AGSSEA
ASSOCIATION OF GEOTECHNICAL SOCIETIES IN SOUTHEAST ASIA
AIT Asian Institute of Technology
Griffith UNIVERSITY
NEWS CIRCULAR
MAY 2018

Geotechnics in Singapore- Past-Present & Future: Based on Commemoration Lecture: Professor Kwet-Yew YONG Vice President, National University of Singapore Past President

SEAGS President (2001 -2004; 2004 - 2007)
Past Chairman, AGSSEA (2010-2013; 2013 -2016)

Preamble: We are fortunate to have Prof. K.Y. Yong comprehensively covering 50 years of Geotechnical Contributions to Singapore by SEAGS in Infrastructure Development. The Presentation is a REFLECTION of the

(1) Influence of SEAGS (50 years) and AGSSEA (10 years) on geotechnical development in Singapore and the

(2) Contributions of geotechnical professionals and researchers to the infrastructure development in Singapore in the past 50 years

Photo set 1

Tan Swan Beng
SEAGS President
1977-1980

Seng Lip Lee
SEAGS President
1987-1990

Kwet Yew Yong
SEAGS President
(2001-2004; 2004-2007)

INFLUENCE OF SEAGS ACTIVITIES IN SINGAPORE

SEAGS as a catalyst for geotechnical activities in the region

- Singapore has contributed its share of geotechnical developments in the Southeast Asian region
- Its geotechnical engineers, academics and researchers played a key role in the infrastructure development over past 50 years that transformed Singapore from a third world country to a first world urbanised nation.
- SEAGS and AIT played an important role in these developments and the Society provided platform for Singapore geotechnical community to share and learn from other countries in the region through geotechnical conferences and specialty symposiums
- SEAGS was a catalyst to the emergence of many national geotechnical societies in Southeast Asia, including the Geotechnical Society of Singapore (GeoSS) which was established in 2008.

Past SEAGC/Asian Regional Conferences (ARC) held in Singapore

- ***1967 1st SEAGC in Bangkok***
- ***1970 2SEAGC***

- ***1979 6ARC***
- ***1993 11SEAGC***
- ***2003 12ARC***
- ***2013 Inaugural 18SEAGC-1AGSSEA***

Photo Set 2

YGEC 2013 at NUS, Singapore

9SEAGC Bangkok 1987 & 18th SEAGC Singapore

AGSSEA Council at 15ARC Fukuoka 2015

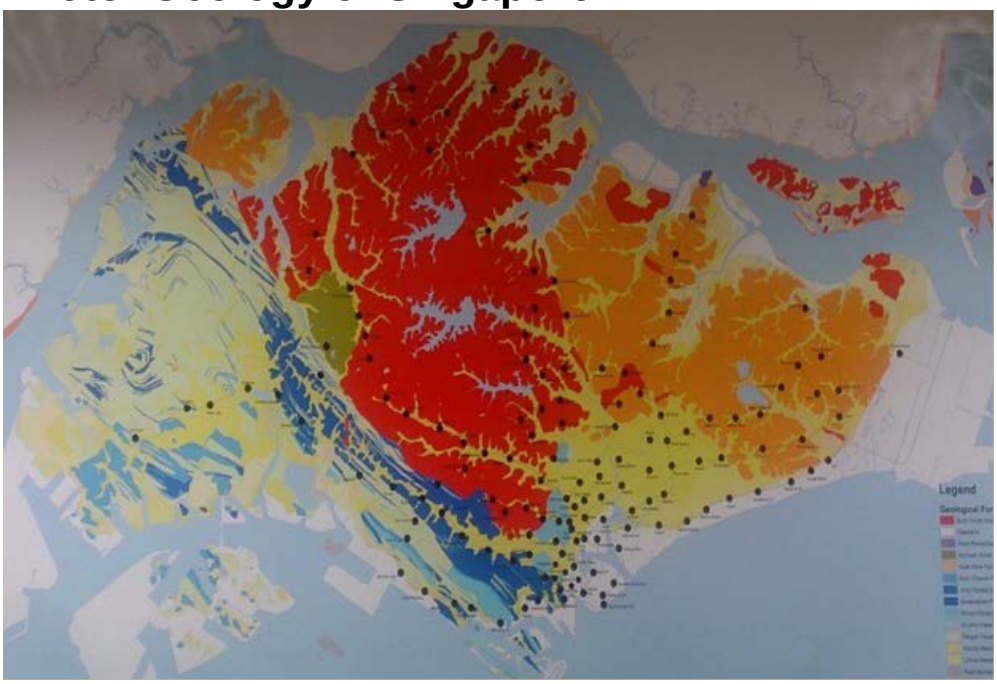
Geotechnical Contributions to Singapore Infrastructure Development

The geotechnical contributions to Singapore during the past 50 years reflect the infrastructure development of the country since independence in 1965, two years before the establishment of the Southeast Asian Geotechnical Society.

