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GEOSYNTHETICS

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JURUTERA

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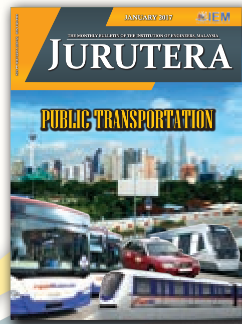

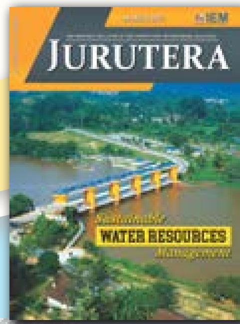

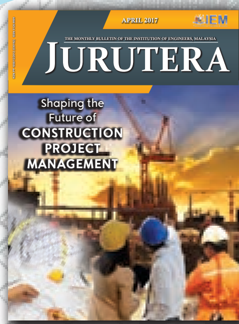

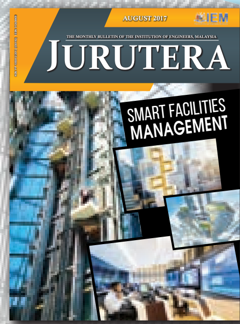

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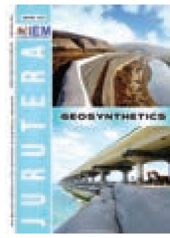

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Geosynthetics

by Ir. Lee Peir Tien
Chairman,
Geotechnical Engineering Technical Division

In general, soil is inherently weak in tension and some types, especially soft clay, have low shear strength and low permeability. In the past, engineers would use natural materials to improve the soil/ground. For example, using bamboo allows an embankment to be built on soft ground.

But, with new technology, geosynthetics are now commonly used in the construction industry to improve the soil/ground and thus allow construction works to be carried out effectively (cost & time), practically and in an environmentally-friendly manner. For example, Prefabricated Vertical Drain (PVD) is being used widely in the place of sand drain due to its cost effectiveness and fast installation.

Geosynthetics are used extensively in the construction industry, especially in geotechnical engineering applications, to provide technical practicality and cost effective solutions. But although relevant standards and handbooks are available, engineers often face difficulties in specifying the appropriate and adequate technical requirements of geosynthetics products. Other than that, correct testing methods are also important to ensure the selected geosynthetics products will perform as per design intention. A proper understanding of the behaviour, advantages, disadvantages etc. of each type of product is vital in the selection process. As such, The Institution of Engineers, Malaysia looks forward to working with the Malaysian Chapter of International Geosynthetics Society (MyIGS) to equip our engineers with the proper knowledge and to safeguard public interest. ■

GEOSYNTHETICS

Come of Age in Malaysia

Ir. Dr Ooi Teik Aun, a civil engineer with postgraduate training in geotechnical engineering since the 1960s, has seen significant progress and development in the field over the last five decades.

"When I first started my professional training in 1968, the scale of projects was small; buildings were not higher than 20 stories and retaining walls not more than five metres in height," he said.

"Today, we have 118-storey buildings with six basements, 80m-deep TBM twin tunnel borings under buildings and cable-stayed long-span bridges are the norm. It's a changed and different scenario, where structures not only need to withstand the natural elements but also acts of terrorism."

Professor Dr Fauziah Ahmad lectures on geotechnical engineering at Universiti Sains Malaysia. She is also the President of International Geosynthetics Society (Malaysia Chapter) or MyIGS. She has been a civil engineer since 1983.

In 1977, when Paris hosted the first International Conference on The Use of Fabrics In Geotechnics, the terms geotextile and geomembrane were introduced to an audience captivated by the fast-developing field of geosynthetics.

The conference served to connect manufacturers, researchers and consumers eager to explore and learn more about these still-new materials and all aspects of their potential.

Today, geosynthetics are used in every aspect of civil and some environmental engineering – as reinforcement, filter and separation layer – enabling the construction of challenging projects while protecting the environment at the same time.

In this issue of *JURUTERA*, Ir. Dr Ooi Teik Aun and Professor Dr Fauziah Ahmad explain more about geosynthetics.

Q What are geosynthetics?

Prof. Fauziah: Geosynthetics are synthetic products of which at least one component is a synthetic or natural polymer in the form of a sheet, a strip or a three-dimensional structure. They can be non-woven, knitted or woven and used in contact with soil/rock and/or other materials in geotechnical and civil engineering applications. These include planar structures (geomembranes, geotextiles, geosynthetic barriers, geonets, geogrids, geostrips, geospacers and geomats, etc.) and three-dimensional structures (geocells, geofoams, gabions and concrete-filled mattresses).

Dr Ooi: To add on, the polymeric nature of the products makes them suitable for use in the ground where high levels of durability are required. They can also be used in exposed applications.

Geosynthetics are available in various forms and materials. These products have a wide range of applications and are currently used in many civil, geotechnical, transportation, geoenvironmental, hydraulic and private development applications including roads, airfields, railroads, embankments, retaining structures, reservoirs, canals, dams, erosion control, sediment control, landfill liners and covers, mining, aquaculture and agriculture.

Q Can geosynthetics be categorised into certain groups or families?

Dr Ooi: Geosynthetics can be broadly classified into categories based on method of manufacture. The eight main categories are geotextiles, geogrids and geonets, geomembranes, geosynthetic clay liners (GCL), geofoam, geocells, geocomposites and geopipes.

1. ***Geotextiles*** are continuous sheets of woven, nonwoven, knitted or stitch-bonded fibres or yarns. The sheets are flexible and permeable and generally have the appearance of fabric. Geotextiles are used for separation, filtration, drainage, reinforcement and erosion control applications.
2. ***Geogrids*** are geosynthetic materials which have an open grid-like appearance. The principal application for geogrids is the reinforcement of soil. Geonets are open grid-like materials formed by two sets of coarse, parallel, extruded polymeric strands intersecting at a constant acute angle. The network forms a sheet with in-plane porosity that is used to carry relatively large fluid or gas flows.
3. ***Geomembranes*** are continuous flexible sheets manufactured from one or more synthetic materials. They are relatively impermeable and are used as liners for fluid or gas containment and as vapour barriers.
4. ***Geosynthetic Clay Liners (GCLs)*** are geocomposites prefabricated with a bentonite clay layer typically incorporated between a top and bottom geotextile layer or geotextile bentonite bonded to a geomembrane or single layer of geotextile. Geotextile-encased GCLs are often stitched or needle-punched through the bentonite core to increase internal shear resistance. When hydrated, they are effective as a barrier for liquid or gas and are commonly used in landfill liner applications, often in conjunction with a geomembrane.
5. ***Geofoam*** blocks or slabs are created by the expansion of polystyrene foam to form a low-density network of closed, gas-filled cells. Geofoam is used for thermal insulation as a lightweight fill or as a compressible vertical layer to reduce earth pressures against rigid walls.
6. ***Geocells*** are relatively thick, three-dimensional networks constructed from strips of polymeric sheet. The strips are joined together to form interconnected cells in-filled with soil or, sometimes, concrete. In some cases, 0.5m to 1m wide strips of polyolefin geogrids are linked together with vertical polymeric rods to form deep geocell layers called geomattresses.
7. ***Geocomposites*** are geosynthetics made from a combination of two or more geosynthetic types. Examples include geotextile-geonet, geotextile-geogrid and geonet-geomembrane. Prefabricated geocomposite drains or prefabricated vertical drains are formed by a plastic drainage core surrounded by a geotextile filter.
8. ***Geopipes*** are perforated or solid-wall polymeric pipes used for drainage of liquids or gas (including leachate or gas collection in landfill applications). In some cases the perforated pipe is wrapped with a geotextile filter.

Q What are the most commonly-used families of geosynthetics in Malaysia? Where are they usually utilised?

Prof. Fauziah: In Malaysia, which has seen much development in many areas of construction, some of the more popular applications include:

- Roads and pavements: Subgrade Separation and Stabilisation, Base Reinforcement, Overlay Stress Absorption and Reinforcement.
- Subsurface drainage: Subgrade Dewatering, Road Base Drainage, Structure Drainage.
- Erosion and Sediment Control: Hard Armor Systems, Silt Fence.
- Reinforced Soil Systems: Embankments Over Soft Foundations, Reinforced Steepened Slopes, Reinforced Soil Walls.
- Seepage Control Systems: Structure Water Proofing, Environmental Protection.

Dr Ooi: From my experience, commonly-used families of geosynthetics in the country include geotextiles, prefabricated vertical drain and geogrid (going by the amount of reinforced soil slopes and walls nationwide). Along with geogrids, geomembranes and geocells, these are utilised because they are manufactured to be lightweight, yet possess tensile strength and are inert, green and sustainable as well.

Q Based on their main functions, why would we want to use geosynthetics?

Dr Ooi: Geosynthetics have tensile strength with a consistent quality that can be subjected to control. They are sustainable and green in their application and are used for functions such as separation, filtration, drainage, reinforcement, fluid/gas containment and erosion control. In some cases, geosynthetics may serve dual functions.

In the case of separation, geosynthetics act to separate two layers of soils with different particle size distribution. For example, geotextiles are used to prevent road base materials from penetrating the underlying soft subgrade soils, thus maintaining design thickness and roadway integrity. Separators also help to prevent fine-grained subgrade soils from being pumped into permeable granular road bases.

For filtration, geosynthetics act like a sand filter by allowing water to move through the soil while retaining all upstream soil particles. For example, geotextiles are used to prevent soils from migrating into drainage aggregate or pipes while maintaining the flow through the system. Geotextiles are also used below rip rap and other armour materials in coastal and river bank protection systems to prevent soil erosion.

In the case of drainage, geosynthetics act as a drain to carry fluid flows through less permeable soils. For example, geotextiles are used together with granular fill to dissipate pore water pressures at the base of roadway embankments. For higher flows, geocomposite drains have been developed. These materials are used as pavement edge drains, slope interceptor drains as well as abutment and retaining wall drains. Prefabricated Vertical Drains (PVDs) have been used to accelerate consolidation of soft cohesive foundation soils below embankments and preload fills.

For reinforcement, geosynthetics act as a reinforcement element within a soil mass or in combination with the soil to produce a composite with improved strength and deformation properties over the unreinforced soil. For example, geotextiles and geogrids are used to add tensile strength to a soil mass in order to create vertical or near-vertical changes in grade (reinforced soil walls). Reinforcement enables embankments to be constructed on very soft foundations and to build embankment side slopes at steeper angles than would be possible otherwise. Geosynthetics (usually geogrids) have also been used to bridge over voids that may develop below load bearing granular layers (roads and railways) or below cover systems in landfill applications.

In the case of fluid/gas (barrier) containment, the geosynthetic acts as a relatively impermeable barrier to fluids or gases. For example, geomembranes, thin film geotextile composites, geosynthetic clay liners (GCLs) and field-coated geotextiles are used as fluid barriers to impede flow of liquid or gas. This function is also used in asphalt pavement overlays, encapsulation of swelling soils and waste containment.

For erosion control, geosynthetics act to reduce soil erosion caused by rainfall impact and surface water runoff. For example, temporary geosynthetic blankets and permanent lightweight geosynthetic mats are placed over exposed soil surface on slopes. Geotextile silt fences are used to remove suspended particles from sediment-laden runoff water.

Geotextiles are also used in other applications. For example, they are used as cushion layers to prevent puncture of geomembranes (by reducing point contact stresses) from stones in the adjacent soil, waste or drainage aggregate during installation and while in service. Geotextiles are used as daily covers to prevent dispersal of loose waste by wind or birds at the working surface of municipal solid waste landfills. Geotextiles have also been used for flexible concrete formworks and for sandbags. Cylindrical geotubes are manufactured from double layers of geotextiles which are filled with hydraulic fill to create shoreline embankments or to dewater sludge.

Prof. Fauziah: Based on the functions of geosynthetics as mentioned by Dr Ooi, when properly applied in projects, using the right design-by-function method can lead to advantages such as:

- Commonly-accepted as durable, long-lasting and environmentally-safe solutions to geotechnical engineering projects.
- Savings of 30% in total project costs.
- Directly minimising regular repair and maintenance costs.
- Preventing accidents, increasing the efficiency of structures, minimising pollution and leading to efficient use of natural resources.

Q Can you share some historical applications of geosynthetics and some of the early projects?

Dr Ooi: The idea to reinforce soil is not new to human civilisation. For instance, split-log corduroy roads over peat bogs date back to 3,000 BC. Other examples are the construction of Ziggurats of Mesopotamia (built using clay bricks reinforced with woven mats of reed laid horizontally on a layer of sand and gravel at certain vertical spacing) and Great Wall of China (built with clay or pounded earth reinforced with tree branches).

In Malaysia, geotextiles were the first materials to be used in the 1970s for soft ground and ex-mining land such as Kampung Pandan, soil reinforcement and in prefabricated vertical drains as filter material for ground improvements.

In 1985, geogrid products were first used by Professor F.K. Chin for the Jitra-Butterworth highway as basal reinforcement of soil embankment in soft ground.

He also used geogrids in the rehabilitation of the Petronas bungalow slope failure in Fraser's Hill in 1987. In this case, geogrid was used as soil-reinforced slope. It was also used as soil reinforcement in the repair of the Motel Desa slope failure in Terengganu in 1985 and to repair the Temerloh-Mentakab highway embankment failure with a soil reinforced slope that same year so as to build a steeper slope within the road reserve.

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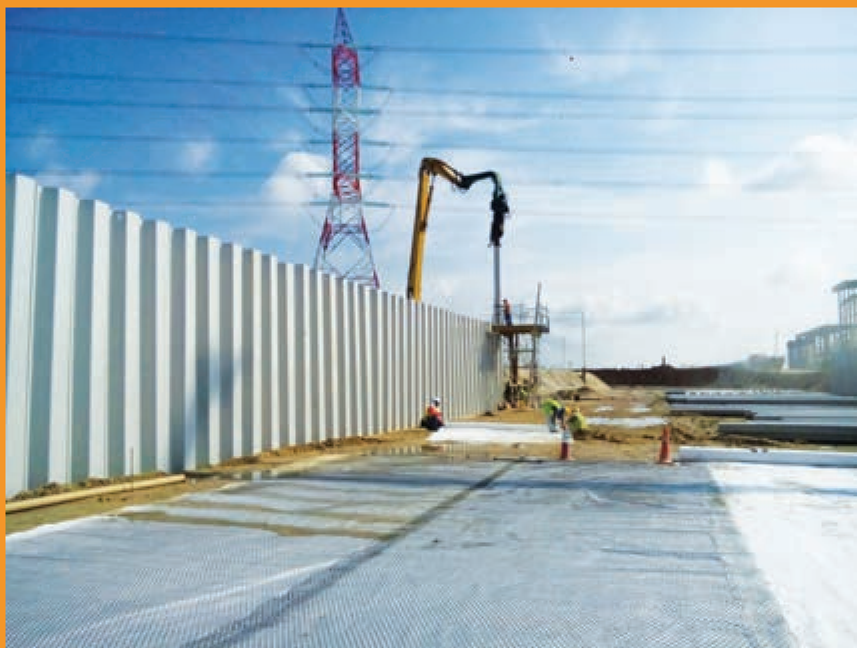


The use of geogrid in pavement design started with the Sungei Way Quarry Trial, in 1985 as well. Geogrids were also used in the world-renowned Muar Flats Embankment programme in 1987. Full-scale testing of the hexagonal/ triangular shape geogrids (TriAx) was carried out at the Q-Cell site in the Selangor Science Park in 2008/09, prior to the actual design and construction of TriAx geogrids at the site.

All these works were described in the state-of-the-art paper by Ooi & Tee, published in the SEAGS-AGSSEA Journal in March, 2011. The paper also covered many recent major slope repair works, including that at the massive landslide in Kampung Pasir in 2006.

Q Geosynthetics have emerged as exciting engineering materials with a wide range of applications. The rapidity at which the related products are being developed and used, is nothing short of amazing. What do you think are the reasons for the explosion of geosynthetic products?

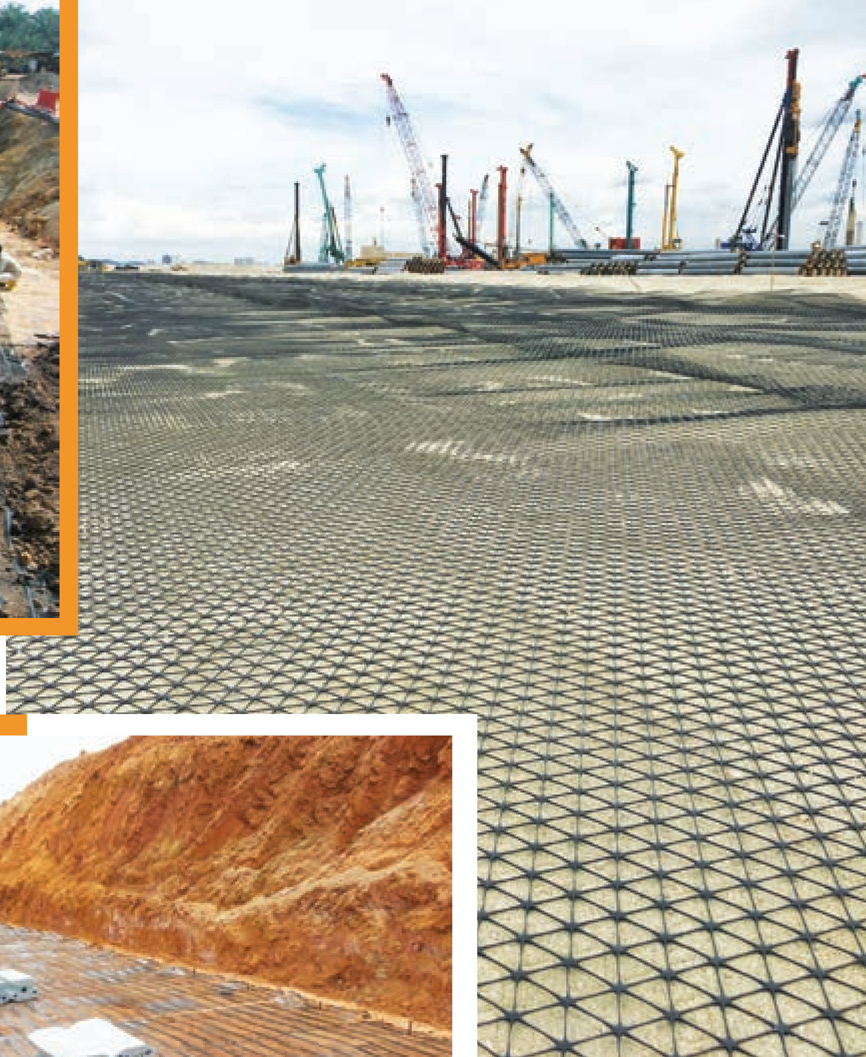
Prof. Fauziah: Some of the reasons why geosynthetics are accepted widely by the construction industry are:

- They are quality-control manufactured in a factory environment.
- They can be installed rapidly.
- They generally replace difficult designs that use soil or other construction materials.
- They are generally cost competitive when compared to soils or other construction materials. For instance, reinforcing a soil wall using geosynthetics can provide savings of 20%-50% from the conventional reinforced concrete wall.
- They allow for the reduction of carbon footprint.
- In some cases, they make heretofore impossible designs and applications possible.
- Their technical database (both design and testing) is reasonably established.
- They are being integrated into the industry via generic specifications.
- They are being actively marketed and are widely available.

Q What are the more interesting, challenging or important projects using geosynthetics that you have completed?

Dr Ooi: Some aspects of ground improvement works for the new Deep Water Port in Kampung Senari, Sarawak. Also the proceedings conference on Recent Advances in Soft Soil Engineering in Kuching, Sarawak.

Prof. Fauziah: I have not designed or been involved in any



big project but rather, I am conducting research related to reinforced earth using innovative material. My peers and fellow committee members have solved many slope-protection issues in the Bukit Antarabangsa development and in Putrajaya, they are also solving issues related to slope protection and erosion control.

