One Day International Seminar on "*Engineering a Sustainable Development: Role played by Geotechnical Engineering*"

By: Ir. Chua Chai Guan

Brundtland Report (1987) defines ***sustainable development*** as a ***development that meets the needs of the present without compromising the ability of future generations to meet their own need***. Basically it is about a living pattern dealing with the use of resource in current and future timeline. Is this a realistic target with the current trend with 20% of population consuming 80% of the natural resources? Are we consuming natural resources more than its ability to replenish? Are we exploiting the resources of future generation? Is the planet we are living now a sustainable environment? How do we measure a sustainable development? What can we engineers contribute to a sustainable development?

The above questions motivated the GETD to organize this international seminar to exchange opinions with experts from regional countries such as Hong Kong and Singapore on what have been done and the future trend in shaping our world towards a more sustainable development, particularly from the perspective of geotechnical engineering. This seminar was co-organised by the IEM's Geotechnical Engineering Technical Division (GETD), IEM Kuching Branch, Geotechnical Society of Singapore (GeoSS), Hong Kong Institution of Engineers (HKIE) Geotechnical Division and Hong Kong Geotechnical Engineering Society (HKGES) and supported by the Association of Geotechnical Societies in South East Asia (AGSSEA). It toured the four cities of Kuching, Petaling jaya, Singapore and Hong Kong from 21st Feb to 28th Feb 2011. The second stop took place at PJ Tropicana Golf Club and Country Resort on 23rd Feb 2011. There were in total 8 invited speakers, namely Prof. Chu Jian from Nanyang Technological University, Prof. Bujang Huat from University Putra Malaysia, Dr. Leong Kam Weng from Keller Singapore, Mark Wallace, Freda Chu and Ir. Albert Ho from Arup Geotechnics in Hong Kong, Ir. Dr.Loke Kean Hooi from Tencate Malaysia and Ir. Lee Eng Choy from LEC Geo Consult. In the Petaling Jaya stop, there were in total about 50 participants. Ir. Albert Ho and Ir. Dr. Loke were replaced by Mark Wallace and Ir. Lee at Singapore and Hong Kong stop, respectively.

Prof. Chu Jian delivered his lecture entitled "***Research on Solutions for Sustainable Development in Construction***". He started his lecture by explaining his research was driven by the demand of construction industry in sourcing innovative and sustainable technologies. "The public is more aware of environmental conservation due to the scarcity of energy resources in Singapore", said Prof Chu. Basically his research is exploring new construction materials which consume relatively less energy, the recycle of waste materials as construction materials and new construction technologies which are environmental friendly.

Prof. Chu revealed that the idea of using ***bio-cement*** to replace cement in geotechnical applications appeared to be promising. This bio-cement made of naturally occurring micro-organisms and waste material consumes less energy. Moreover it costs less than the conventional cements. The bio-cement can be used in liquid or powder form and the micro-organisms can reproduce and spread themselves at site without using intensive mechanical mixing. Some practical applications are stabilisation of slopes and dams, mitigation of coastal erosion and ground strengthening. He also highlighted that the current achievable strength by the treated sand using bio-cementation process was less than 2MPa. "There are still more rooms for researchers to upgrade the performance of bio-cement", said Prof Chu. This new field of research is termed as ***microbial geotechnology*** - a new branch of geotechnical engineering.

Prof. Chu further introduced that industrial waste such as **sewage sludge**, **copper slag and plastic waste** can be converted into construction materials. The sewage sludge which contains heavy metal elements (zinc, copper, Chromium, Barium, etc.) and high moisture content could be **mixed with either cement or copper slag and cement and then consolidated**. As a result, the microstructure of sludge could be changed and engineering properties such as strength and un-leachability and permeability could be improved. Figure 1 shows that the UCS strength of an improved sludge material tested (~130 to 240 kPa at 5% strain as compared with ~USC strength of 14kPa for normal sewage sludge).

