

Challenges in the Underground Space Development in the Urban Environment



By Ir. Dr. Ooi Teik Aun

Ir. Dr. Ooi Teik Aun is the Founder Chairman of the IEM Tunnelling and Underground Space Technical Division and an Organizing Chairman of the International Conference & Exhibition 2015 (ICETUS2015). He is also the current Chairman of Dispute Resolution Practice (DRP) Subcommittee. He is an Advisor for Consulting Engineering Special Interest Group (CESIG). Ir. Dr. Ooi is an Honorary Fellow of IEM, Fellow of the Malaysian Institute of Arbitrators and Past President and is ICE Country Representative for Malaysia. He is President of Southeast Asia Geotechnical Society (2010-2016).

Part of the Kuala Lumpur City Centre (KLCC), the Petronas Twin Towers building is located in the contact zone of the Kuala Lumpur limestone and Kenny Hill formation.

Kuala Lumpur limestone formation is characterised by subsurface karstic features consisting of pinnacles, solution channels, cavities, overhangs and floaters. The Kenny Hill formation comprises a series of interbedded shale, phyllite, sandstone and quartzite. Ooi, T.A. (1986) discussed the design and construction problems of foundation for highrise structures in the Kuala Lumpur area at that time.

Bored piles and barrette piles were used as the foundation for Pan Pacific Hotel, Putra World Trade Centre and the Mall. It is common practice to install a diaphragm wall or contiguous bored pile wall at the boundaries of the sites. These walls are constructed prior to excavation work being carried out.

In the KLCC Petronas Twin Towers, 20m excavation was made for the basement car park in Kenny Hill Formation. Ooi *et al.*, (2013) reported a recent mixed development of approximately 9ha (22acres) in the southern

region of Kuala Lumpur city where the site is located in variable quality of limestone formation. The development (known as Velocity) is divided into 3 phases with Phase 1A having limestone bedrock from 3m to 45m below ground level.

The site is bounded by the Cochrane and Maluri Klang Valley Mass Rapid Transit (KVMRT) stations. The quality of limestone bedrock at the shallow part of the site has average RQD (rock quality designation) of 0 percent and 70 percent while that of the deep part has average RQD of 0 percent to 80 percent. The Unconfined Compressive Strength (UCS) of the limestone below the basement 3 level varies from 20 MPa to 80 MPa. Contiguous Bored Pile (CBP) walls were used at the north and south sides of the site. The length of the CBP wall varies from 13.5m to 24m below ground level.

Open cut method was adopted on the east and west side to the basement 3 level with a slope height of 13m. No ground water was encountered during the construction of the basement even though at the time of site investigation, monitoring indicated ground water at 1-2m below ground level. The building consists of one 18-storey service apartment and one block of 13-storey shop office. Raft foundation was used for 3 level of basement built on excavated sound limestone outcrop while bored piles were used for those areas with limestone outcrop in a deeper part of the site.

In the KVMRT underground stations, Goh *et al.*, (2015) discussed an overview of the construction of the Maluri MRT Underground Station by MMC-Gamuda since May 2012, outlining strategies for the successful management and mitigation of the challenges of safely incorporating an underground station into the substrata of a densely populated urban centre predisposed towards gridlocked traffic conditions and located in direct proximity to established residential properties and active

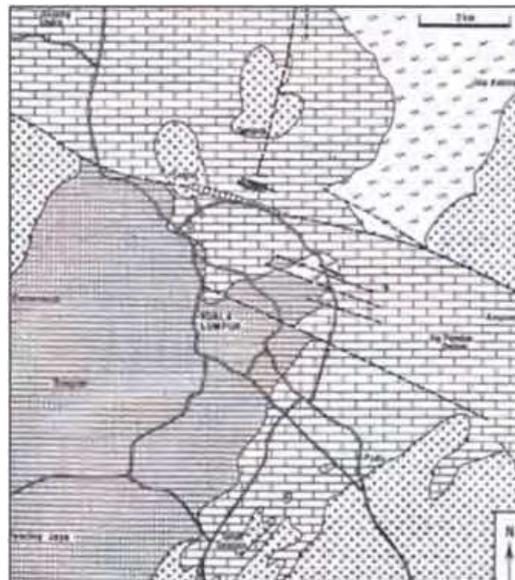


Photo 1: Surface geology of the Kuala Lumpur area (after Yeap, 1985; Ooi, 1986)

