Underpinning Works in Construction of MRT Changi Airport Station in Singapore

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1. Introduction

Kumagai Gumi was awarded the construction of the MRT Underground Station at Changi Airport in October 1998 as a Joint Venture with a local contractor, Semb-corp in Singapore. This project is the extension of the existing metro line to International Changi Airport. It is the one of the most complex metro stations in the world because there is 140m of overrun tunnel beneath the airport terminal 2 structures and the entire overrun tunnel requires a large extent of so called "Underpinning Works".

This report describes the design and construction aspect of underpinning works in the Overrun Tunnel and organization of the Joint Venture with a local contractor and a Japanese contractor.

Fig.2

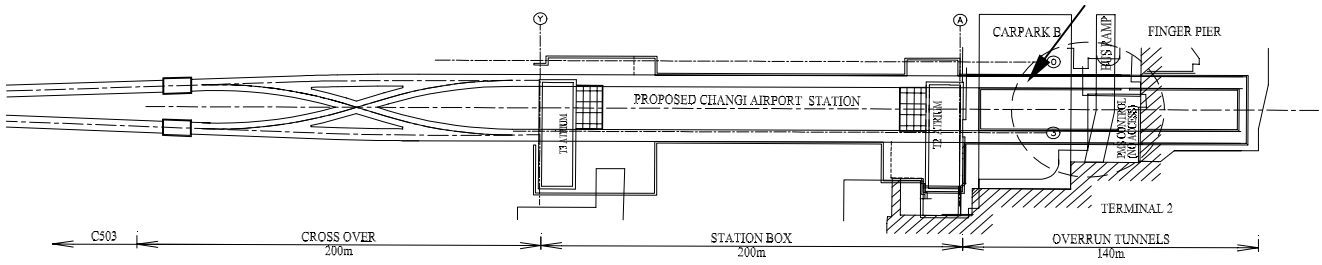

Fig.1 Scope of Work in C504

2. Out line of Project

The project consists of crossover tunnels, underground station beneath the Boulevards to the Airport and overrun tunnel beneath the terminal 2 structures.

- Project : Contract 504 Changi Airport Station
- Client : Singapore Land Transport Authority (LTA)
- Period : 31 Oct. 1998 – 29 Oct. 2001 (36 months)
- Major Structure Out line

Cross-over Tunnels : 200m*2 nos. RC structure
Station Box : 40m(W)*18.5m(H)*200m(L)
Over-run Tunnels : 6.4m(W)*6.2m(H)*140m(L)
for 2 nos. MRT tunnel and 1 no. baggage tunnel

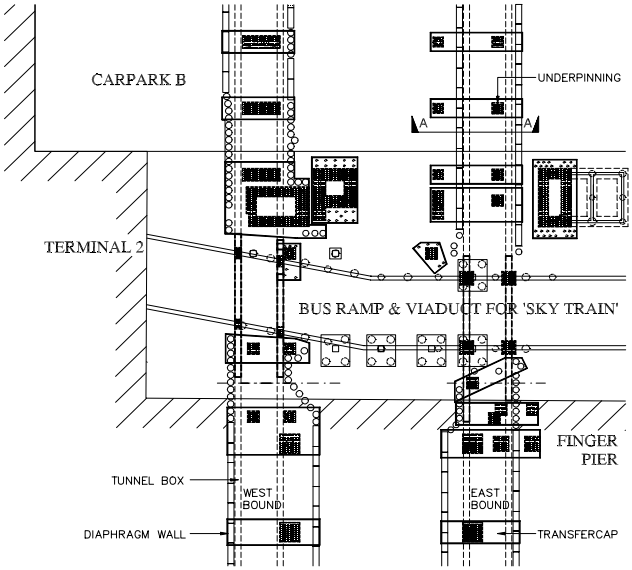

Fig.2 Over-run Tunnel Underpinning Works

3. Construction of Over-run Tunnels

The excavation work required for the construction of the Overrun Tunnel located beneath of Car park B, the existing Bus Ramp and Viaduct for the 'Sky Train' People Mover System, and Finger Pier is complex. The piled foundations for the existing structures lie within the tunnel alignment and these structures require underpinning prior to the main excavation.

