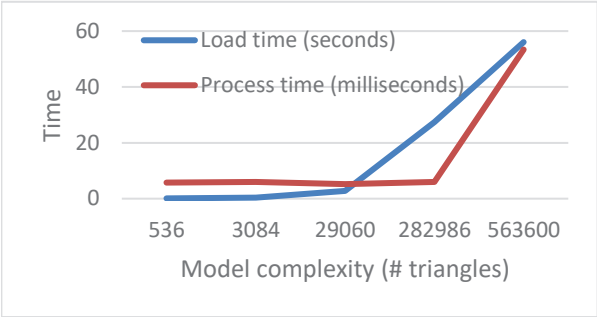

Figure 1 – Load & process times vs model complexity

5. Further Work

Exporting a minimum size, while sufficiently detailed model from 3D software will require the most effort to make this project commercially viable.

6. Conclusions

If a suitable 3D model is available, the project has delivered the desired result. The model complexity handled, and processing time show promise for continued development.

Acknowledgements

Thanks to Pedro De Jesus, of Mexx Engineering for being a sounding board for my wild ideas. Collision detection in this project is thanks to SOLID library (van den Bergen 1999). Understanding the requirements of EtherCAT came from EtherCAT Technology Group, 2009).

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Automated resume grading and diagnostics using a rule-based approach

Sponsor - School of Mechanical and Electrical Engineering

Partheeban Elangovan

Bachelor of Engineering

(Honours)

(Mechatronics)

Supervisors: Dr Jason Brown

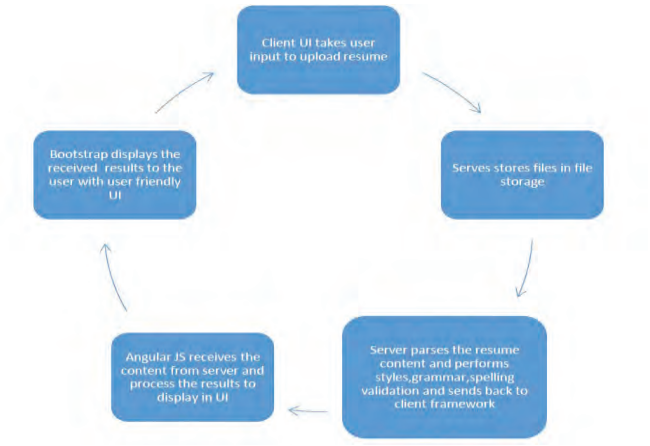

Figure 1 – High-level Workflow

Keywords: Resume, Grading & Ranking, Rule-based approach

1. Introduction

This project is about developing a software application to grade resumes by using pre-defined rules. Through the research, some of the most common mistakes and expectations in a resume are identified and defined as a rule for grading the resumes. All these rules will be written as code in a program which runs as a back end for this application. A User-Interface will be developed which will take input in .docx format and process it and the output will be displayed with the ranking for the resume.

2. Background

Resume grading is used by recruiters and employers for years. It helps them to identify a suitable candidate for jobs. For candidates, preparing a good resume is the first step to apply for a job. Simple mistakes like formatting, missing crucial information and spelling will cost the chances of getting a job. This tool will identify these mistakes and help to write a better resume.

3. Methodology

Through extensive research, common expectations and mistakes in a resume are identified. From that list top priorities are identified and transformed into rules in developing the software. This program is designed to take the .docx document as an input.

The backend of the software will read the content and layout of the document. The user interface will be used to interact with the user. After some research 'Java' was chosen to write the code for back-end and 'Angular JS' was used to develop the user interface see Figure 1).

4. Key Outcomes

At this stage, this application detects most of the common errors in a resume. It also provides diagnostic feedback. The user interface has been modified to give detailed feedback.

5. Further Work

This application can be further developed with a user-friendly interface with a few more customized options. This application has lots of room for Machine Learning exercises.