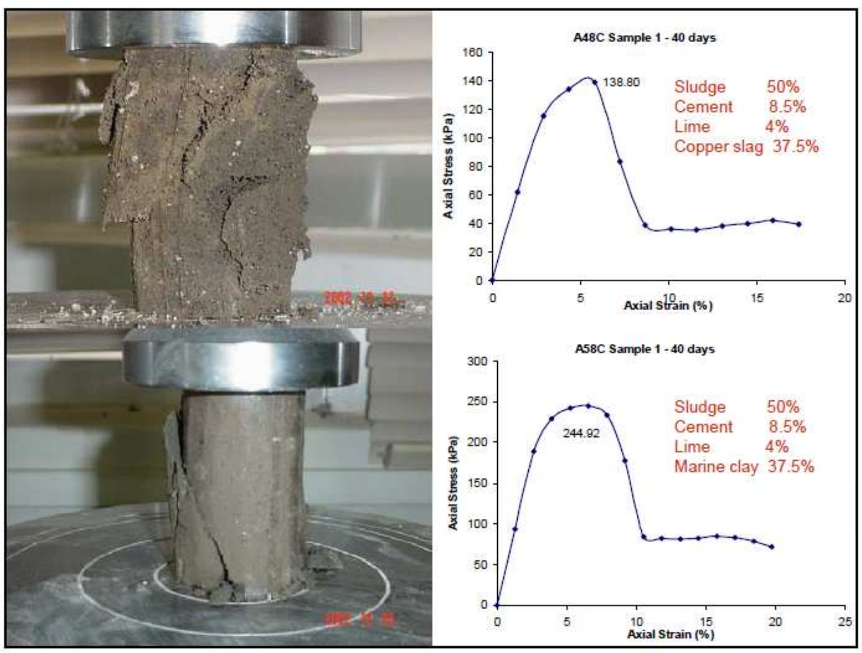

Figure 1- UCS strength for two sludge samples treated using cement and lime and mixed with cooper slag and marine clay, respectively.

The second speaker, Prof. Bujang presented his lecture entitled "***Use of Bioengineering (live pole) for Mitigation of Slope Failures***" which was based on the finding of a funded research by the Ministry of Science, Technology and Innovation (MOSTI) Malaysia. The research explored which type of hardy species of live poles (short trees or shrubs) suitable for stabilizing a slope, as well as engineering properties of live poles, slope stabilising mechanism by the root of live poles, see Figure 2. This live pole technique can be used in the prevention and ***repair*** of ***shallow slips*** on highway embankment and cut slopes.

Prof. Bujang claimed that this bio-engineering approach for slope cover could increase carbon sequestration to counter rising carbon dioxide level in the atmosphere.

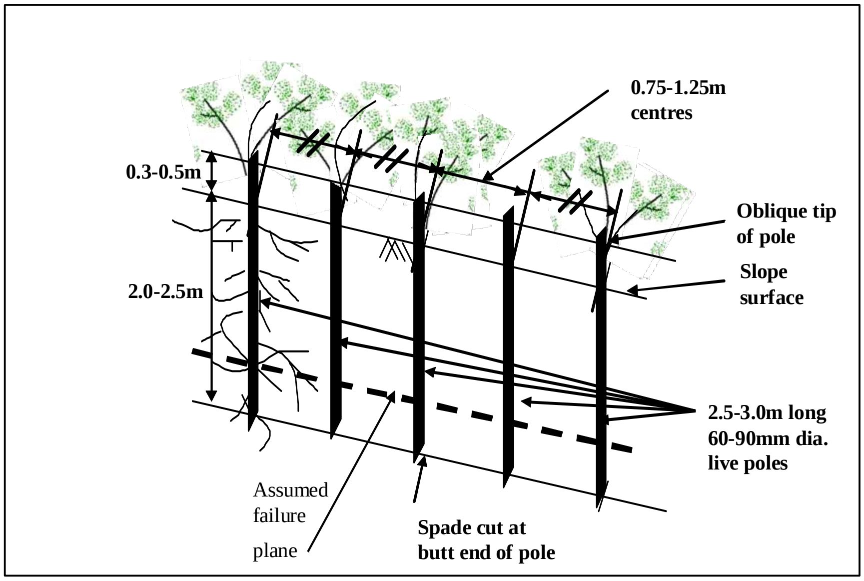

Figure 2: Live pole array stabilization.