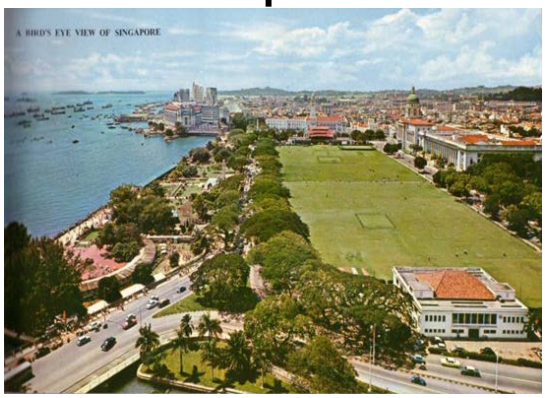
About Singapore Infrastructure Development since 1965

- No typhoon but strong winds (“sumatras”)
- No earthquakes but far-field seismic response
- No tsunamis but 40% low land
- Plenty of Rain – extreme events
- Plenty Sunshine – drought events
- Only 700sqkm – build higher, deeper and further
- Challenging geology of soft clay and rock (sedimentary and granite)

Photo: Geology of Singapore



Photos: comparison: 1960 and 2010



Singapore (Clifford Pier) in the 1960s

Singapore (Marina Bay) in the 2010s

Creation of land began in 1971 at Jurong, West Singapore

Jurong transforming into a industrial estate Central Business District Now

From the 1970s – 1990s during the building boom, use of deep pile foundations and caissons, as well as deep excavation in soft ground condition are common

Collyer Quay 1960s – mostly low rise buildings with 8-storey Asia Insurance Building, then tallest building.
Pile foundations typically RC piles, bored piles and even Franki-piles and West-piles

Recent buildings of 50-60 storeys founded on caissons, pile-raft foundation, large dia. bored piles and barrettes – negative skin friction in reclaimed area with consolidating ground

Land Reclamation Story (1960s-2030s)

Since the first reclamation works began in 1822, Singapore's land area has expanded by almost 25 percent from 580sqkm to 720 sqkm [sea space about 700 sqkm]

