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.

2. It is essential that each student shall have agreed on a topic with a supervisor and have submitted the title on a Project Allocation Form to the Head of School by Friday 15 March 2013.

3. 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.

4. 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.

5. 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.

6. 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:

   - 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.

Winthrop Professor Andy Fourie
Head of School
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<th>Name</th>
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<td>Cristina Vulpe</td>
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<td>Tongming Zhou</td>
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1. **Numerical simulations about a circular cylinder subject to ramping-up currents.**

In this study the force components and vortex shedding frequency of a pipe exposed to a ramping-up flow will be investigated numerically in terms of the drag coefficient, lift coefficient and Strouhal number. The effects of these mentioned parameters, particularly their influence on vortex shedding conditions will be studied.

2. **Local scour around submerged caisson type of structures.**

This project aims to determine the maximum equilibrium scour depth and the location of the maximum scour depth for caisson dimensions. The tests will determine how the scour is influence by the combination of scour and waves, it will also investigate how the caisson dimensions and flow attack angle influence the scour profile. The tests will be conducted in the Large O-tube Facility.

3. **Local scour around a truncated pile group.**

This project aims to determine the maximum equilibrium scour depth and the location of the maximum scour depth for various pile arrangements. The tests will determine how the scour is influence by the combination of scour and waves, it will also investigate how the gap to pile diameter ratio influences the scour for a single configuration of the waves to current ratio. The tests will be conducted in the Large O-tube Facility.

4. **Experimental investigation about pressure distribution in a horseshoe vortex around a cylinder-wall junction.**

A horseshoe vortex exists at a cylinder-plane junction due to the boundary layer induced pressure gradient on the cylinder surface. In this project, pressure sensors will be installed on the cylinder surface to measure pressure distribution in the horseshoe vortex. The pressure information will be used to calculated force on the cylinder. The testing results will improve the understanding about horseshoe vortex and its effect on aerodynamic force. The tests will be conducted in the wind tunnel.
1. **Influence of spatially varying ground motions on the seismic responses of buried pipelines**

Pipelines are important lifeline structures but are vulnerable to earthquake damages with catastrophic consequences. It has been proven that the current seismic design guides to prevent pipeline systems from damage might not be adequate because they neglect the influence of inevitable earthquake ground motion spatial variations. This project tends to study the seismic responses of pipeline systems under spatially varying ground motions.

2. **Parametric study of earthquake induced pounding damage to bridge structures.**

Earthquake induced pounding damage to bridge structures were observed in many previous major earthquakes. The recent developed 3D finite element model based on LS-DYNA enables a realistic simulation of pounding damage to bridge structures. This project tends to carry out parametric study on the seismic induced pounding damage to bridge structures. Many parameters such as the influence of pounding effect, PGA of incident waves, aspect ratios of bridge columns and reinforcement configurations will be studied.

3. **Influence of side stopers on the seismic induced pounding damage to bridge structures**

Earthquake induced pounding damage to bridge structures were observed in many previous major earthquakes. The recent developed 3D finite element model based on LS-DYNA enables a realistic simulation of pounding damage to bridge structures. The side stopers are usually designed to prevent the dislocation damage of bridge structures. None of previous studies investigates the influence of side stopers on the pounding effect of bridge structures. This project tends to study the influence of side stopers on the seismic induced pounding damage to bridge structures.

4. **Parametric study of seismic responses to a CFST arch bridge**

The concrete filled steel tubular (CFST) arch bridge is becoming more and more popular recently. However, the investigation of seismic response of CSFT arch bridges to earthquake loading is relatively rare. This project tends to carry out numerical simulation on the seismic responses of a CFST arch bridge. Various parameters including geometric nonlinearity, material nonlinearity and influence of dead load will be investigated.
1. Particle breakage of a soil with crushable grains in one-dimensional compression

Geomaterials with relatively weak grains may not be properly modelled using classical constitutive relationships relying upon friction and dilatancy only. Examples of such materials include (but are not limited to) some types of offshore sediments, railway track foundations and weathered mine waste rock used to construct tailings dams. Thus, while it may not be well understood, the phenomenon of particle breakage impacts both offshore and onshore geotechnical analyses and adds a challenging component to otherwise conventional geotechnical designs. In this final year thesis project, the student will conduct exciting research and become knowledgeable on the poorly understood but critical effect of particle breakage on the one dimensional compression response of a crushable geomaterial. The well-known effects of factors such as stress and density on geomaterial behaviour will be systematically assessed using a modern consolidometer apparatus as well as how these factors might impact the (unknown) amount of particle breakage during one-dimensional compression.

Co-Supervisor: Asst Prof. Nathalie Boukpeti

2. Critical-state strength degradation of a crushable geomaterial

Critical-state strength is a classical yet rigorous feature of the mechanical behaviour of geomaterials. The critical-state friction angle ($\phi_c$), perhaps a more practical representative of critical-state strength, is accordingly a widely used parameter required in modern geotechnical analyses. While critical states would theoretically define a unique relationship between density and stress for a given soil, the concept might not be directly applicable to geomaterials undergoing a substantial amount of particle breakage upon shearing. Such materials are relatively common in foundation layers for offshore structures, railways or as the main constituent of embankment tailings dams. In this final year thesis project, the student will carry out exciting research and become knowledgeable on the relatively poorly understood effect of particle breakage on this important design parameter (i.e., $\phi_c$) that is commonly required by consulting geotechnical engineers in both offshore and onshore projects. Due to its convenience in assessing strength characteristics at very large strains, a ring shear apparatus will be employed in this study to systematically characterize the amount of particle breakage induced to a soil with relatively weak grains.

Co-Supervisor: Asst Prof. Nathalie Boukpeti

2. Evaluation of a modified direct shear apparatus

The purpose of this final year project is to establish a baseline comparison between standard and modified direct shear apparatuses. Results obtained using conventional and modified testing procedures will be interpreted to assess differences in shear strength properties and parameters of the soils selected for testing.

Co-Supervisors: Dr. Hackmet Joer and Dr. Mostafa Ismail
1. **Determination of thermal properties of rammed earth (Suitable for Bachelor only)**

Rammed earth (RE) is a construction technique which, although it has been used to create comfortable, durable structures in a wide range of conditions for thousands of years, cannot currently be used for construction in many countries due to its low thermal resistance. This project aims to determine the thermal comfort and the contributions made to it by both thermal resistance (the property currently considered by many green building guidelines as essential for sustainable construction) and thermal mass. This project includes an experimental program in the Structure lab of UWA.

**Co-Supervisor: Dr. Chris Beckett (UWA)**  
**Co-Supervisor: Glen Lawson (Curtin University)**

2. **Durability of cement-stabilised rammed earth (Suitable for Bachelor only)**

In Western Australia, the oldest cement-stabilised rammed earth buildings are 30-year old. Although so far the majority of these structures do not show visible signs of aging and damaging, it is important to predict the life span of the building. Current experimental procedures (like the accelerated erosion test) have proven to not be reliable methods to predict the durability of this material. The student undertaking this project will have to conduct a research on the current state of the oldest cement-stabilised rammed earth building in the metropolitan area of Perth and Margaret River. An experimental program in the Structure lab of UWA will be carried out to establish new testing procedure to measure and predict the durability of rammed earth.

**Co-Supervisor: Dr. Chris Beckett (UWA)**  
**Co-Supervisor: Mr. Stephen Dobson, Ramtec Pty Ltd**

3. **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.
4. Investigation of the accuracy of a new non-destructive testing technique to estimate the stiffness of early-aged concrete (Suitable for Bachelor and Master)

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.

