FINAL YEAR PROJECTS 2012

1. Attached is a list of projects that are being offered by staff members in the School, the Centre for Offshore Foundation Systems (COFS) and the Australian Centre for Geomechanics (ACG). Students may propose other topics (for example with an external company or government agency), in consultation with any staff member. By the end of the third week of 1st Semester (by the end of the third week of 2nd Semester if a Mid Year enrolment) it is essential that each student shall have agreed on a topic with a supervisor and have submitted the title to the Head of School.

2. Each Project unit will have a 12 point weighting out of about 48 points for the year. Since this is a unit equivalent to a quarter of the total year’s work, each student is expected to devote at least the equivalent amount of time to the project throughout the whole year. You cannot expect to get a high grade in your Project unless you put the appropriate effort (and time commitment) into this unit.

3. Each project will be broad enough to be completed at a high enough level that can justify the award of Honours. Project reports (theses) will be graded on a continuous scale. At the end of the year, the performance in the Project, combined with the performance in the coursework component over the four years of the degree will be used to assign results on a continuous scale, from 1st Class Honours, through 2A and 2B Honours, to Pass. Students should refer to the Final Year Handbook for details.

4. Students are encouraged to choose projects that are consistent with their goals for employment and the general thrust of their choice of other options in final year. The Head of School, or other supervisors, should be consulted about the wisdom of the choice being made, particularly with regard to appropriateness of the choice in relation to the other final year options chosen.

5. At the start of 1st semester, a Project Booklet, giving details of various aspects of the projects, will be distributed. Briefly, the assessable components of the project are:
   - a progress report, submitted during 1st semester;
   - a short summary paper submitted prior to the “Final Year Project Symposium”, held in 2nd semester;
   - an oral presentation of your project made at the above Symposium in front of fellow students, staff, and industry representatives; and
   - the final Project Report (Thesis), submitted at the end of 2nd semester.

Liang Cheng
Head of School
List of Supervisors

(Updated 5 December 2011)

Daniela Ciancio ................................................. 1
Scott Draper .................................................... 3
Richard Durham ............................................... 4
Andy Fourie ..................................................... 5
Hong Hao ......................................................... 13
Greg Ivey ......................................................... 16
Barry Lehane .................................................... 17
Guowei Ma ......................................................... 18
Chari Pattiaratchi (SESE and UWA Oceans Institute) 20
Tongming Zhou .................................................. 23
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Note for the students interested in these projects: please note that Assist. Prof. Ciancio will be away on sabbatical from July to December 2012. During this period the supervision of the thesis might be carried out by the co-supervisor of the project, depending on his availability. There will be limited supervision from Dr Ciancio during her sabbatical period.

1. Effect of soil grading and compaction on the strength of unstabilised and cement-stabilised rammed earth (Suitable for Bachelor only)

It is quite understood that the particle size distribution of a rammed earth mix plays a very crucial role in the mechanical characteristics (compressive strength, erosion rate, shrinkage, etc…) of the material. However, the current rammed earth research available in literature lacks of a deep and comprehensive understanding of how the grading truly influences the behaviour of this construction material.

This thesis aims to use the exhaustive literature on soil grading and soil compaction for road bases to understand if the same principles apply for rammed earth mixes.

The literature review represents a very important part of this research project. The student will be asked to undertake an analysis of the collected data and elaborate a theory that can prove how compaction and grading affect the strength of unstabilised and cement-stabilised rammed earth. The theory will be validated by an experimental program carried out in the UWA structure laboratory.

Supervisor: Assistant Professor Daniela Ciancio (UWA)
Co-supervisor: Dr. Chris Beckett (UWA)

2. Use of recycled concrete aggregate in rammed earth mixes (Suitable for Bachelor only)

The importance of sustainability is on the rise within the construction industry and because of this, there is an increased consideration of the recycling of construction and demolition waste. In Australia, the major proportion of construction and demolition waste is concrete. Thus, from a sustainability perspective, there is great benefit in incorporating recycled concrete aggregates (RCA) into traditional rammed earth. Even though the use of RCA has been widely investigated so far, the research carried out on the application of RCA in rammed earth mixes is very scarce. Some valuable results have been recently obtained at UWA. This thesis aims to examine the effect of varying the replacement percentage of RCA on the compressive strength, absorption capacity, erosion rate and shrinkage of rammed earth samples. The overall target is to improve knowledge of rammed earth structures that incorporate RCA, furthering the development of future construction guidelines and standards.

Supervisor: Assistant Professor Daniela Ciancio (UWA)
Co-supervisor: Mr. Stephen Dobson, Ramtec Pty Ltd
3. **Use of rammed earth in Indigenous remote communities of WA (Suitable for Bachelor only)**

This thesis is proposed as part of the ARC Linkage project on the use of rammed earth as sustainable and affordable construction technique in remote areas. The student will collaborate with Dr. Chris Beckett to carry out an experimental investigation to characterize the suitability of soil available in Fitzroy Crossing (Kimberley’s). He will also investigate the possibility of using rammed earth in floor systems. The student involved in this project should be available to fly to remote areas of WA.

Supervisor: Assistant Professor Daniela Ciancio (UWA)
Co-supervisor: Dr. Chris Beckett (UWA)

4. **Investigation of the accuracy of a new non-destructive testing technique to estimate the stiffness of early-aged concrete (Suitable for Bachelor only)**

A new non-destructive device has been recently developed consisting of an embedded disposable piezoelectric transducer that generates compressive waves into the freshly poured concrete and a control box able to read the velocity of these waves. The measured velocities can be used to estimate the stiffness of concrete using well-established physical principal. This thesis aims to validate the accuracy of this new device by comparing the obtained results with stiffness data obtained through a separate experimental program.