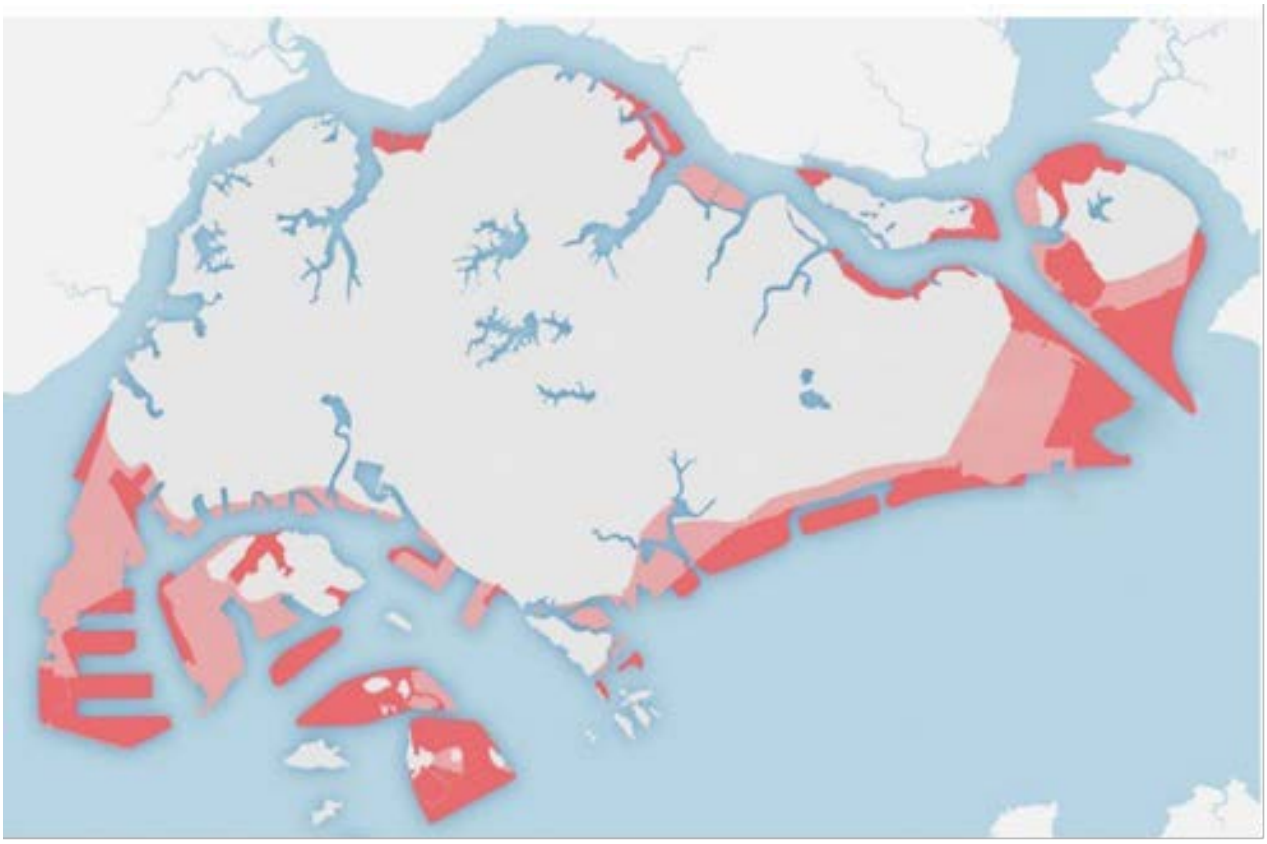
Depth of water

- Early phases – less than 5m
- Recent phases – up to 30m
- Future phases – up to 45m

Fill materials

- Hill cut from old alluvium
- Hydraulic fill dredged from sea shoals
- Barge transported sand from overseas
- Challenges of fill availability

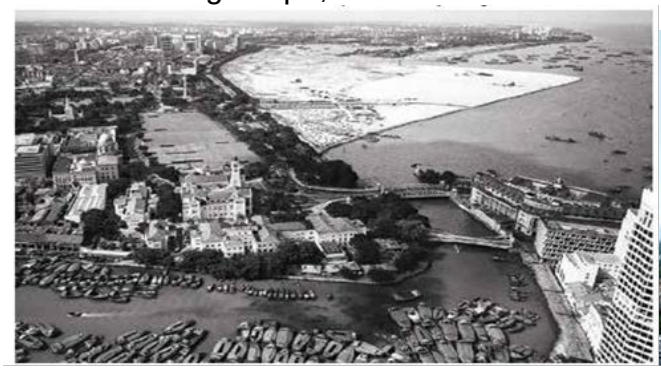
Photo: Reclamation works



- **Areas shaded in pink indicate how much has been reclaimed thus far (2015).**
- **Areas in red show possible plans for future reclamation up to by 2030**

Land Reclamation in East Coast and Marina Bay for housing, recreational and commercial

- East Coast Reclamation, began in 1966, carried out over seven phases spanning some 30 years
- Project culminated in creation of Marina Bay in the mid-2000s
- Background of top photograph taken in 1976 are beginnings of Marina Bay reclamation site taking shape, with the east coast in far distance



Land Reclamation in Western Singapore for port and industries

Pasir Panjang Container Terminal - ground improvement includes PVD + Surcharge vibro, deep sand compaction and dynamic techniques

Jurong Island formed from merging 7 islands; ground improvement mostly vibro and stone columns with dynamic techniques

Research in Land Reclamation

- Layered clay-sand scheme of reclamation conceived in 1980s
- Use of dredged materials as reclamation fill in 1990s
- Use of excavated spoils and lumpy clays for reclamation in 2000s
- Research in non-traditional fills and methods of reclamation in 2010s
- Large floating platforms
- Very large floating islands

Photos

Lumpy clays

Large Floating Platforms

The Changi Airport Story 1970s – 2010s

- 1975 - Site preparations, earthworks, reclamation and soil improvement
- Terminal T1 operational in 1981, T2 in 1991, T3 in 2007 and T4 in 2017
- Extensive ground improvements involving PVD+surcharge, sand compaction piles, dynamic techniques were used in the Changi Airport Development