Co-Supervisor: Dr. Alex Gibson.

5. Effect of changing parent material strength on strength of RE (Suitable for Bachelor and Master)

This project aims to find an answer to the following questions:
- Does a strong aggregate lead to a strong RE?
- What is the real effect of WC and compaction energy in the final strength of the material?
- Over compaction – does it lead to decreases in strength? How to even define “over compaction”?
- Shrinkage of RE raw materials. Some texts claim that sand has less shrinkage than silt – is this true, given the inert nature of both particle types?

Co-Supervisor: Dr. Chris Beckett (UWA)

6. Effect of lime stabilisation on rammed earth (Suitable for Bachelor only)

Rammed earth is considered a sustainable material due to its low embodied energy. However, when stabilised with cement, its carbon footprint cannot be neglected. Other methods to stabilise rammed earth exist, and amongst these the use of lime. This project aims to find the effect of changing clay content on amount of lime required and the effect of lime content on shrinkage and durability.

Co-supervisor: Dr. Chris Beckett (UWA)

7. Comparison of different Stress Recovery Methods existing in literature (Suitable for Master only)

Stress calculations are of interest because in structural analysis and design, stresses are often more important than displacements to the engineer. In the displacement-based FE method, stresses are obtained from the computed displacements, and are thus derived quantities. The accuracy of the
derived quantities is generally lower than that of primary quantities.

Once the nodal displacements are obtained, the stresses are computed at the integration points of each element and then extrapolate to the element nodes. It is important to highlight that the stresses computed at the same node from adjacent elements will not generally be the same. This drawback requires the use of stress averaging to recover a single stress value at the mesh node.

Taking into account that knowledge of statically admissible forces or stresses forms the basis of safe designs of structures, and that the proposed 2007 revisions to AS3600 permit the design of reinforced concrete members using linear finite element analysis, it becomes clear why it is of interest the study of techniques that enhance the accuracy of the stresses obtained by computed displacements.

These techniques have the generic name of stress recovery methods (SRM). Recently a new SRM has been proposed (D. Ciancio, I. Carol, M. Cuomo. On inter-element forces in the FEM-displacement formulation, and implications for stress recovery, *International Journal for Numerical Methods in Engineering*; Volume 66, Issue 3, Pages: 502-528, 2006) that ensures suitably accurate results without imposing high computational costs. In literature different other procedures exist that try to find a reasonable equilibrium between the efforts needed in the calculation of the recovered stresses and the accuracy of the obtained solution. Usually it holds the higher the accuracy the higher the computational cost, and vice versa.

This project will examine the benefits in terms of computational cost and accuracy in the results of this new SRM, comparing it with other SRM implemented in commercial FE software.

8. **Investigation of the Scaled Centrally Loaded Round Determinate Panel Test (Suitable for Bachelor and Master)**

The Centrally Loaded Round Panel Test (ASTM C1550) was originally developed for fibre reinforced shotcrete. It is a test that measures the energy absorption up to a certain deflection. The dissipated energy is then used as a parameter to characterize the material and to control its performances.

The test is carried out on a round panel of 800X75 mm. The main drawback of this test is the transportation of the samples from the site where it is cast to the laboratory where it is tested. Not only during the transportation the sample can be damaged, but also the different temperature and humidity conditions between the source site and the lab might affects the final results.

This project aims to investigate the suitability of the same test on a reduce-scaled panel, with the final goal to implement a testing machine that can be used in the mining site.
1. **Soil Parameter Selection using Numerical Optimisation**

This project will explore the use of mathematical optimisation techniques to calibrate soil constitutive models based on the stress-strain/load-displacement response measured from both laboratory and in-situ tests, including triaxial, pressuremeter and foundation load tests. Finite element models representing each test will be used to generate model data. This data is then compared with measured test data. Direct search methods are then employed to change the constitutive model parameters between specified upper and lower bounds, in order to minimise the difference. The project will involve programming in MATLAB, as well as using Abaqus finite element software.

2. **Development and Documentation of a MATLAB Finite Element Library**

A “Library” of MATLAB functions is being developed to perform non-linear finite element analysis for geotechnical problems. Students should have a strong interest in programming and numerical methods.

3. **Effective Stress versus Total stress analysis of undrained problems in geotechnical engineering (excavations)**

Several different options are available for modelling undrained behaviour in finite element analysis. If they are not properly understood, results may be grossly incorrect, leading to catastrophic collapse. This was highlighted by the recent collapse of a major excavation in Singapore. The aim of this project is to simulate undrained excavations in several different ways, compare the results and make recommendations regarding the suitability of each approach.

4. **Effective Stress versus Total stress analysis of undrained problems in geotechnical engineering (offshore foundations)**

Several different options are available for modelling undrained behaviour in finite element analysis. If they are not properly understood, results may be grossly incorrect, leading to catastrophic collapse. This was highlighted by the recent collapse of a major excavation in Singapore. The aim of this project is to simulate undrained loading of offshore foundations in several different ways, compare the results and make recommendations regarding the suitability of each approach.

5. **Three dimensional finite element analysis of the simple shear test**

This project will involve a finite element study of the UWA and Cambridge type simple shear test, carried out using the Abaqus finite element software. The results will be used to show the strengths and limitations of the simple shear test and determine which design performs best and how the test results should be interpreted.
6. Testing and interpretation of the UWA centrifuge scale pressuremeter

A miniature soil pressuremeter has recently been developed at UWA for use in the geotechnical centrifuge. This project will involve conducting tests with the device in a pressure chamber and interpreting the results of the tests using conventional cavity expansion theory as well as back analysis using finite element software packages.
1. Modelling caving using discrete particle analysis

Modelling the drawdown behaviour of a caving operation as a particulate process, using EDEM software (http://www.dem-solutions.com)

2. Underground decline gradients

A 2011 thesis showed that the industry “norm” of 1:7 for an underground decline may be outdated and that modern trucks should have steeper gradients. This work needs to be continued and refined in areas such as tyre wear, machine wear, suitability for other equipment, decline maintenance, ventilation, safety etc..

3. Open Pit ramp gradients

A 2011 thesis showed that the industry “norm” of 1:7 for an underground decline may be outdated and that modern trucks should have steeper gradients. This work needs to be replicated and expanded for the open pit “norm” of 1:10.

4. 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.

5. 3D stereo-nets

The classical stereo-nets used in rock mechanics is a projection of a sphere (either equal angle or equal area) on to a 2D piece of paper. Similar to the manner in which maps represent the curved earth’s surface. However, nowadays with 3D software, it should be possible to reproduce all the mathematics of stereo-nets in a true 3D environment.

6. In Pit Crusher Conveyor

A model of an IPCC system needs to be developed, validated and then used to produce some “rules of thumb” as to under what conditions (e.g. tonnes pa, haulage distance, fuel cost, labour costs, maintenance costs etc.) it is most advantageous. The key factors for a successful installation could be determined.
7. Simulation of Ventilation on Demand

There is growing interest, amongst underground mines, in “Ventilation on Demand” systems, where the secondary ventilation only operates in an area of the mine when people/equipment are working there. A simple simulation of a mine is required to predict how much this will reduce the operating hours of the ventilation equipment. From this a financial analysis of the benefits (reduced power usage) and costs (sensors) would be performed.