Supervisor: Assistant Professor Daniela Ciancio (UWA)
Co-supervisor: Dr. Alex Gibson
1. Development of an Efficient Sand Slide Model for Numerical Simulations of Morphodynamics and Scour

Two and three dimensional numerical models of sediment transport phenomena, such as scour close to subsea structures, typically (i) solve the Navier Stokes equations to determine the velocity field within the fluid, (ii) estimate the shear forces on the seabed, based on the velocity field in the fluid, (iii) calculate the resulting sediment transport based on the shear forces, and (iv) ultimately adjust the seabed according to the transport of sand along the seabed. Although this methodology is often reliable in practice, in some cases the movement of the seabed in step (iv) leads to the formation of undulations or ripples that do not satisfy the angle of repose of the sediment. Consequently adjustment is needed, which must mimic sand sliding, to ensure a physically admissible seabed. The aim of this project is to formulate an algorithm for sand slide which can correctly redistribute sand when the angle of repose is exceeded along the seabed. The algorithm will aim to improve on (i) existing methods which do not conserve sediment and (ii) existing methods that are slow to calculate. The algorithm can be validated by undertaking experiments on sand in a flume.

2. Experimental Investigation of Morphodynamics of Narrow Subsea Trenches

The use of on-bottom subsea pipelines is common for the transportation of oil and gas from offshore facilities to the coast. To stabilize these pipelines from hydrodynamic loading in shallow water it is common to lay them in a dredged man-made trench which may backfill naturally over time to bury the pipeline. However, for this form of trenching to be successful in practice there is a need (i) to ensure that a dredged trench will not backfill too quickly and fill between the time of dredging and pipeline installation (which can be of the order of months) and (ii) to predict the depth of backfill after placement of the pipe to ensure the pipe is covered. With these needs in mind, this project will aim to conduct a series of sediment transport experiments of trench backfill using the mini O-Tube at UWA (the O-Tube is a closed circuit pipe, connected to a see-through working section containing sand, which is capable of driving steady and oscillating flow). Detailed measurements of both the spatial and temporal variation in trench backfill will be made for trenches of varying geometry subjected to steady currents, waves and combined currents and waves.
1. Energy impact of ore passes

It is common in underground mines to have ore passes where the rock is dumped into the top and drawn from the bottom. Invariably it then has to be hauled (truck or shaft) up past the level at which it was dumped into the ore pass. In other words, we are deliberately dropping the rock, only to spend money hauling it back up. An economic and energy balance of this might indicate whether this is the best methodology.
1. Developing design charts for Tailings Storage Facilities (TSFs) in Australia

Techniques for construction of TSFs in Australia require that enough time be allowed between deposition cycles for the tailings to gain strength, both through drainage and through evaporation of water. A numerical modelling code, called MinTaCo (Mine Tailings Consolidation) was developed at UWA about a decade ago. This project will use MinTaCo to prepare design charts for a range of different types of mine tailings, as well as for a range of climatic conditions. Using various combinations of the governing factors (such as evaporation and rainfall rates for climate, and consolidation and strength gain factors for the tailings itself), charts will be produced that allow designers to optimise the land available for tailings management. The results of the study will be compared with data available from a number of Australian mine sites.

2. Including the influence of evaporation in 2D consolidation codes of Tailings Storage Facilities

Consultant-level consolidation analyses of Tailings Storage Facilities, which are frequently coupled to stability analyses, almost never include the potential influence of evaporation. This assumption may be valid for facilities with high rates of rise, or those in high rainfall environments. However, in the context of Western Australian facilities where evaporation can often be the primary driver for consolidation, this assumption is excessively conservative. The influence of evaporation in consolidation problems has been explored in a 1D context in research settings, notably the MinTaCo code at UWA. The MinTaCo code has provided useful information and capabilities in this regard. However, it operates on a text input system, and is limited to one dimensional consolidation. Therefore its use in consulting practice is limited. This project will develop 1D consolidation columns in the Finite Difference Code FLAC, with and without the influence of evaporation. The models will be benchmarked to MinTaCo, and to consolidation theory. Inputs to evaporation potential will include air drying tests conducted by the student. Models will be prepared in FLAC using both conventional flow logic, and the more advanced Two Phase flow logic. The reduced evaporative potential of a dry tailings surface, with increasing salt content, will be modelled through the use of FISH codes developed by the student.

3. Achieving optimal backfilling of mining voids using blended waste streams

In the mineral sands industry, mined-out pits are usually backfilled with tailings, which consists of two distinct materials; an ultrafine clay material, and a fine to medium sand. If not correctly blended and placed, these materials segregate, resulting in poor shear strength and consolidation characteristics of the backfill. If properly blended and placed, a homogeneous backfill results, which can be relatively easily placed into the void. Attention is now focussing on the final settlement of the backfill, so that the desired landform shape can be ensured for the use of final landowners (e.g. farmers). This project will investigate the effect of the relative proportions of the two materials (the ultrafine clay and the sand) on the consolidation
behaviour of the blended mix. In particular it will identify the void ratio at which the compression behaviour changes from being dominated by the properties of the clay to one which is dominated by the sand particles – the transition void ratio. Numerical modelling to interpret the laboratory data will also be required.

4. Penetrometer testing to determine liquefaction potential of silts and sands

Recent research in Chile has shown that a new type of penetrometer, developed in France, can be used to estimate the likely liquefaction potential of in-situ silts and sands. This new device, called a PANDA penetrometer has been extensively proven for use in Chilean copper tailings dams. This project will develop correlations between the penetrometer results and a range of silts, sands, and silty sands found in the Perth area. Laboratory testing chambers will be built and filled with material at known densities. The PANDA will be used to obtain corresponding profiles of penetrometer resistance and the results compared. The influence of factors such as moisture content will be evaluated, for particular densities. If possible, the PANDA will be compared with other penetrometer techniques at field sites around Perth.