Q Have geosynthetics changed the way engineers construct their projects?

Dr Ooi: Geogrid technologies help save materials and resources, contributing to more sustainable construction methods. Geogrid technologies utilise inferior in-situ materials and reduce waste as well as carbon emission.

Geotechnical design is often associated with risks, failures, disputes, rehabilitations and mitigations. The introduction of reducing carbon footprint in geotechnical works would have added some complications.

Prof. Fauziah: Yes, they have. When properly identified, the design-by-function method of geosynthetics will lead to advantages in design and applications as mentioned earlier.

Q Do Malaysian engineers use geosynthetics effectively in construction projects? What more can be done to encourage the effective and efficient adaptation of geosynthetics in the construction industry?

Dr Ooi: Every job must be designed to suit a particular requirement, as not one recipe fits all. Those in the industry who are not engineers should also not ignore the expertise of the professionals.

Prof. Fauziah: Yes, local engineers have been using geosynthetics effectively in construction projects. To further encourage their effective and efficient adaptation in the construction industry, geosynthetics can be promoted as:

- Being cheaper in cost, transport and installation.
- Being easy to design and according to functions.
- Being easy to install and flexible enough for construction

for short periods.

- Being consistency over a wide range of soils.
- Being space saving.
- Being more homogeneous than soil and aggregates for material quality control.
- Being better for construction quality control at site.
- Being easy for material deployment.
- Being less environmentally-sensitive.
- Showing improved performance and extended life.
- Increased safety factor.
- Being compatible with field conditions.

Q Do you think geosynthetics have a greater role to play in Malaysia's construction industry?

Dr Ooi: Yes. As with the rest of the world, we need to follow global trends so as not to be left out. Malaysian professionals are leaders in innovation in the use of geosynthetics, particularly in the ASEAN region.

Prof. Fauziah: Yes, of course. Geosynthetics have been progressing in many areas now. In fact, industries in Malaysia are servicing and providing technical solutions in the ASEAN region. This shows that these industries are doing well and their relevance in offering solutions to environmental/geotechnical issues. MyIGS is the Malaysian Chapter Society and the platform that brings together academics, engineers, consultants, manufacturers and suppliers to discuss improvements related to knowledge and training for the local community.

Q It has been 40 years since the first international conference on geosynthetics held in Paris in 1977. Is still room for improvement or innovation in the geosynthetics industry in terms of products and applications?

Dr Ooi: There is always room for improvement with R&D and new challenges faced by the construction industry. There needs to be new innovations as otherwise, more competitive materials will take over or the geosynthetics industry will decline and eventually disappear. For example, in this digital age, if we do not adapt, we will become obsolete. Future engineers will need to be able to work with digital data.

I am 76 years old, yet there is no end to learning for me. We need to continuously benchmark ourselves against the best. The good thing is that these days, it is easy to access information and that in itself, presents endless opportunities.

Prof. Fauziah: We have the International Geosynthetics Society (IGS) which coordinates all conferences, seminars and training all over the world. Conferences have been held in different continents and during these events, industries related to geosynthetics will exhibit their products showcasing innovative materials and construction processes. This shows the relevance of geosynthetics, which is a vital solution to many issues related to geotechnical engineering and related construction. ■

Concept of Centrifuge Modelling for Geotechnical Studies

Ir. Assoc. Prof. Dr Dominic Ong Ek Leong

In a rapidly growing urban landscape, the serviceability performance of buildings and infrastructure in tight spaces becomes as critical as its strength performance in design. With the current trend where design is heading towards performance-based, tools which can accurately predict complex soil-structure interaction becomes essential. Centrifuge technology is a powerful and useful means available to geotechnical engineers besides numerical analyses, to study real-life complex soil-structure interaction problems. Centrifuge technology can be applied to several areas within the field of geotechnical engineering, some of which are presented below.

While the failure of a building or infrastructure is considered not so common, the problems of how they deform or how they behave when acted upon by external loads, is becoming a common concern. In an interview with *Jurutera*, Professor Bolton (1) stated that "a safety factor is the ratio between an estimated material resistance or estimated resistance of the structure and the ground in some way where the load is placed upon it. As these two estimated things are somewhat imaginary and because the ratio of them has no particular physical meaning, safety factors cannot be related to observed behaviour."

In cases where means of geotechnical field testing and instrumentation may not be practical, physical models help to idealise the situations and to accurately predict complex soil structure interactions in order to ensure structural performance. Furthermore, while conventional soil mechanics laboratory tests may be useful in helping to characterise certain behaviour and properties of soils and rocks, the limitations of applying the outcomes directly to geotechnical engineering practice (e.g. three-dimensional conditions) can be overcome by physical modelling.

Early works on the use of centrifuge were noted as far back as in 1931 (2) in the USA and 1963 (3) outside of the USA and Russia. These works were related to solving mining and tectonics problems (4, 5). The development of sound principles of geotechnical centrifuge technology in the later years has contributed to a consistent increase in the number of centrifuge facilities around the world, including in the USA, UK, France, Netherlands, Canada, Singapore, Switzerland, China, Taiwan, Korea, Hong Kong and India.

In addition to the increased number, capacity and size, newer centrifuges are being built with specialised features for better measurement of model deformations including in-flight technology to simulate heating, freezing, excavations, surcharge loadings and measurement of soil strength profiles. Currently, centrifuge technology is being used to develop fundamental understanding and to resolve both common and unique problems related to various areas of geotechnical and geo-environmental engineering such as slopes, embankments, excavations, tunnelling, earthquakes, dams, mining, land reclamation and ground improvement.

THEORY OF CENTRIFUGE MODELING

The basic theory of centrifuge modelling depends on the fact that soil behaviour is governed by its natural triangular stress distribution due to the self-weight of the soil body, which is impossible to reproduce in the laboratory over real-life installation depths (e.g. a long pile).

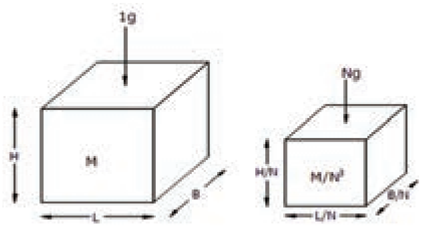


Figure 1: Basic principle of centrifuge modelling [6]

A centrifuge creates "artificial gravity" by spinning a body of soil at a constant radial velocity. This acceleration is usually defined in terms of a multiplier of gravity, or N times Gravity. As such, when increasing the gravitational force applied to the soil body, we are able to achieve similar stress distribution with depth, as experienced by the prototype in the field.

In principle, by revolving a soil body at N times Gravity, the unit stresses in the prototype can be achieved while simultaneously decreasing the scale of the model by the same ratio N (see Figure 1). While the scale of the model needs to be reduced by the ratio N, other analogous scaling laws can also be derived from this for parameters such as unit weight, velocity, force, acceleration etc. Typical scaling laws used in centrifuge modelling are shown in Table 1.

Table 1: Scaling relationships for centrifuge models

PARAMETER	PROTOTYPE (REAL-LIFE DIMENSION)	CENTRIFUGE MODEL AT Ng
Linear dimension	1	1/N
Area	1	$1/N^2$
Volume	1	$1/N^3$
Density	1	1
Mass	1	$1/N^3$
Acceleration	1	1/N
Displacement	1	1/N
Strain	1	1
Energy	1	$1/N^3$
Stress	1	1
Force	1	$1/N^2$
Time (creep)	1	1
Time (dynamics)	1	1/N
Time (seepage)	1	$1/N^2$
Flexural rigidity, EI	1	$1/N^4$
Axial rigidity, EA	1	$1/N^2$
Bending moment	1	$1/N^3$

1. ADVANTAGES AND LIMITATIONS OF CENTRIFUGE MODELLING

As with any tool, there are advantages and limitations when using the centrifuge. One major advantage is its ability to accurately model and predict various problems involving soil media.

Smaller scale models of real-life construction scenarios can be modelled and various types of miniature equipment can be installed. The soil preparation and the consolidation process / history can be controlled so as to simulate real-life situations. Commonly, miniature pore pressure transducers are employed to measure pore pressure development while Linear Variable Displacement Transducers (LVDT) and non-contact laser transducers are used to measure soil surface deformations or foundation movements. A hydraulic cylinder (actuator) is used for any movements required during high-g spinning, such as when carrying out T-bar or vane shear tests, excavation or installation of piles in-flight.

A particularly useful application is the Particle Image Velocimetry (PIV) technique, where flock particles are applied to the front face of the soil model and tracked via a series of images. Small subsets of the photographs are analysed via PIV (7) to see the overall soil movement patterns.

When the time aspect of the models is considered, the particular process that is being considered plays a significant role. For consolidation, the time scales are calculated based on the theory of consolidation by Terazaghi. By applying linear scaling laws to the governing equation for consolidation, the time scale is found to be:

$$\frac{t_{model}}{t_{prototype}} = \frac{1}{N^2} \qquad (1)$$

This suggests that the model consolidation rate is N^2 times faster than the prototype, which can be a major advantage in modelling many soil mechanics problems. For example, a soil sample which takes 3 years to achieve 95% consolidation could finish consolidation within 10.5 hours at 50g in the centrifuge.

On the other hand, time scales for dynamic problems which involve inertial effects need to consider a different scaling law where the time in the prototype is scaled as N rather than N^2 as is the case for diffusion events. Furthermore, the time scale for creep is unity. This conflict needs further consideration, especially in tests involving different types of events, such as stability of embankment during a seismic event. Before the seismic event, the consolidation time scales are used but during the event, significant water flow may be prevented due to relatively low permeability and the dynamic time scaling law is applied.

In some cases, the particular problem that is being modelled needs to be considered where one aspect of soil behaviour may be more significant than others and has to be correctly modelled.

APPLICATIONS

1. RIVERBANKS SUBJECT TO TIDAL FLUCTUATIONS

Wong, et al., (8) designed and tested a river bank slope problem where continuous tide movement resulted in a cumulative deflection of piles. The tests were carried out at the NUS Geotechnical Centrifuge Laboratory (Figure 2). The model was set up in a container with a back panel which contained a water tank that could be moved up and down (Figure 3). The tank movement draw-downs or raises the water level in the model river bank, simulating tide movements. Model piles were installed with attached

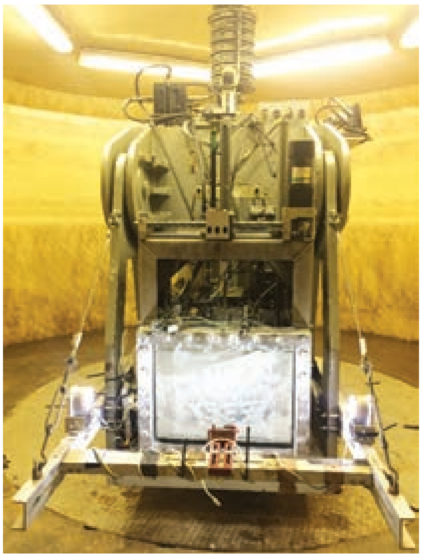


Figure 2: Riverbank slope model set up at NUS geotechnical centrifuge laboratory

Figure 3: Water tank fixed to back panel of container to simulate tidal fluctuation [8]

strain gauges while lasers were used to measure pile head deflection.

The maximum lateral soil movements (Figure 4) and bending moments occurred at the mid-slope locations and showed a decreasing trend over time while pile head movements were observed to increase over continuous cycles, reaching an asymptote (Figure 5).

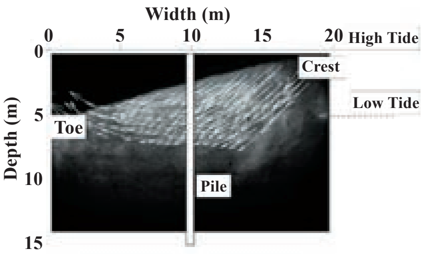


Figure 4: Soil movements captured using imaging and PIV techniques [8]

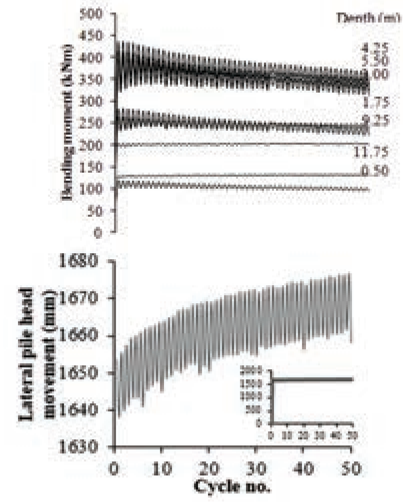


Figure 5: Development of pile bending moment and head movements over continuous cycles of fluctuations [8]

With each cycle of drawdown, the slope moved towards the river and during the subsequent water level rise, the slope rebounded from the river but did not completely recover. Thus, a cumulative movement is seen over 50 cycles of fluctuation. Using miniature PPT embedded in the slope, it was observed that negative pore water pressures accumulated at the mid-slope and toe levels, possibly due to this cyclic shearing of the soil slope. The increase in the effective stresses due to the development of excess pore water pressure would reduce the bending moments over time. On the other hand, the creeping behaviour of the slope over each cycle would drag the pile with the slope, thus

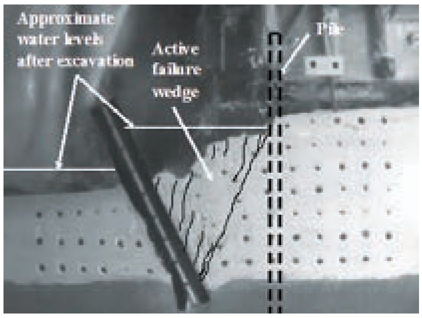


Figure 6: High resolution pictures showing failure mechanism of soil behind retaining wall [10]

showing a continuous increase in pile head movements.

These observations suggest that, in the short term, bending moments were more critical. Meanwhile, due to the continuing increase in pile head movement, an uncapped pile foundation system can be vulnerable when embedded in the riverbank and can face serviceability issues in the long-term.

2. DEEP EXCAVATIONS AND TUNNELS

Ong, et al., (9) and *Leung, et al., (10)* carried out a series of tests to determine the behaviour of piles behind a stable and failing retaining wall (see Figure 6), respectively. By controlling the amount of fluid in the latex bag, the excavation process could be sequentially modelled in-flight.

The test results showed that after excavation, the generated excess negative pore pressure would dissipate, resulting in a continuous increase in pile bending moment as well as pile head movements even after the excavation had ceased.

Tunnel construction is another area where centrifuge can be used to study the detrimental effects of induced vertical and lateral movements on the existing foundations of buildings above and near the affected areas. *Sharma, et al., (11)* used a relatively new approach to model tunnel construction in a centrifuge i.e. by using polystyrene foam which could be dissolved in-flight using acetone. Thus, proper construction sequence can be simulated. The tunnel lining was installed with strain gauges and the surface measurements carried out with LVDT for subsequent interpretation of soil-structure interaction.

3. SEISMICITY AND DAMS

Seismic events or earthquakes are modelled in the centrifuge by using shaking tables and shear boxes. A rare and interesting case is where dams are modelled for earthquake scenarios. In case of concrete dams, the energy required to fracture and for cracks to form, is dependent on grain size. Scaling down the size of aggregates used in concrete so as

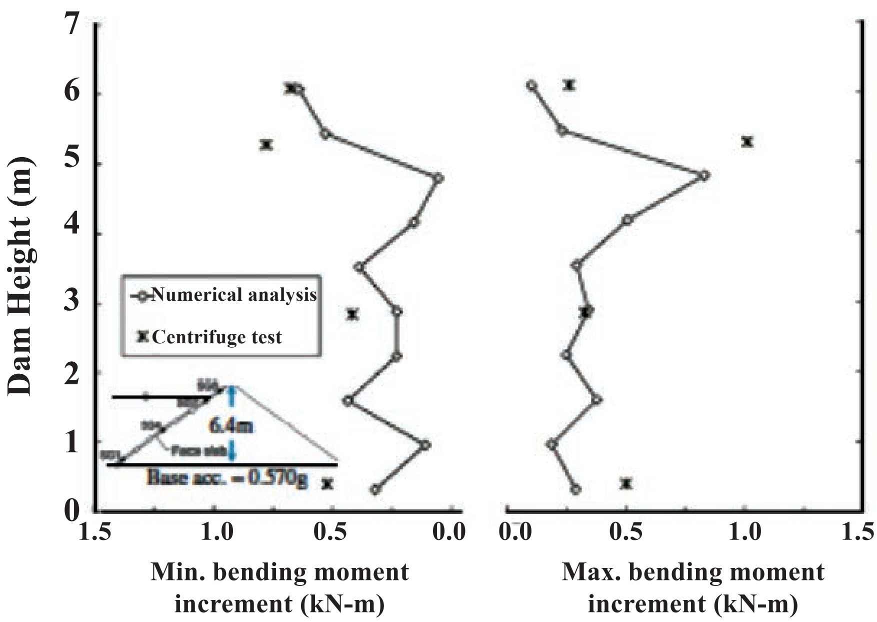


Figure 7: Comparison of centrifuge test and numerical analysis [12]

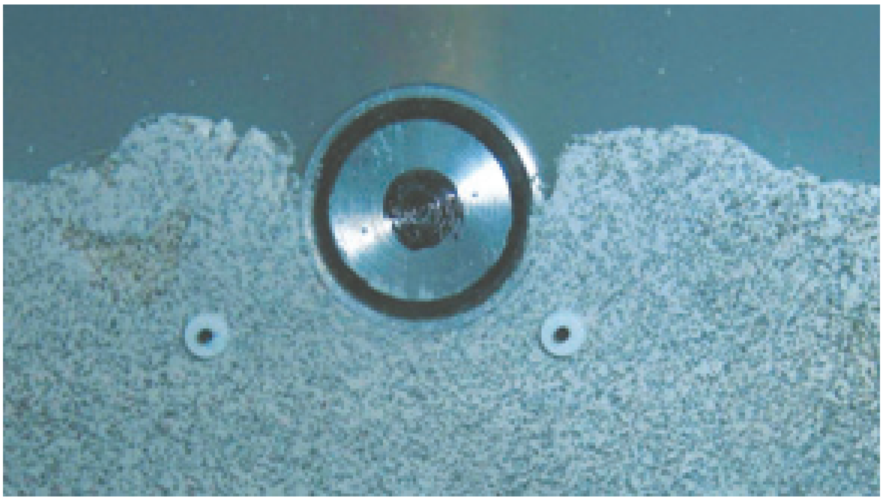


Figure 8: Model pipe on seabed as seen through a perspex window [13]

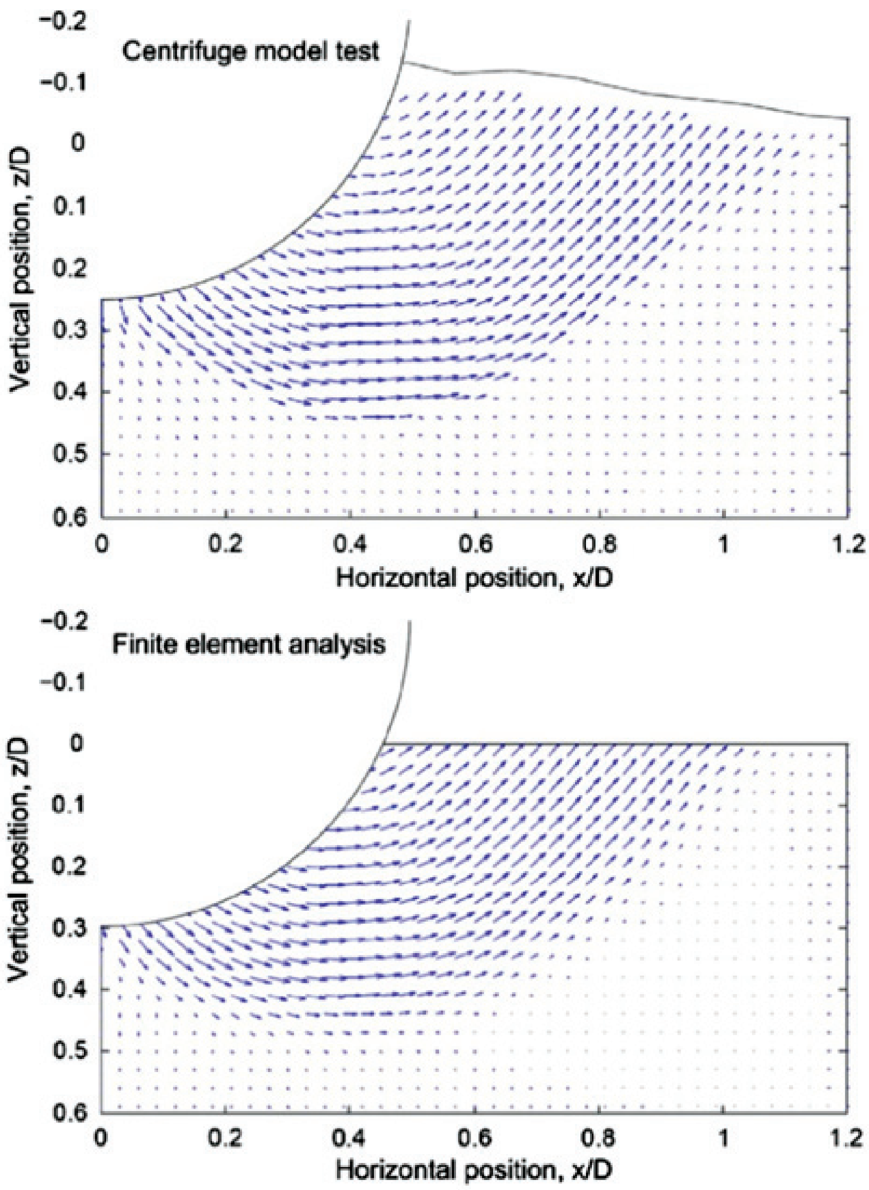


Figure 9: Comparison of soil vectors from centrifuge and numerical tests [14]

to achieve the same concrete as the prototype means that dam failure mechanism will be affected.