2010s – 2030s

- 2014 – Changi East Land Preparation works including extensive ground improvements involving PVD+surcharge/vacuum loading, dynamic techniques and deep soil mixing
- 2018 – start of construction of Terminal T5 and Runway 3 with tunnels linking Terminals and for MRT underneath runway and taxiway

Photos

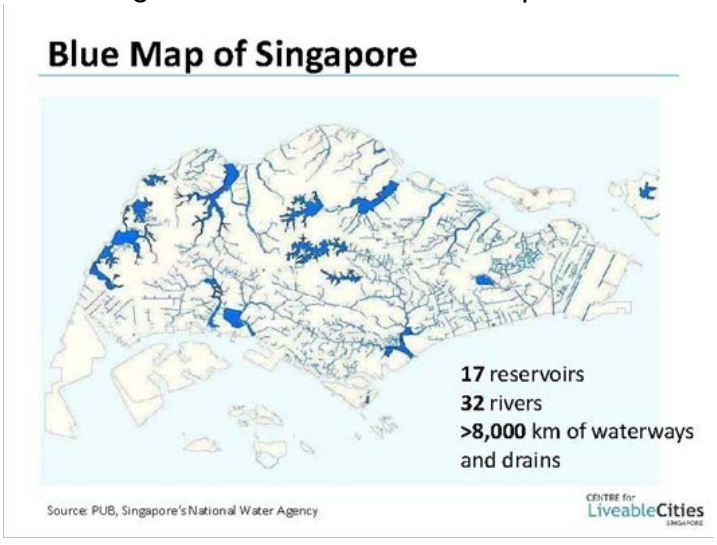
Changi Airport Terminal T1 (1981)

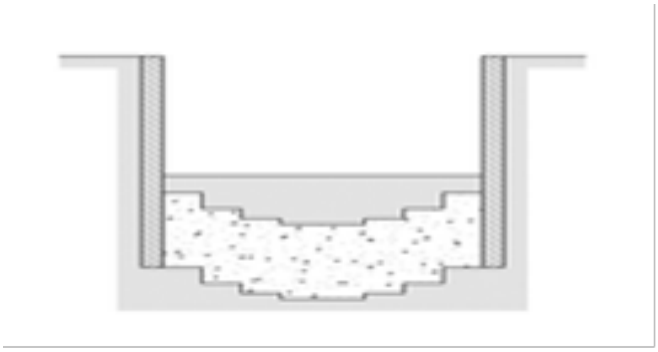
Changi East Development and Terminal T5

The Singapore Water Story

The Blue Map Strategy

- Create water containments
- Flood Alleviation
- Flood Control – Marina Barrage Geotechnical solutions
- Dams with bentonite cut-off for rivers and waterways
- Clean, widened and deepened rivers and waterways– innovative use of inverted jet-grouted arch to stabilize slope and control ground movement





Inverted JGP arch

Singapore River

Land Optimization Story 1 - expanding the rail network underground

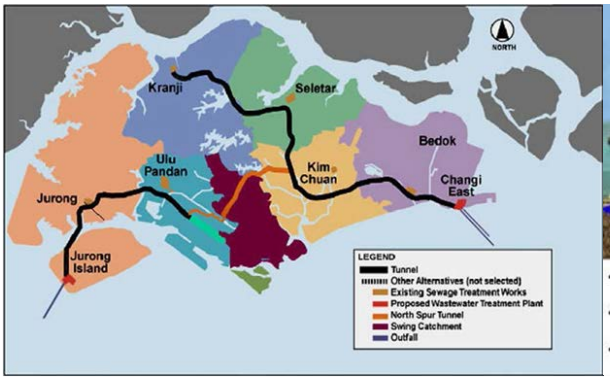
- 1983 – construction started on 1st Singapore MRT line
- Under Long Term Master Plan, LTMP2013 rail network to be expanded and by 2030, 8 in 10 homes within a 10-min walk of train station.