8. Artificially created fog

Some recent technology creates floatable water particles or “artificial fog” for a variety of purposes (http://www.fogsystems.com.au/ and http://www.fog-systems.de/ ). Known benefits of the artificial fog include, less water use, greater effectiveness and less wetting of material, equipment or people. Potential mining applications, would include dust suppression using much less water than current water sprays, and methane explosion containment. However, the technology is not fully developed and some further test work is required before successful practical implementation. This would be done in conjunction with the “owner” of the rights to this technology. Some of his proposed programs include:

• A quantitative assessment of the dust reduction of Fog Sprays on (Coal/iron ore/nickel/bauxite/etc…) dust from (crushers/loading pockets/ship loaders/transfer points/etc…)  
• Comparison of dust extraction performance of a Fog Chamber to bag dust extractor. (Capital and operating cost and dust removal)  
• Using a Fog chamber to reduce atmospheric emissions from an underground mine (soluble gases, explosive fumes and dust)  
• Creating a Fog chamber for dust extraction on exploration drilling rigs  
• Quantitative assessment of contaminant removals of fog system on underground ventilation circuits  
• Impact of fog system on dust explosiveness properties? (methane/sulphide/other?)  
(Preliminary research has been done on this - I have videos showing the tests)  
• Potential reduction in plume pollution from roasters or smelters (Kalgoorlie nickel, Gidji Roaster, etc).
All projects are suitable as Masters projects

1. **Structures based on interlocking blocks (a group of projects)**

   The projects from this group form a part of a large ongoing project focused at developing novel methods in Structural Engineering. This is based on interlocking building blocks/bricks which are the blocks that due to the specifics of their geometry can form self-holding assemblies. Different smooth block shapes have been discovered that allow the interlocking without the aid of keys or connectors. Thus the blocks are produced that can hold together without adhesive, which leads to a range of possible civil engineering applications from demountable structures and pavements (e.g. for air fields) to seismic-proof foundations and can cast a light on the astonishing longevity of ancient dry stone structures.

2. **Bending stiffness of interlocking structures (Numerical, 3 projects)**

   The ultimate load bearing capacity of interlocking structures as well at their vibration and sound properties are controlled by bending rigidity. As the blocks in the interlocking structures, as well as in fragmented structures are not connected, in the process of bending they can delaminate. The delamination affects the bending rigidity, differently for different types of interlocking blocks. On top of that, the delamination depends upon the magnitude of confining pressure. There are three projects, which aim to study the change of bending rigidity and associated mechanical behaviour of fragmented structures due to delamination.

   Project Buckling of interlocking and fragmented beams involves analysis and computer simulation of buckling and the determination the buckling loads and modes as functions of the beam length.

   Project Bending vibrations in interlocking and fragmented beams involves studying the bending (flexure) oscillations in a fragmented beam and finding the resonances.

   Project Bending of interlocking plates involves analysis and computer simulation of bending rigidity and static deformation of fragmented plates. The results will be compared to available experimental data.

3. **Modelling vibration damping in interlocking structures**

   A very important property in buildings and foundations is the ability of structural members to dump vibrations and attenuate noise. This property has a number of applications, from noise reduction (both industrial and domestic) to seismic-proof construction. The principle of interlocking offers new opportunities to design structures with very efficient vibration and noise reduction since preliminary experiments have revealed considerable vibration damping and sound absorption (up to 95% on a specific frequency).

   The project aims at investigating the vibrations in a one-dimensional interlocking structure. The structure is modelled as an assembly of rigid blocks whose interfaces are represented by springs with different stiffnesses in tension and compression. The project comprises numerical modelling
using Matlab and the analysis of results.

4. **Dynamics of bilinear engineering systems (Numerical with A/Prof. Elena Pasternak)**

The project deals with engineering structures that contain links or parts with different stiffness in tension and compression. Examples of such systems include:

- or any mortar-less structures
- Mooring lines
- Links between train carriages

Another group of examples is constituted by:

- Concrete, rock and rock mass as they usually have different moduli in tension and compression
- Granular materials
- Materials with thin cracks

Characteristic features of such systems are the presence of resonance frequencies, which have no correspondence in traditional linear approximation, in particular sub-harmonics, and the ability of the system to be excited by random forces. In many cases the subsequent behaviour becomes chaotic. It is believed that these features can be responsible for catastrophic failures in traditional structures (such as breakage long trains), liquefaction in sands and the extraordinary height energy absorption and self-healing in potentially unbreakable structures made of interlocking bricks. In concretes and rocks these features could potentially be used for non-destructive control.

The project aims to investigate these resonances using one-dimensional system of masses connected by bilinear springs. The numerical analysis will be based on standard procedures of solving systems of differential equations that can be found in any package (e.g. Matlab, Mathcad, Mathematical) with subsequent spectral analysis.

5. **Mortarless construction throughout history – Classification, analysis and perspective**

Mortarless construction is historically first building method. In ancient times before mortar was invented, or readily available, structural stability and integrity was provided by either friction between the structural units (if their weight was sufficient) or by special shape of the units or by machining keys or connectors (usually in wooden structures). These methods required considerable manual labour associated with either lifting of heavy blocks or selection stones of special shape and arranging them in the correct order or machining the connectors. With the advent of mortar, the brick and mortar method superseded the mortarless ones as it ensured faster and more reliable construction. In the last century with the development of advanced manufacturing the interest to mortarless (interlocking) structures resurfaced as it provided the reduction of manual labour on the construction site shifting the weight of manufacturing to factories. Recently the concept of topological interlocking emerged whereby the stability of the structure is provided by special overall shape of the blocks without the need for local connectors. As the building methods seem to make the full circle by returning to the mortarless construction it becomes necessary to look at the history of the technology in an attempt to learn lessons from the centuries of prior experience, in particular in the reasons for the amazing longevity (especially in earthquake-prone regions) of the ancient structures.
The project is of historical-conceptual nature. The student is supposed to collect all available descriptions of the mortarless structures, propose a classification based on the current understanding of interlocking and categorise these construction methods in terms of the stability and longevity achieved. Depending on personal inclination the student could dwell into the theoretical foundations of topological interlocking and use this concept to enrich the classification of mortarless construction methods.

6. **Directional friction**

When a block is moving in a constrained environment, for instance in a channel with stiff walls, the magnitude of compressive stress that controls friction is determined by the displacements of the walls and the block. When a soft isotropic insert is put between the walls and the block, the compressive stress will mainly be determined by deformation of the insert, independent of the sliding direction. When however the insert is anisotropic such that the shear strain is coupled with normal stress, sliding will change the compression. The change, that is the increase or reduction of the magnitude of compression and hence the friction shall depend upon the direction of sliding thus achieving directional friction. Directional friction if proven to be achievable can find a wide range of applications in engineering structures.

The project aims at investigating this mechanism of directional friction. The project consists of the following stages: (1) Literature review aimed at finding any prototypes; (2) Numerical modelling of the directional friction; (3) Designing experiment to prove the concept; (4) Conducting experiment

**Co-Supervisor: Professor Elena Pasternak**
(School of Mechanical and Chemical Engineering)

7. **Investigation of shear bands and pattern formation in granular materials**

The abundance of granular materials (sand, aggregates, fragmented rock, etc.) used in Civil Engineering warrants comprehensive investigation of mechanics of their deformation and failure. It is well known that large deformation starts with the formation of shear bands and with the subsequent deformation and failure concentrating along the bands. What our recent research has shown that in the process of deformation the shear bands appear then disappear and reappear again. It was observed that smaller scale patterns could be formed in between the instances of the shear band generation.

The aim of the project is to investigate the shear band formation and patterning in a 2D physical model of granular material as a function of inter-grain friction and grain size distribution. The project involves experimentation using the apparatus built in the course of a last year final year project.

