

# Mass Transit Railway Station & Tunnels

Diaphragm wall - Barrettes - Jet grouting - Umbrella arch

## CLARKE QUAY STATION & TUNNELS

SINGAPORE



### Geotechnical works associated with the construction of a major underground station for the Singapore MRT North East Line

As a further development to the infrastructure of Singapore, the new North East Line adds a further 16 stations to the existing Mass Rapid Transport network.

Clarke Quay Station is in the heart of the City and serves an area of the city centre along the Singapore River in full redevelopment. Linked to a commercial development above and doubling as a Civil Defence shelter, the station is a complex civil engineering structure in its own right. Additionally, the contract also included the construction of the tunnels both north and south of the station towards the Dhoby Ghaut and Peoples Park stations.



KS and cable grab operations underway

The North East Line construction packages were let as Design & Build contracts. For Contract 708 Clarke Quay Station and Tunnels, the station box was to be built adjacent to the Singapore River and the geotechnical conditions were difficult with a significant layer of marine clay to overcome and heavy foundations to be constructed for the commercial development above the station. As a member of the Main Contractor Joint Venture, Bachy Soletanche were heavily involved in the evolution of an alternative foundation scheme

OWNER:	LAND TRANSPORT AUTHORITY
CONTRACTOR:	NLB JV (NISHIMATSU-LUM CHUNG-BACHY SOLETANCHE JV)
CONSULTANT:	LAND TRANSPORT AUTHORITY MAUNSELL CONSULTANTS ASIA (FOR JV)
DATE OF WORKS :	OCTOBER 1997 - JUNE 1999

WORKS DONE:		
<b>Diaphragm wall</b> <ul style="list-style-type: none"> <li>• Thickness: 1 200 mm</li> <li>• Area: 22,200 m<sup>2</sup></li> <li>• Depth: 50 m</li> </ul>	<b>Bored Piling</b> <ul style="list-style-type: none"> <li>• 173 Nr</li> <li>• 900 mm to 1 200 mm</li> <li>• Secant &amp; Isolated Piles</li> </ul>	<b>Pipe pile roof</b> <ul style="list-style-type: none"> <li>• 25 Nr</li> <li>• 36 m long</li> <li>• 300 mm diameter</li> </ul>
<b>Barrettes</b> <ul style="list-style-type: none"> <li>• Size: 2 800 x 1 200 mm</li> <li>• Area: 5,900 m<sup>2</sup></li> <li>• Depth: 41 m</li> </ul>	<b>Jet grouting</b> <ul style="list-style-type: none"> <li>• Soil Treated: 11,500 m<sup>3</sup></li> <li>(Ground Improvement &amp; Tunnel Eye Plug)</li> </ul>	



General view of diaphragm wall excavation adjacent to the Singapore River

to simplify the station construction and propose economic methods for the Station's geotechnical works.

In the event the piled foundations of the station were deleted and the whole station box lowered to found directly on good soil. However, due to the presence of the particularly thick layer of marine clay, it was necessary to use Jet Grouting in some areas to improve the soil and therefore increase the bearing capacity. Jet Grouting was also used at the station tunnel

break in and break out and at two of the station pedestrian access tunnels. Additionally, bored pile foundations were required for the station entrances and secant piles were used at Dhoby Ghaut for a future access.

The Clarke Quay station box was formed with a 1 200 mm thick diaphragm wall, excavated using a combination of conventional cable grabs and the KS3000 hydraulic grab. Complex traffic management was required to allow the busy city centre traffic to flow smoothly at all times the works programme was tight with many areas critical to the success of the overall project. During the excavation of the wall there were unforeseen difficulties to overcome, particularly old driven concrete and timber piles and debris from an old shipyard located by the Singapore River. However, the experienced site team and the modern equipment were able to cope with the surprises in the ground.

A particular feature of the station temporary works design was the seven levels of strutting required for the bottom up construction technique. The sketch on the left shows the strutting layout.

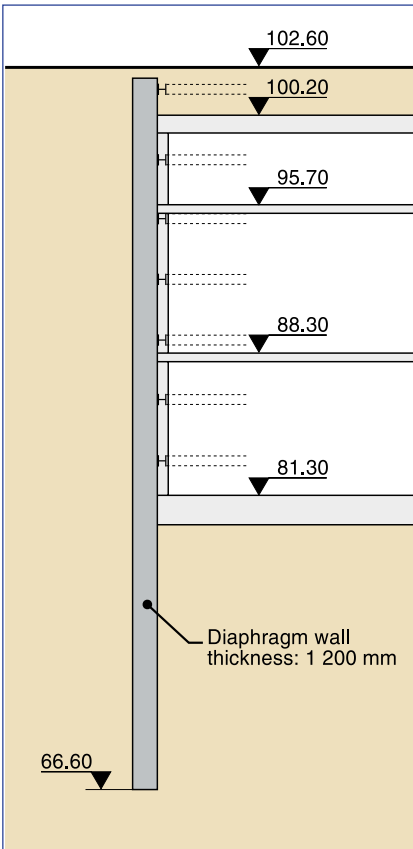
Some heavily loaded foundations were required outside the station at the northern edge for the future commercial development above. Barrette foundations were chosen given the high loads involved.

At the Dhoby Ghaut Station end of the work site, an additional problem was identified by the Client. Here the new tunnels crossed only a few metres below the existing MRT running tunnels. The particularly poor ground conditions in this area necessitated special measures. At this locations the ground was highly fractured mudstone and a fault zone had been identified during previous MRT works. In order to protect the existing running tunnels a 36 m long horizontal pipe pile roof (umbrella arch) was constructed.



Jet grouting under progress

With the close proximity of the existing tunnels very tight tolerances were required to ensure the 300 mm diameter pipes could be installed between the existing operational tunnels and the future NEL tunnels. A Down-The-Hole hammer was used to drill in the pipes through the very fractured layers. Despite the difficult nature of the ground the pipes were successfully installed and sealed to provide further protection to the existing structure.



Typical section