Pahang-Selangor Raw Water Transfer Tunnel Project, Malaysia

The Longest Raw Water Tunnel in Asia

Ir. Chong Chi Koong

The Pahang Selangor Raw Water Transfer Tunnel (PSRWT) project is a massive project undertaken by Kementerian Tenaga, Teknologi Hijau dan Air (KeTTHA) to convey 1,890 million litres of raw water daily from the Semantan River in Pahang to the south Klang Valley region of Selangor, Kuala Lumpur and Putrajaya to meet demands up to 2025.

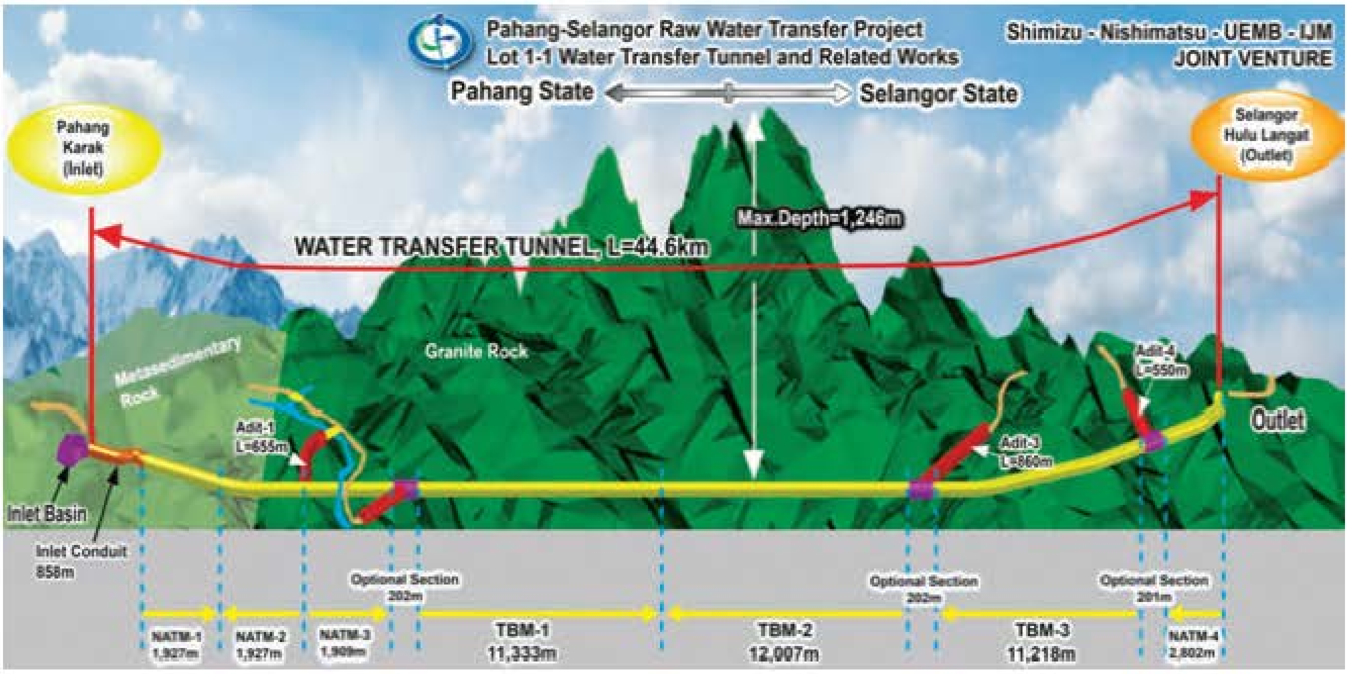

Diagram courtesy of Shimizu-Nishimatsu-UEMB-IJM Joint Venture

Completed in May 2014, PSRWT comprises three tunnels totalling 44.6km. It is, by far, the longest raw water tunnel in Asia and the 11th longest in the world. The tunnel will transfer 27.6 cubic metres of raw water per second to the new Langat 2 Water Treatment Plant (L2WTP) in Hulu Langat, which is being constructed and which will address the projected water demands from the ever-increasing population in these regions.

Costing an estimated RM3.74 billion, L2WTP will have a system of downstream distribution networks (under Phase 1) and the capacity to produce 1,130 million litres of portable water daily.

The PSRWT project was awarded to two Japanese contractors – Shimizu Corporation and Nishimatsu – which formed a joint-venture with local contractors UEM Builders and IJM (SNUI JV). The project was financed with a loan provided under the Japanese Official Development Assistance (ODA) programme.

The main components of the RM3.9 billion PSRWT project, including a raw water transfer tunnel, are:

- A 35m-high Kelau Dam with an effective capacity of 299 million cubic metres.
- Intake facility at Semantan.
- Ancillaries to the project consisting of a pumping station, twin pipelines, access roads and a telemetry system.

Raw water will be conveyed into the PSRWT tunnel via a 858m-long inlet conduit structure with the help of a pumping station in the Pahang River Basin. The raw water will then flow 44.6km to the outlet structures in Selangor before it is transferred to the L2WTP for treatment.

DESIGN OF TUNNEL BORING MACHINE (TBM) AND TUNNEL WALL SUPPORT

The raw water tunnel crosses six fault zones (Karak, Krau, Bukit Tinggi, Lepoh, Kongkoi and Tekali), 17 lineaments and two rivers (Kelau and Karak). The geology strata encountered in the initial stages of tunnelling advance consisted of hard, abrasive granitic rock of 17-176 MPa Unconfined Compressive Strength (UCS), with a mean of 77 MPa. The rock classification was based on that of the Japan Highway Public Corporation.