**Co-Supervisor: Professor Elena Pasternak - experimental**
(School of Mechanical and Chemical Engineering)

8. **Risk assessment of excavation instability and borehole breakouts in homogeneous rocks**

Instability of excavations and borehole breakouts caused by failure of rocks leads to the breakage of
equipment with considerable financial loss and, in the worst-case scenario, loss of life. At large scale instability of excavation can trigger natural disasters like earthquakes. There are therefore serious social and economic needs to improve the stability of excavations and boreholes. In order to achieve this, computer models capable of predicting rock failure for different cases are required. Two issues need to be resolved for such models to be adequate for the needs of mining and petroleum industries are: (1) each element of the model representing the rock should accurately model the realistic rock behaviour. This can be achieved using the information from high quality laboratory tests; (2) the choice of the element size is crucial for the model to be successful. This second issue can be resolved based on the new concept of scalability developed at the School. The aim of the project is to develop the simplest realistic model of rock failure at the openings in rock mass that resolves the above issues. The model will be used to determine the failure extent and provide the means for risk assessment.

The project will consist of a number of computer simulations using ABAQUS with realistic rock behaviour specified for the finite element.

9. Modelling of crack growth in compression (computer modelling)

Catastrophic collapse of underground excavations and rock masses as well as heavy loaded concrete structures is often caused by sudden crack propagation under the action of high compressive load. Proper understanding of crack growth in compression is therefore of paramount importance for the prediction of failure and the development of the methods of preserving the structures. Extensive experimental studies of this failure mechanism have cast some light on its basics but failed to provide comprehensive understanding because of significant difficulties in conducting precise fracture tests in such heterogeneous materials as rocks and concrete. With the advance of computer technologies, computer simulation and modelling is become a viable and cheap alternative to experimentation.

The research aims at computer simulation of crack growth in compression using an ABAQUS Finite Element model.

10. Mechanism of post-peak softening in concrete and rock (computer simulation)

Post-peak softening – stress reduction with increasing strain after the peak load (strength) is passed – is a very important characteristic of brittle materials such as concrete, masonry and many types of rock and cemented soil which controls the long term survival of the structures. While being routinely measured in the lab and refereed to, the mechanism of post-peck softening is still far from being understood. Furthermore, there is evidence that the post-peak softening depends upon subtle details of the loading frame, in particular its ability to prevent or otherwise the rotation of the loading platens.

The project is aimed at investigating the mechanism of post peak softening and the effect of axial and rotational stiffnesses of the loading frame. The analysis will be based on the fibre model whereby the sample is represented as a set of many parallel elastic fibres with randomly assigned strength, while the loading frame is modelled as two rigid blocks connected by a link with given axial and rotational stiffnesses. The project involves computer simulation of subsequent breakage of the fibres as the blocks are pulled apart with a constant rate.
11. Risk assessment of excavation collapse due to catastrophic pillar failure

The project, being a continuation of 2007 and 2009 final year projects deals with stability of large slot-like opening whose roof is supported by many pillars (parts of rock mass left unmined) – so-called room and pillar mining method. Typically the height of the opening is 5 m, the area - hundreds of metres. When a pillar is broken its load is transferred to the neighbouring pillars increasing the probability of their failure. The strengths of separate pillars can vary a lot, so initially failure of few weakest pillars does not yet pose a problem. However, when a certain number of pillars are broken, the breakage of the next one can trigger an avalanche-type failure of the rest of pillars and, eventually, the collapse of the excavation. The situation is further complicated when the pillars are deliberately removed to utilise the resources left in them.

The project will use computer simulation to model the catastrophic pillar collapse. With the aid of this simulation the design for determining the stability of the excavation and the failure risk chart will be refined. An @Risk (or a Matlab) model will be created to simulate the variability of pillar strength from the known variability of rock strength and pillar width. The information on the distributions of rock strengths and pillar widths will be found in the literature.

Co-Supervisor: Professor Phil Dight (ACG)

12. New method of manufacturing synthetic rock samples

Synthetic rock samples are used to investigate the fundamental mechanisms of rock fracturing and fragmentation. These investigations are important in Mining and Petroleum industries to ensure safety of operations and increase efficiency of hydraulic fracturing. Recently new areas of application emerged: geothermal energy and CO2 sequestration. The main problem with the current, cement-based synthetic rock is the lack of reproducibility: no matter how carefully the cement mix is produced the internal structure of different samples are not identical. This makes tracing the evolution of internal damage very difficult.

The aim of the project is to try out a new method of manufacturing synthetic rock – laser prototyping or selective laser melting (SLM). In this method the synthetic rock samples will be made from metal powder by point melting using the computer-controlled laser beam. In this way any number of samples with identical microstructure can be produced. The project will involve learning the method and the SLM machine, producing and testing samples with internal cracks and determining the regime ensuring the best quality samples.

Co-Supervisor Professor Elena Pasternak and Professor Tim Sercombe (School of Mechanical and Chemical Engineering)

Methods Of Stress Determination In Rocks

Rocks at depth are subjected to high in-situ stress produced by the weight of overburden and tectonic movement. This stress is the main cause of rock falls in mining industry and borehole breakouts in petroleum industry. Stress also effects petroleum production and flooding of excavations. Currently there are a number of methods used in stress measurements. The following projects will look into some of from.
13. **Hollow inclusion cell method**

The stress determination using this method is based on the interpretation of strain measurements utilising a model of rock deformation. Conventionally, the method assumes that the rock is isotropic, i.e. its response to loading is the same in all directions. However, rocks are rarely isotropic. Moreover, in some cases the elastic module can vary more than 10 times when the loading direction changes. The aim of this project is to conduct computer simulation to analyse the effect of rock anisotropy on the accuracy of stress determination with the Hollow inclusion cell method and, if necessary, modify the method. The project will use computer simulation using a Finite Element or Boundary Element package.

**Co-Supervisor: Professor Phil Dight (ACG)**

14. **Rock memory methods**

The information of the stress distribution in rock man is often limited due to the restricted access to the places of stress measurement and due to high cost of the existing methods of in situ stress determination. Recently, a new approach to stress measurements emerged based on the rock stress memory effect. The main advantage of the method is that it can use the abundance of the rock cores left form the exploration boreholes and potentially having the memory of the stresses they were subjected at the time of extraction.

Currently, there exist two methods of stress Measurements based on rock memory: the acoustic emission method (Kaiser effect method) and the Deformation Rate Analysis (DRA). The aim of this experimental project is to calibrate these methods using samples of rock or rock-type materials subjected to known stress and develop recommendations for the stress measurements based on the combined use of these methods. In the course of the project the student will master the techniques of rock testing, acoustic emission measurements and wave velocity determination.

**Co-Supervisor: Professor Phil Dight (ACG)**

15. **Scale effect in determination of rock deformability**

In situ rock deformability is currently measured by testing rock samples. Rock in the rock mass can be anisotropic with difference in deformability in different directions reaching 2-3 times. In this case one needs to test a lot of samples cut out in a number of different directions. The only economically viable technology currently available is sub-sampling of a core. This method however produces samples of relatively small sizes, which leads to very high variability of the deformability measurements and, subsequently, the necessity to test large numbers of samples. This translates into high cost associated with this stage of the rock mass characterisation. The aim of the project is to investigate a mechanism of variability in deformation measurements in anisotropic foliated rock and quantify it. The project will consist of finite element modelling of layered and foliated rocks and simulating subsampling in different directions. It is anticipated that a new sequential method of subsampling will be designed whereby the location and orientation of the next sub sample is determined on the basis of the results of the testing of previous subsamples.

