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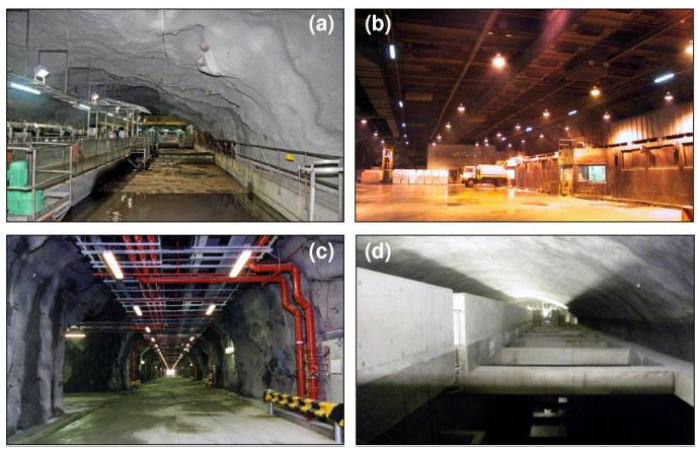
Sing Lok Chiu *(Part A: Hong Kong)*, **Tiong Guan Ng** *(Part B: Singapore)* &

San Shyan Lin *(Part C: Contributed Papers)*

1972 Po Shan landslide in Hong Kong
(After Ho and Cheung, 2016)



Examples of purpose-built caverns in Hong Kong
(After Ng et al, 2016)

Layout plan of DTL3 alignment and location of C922 ORT in Singapore *(After Ng and Low, 2016)*

Underground Ammunition Facility cavern in Singapore
(After Zhou and Zhao,2016)

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GEOTECHNICAL ENGINEERING

PREFACE

This is a combined Issue of paper contributions from Hong Kong and Singapore; it contains eighteen excellent papers including four papers directly submitted to the SEAGS Secretariat.

The first paper by Ho & Cheung is on challenges in improving slope safety through the landslip prevention and mitigation program. In 1977, the Hong Kong Government embarked on a systematic retrofitting programme, known as the Landslip Preventive Measures (LPM) Programme, to systematically upgrade existing substandard man-made slopes to meet modern safety standards. By 2010, some 4,500 high-risk government man-made slopes have been upgraded through engineering works, and the overall landslide risk arising from man-made slopes has been reduced to less than 25% of the 1977 level. Over the years, the programme has evolved progressively in response to Government's continuous improvement initiatives and rising public expectations in respect of slope safety and slope appearance. In 2010, the Government launched the Landslip Prevention and Mitigation (LPMit) Programme to dovetail with the LPM Programme, with the focus being on retrofitting the remaining moderate-risk substandard man-made slopes and systematically mitigating natural terrain landslide risk. This paper presents the challenges, technical advances and achievements of the LPM and LPMit Programmes.

The second paper is by Ng et al on Rock caverns- Hong Kong's hidden land. The hilly terrain and underlying geology of Hong Kong offer an excellent opportunity for placing urban facilities underground. About two-thirds of Hong Kong's land is found to be suitable for rock cavern development. Given the potential for multi-layer cavern development, a substantial usable area could be created. In September 2012, the Civil Engineering and Development Department of the Government of the Hong Kong Special Administrative Region commenced a study on "Long-term Strategy for Cavern Development", to develop a holistic approach in planning and implementing cavern development and render it a sustainable means for expanding land resources. The study also places emphasis on private sector participation as facilities, such as storage, warehousing and data centres, can benefit from rock caverns' stable and secure setting. Implementation of a long-term strategy for cavern development could provide a sustainable approach in easing the pressure of land shortage. Developing a systematic relocation programme for suitable Government facilities could release surface sites for other uses including housing, and placing nuisance or potentially hazardous facilities in caverns could remove incompatible land uses. Reserving rock cavern space to accommodate future public and private sector facilities underground could further reduce the land take. The Hong Kong Government has also commenced an initiative to explore the potential of underground space development in the urban areas. Facilitating rock cavern development at the urban fringes and underground space development in the urban areas could enhance Hong Kong's utilisation of land resources in pursuit of sustainable development.