The third speaker, Dr. Leong started his talk entitled "***Ground Improvement: A Green Technology***" by defining what was ground improvement and how it could be classified as a green technology. "Ground improvement is a ***controlled alteration of the state, nature or mass behaviour of ground materials in order to achieve an intended satisfactory response to existing or projected environmental and engineering actions",*** he cited the definition given by CIRIA C573***.*** Dr. Leong explained that the ground improvement solution had less impact to the environment as it rarely involved steel and concrete which consumed considerably high carbon footprint.

Dr. Leong demonstrated that carbon footprint (in equivalent tons of carbon dioxide) was a recognized measurement on total amount of greenhouse gases emission produced directly and indirectly by construction activities. He cited that carbon footprint of various foundation techniques whereby the carbon footprint of stone column was 100 times less than that of 90cm diameter of bored piles (see Figure 3). He then wrapped up by presenting three cases of application where ground improvement techniques were employed in alternating the conventional solution and attaining goal of sustainability.

The fourth speaker, Dr. Loke presented his talk entitled "***Engineering a sustainable development through geosynthetic technology***". He introduced that modern geosynthetics were made of polymers (Polyethylene (PE) or Polyamide (PA) or Polyester (PET) or Polypropylene (PP)) and types of geosynthetics were geotextile, geogrid, geomembrane, geonet and geocomposite. "The basic functions of geosynthetics in geotechnical engineering are **separation**, **filtration**, **reinforcement**, **erosion**, **drainage**, **protection** and **sealing"**, said Dr. Loke.

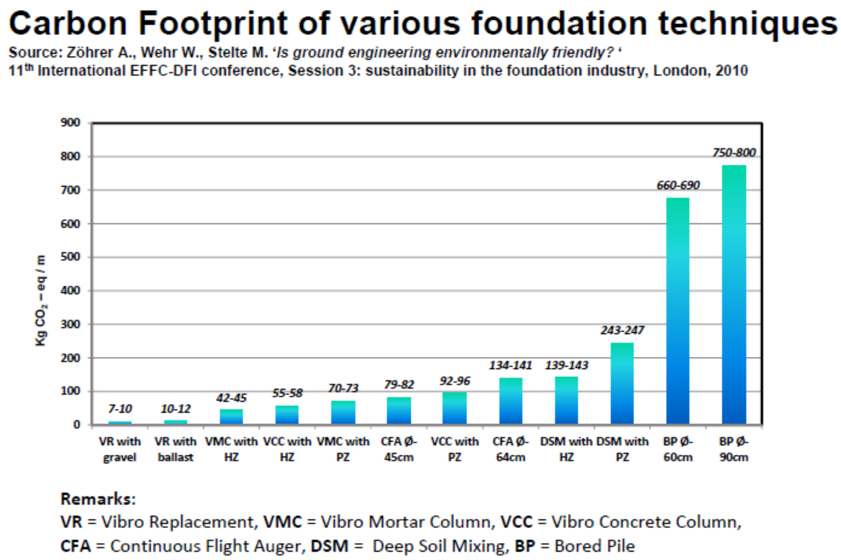

Figure 3: Carbon footprint of different foundation techniques

Dr. Loke advised participants not to design geosynthetic neither by cost and availability nor by specification as this may lead to high failure risk. "It is important to understand the primary and secondary functions of geosynthetic products and relate it to project performance requirements", said Dr. Loke. Figure 4 shows the testing standards normally used to identify certain properties for various functionalities of applications.