The scaling of energy and particle sizes will mean a special mix of concrete is required. Furthermore, in order to simulate the correct pore pressure response, high viscosity fluid has to be used to saturate the soil.

Kim, et al. (12) successfully carried out dynamic centrifuge tests on two major dam types: Earth-core rockfill dam and concrete-faced rockfill dam. They found that residual settlements and displacements were relatively small and failure mostly occurred by surface sliding. Furthermore, they verified their findings by carrying out numerical analyses. The results of the analysis closely resembled the results of centrifuge tests (Figure 7).

4. OFFSHORE INFRASTRUCTURE

Offshore infrastructure, as used in the oil and gas industry, is a unique situation where environmental loading plays an important role. A lot of research has been carried out in this area, including studies on offshore foundation systems, anchoring systems, submerged pipelines and submarine landslides.

A common application in this field is to model soil-pipe interactions on a sea bed. *Dingle, et al., (13)* carried out studies on the embedment and lateral breakout mechanism of pipes in soft clay. Using high-resolution pictures (Figure 8) to capture soil behaviour and load displacement data from the centrifuge tests, the brittle breakout mechanism was identified.

Furthermore, soil vectors generated from the images during centrifuge testing closely followed the results from numerical studies (Figure 9).

CONCLUSION

Centrifuge technology presents many advantages in terms of time, cost, repeatability (consistency) and quality of acquired data if the centrifuge model is diligently idealised, based on the established scaling laws and sound geotechnical engineering knowledge.

While designing for strength based on a given factor of safety is still common, performance-based design is becoming as important. With the increasing number of centrifuge facilities being constructed in Asia, coupled with more innovative test methods being applied in centrifuge modelling, this means that engineers now have the opportunity to perform forensic engineering and parametric study on challenging and complex real-life geotechnical problems, which would otherwise be too costly to test (e.g. fullscale test).

The ability to study and understand a potential failure mechanism is the basis for developing innovative engineering solutions. Therefore, centrifuge modelling can be readily used to verify complex soil-structure interaction problems and to complement numerical modelling, laboratory testing as well as field observational approach. ■

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Authors' Biodata

Ir. Assoc. Prof. Dr Dominic Ong Ek Leong, *obtained his Bachelor's Degree from the University of Western Australia (UWA) and his PhD in Geotechnical Engineering from the National University of Singapore (NUS). He is currently an Associate Professor and Director of the Research Centre for Sustainable Technologies, Faculty of Engineering, Computing & Science, Swinburne University of Technology Sarawak Campus and an EXCO Member of the Association of Consulting Engineers Malaysia (ACEM) Sarawak Branch, Vice-Chairman Institution of Engineers Malaysia (IEM) Sarawak Branch and a Founding Member of the Malaysian Geotechnical Society (MGS) and the Malaysian Society for Trenchless & Tunnelling Technology (MSTTT).*

He is also an Editorial Board Member of the UK's Institution of Civil Engineer (ICE) journal, Geotechnical Research and SEA Geotechnical Society's Geotechnical Engineering journal.

IEM DIARY OF EVENTS

Title: 2-Day Course on Executive Management In Primavera P6

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Organised by: Project Management Technical Division
Time : 9.00 a.m. - 5.30 p.m.
CPD/PDP : 14

Title: 2-Day Seminar on "Fire Control Concept & Design of Active Wet System"

24-25 January 2018

Organised by: Building Services Technical Division
Time : 8.30 a.m. - 5.15 p.m.
CPD/PDP : 13

Title: Talk on "Introduction to BIM for Civil and Structural Engineeers Series - Overview and the Malaysia Roadmap" (2nd Session)

25 January 2018

Organised by: Civil & Structural Engineering Technical Division
Time : 5.30 p.m. - 7.30 p.m.
CPD/PDP : 2

Title: 5-Day Course on PMP Exam Prep Combo

5-9 February 2018

Organised by: Seniors Special Interest Group & Project Management Technical Division
Time : 9.00 a.m. - 5.00 p.m.
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Kindly note that the scheduled event is subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.

CONGRATULATIONS

Congratulation to ***Ir. Dr Ahmad Anuar bin Othman*** *on being promoted as* ***State Director, Jabatan Pengairan Dan Saliran Negeri Perak (JPS)*** *on* ***15 December 2017****.*

Geosynthetics Engineering

Mr. Tee Choon Heng

In the 1970s, geotextiles (geosynthetics) were largely ignored by geotechnical engineers who thought the only supplier of geotechnical materials was GOD. However, the abundantly available natural soil is sometimes far from being an ideal construction engineering material. In general, soil is inherently weak in tension, shear and can be compressible with poor drainage property. Adding geosynthetics to soil would convert it into a composite material with enhanced properties.

Since the 1980s, geotextiles have progressively pervaded all branches of geotechnical engineering. This may yet be one of the most important revolutions to date in the history of geotechnical engineering.

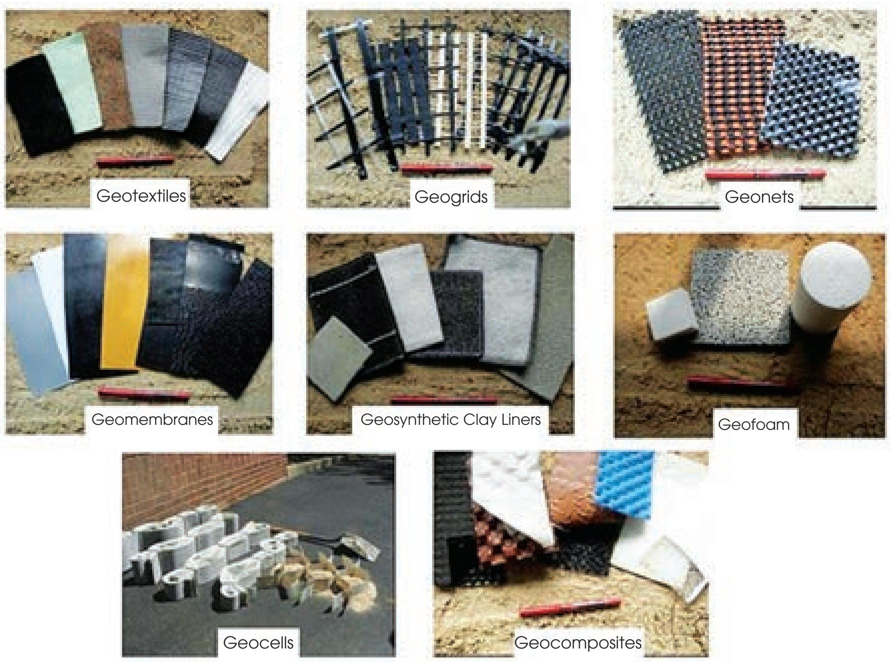
DEFINITION

Geosynthetics are defined as "planar products manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made product, structure or system" – ASTM Committee D35 (1984).

Geosynthetics can be formed by manufacturing processes such as extrusion, spinning, stretching, weaving and bonding. Typically, they are composed of one or more of polymers such as polyethylene (PE), polypropylene (PP), polyesters (PET), polyamide/Nylon (PA), polyvinyl chloride (PVC), Polyvinyl Alcohol (PVA), Polystyrene (PS). Geosynthetics may also be combined with carbon fibre, glass fibre, natural fibre materials and other materials such as bentonite.

In Geotechnical Engineering applications, geosynthetics can be used to separate materials, reinforce soil, permit drainage, provide filtration or act as impermeable barrier. Types of geosynthetics and their key functions are listed below:

- Geotextiles - drainage, filtration, separation, protection.
- Geogrids - reinforcement, stabilisation.
- Geomembranes -fluid barrier, liner.
- Geonets – drainage.
- Geofoam - lightweight fills, insulation.
- Geocomposites - liner, combination of functions.
- Electrokinetic geosynthetics – incorporates electrokinetics to traditional functions.



Types of Geosynthetics

Geosynthetics are being used extensively in geotechnical, transportation, environmental and hydraulic engineering as well as to provide technically efficient, cost effective, environment-friendly and/or energy-efficient solutions to a wide range of civil engineering problems. Hand in hand, rational design methods are now available, based on sound engineering concepts and standardised testing methods to determine engineering properties to geosynthetics and geosynthetics engineered composites.

Geosynthetics Engineering is fast gaining prominence worldwide to deal with the application of scientific principles and methods to the acquisition, interpretation and use of knowledge of geosynthetic products for the solution to geotechnical, transportation, environmental, hydraulic and other civil-engineering-related problems.

GEOSYNTHETICS IN MALAYSIA

Introducing any state-of-the-art technology to the local industry is never an easy task. It is particularly

challenging in the absence of specific codes of practice for such new technology or product. The new technology may have gained acceptance worldwide, but the local industry will still demand a local case history to be convinced. This is a chicken-and-egg situation. If it is not accepted in the first instance, there cannot be a local case history!

In the case of the first application of geogrid in Malaysia, the late Professor Chin Fung Kee took a bold step when he designed and introduced the application of geogrids in the Jitra-Butterworth Expressway in 1985. This small proactive action would eventually be a big step in the development of Geosynthetics Engineering in Malaysia. Since then, the achievements using geosynthetics material in engineering practice in Malaysia has been impressive.

IEM has organised many conferences, workshops and lectures to promote and develop the applications of geosynthetics here. These include:

- Symposium on Application of Geosynthetic and Geofibre in Southeast Asia (1989).
- Workshop on Geotextile Design and Applications (1992).
- 2nd Asian Geosynthetics Conference (2000).

On the international front, the International Geosynthetics Society (IGS) is dedicated to the scientific and engineering development of geotextiles, geomembranes, related products and associated technologies. (More at www.geosyntheticssociety.org).

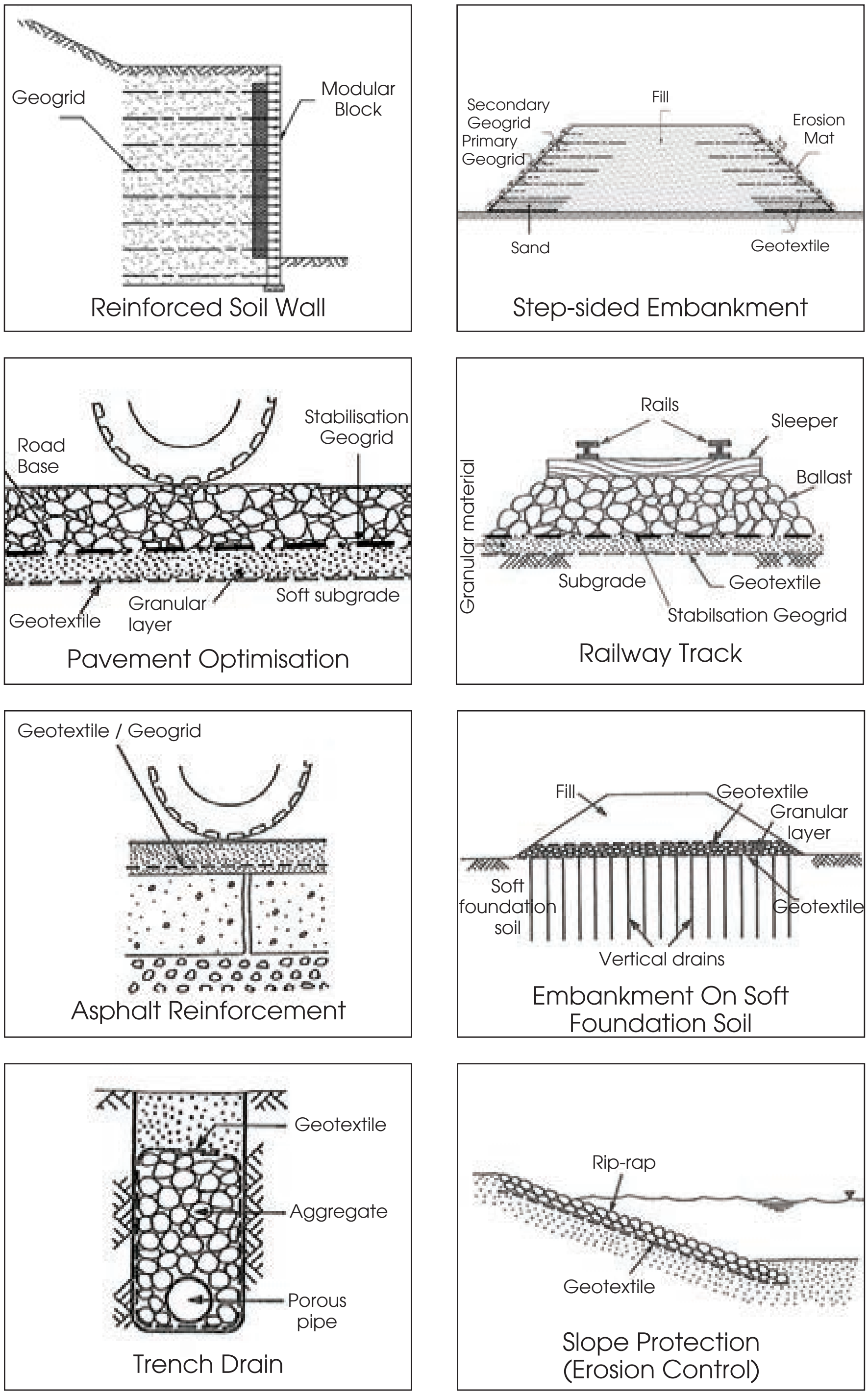
The core purpose of IGS is to provide an understanding of and to promote the appropriate use of geosynthetic technology globally. The society envisions that, in the near future, geosynthetics will become indispensable to the point that they will be regularly included in engineering curricula and relevant design standards.

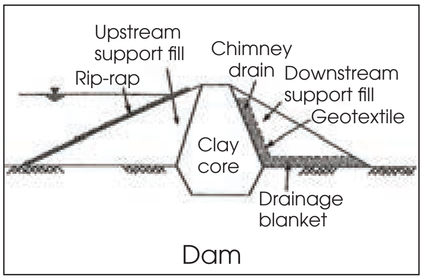
The flagship events of IGS are the international and regional conferences. The International Conference is held once every 4 years while the Regional has the same structure but in years alternate to the International Conference. Each national chapter hosts conferences each time. It allows the chapters to improve involvement, community and geosynthetics success locally and regionally.

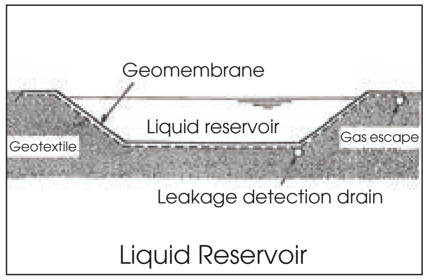
Since its beginning in the early 1990s, IGS membership has grown to over 4,000 and includes corporations, professionals, individuals and students. With 43 chapters worldwide, it's easy to be involved with the society by joining a local IGS chapter.

Malaysia's first application of geogrid in Jitra-Butterworth Expressway (1985)

Typical Applications Of Geosynthetics In Malaysia







IGS publishes two journals, a peer-reviewed technical journal, *Geosynthetics International* and *Geotextiles & Geomembranes*.

Founded in 2014, the Malaysia Chapter (MyIGS) is officially registered as Pertubuhan IGS Malaysia. Its members comprise a healthy mix of academicians, consultants, contractors, manufacturers, distributors and installers. Over the past few years, MyIGS had collaborated with IEM's Geotechnical Engineering Technical Division to deliver a few evening lectures and talks.

The continuous research & development in Geosynthetics Engineering is achieved through the efforts of all parties in the industry. The current infrastructure construction such as highways, railways, airports, urban developments as well as preservation of the ecological environment have all benefited tremendously through the use of this new, innovative construction material/technology in meeting the requirements of quality, time and cost. ■

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Author's Biodata

***Mr. Tee Choon Heng**, Director of Mega Geoproducts and Services Sdn. Bhd., is a pioneer in the application of geosynthetics in Malaysia since 1986. He distributes Tensar geogrids and involves in the design and construction of reinforced soil structures.*

Every year for the IEM Council election, some 9,000 ballot papers are sent out to corporate members. Out of the 9,000, less than 2,000 papers are returned.

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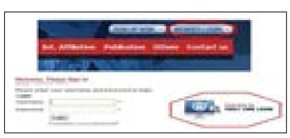

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Comparison of Friction Angle Measured in Square and Circular Direct Shearbox Tests


Ir. Dr Chan Swee Huat


Wong Soon Yee


Dr Wong Kim Yuen

This article deals with drained direct shearbox tests on sand. The objective is to investigate whether the shape and size of the shearbox affect the determined friction angle (Ø).

In a direct shearbox test, soil is laterally restrained (upper box) and sheared (lower box) along a mechanically induced horizontal plane, while subjected to a pressure applied normal to that plane, as shown in Figure 1. The shearing resistance offered by the soil as one portion is made to slide on the other is measured. Failure occurs when the shearing resistance reaches the maximum value which the soil can sustain. By carrying out tests on a set (usually three) of similar specimens of the same soil under different normal pressures, the relationship between measured shear stress at failure and normal applied stress is obtained. If it can be assumed that the relationship is linear, the slope of the line and its intercept with the shear strength axis can be derived from the line of best fit through the plotted points. The slope gives the friction angle, Ø (in degrees), and the intercept gives the apparent cohesion, *c* (in kPa) (BS 1377-7:1990+A1).

According to the Mohr-Coulomb failure criterion, the strength or shear resistance (τ) of soil is given by:

$$\tau = \sigma \tan(\phi) + c \qquad (1)$$

For a non-cohesive soil, e.g. sand, *c* can be ignored.