6. Conclusions

This software application identifies the common mistakes in a resume and helps the applicants to write better resumes. This will also help the recruiters to filter the resumes to suit the need.

Acknowledgements

I would like to acknowledge my supervisor Dr. Jason Brown and Mr Chris Snook for their assistance and guidance throughout my research project.

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Autonomous Navigation of a Partially Unknown Environment

Sponsor - School of Mechanical and Electrical Engineering

Jason Pont

Bachelor of Engineering Honours , Major Mechatronic Engineering

Supervisor: Craig Lobsey, USQ

Keywords: autonomous, Mars, navigation

1. Introduction

The aim of this project was to investigate navigation methods for supporting autonomous operations on Mars. To date there have been several robotic rover missions to Mars for the purpose of scientific exploration. These missions have relied heavily on human input for navigation due to the limited confidence in computer decision-making and difficulty localising in an unknown environment with limited supporting infrastructure such as satellite navigation. By increasing the confidence in the performance of an autonomous rover on Mars, this project will contribute to increasing the efficiency of future missions by reducing or removing humans from the control loop.

2. Background

Due to the signal propagation delay between Earth and Mars, a certain level of autonomy is required to ensure a rover can continue operating while awaiting instructions from a human on Earth. However, due to the level of risk in relying solely on automation, there is still considerable human intervention. This can result in significant downtime when awaiting a decision by a human operator on Earth. While acceptable for scientific missions, greater autonomy will be required for routine Mars operations.

3. Methodology

The project began by examining systems and sensors that have been used on previous robotic missions to Mars and other experiments on Earth. The most appropriate systems were assembled into a simulated test environment consisting of a small rover, an overhead camera that might be carried by a drone or balloon and wireless communications between the systems. A computer vision algorithm was developed to test this concept of an overhead camera mounted on a drone or balloon and evaluate different path-planning algorithms for speed in navigating a previously unknown environment.

4. Key Outcomes

The key outcomes to date are the development of a rover and its operation in the test area. The rover could navigate rotate towards and travel to a target location after receiving instructions via serial radio communications. Figure 1 shows the assembled rover in the test location.

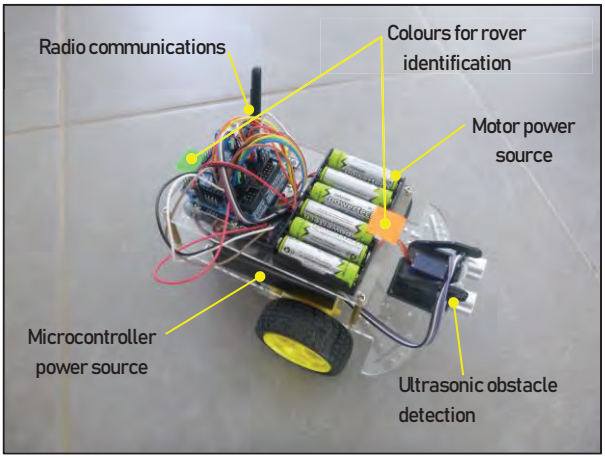

Figure 1 - Test rover showing key features

5. Further Work

The final step of the project is to use the rover location, target location and obstacle locations as arguments for a path-finding algorithm to find the best possible path to a target location. The rover will then be guided to the target, avoiding any obstacles, with the aid of the overhead camera.

6. Conclusions

By using the overhead camera system, a solution is possible to the problem of navigating on Mars, where there is no magnetic field for orientation and no satellite navigation system yet . This may be a way to conduct a sample return mission or a future mining operation, without the need for a human in the control loop.

Acknowledgements

I would like to thank my supervisor, Craig Lobsey who has been consistently helpful throughout the project with problem solving suggestions and coding expertise.