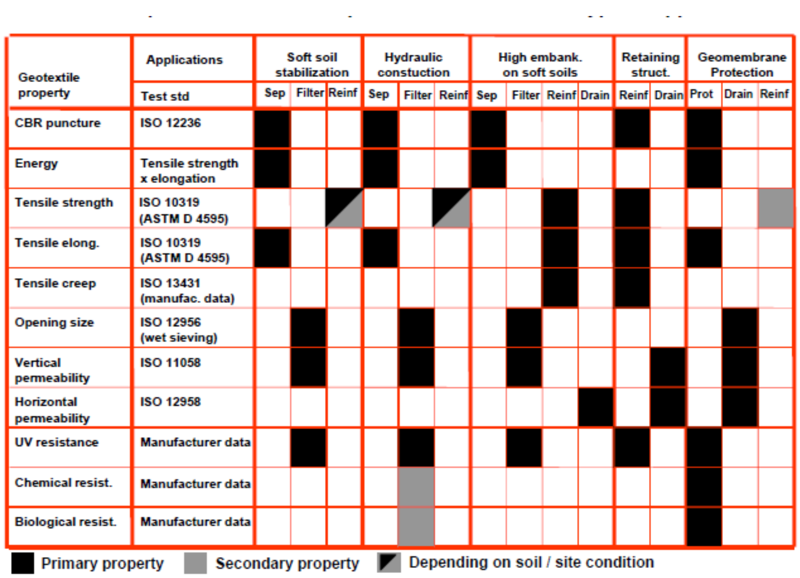

Figure 4: Review of required geotextile properties & functions for typical applications

Dr. Loke opined that relative sustainability could be assessed by comparing the amount of embodied carbon in various construction projects. The embodied carbon is a measure of cumulative energy (carbon emission) required to produce, deliver and use the produce concerned, as well as associated construction activities (similar to the carbon footprint cited by Dr. Leong).

Through a case study of comparison between geosynthetic reinforced bund and gabion wall, he demonstrated that the latter reduced the carbon footprint by 89% as it cut down volumes of excavation, material wastage, construction haulage, more significantly it reduced usage of high embodied carbon materials like steel, concrete and primary aggregates.

Freda Chu is the fifth speaker who presented the talk entitled "***Ground Source Energy – Experiences & Prospects***". She started the talk by showing that 80% of energy used to power our world came from depleting resources i.e. oil, gas and coals. The demand for sourcing more energy, particularly replenishable type is surging high as our population is growing at phenomenal speed, see Figure 5. She pointed out that **sustainability was not just about being green and use less.** Echoing Brundtland Report (1987) on sustainable development, "We should be leaving behind a planet fit enough for our future generation to pursue opportunities in their own way", said Freda Chu.

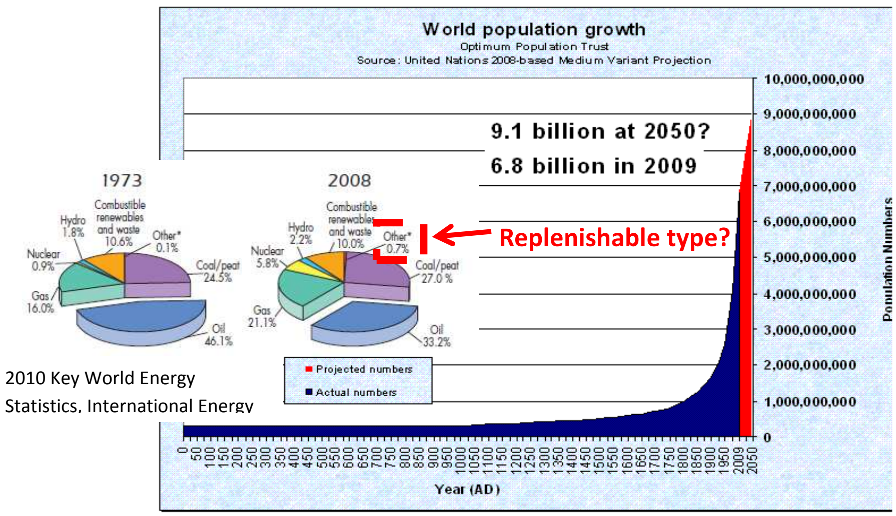

Figure 5: Depleting energy source and growing population.

Freda went on to introduce the principle of ground source heat pump (GSHP) which makes use of the stable temperature (~13^{o}c varies regionally) within ~50m of ground for heat exchange. Theoretically, during the summer when the surface temperature is hot then the cooler energy source from the ground (~13^{o}c) can be used to dissipate the heat and the other way round in winter see Figure 6. This type of renewable energy has been gaining popularity in Indonesia and China which some of them Freda has personally involved as the designer.