The third paper is on the first subsea TBM road tunnel in Hong Kong by Liu et al. Subsea tunnels for transportation are traditionally constructed in the form of Immersed Tunnel (IMT). With the technical advancement of mechanized Tunnel Boring Machine (TBM) construction, subsea TBM bored tunnels were successfully constructed in different parts of the World over the last decade. Using a TBM has benefits over the IMT when excavating beneath the sea, since it does not require dredging and marine access. This makes it particularly favourable when coping with environmental concerns and constraints within existing shipping passages. Since the first subsea tunnel across the Victoria Harbour in Hong Kong was constructed in 1972 by immersed tunnel method, four other additional subsea immersed tunnels were constructed across the same Victoria Harbour between 1979 and 1997. The subsea tunnel of Tuen Mun – Chek Lap Kok Link (TM-CLKL) was also originally proposed using immersed tunnel method in the feasibility study stage. However, the tunnel scheme was changed to TBM bored tunnel in the Investigation and Preliminary Design Stage. The TBM bored tunnel scheme was further developed in the Detailed Design Stage and the project is now under construction. This would be the first subsea TBM road tunnel in Hong Kong and this paper discusses the key considerations and rationales in changing the original IMT scheme to the TBM bored tunnel scheme for the subsea tunnel section of TM-CLKL.

The fourth paper is by Tam and Chang on achievements and challenges to the Hong Kong landslide risk management. Landslide is one of the common natural hazards in Hong Kong. With the Government and public's concerted efforts, landslide risk in Hong Kong has been drastically reduced since the establishment of a comprehensive slope safety system in 1977. However, given Hong Kong's climatic and geographical conditions and the current state of technology, occurrence of serious landslides that could potentially cause multiple fatalities remains a distinct possibility, particularly during extreme rainfall events.

The fifth paper by Tsang et al is on sub sea horizontal directions coring (HDC). The Tuen Mun – Chek Lap Kok Link comprises a 9 km long dual 2-lane carriageway between Tuen Mun and North Lantau, with approximately 5 km long sub-sea tunnel between Hong Kong Boundary Crossing Facilities and Tuen Mun. This is a major highway infrastructure constructed to alleviate the increase in cross boundary traffic due to projected developments in the Northwest New Territories and North Lantau in Hong Kong, including the Airport developments and the Hong Kong-Zhuhai-Macao Bridge. The proposed subsea tunnel is to be constructed by large diameter Tunnel Boring Machines (TBM) which will bore underneath two sets of existing submarine power cables providing power supply to the Hong Kong International Airport. Ground investigation using conventional vertical marine drill holes is not allowed within the cable protection zone with the considerations of the potential risk of damaging the power cables. To provide sufficient ground information for the design of the proposed TBM tunnel, Horizontal Directional Coring (HDC) with a total length of 660m was proposed at the invert level along the tunnel alignment. It was anticipated that the HDC would go through rock, soil or soil/rock interface and terminate at interface of soft / mixed ground. The HDC works has been completed in mid-2013. This paper describes the design considerations and the trajectory planning of the HDC work, with construction of a marine platform (of size 15m x 20m to facilitate the installation of the HDC). The difficulties and problems encountered during the subsea horizontal drilling is also discussed.

The sixth paper from Hong Kong contribution is the seventh Lumb lecture by Endicott. The Lumb Lecture is held in Hong Kong biennially to celebrate the work and the legacy of a great Geotechnical Engineer, Professor Peter Lumb. This paper reviews changes in geotechnical practice, in and around Hong Kong, since his retirement and shows remarkable developments and some folly. What would he think of his legacy? Would he be disillusioned by folly or would he have taken satisfaction to see that, in many instances, his legacy lives on. There are a number of valid successors following in Peter's footsteps. This paper has drawn extensively upon the work of many good geotechnical engineers and is dedicated as a tribute to all of the geotechnical engineers, engineering geologists, geologists and other people who have made the name of Hong Kong synonymous with ground engineering. There are too many to single out individually.