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Earthing Systems and Earth Fault Protection in Power System Distribution Network

Sponsor - School of Mechanical and Electrical Engineering

Sanjay Narayan

BENH (Power)

Supervisors: Mr Matthew Quinton, USQ

Mr Robert W. Coggan, Energy Queensland

Keywords: Power, Earthing, Protection

1. Introduction

Ergon Energy and Energex Limited are both subsidiary companies of Energy Queensland and have the responsibility to provide safe and affordable electricity to customers in Queensland. In maintaining a safe distribution power network, earthing and power system protection plays a vital role. This research project performs analysis on different earthing systems and various forms of earth fault protection utilised in distribution power network to improve the detection of high impedance earth faults.

2. Background

Earth faults are not only by far the most frequent of all faults, but the fault currents may be limited in magnitude by the neutral earthing impedance, or by the earth contact resistance which makes detection challenging for conventional protection schemes. Currently, normal earth fault protection together with sensitive earth fault protection has been employed in both distribution networks to detect and clear these faults. There have been incidences where earth fault detection has been extremely challenging.

3. Methodology

Analysis was performed on existing earthing systems and earth faults were simulated on 11kV feeder model in Dig-Silent Power Factory Software package. Test cases were developed for earth fault scenarios and the results for each of the different simulated scenarios were recorded. Figure 1 represents earth fault values on a 11kV feeder with different earthing methods utilised for supply transformers at zone substations.

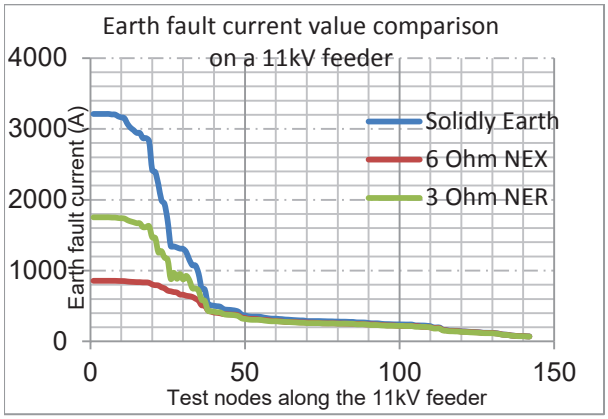

Figure 1 – Earth Fault Current Value Comparison

Comparison between earthing systems and earth fault current with fault resistance was further analysed.

4. Key Outcomes

Rapid Earth Fault Current Limiters as an alternate form of earthing and Voltage Supervised Sensitive Earth Fault protection have been identified as part of this research study which can be utilised in Energy Queensland's distribution power network to enhance earth fault detection capabilities.

5. Further Work

Work closely with protection relay manufacturers to develop relay algorithms with improved low value earth fault detection capabilities which can further assist distribution power utilities.

6. Conclusions

This research project led to the identification of alternate earthing systems and improved earth fault detection capabilities in protective devices. It also enhanced my knowledge and understanding of concept.

Acknowledgements

I would like to acknowledge my work colleagues and Energy Queensland for providing the support in completion of this project. Enormously thank Dr Andrew Hewitt and Mr Matthew Quinton from USQ as my supervisors and providing me valuable guidance.

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Capacitive Voltage Transformer Monitoring and Failure Mode Analysis

Sponsor – School of Mechanical and Electrical Engineering

Morgan Viero

Bachelor of Engineering Honours (Power)

Supervisors: Mr Gordon Hampson, USQ

Mr Simon Hickey, Ergon Energy

Keywords: Capacitive Voltage Transformer (CVT , Capacitive Voltage Divider (CVD), CVT monitoring.

1. Introduction

Capacitive Voltage Transformers CVT s) are used in the power distribution and transmission industry as instrumentation transformers for accurate measuring of the system operating voltages. Failures of CVTs have become a common hazard in the power transmission and distribution industry. Reliability issues with these instrument transformers have had a detrimental effect on network performance and reliability.