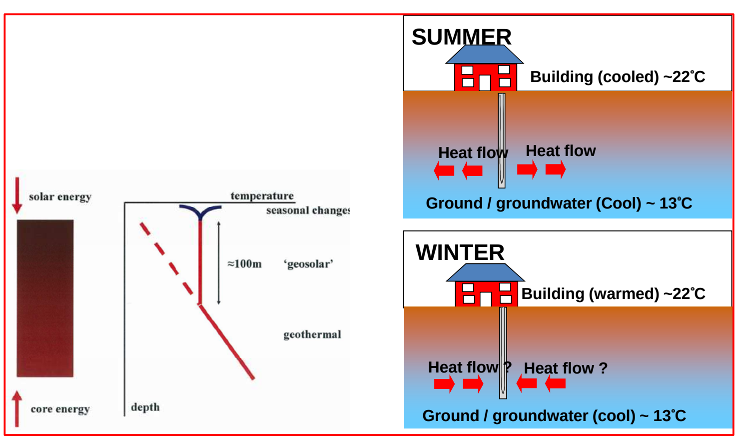

Figure 6: Principle of Ground Source Heat Pump

Freda Chu highlighted that the GSHP is more efficient in seasonal regions compared with equatorial regions. "The installation is considerable high such that it needs a long time to pay back for the investment", said Freda Chu.

The last speaker, Albert Ho presented a talk entitled "***Underground Space Development and Caverns in Hong Kong***". He shared with audiences by introducing Hong Kong's existing and proposed tunnelling infrastructure and major rock caverns in Hong Kong. There are in total about 436 km of tunnel built till 2008 and there will be additional 178km by 2019 in Hong Kong. They comprise of drainage & sewage, road, railway, water supply and cable tunnels. The first cavern in Hong Kong was built in 1984. The width of cavern varies from 10m to 60m. They are used as valve chamber, MTR substation, sewage treatment works, explosive depot, refuse transfer station and saltwater reservoir.

Albert explained that hilly terrain and underlying strong rocks naturally precipitated the development of underground space in Hong Kong. Especially when rock caverns locates on urban fringes could help release land for other uses. "Due to the significant urban growth on limited land area and high land value in recent years, underground space development is becoming a viable alternative option in Hong Kong", said Albert Ho. Besides these economic considerations, the underground development would provide environmental benefits such as stable temperatures, avoidance of noise and dust impact compared to constructions above ground, possible combined aggregates supply with underground quarrying and underground space creation. New technology which improves natural light and ventilation also makes the underground space environment more acceptable by public. Nevertheless, Albert reminded that there were potential negative impacts such as pollution of ground water and increased cost of life cycle which need to be evaluated. He stressed that the cavern related studies such as strategic planning, inventory of current Government facilities and master cavern areas plan in Hong Kong started in 90's (Figure 7). He added "these continual efforts have laid the foundation for Hong Kong Government in promoting the enhanced use of rock caverns and pursue of sustainable development."

There were active Q&As from the floor after the presentation. At the end of the seminar the speakers were appreciated by a big applause from participants and presentation of token of appreciation by the organiser.

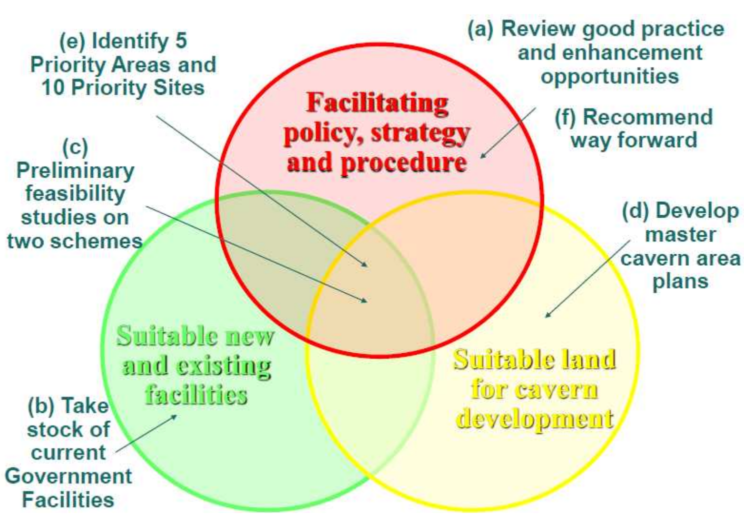

Figure 7: Key elements of underground space study in Hong Kong