**Co-Supervisor: Professor Phil Dight (ACG) - Numerical**
16. **Utilisation of pressure sensitive mixtures in remote stress measurements**

It has recently been found that liquids and jellies filled with hollow plastic microspheres can considerably alter the velocities of wave propagation even for minute concentrations of spheres. As the wave velocities can be measured remotely, this effect calls for applications in distant stress measurements, especially in Mining and Petroleum Industries. The aim of the project is to study the effect further and investigate a potential for utilising it for stress measurements. The project consists of modelling and conceptual parts.

The computer modelling part involves calculating the wave velocity reduction with pressure for mixtures of different concentrations of spheres.

The conceptual part will review the existing methods of in-situ stress and wave velocity measurements, investigate the ways the mixtures can be injected in the ground and develop recommendations for the use of the proposed techniques for the stress determination.

*Co-Supervisor: Professor Elena Pasternak - numerical*
*(School of Mechanical and Chemical Engineering)*

17. **Wedge Failure in Open Pits**

Sliding of wedges in open pits can be assisted or in some cases triggered by external vibrations. The vibrations are regularly produced by production blasting and by seismic events (e.g. earthquakes, rock bursts in adjacent excavations) when they occur. It is hypothesised that the mechanism of this form of slope instability is in temporary friction reduction caused by high amplitude vibrations, mostly when the system wedge-rock mass is in resonance. The aim of this project is to check this hypothesis. To this end a simple model of the contact vibration under applied pressure will be developed using Matlab or any suitable computer language. This will be used to gain initial insight before a move complex Fianal Element Model of a rock slope with wedges is set up. The stability of the wedges will be checked under applied vibrations of different frequencies. Different types of wedge/slope interfaces will have to be tried. A computer package ABAQUS will be used for the final element modelling.

*Co-Supervisor: Professor Phil Dight (ACG) - Numerical*

18. **Photogrammetric method of distant strain measurements**

Strain and displacement measurement is one of the main methods of stress determination and structural health monitoring. In some cases attaching the strain gauges to the surface is not possible or desirable. The advance of digital photography present a method of displacement (and strain) measurements is based on attaching light luminescent targets and making large numbers of photographs of their movements in the process of deformation. The photographs are then processed using specialised software. The main difficulty with using this method is to eliminate possible errors related to the camera resolution and vibration.

This experimental project aims at refining the measuring technique and determining the possible attainable resolution. In particular, the optimal shutter speed, flash duration and distance to the
object will be determined. Also, the methods of reducing the camera and sample vibrations will be research. The measurements will be conducted on loaded samples of different stiffnesses and comparison of the results of the measurements with the ones obtained by conventional strain gauges.

**Co-Supervisor: Professor Elena Pasternak and Dr Igor Shufrin - Experimental – (School of Mechanical and Chemical Engineering)**

19. **Modelling crack growth in concrete (Numerical, Matlab)**

Crack propagation is a major cause of failure of brittle materials such as concrete and rock. Increase of the life time of structures and failure prediction require accurate modelling of crack growth. Concrete and rock are highly heterogeneous materials, which imposes specific conditions of crack growth. A main feature is the development of so-called process zone at the crack tip – a narrow zone where the non-linear processes of deformation and fracture are concentrated. The aim of the projects is to simulate the process zone based on so-called fibre-bundle model whereby material in the process zone is replaced with a layer of parallel elastic fibres with random strengths. When the load exceeds the strength of a fibre it breaks. The load increase continues until sufficient number of fibres breaks enabling a step of crack propagation.

There are two ways this model can be implemented. Both ways will be tried and the results compared.

The first way is a direct Monte-Carlo simulation of breakage of the fibres situated in the process zone. This is the scope of project Simulation of crack growth in concrete. The project will be heavily based on statistical simulation and analysis.

The second way is to apply homogenisation technique whereby the stress-strain relationship of a uniformly loaded fibre bundle is obtained first and then it is incorporated in the process zone when the crack is modelled. This is the scope of project Homogenised modelling of crack growth in concrete. The project will involve solving the integral equation using the method of collocation. The method will involve the use of complex numbers.

20. **Computer simulation of frictional sliding in granular materials (Numerical, Matlab)**

Granular materials such as sand, some soils and rock debris are often used as construction material. They also form foundations and fault gouge. Plastic deformation of granular material is usually localised over slip lines where sliding is characterised by friction. In order to ensure efficient performance of this type of structural materials as well as to be able to predict failure accurate models are required. Currently, the modelling is based on the assumption that the grains are spherical. The real grains are not. Furthermore, it has been recently discovered that a non-spherical grain produces a specific shape effect that is akin to negative friction. The aim of the project is to study a collective behaviour of non-spherical shape of grains and their effect on frictional sliding. The project involves Monte-Carlo style computer modelling using Matlab or a similar computer language.
1. An improved design approach for lining systems beneath waste disposal sites.

Most waste disposal sites include provision for an impermeable lining system, to minimise the potential for groundwater contamination. These lining systems usually include one or more layers of geosynthetic material. The primary layer is a geomembrane or geosynthetic clay liner, which is often protected with a layer of geotextile and perhaps includes a synthetic drainage material such as a geonet. There have been a number of failures of lining systems on the slopes of landfills, the best known of which is the Kettleman Hills landfill in the USA. The failures are usually caused by slippage between the various layers of geosynthetics. Current design approaches focus on limit equilibrium analyses of these lining systems, ignoring the importance of strain compatibility between the layers. This project will develop a design methodology that includes provision for strain compatibility, using a spreadsheet or other relatively simple approach to modelling the problem.

2. The bearing capacity of soft clays beneath a sand layer and the relationship to access time on a mineral sands mine.

In many mineral sands mining operations in Western Australia, the mined void is filled with a low strength mixture of sand and fine clay material, as soon as possible after mining has been completed. As part of the re-instatement process, the objective is to cover this backfilled material as soon as possible with topsoil and then to begin revegetation procedures. Problems are frequently encountered with earthmoving machinery becoming bogged, or worse still, completely submerged in the soft backfill. This project will develop guidelines on safe access to the backfill surface, with the objective of minimising risk to machinery operators, but improving access time. The project will require modelling of a two-layer system – the soft backfill overlain by a thin layer of sand – with earthmoving equipment working on the sand surface. The modelling will involve use of a finite element package. In a previous study, tests were carried out on the UWA geotechnical centrifuge to study this problem, and data from this study will be used for comparison purposes.

3. Penetrometer testing to determine liquefaction potential of mine tailings

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 for the penetrometer using a range of tailings from mine sites in WA. A laboratory testing chamber from a previous study will be used, and factors such as moisture content will be evaluated, for particular densities. The PANDA will be used to obtain corresponding profiles of penetrometer resistance and the results compared.
4. Liquefaction of ship cargo and the risk of triggering sinking of ships during sea voyages

Recently there have been a number of ships that have overturned and sunk while carrying cargoes of ore, such as nickel and coal. The trigger for these events has been liquefaction of the cargo due to wave and storm actions. This project will evaluate the currently available laboratory techniques that are used for checking the liquefaction susceptibility of a particular cargo. In particular, the Proctor-Fagerberg test method will be evaluated in terms of critical state soil mechanics principles, and results from this method compared with results from cyclic loading tests using equipment available at UWA.

5. Design and testing of a laboratory chamber for evaluating flow capacity of Geosynthetic drainage products

There is increasing use of prefabricated drainage products in applications such as roadside drainage, drainage behind retaining walls, and drainage of tailings storage facilities. In this project, a testing chamber will be designed and manufactured (by the UWA workshop) for evaluating the effectiveness of these products. Particular emphasis will need to be paid to the influence of the unsaturated flow characteristics of the Geosynthetic product (such as geotextiles) and of the soil used for backfill around the drainage product. Numerical modelling using SEEP/W will be required, to assist with the design of the testing chamber. Tests will be carried out on typical soils used as base and subbase layers for roads in Perth, and potentially on mine tailings from a site in WA.