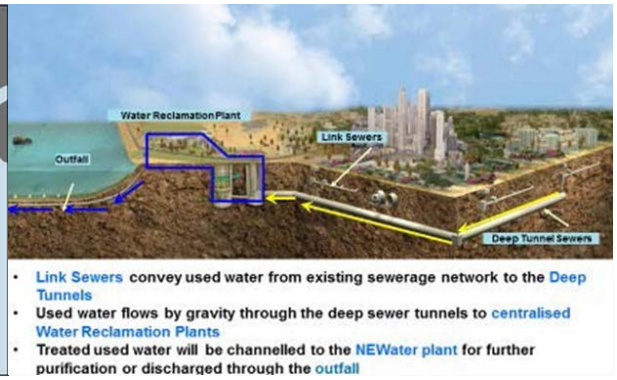
New Lines include:

- 50 km Cross Island Line (CRL)
- 20 km Jurong Regional Line (JRL)
- Extensions to Circle Line (CCL), Downtown Line (DTL) and North-East Line (NEL)
- Now, 176km rail and 122 stations; by 2020, 280 km rail, 183 stations and by 2030, around 360km, and by then a rail density comparable to London.
- In addition to above new lines, there are two cross borders lines:
- The Singapore-Johor Rapid Transit System Link to enhance connectivity between Iskandar Malaysia and Singapore
- The High Speed Rail (HSR) connecting Kuala Lumpur and Singapore.

Photo:

Land Optimization Story 2: The Deep Tunnel Sewerage System (DTSS) developed by PUB will save large areas of land sterilized by Sewage Treatment Plants

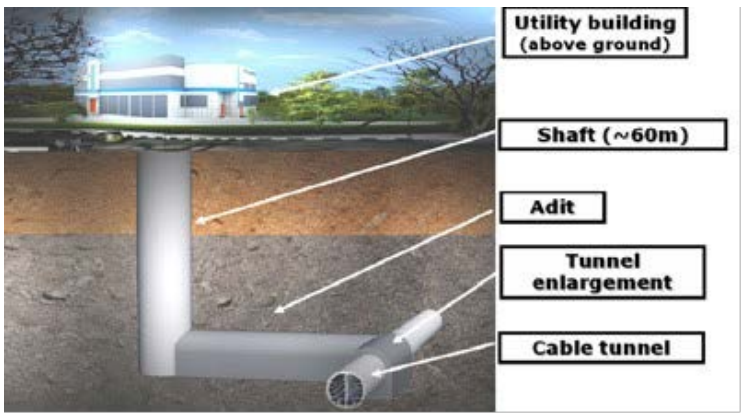


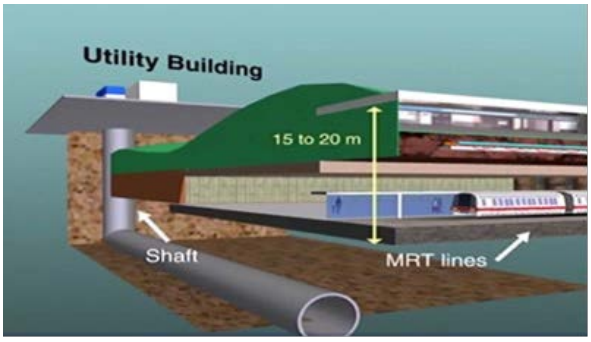


- DTSS – a used water underground gravity superhighway to meet long term needs for used water collection, treatment, reclamation and disposal – deep sewers typically 30m – 50m depth and run under roads
- DTSS Phase 1 (2000-2008) – 48km long deep sewer tunnel by TBMs + 60km link sewer by micro- tunnelling/pipe jacking
- DTSS Phase 2 (2013- 2025) – 40km long deep sewer tunnel + 60km link sewer

Land Optimization Story 3 - High voltage power transmissions cable tunnels

- 35km cable tunnels (50m- 60m deep) + 14 utility buildings – completed tunnelling in April 2017
- No competition for shallow underground space and minimal service diversion in future
- 10 hard rock TBMs and EPBMs in 6 contract packages





6m dia cable tunnel 60m below GL

Land Optimization Story 4 – Go deeper underground to create space

- Technology development on Underground Ammunition Facility (UAF) require 90% less land to be sterilized and free 140 ha surface land for development (opened in 2008)
- Jurong Rock Cavern (JRC), 130m beneath seabed and 9-storey tall cavern – SEAsia first underground liquid hydrocarbon storage; saved 60 ha of surface land, enough for 6 petrochemical plants – completed 2014
- Singapore still many options for development despite its physical constraints, and one way is to build more infrastructure underground:
- Underground power stations
- Underground reservoirs
- This subterranean potential is among the plans of the Singapore Government Committee on the Future Economy (CFE)
- On-going development of an Underground Master Plan