RELATIVE DENSITY OF SAND

One of the important variables that would affect the results of a direct shearbox test on sand is in the state of sand packing, which can be expressed in terms of relative density, void ratio, porosity or dry density. The term relative density, which is also known as density index, I_D, is used to describe the denseness or looseness of soil. The index relates dry density (or void ratio) of a soil sample or of an in-situ soil, to the limiting dry densities (or limiting voids ratios). The relationship can be defined in terms of maximum and minimum dry densities as follows:

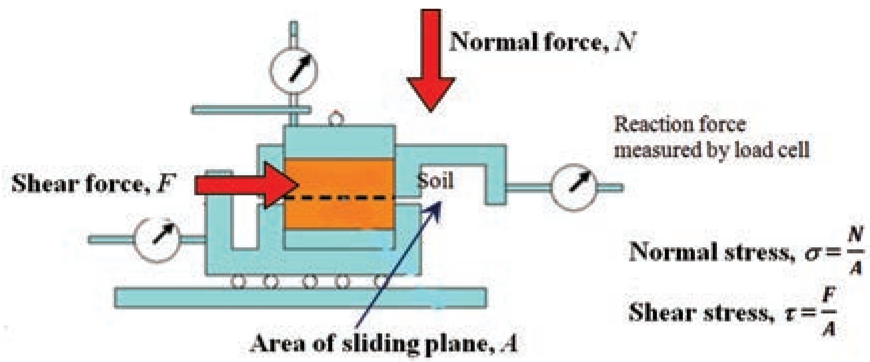

Figure 1: Principle of direct shearbox test

$$I_D = \frac{\rho_d - \rho_{dmin}}{\rho_{dmax} - \rho_{dmin}} \times \frac{\rho_{dmax}}{\rho_d} \times 100\% \qquad (2)$$

where ρ_d denotes the dry density of the soil in question, ρ_d min the dry density at the least dense state, and $\rho_{d\ max}$ the dry density at the densest state.

The British Standard, BS 1377-4:1990+A2 contains the methods of test for determination of maximum and minimum dry densities of sand. Subclause 4.2 of the related standard is used for the determination of maximum density and Subclause 4.4 for minimum density. Table 1 shows the commonly used qualitative descriptions of granular soil deposits.

TEST STANDARDS FOR DIRECT SHEAR

1. BRITISH STANDARD

The British Standard (BS) describing

Table 1: Qualitative descriptions of granular soil deposits

DESCRIPTION	RELATIVE DENSITY, ACCORDING TO LAMBE AND WHITMAN (1969) (%)	RELATIVE DENSITY, ACCORDING TO DAS AND SOBHAN (2014) (%)
Very loose	0 - 15	0 - 15
Loose	15 - 35	15 - 50
Medium dense	35 - 65	50 - 70
Dense	65 - 85	70 - 85
Very dense	85 - 100	85 - 100

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methods of test for soils for civil engineering purposes is BS 1377. This series contains nine parts, in which Part 7 contains the methods of test for direct shear. Clause 4 – Determination of shear strength by direct shear (small shearbox apparatus) in BS 1377-7:1990+A1 is applicable in this study.

2. ASTM STANDARD

The American Society for Testing and Materials (ASTM), since 1898, is one of the largest voluntary standards developing organisations in the world. The direct shearbox test reference is ASTM D3080/D3080M: 2011 Standard test method for direct shear test of soils under consolidated drained conditions.

3. CHOICE OF TEST STANDARD

In this study, the British Standard is used for shearbox of square shape and the ASTM Standard for the circular shape. It is noted that the BS covers only square shaped shearboxes while the ASTM covers both the square and circular shapes.

4. RESEARCH FRAMEWORK

The project problem is defined by deductive reasoning on how the box shape and size will influence the friction angle determined by a direct shearbox test. In a narrow sense, two types of sand with different grading are considered in order to effectively manage the project deliverables. The three relevant aspects (variables) of interest are: (a) box shape and size, (b) relative density, and (c) friction angle. The concepts relating to the variables can then be developed into a theoretical framework.

As a technical condition or pre-requisite, "relative density" can be a moderating variable that is related to the test method which delivers the result. The prevalent theory is that the "friction angle" is influenced by the "Test Method". Only the relative density seems to contribute to friction angle. In the preceding situation, friction angle is the dependent variable that will be positively influenced by the box shape and size (independent variable). Thus, the conceptual relationship between Test Method and Result has now become contingent on the Procedure (categorised as either loose or dense) in acting as a catalyst. This Procedure becomes the moderating variable. The concepts relating to variables and the theoretical framework are presented in Figure 1.

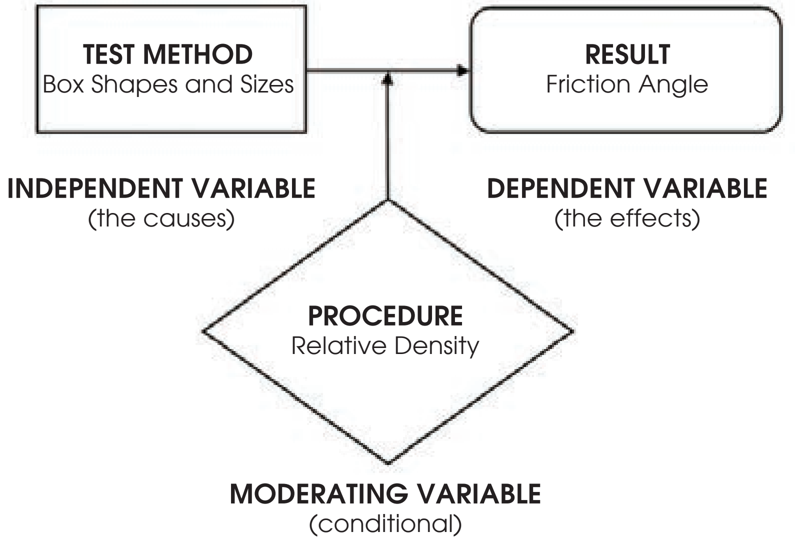

Figure 2: Concepts relating to variables and theoretical framework

While the study of friction angle (dependent) can influence box shape and size (independent) in a certain way, the possibility of the relative density (moderating) variable in modifying the independent and dependent relationship can also present a contingent effect. In other words, box shape and size can be selected independently with the expected or perceived friction angle and the relative density effects. However, to apply the potential benefits of box shapes and sizes, the friction angle will have to be analysed and verified by conducting laboratory tests at pre-determined or controlled cause-effect relationships.

RELATED LABORATORY TESTS

Other than the direct shearbox test, the study also involves other related laboratory tests to characterise the sand sample used. The five related laboratory tests are bulk density, particle density (or specific gravity), maximum dry density, minimum dry density and particle size distribution tests.

1. **Bulk Density Test:** This is performed according to BS 1377-2:1990+A1, Subclause 7.2 – Linear measurement method. This procedure applies to soils that can be formed into a regular geometric shape, the volume of which could be calculated from linear measurements of known area of the box and the height of the test specimen. The test specimen density, ρ (in Mg/m^3), is calculated from the following equation.

$$\rho = \frac{1000m}{AH} \quad (3)$$

   where m denotes the specimen mass (in g), A the specimen area (in mm^2), and H the specimen height (in mm).

2. **Particle Density Test:** This is performed according to BS 1377-2:1990+A1, Subclause 8.3 – Small pyknometer method. This test is suitable for soils consisting of particles finer than 2 mm. The particle density of the soil, ρ_s (in Mg/m^3), is calculated from the following equation.

$$\rho_s = \frac{m_2 - m_1}{(m_4 - m_1) - (m_3 - m_2)} \quad (4)$$

   where m_1 denotes the mass of density bottle; m_2 the mass of bottle and dry soil; m_3 the mass of bottle, soil and water; and m_4 the mass of bottle when full water only.

3. **Maximum and Minimum Dry Density Tests:** These are performed according to BS 1377-4:1990+A2,


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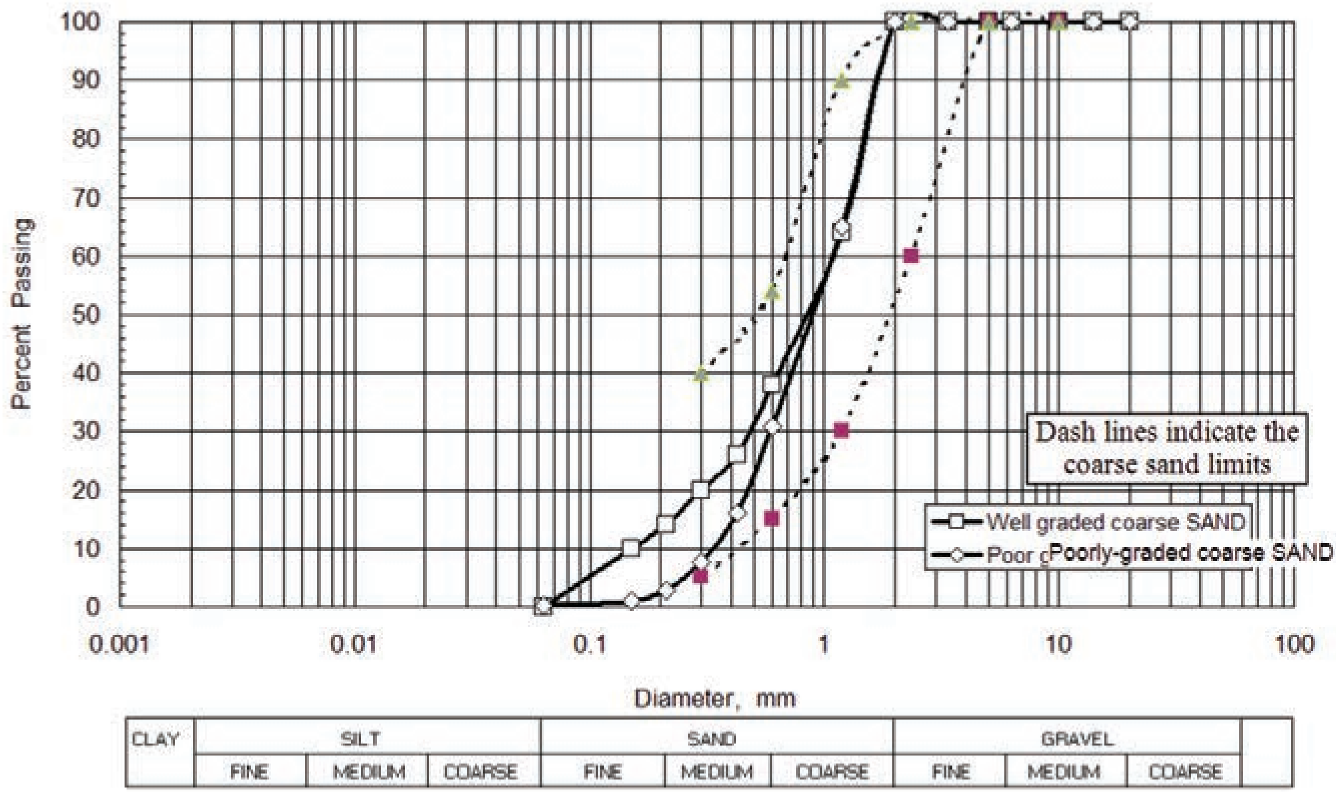

Figure 3: Particle size distribution of sand sample used

Table 2: Sand characteristics

Soil Type	ρ_s (Mg/m³)	$\rho_{d\,min}$ (Mg/m³)	$\rho_{d\,max}$ (Mg/m³)	d_{10} (mm)	d_{30} (mm)	d_{60} (mm)	$C_c = \frac{d_{30}^2}{d_{60} \times d_{10}}$	$C_u = \frac{d_{60}}{d_{10}}$	Remark
Poorly-graded sand	2.65	1.418	1.765	0.35	0.6	1.1	0.9	3.1	$C_c < 1$ and $C_u < 6$
Well-graded sand	2.65	1.460	1.822	0.15	0.5	1.1	1.5	7.3	$1 < C_c < 3$ and $C_u \geq 6$

Notes:
1. *d_{10}, d_{30} and d_{60} denote the diameters corresponding to 10%, 30% and 60% finer, respectively, in Figure 3.*
2. *C_c denotes the coefficient of gradation or coefficient of curvature, and C_u the uniformity coefficient.*

Table 3: Test specimen density computation

	Box size (mm)	60 x 60			100 x 100			60 dia.			100 dia.		
Poorly-graded	Specimen state	L	MD	D	L	MD	D	L	MD	D	L	MD	D
	Relative density (%)	22	52	72	22	52	72	22	52	72	22	52	72
	Specified dry density (Mg/m³)	1.482	1.580	1.652	1.482	1.580	1.652	1.482	1.580	1.652	1.482	1.580	1.652
	Soil weight (g)	112	119	125	311	332	349	88	94	98	244	261	273
Well-graded	Box size (mm)	60 x 60			100 x 100			60 dia.			100 dia.		
	Specimen state	L	MD	D	L	MD	D	L	MD	D	L	MD	D
	Relative density (%)	22	52	72	22	52	72	22	52	72	22	52	72
	Specified dry density (Mg/m)	1.527	1.628	1.704	1.527	1.628	1.704	1.527	1.628	1.704	1.527	1.628	1.704
	Soil weight (g)	115	123	129	321	342	358	91	97	101	252	269	281

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Subclause 4.2 – Determination of maximum density of sands and Subclause 4.4 – Minimum density of sands, respectively. The density index, I_D (%) can be calculated from Eq. (2).

4. **Particle Size Distribution Test:** This test is performed according to BS 1377-2:1990+A1, Clause 9 – Determination of particle size distribution. The test specimen is verified to meet the requirements specified in BS882:1992, under the coarse sand limits (dash lines in Figure 3).

SAMPLE TYPE AND TEST SPECIMEN CRITERIA

1. **Sample Type:** The sand used in this project is characterised using the five related laboratory tests described in Section 4. The results obtained are summarised in Table 2 and Figure 3.

   The grain size of the coarse sand is verified to be suitable and meets the requirements of the small shearbox apparatus, as follows:

- The size of the largest particle (2-2.5mm) shall not exceed one-tenth of the height of the specimen of 20 to 25mm box height.
- The minimum specimen diameter for circular specimens, or width for square specimens, shall be 50mm or not less than 10 times the maximum particle size diameter, whichever is larger, and shall conform to the width to thickness ratio of 2.
- The minimum initial specimen thickness shall be 0.5 in. (12 mm), but not less than six times the maximum particle diameter.

2. **Shearbox Test Specimen:** It is necessary to have a Procedure to replicate sand preparation to the specified dry density so that results of the friction angle in the Test Method can be compared and validated. A trial and error procedure is used in a test specimen preparation. The proportion of the sample to be well-graded in test specimen is prepared. The specified dry densities for loose (L), medium dense (MD) and dense (D) are then based on determined index of relative density. The computed density values are derived from relative density and are summarised in Table 3.

3. **Method of Sand Deposition:** A loose test specimen is prepared according to BS 1377-7:1990+A1, Subclause 4.4.4.2 – Dry Sand: Loose. The loose density state is achieved by rapid pouring of a test specimen into the shear box from a small height (25mm). The surface of the specimen is levelled using a suitable tool (extrusion dolly) to achieve the required thickness. The required soil weight for specified loose density is presented in Table 3. A medium dense or dense test specimen is prepared according to BS 1377-1:1990+A1, Subclause 7.7.4.2.2 – Compaction to specified density. The specimen is compacted in the shearbox in three different layers by light tamping for 25 times per layer. The required soil weight for specified dense density is presented in Table 3. The sample designation for each test specimen is presented in Table 4.

Table 4: Shearbox test specimen designation

Grading type	PG = Poorly-graded		WG = Well-graded
Prefix	S = Square shape		C = Circular shape
Size	60 = 60 mm		100 = 100 mm
Relative density	22% (L = Loose)	52% (MD = Medium dense)	72% (D = Dense)

RESULTS AND ANALYSIS

The friction angles obtained from all the shearbox tests performed are presented in Table 5. A total of 24 cases are studied, i.e. 2 (grading: poorly-graded & well-graded) × 2 (shape: square and circular) × 2 (size: 60 mm and 100 mm) × 3 (relative density: loose, medium dense and dense) = 24 cases. The friction angles are projected by best line fit, on the assumption that there is no cohesion for remoulded coarse sand. The ultimate shear strengths are taken at the end

Table 5: Direct shearbox test results

1	2	3	4	5
Test Specimen	γ_d (Mg/m³)	I_D (%)	φ (°)	Range of Error ± (°)
PGS60	1.482	22 (L)	39 (39)	0.2 (0.2)
	1.580	52 (MD)	39 (45)	0.2 (0.1)
	1.652	72 (D)	39 (47)	1.3 (1.1)
PGS100	1.482	22 (L)	39 (39)	0.2 (0.2)
	1.580	52 (MD)	38 (44)	1.4 (1.1)
	1.652	72 (D)	37 (47)	0.1 (1.1)
PGC60	1.482	22 (L)	43 (43)	0.1 (0.1)
	1.580	52 (MD)	43 (49)	0.1 (0.1)
	1.652	72 (D)	43 (53)	0.3 (0.1)
PGC100	1.482	22 (L)	39 (39)	0.3 (0.3)
	1.580	52 (MD)	39 (46)	0.9 (1.3)
	1.652	72 (D)	39 (48)	1.1 (1.0)
WGS60	1.527	22 (L)	40 (40)	0.3 (0.3)
	1.628	52 (MD)	41 (50)	0.4 (1.3)
	1.704	72 (D)	41 (54)	0.1 (1.1)
WGS100	1.527	22 (L)	40 (39)	3.0 (3.0)
	1.628	52 (MD)	39 (44)	3.1 (1.0)
	1.704	72 (D)	36 (48)	0.6 (0.9)
WGC60	1.527	22 (L)	40 (40)	0.5 (0.5)
	1.628	52 (MD)	41 (47)	1.1 (0.4)
	1.704	72 (D)	40 (51)	4.5 (2.6)
WGC100	1.527	22 (L)	40 (40)	0.1 (0.1)
	1.628	52 (MD)	38 (44)	0.1 (0.7)
	1.704	72 (D)	38 (48)	1.2 (0.1)

Note: Values in parentheses in Columns 4 and 5 indicate peak friction angles

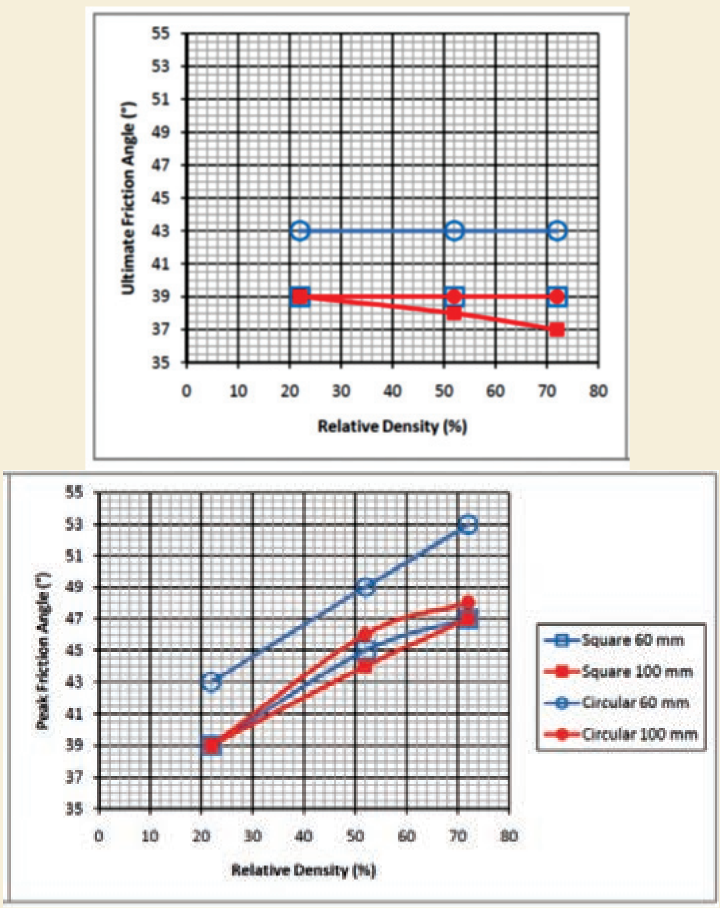

Figure 4: Ultimate and peak friction angles obtained in poorly-graded sand

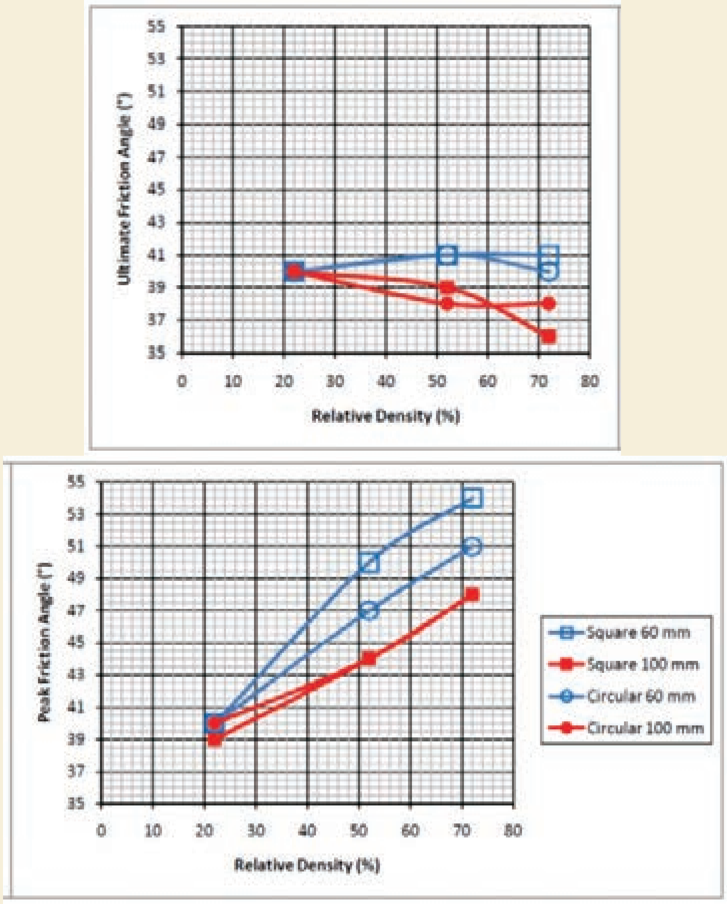

Figure 5: Ultimate and peak friction angles obtained in well-graded sand

of 10 mm travel (displacement) of the box capacity. From the stress paths analysis, noticeable peak shear strengths are observed in the medium dense and dense states.