5. Implementation of the Cap-Yield Model in FLAC, with benchmarking to the Soil Hardening Model of Plaxis

The Cap Yield model is an advanced constitutive model developed for FLAC v6.0. It provides vastly improved modelling of soil behaviour to more conventional elastic-plastic codes such as Mohr Coloumb. It equals, and possibly surpasses, the capabilities of the Plaxis Soil Hardening Model, which could be considered the leading state of practice model for consulting-level analyses. The capabilities of the Cap Yield model have not fully been explored in research or consulting owing to its relatively recent debut. Only a small number of published papers exist on the use of this model. The project will investigate the potential of this model, largely through the simulation of triaxial tests. A number of difficult-to-model behaviours will be attempted, including static liquefaction, quasi-steady state behaviour, and possibly the differing undrained shear behaviour in triaxial compression, extension, and simple shear (through implementation of FISH codes). The capabilities of the Cap Yield model to produce these behaviours will be compared to the Soil Hardening Model. Dependent on progress with the above, attempts to reproduce a static liquefaction failure of an upstream Tailings Storage Facility from the literature may be made.

6. Dynamic modelling of earthquake-induced liquefaction

In the past 20-30 years, constitutive modelling of earthquake-induced liquefaction has greatly improved our understanding of this behaviour. It has allowed simulation and reasonable reproduction of prominent liquefaction case histories. This project will involve a literature review of the currently available liquefaction constitutive models, including the Byrne/Finn and UBCSand models. The student will then utilise the Finite Difference Code FLAC to reproduce cyclic triaxial and cyclic simple shear tests from the literature using these different constitutive models. Depending on the progress with the above, modelling of an existing Western Australian Tailings Storage Facility under a simulated earthquake event may be conducted.
7. Estimating the horizontal to vertical permeability ratios of tailings and compacted fill

It is well established that both deposited tailings, and layers of compacted fill, exhibit much higher permeability in the horizontal direction than the vertical direction. The magnitude of this difference can drastically alter the performance of a tailings or water dam. A number of methods to determine these values are available once the structure has been created. However, there are few ways to estimate these prior to construction/deposition other than engineering judgement and experience. The project will involve attempting to recreate the mechanisms that cause these effects on a laboratory scale. This may include deposition of tailings in layers within a Rowe Cell, with variable quantities of air drying allowed between layers. Deposition into a larger vessel in layers and sampling via tubes may also be attempted. Similar efforts will be made via compaction of layers of clayey fill material. Simple seepage models will likely be developed, to explore the effects of high permeability horizontal seams on the overall horizontal and vertical permeabilities.

8. The influence of deposition method on the resulting normal consolidation behaviour of mine tailings

A number of researchers have published findings that the normal consolidation lines of tailings can vary, depending on the method of deposition, extent of air-drying prior to subsequent fill placement, and other effects. This can have important impacts on the design of Tailings Storage Facilities, particularly in relation to liquefaction assessments. This project will investigate the maximum extent of the differences in the Normal Consolidation Line that can be induced through changes to the deposition method used. Methods to explore this may include: deposition into the Rowe Cell at different slurry densities, allowing air drying in the Rowe Cell prior to commencement of consolidation, or similar methods utilised on a larger scale and sampled through the use of tubes.

9. Effect of load increment size in consolidation tests using the Rowe cell

Testing of soft clays, mine tailings, and other slurries is increasingly being done using the Rowe consolidation cell. As these types of materials consolidate, the coefficient of permeability decreases very rapidly, and there is the potential for this effect to create a very low-permeability zone of material adjacent to the drainage face in the Rowe cell, which would severely affect the test results. This project will carry out a range of tests in one of our Rowe cells, in which different size load increments are used to investigate this effect. The laboratory testing will be complemented by numerical modelling using the code PLAXIS, as well as the mine tailings software MinTaCo.

10. Predicting the ideal state of drying of high density paste and thickened tailings

The occurrence of regular and catastrophic failures of Tailings Storage Facilities, coupled with the increasing need to conserve water, has led to the development in recent years of the use of highly-thickened tailings, in which much more water is removed from the tailings than has previously been the case. However, the recent adoption of this technology means that design guidelines are still being developed, and owners and operators need more guidance on how to manage these facilities to ensure safe and economical conditions are achieved.
This project will investigate the required state of drying of a thickened tailings material, prior to deposition of subsequent layers of tailings. The relevance of the currently-used Shrinkage Limit will be evaluated, and the relation between this state of drying and the undrained shear strength will be determined. Changes in the Shrinkage Limit as a consequence of the addition of flocculants will also be evaluated, as these chemicals (flocculants) are key to achieving the required densities in thickened tailings.

11. How the mineralogy of the fines component of a silty sand affects its liquefaction potential

Recent research has shown that the liquefaction of sands (such as occurred in the recent Christchurch earthquake) is highly dependent on the particle size distribution of any silty material present in the sands. Depending on this parameter, the liquefaction susceptibility of sands could be either decreased or increased. Following on from this work, this project will investigate the effect of the mineralogy of the fines content on liquefaction susceptibility of sands. Various materials, such as quartz, kaolin and mica will be added to a standard, medium-sized sand from a Perth site, to produce soils having exactly the same particle size distribution, but with different mineralogies of the fine component. Tests will then be carried out on these materials, including consolidation tests and triaxial tests to determine the Critical State Line and ultimately determine the liquefaction potential.

12. Modelling the impact of Tailings Storage Facility (TSF) failures on downstream communities

Catastrophic failures of TSFs occur regularly, with the most recent being a failure in China in July 2011 that resulted in multiple fatalities. Current legislation in Australia requires that a DamBreak analysis be carried out to ensure the potential impact of the failure of all new TSFs are quantified. However, the tools currently available for carrying out these DamBreak studies are extremely crude and not considered to be sufficiently accurate. This project will investigate the potential use of the software MIKE21, developed by the Danish Hydraulic Institute, to model the DamBreak of a TSF. The available database of TSF failures around the world will be used to establish input for MIKE21, such as typical volumes of material involved in a flow-failure, the rheological parameters of the flowing material, and the extent of downstream impact. Ultimately, this project will lead to better quantification of the risks posed to downstream communities.