2. Background

Explosive failures of CVTs have an impact on the safety of personnel and the public and can also cause damage to neighbouring substation yard equipment. Extended outages for emergency rectifications and network switching are costly and can negatively influence public perception through high numbers of customer outages and decreased network reliability. Capacitive voltage transformer monitoring is common place within the industry. There are many forms of monitoring with significant differences in degradation detection methods and accuracy. A push in safety in design has made the issue of capacitive voltage transformer monitoring a significant topic in deciding what adequate monitoring is for Energy Queensland.

3. Methodology

Previous failures of CVTs have been analysed using their recorded secondary signal output and investigations carried out on the failed units. A model was developed with Simulink software to simulate the symptoms of a failing CVT which was verified against the real failure events, shown in Figure 1. Testing of CVT monitoring equipment currently in use in the Energy Queensland network will be carried out using the developed failure signals to determine the accuracy and limitations of each method.

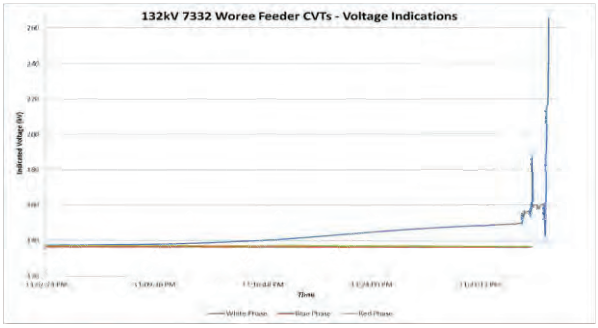

Figure 1 – Secondary signal of failing CVT

4. Key Outcomes

A simulation model has been created that mimics the secondary output of a CVT with failed capacitive elements within the capacitive voltage divider. This model was diven by analysing prevous failures and failure modes. Each method of CVT monitoring was researched in detail without bias to be able to make an assessment of what method should be used going forward.

5. Further Work

Laboratory testing has yet to be carried out due to high workloads of the required personnel. This will form a major part of the evaluation of each form of monitoring.

6. Conclusions

While considerable learnings have been gained into CVT failure modes and on-line monitoring it is hard to drive change in an industry where the consequences of failure are extreme. Trials and further testing of alternative equipment will need to be carried out.

Acknowledgements

Dr Andrew Hewitt and Mr Gordon Hampson have helped in the development of my research, I am very thankful. A special thankyou to my wife and two little girls for their sacrifices, patience and support.

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Home based Solar and Battery Optimization

Sponsor – School of Mechanical and Electrical Engineering

Peter Becker

Bachelor of Engineering Power (Honours)

Supervisors: Professor Paul Wen, USQ

Keywords: Solar, Battery, Electrical Storage

1. Introduction

With the introduction of government grants and rebates roof top solar generation in the domestic market has grown from 8000 in 2017 to 2.6 million in 2013 (Flannery Sahajwalla, 2013). This increases in solar generation has seen a greater difference in peak and off-peak demand making it hard to manage the overall energy market.Batteries are seen has one way of solving this problem. Storing the excess energy generated by a household for use at a later time.

2. Background

Every household is different so it is not possible to come up with one solution that will work for every house. There are many things that can affect the energy usage and generation of a home; Location, house size, type of household, age of the building and many others Australian Bureau of Statistics, 2013 . Figure 1 shows the energy generation from a 1kW solar system per day based on its location with in Australia. Using data like this a tool could be developed of households to use to help them decide on the optimum system for their location and needs

3. Methodology

Using Homer Pro software I will be able to simulate different types of installation in different location right across Australia. This data will then be used in Matlab to generate equation like what is shown in figure 1. These equation could then be used in a Spread sheet program. The spread sheet I develop could then be used as a tool for households to decide on the optimum system for them. By just entry some simple information like location and energy usage a suggestion for the best solar and battery system could be suggested