The ultimate and peak friction angles of sand as a function of relative density are presented in Figure 4 for the poorly-graded sand, and Figure 5 for the well-graded sand. The following observations can be made from Figures 4 and 5.

a) In all cases, the peak friction angle increases with relative density.
b) The ultimate friction angle is not or slightly affected by relative density.
c) In most cases, the ultimate and peak friction angles decrease with shearbox size. Hence, the use of shearbox size of 60 mm in determining friction angle may be risky.
d) In general, for the shearbox size of 100 mm, square and circular shearboxes give approximately the same friction angles with an occasional maximum variation of about 2º.
e) However, for shearbox size of 60 mm, the square and circular shearboxes give different friction angles in most cases with a general variation range of about 3º to 6º.

CONCLUSION

The following conclusions can be drawn from this study:

1. The ultimate and peak friction angles decrease with shearbox size. The use of shearbox size of 60 mm in determining friction angles may be risky.
2. Compared to the shearbox size of 60 mm, the square and circular shearboxes of size of 100 mm give more similar friction angle values.
3. Shearbox size of 100 mm, either square or circular, is preferable to the size of 60 mm in determining ultimate and peak friction angles. ■

REFERENCES

[1] ASTM D 3080/3080M:2011, *Standard Test Method for Direct Shear Test of Soils under Consolidated Drained Conditions*.

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[3] Das B.M. and Sobhan K. *Principles of Geotechnical Engineering*. 8th Ed., Cengage Learning, Australia, 2014.

[4] Lambe T.W. and Whitman R.V. *Soil Mechanics*. John Wiley & Sons, New York, 1969.

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One-Day Seminar on Response of Buildings to Excavation-Induced Movements

GEOTECHNICAL ENGINEERING TECHNICAL DIVISION

reported by

Ir. Dr Gue Chang Shin

IEM's Geotechnical Engineering Technical Division (GETD) invited Er. Dr Oskar Sigl of Geoconsult Asia Singapore and Er. Dr Goh Kok Hun of Land Transport Authority of Singapore, to deliver a talk at the Hilton Petaling Jaya Hotel on 22 August, 2017. The seminar, chaired by Ir. Dr Gue Chang Shin, was attended by 128 participants. It covered four key areas:

- Evaluating the impact of underground construction on buildings.
- Analysis of ground movements: Simplified approaches for difficult situation.
- Influence of building stiffness and case studies of building response to underground construction.
- Analysis and impact assessment of underground construction on existing rail infrastructures.

Dr Goh began the first session by showing that main movements due to underground constructions are typically from tunnelling and deep excavations. Ground movements, particularly settlements from tunnelling, can be reasonably predicted using Gaussian curves based on volume loss (volume of surface settlement trough over the volume of excavated tunnel).

For deep excavations, Finite Element Method (FEM) is valuable in modelling construction processes where various stages of excavations can be simulated. It is also useful to verify FEM using empirical correlations. He then introduced the framework for a 3-staged risk assessment of building damage as depicted in Figure 1. It is important to note that categories of damage are related to induced tensile strains.

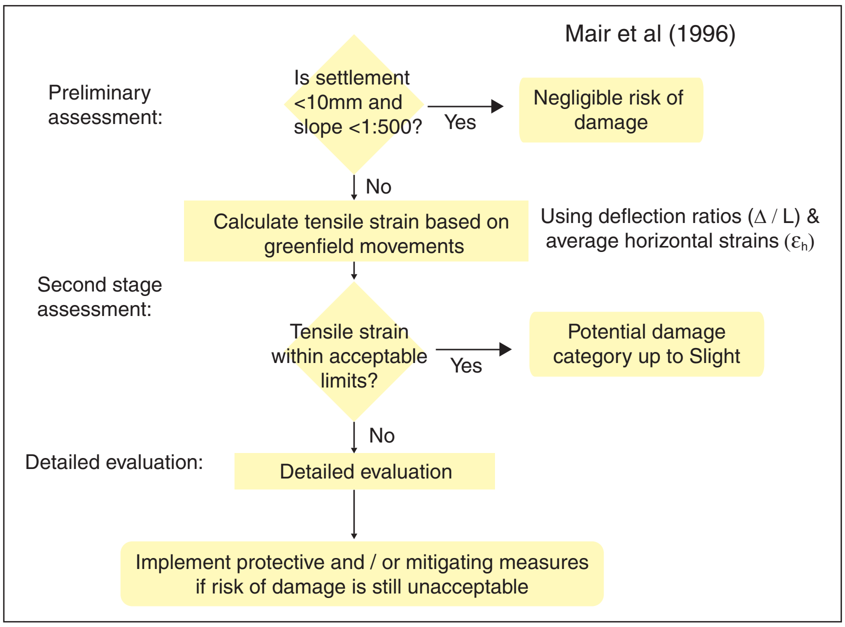

Figure 1: Framework for 3-staged risk assessment of building damage

In the second session, Dr Sigl pointed out that conservatism is relative. Structural analysis is based on the Ultimate Limit State whereas geotechnical analysis is based on Serviceability Limit State, where both have divergent input requirements. He highlighted some limitations of 2D analysis which can be overcome by 3D analysis. However, 3D analyses become complicated for geometries with subdivisions.

He then moved on to a simplified approach for complicated situations. For estimating greenfield tunnelling-induced settlements, the use of volume loss approach (i.e. conventional tunnelling-induced ground settlement equations) can simplify 3D settlement analyses. The approach is to create a 3D model for a single excavation advancement for which the incremental settlement value in the 3D model is determined.

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The equivalent volume loss is then back-analysed by matching the settlement troughs from both analyses. This calibrated volume loss value is subsequently adopted as an input for the conventional ground settlement analyses to extrapolate settlements for the entire length of tunnel within comparable geology.

The third session was on the influence of building stiffness that had significant influence on its response to excavation as well as tunnelling induced movements. Dr Goh presented the concept of modification factor as a means to quantify the relative building settlements to greenfield. He then showed a useful chart that indicated a consistent relationship between these modification factors and building relative stiffness from field monitoring. For example, buildings with relative stiffness of more than 1.0 is considered rigid and are expected to experience little or no differential settlements. Dr Goh said that, by assuming buildings conform to greenfield, settlement conditions will overestimate the damage category. He also said that horizontal strains induced in buildings are often very small. Some case studies were presented and these showed that tunnelling directly below buildings do not generally cause building to settle much more than the ground. The key is to limit ground deformations by applying good tunnelling controls.

In the fourth session, Dr Sigl shared the principles of impact assessment approach for existing rail infrastructure. The maximum movement limits applied to rail infrastructures in Singapore are typically less than 15mm, with a maximum gradient change (distortion) of less than 1:1000. It is interesting to note that Malaysia enforces an even more stringent criterion where distortion is limited to 1:2000, as stipulated in the Malaysia Railways Act 1999.

Dr Sigl also identified some of the limit states in tunnels and railway tracks and the potential effects. Some typical control values for "Alarm" and "Limit" levels were provided but he stressed that control values need to be assessed on a case-to-case basis, where pre-existing conditions need to be taken into account. Various cases studies, where complex analyses were carried out for the impact assessments, were then discussed.

The seminar ended with rounds of applause from the audience and then, GETD Chairman Ir. Lee Pier Tien presented tokens of appreciation to Er. Dr Oskar Sigl and Er. Dr Goh Kok Hun (Figure 2). ■

Figure 2: GETD Chairman Ir. Lee Pier Tien (centre) with Er. Dr Oskar Sigl (left) and Er. Dr Goh Kok Hun after presenting the tokens of appreciation

Technical Talk on Mechanistic-Empirical Pavement Design with Hexagonal Geogrids

GEOTECHNICAL ENGINEERING TECHNICAL DIVISION

reported by

Ir. EG Balakrishnan

Mr. Piotr Mazurowski from Tensar International gave an evening talk on Mechanistic-Empirical Pavement Design (M-E) with Hexagonal Geogrids on 19 September, 2017, at the Tan Sri Prof. Chin Fung Kee Auditorium, Wisma IEM. Mr. Mazurowski has over 17 years' experience in pavement and geotechnical engineering.

The talk was organised by the Geotechnical Engineering Technical Division, and 38 participants attended. The purpose was to introduce the benefits of hexagonal geogrids in pavement design, the rationale design approach using mechanistic-empirical methods incorporating geogrids, the test results and case studies on the use of hexagonal geogrids. This method is an elegant approach to pavement design, incorporating sound theoretical knowledge and empirical testing of pavement materials under traffic loading.

First, Mr. Mazurowski introduced the concept of Mechanically Stabilised Layer (MSL). The bearing capacity of MSL is improved where the aggregate particles are confined within the stiff geogrid appertures through the mechanism of interlocking. He presented a short overview of the M-E design methods in 3 stages:

1. Pavement modelling in layered elastic analysis software.
2. Calculation of pavement response (strains & stresses) to single ESAL.
3. Calculation of pavement life for the pavement layers – number of ESAL to reach damage level using transfer functions (fatigue criteria).

Speaker delivering the talk

The design of flexible pavements using MSL, allows reduction of pavement layers (including asphalt layers) while maintaining pavement life or increasing pavement life and maintaining the thickness or a combination of both.

The modelling of the hexagonal geogrids in the pavement design method is carried out by:

1. Using Stiffness Enhancement Concept where the stiffness of unbound aggregates is increased in Linear Elastic Analysis (LEA).
2. Using Stiffness Retention Concept where it is modelled with shift factors. In post LEA, the calculated life (fatigue and subgrade deformation life) is multiplied by a shift factor.

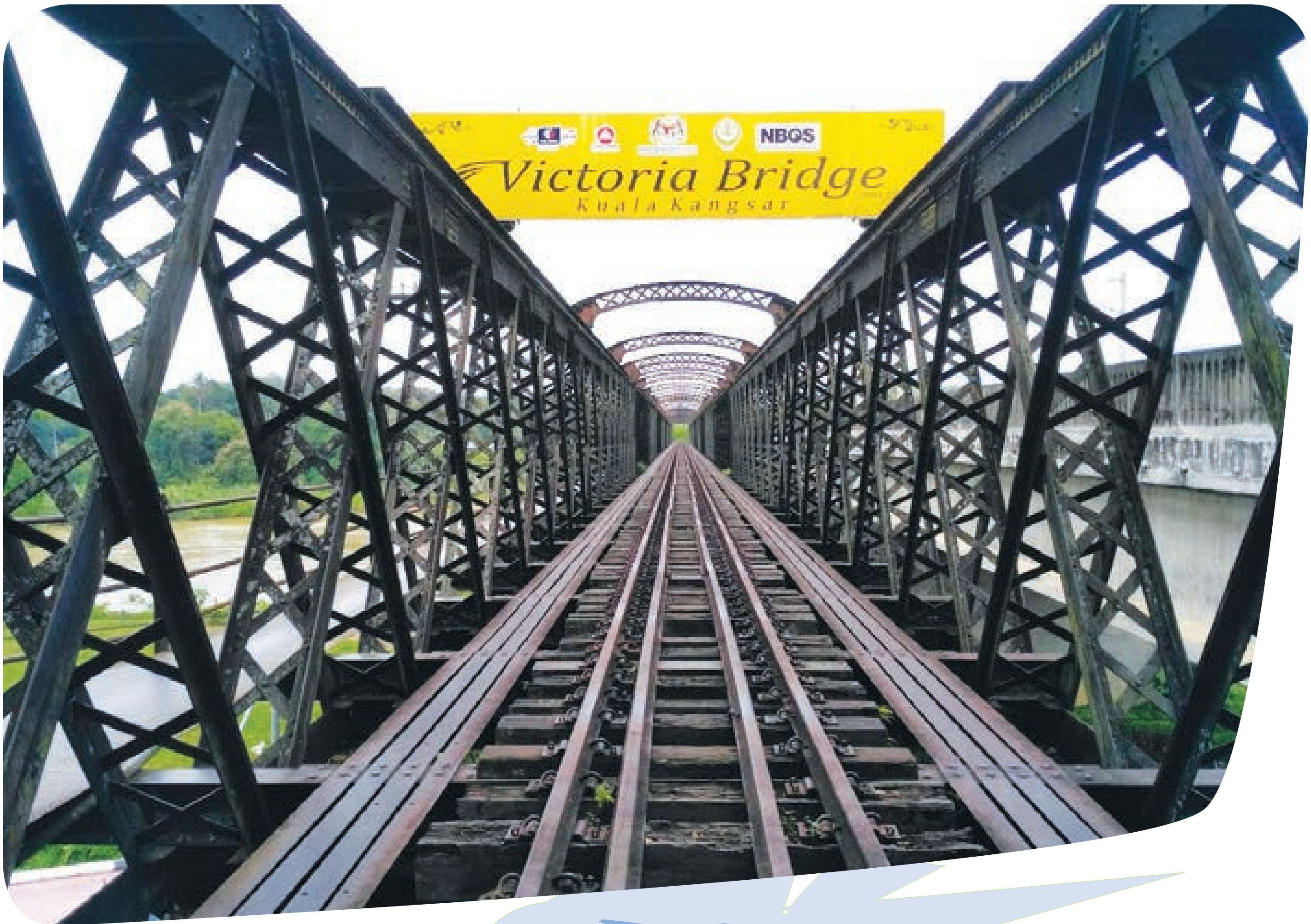
The results of the following tests were carried out to validate the performance of MSL and the stiffness increase using hexagonal geogrids:

1. Accelerated plate bearing tests, triaxial tests and PennState Smart Particle tests.
2. Full scale accelerated pavement testing was used to calibrate the empirical based shift factors.

Mr. Mazurowski also presented the following case studies where hexagonal geogrids and the design method had been successfully implemented, tested and validated.

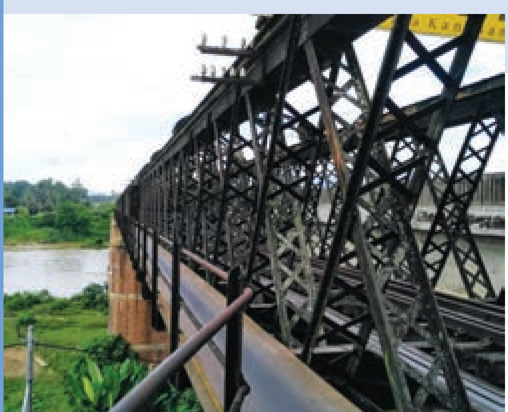
1. Finningley & Rossington Route Regeneration Scheme (UK)
2. Rzepin By-pass – Voivodeship Road (Poland)
3. Test section in Gliwice (Poland).

Finally, he took questions from the floor, after which he was presented with a token of appreciation and the seminar ended at 7.00 p.m. ■



VICTORIA BRIDGE

Victoria Bridge is located at Enggor which is about 6km to the northeast of Kuala Kangsar town in Perak Darul Ridzuan. It is one of the oldest railway bridges constructed by the British in Malaya. Construction began in December 1897 and the single track bridge was completed in March 1900. The steel truss rests on 6 intermediate piers and spans approximately 353 metres across the Sungai Perak. With the completion of an adjacent reinforced concrete bridge designed for double track operation, Victoria Bridge is now used by motorcyclists and pedestrians.



JURUTERA thanks Ir. Ong Guan Hock for his contribution to this column.

Clifton Bridge and I.K. Brunel

Ir. Chin Mee Poon | *www.facebook.com/chinmeepoon*

Ir. Chin Mee Poon *is a retired civil engineer who derives a great deal of joy and satisfaction from travelling to different parts of the globe, capturing fascinating insights of the places and people he encounters and sharing his experiences with others through his photographs and writing.*

The Clifton Suspension Bridge, spanning the Avon Gorge and linking Clifton in Bristol to Leigh Woods in North Somerset, England, was completed in 1864. It is still serving its purpose well after more than 150 years.

With a central span of 214.05m and an overall length of 412m, the bridge is justifiably famous for its setting as much as for its pioneer status as one of the earliest and finest precursors of modern suspension bridges.

The principal load-bearing members of the bridge are 3 wrought-iron chains at each edge of the carriageway suspended from the pylons.

When my wife and I were backpacking in England and Wales in March 2017, we made a day trip to Bristol from Bath. The first spot we visited in Bristol was Clifton Bridge, just 5 minutes' walk from the bus stop in Clifton Village. A visitors' centre was added in 2015 near the bridge abutment on Leigh Woods side. We spent two hours at the bridge and in the visitors' centre.

The idea of a bridge over the chasm at this spot was mooted way back in mid-1700s, but nothing was done until 1829 when a competition was held for the design of a suspension bridge for the site. Twenty-two entries were received, including 4 from the great engineer Isambard Kingdom Brunel, but the judge, Thomas Telford, another great engineer of the 19th century, rejected them all as being impractical. Telford's own design, submitted subsequently, was also rejected by the committee.

A second competition was held the following year and Isambard Kingdom Brunel's design was chosen as the winner. Construction work started in June 1831 but soon stopped due to severe riots in Bristol. Work resumed in 1836 but was woefully slow due to a shortage of funds.

The two pylons were finally completed in 1843 but no further work was done on the bridge until 1862. By then Brunel had passed away on 15 September, 1859, at the age of 53 and his colleagues in the Institution of Civil Engineers, William Henry Barlow and Sir John Hawkshaw in particular, amended his design in some significant ways, including raising the bridge deck, making it sturdier and increasing the number of chains from two to three. They also managed to raise enough money to complete the bridge as a tribute to Brunel.

The bridge was finally completed in 1864 and officially opened to traffic on 8 December. Since then the bridge has witnessed the first modern bungee jump from its deck on 1 April, 1979. It has also become somewhat notorious as a suicide bridge as many people have jumped over its edge to their death.