13. Use of Time Domain Reflectometry (TDR) techniques to monitor the rate of drying of cemented paste backfill (CPB)

CPB is increasingly being used for backfilling of Australian mines, providing an economical technique for improving the stability of mined stopes and minimising dilution of ore during subsequent drilling and blasting activities. The stability of exposed faces of CPB depends to a large extent on the moisture content in the paste, with a decreasing moisture content resulting in an increased shear strength. Using both laboratory tests and numerical modelling, this project will investigate whether the potential decrease of water content in a CPB stope, which may occur as a consequence of the movement of a ‘drying front’ can be relied upon. Time Domain Reflectometry (TDR) instruments will be used to measure the rate of advance of drying fronts in laboratory experiments using simple columns. The project will require that
techniques for accurately calibrating TDRs for used in CPB is ensured, as this is a completely new application of this technique.

14. **Measuring the volume change of a cementing paste backfill (CPB) during the hydration process, and the effect of type of binder**

During the hydration of CPB, previous results have shown a tendency for the material to decrease in volume, largely as a consequence of the process known in concrete technology as ‘self-desiccation’. An experimental apparatus has been developed at UWA for quantifying the magnitude of these volume changes, which are crucial in the understanding of CPB behaviour in the field. This project requires a range of tests be carried out using this equipment, including standard tests to compare with previously published results. Further testing will include a range of binder types (such as Ordinary Portland Cement, flyash, and slag material), as there is some indication from field studies that some binders may have a negative effect on CPB behaviour, for example by exhibiting a volume increase, an effect that will be easily apparent in the tests to be carried out.

15. **Measurement of unsaturated soils properties from soil water characteristics curves (together with Newmont Australia)**

The relationship between unsaturated soil moisture content variations and associated hydraulic/mechanical properties is more complex than saturated soils. A constitutive relationship that exists between the soil moisture content or degree of saturation under various suction pressures is called the Soil Water Characteristic Curve (SWCC). This relationship between phases is hysteretic and takes on different forms to influence its engineering properties. For example, under a given matric suction, the soil moisture content is different, depending on whether it is on the drying or wetting path. Understanding of SWCC is critical for assessing design performance of geotechnical structures such as pavement subgrade and other geo-environmental structures such as cover/capping and liner systems for waste containment facilities under service conditions. This project seeks to examine SWCC for three commonly occurring soils such Sandy, Clayey and Gravelly materials through actual measurements of SWCC curves at various compaction efforts and initial moisture conditions. The project will require laboratory tests.

16. **A review of engineering behaviour of unsaturated soils (together with Newmont Australia)**

The geotechnical engineering properties of saturated soils are very well understood compared to those of unsaturated soils. Design performances of geotechnical structures such pavement subgrade, engineered soil liners and cover/capping systems for waste containment facilities require the understanding of unsaturated soil properties and their behaviour service conditions. The constitutive relationship between the unsaturated soil moisture content or degree of saturation under various matric suctions is expressed as Soil Water Characteristic Curve (SWCC). In this project, the student will conduct an extensive literature review to document the various factors influencing the SWCC, and how these effects relate to typical real-life performance of geotechnical structures, in terms of the latters hydraulic and mechanical behaviour compared to saturated soils under similar service conditions.
17. **Assessment of flow liquefaction of Cemented Paste Backfill (consolidated undrained triaxial testing); Co-supervisor: Dr Matt Helinski, Backfill Specialists**

When paste backfilling underground stopes large rockfalls or seismic events can cause cemented paste backfill to liquefy. Should this destroy containment bulkheads this material could flow throughout the mine. The method typically adopted for managing this involves sectioning off an exclusion zone beyond bulkheads to minimise the consequences of such a failure. However, the size of this exclusion zone can restrict mining activities in the area and minimisation of this area is critical.

Previous evidence shows that when mine tailings are dilatant in nature they are unlikely to flow if liquefied. Furthermore, it has been shown that cement hydration can change the behaviour of a cemented paste backfill from contractive to dilatant. The purpose of this project is to undertake a series of consolidated undrained triaxial tests on cemented paste backfill samples at various ages of cement hydration to determine the stage at which paste changes from contractive to dilative behaviour. In parallel with the triaxial testing unconfined compressive strength (UCS) and shear wave velocity measurements will also be undertaken in an effort to derive simple relationships between these characteristics and flow liquefaction resistance. It is proposed to carry out testing on two different paste fill types (a dense, coarse grained paste and a loose, fine grained paste) to assess if a unified approach can be developed.

18. **Investigation of paste sample preparation methodology; Co-supervisor: Dr Matt Helinski, Backfill Specialists**

At most paste fill sites, quality control specimens are collected on a regular basis, to ensure that the desired strength is achieved. However, the strength of paste is highly dependent on the detail of the sample preparation strategy. One particular aspect that influences the resulting strength is the amount of energy imparted to the sample during preparation, because too little energy can result in leaving large air voids that are formed when casting the sample, but too much energy may remove smaller air voids that have already been imparted into the paste during the mixing phase. Testing will be undertaken to determine how much energy needs to be imparted to a given sample to ensure the appropriate density is achieved. Another factor that influences the rate and ultimate strength gain is curing temperature. It is proposed to carry out curing under a range of different temperatures, which will be based on field measurements, to determine the most suitable curing temperature.

19. **Use of Tensiometers in Paste; Co-supervisor: Dr Matt Helinski, Backfill Specialists**

The strength of cemented paste backfill is highly dependent on its degree of saturation. It is critical that laboratory testing is carried out at the same saturation levels as those in the field. A common method for measuring the degree of saturation of soil in the field is the use of tensiometers. However, manufacturers’ calibrations can be highly variable for different soils. The objective of this project is to investigate the performance of various tensiometers on a laboratory scale and then to implement the most suitable instruments in the field. Laboratory scale testing will involve testing with two different paste fill types to assess if the instruments provide a consistent performance at various binder contents and densities. Field testing would include installation of these instruments at various locations in a mine stope to allow variations in saturation levels to be monitored with time.
20. **Seismic testing of cemented paste backfill; Co-supervisor: Dr Matt Helinski, Backfill Specialists**

Recovery of undisturbed, weakly cemented paste fill samples from the field has proven extremely challenging using conventional drilling methods. Testing of cemented paste backfill at laboratory scale has proven that, for a given paste, a unique relationship exists between the material strength and the shear wave velocity. Therefore, one method for *in situ* testing of paste is to use seismic methods. UWA have developed an *in situ* seismic apparatus to allow the shear wave velocity of a paste fill to be measured, but this is yet to be proven in the field. In conjunction with one of the project sponsors, it is proposed to carry out *in situ* testing to verify the performance of this equipment.