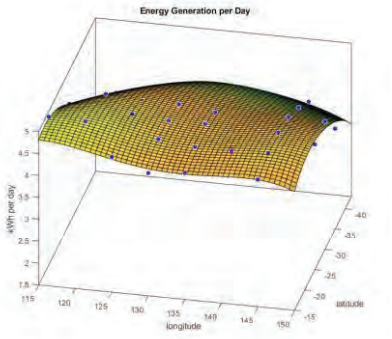

Figure 1 – Energy Generation per Day

4. Key Outcomes

With so many factors effecting energy usage and solar and battery efficiency. This tool should help to simplify the market for consumers. With consumers more confident in their choose we could see and up take in battery storage at the domestic level that could help to low the difference between peak and off- peak usage creating a more easier energy market to manage.

5. Further Work

Scaling up this work from 1 household to a small community of 10 or more house in a micro-grid to see how solar and battery storage on individual houses could work together with others to stabilize the network would be a step toward a smart grid. A smart grid where all parts are able to communicate and work together.

6. Conclusions

The developed tool will be very helpful in encouraging consumers to take up energy storage. Showing them the benefits both environmentally and financially.

Acknowledgements

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The viability of small scale wind turbines for domestic applications in South East Queensland

Sponsor - School of Mechanical and Electrical Engineering

Darryl Regan

Bachelor of Power Engineering (Honours)

Supervisor: Dr Les Bowtell, USQ

Exploring Wind Power

1. Introduction

Australia lags other developing nations in wind power generation. To date, wind power has been the domain of large scale energy producers. Smaller scale wind turbines are significantly under represented. The aim of this research is to theoretically establish if small scale wind turbines (SSWTs) can be a viable renewable energy source for domestic applications.

2. Background

Power prices in Queensland have risen over 136% in 10 years. Roof top solar has been one answer to reducing energy costs, however wind power could provide another option. Wind power for domestic use is largely unexplored and further research may unlock its full potential.

3. Methodology

Five SSWTs were selected to operate on three SE QLD locations, a coastal, city and rural site. Wind data was sourced from the Bureau of Meteorology for each site and logged into a *MATLAB* program. Using the power curves for each SSWT, power outputs are calculated. This data is compared to a photovoltaic system for power generation, savings in electricity and installation costs. A pay-back period for each turbine is then calculated and feasibility established.

4. Key Outcomes

Outstanding power generation was recorded in February and April when Ex Tropical Cyclone Oma and Trevor effected SE Queensland. On the coast, two wind turbines out performed the solar system by more than 80%. The results can be seen clearly in Figure 1. However, the same results were not recipricated further inland.

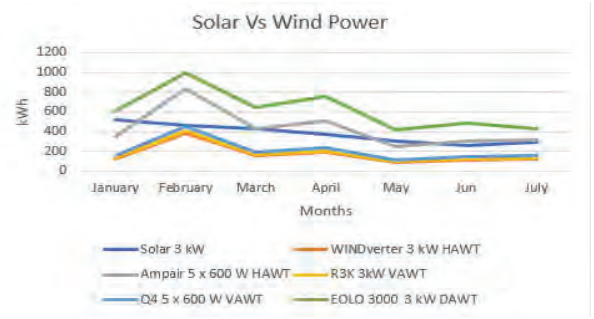

Figure 1 – Solar Versus Wind Power (Sunshine Coast)

Overall, only the coast showed that generating power by wind can eclipse solar. An electricity saving of $1,915 was achieved resulting in a payback period of 5 years. For the city and rural sites the winds were not consistent enough to produce a reliable source of power. Savings were low and payback well outside the life of the system. Another finding found a combination of smaller wattage wind turbines, in some cases, performed better than a single high wattage turbine. A disadvantage was the additional cost of purchasing more than one turbine.

5. Further Work

On paper, one turbine substantially outperformed the other systems. Generally, turbines do not perform to the rated power curves when under operational conditions. The next phase would be to install this turbine on a coastal site and perform real time testing.