I.K. Brunel was undisputedly one of the greatest engineers of the 19th century. He was an ingenious and prolific engineer, who built dockyards, steamships, the Great Western Railway and many important bridges and tunnels in his short but illustrious life. Among his most outstanding achievements were the first tunnel under a navigable river and development of SS Great Britain, the first propeller-driven ocean-going iron ship which was also the largest ever of its time when completed in 1843.

His name itself is considered a novelty of sorts. Isambard Kingdom Brunel sounds somewhat like "Islamabad, Kingdom of Brunei", doesn't it? His first given name actually came from his father, Marc Isambard Brunel, and his middle name was his mother's surname.

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Mengikut Undang-Undang Kecil IEM, Seksyen 3.8, nama-nama seperti tersenarai berikut diterbitkan sebagai calon-calon yang layak untuk menjadi Ahli Institusi, dengan syarat bahawa mereka lulus Temuduga Profesional tahun 2017.

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Ir. Yap Soon Hoe
Setiausaha Kehormat, IEM

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32120	MARIAM BINTI AHMAD	BE HONS (USM) (CIVIL, 2008) ME (UPM) (HIGHWAY & TRANSPORTATION, 2012)
58739	TIONG VUI YEN	ME (BIRMINGHAM) (CIVIL, 2010) MSc (LEEDS BECKETT) (CONSTRUCTION LAW & DISPUTE RESOLUTION, 2017)
94351	NOR HALIF BIN NOR AZMAN	BE HONS (UTHM) (CIVIL, 2012)
39049	HAZEL KIDDO RICHARD	BE HONS (UTM) (CIVIL & ENVIRONMENTAL, 2002)
19372	NINA IMELDA BINTI MOHAMMAD SULANAH	BE HONS (UTM) (CIVIL, 2000) ME (UTM) (STRUCTURE, 2005)
87604	AHMAD SAIFUDDIN BIN ABDUL	BE HONS (UiTM) (CIVIL, 2000)
69498	STEVE ZHEN XIONG LOH	BE HONS (SINGPORE) (CIVIL, 2011)
29533	HONG BOON KHANG	BE HONS (UPM) (CIVIL, 2010)
64762	MOHD ZIKRI BIN MD. ZAINI	BE HONS (UiTM) (CIVIL, 2011)

KEJURUTERAAN ELEKTRIKAL

77636	SYAIFUL ANUAR BIN SAPUAN	BE HONS (UTM) (ELECTRICAL, 2007)
73284	NUZILAN BIN MUHAMAD	BE HONS (UNITEN) (ELECTRICAL POWER, 2013)
66835	SASHIKUMARAN A/L JAYARAMAN	BE HONS (UKM) (ELECTRICAL & ELECTRONIC, 2011)
77471	ROSYIMAH BINTI ABD AMIN	BE HONS (UTP) (ELECTRICAL & ELECTRONIC, 2010)
81503	LEE YUN PHING	BE HONS (BRADFORD) (ELECTRICAL & ELECTRONICS, 2007) ME (UTM) (ELECTRICAL POWER, 2014)
88961	DURRANI MUHAMAD BIN SULAIMAN	BE HONS (UNITEN) (ELECTRICAL & ELECTRONICS, 2009)
66088	ASRIDUAN BIN RAMLI	BE HONS (UTM) (ELECTRICAL, 2011)
93996	NURUL NABILA BINTI ZUBIR	BE HONS (UNITEN) (ELECTRICAL POWER, 2008)
37770	HIRUDDIN BIN MUSTAFA	BE HONS (UNITEN) (ELECTRICAL POWER, 2010)
44182	ALFRED LING KWAN YEW	BE HONS (UMS) (ELECTRICAL & ELECTRONICS, 2007)
41122	NORSYEILA BINTI MOHD KAMARUZAMAN	NORSYEILA BINTI MOHD KAMARUZAMAN
25025	AHMAD ARIPIN BIN SAIMAN	BE HONS (UNIMAS) (ELECTRONIC & TELECOMMUNICATION, 2000)
49911	AIDA MARIA BINTI AZMI	BE HONS (UPM) (ELECTRICAL & ELECTRONIC, 2008)
49921	AMIRUL IDZUAN BIN IDERIS	BE HONS (UNITEN) (ELECTRICAL POWER, 2008)
24353	JA'AFAR BIN OMAR	BE HONS (UKM) (ELECTRICAL, ELECTRONIC & SYSTEM, 1999)
30952	CHANG AI FANG	BE HONS (UTHM) (ELECTRICAL, 2008)
50702	SALLINDA BINTI MOHD ALI	BE HONS (UNITEN) (ELECTRICAL POWER, 2008)
34054	KHAIRUL HAFIZUL BIN AHMAD KAMAL	BE HONS (UiTM) (ELECTRICAL, 2009)
93823	AZLEY BIN JAMALUDDIN @ ABDUL AZIZ	BE HONS (UNITEN) (ELECTRICAL POWER, 2007)
94024	MOHD SHAHLAN FITRY BIN NOOR RAHIN	BE HONS (UiTM) (ELECTRICAL, 2006) CONVERSION (UNITEN) (ELECTRICAL, 2013)
62001	MOHAMAD NAIM BIN MOHAMMAD	BE HONS (UTeM) (INDUSTRIAL POWER, 2008) ME (UTM) (ELECTRICAL POWER, 2017)
43147	NORULHAKIMA BINTI ZAKARIA	BE HONS (UTP) (ELECTRICAL & ELECTRONICS, 2006)
66680	HARIBALAN A/L RAMANATHAN	BE HONS (UTeM) (CONTROL, INSTRUMENTATION & AUTOMATION, 2010) ME (UTM) (ELECTRICAL POWER, 2014)
33762	WAN OTHMAN BIN WAN JUSOH	BE HONS (UTM) (ELECTRICAL, 2002)
43641	MOHD DZAKI BIN MOHD AMIR	ME (LOUGHBOROUGH) (ELECTRICAL & ELECTRONIC, 2008)
50166	MOHD ALIF BIN MOHD NOR	BE HONS (UTM) (ELECTRICAL, 2009)
49599	LAM FOO CHEE	BE HONS (UniMAP) (ELECTRICAL SYSTEM, 2010)
49920	MOHD AZHAR BIN ABDUL MAJID	BE HONS (UNITEN) (ELECTRICAL & ELECTRONIC, 2007)
52920	MUHAMMAD NURZUHAILI BIN ZAINUDI	BE HONS (UMP) (POWER SYSTEM, 2012)
53798	MATHANRAJ GANGADARAN	BE HONS (UNITEN) (POWER ENGINEERING, 2011)
94130	ZUL HAZUZAN BIN ALI	BE HONS (UMS) (ELECTRICAL & ELECTRONICS, 2011)
29246	TANAPAL A/L BALARAMAN	BE HONS (UM) (ELECTRICAL, 2004)
94006	TANG JU YEW	BE HONS (UM) (ELECTRICAL, 2012)
45792	LIM CHIA YIH	BE HONS (UNITEN) (ELECTRICAL & ELECTRONIC, 2002)
94146	SIDI AMAN BIN MUHAAMMAD	BE HONS (UTM) (ELECTRICAL, 2001)
81946	PANG YAP SENG	BE HONS (UTAR) (ELECTRICAL & ELECTRONIC, 2013)
87513	AHMAD FAKHRUL HAKIM BIN ZAMRI	BE HONS (UNITEN) (ELECTRICAL-POWER, 2011)
43855	CHIENG LEE FENG	BE HONS (DUNDEE) (ELECTRONIC & ELECTRICAL, 2003)
67807	MOHD AZIZUL BIN MAT ARIFF	BE HONS (UiTM) (ELECTRICAL, 2008)

KEJURUTERAAN ELEKTRONIK

39724	ANAS BIN ABDUL LATIFF	BE HONS (UTHM) (ELECTRICAL, 2009) ME (UM) (2012) PhD (UM) (2017)
33926	SYAMSUL KAMAL BIN ISMAIL	BE HONS (UiTM) (ELECTRICAL, 2000)
43098	MUHAMMAD ADIB BIN HARON	BE HONS (KUiTTHO) (ELECTRICAL, 2006) ME (UTM) (ELECTRICAL-ELECTRONICS & TELECOMMUNICATION, 2008)
53751	MD SAIFUL ANUAR BIN MOHD NASIRRUDDIN	BE HONS (UTeM) (INDUSTRIAL ELECTRONIC, 2008)
25354	AIZAT HELMI BIN ZAMZAM	BE HONS (UiTM) (ELECTRICAL, 2007) ME (UiTM) (ENGINEERING MANAGEMENT, 2013)
23268	PU CHUAN HSIAN	BE (NOTTINGHAM) (ELECTRONICS & COMPUTING, 2001) ME (MMU) (TELECOMMUNICATION, 2005)

KEJURUTERAAN MEKANIKAL

36705	YAP ZHENG DAO	BE HONS (UPM) (MECHANICAL, 2011)
57242	MATHAN A/L SAMBU	BE HONS (UTHM) (MECHANICAL, 2014) ME (UTHM) (MECHANICAL, 2016)

94361	KOO WEE TAK	BE HONS (UPM) (MECHANICAL, 2009)
61912	SARUNAN A/L LETCHMANAN	BE (McMASTER) (MECHANICAL, 2012)
54597	WOON CHENG YEE	BE HONS (BATH) (AEROSPACE, 2008) MSc (NEW SOUTH WALES) (MECHANICAL, 2010)
77638	KAH WEI SHERN	BE HONS (MMU) (MECHANICAL, 2014)
39431	SAIFUL BAHRI BIN MD NASIR	BE HONS (UiTM) (MECHANICAL, 2013)
17106	LEE SOON THIAM	BSc HONS (MANITOBA) (MECHANICAL, 1995)
31298	AHMAD FAZRUL FAHMI BIN ZANUDIN	BE HONS (UiTM) (MECHANICAL, 2009) ME (UiTM) (MANAGEMENT, 2015)
37585	NG YEN CHEONG	BE HONS (SHEFFIELD HALLAM) (MECHANICAL & MANUFACTURING SYSTEM, 2007) ME (UTM) (MECHANICAL, 2013)
52378	LOH ENG HONG	BE HONS (UTM) (MECHANICAL, 2000)
20818	MOHD JAIS BIN ABU SAMAH	BE HONS (UPM) (MECHANICAL, 2004)
32357	KHAIRUL FAIZAL BIN KUSHIAR	BE HONS (UiTM) (MECHANICAL, 2009)
38787	NIK MUHAMMAD HAFIZ BIN NIK AB RASHID	BE HONS (MEIJI) (MECHANICAL, 2007) MSc (UKM) (MECHANICAL & MATERIAL, 2007)

KEJURUTERAAN BIOMEDIKAL

70527	JONATHAN OOI SHI KHAI	BE HONS (UTAR) (BIOMEDICAL, 2014) MSc (UPM) (BIOMEDICAL, 2017)
22700	BONG WEE THIAN	CITY & GUILDS (ELECTRICAL, 1994) ENGINEERING COUNCIL EXAM – PART II A& B

KEJURUTERAAN SUMBER AIR

25614	NUR SHAZWANI BINTI MUHAMMAD	BE HONS (UM) (ENVIRONMENT, 2003) MSc (WALES) (WATER ENGINEERING, 2005)

PERMOHONAN BARU/PEMINDAHAN MENJADI AHLI KORPORAT

No. Ahli	Nama	Kelayakan
KEJURUTERAAN AWAM		
27074	LOGANATHAN RADZAKRISHNAN	BE HONS (UNISEL) (CIVIL, 2006) ME (UTM) (MECHANICAL, 2014)
KEJURUTERAAN KIMIA		
52482	YEO THIAN SOON	BE HONS (UKM) (CHEMICAL, 2005)
KEJURUTERAAN ELEKTRIKAL		
	MOHD SYAHMI BIN MOHD NASIM	BE HONS (SYDNEY) (ELECTRICAL, 2010)
	AZHAR BIN SAFII	BE HONS (UiTM) (ELECTRICAL, 1997)
KEJURUTERAAN PEMBUATAN		
	REZAINI BIN AHMAD TASMAN	BE HONS (UniMAP) (MANUFACTURING, 2007)
KEJURUTERAAN KIMIA		
	BENNY TAN CHEAH HEE	BE HONS (UTM) (CHEMICAL, 2009) ME (UTM) (ENVIRONMENTAL, 2011)

KEAHLIAN

CONTINUATION LIST FROM DECEMBER JURUTERA 2017 ISSUE

94143	LIM HERNG	B.E.HONS.(UNI. OF ADELAIDE) (CIVIL & STRUCTURAL, 2016)
94039	TEAH SOO HONG	B.E.HONS.(UNI. OF BIRMINGHAM)(CIVIL, 2010) M.SC.(UNI. OF SHEFFIELD) (ARCHITECTURAL ENGINERING DESIGN, 2011)
94113	BEH WEI LIP	B.E.HONS.(UNI. OF SOUTH AUSTRALIA)(CIVIL & STRUCTURAL, 2014)
93835	JOHN GARY ANAK JENTRY	B.E.HONS.(UNIMAS)(CIVIL, 2009)
93992	LAW CHEE SEONG	B.E.HONS.(UNIMAS)(CIVIL, 2010)
93927	YAP KAH MING	B.E.HONS.(UNIMAS)(CIVIL, 2011)
93808	TAN YUN PING, JERREN	B.E.HONS.(UNIMAS)(CIVIL, 2013) M.E.(UNIMAS)(2016)
93962	HASMIDAH BINTI SAID	B.E.HONS.(UNITEN)(CIVIL, 2016)
93959	NUR ZUKRINA BINTI ZUHAIRI	B.E.HONS.(UNITEN)(CIVIL, 2016)
93974	TAN WEI CONG	B.E.HONS.(UNITEN)(CIVIL, 2016)
93831	LEE LONG GUANG	B.E.HONS.(UNITEN)(CIVIL, 2017)
93844	NORHAFIZAH BINTI BAZAL AHMAD	B.E.HONS.(USM)(CIVIL, 2014)
93921	LAU JIAN NING	B.E.HONS.(USM)(CIVIL, 2016)
93951	HIU CHI YIP	B.E.HONS.(UTAR SG LONG) (CIVIL, 2017)
93888	TONG KWAN SHEN	B.E.HONS.(UTAR)(CIVIL, 2016)
93841	NORHAFIZAH BINTI SAFRIMAN	B.E.HONS.(UTHM)(CIVIL, 2014))
93979	MOHD FAIRUZ BIN MD RAMLI	B.E.HONS.(UTM)(CIVIL, 2003)
93809	TAN KOON WEE	B.E.HONS.(UTM)(CIVIL, 2005)
93965	UMMU BALQIS BINTI JOHARI	B.E.HONS.(UTM)(CIVIL, 2005)
93970	DR. TAN CZHIA YHEAW	B.E.HONS.(UTM)(CIVIL, 2005) PHD.(NUS)(2012)
93907	MUHAMMAD NASHRIQ FARHAN BIN SUPANDI	B.E.HONS.(UTM)(CIVIL, 2007)
93782	RAHMAT ZULHAIRI BIN MOHAMED	B.E.HONS.(UTM)(CIVIL, 2010)
93997	ABDUL SALAM BIN MAHMUD	B.E.HONS.(UTM)(CIVIL, 2011)
93966	CHEE CHIEN CHERN	B.E.HONS.(UTM)(CIVIL, 2012)
93968	LAM TIAN FOOK	B.E.HONS.(UTM)(CIVIL, 2012)
94115	NUR SYAZANA AMALINA BINTI AZHAR	B.E.HONS.(UTM)(CIVIL, 2012)
94034	MOHD AKHMAL BIN MD ARIPIN	B.E.HONS.(UTM)(CIVIL, 2013) M.E.(UTM)(CIVIL-STRUCTURE, 2014)
93969	NUR'ATIAH BINTI ZAINI	B.E.HONS.(UTM)(CIVIL, 2013) M.E.(UNITEN)(CIVIL, 2016)
93917	BONG MAI WENG	B.E.HONS.(UTM)(CIVIL, 2015)
93898	MOHD SUKRY BIN ISMAIL	B.E.HONS.(UTM)(CIVIL, 2016)
94140	TAN SILK SHEN	B.E.HONS.(UTM)(CIVIL, 2016)
93787	ABDUL QADIR BIN JAILANI	B.E.HONS.(UTP)(CIVIL, 2010)
93868	MUHAMMAD AMIN BIN AZHARI	B.E.HONS.(UTP)(CIVIL, 2012)
94142	KOK HOY SENG	B.E.HONS.(UTP)(CIVIL, 2015)
93820	TAN MING EE	B.E.HONS.(UTP)(CIVIL, 2016)
93837	LIM CHONG WEI, FABIAN	B.SC.(OKLAHOMA STATE UNI.) (CIVIL, 1997)
93982	PHILEMON LAJAWAI	B.SC.(TEXAS TECH. UNI.) (CIVIL, 1989)
93714	IR. MOHAMMAD AZMAN BIN RAZALI	B.SC.(UNI. OF ABERDEEN)(CIVIL, 1988) M.SC.(LOUGHBOROUGH UNI.)(AIRPORT PLANNING & MANAGEMENT, 1997)
94004	WONG HSUI HAN	M.E.HONS.(UNI. OF EXETER) (CIVIL & ENVIRONMENTAL WITH INT. STUDY, 2016)
93825	NUR ALIA BINTI SULAIMAN	M.E.HONS.(UNI. OF NEWCASTLE UPON TYNE) (CIVIL,2016)
94016	NOOR HAYYI HAQQ BIN SULAIMAN	M.E.HONS.(UNI. OF NOTTINGHAM)(CIVIL, 2014)
94112	THAM TAO CHOR	M.E.HONS.(UNI. OF NOTTINGHAM)(CIVIL, 2016)
93911	KONG SOON THAI	M.E.HONS.(UNI. OF NOTTINGHAM)(CIVIL, 2017)

KEJURUTERAAN BAHAN

93815	YEE SWEE LI, MAXINE	B.E.HONS.(MALAYA) (MATERIALS, 2000) M.TECH.(MALAYA)(MATERIAL SCIENCE, 2004)
94023	DR. KOAY SEONG CHUN	B.E.HONS.(UNIMAP) (MATERIALS, 2010) MSC.(UNIMAP) (MATERIALS, 2012) PHD.(UNIMAP)(2015)
93943	LEE SUE MAYNE	B.E.HONS.(UTAR SG LONG) (MATERIALS, 2017)

KEJURUTERAAN BIOPERUBATAN

94136	JULIANA BASHEER ALI	B.E.HONS.(MALAYA) (BIO-MEDICAL, 2001) M.E.SC.(UNSW)(BIO-MEDICAL, 2003)
93786	HANAFI BIN MUSA	B.E.HONS.(UTM) (BIO-MEDICAL, 2014) M.SC.(UNI. OF MANCHESTER) (BIOMATERIALS, 2015)