6. Modelling particle contact using Three Dimensional Particle Flow Code (PFC3D)

In fully saturated soils, water occupies all the voids in a soil’s matrix. In the ‘pendular regime’ (unsaturated soils), water only occupies a thin layer (capillary) between particle-to-particle space, which acts like a ‘bridge’ between particles. The volume and the capillary force of the water ‘bridge’ will be a function of particle’s geometry and their relative distances. The project will develop a constitutive model between two particles and apply it to large number of particles (assembly) to simulate the Soil Water Characteristic curve (drying and wetting) using Three Dimensional Particle Flow Code (PFC3D).

7. Strength properties of Cemented Paste Backfill (CPB) materials.

CPB is used to fill mine underground voids (stopes). It is a mix of tailings, cement and water. In some cases, sand is added to reduce the cement usage. The total strength of CPB is contributed largely from shear strength, cementation and matric suction. To understand the relative contributions, one has to be able to decompose such strength components. The project will investigate the strength components of CPB by conducting some fully saturated triaxial tests and uniaxial compressive tests of CPB with and without cement under ranges of conditions and curing times.
8. Simulation of strength properties of Cemented Paste Backfill (CPB) using Three Dimensional Particle Flow Code (PFC3D)

Conducting laboratory tests for CPB is time consuming, labour intensive and costly. PFC3D provides numerical tools and a mathematical function to model the soil particle interaction based on the Discrete Element Model (DEM). DEM is a relatively new method and becoming more popular in geotechnical practice since it provides a more realistic approach in tackling geo-mechanical problems. Contrary to the Finite Element Method (FEM), DEM treats soils as discrete particles rather than a continuum/solid mass. The project will involve the development of PFC3D models to simulate cemented paste backfill. Furthermore, the student will gain skill in writing script and modelling a wide range of soil mechanics problems.

9. Desaturation of Cemented Paste Backfill (CPB) using soil column tests

The desaturation behaviour of CPB in an actual stope (underground mining void) is difficult to monitor. This project will investigate the desaturation of CPB in the laboratory using soil column tests, which will be used to predict the actual CPB desaturation behaviour in the field. The evolution of moisture content and matric suction will be determined using a soil moisture meter, tensiometer and suction probes.

10. Accelerated dewatering of mine tailings using a Coiled Plug Flow Reactor

The properties of thickened tailings slurry is affected by various parameters that include the percent solid content, type and dose of flocculants, method of flocculant’s addition into slurry, as well as its shear history. In this work, the effects of flocculants addition into kaolin slurry will be investigated. In-line flocculant injection into slurry is one of the methods that is currently being explored to improve the dewatering characteristics of slurry in the mining industry. One of the advantages of this method is the possibility to more easily control the level of shear that is introduced into the slurry prior to further processing inside a thickener, or prior to sending the slurry directly to the Tailings Storage Facility. A unique part of this study is the use of the Coiled Plug Flow Reactor (PFR) that will facilitate the slurry mixing with the flocculant. This Coiled PFR, equipped with 4 flocculant injection points, is currently being developed in our laboratory and is the first of its kind. Optical microscope and Scanning Electron Microscope (SEM) will also be utilized to study the microstructure of the slurry that is produced to aid the interpretation of the behaviour observed.

11. Optimising operation of a Plug Flow Reactor (PFR)

This project will explore the effects of the number of injection points along the slurry flow and the length of reactor which will determine its residence time and hence the amount of shear that is experienced by the slurry (see topic #10 for some background info). Factors such as the diameter of the coil for the PFR will be investigated. All these parameters will contribute to the amount of shear that is applied to the slurry during the in-line flocculation process as well as during transport within the pipes. Similar analyses to those mentioned in Project #5 will be carried out. The type and concentration of the flocculant will be kept constant in this work to limit the number of parameters studied.
12. Enhanced tailings disposal

Enhanced tailing disposal (ETD) for thickened tailings slurry has become a new trend to tackle the disposal of thickened tailings currently produced in the mining industries. The thickened slurry, such as produced from a gravitational thickener (30-35% solid), will be further treated by the addition of specifically designed flocculants to induce further water removal which will improve the efficiency of water recovery. Furthermore, the ETD process for tailings slurry will also modify the characteristics of the slurry making it more favourable for the reduction of footprint of the tailing mud. The process may also reduce the time to achieve target density, as well as reduce time to target strength. In this project, flocculated and non-flocculated kaolin slurries that have been thickened using gravitational sedimentation processes (with or without raking), will be further treated by the addition of flocculant suitable for this purpose. Various characteristics of the slurry will be measured such as yield stress, further water release characteristics, and slump test characteristics. Moreover, optical microscope and Scanning Electron Microscope (SEM) will also be used to study the microstructure of the slurries to assist in the interpretation of the results obtained. Parameters such as the concentrations of flocculants will be applied in this work.
1. Mitigation of spudcan-footprint interaction issues through Swiss cheese drilling

Swiss cheese drilling has been successfully used to mitigate punch-through for spudcan penetration in stiff-over-soft clays. An innovative tool, referred to as ‘shower head’, was developed to carry out drilling operation. It is considered by the offshore industry Swiss cheese drilling has potential application when there is a compatibility problem between the installing rig spudcan footprint and existing footprints.

In this project, a series of tests will be undertaken at 1g to investigate the potential of using Swiss cheese drilling for safe jack-up installation near existing footprints, alleviating sliding issues. Tests will be conducted on over consolidated moderate to stiff clay deposits. Footprints will be created by using a cutting tool and through extraction of installed spudcans.
1. Dynamic response and fatigue design of steel catenary risers in the touch down area

Steel Catenary Risers (SCRs) are one of the most popular and cost effective types of risers for development of offshore fields in shallow to medium water depths. There are many engineering challenges for design of SCRs but their fatigue design in the touch down area (TDA) has always been among the major design challenges.

The riser-seabed interaction in the TDA is highly nonlinear because of the nonlinear behaviour of the soil and the random nature of cyclic motion of the riser too. Traditional design approaches, based on linear solutions to these nonlinear problems, usually lead to very conservative fatigue design of SCRs.

Main objective of this numerical research is to get a better understanding of dynamic response and fatigue design of SCRs at TDA. This study will be in continuation of the previous studies carried out at COFS on fatigue design of SCRs. In a series of sensitivity studies, using Orcaflex software, effects of main input parameters (environmental loading, soil behaviour, etc) which will influence fatigue life the system will be investigated.

This project will suit both bachelor and master students who are interested in deep water offshore engineering concepts and strong backgrounds in analysis of structural systems. Knowledge of fatigue analysis is a bonus, but not essential.

2. Nonlinear dynamic analysis of offshore platforms under randomly generated waves

Wave loads are usually the most important environmental loads that should be taken into account for structural design of offshore platforms. Regular wave theories are used widely for estimation of wave loads on offshore platforms but waves are irregular and random in shape and in height by nature.

Dynamic analysis of offshore platforms under irregular random waves can provide the most accurate results for the platform responses under wave loads but it needs excessive computational efforts. Constrained NewWave is a new approach for generation of random waves that allows for robust evaluation of the response statistics.

In this study nonlinear dynamic response of offshore platforms, using USFOS software, under extreme waves will be investigated. Previous works carried out at COFS on dynamic pushover analysis of offshore platforms using deterministic or probabilistic waves will be continued in this study. Main objective of this numerical study is to get a better understanding of ultimate strength of offshore platforms under randomly generated waves.