This project will include a “Summer Scholarship” whereby the student with be employed by UWA and the project sponsor on a working roster over the summer vacation period. In addition to day-to-day mining tasks, the role will specifically allocate 50% of the time to UWA paste backfill research onsite.

21. **Influence of pore water suction / desaturation on paste fill strength; Co-supervisor: Dr Matt Helinski, Backfill Specialists**

One of the most costly components of any underground mining operation that utilises cemented paste backfill is the cost of binder. Previous testwork has demonstrated that negative pore water pressure, resulting from desaturation of paste after filling, can create strengths that are comparable to those developed by cement bonding. The use of suction rather than binder to maintain stability could potentially lead to significant binder and therefore cost reductions.

This project aims to investigate the influence of saturation levels on the strength of cemented paste backfill. Specifically, it is proposed to cast a series of cemented paste backfill specimens and carry out testwork under different levels of saturation. Desaturation would be achieved using the UWA pressure plate apparatus. In addition to determining the material strength, the “filter paper” method would also be used to determine the suction in each sample at the time of testing. In addition, shear box testing would be required to determine the friction angle of the material. The measured relationship between strength and saturation will be compared with current theory to determine if the conventional unsaturated soil mechanics approach was appropriate for cemented paste backfill.

22. **Electrokinetic transport and activation of persulfate; Co-supervisor: Mr Tim Robertson, Golder Associates**

Contamination of soils and groundwater by recalcitrant organic compounds presents significant challenges for environmental cleanup, particularly in low permeability strata. Recent breakthroughs have demonstrated the potential for transporting persulfate into difficult to remediate strata using electromigration to enhance *in situ* chemical oxidation. This project will use electrokinetics to both deliver, and activate the persulfate anion *in situ*. The project will utilise experimental apparatus developed for EK testing in 2010 to quantify persulfate transport under pH-controlled conditions. The project will aim to evaluate the potential for EK to activate persulfate in the treatment zone via alkaline and joule heating methodologies.
23. Electrokinetic enhanced oil recovery; Co-supervisor: Mr Tim Robertson, Golder Associates

Enhanced oil recovery (EOR) techniques are being increasingly employed by the oil and gas industry to improve the recoverability of unconventional and/or economically marginal reserves. The use of electrokinetics has emerged as a novel EOR technique, with potentially significant economic benefits for mature Australian oilfields. Project aims are to conduct an extended literature review on EOR, with particular emphasis on electrokinetic mechanisms. The project will then aim to design a set of experimental apparatus for testing electroosmotic enhanced oil recovery by retrofitting a set of laboratory apparatus, with a view to achieving a reduction in residual saturations.

24. Testing the consolidation behaviour of slurries using a new desktop centrifuge

A modified scientific centrifuge is currently under development at UWA to provide accelerated consolidation testing. This device has been utilised on a small number of samples with success. A number of enhancements are still possible, and are planned. This project will involve consolidation testing using the centrifuge to develop new methods to achieve higher effective stresses, perform testing on samples settled from a slurry state, and study effects like creep and elastic unloading. The student will also perform numerical modelling of the results utilising a code under development.
1. **Shaker table tests of scaled bridge model with and without foundation uplift in mitigating earthquake loadings**

Many passive energy dissipation devices and design techniques are available to mitigate seismic loading effects on structures. Recently some researchers studied the possibility of letting foundation to uplift to mitigate earthquake loading effect. This project will perform shaker table tests on two scaled bridge models with or without foundation uplifting to investigate the effectiveness of foundation uplifting on responses of bridge structures. Scaled bridge models with fixed and free piers will be designed, constructed and tested on shaker table. The bridge responses to earthquake ground motion will be recorded and results compared to examine the effectiveness of uplifting piers on reducing the bridge responses.

Two students are needed to work on this project to construct the scaled model and perform the shaker table tests together.

2. **Pounding analysis using simulated ground motions according to Australian earthquake loading code**

Pounding damages between adjacent building structures were observed in all previous major earthquakes. Earthquake design codes, including Australian earthquake loading code, specify a required separation distance between structures to avoid pounding damage. In this project, numerical simulations will be carried out to calculate the required separation distances subjected to simulated ground motion time histories according to Australian earthquake loading code. The results will be compared with the code specifications. This is an extension of a project carried out in 2011. In 2011, only SDOF numerical models were considered. In this extended project, multiple DOF numerical models will be used.

3. **Numerical simulations of torsional responses of asymmetric structures to earthquake ground motions**

In many existing or newly-designed dual lateral resisting buildings, the centers of resistance do not coincide with the centers of mass, resulting in coupled torsional-lateral responses of building structures under seismic ground excitation. This coupling between translational and torsional responses may significantly magnify the displacements and forces induced in certain structural elements, leading to larger displacements and ductility demands. In this study, numerical simulations will be carried out to calculate responses of eccentric multi-storey building structure responses to earthquake ground excitations simulated according to Australian earthquake loading codes. The results will be compared with code specifications. Adequacy of code specifications will be discussed. This is an extension of a project carried out in 2011, in which only single single-storey building structure model was considered. In this new project, multi-storey building models will be used in the calculations.
4. Reliability analysis of RC slabs with or without FRP strengthening to blast loads