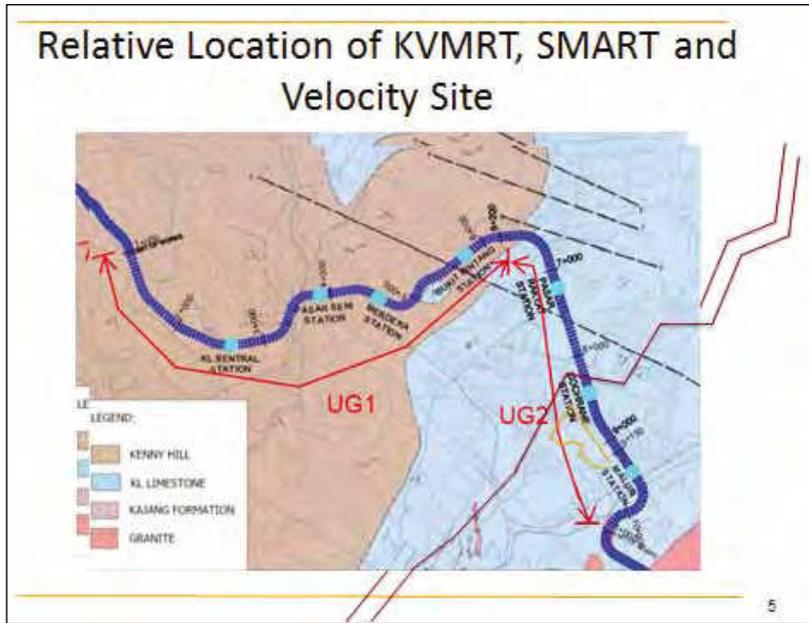


Photo 2: Relative locations of KVMRT, SMART and Velocity (after Ooi et al., 2013)

retail business premises. The project design, from the ground up, focused on pragmatic, usable connectivity on three fronts, namely for pedestrians, private vehicle access and connectivity to public transport networks.

In addition to project design, the scope of engineering works included a systematically sequenced roll-out, beginning with relocation of underground civil utilities serving the existing built environment, traffic mitigation through staged traffic diversion retaining full unimpeded use of six fast-flowing traffic lanes, construction of underground station including activities such as ground treatment, secant pile wall installation, strutting, decking, rock blasting and miscellaneous works, concurrent with installation of steel decking as an expedient to allow heavy traffic flow to continue directly over the station excavation and construction works area and ending with final reconstruction of the road surface and completion of pedestrian access infrastructure.

The total time allowed for the construction of Maluri MRT Underground Station was 60 months. Amberg &

Cornaro (2012) discussed the use of underground space for the sustainable transformation of urban infrastructures. It concluded that using the underground space strategically could contribute to the sustainability of cities in a major way.

It suggested some examples of various uses that had helped to create more liveable cities by placing transport, utilities and other “land consumers and polluters” underground, thereby freeing up valuable surface space and leaving space for more amenable uses to urban life above ground. Underground space should be considered a crucial layer in urban spatial planning and land use in the bid to accommodate an additional 3 billion global population in urban environments in the next few decades.

In accommodating the increased associated traffic and congestion in urban areas, in reducing the pollution from transport, industrial or production facilities, in securing our drinking water supply and recycling waste water, in protecting us and our cities and infrastructures from natural disasters, we

are reaching the conclusion that the use of underground space will be an important component for improving overall urban qualities and towards a sustainable transformation of urban infrastructures. Kuala Lumpur has the advantage of learning from others at this stage. ■



Photo 4: Overview of Maluri Station and Crossover (after Goh et al., 2015)



Photo 3: Excavations in Limestone at Velocity Site



Photo 5: Blast area preparation at Maluri site (after Goh et al., 2015)