KEJURUTERAAN ELEKTRIKAL

94121	PRITHIVIRAJ CHINNA GOUNDER NATARAJAN	B.E.(ANNA UNI.)(ELECTRICAL & ELECTRONICS, 2006) M.E.(MALAYA)(POWER SYSTEMS, 2015)
94001	MUHAMMAD AMIRUDDIN BIN AZHAR	B.E.(UNI. OF QUEENSLAND) (ELECTRICAL, 2015)
93843	AHMAD FIRDAUS BIN KAMARAZAMAN	B.E.(UNSW)(ELECTRICAL, 2013)
93859	LIM YIN KIN	B.E.HONS.(LIVERPOOL JOHN MOORES)(ELECTRONICS & CONTROL SYSTEMS, 2012) M.SC.(UNI. OF NEWCASTLE UPON TYNE)(ELECTRICAL POWER, 2016)
93854	MOHD FAZLI BIN ZAKARIA	B.E.HONS.(MALAYA) (ELECTRICAL, 2006)
93999	YUEH TIAM YONG	B.E.HONS.(MALAYA) (ELECTRICAL, 2008)
94006	TANG JU YEW	B.E.HONS.(MALAYA) (ELECTRICAL, 2012)
93915	THEN KIM KIAN	B.E.HONS.(MALAYA) (ELECTRICAL, 2012)
93977	EYLIA NADIYA BINTI AB. RAZAK	B.E.HONS.(MALAYA) (ELECTRICAL, 2013)
93964	CHIN KIAN SENG, ALSTON	B.E.HONS.(MONASH UNI.) (ELECTRICAL & COMPUTER SYSTEMS, 2011)
94032	SHANGAR EAGAMATHAN	B.E.HONS.(NTU)(ELECTRICAL & ELECTRONICS, 2011) MSC.(NTU)(POWER, 2016)
94024	MOHD SHAHLAN FITRY BIN NOOR RAHIN	B.E.HONS.(UITM) (ELECTRICAL, 2006)
0	SYAHRIL IZUAN BIN ILIYASAK	B.E.HONS.(UITM) (ELECTRICAL, 2007)
93912	AMIRZAKI BIN ZAHARI	B.E.HONS.(UITM) (ELECTRICAL, 2009)
93960	MOHD FAISAL AMIR BIN MUSTAPHA	B.E.HONS.(UITM) (ELECTRICAL, 2009)
93849	MOHD YASMER BIN DAUD	B.E.HONS.(UITM) (ELECTRICAL, 2009)
93840	MOHD ZULHILMI BIN ABD RAHNI	B.E.HONS.(UITM) (ELECTRICAL, 2011)
93785	MOHD KHAIRIL BIN MOHAD HZER	B.E.HONS.(UITM) (ELECTRICAL, 2013)
93975	MUHAMMAD ADI IYLIA BIN MOHAMMAD FAZIN	B.E.HONS.(UITM) (ELECTRICAL, 2016)

94159	MOHAMMAD ZULFHIAN NIZAM BIN JIKIRUN	B.E.HONS.(UMS)(ELECTRICAL & ELECTRONIC, 2011)
94130	ZUL HAZUZAN BIN ALI	B.E.HONS.(UMS)(ELECTRICAL & ELECTRONIC, 2011)
93788	CHUNG TIIN KANG, MATTHEW	B.E.HONS.(UMS)(ELECTRICAL & ELECTRONIC, 2011)
93784	LIM CHIA YEE	B.E.HONS.(UMS)(ELECTRICAL & ELECTRONIC, 2016)
93925	OOI YEW CHONG	B.E.HONS.(UMS)(ELECTRICAL & ELECTRONICS, 2014)
93981	MOHD AZLAN BIN AHMAD FUAD	B.E.HONS.(UNI. OF AUCKLAND)(ELECTRICAL & ELECTRONIC, 2009)
93824	DR. TAN CHEE PIN	B.E.HONS.(UNI. OF LEICESTER)(ELECTRICAL & ELECTRONIC, 1998) PHD.(UNI. OF LEICESTER)(2002)
93789	NG CHIEN MING	B.E.HONS.(UNI. OF NURTHUMBRIA AT NEWCASTLE)(ELECTRICAL & ELECTRONIC, 2013) M.E.(MALAYA)(POWER SYSTEMS, 2016)
93806	NG KAR LAI	B.E.HONS.(UNI. OF NURTHUMBRIA AT NEWCASTLE)(ELECTRICAL & ELECTRONIC, 2013) M.E.(MALAYA)(POWER SYSTEMS, 2016)
94029	MEOR FAIZZUDIN BIN MEOR SHAHIMUDIN	B.E.HONS.(UNIMAP)(ELECTRICAL ENERGY SYSTEMS, 2014)
93905	MUHAMMAD FAHMI BIN ISA	B.E.HONS.(UNIMAP)(ELECTRICAL SYSTEM, 2016)
93899	KHAIRUL AZHAR BIN MD. JAMIL	B.E.HONS.(UNIMAP)(ELECTRICAL SYSTEMS, 2010)
93829	TING SIAW HUI, JACQUELINE	B.E.HONS.(UNIMAP)(INDUSTRIAL ELECTRONIC, 2014)
93862	RUEBAN ANTONY	B.E.HONS.(UNITEN)(ELECTRICAL & ELECTRONIC, 2011)
93913	DR. AVINASH ASHWIN RAJ	B.E.HONS.(UNITEN)(ELECTRICAL & ELECTRONICS, 2007) M.E.(UNITEN)(ELECTRICAL, 2012) PHD.(UNITEN)(ENGINEERING, 2016)
93823	AZLEY BIN JAMALUDDIN @ ABDUL AZIZ	B.E.HONS.(UNITEN)(ELECTRICAL POWER, 2007)
93996	NURUL NABILA BINTI ZUBIR	B.E.HONS.(UNITEN)(ELECTRICAL POWER, 2008)
93817	SAIFUL ISHAM BIN ISMAIL	B.E.HONS.(UNITEN)(ELECTRICAL POWER, 2011)
93914	MUHAMMAD ZA'IM HAKIMI BIN JAFAR	B.E.HONS.(UNITEN)(ELECTRICAL POWER, 2016)
94014	MUHAMMAD AMIR ASRAF BIN RAMLI	B.E.HONS.(UNITEN)(ELECTRICAL POWER, 2017)
94118	ROSZAIDI @ZAI BIN ABDULLAH	B.E.HONS.(UPM)(ELECTRICAL &ELECTRONICS, 2001)
93978	EE GEE KENG	B.E.HONS.(UPM)(ELECTRICAL & ELECTRONICS, 2009) MSC.(UPM)(COMMUNICATION & NETWORK, 2013)
94036	KARTHINATHAN A/L RANGANATHAN	B.E.HONS.(UPM)(ELECTRICAL & ELECTRONICS, 2012)
94019	SYED MUHAMMAD NASHRIQ BIN SYED YAHAYA	B.E.HONS.(UPM)(ELECTRICAL & ELECTRONICS, 2013)
93926	MUHAMAD HAZIM BIN ABDULLAH	B.E.HONS.(UPNM)(ELECTRICAL & ELECTRONIC-POWER, 2013)
93865	MUHAMMAD MAZHAR BIN MOFTY	B.E.HONS.(UPNM)(ELECTRICAL & ELECTRONIC-POWER,2012)
94144	ZHARIF NAIM BIN HAMDAN	B.E.HONS.(USM)(ELECTRICAL, 2016)
93935	TENG JIA HO GAVIN	B.E.HONS.(UTAR SG LONG)(ELECTRICAL & ELECTRONIC, 2017)
93961	MISHAN ARAVIND S/O DINESH ARAVIND	B.E.HONS.(UTAR)(ELECTRICAL & ELECTRONIC, 2013)
93833	MOHD MAZLIH BIN AWANG	B.E.HONS.(UTEM)(ELECTRICAL-CONTROL, INSTRUMENTATION & AUTOMATION, 2007)
94028	AHMAD AKMAL BIN ABD KUDUS	B.E.HONS.(UTEM)(ELECTRICAL-CONTROL, INSTRUMENTATION & AUTOMATION, 2012)
94139	NOOR ADLIA SYUHADA BINTI MAAMIN	B.E.HONS.(UTEM)(ELECTRICAL-CONTROL, INSTRUMENTATION & AUTOMATION, 2015)
93810	WAN ABDUL AZIR BIN WAN MUSA	B.E.HONS.(UTHM)(ELECTRICAL, 2005)
93918	RAJA ISKANDAR BIN RAJA IDRIS	B.E.HONS.(UTHM)(ELECTRICAL, 2012)
94146	SIDI AMAN BIN MUHAAMMAD	B.E.HONS.(UTM)(ELECTRICAL, 2001)
93781	ZULAZHAN BIN ABU BAKAR	B.E.HONS.(UTM)(ELECTRICAL, 2004)
94150	MOHD SUHAIMI BIN MOHD YUNUS	B.E.HONS.(UTM)(ELECTRICAL, 2006)
93780	MAHYARUDIN BIN MOHD	B.E.HONS.(UTM)(ELECTRICAL-INSTRUMENTATION & CONTROL, 2008)
93795	MOHD AZRIN BIN MOHD IZAB	B.E.HONS.(UTM-SPACE)(ELECTRICAL, 2012)
93798	MOHD ADZHAR BIN AZIZAN	B.E.HONS.(UTM-SPACE)(ELECTRICAL, 2016)
94132	MOHD SHAHRIMAN B M SHARIF	B.E.HONS.(UTP)(ELECTRICAL & ELECTRONIC, 2005)
93894	ABDUL AZEEM BIN MOHAMED MOHIDEEN	B.E.HONS.(UTP)(ELECTRICAL & ELECTRONIC, 2013)
93869	MELISSA SHAMANI GANASON	M.E.HONS.(ICL)(ELECTRICAL & ELECTRONIC WITH MANAGEMENT, 2008)
93864	CHIN JIAN JI	M.E.HONS.(NOTTINGHAM)(ELECTRICAL & ELECTRONIC, 2017)
93832	YEOH CHEE KEONG	M.E.HONS.(UNI. OF NOTTINGHAM)(ELECTRICAL & ELECTRONIC, 2017)
93903	FOO CHUAN CHUEN	M.E.HONS.(UNI. OF NOTTINGHAM)(ELECTRICAL, 2013)

KEJURUTERAAN ELEKTRONIK

94147	DR. ALIZA AINI BINTI MD RALIB @ MD RAGHIB	B.E.HONS.(IIUM)(COMPUTER & INFORMATION, 2006) PHD.(IIUM)(ENGINEERING, 2016)
93902	FONG LEN NIE	B.E.HONS.(KUITTHO)(ELECTRICAL-MEDICAL ELECTRONICS, 2003)
93793	SOO ZHEYAN, JOSHUA	B.E.HONS.(MMU)(ELECTRONIC-NANAOTECHNOLOGY, 2016)
93955	TAN THENG GUAN	B.E.HONS.(MMU)(ELECTRONICS, 2005)
93980	TAN POI NGEE	B.E.HONS.(MMU)(ELECTRONICS-TELECOMMUNICATIONS, 2009) MESC.(MMU)(2014)
93919	SHAHMINI SUBRAMANIAM	B.E.HONS.(MMU)(ELECTRONIC-TELECOMMUNICATIONS, 2013)
93860	FLETCHER SARIP	B.E.HONS.(MONASH)(ELECTRICAL & COMPUTER SYSTEMS, 2016)
93971	NOR ASHRAF BIN MOHD SALIM	B.E.HONS.(STAFFORDSHIRE UNI.)(ELECTRICAL, 2006) M.E.(STAFFORDSHIRE UNI.)(ELECTRICAL, 2008)
93871	SITI AZURA BINTI RAMLAN	B.E.HONS.(UITM)(COMPUTER, 2007)
94160	AHMAD ASYRAF BIN AHMAD ANUAR	B.E.HONS.(UITM)(ELECTRICAL & ELECTRONIC, 2016)
94037	ANITH NURAINI ABD RASHID	B.E.HONS.(UITM)(ELECTRICAL, 2007) MSC.(USM)(ELECTRONICS SYSTEMS DESIGN, 2015)
93900	DR. SARAH YASMIN BINTI MOHAMAD	B.E.HONS.(UITM)(ELECTRICAL, 2009) M.E.(UKM)(COMMUNICATION & COMPUTER, 2011) PHD.(THE QUEEN'S UNI. OF BELFAST)(2015)
93972	NOOR ADZIELLA BINTI MOHAMAD	B.E.HONS.(UITM)(ELECTRONICS-INSTRUMENTATION, 2013)
93779	ASYRAN BIN AHMAD	B.E.HONS.(UKM)(ELECTRICAL, ELECTRONIC & SYSTEMS, 1999)
93805	AZRIF BIN MANUT	B.E.HONS.(UKM)(ELECTRICAL, ELECTRONIC & SYSTEMS, 2001) M.SC.(UKM)(ELECTRICAL, ELECTRONIC & SYSTEMS, 2007)
93813	AZMAN BIN ABD AZIZ @ MOHD YUSOF	B.E.HONS.(UNI. OF HERTFORDSHIRE)(ELECTRICAL & ELECTRONIC, 1999) M.SC.(IIUM)(MECHATRONICS, 2009)
93922	ALI IMRAN BIN IBRAHIM	B.E.HONS.(UNIMAP)(BIOMEDICAL ELECTRONIC, 2011) M.E.(MALAYA)(INDUSTRIAL ELECTRONICS & CONTROL, 2016)
94124	DR. SUHANA BINTI MOHAMED SULTAN	B.E.HONS.(UNITEN)(ELECTRICAL & ELECTRONICS, 2003) MSC.(NUS)(ELECTRICAL, 2007) PHD.(UNI. OF SOUTHAMPTON)(ELECTRONICS & ELECTRICAL, 2013)
94162	MUHAMAD FAZREE BIN SHARIP	B.E.HONS.(UPNM)(ELECTRICAL & ELECTRONIC-COMMUNICATIONS, 2013)
94117	WAN MUHAMMAD NABIL BIN WAN HUSSIN	B.E.HONS.(UPNM)(ELECTRICAL & ELECTRONIC-COMMUNICATIONS, 2014)
93850	AZFAR ASYRAFIE BIN AHMAD	B.E.HONS.(UPNM)(ELECTRICAL & ELECTRONIC-COMMUNICATIONS, 2015)
94148	MOHAMAD HUZAIRIE BIN ABDUL HALIM	B.E.HONS.(USM)(ELECTRONIC, 2015)
93944	LEE QING XIANG	B.E.HONS.(UTAR SG LONG)(ELECTRONIC COMMUNICATION, 2017)
94151	SITI DHAMIRAH 'IZZATI BINTI DAMNI	B.E.HONS.(UTEM)(ELECTRONICS-COMPUTER, 2011)
93895	NOOR ARJUNADI BIN MOHD NOOR	B.E.HONS.(UTM)(ELECTRICAL, 2000)
93818	ROSLI BIN KHALID	B.E.HONS.(UTM)(ELECTRICAL, 2004)
93819	MUHD FAIZ BIN ROSLI	B.E.HONS.(UTM)(ELECTRICAL-ELECTRONIC, 2009)
93991	RAJ KUMAR A/L KRISHNASAMY	B.E.HONS.(UTM)(ELECTRICAL-MICROELECTRONICS, 1998)
93821	RABINDRA A/L GANDHI THANGARAJOO	B.SC.(ROBERT GORDON UNI.)(ELECTRONIC & ELECTRICAL, 1998) M.E.(UTM)(ELECTRICAL-ELECTRONICS & TELECOMMUNICATIONS, 2009)
93804	MOHD TOHER BIN MOHAMED KENAPIAH	DIPL-ING.FH.(FRANKFURT UNIVERSITY OF APPLIED SCIENCES)(ELECTRICAL ENERGY & AUTOMATION TECHNOLOGY, 2010)
94137	DR. ASNIDA BINTI ABD WAHAB	M.E.HONS.(UNI. OF BRISTOL)(ELECTRICAL & ELECTRONIC, 2008) PHD.(UTM)(BIOMEDICAL, 2016)

KEJURUTERAAN KIMIA

94002	ASHRAF BIN A.RAZAK	B.E.HONS.(CURTIN U NI. OF TECH.)(CHEMICAL, 2012) MSC.(UNI. OF BIRMINGHAM(ADVANCED CHEMCAL, 2013)
93812	LIM GEK JOO, SHERON	B.E.HONS.(CURTIN UNI. OF TECH.)(CHEMICAL, 2016)
94134	DR. TAN LLING LLING	B.E.HONS.(MONASH UNI.)(CHEMICAL, 2012) PHD.(MONASH UNI.)(2015)
93906	BRENDAN VINSENT	B.E.HONS.(MONASH UNI.)(CHEMICAL, 2016)
93838	ABDUL RAHMAN BIN HARIRI	B.E.HONS.(MONASH)(ENGINEERING, 1986)
93890	NUR IZZAQIAH BINTI JAMADIN	B.E.HONS.(UITM)(CHEMICAL & PROCESS, 2017)
93956	DR. CHUNG YING TAO	B.E.HONS.(UKM)(CHEMICAL, 2012) PHD.(UKM)(CHEMICAL & PROCESS, 2016)
93797	DR. LEE CHERN LEING	B.E.HONS.(UNI. OF ADELAIDE)(CHEMICAL, 2006) PHD.(UNI. OF CAMBRIGDE)(2011)
93828	DR. KOR YANN KAE	B.E.HONS.(UNI. OF SDYNEY)(CHEMICAL, 2006) PHD.(UNI. OF SDYNEY)(ENGINEERING, 2010)
94009	DENG JIAHUA	B.E.HONS.(UNI. OF SYDNEY)(CHEMICAL, 2011)
94111	SHIMALAA SANMUGGAM	B.E.HONS.(UTAR KAMPAR)(PETROCHEMICAL, 2017)
94110	TAN SIEW HUNG	B.E.HONS.(UTAR KAMPAR)(PETROCHEMICAL, 2017)
93954	CHEAH CHEE CHONG	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)
93952	GAN FUNG PING	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)
93950	KEK LI YIN, KRYSTIN	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)
93948	KONG WEN GIE	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)
93941	NG SU XIN	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)
93940	PONG XIU MAN, JOANNE	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)
93939	SUMITHIRA A/P NANTHA KUMAR	B.E.HONS.(UTAR SG LONG)(CHEMICAL, 2017)

93938	TAN MAY YEE	B.E.HONS.(UTAR SG LONG) (CHEMICAL, 2017)
93937	TAN SHU HAU	B.E.HONS.(UTAR SG LONG) (CHEMICAL, 2017)
93934	TING HUI LING	B.E.HONS.(UTAR SG LONG) (CHEMICAL, 2017)
93932	YEE HSIN YI	B.E.HONS.(UTAR SG LONG) (CHEMICAL, 2017)
93957	NICOLAS SELVAKUMAR PAUL	B.E.HONS.(UTAR)(CHEMICAL, 2014)
94131	MOHD AMINUDIN BIN MANSOR	B.E.HONS.(UTM)(CHEMICAL, 2008)
94141	MOHD FADZLEE BIN MOHD OTHMAN	B.E.HONS.(UTP)(CHEMICAL, 2008)
93846	MOHD AIMAN BIN MOHD NOOR	B.E.HONS.(UTP)(CHEMICAL, 2011)
93916	CHIAH YOKE YI	B.E.HONS.(UTP)(CHEMICAL, 2014)
94133	KANAGESH A/L MANOHARAN	B.E.HONS.(UTP)(CHEMICAL, 2015)
93816	ONG EU JIN	M.E.HONS.(UCL)(CHEMICAL, 2016)
94156	KON KEE JUN	M.E.HONS.(UNI. OF NOTTINGHAM)(CHEMICAL, 2012)
93783	ANG WEI HAO	M.E.HONS.(UNI. OF NOTTINGHAM)(CHEMICAL, 2016)
94145	LIM CHAN HENG	M.E.HONS.(UNI. OF NOTTINGHAM)(CHEMICAL, 2016)

KEJURUTERAAN KOMPUTER

94157	YONG CHANG KIM	B.E.HONS.(CURTIN UNI. OF TECH.)(COMPUTER SYSTEMS, 2017)

KEJURUTERAAN KOMPUTER & KOMUNIKASI

93928	DR. MOHD SHAHNAN BIN ZAINAL ABIDIN	B.E.HONS.(UPM) (COMPUTER SYSTEM & COMMUNICATIONS, 2002) M.SC.(UPM) (COMMUNICATIONS & NETWORK, 2005) PHD.(UPM)(PHOTONICS & FIBER OPTIC SYSTEMS ENGINEERING, 2014)

KEJURUTERAAN KOMUNIKASI

93893	DR. NORUN FARIHAH ABDUL MALEK	B.E.HONS.(IIUM) (COMMUNICATION, 2006) PHD.(LOUGHBOROUGH UNI., 2013)
94154	DR. FARAH DIYANA BINTI ABDUL RAHMAN	B.E.HONS.(IIUM) (COMMUNICATION, 2006) M.SC.(UNI. OF LEEDS) (ENGINEERING, 2007) PHD.(UNI. OF BRISTOL)(2016)