Structural reliability analyses are commonly applied to estimation of probabilities of structural damage to static and dynamic loads such as earthquake, wind and wave loads. Although blast loadings acting on structures from accidental explosions or hostile bombings are very difficult to be accurately predicted owing to many uncertain parameters that influence explosion shock wave propagation and shock wave interaction with structures, reliability analyses of structural failure to blast loadings with consideration of uncertainties in blast loading and structural parameters are very limited. Instead, a large safety factor is usually used to account for uncertain variations in blast loading and structural parameters in blast-resistant design and analysis. This may lead to an inaccurate design of structures to resist blast loads, and an inaccurate assessment of structure performance in a given explosion scenario. In this study, reliability analyses of example RC slabs without or with FRP strengthening to randomly varying blast loads are carried out. The slab dimensions, reinforcement ratios and material strengths are assumed to be normally distributed with the respective design parameters as the mean values. The mean value and standard deviation of the peak reflected pressure and duration of the blast load at various scaled distances are derived from available empirical formulae, and are used in this study to model the blast pressure variations. Failure probabilities of the example RC slabs subjected to blast loads of different scaled distances are estimated. Numerical results will be compared with those obtained with the deterministic blast loading or deterministic slab property assumptions. The importance of considering the random variations of structural properties and blast loadings in assessing the blast load effects on RC slab is discussed.

5. Numerical investigation of a new segmented BRB in resisting seismic loads

Brace members are usually applied to frame structures to resist earthquake loads. They enhance structural lateral stiffness and provide significant lateral resistance. Under seismic ground excitation, a brace member experiences both tensile and compressive loading. Under compressive force, buckling of brace members often occurs, which makes the brace members ineffective in resisting seismic loads. Recently intensive researches have been carried out to develop Buckling Restrained Braces (BRB). A number of different designs have been proposed to prevent buckling of a brace member under compressive loading. In this study, numerical analysis will be carried out to investigate the effectiveness of an innovative segmented brace member to prevent buckling and to resist seismic ground motions in frame structures. Nonlinear computer code DRAIN2DX will be used in the study.

6. Numerical study of FRP strengthening of steel structures to resist blast loading

FRP has been commonly used to strengthen reinforced concrete structures to resist seismic, impact and blast loads. Researches on using FRP to strengthen steel structures have also been reported, but most of these studies are limited to the static loading conditions. Studies of using FRP to strengthen steel structures to against blast loading are limited. This project will conduct numerical simulations to study the effectiveness of using FRP to strengthen steel plate to against blast loadings.
7. Laboratory tests of window structure to against impact loads

This project will perform laboratory tests of scaled window structures to impact loads. The window structures with different boundary conditions, different glasses and laminates will be tested. The dynamic responses, failure modes and fragments of windows subjected to different impact loads will be recorded and compared. The capacities of windows with different glasses, laminates and boundary conditions in resisting impact loads will be discussed.

8. Laboratory tests of a multi-arch double-layered panel to against impact loads

An innovative multi-arch double-layered steel panel has been proposed recently. Numerical simulations demonstrated that this new panel outperforms any other panels in resisting blast loadings. This project will fabricate a few such panels and test in the laboratory to impact loads to further demonstrate its capacity.
1. **Convective flushing of the North-West Shelf**  
   *(Supervisors: Greg Ivey and Nicole Jones)*

Buoyancy driven currents on continental shelves provide a mechanism for the exchange of water between, shallow coastal regions, the adjacent shelf, and the deep ocean. In mid-latitudes, freshwater input and surface heating often provide a source of lighter fluid on continental shelves, while surface cooling and evaporation lead to the formation of dense water in shallow coastal regions. The proposed project will quantify the role of buoyancy driven currents in flushing the Australian North-West Shelf. This will be achieved by examining the output of two numerical models: the BLUELink Reanalysis global ocean model and the Regional Ocean Modeling System.

2. **Boundary layer dynamics on the North-West Shelf**  
   *(Supervisors: Greg Ivey, Nicole Jones and Cynthia Bluteau)*

When using numerical models to reproduce hydrodynamics in aquatic environments, one ultimately selects a turbulence closure scheme. Many closure schemes exist, each of them with their assumptions, limitations, and applicability to the physical question at hand. This choice can have significant consequences on mixing and circulation predictions. Furthermore, the dynamics of the bottom boundary layer, which are usually of smaller scale than a model's grid resolution, must be properly parameterized to accurately simulate ocean circulation.

For this project, field measurements taken in the boundary layer will be compared to the output obtained from the numerical model: Regional Ocean Modeling System (ROMS). The model has been run using different closure schemes, and the main objective is to establish if any of them can reproduce the features seen in the field observations.
1. **Develop a spreadsheet tool to take load from a FE model to allow for plate check**

   *(External supervisor: Dr Rod Pinna, Arup)*

Current industry standard design tools for offshore structures are generally focused on space frame structures, such as traditional tubular jackets. There are well-established automated design checking tools for these structures which allow for the efficient checking of multiple load cases. The use of plated stiffened structures is an area of increasing interest in the offshore industry, including recent Arup projects such as the Maari and MCR-A platforms. The design of such plated structures is well established in areas such as ship design. In these areas there are well-established procedures which reduce the number of load cases to a minimum, which together with the use of restrictive design requirements means that the number of load cases is greatly reduced.

As the use of plated structures in offshore substructure design is a relatively new trend such rules, backed by experience, does not exist. This means that it is necessary to return to first principles in the design of such structures. The use of finite element models to calculate stresses throughout the structure is routine. Typically, this results in a large number of load cases to check, with a large number of potential critical locations which may also vary between load cases. In the absence of automated design checks, the designer may either resort to ship design rules, attempt to identify a limited number of critical load cases and locations, or undertake an extensive manual extraction of stresses. The stresses which are then found are used as input into plate design codes.