Depending on the conditions, the walls of the tunnel were supported by ring beams, rock bolts and shotcrete. When ground conditions were unstable, invert thrust systems were used to prevent the TBM from gripping against the tunnel walls.

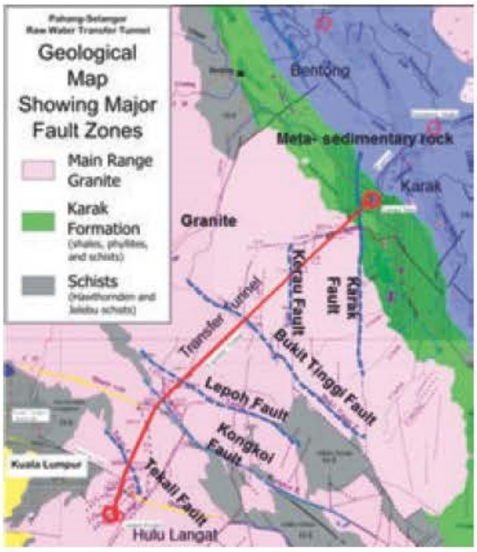

Diagram courtesy of T. Matsumato

To ensure that the high performance TBM could successfully cut into hard rock, it was fitted with 482mm back-loading disc cutters, the smallest diameter back-loading cutter-heads ever used. The cutter-heads were diligently monitored during each operation for wear and tear, using remote monitoring systems. These monitoring systems enabled the tunnelling crew to decide on cutter-head changes and to keep track of wear by recording several changes on each cutter-head, which included cutter-head rotation (recorded in percentage wear), temperature and vibration.

Each 482mm face and gauge cutter-head was equipped with a sensor secured inside the cutter-head housing and this permitted the sending of the raw data to a computer program display unit in the operator's cabin.

TUNNELLING WORKS TO MAIN TRANSFER TUNNEL

The SNUI JV chose three Robbins 5.23m diameter Main Beam TBMs to tunnel through three sections. The total supply included back-up systems, continuous conveyors, cutter-heads, spares and underground field service personnel.

The 44.6km-long, 5.23m-diameter tunnel was excavated under challenging conditions with high overburden, ranging from 20m to 1,200m below the Titiwangsa mountain range and hot springs which had the capacity to discharge 28 cubic metres of spring water per second.

Diagram courtesy of T. Matsumato

Application of fibre mortar shotcrete behind TBM (Picture courtesy of T. Matsumoto)

Tunnelling works using TBMs were carried out for 35km, while the remaining length and adits were excavated using either conventional drilling-and-blasting or cut-and-cover. The upper and lower ends were excavated by New Austria Tunnelling Method (NATM) where four numbers of which were used.

The main tunnelling works were done using three TBMs from Robbins, namely Kamila, Selpah and Tiara Midori. In areas under high overburden, ring beams, rock bolts and the near-zero rebound fibre mortar shotcrete were used to support the tunnel walls.

It is worth mentioning that this was the first time that the near-zero rebound fibre mortar shotcrete was used outside of Japan and its success showed in reduced downtime, good bonding with tunnel walls as well as the cutting down of dust generated.

ENCOUNTERING AND OVERCOMING CHALLENGES

The main challenges in the PSRWT project included face collapses at fault zones, such as that at Lepoh Fault, one of the major fault zones. The face collapsed as soon as the TBM open section passed the fault, causing the face collapse with ingress of high water flow reaching 10 tonnes per minute. A 50m-high cavern was created above the TBM. The ground was stabilised with forepoling, fibre mortar and grouting.

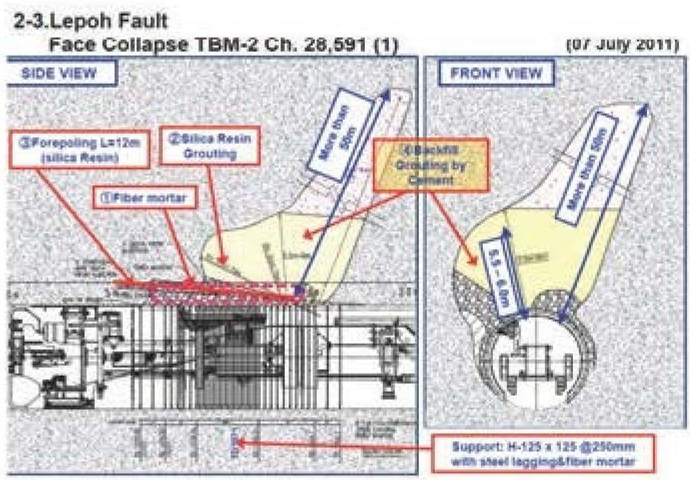

Diagram courtesy of T. Matsumoto

Another challenge was high water ingress of up to 10 tonnes per minute. The maximum temperature of hot spring water ingress was recorded at 56.2ºC while the maximum rock temperature recorded was 55.5ºC. Other challenges included rock bursts at two TBM drives with over 800m-high overburden where 30mm thick fibre mortar was applied to prevent fly rock.

The maximum advance rate in a day recorded for the project was 49m while the best rates in a week and a month were 198m and 657m respectively.

The lessons learnt from the project can be used as referrals for future projects, noting that Open Type higher power TBM for hard rock performs well in poor geological conditions under high water ingress. Another lesson learnt suggests that the early installation of tunnel support, such as fibre mortar (5m away from face), will be effective in stabilising the tunnel wall structurally.

These lessons and experiences can be used as a benchmark for Malaysia and elsewhere around the world. As a way forward and for effective sustainability of future underground development, the country needs more local talents in the tunnelling industry.

Author's Biodata

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