The second part of this Issue is contributions from Singapore. The papers are numbered continuously. Thus the seventh paper is by Ng and Low on Singapore case histories for the circle line and down town line projects. The case history of Overrun Tunnel (ORT) of C922 is basically an underground facility building functions as both Railway Facility (Operation Control Centre) and Electrical Substation (ESS) which is to be built next the Expo Station. ORT is located in old alluvium (OA). The proposed underground overrun tunnel is a box structure with dimensions of approximately 23m wide, 25m deep and approximately 440m long. The proposed diaphragm wall function as the earth retaining system (ERSS), it designed for both temporary loading conditions during excavation and permanent load conditions in accordance with LTA Civil Design Criteria. Bottom-up construction sequence is adopted where lateral supports using four (S3 to S6) or six (S1 to S6) layers of steel strutting were installed as excavation progresses downward. The most challenging part is the omission of the last layer of strut S6 for the whole ORT by using observational approach. The case history of C824 Nicoll Highway Station demonstrates that Jet Mechanical Mixing (JMM), if properly installed, has major benefits in controlling the stability and movements induced by deep excavations in soft ground. The reasons can be attributed to the fact that the inner soil column is comprehensively mixed, combined with the attributes of the outer jet grouted column with sufficient overlapping. The whole process undergoes tight quality control and rigorous testing to ensure a continuous and comprehensive slab. In addition to the JMM slab, there is the major benefit of the discrete soil mixing columns formed above the JMM slab during the withdrawal of the auger.

The eighth paper is on an update of the vacuum preloading methods by Chu et al. It has been more than 60 years since the concept of vacuum preloading was proposed. The vacuum preloading method has been evolving. There have been considerable improvements in the techniques as well as new applications. In this paper, several vacuum preloading methods including some new variations are introduced. The advantages and disadvantages of each method are compared. Technical issues such as improvement depth, vacuum pressure distribution in soil, and evaluation of degree of consolidation for soil under vacuum consolidation are discussed. A case history using a combined vacuum and fill surcharge preloading method for soft soil improvement is also used to illustrate the changes in the pore pressure versus depth profiles and the application of the method to calculate degree of consolidation using pore water pressure distributions.

In the ninth paper a new lithostratigraphical framework is proposed for Singapore by Lat et al. A study was initiated in mid-2013 by Building & Construction Authority of Singapore (BCA) to review the existing stratigraphy framework of Singapore. The new lithostratigraphical framework follows the recommendations of International Commission of Stratigraphy (ICS) and it was developed based on geological fieldworks observations and rock cores examination obtained from new deep boreholes. This paper will only cover on the Jurong Formation, Fort Canning Boulder Bed and Old Alluvium. The Jurong Formation has been upgraded to Jurong group according to ICS stratigraphy guidelines and the Jurong group is sub-divided into three (3) formations, known as Tuas formation, Bukit Resam formation and Pasir Panjang formation. The Fort Canning Boulder Bed and Old Alluvium have been re-classified as Fort Canning formation and Bedok formation respectively.

The following paper tenth in the series is by Tan on economical design of non-negative skin friction piles in soft clays. Code based design of piles with NSF consider the NSF force as a dragload to be imposed on the pile as an unfavourable design action. These codes like Singapore CP4, UK BS 8004 and the recent EC7 would indirectly factor up the value of the dragload while at the same time factor down the positive shaft friction below the neutral plane. Thus the pile design in very deep soft clays typical of Singapore and Asean coastal plains will lead to very conservative pile lengths to meet the code requirements. The Unified pile design method of Fellenius recognized this deficiency and it allows for better pile design with NSF taking into account the need for both force and settlement equilibrium between pile and soil. Fortunately, EC7 also allows for interactive pile/soil analysis using modern FEM tools that can optimise pile design for NSF, particularly when the remaining consolidation settlements around the piles are relatively small. This paper will compare these methods and provide insights into the proper understanding of NSF effects on pile behaviour, and recommend the way forward for rational and economical pile design in settling soils.

The eleventh paper is by Liu et al on design framework for spatial variability in cement tratemenent for underground construction. The most common form of ground treatment used to facilitate underground construction in Singapore is cement treatment. However, there is currently no indication on how safe and how conservative this adopted strength is since the prescribed strength bears no relationship to the probability of failure or factor of safety. This paper examined several sources leading to non-uniformity and spatial variation in cement-treated soils, including curing time effect, influence of operating parameters on slurry concentration, in-situ water content and column positioning errors. A framework for design and monitoring of ground treatment by cement was proposed.