The aim of this project is to develop an automated stress extraction routine that will extract stresses from a FE model in a form suitable for use in an existing design checking spreadsheet. It is expected that this will require some degree of Excel macro programming. The output from this will need to be validated. To demonstrate the utility of this methodology, it is proposed that the project will also undertake a similar design using typical ship design rules and demonstrate the appropriateness of these rules when compared to results from a “first principles” analysis. In this project the student would be expected to develop skills in finite element analysis and Excel macro programming.
1. Fluid flow in discrete fracture networks (Suitable for undergraduate and postgraduate students)

Fluid flow in discontinuous fractured rock mass is an important issue in underground engineering. The objective of this project is to simulation and find out the outstanding pathways of fluid in fracture networks. A computational model will be carried out by considering the fracture connectivity and conductivity. Different geological models will be used based on statistical data from site survey.

2. GPU technology for large engineering computations (Suitable for postgraduate students)

Graphics Processing Unit technology becomes more and more important in large engineering computations. The present study explores to use the GPU technology for numerical simulation. The student is expected to have good mathematics and programming background.

3. Probability based key block analysis (Suitable for undergraduate and postgraduate students)

Key block analysis is a simple and cost-effective method for stability analysis of blocky rock mass. Due to the uncertainties in rock mass geometry and properties, probability based methods are the only realistic and practical approach that can be used to cover these uncertainties. Based on the developed block generation program and key block program, this project aims to incorporate Monte Carlo simulation into key block analysis and investigate how to apply the results for support design.

4. Key block theory based support design for rock mass (Suitable for undergraduate and postgraduate students)

Key block theory is a convenient method in analyzing rock mass stability. The traditional rock support designs are based on Q-value and RMR methods. This project aims to develop an key block theory based rock support design method which will be more suitable for rock bolting and shotcrete design for blocky rock mass.

5. Feasibility study of compressed air storage in rock cavern (Suitable for undergraduate and postgraduate students)

Compressed air storage in rock cavern provides an alternative option in generating renewable energy. Installation of a concrete plug in underground rock cavern makes it possible to seal the stored compressed air without leakage. The present project conducts a feasibility study in developing compressed air storage in wasted deep mine. Advantaged and challenges of such storage will be discussed.
6. Kinematic model of ore and waste discharge (Suitable for undergraduate and postgraduate students)

In the mine, according to the drawing dilution under overburden, it is important to find the laws of the ore and waste flow, and the ore and waste mixed characteristics. The objective of the present project is to build up a kinematic model to simulate ore and waste discharge. The numerical manifold method will be used. Parametric study of the ore and waste discharge will be carried out.

7. Fragmentation analysis of window glass under blast load (Suitable for undergraduate and postgraduate students)

Glass is a typical brittle material and vulnerable to impact and blast loads. The present project aims to simulate glass failure under blast load. Fragmentation of window glass will be simulated by using LS-DYNA. Parametric analysis of glass failure with respect to stand-off distance, window size and glass properties will be carried out. This project is joined with Prof Hong Hao.

8. Vulnerability mapping of hazards and economic loss assessment of offshore oil and gas platforms subject to accidental explosion and fires (Suitable for undergraduate and postgraduate students)

The aims of this proposal are to assess the impact of explosion and fires on offshore oil and gas fixed platforms; to evaluate explosion induced offshore platform damage by using advanced analytical and numerical modeling; to generate a set of vulnerability maps suitable for typical offshore platforms with equipment layouts, by consideration of explosion occurrence probabilities at different platform parts; and to carry out economic loss assessment in terms of structural engineering, social and environmental aspects.
Supervisor: Professor Chari Pattiaratchi
Chari.pattiaratchi@uwa.edu.au

The following are a selection of projects, if you are interested in undertaking a project in the coastal area and have a particular interest - I am happy to discuss and develop a project which will suit your interests.

1. **Relative importance of extreme water levels and waves on beach stability in SW Australia**

   (Supervisors: Chari Pattiaratchi and Ivan Haigh)

Through different projects we have developed a 40 year hindcast of water levels and wave climate for south-west Australia. Beach erosion data are available from Department of Transport for different years and locations. This project will investigate the relative importance of water levels and waves on beach erosion by combining the 3 different data sets.

2. **Seasonal oceanographic dynamics off southwestern Australia via ocean gliders**

   (Supervisors: Chari Pattiaratchi, Christine Hanson, Mun Woo)

The Australian National Facility for Ocean Gliders (ANFOG), based at UWA, currently operates a fleet of 17 ocean gliders. These autonomous vehicles operate in water depths up to 1000 m, and collect detailed profiles of temperature, salinity, fluorescence, turbidity and dissolved organic matter with depth. A semi-continuous series of transects have been conducted since 2009 along an onshore/offshore gradient north of Perth (Two Rocks) and along the length of the Perth Canyon, and provide an unprecedented level of detailed oceanographic data for these areas. These data will form the basis of the project to examine the seasonal oceanography of the region, and the student will also have the opportunity to participate in upcoming glider deployment and recovery missions off Perth.

3. **Surface current measurements using HF Radar**

   (Supervisors: Chari Pattiaratchi and Florence Kaempf)

As part of the Integrated Marine Observation System (IMOS) several HF radar installations between Lancelin and Fremantle will provide high resolution surface currents at hourly intervals to a distance 200km of the coast. This is a great opportunity for a student to examine the variability in the surface currents adjacent to the WA coast at unprecedented spatial and temporal scales. The radars are already deployed so the data will be available for analysis immediately.

4. **Field measurements of turbulence in estuarine and/or coastal waters**

   (Supervisors: Chari Pattiaratchi and Florence Kaempf)

In this project we will collect high resolution (both space and time) current data using an Acoustic Doppler Current Profiler (ADCP) deployed at several locations (beach, coastal or
estuarine) to examine the relationship between turbulence characteristics and sediment re-suspension.

5. **Tsunami risk for north-west Australia**  
   (Supervisors: Chari Pattiaratchi and Sarath Wijeratne)

In this project we will examine the tsunami behavior along the Kimberley coast (Scott Reef and Dampier Peninsula) using a high resolution numerical model already developed. The availability of high resolution data sets provide a unique opportunity to examine these effects particularly in regions where offshore installations are planned (Browse Basin, James Price Point).