This project will suit bachelor students with interests in offshore structural engineering concepts and strong backgrounds in analysis of structural systems. Knowledge of nonlinear structural analysis is a bonus, but not essential.
1. **Calculation of lateral pile capacity**

This project will involve extension of an existing Excel based computer program to determine the lateral capacity of a single pile.

2. **Soil suctions in Perth’s dune sand**

Psychrometers will be installed at the UWA Shenton Park site to determine the seasonal variation of suctions in the sand at this site. These results will be compared with in-situ test data that showed seasonal variations and also with the expectations based on AS2870.

3. **Using temperature as a means of assessing pile integrity**

The integrity of concrete piles (i.e. its diameter and stiffness variation with depth) is usually assessed using sonic methods. This project will explore the potential of using temperature sensors embedded within piles to provide an alternative, more effective means of assessing pile integrity.

4. **The use of the CPT end resistance in predicting lateral pile response in clay**

The p-y approach, employing the framework set out in the American Petroleum Institute recommendations, is currently the Industry standard for predicting lateral pile response. Use of these recommendations in clays requires the Engineer’s (subjective) assessment of the soil’s undrained shear strength. More reliable and less subjective predictions could be obtained if the p-y springs could be related directly to the CPT end resistance (qc). This project will aim to numerically derive a CPT-based p-y formulation using Plaxis 2D to calculate the qc value in a given soil at a given depth and using Plaxis 3D to predict the variation of the lateral pressure with displacement in the same soil at the same depth.

5. **A laboratory investigation of the geotechnical properties of residual soil**

Many future developments around Australia will be in areas where residual soils predominate (residual soils are formed through the action of weathering etc. on intact rock). This project will extend 2012 research into the properties of carefully sampled block specimens of a residual material. The results of these investigations combined with a review of information in the literature will be used to provide much needed guidance for geotechnical practitioners.

6. **Pile group analysis**

Pile groups are often subjected to large lateral and moment loading (e.g. foundations for wind turbines, towers etc.. This project will compare the results obtained under these loading conditions from two heavily used commercial programs namely PIGLET and GROUP8 programs. Where
possible, the predictions will also be compared with full scale load tests on pile groups.

7. **Failure mechanisms for skirted foundations**

This project will examine critical sliding and bearing mechanisms predicted by Plaxis for typical offshore gravity skirted foundations.

8. **Embedded retaining wall design in Perth**

This project will use the Finite Element method and a recent well instrumented cantilever wall experiment in Perth to produce a new series of design charts for retaining walls in Perth's dune sand. The findings of the case history will also be extended to consider the effect of footings adjacent to the retaining walls.

9. **The shaft capacity of bored piles in sand**

A database of pile load tests will be compiled and subsequently used to develop an empirical correlation (supported by theory) between the CPT resistance and shaft capacity of a bored or CFA pile in sand.

10. **Influence of particle shape on shear strength characteristics**

This project will involve completion of a number of shear box tests using particles with well-defined shapes and mineralogy. The series of tests will build on previous UWA research and examine the influence of particle size distribution.

11. **Design guidelines for buried pipes**

The project will entail use of an existing experimental set-up to improve understanding of the response of buried pipes to surface loading. Finite Element backanalyses of the experiments will be used to improve existing design guidelines.

Creep settlement of shallow found a UWA research and examine the influence of particle size distribution.

12. **Creep settlement of shallow foundations on sand**

Recent footing tests in Perth revealed that long term settlements are significantly higher than originally thought. This project will involve collation of footing test data from around the world to improve our understanding of creep and to formulate design guidelines.
13. **A comparison of EuroCode 7 (EC7) with Australian Geotechnical Standards**

EC7 has some significant attributes that should be incorporated into Australian Standards. This research project will involve examination of various approaches employed for embedded retaining walls – with a view to providing recommendations for improvement of Australian geotechnical Standards.

14. **End bearing of H-piles**

This numerical FE research project will be performed to determine the degree of plugging that can be expected in various soil types and under various loading conditions. It is hoped that this research will lead to an improvement in current recommendations.
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 simulate and find out the outstanding pathways of fluid in fracture networks. A computational model will be created by considering the fracture connectivity and conductivity. Different geological models will be used based on statistical data from site survey.

2. Underground oil and gas storage in rock cavern and related scientific issues (Suitable for undergraduate and postgraduate students)

Oil and gas can be stored underground by different means. Conventional methods for underground oil and gas storage include the uses of aquifers, depleted reservoirs in oil and gas field and in rock salt caverns. The objective of the present project is to investigate the major scientific issues related to underground oil and gas storage, especially on the leakage control including permeability control and hydrodynamic containment. Environmental impact and cost in constructing and maintenance of the storage cravens will be preliminarily assessed.

3. 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.

4. 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 modelling; 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.

5. Simulation of natural gas decompression in high pressure pipelines

 Decompression of natural gas through the crack opening or the open end of the pipeline may cause high stress, thus, the catastrophic rupture of the pipeline. Numerical simulation of fluid-structure interaction to derive the decompression curve against internal high pipeline pressure and the pipeline structural configuration will cast light on the optimization of the structural configuration and the pipeline pressure. CFD/Abaqus will be applied to carry out the numerical simulation. The objectivity of the respective failure
criteria will be discussed. The burst test in open literature will be modeled as a benchmark for the numerical modeling and simulation procedure.
The following are a selection of projects, if you are interested in undertaking a project in the coastal area and have an particular interest - I am happy to discuss and develop a project which will suit your interests.

1. Circulation in the Timor Sea and subsequent modelling

A student with knowledge of and interest in oceanic flows to assist on investigating the circulation in the Timor Sea in order to inform a model study of the same area. Includes a literature review, acquiring public domain data, data analysis and assisting on 3D hydrodynamic modeling. Experience with numerical modeling preferred. This project will include vacation employment at the DHI Perth offices. DHI is the developer of the MIKE suite of models.

Co-Supervisors: Jørgen Erik Larsen from DHI Perth

2. Seasonal oceanographic dynamics off southwestern Australia via ocean gliders

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. Data are being collected off Two Rocks, Pilbara and the Kimberley regions. 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.

Co-Supervisors: Christine Hanson - UWA Oceans Institute

3. Planning ocean glider tracks across the Indian Ocean

In 2014, UWA will participate in a Global Challenge which will involve several along-range route for glides. These include: Cape Town to Fremantle; Fremantle to Sri Lanka; Sri Lanka to Cape Town; Fremantle to Auckland. This project will make an attempt on planning the routing of the gliders in terms of glider tracks, timing of releases to take into changing ocean currents etc. This will involve the use of an existing ocean model together with glider tracking routine.

Co-Supervisors: Christine Hanson - UWA Oceans Institute and Sarath Wijeratne - UWA Oceans Institute
4. **Surface current measurements using HF Radar**

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.

**Co-Supervisors:** Dr Florence Kaempf - UWA Oceans Institute

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

In this project we will collect using a turbulence profiler and high resolution (both space and time) current data using an Acoustic Doppler Current Profiler (ADCP). We aim to occupy a 24 hour station during the summer months to collect data over a the sea breeze cycle to determine the wind mixing of the water column and associated turbulence.

**Co-Supervisors:** Florence Kaempf - UWA Oceans Institute

6. **Design of an artificial surfing reef in Geraldton**

A feasibility study has been undertaken to build an artificial surfing reef in Geraldton. This project will review the existing work undertaken 10 years ago and use more up to date wave modelling to improve on the design of the reef.