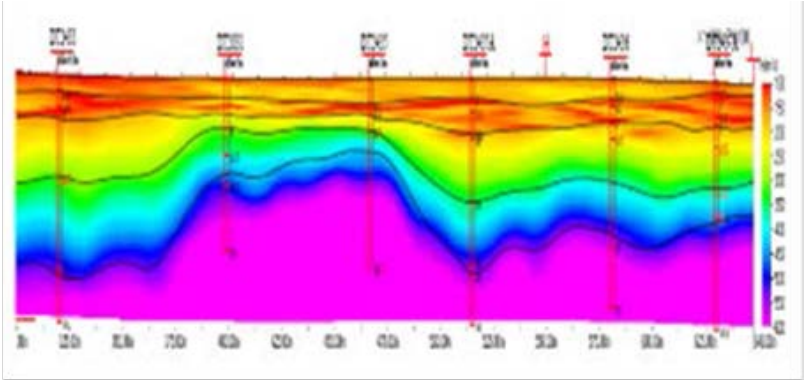
Photos

Research in tunnelling and underground construction 1

Urban Geotechnics

- In the 1990s, several innovative methods of ground improvement including jet grouting and deep cement mixing developed to control ground movements associated with deep excavations in a highly urbanized environment.
- More reliable geophysical methods using quantum physics
- Horizontal directional drilling for SI sampling or for ground treatment due to access restriction – catchment and private properties

Photos



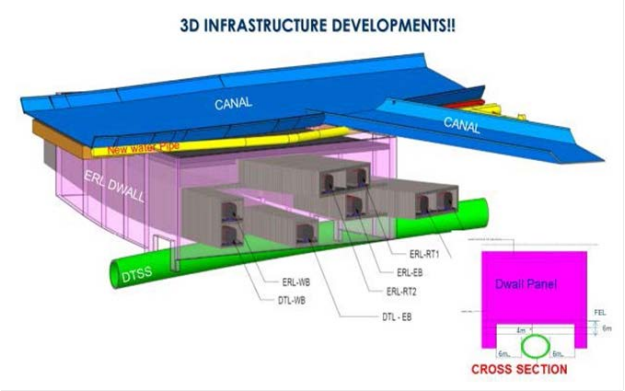
Geophysical Surveys

Horizontal directional drilling

Research in tunnelling and underground construction 2

- Tunnelling in mixed-faced ground and congested space
- Detection of existing cavities, piles and obstructions
- Cutting technologies for piles and obstructions
- Protection and underpinning of live MRT tunnels
- Challenges in constructing Deep Shafts up to 70m

Photo



Geotechnical Engineering in Singapore next 50 years….

Going forward beyond 2010s Near Term
Urban Geotechnics

- geotechnical challenges to optimum land use
- invariably more complex with greater reclamation depth and more conflicts of underground infrastructures
- Data-driven analytics of the Observational Method – real time integration of observations, test data, analysis, design, construction

Future Ready Cities – Virtual Singapore Concept

- Smart and sustainable city with big data analytics as its enablers
- Virtual Experimentation to facilitate better infrastructure plan
- Cross-domain modelling for better decision making
- Predictive geo-modelling for weather variations
- Rich data environment for research to innovate and develop new technologies

Long Term

- Climate change
- Technology Disruptors – 3D printing, Internet of Things
- Drones – changing the way we see the world

Photos:

Climate Change

Acknowledgements and Tributes

- Influence of SEAGS (50 years) and AGSSEA (10 years) on geotechnical development in Singapore and the region
- Many eminent academics and geotechnical engineers contributed to making SEAGS an internationally respected society in ISSMGE
- Dr. Za-Chieh Moh, founder President
- Prof. A. S. Balasubramaniam, the longest serving Secretary-General from 1972-2000
- Dr. Teik-Aun Ooi continued the dedicated service of Dr Moh and Prof Bala
- Prof. Seng-Lip Lee, a great mentor and colleague
- Past and Present Presidents and Secretary-Generals
- I am proud to have been a part of SEAGS for the past 40 years and I wish the Society a Happy 50th Anniversary! Thank You

Photo AIT Campus now

50th Anniversary Symposium of

Southeast Asian Geotechnical Society 14-15 September 2017

AIT Conference Center, Pathumtani, Thailand

THAI GEOTECHNICAL SOCIETY TGS

SOUTHEAST ASIAN GEOTECHNICAL SOCIETY FOUNDED IN 1967

AGSSEA

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