6. Conclusions

Results showed that some wind turbines can match a solar system in power generation. When comparing costs, with one exception, the wind turbines had significantly higher purchasing costs resulting in a payback period, that is considered, unacceptable.

Acknowledgements

The Bureau of Meteorology has been instrumental in this project. Without the wind data this research project could not have been extended to all three sites.

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The Development of Hydraulic Fracturing Equipment to Enhance Mining Process Safety

Sponsor – Silverline Hydraulix and Zoom Hydraulics Pty Ltd

Orlando Deeth

Bachelor of Engineering (Honours) (Mechanical Engineering)

Supervisors: Dr Ali Mirzaghorbanali, USQ

Mr Brad Deeth, Silverline Hydraulix pty ltd

Keywords: Mining methods, hydraulic fracturing, equipment development, numerical simulations

1. Introduction

Machines increasingly pervade the mining industry, raising production and reducing manual labour. Hydraulic fracturing or hydro-fracking (HF) is a process of extending fractures in a rock by injecting a liquid under high pressure to a predrill of a borehole. The high-pressure liquid will form tensile stress, which causes a fracture towards the rock. As the pressure increases, the fracture extends further into the rock.

2. Background

Hydraulic fracturing will enhance the mining process and safety level in the mining industry. The device will be utilised both in mining and building sites. It is the most efficient way to break downs the rock rather than using detonator or any blasting devices, which can be dangerous and may require strict rules and regulations. This project evolves around the understanding of system design, and numerical simulations. Finite Element Analysis, (FLAC Fast Lagrangian Analysis of Continua) is incorporated to simulate HF in the two and three-dimensional framework.

3. Methodology

Initially, several trial designs were carried out. The final model was then developed, as shown in Figure 1. Safety factors and various standards were considered during the designing phase of the project. The final design was severely scrutinised by technical staff at the University of Southern Queensland (USQ) and Silverline Hydraulix pty ltd. Once the final handmade design was approved, the three-dimensional model was created using CREO. The final design was given to the USQ workshop for production.

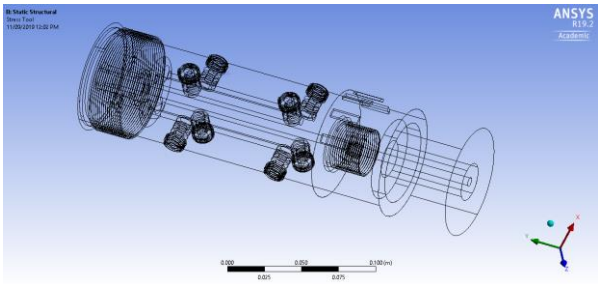

Figure 1 – Final Hydro-Fracking system design (ANSYS)

Concrete samples with 20 MPa of Uniaxial Compressive Strength will be cast to represent low strength rock mass. PVC conduit will be positioned inside the mould during casting to create a hole for HF. The equipment then will be placed inside the hole and will be used to generate fractures within the concrete samples.

FLAC which is a finite difference software, will be incorporated to simulate numerically HF process within the rock mass. For this purpose, rock mass will be simulated using Mohr constitutive model. A hole will be nulled within the rock mass where hydraulic pressure will be applied increasingly to generate tensile failure. Various rock mass strengths and confinement conditions are investigated as part of this study.

4. Key Outcomes

This study will pave the way for in-depth analysis of HF for various geotechnical conditions. The outcome of the experiment will prove the capability of the equipment in fracturing the rock mass using hydraulic pressure.

5. Further Work

Experimental work will carry out once the USQ workshop produces the equipment. Numerical simulation is ongoing using FLAC and ANSYS in the two and three-dimensional framework.

6. Conclusions

It will be concluded that the designed equipment can generate and extend fractures within the rock mass. Hydraulic pressure at the failure is a function of rock strength and confinement stresses.

Acknowledgements

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