The twelfth paper by Zhou and Zhao is on advances and challenges in underground space utility in Singapore. Despite its promise and many benefits for sustainable urban development, the use of underground space has tended to be the last resort, due to high development cost and the complexities in the planning and development of underground space. In 2010, the Economic Strategies Committee of the Singapore government made developing underground space part of the government’s long-term economic strategy with specific recommendations on master planning, geological investigations, investment in research and development, and various policy issues. With this, the use of underground space has been

elevated to a strategic level and has become an economic imperative in land-scarce Singapore. The ESC report also recommended that the government should take the lead in catalysing the use of underground space. Based on these recommendations, the Singapore government has taken various initiatives and studies, and initiated various research projects in support of these initiatives. This top-down strategy has also made it possible to plan and coordinate the development of underground space in a holistic manner, and helps overcome of the key challenges at the systems. This paper gives a review of advances in underground space development, highlights some key challenges, and discusses the various recent studies and planning issues, and examines possible strategies for future use of underground space in Singapore. Furthermore, another four papers are included as contributed directly to the Editorial Team in this issue.

The thirteenth paper by Shaia and Abuel-Naga investigated the ageing induced changes in Fiber-Reinforced Polymer (FRP)/Granular interface shear behaviour under different aging environments. The test results indicated that FRP-granular interface shear behaviour was improved after subjected to the adopted aging environments. This improvement in the FRP interface shear behaviour could be mainly attributed to the observed increase in surface roughness under aging process.

The fourteenth paper authored by Dassanayake, Phien-wej and Giao dealt with modeling the groundwater pressure effect and slope stability analysis of C1 pit on deep pit mining of Mae Moh open pit lignite mine, Thailand. Stability of the west wall of the C1 pit for 2017 pit slope was evaluated in terms of the safety factor by the limit equilibrium method. Results obtained in this study indicated that the west wall is susceptible to failure due to water pressure associated with it. To maintain a safe slope, potentiometric head within west wall of C1 pit should be maintained below 170m, MSL.

In the fifteenth paper, Chen**,** Lin**,** Lee and Chen developed a seepage flow direct shear test device to investigate the effects of internal erosion to non-plastic silty sand prior to shearing. Tested results revealed that fines contents had noticeable influence on soil behaviours, regardless of whether an internal erosion process was applied to the samples.

In the sixteenth paper the Influencing factors including the Poisson’s ratio and the rock specimen thickness on Brazilian test results are investigated by Yang and Wang using PFC3D program based on a complex-shaped grain model which can capture all the characteristics of brittle rock in three-dimensional environment. Through investigating the stress-strain curves and crack developing processes of the Brazilian test specimens, it was concluded that the Brazilian tensile strength will increase with the specimen thickness due to the great loading increment.

In the seventeenth paper an attempt was made by Cheng, Chern, Wu, and Lin to investigate the shear behaviour of soft rock joints under Constant Normal Load conditions, with special reference to the influences of infill thickness and moisture content on shear behavior of planar and rough joints. The results of this study showed that infilled water content could influence shear strength of planar and rough rock joints, more significant than infill thickness.

The last paper, by T.G.Santhoshkumar, Benny Mathews Abraham, A, Sridharan, and Babu T Jose, investigated the effectiveness of bentonite in improving the lateral flow of cement grouts in a coarse sand. It was found in the paper that addition of small percentages of bentonite and detergent increases the lateral flow of cement grout in coarse sand. The results indicated that addition of even a small amount of bentonite to the cement grout increases the grouting efficiency in coarse sand.

This combined Issue of the papers from Hong Kong, Singapore and other submisions makes futher contributions in the development of Geotechnical Engineering in SE Asia. The editors are very pleased to have the opportunity in compiling the material presented herein.

Sing Lok Chiu (Hong Kong Part),
Tiong Guan Ng (Singapore Part)
San Shyan Lin (Contributed Papers)

ACKNOWLEDGEMENT

Eighteen paper contributions contained in this issue are from Hong Kong, Singapore and papers contributed directly to the Editorial Team. No doubt the material contained therein would be most valuable to our engineering profession. The editors have adequately described the contributions in the preface. They are to be congratulated for these contributions.