**Supervisors:** Chari Pattiaratchi in conjunction with Department of Transport

7. **Jurien harbour sea grass study**

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.

**Co-Supervisors:** Sarath Wijeratne - UWA Oceans Institute in conjunction with Department of Transport
8. Forecast model for Bunbury Storm surge barrier

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.

Co-Supervisors: Sarath Wijeratne in conjunction with Department of Transport

9. Channel sedimentation rates at Broome

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.

Co-Supervisors: Sarath Wijeratne - UWA Oceans Institute in conjunction with Department of Transport

10. Evaluation of a beach laser scanner

Department of Transport hydrographic surveyors now have a laser scanner which produces 3D survey data similar to a multi-beam system, but for everything above the water on the beach. This project will involve evaluation of the data in terms of repeated surveys of the same beach and relating it to offshore wave conditions.

Co-Supervisor: Sarath Wijeratne - UWA Oceans Institute in conjunction with Department of Transport

11. Sediment transport modelling for Thompson Bay in Rottnest Island.

There are some ongoing erosion concerns between the hotel and old army jetty and this project will use numerical modelling to better understand the problem and provide possible solutions.

Co-Supervisor: Sarath Wijeratne - UWA Oceans Institute in conjunction with Department of Transport
12. Modelling continental shelf waves

Continental shelf waves are generated by tropical cyclones and travel long distances: for example those generated in the north-west shelf travel as far as Tasmania. This project will use a simple numerical model to attempt to model the generation and propagation of these waves.

Co-Supervisor: Sarath Wijeratne - UWA Oceans Institute

13. Analysis of ocean current and temperature data from the North-west shelf

The Australian Integrated Marine Observing System (IMOS) has deployed instruments to measure currents and temperature in Joseph Bonaparte Gulf, Kimberley and Pilbara. This project will analyse a selection of these data sets to examine different oceanographic processes.

Co-Supervisor: Dr Florence Kaempf - UWA Oceans Institute
1. **Study on the plate anchor with a keying flap**

One of the critical issues associated with plate anchors performance and design relates to the reduction of the loss of embedment during the keying process. As deep water offshore sediments typically exhibit an increasing soil strength with depth, the loss of embedment results in a reduction in anchor bearing capacity. A keying flap hinged to the main plate has been developed and adopted by industry with the aim to reduce the loss of embedment by limiting the vertical motion of the anchor. However, uncertainties remain regarding the behaviour and the performance of the keying flap. This study will conduct a series of numerical analysis to investigate the flap rotation mechanism and the condition of activation of the flap. The numerical results will be used to validate the centrifuge observations and demonstrate the keying flap for typical anchor pull-out conditions.

2. **Centrifuge study of the pipe-soil interaction behavior on calcareous sand**

This study aims to:
- observe and understand the pipe-soil mechanism in sand;
- develop a more theoretical sound but practical approach to describe the soil berm development;

3. **Developing guidelines for on-bottom stability of offshore pipelines**

Offshore pipelines are a key element in the oil and gas industry and consume a considerable amount of total expenditure. For example, it takes more 4.5 million dollars to build one kilometre pipeline on average in the West Shelf of Australia. 1/3 of this investment is spent on the maintaining the on-bottom stability. This study will use in-house developed program to investigate pipeline stability and to develop practical design guidelines as pipeline engineers’ reference.

4. **Numerical large deformation analysis of pipe ploughing**

This study will employ large deformation analysis technique to investigate the pipe ploughing, which is commonly used in the offshore engineering
1. **Spudcan foundation on multilayered soils-Physical modelling**

Offshore jack-up structures are normally supported by individual spudcan foundations. When layered soil profile is encountered, it is important to understand the spudcan behaviour on layered soils for foundation design. This project will test spudcan behaviours in centrifuge.

2. **Spudcan foundation on multilayered soils-Numerical modelling**

When multilayered soils are encountered in offshore fields, the offshore foundation bearing capacity and penetration response can affect the foundation design and the foundation safety greatly. This project is to study these effects using AFENA finite element software.

3. **Numerical analysis of CBR testing for pavement design – surcharge and soil type effect**

California Bearing Ratio (CBR) is a design parameter for subgrade soils in pavement design. There are few methods used currently to measure the CBR value. The laboratory testing is commonly conducted by CBR apparatus. This project is to use numerical tool to look into the soil responses in CBR testing.

4. **Numerical analysis of falling weight deflectometer for pavement testing**

Falling weight deflectometer (FWD) has been used in pavement monitoring in the field. This project is to analysis FWD field results using numerical analysis. The numerical analysis will show insight of the FWD responses on pavement layers.

5. **Pavement layer friction effect on pavement failures**

Pavement design is governed by tension failure of the top layer. However, the frictions between pavement layers may have significant effect on the tension failure criterion. This project is to study this friction effect on pavement behaviours.

6. **Effect of horizontal loading on pavement design**

In current pavement design guidelines, the vehicle loading was designed as Equivalent Standard Axles (ESA) for all types of vehicles on the road under vertical loads. However, there are evidence showing that horizontal loading during vehicle turning can be crucial in design. This project is to study the impact of horizontal loading on pavement design.

7. **Thornwaite Moisture Index around Perth Regions**

In designing footings for structures on expansive soil, the depth of soil suction change (hs) is used in AS2870 to estimate soil movement.
The depth of soil suction change is commonly selected based on the Thornthwaite Index. This project will look at the few aspects listed below:

a) Calculate Thornthwaite moisture index for several key centres in WA (Perth, Karratha, Bunbury, Albany, Kalgoorlie etc) using the most recent rainfall data (say 1990 to 2010);
b) Develop a spreadsheet for calculating Thornthwaite moisture index;
c) A literature review of the correlation(s) between depth of soil suction change and Thornthwaite Index; and
d) Effect of sand cover on depth of soil suction change.

8. Effect of sea level rise on ground water levels in Perth

Ground water level is one of the key design parameters for residential footing, especially in soft ground area. This project will look at the effect of sea level rise on residential footing design.
1. Effect of consolidation on the undrained vertical bearing capacity of shallow footings. Numerical study

Both onshore and offshore structures suffer changes in the loading during their intended lifetime. Some are intentionally preloaded to induce consolidation and thus increase their bearing capacity. A typical example is the installation of spudcans (foundations for offshore jack-up drilling rigs) on the seabed. Existing structures suffer changes too: new heavy equipment is brought in industrial buildings, new floors are being built, water towers installed. In these cases, the soil consolidated during the initial loading and an increase in bearing capacity is acknowledged. A famous example of the effect of consolidation is the Tower of Pisa which was built in stages over a period of around 350 years.

The effect of consolidation on shallow footings will be investigated by means of finite element analyses (FEA). Different footing geometries and overconsolidation ratios (OCR) for the soils will be considered in the FEA.

Co-supervisor: Professor Susan Gourvenec
susan.gourvenec@uwa.edu.au
1. **Suppression of vortex-induced vibration of a pipeline using porous shroud (2 students)**

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. **Suppression of vortex from a wavy cylinder (1 students)**

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, 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.

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

3. **Hydrodynamic forces on an inclined bluff body in oscillatory flows (2 students)**

For the design of offshore structures, it is important to evaluate the hydrodynamic forces on the structures in waves and steady current. 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 an oscillatory flow to study the hydrodynamic forces on the structures at different inclination angles, KC numbers and Reynolds numbers. Dependents of the drag coefficients, vortex shedding frequency and Strouhal number on Reynolds number and inclination angles will be examined and compared with that obtained in wakes of cross-flows. The experiments will be conducted in the towing tank in the Hydraulics Lab of UWA.