6. **Jurien harbour sea grass study**  
   (Supervisors: Chari Pattiaratchi, Sarath Wijeratne in conjunction with Department of Transport)

Jurien Bay has a siltation problem where there is ingress of sea grass wrack into the harbour which then affects safe navigation. This is somewhat a smaller problem to that experienced in Port Geographe where UWA provided a solution. In this project the student will develop a hydrodynamic model of the region and possible include sediment transport.

7. **Analysis of Extreme conditions on WA beaches**  
   (Supervisors: Chari Pattiaratchi)

There have been many extreme events which have caused wide spread/erosion and flooding along the south-west of WA. These include storms in 1996, 2003 (highest water level recorded), 2004 and 2009 (1:100 year wave event). This project will document these events in detail by analysing all of the available data sets (meteorology, waves, water levels) to understand the circumstances which led to the extreme event.

8. **Forecast model for Bunbury Storm surge barrier**  
   (Supervisors: Chari Pattiaratchi, Sarath Wijeratne in conjunction with Department of Transport)

Department of Transport is responsible for the management of Bunbury Storm surge barrier and the current process for forecasting a surge is based on an empirical estimate method and difficult for the contractors to perform. In this project a numerical model will be developed to forecast the storm surge using meteorological data and compared to available data.

9. **Channel sedimentation rates at Broome**  
   (Supervisors: Chari Pattiaratchi, Sarath Wijeratne in conjunction with Department of Transport)

Department of Transport is designing a boat ramp with a dredge channel to provide access during all tide state. There is a great uncertainty in how to calculate the likely sedimentation rates for the channel. Department of Transport are currently collecting current recordings and these will be incorporated onto to a numerical model.
10. **Climate change risk to Busselton**  
**Supervisors: Chari Pattiaratchi, Sarath Wijeratne**  
in conjunction with Department of Transport

Previous students have undertaken inundation studies of Mandurah and Perth and this will an extension of similar techniques (although for a coastal system) to Busselton to review potential inundation, with an incorporation of future climate change sea level rise scenarios.

11. **Bandy Creek Boat Harbour**  
**Supervisors: Chari Pattiaratchi, Sarath Wijeratne**  
in conjunction with Department of Transport

Review of the configuration of the Bandy Creek Boat Harbour breakwaters with a view to modelling different configurations which decrease the need for regular maintenance dredging of the harbour entrance. This will be undertaken through the development of a numerical model.
1. Suppression of vortex-induced vibration of a pipeline using porous shroud

Vortex shedding is a phenomenon which occurs when a flow passes a bluff body (e.g. a single or a group of tall chimneys, tall buildings, marine risers for oil production, mooring lines, deepwater structures such as the pipelines). It is well known in the offshore community that the cylindrical bluff structures suffer from vortex-induced vibration (VIV) in strong current conditions. The marine risers, for example, also induce the flow around them to separate and initiate vortex shedding. These vortices cause extra dynamic forces and vibration to the risers. VIV should be avoided in engineering applications. This is because: (1) VIV will increase the fluid dynamic loading to the structures, (2) it will also influence the stability of the structures, (3) the vibration of the structures will accelerate the fatigue failure etc. The above factors will influence both the capital investment of the structures and the expenses for maintenance. Therefore, great effort has been devoted to the control of vortex shedding from a bluff body, both using active methods and passive methods.

In the present project, vortex shedding will be suppressed using a porous shroud. The objective of the project is to examine the effectiveness and mechanism of porous shroud on VIV suppression. The experiments will be conducted in the wind tunnel of School of Civil and Resource Engineering of UWA.

2. Wake and force characteristics on an inclined bluff body and its dependence on Reynolds numbers

Vortex shedding is a well known phenomenon that occurs when a flow passes a bluff body. The vortices shed from the bluff body can induce vibration, which, at resonance, will result in excessive motion and possible structural failure. There are extensive studies on vortex shedding from single cylinders in a cross-flow (i.e. the incoming flow is perpendicular to the axis of the structure). In many engineering applications, the structures are not necessarily perpendicular to the incoming flow, and yet the flow structures and vortex shedding characteristics of the inclined cylinder wakes are not studied extensively. In the present project, experiments will be conducted in a wind tunnel to study the wake flows of bluff structure (either a circular cylinder or a square cylinder or a flat plate) at different inclination angles between the cylinder axis and the flow. Dependents of the drag coefficients, vortex shedding frequency and Strouhal number on Reynolds number and inclination angles will be studied and compared with that obtained in wakes of cross-flows. The experiments will be conducted in the wind tunnel of School of Civil and Resource Engineering of UWA.
3. **Measurements of forces on two particles of various arrangements in terms of particle separations and inclination angles**

When particles are put in a moving fluid, forces will be formed on them. The force in the streamwise direction is called drag and in the cross-flow direction is called lift. In the present project, you are required to measure the drag and lift forces on the two particles. The two particles can be arranged at various relative locations in terms of their separation and inclination angles. The experiments will be conducted in the water tunnel of School of Civil and Resource Engineering of UWA.
Below are projects offered by Structerre Consulting Engineers. If you are interested in any of the topics, please contact Mr. Gaetano (Guy) Anza at ganza@structerre.com.au

Please note that you would also need an academic supervisor for your project.

1. Finite element analysis of light steel baseplates (Supervisor: Stefan Tschirren)
2. Vibration effects of plate compactors (Supervisor: Neil Scott)
3. Lateral stability of roof trusses (Supervisor: Greg Higham)
4. Portal frame stiffness (Supervisor: Greg Higham)
5. Tilt-up fire (Supervisor: Greg Higham)
6. Improving Hs values (Supervisor: Mel Castle)
7. The final drying basic shrinkage strain in concrete for Perth (Supervisor: Gaetano (Guy) Anza)
8. Tensile and shear strength of chemical and mechanical anchors in limestone blocks (Supervisor: Gaetano (Guy) Anza)
9. Pier spacing in masonry screen walls (Supervisor: Gaetano (Guy) Anza)
10. Direct tensile strength of unreinforced masonry (Supervisor: Gaetano (Guy) Anza)