KEJURUTERAAN MEKANIKAL

94161	DR. ZUNAIDI BIN IBRAHIM	B.E.(MIE UNI.) (MECHANICAL, 1997) PHD.(MIE UNI.)(MECHANICAL, 2003)
93857	MUHAMMAD SHAHZALIE B IBRAHIM	B.E.(UNI. OF NEWCASTLE) (MECHANICAL, 2014)
94120	TOO HENG YUEN, JEFFREY	B.E.HONS.(NOTTINGHAM TRENT UNI.) (MECHANICAL, 2002) MSC.(UTM)(MECHANICAL, 2016)
94149	AHMAD FITRI BIN AHMAD	B.E.HONS.()(MECHANICAL-MANUFACTURING, 2009)
93790	HENG CHIANG LEONG	B.E.HONS.(CURTIN UNI. OF TECH.)(MECHANICAL, 2011)
93814	HILMI HARIZ BIN MAHABOT	B.E.HONS.(IIUM) (MECHANICAL-AUTOMOTIVE, 2016)
93990	LAI CHIEN SIN	B.E.HONS.(INTI INT. UNI.) (MECHANICAL, 2015)
93984	RATHAKRISHNAN ARUMUGAM	B.E.HONS.(MALAYA) (MECHANICAL, 1992) M.E.(MALAYA)(1997)
94018	QUAH CHEE KIANG	B.E.HONS.(MECHANICAL,
94126	CHAN WAI TI	B.E.HONS.(MMU) (MECHANICAL, 2008) M.E.SC.(MMU)(2013)
94026	LIM CHONG HOOI	B.E.HONS.(MMU) (MECHANICAL, 2011) M.E.(UTM)(MECHANICAL, 2013)
93792	NOR FARAHTUL AIN BINTI HARUN	B.E.HONS.(MMU) (MECHANICAL, 2016)
94008	MOHD HAFIZ BIN MOHAMAD MAHAYUDDIN	B.E.HONS.(MONASH UNI.) (MECHANICAL, 2013)
93993	YAP KEAN CHIANG	B.E.HONS.(MONASH UNI.) (MECHANICAL, 2017)
93867	CALVIN CHANDRAPAL	B.E.HONS.(MONASH) (MECHANICAL, 2016)
94158	CHOW KOK MIN	B.E.HONS.(NUS) (MECHANICAL, 2014)
94017	CHAN WEI YEAP	B.E.HONS.(SEGI UNI.) (MECHANICAL, 2016)
93973	YAP YIAN HEE	B.E.HONS.(SHEFFIELD HALLAM UNI.)(MECHANICAL & MANUFACTURING SYSTEMS, 2006) PART II & III(IEM/BEM EXAMS) (2014)
93909	PUA HAU KUAN	B.E.HONS.(UNI. OF BRADFORD) (MECHANICAL, 2010) M.SC.(UNI. OF BRADFORD) (MECHANICAL, 2011)
93988	TENG JING KAI	B.E.HONS.(UNI. OF MELBOURNE)(MECHANICAL, 2011)
94119	LIM CHEE CHEONG	B.E.HONS.(UNI. OF NOTTINGHAM) (MECHANICAL, 2007) M.E.(MALAYA)(MECHANICAL, 2016)
94003	MUHAMMAD ABDUL AZIZ BIN MOHD ZAIZ	B.E.HONS.(UNIMAP) (MECHANICAL, 2015)
93803	MOHD RAFIQ BIN MOHD HANI	B.E.HONS.(UNISEL) (MECHANICAL, 2011)
94000	MOHAMAD KHAIROL AMILIN	B.E.HONS.(UNISEL) (MECHANICAL, 2015)
94128	MUHAMMAD SYAKIRIN BIN RAZAKI	B.E.HONS.(UNITEN) (MECHANICAL, 2008)
94122	RASYIDA BINTI OMAR	B.E.HONS.(UNITEN) (MECHANICAL, 2011)
94033	MUHAMMAD HANIF BIN RAZALI	B.E.HONS.(UNITEN) (MECHANICAL, 2013)
93987	MOHD ENDRA BIN JAMARIS	B.E.HONS.(UNITEN) (MECHANICAL, 2015)
93796	MUHAMMAD FADIL ARSAD BIN MOHD USOPE	B.E.HONS.(UNITEN) (MECHANICAL, 2015)
93830	SHAIK MOHAMMED HAIKHAL BIN ABDUL RAHIM	B.E.HONS.(UNITEN) (MECHANICAL, 2015)
93924	PUVANESAN A/L VELAYUTHAM	B.E.HONS.(UNITEN) (MECHANICAL, 2016)
94025	AHMAD RAJI BIN KAMARUDIN	B.E.HONS.(UPNM) (MECHANICAL, 2014)
94153	ASWAD BIN CHE RUSMIN	B.E.HONS.(UPNM) (MECHANICAL, 2014)
94010	MOHAMAD KHAIROL AZUAN BIN MOHD AZMAN	B.E.HONS.(UPNM) (MECHANICAL, 2014)
94022	MOHAMMAD FARIS BIN MUSTAPA	B.E.HONS.(UPNM) (MECHANICAL, 2014)
94015	MOHD AIDIL BIN MOHD YUSOP	B.E.HONS.(UPNM) (MECHANICAL, 2014)
93866	MUHAMMAD HAIKAL BIN ROSLAN	B.E.HONS.(UPNM) (MECHANICAL, 2014)
93794	AZMI BIN KISSON	B.E.HONS.(USM) (MECHANICAL, 1994)
0	MUHMAD ROSDI BIN AB RAHIM	B.E.HONS.(USM) (MECHANICAL, 2001)
93920	CHAN SAI MUN	B.E.HONS.(USM) (MECHANICAL, 2012)
93953	CHUO CHUNG HENG	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
93949	KEU JIANN RONG	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
93946	LEE PEI LUN	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
93945	LEE PIN YANG	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
93942	LEW KANG JUN	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
93933	WOO YIK HWAN	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
93931	YEW KHAI CHUN	B.E.HONS.(UTAR SG LONG) (MECHANICAL, 2017)
94035	AFIQ AIMRAN BIN AHMAD	B.E.HONS.(UTEM) (MECHANICAL-THERMAL FLUIDS, 2015)
94031	ABDUL HALIM BIN BACHOK @ AMBOK LALEK	B.E.HONS.(UTHM) (MECHANICAL, 2008)
94152	ENGKU AFIF BIN ENGKU ZAM	B.E.HONS.(UTHM) (MECHANICAL, 2012)
93839	MOHD FAIZAL BIN NORSARI	B.E.HONS.(UTHM) (MECHANICAL, 2012)
94005	MOHD LATTIF KHAN BIN AHMAD BASHIR	B.E.HONS.(UTM) (MECHANICAL PRECISION, 2015)
94114	MOHD SHUKRI BIN ABDUL WAHAB	B.E.HONS.(UTM) (MECHANICAL, 2000)
93791	AZLIN BIN SAMSUDIN	B.E.HONS.(UTM) (MECHANICAL, 2001)
93826	MOHAMMAD KHALID BIN WAHID	B.E.HONS.(UTM) (MECHANICAL, 2006) M.E.(UPM)(MANUFACTURING SYSTEM, 2012)
93715	MOHD FAISAL BIN JAMIL	B.E.HONS.(UTM) (MECHANICAL, 2008)
94125	SEBASTIAN DAYOU	B.E.HONS.(UTM) (MECHANICAL, 2008) M.E.(UMS)(MECHANICAL, 2013)
93985	MUHAMAD SHAFRILNIZAM BIN ROSLI	B.E.HONS.(UTM) (MECHANICAL-AERONAUTICS, 2002) M.E.(UTM)(MECHANICAL-MARINE TECH., 2014)
94027	AHMAD ZAHIRUDDIN BIN SARUJI	B.E.HONS.(UTM) (MECHANICAL-AUTOMOTIVE, 2008)
93799	MOHD AZLAN IBERAHIM	B.E.HONS.(UTM-SPACE) (MECHANICAL, 2016)
93986	MUHAMMAD ZUKNI BIN IBRAHIM	B.E.HONS.(UTP) (MECHANICAL, 2009)
93863	MUHAMMAD ISKANDAR BIN ISMAIL	B.E.HONS.(UTP) (MECHANICAL, 2013)
93822	MUHAMMAD ZAFIRUL HAKIM BIN NORDIN	B.E.HONS.(UTP) (MECHANICAL, 2015)
93896	RUBHENDRAN KRISHNAN	B.SC.(KOREA UNI.) (MECHANICAL, 2011)
93976	BOO HENG CHUAN	B.SC.(SOUTHERN TAIWAN UNI. OF SC. & TECH.) (MECHANICAL, 2005)
94155	SHAHRUN NIZAM BIN SAFIIN	B.SC.(UNI. OF MISSOURI) (MECHANICAL, 2000)
93861	CHONG YIN HO	M.E.HONS.(NOTTINGHAM) (MECHANICAL, 2011)
93908	MUHAMAD FARID MUHAMAD KHOSIM	M.E.HONS.(THE UNI. OF SHEFFIELD)(MECHANICAL, 2016)
94020	CHIENG BENG CHWEN	M.E.HONS.(UNI. OF NOTTINGHAM)(MECHANICAL, 2015)
93958	ONG CHEW YI	M.E.HONS.(UNI. OF NOTTINGHAM)(MECHANICAL, 2016)
93827	MUHAMMAD SIDDIQ BIN SALLEHUDDIN	M.E.HONS.(UNI. OF SHEFFIELD)(MECHANICAL, 2013)
93989	TAN JIAYAO	M.E.HONS.(UNI. OF SHEFFIELD)(MECHANICAL, 2014)

KEJURUTERAAN MEKANIKAL SISTEM

93800	MUHAMMAD TAQIYUDDIN BIN CHE AB MALIK	B.E.HONS.(TAKUSHOKU UNI.) (MECHANICAL SYSTEM, 2012) M.E.(TAKUSHOKU UNI.) (MECHANICAL SYSTEM, 2015)

KEJURUTERAAN MEKATRONIK

94038	NIK MOHD REDHUAN BIN NIK RUSLAN	B.E.HONS.(IIUM) (MECHATRONICS, 2010)
93998	KHALEEL IBRAHIM M.QWAIDER	B.E.HONS.(IIUM) (MECHATRONICS, 2016)
94012	CHUA WEN-SHYAN	B.E.HONS.(MONASH UNI.) (MECHATRONICS, 2012)
93855	TAY KHENG LIANG, BONAVENTURE	B.E.HONS.(UNIMAP) (MECHATRONICS, 2009)
93802	NOOR HAFIZATUN BINTI ZAINI@ ZULKIFLY	B.E.HONS.(UNISEL) (MECHATRONICS, 2009)
93947	LAU CHEE MAN, BRYAN	B.E.HONS.(UTAR SG LONG) (MECHATRONICS, 2017)
93936	TANG TEE YANG	B.E.HONS.(UTAR SG LONG) (MECHATRONICS, 2017)
93845	SYED MOHD SYAFIQ BIN SYED MAHMUD	B.E.HONS.(UTEM) (MECHATRONICS, 2011)

KEJURUTERAAN PEMBUATAN

93851	JAYEE A/L SREETHARAN	B.E.HONS.(MALAYA) (MANUFACTURING, 2010)
93901	KHOR HAN WEI	B.E.HONS.(UTEM) (MANUFACTURING-MANUFACTURING DESIGN, 2010)
93967	AZIZUL QAYYUM BIN BASRI	B.E.HONS.(UTEM) (MANUFACTURING-MANUFACTURING PROCESSES,2009) M.E.(MANUFACTURING SYSTEMS, 2013)

KEJURUTERAAN PERTANIAN

93847	WONG MUN SHUAN	B.E.HONS.(UPM) (AGRICULTURAL & BIOSYSTEMS, 2010)
94116	RAJAN AYAHSAMY	B.E.HONS.(UPM)(BIOLOGICAL & AGRICULTURAL, 2000)

KEJURUTERAAN PETROLEUM

94138	MOHD AKHMAL BIN MUHAMAD SIDEK	B.E.HONS.(UTM) (PETROLEUM, 2009)
93834	ABDUL RAZAK BIN MOHAMED AFFANDI	B.E.HONS.(UTP)(PETROLEUM, 2009)
93963	SAIDAH NAFISAH BINTI KHALID	B.E.HONS.(UTP)(PETROLEUM, 2014)
93910	SHAHIRA BINTI MOHAMAD JUMAILI	B.E.HONS.(UTP)(PETROLEUM, 2016)

KEJURUTERAAN POLYMER

93848	DR. CHAN MING YENG	B.E.HONS.(UNIMAP) (POLYMER, 2012) PHD.(UNIMAP)(MATERIALS, 2015)

KEJURUTERAAN TELEKOMUNIKASI

93892	DR. NORAZLINA BINTI SAIDIN	B.E.HONS.(MALAYA) (TELECOMMUNICATION, 2005) M.E.(MALAYA)(OPTICAL TECHNOLOGY, 2010) PHD.(MALAYA)(FIBER OPTICS, 2015)
94011	LEE CHEE WEE	B.E.HONS.(MALAYA) (TELECOMMUNICATION, 2012)

PERMOHONAN MENJADI AHLI 'INCORPORATED'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN ELEKTRONIK		
94164	KUAN TEIK HUA	B.E.TECH.HONS.(WAWASAN OPEN UNI.)(ELECTRONICS, 2014) M.E.(UTAR) (ELECTRICAL, 2017)
0	MUHAMAD ARIF BIN AMRAN	BE.TECH.HONS.(UNIKL) (MEDICAL ELECTRONICS, 2015)
KEJURUTERAAN ELEKTRIKAL		
94163	SITI MUSLIHA AJMAL BINTI MOKHTAR	B.E.(KEIO UNI.)(ELECTRONICS & ELECTRICAL, 2012) MSC.(UITM)(ELECTRICAL, 2016)
93884	NG KIENG LENG	B.E.HONS.(UNI. OF LINCOLNSHIRE & HUMBERSIDE, 2001)
0	ABDUL RAHMAN BIN AB RAZAK	BE.TECH.HONS.(UNIKL) (ELECTRICAL, 2014)
0	MOHD ABDUL SYUKUR BIN MUSA	BE.TECH.HONS.(UNIKL) (ELECTRICAL, 2014)
KEJURUTERAAN MEKANIKAL		
94165	HAZIFIZI BIN HAZIZI	B.E.TECH.HONS.(UNIKL) (MECHANICAL-AUTOMOTIVE, 2012)
0	ABU HASANI SAZALI BIN AZAM	BE.TECH.HONS.(UNIKL) (MECHANICAL-AUTOMOTIVE, 2014)
KEJURUTERAAN MEKATRONIK		
0	MOHAMMAD FAIZOL BIN AMRAN	BE.TECH.HONS.(UNIKL) (MECHATRONICS, 2011)
0	MOHD SHAHRUL REDZUAN BIN SHAHSUDIN	BE.TECH.HONS.(UNIKL) (MECHATRONICS, 2014)
0	AHMAD HAZIM BIN MOHD RUSLI	BE.TECH.HONS.(UNIKL) (MECHATRONICS, 2015)
0	MOHD AMIRUL BIN AZMI	BE.TECH.HONS.(UNIKL) (MECHATRONICS-AUTOMOTIVE, 2015)
0	MOHD JAZREEN BIN CHE RAHIM	BE.TECH.HONS.(UNIKL) (MECHATRONICS-AUTOMOTIVE, 2015)
KEJURUTERAAN TEKNOLOGI MAKLUMAT		
0	NOR QUSIAH BINTI ABDUL RAZAK	B. IT.(UMT)(INFORMATION TECHNOLOGY-SOFTWARE ENRG., 2008)
KEJURUTERAAN TENAGA		
93768	MUHAMMAD SUFYAN BIN HAFIZ	BE.TECH.HONS.(UNIKL) (BIOSYSTEM, 2013) M.E.TECH.(UNIKL-HOCHSCHULE ROSENHEIM) (GREEN & ENERGY EFFICIENT BUILDINGS, 2015)

PERMOHONAN MENJADI AHLI 'AFFILIATE'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN BANGUNAN		
93883	RAMASH A/L K. MADHAVAN	B.Sc.HONS.(USM)(HOUSING, BUILDING & PLANNING-BUILDING ENGINEERING, 1995)

PERMOHONAN MENJADI AHLI 'ASSOCIATE'

No. Ahli	Nama	Kelayakan
KEJURUTERAAN ELEKTRIKAL		
93767	ROLAND LAGATA	DIPL.(POLIMAS)(ELECTRICAL-CONTROL & ELECTRONIC POWER, 2003)
KEJURUTERAAN MARIN		
93766	DARMENDRAN RATHINA PANDI	DIPL.(UNGKU OMAR POLYTECHNIC)(MARINE, 2001)

***Note:** New list would be published in the February 2018. For the list of approved "ADMISSION TO THE GRADE OF STUDENT", please refer to IEM web portal at http://www.myiem.org.my.*

Pengumuman yang ke-111

SENARAI PENDERMA KEPADA WISMA DANA BANGUNAN IEM

Institusi mengucapkan terima kasih kepada semua yang telah memberikan sumbangan kepada tabung Bangunan Wisma IEM. Ahli-ahli IEM dan pembaca yang ingin memberikan sumbangan boleh berbuat demikian dengan memuat turun borang di laman web IEM http://www.iem.org.my atau menghubungi secretariat di +603-7968 4001/5518 untuk maklumat lanjut. Senarai penyumbang untuk bulan November 2017 adalah seperti jadual di bawah:

NO.	NO. AHLI	NAMA
1	19728	CHIN JOK MIN, RAYMOND
2	70404	HASHIM BIN ABDULLAH @ ABDUL GHANEY BIN SULAIMAN
3	49450	JAMIL BIN HASHIM
4	88509	LEE CHUN HOONG
5	24382	MOHAMAD YUSRI BIN MOHAMAD YACOB
6	30536	MOHD DALIAS BIN AWI
7	24312	MOHD FARIS BIN ARIFFIN
8	36811	NG HSIN LOON
9	05043	NG YONG KONG
10	09828	SOHAIMI BIN SAMAD
11	80589	SYAZWAN BIN SELAMAT
12	10084	TAIB BIN ABU BAKAR
13	08180	TAN CHING MENG
14	08955	TAN GEEM ENG
15	93518	TAN WENG SENG
16	07537	TIONG HONG HEE
17	03219	ZAMALI BIN MIDUN

IEM DIARY OF EVENTS

Title: 2-Day Short Course on Geosynthetic-Reinforced Pile – Supported Embankments and Other Recent Developments in Transportation Infrastructure

6-7 February 2018
Organised by: Geotechnical Engineering Technical Division
Time : 9.00 a.m. - 6.30 p.m.
CPD/PDP : Applying

Title: Talk on "Petroleum Engineering and the Life of Field"

10 February 2018
Organised by: Oil, Gas & Mining Technical Division
Time : 9.00 a.m. - 11.00 a.m.
CPD/PDP : 2

Title: Technical Visit to Hartalega NGC

10 February 2018
Organised by: Mechanical Engineering Technical Division
Time : 9.00 a.m. - 1.00 p.m.
CPD/PDP : Applying

Title: ICTSIG Digital Class (February 2018) - Python Programming Language (Part 3 Function and Class)

10 February 2018
Organised by: Information and Communications Technology Special Interest Group
Time : 11.00 a.m. - 1.00 p.m.
CPD/PDP : 2

Title: Technical Talk on Geotechnical Challenges on Puah Dam, Hulu Terengganu Hydroelectric Project

27 February 2018
Organised by: Geotechnical Engineering Technical Division
Time : 5.30 p.m. - 7.30 p.m.
CPD/PDP : 2

Kindly note that the scheduled event is subject to change. Please visit the IEM website at www.myiem.org.my for more information on the upcoming events.