Dr. Teik Aun Ooi
Prof. San Shyan Lin
Prof. Kwet Yew Yong
Dr. Noppodol Phienwej
Prof. A. S. Balasubramaniam

GEOTECHNICAL ENGINEERING

September 2016: HONG KONG AND SINGAPORE SPECIAL ISSUE

Edited by

Sing Lok Chiu *(Part A: Hong Kong)*, **Tiong Guan Ng** *(Part B: Singapore)* and **Prof. San-Shyan Lin** *(Part C: Contributed Papers)*

Dr. Sing Lok Chiu

(Hong Kong Part)

Dr. SL Chiu , a registered geotechnical engineer to the Buildings Department of the government of the Hong Kong SAR, a geotechnical specialist. He graduated from Civil engineering department of National Taiwan University, MSc and DIC in "Soil Mechanics" at Imperial College of London University, UK, and PhD in "soil behaviours Mechanics" at Imperial College of London University, UK, and PhD in "soil behaviours at elevated temperature" at University of Sydney, Australia. He is a technical director (geotechnical) with AECOM Asia Company Limited, has been practising in geotechnical engineering field for more than 30 years. He has been DPM, PM, and special task team leader of various L andslip preventive Measures (LPM) Agreements with Geotechnical Engineering Office (GEO) of HKSAR Government as well as natural terrain hazard study agreements with Hong Kong Housing Authority (HKHA) over the past 15 years.

Besides, he has been actively involved in design and construction supervision of numerous prestigious site formation, foundation and deep basement construction works in urban areas, reclamations and ground improvement works in Hong Kong as well as throughout SE Asia and China. He recently led a team of foundation and bridge engineers undertaking design of the 2nd Penang Bridge – a cable-stayed bridge of total length of 26 km in Malaysia. At present, he is leading a team of geotechnical engineers undertaking tender design of KVMRT Line 2.

Dr. Tiong Guan Ng
(Singapore Part)

Dr. TG Ng is the immediate Past President of Geotechnical Society of Singapore (2014-2015). He graduated from the University Technology Malaysia (UTM) with first class honours degree in Bachelor of Civil Engineering in 1992. He obtained his PhD degree in the research of Spud Can Foundation on Sand in 1999 from the National University of Singapore (NUS). He left NUS to join a specialist ground engineering company as design engineer in 2000. In Feb 2002, he co-founded GeoEng Consultants, a consultancy firm specializing in civil and geotechnical works, which grows to become one of the largest geotechnical consultancy firms in Singapore in a few years. In Nov 2011 GeoEng Consultants was acquired and became part of Golder Associates, a global consultancy company specialists in ground engineering and environmental services.

At present, Dr. Ng is the Principal and Executive Director of Golder Associates in Singapore leading the local Geotechnical Business Unit. He specialises in analysis and design of earth retaining system, and has special interest in back-analysis and interpretation of instrumentation. He had involved in the design and supervision of earth retaining structures for several major projects in Singapore which include the world 1st underground MRT Depot (LTA Circle Line Contract 821), Geylang River Cross for Kallang Paya Lebar Expressway (LTA Contract 421), the deepest excavation within Marina Bay Sands Integrated Resort for MRT tunnels below Bayfront Avenue and Construction of Downtown Line 1 Promenade Station (LTA Contract 902). He also involved in the assessment and review of several geotechnical failure cases in Singapore which include excavation failure at Lengkong Empat, foundation failure at Church Street, the collapse of excavation at Nichol Highway Station and water leakage at Jalan Besar Station. He is currently leading the team for design and supervision of Changi Land Preparation Project.

Prof. San-Shyan Lin

(Contributed Papers)

Dr. Lin is a Professor at Department of Harbor and River Engineering of National Taiwan Ocean University in Taiwan. He received his Ph.D. degree in Civil Engineering from Washington University in St. Louis, Missouri USA in 1992. Dr. Lin was an engineer at Taiwan Area National Expressway Engineering Bureau from 1992 to 1994. Prof. Lin also served as TRB A2K03 Committee member on Foundations of Bridges and Other Structures between 1995 and 2004. He is also serving as committee member of TC-212 and ATC-1 of ISSMGE and as editorial board member of four major international journals in geotechnical engineering.

Prof. Lin's research and practical experiences have been dealt with static and dynamic behaviour of deep foundations, ground improvement and effects of scouring on bridge foundations. In the past decades, he was involved in many research projects such as interpretation of pile load testing results due to axial, lateral, or combined loading; effect of soil liquefaction on performance of pile foundation in sand; seismic effect of pile foundations; performance of suction pile in sand or in clay; and effect of scouring on performance of pile and caisson foundations etc. Prof. Lin has published more than 110 peer-reviewed journal papers and conference papers. One of his published Journal papers dealing with cyclic lateral loading effect on permanent strain of deep foundation due to cyclic lateral loading has been cited more than 66 times in Google academic website by many international researchers working on wind turbine foundations.

GEOTECHNICAL ENGINEERING

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