Keywords : Underpinning, Joint Venture, Adjustable Jacks, Permanent Transfer Beams
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Allowable differential settlement of columns at Car park B and the Bus ramp was only 3 to 4mm,however the design value of differential settlement was much greater than these values. Temporary underpinning jack were applied between the existing pile cap and transfer cap for the adjustment of jacks according to the settlement during excavation. Once the transfer cap was constructed, the jacks were loaded using the hydraulic pumps and the existing piles were cut. The loads are transferred to the diaphragm walls through the transfer beams.

Underpinning of the existing structures is carefully monitored using real time monitoring system (Electro Level beams and total station prisms) and manual precise leveling.

Table 1. Summary of Underpinning Works

Underpinning Detail	Max. Structure Settlement (mm)/Actual
Underpinning Location 40	Car park B: 2.8mm, Bus ramp: 0.3mm
Total Jack Nos 175	Jack Adjustment
Underpinned column loading (DL+LL) 110T~760T	E.B. Bus ramp : 2 times jack up, W.B. Bus Ramp: 3 times jack up,
Jack Capacity 50T~200T	Car park B : 1 time jack down

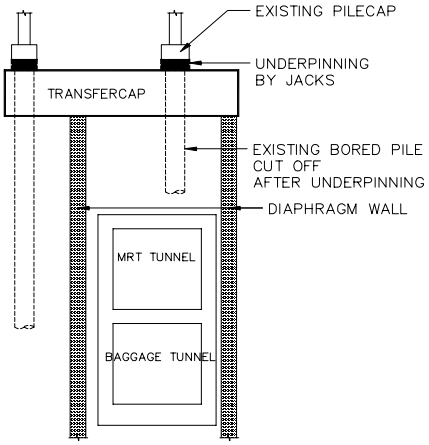

Fig.3 Typical Section A-A

4. Technical Support from Japan

The size and complexity of the underpinning under such a severe condition was the first time attempted in Singapore and the Head office of Kumagai Gumi sent experienced personal to review all the underpinning procedures and sequence before starting the construction. Two specialists from Kumagai Gumi were sent to supervise the underpinning works for six months.

After the procedures and sequencing of the underpinning were determined, many discussions and presentations took place with not only the Client but also with JV staff and subcontractors as well.

The difficulties came when we found that the existing piles and pile caps were off-centered and/or differed from the as-built drawings only after exposing the foundation. The RC transfer beam reinforcement was re-designed to accommodate this. Tremendous coordination was necessitated among the following teams in order to have successful results which were;

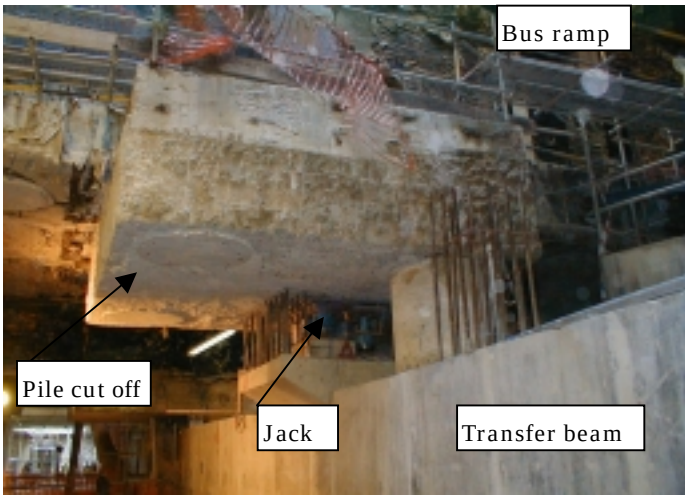

Fig.4 Underpining (Jacking) for Bus ramp

a) Survey Team to survey the existing foundation size and dimensions,
b) Design team to review the design of the transfer beam and make revisions,
c) Construction team to discuss with the client and to receive approval with the design team
d) Monitoring team to summarize all data

5. Conclusion

This project was undertaken by a teamwork effort by combining Japanese technology and experience with local knowledge of subcontractor availability, supplier availability. In addition to the complexity of design and construction of underpinning works, it should be noted that there are two authorities involved namely the client and the airport management authority. All detailed information was given to the airport management to minimize the disturbance to the operation of the airport. At the time of writing this report underpinning has been completed and the W.B. tunnel structures is complete while the E.B. tunnel is still under excavation. The removal of jacks is underway for the Car park area.