Abstract

A 30.5km railway will soon be completed that links the Northwestern part of the territory with the metro area of Hong Kong. This HK$46 billion investment in the West Rail projects will form a major railway strategic and territorial development for the coming 20 years of Hong Kong.

There are nine stations provided within the alignment of the West Rail, 6 of which are located in the northwestern part of the New Territory within a stretch of about 15km. The railway comprises of 5.6km at-grade or surface structures, 11.5km tunnels, and 13.4km elevated sections in the form of viaduct.

Other major features of the project include the construction of two major tunnels, one 1.8km section formed using tunnel boring machine, the remaining sections formed by drill and blast method; the formation of 8 hectares of land outside Tsuen Wan by reclamation to provide room for a new station; the formation of a depot facility in Pat Heung with sufficient land reserve that can support the development of the area in future; 6 station structures with interchanging facilities to the existing mass transit and light rail networks; as well as the introduction of stringent control to the country and rural habitat in the environmental sensitive area of the northwestern territory.

This paper aims to provide an overall highlight of the project from the construction prospective, in particular to demonstrate the unique arrangement that employed to tackle the difficulties in the construction of each major section within this new railway network.

1. Introduction

The West Rail Project is the largest railway project in term of contract sum ever built in Hong Kong. The last large-scale railway project being completed was the Airport Railway, which was a 34km-long, HK$32 billion project designed in the early-90’s and put into operation in 1998, which linked the new airport at Chek Lap Kok with the city center of Hong Kong. With the input of the latest state-of-the-art technology and operation experience, the West Rail is of no doubt one of the world most advanced mass transit railway systems being built within such a densely populated urban environment in a major contemporary city.

2. The Alignment of West Rail that cope with the Railway Development Strategy of Hong Kong

The 30.5km West Rail forms a major part of the Railway Strategy of Hong Kong. It links West Kowloon in the south with the Northwestern part of the New Territory, serving in the near future a population of about 1.2 million in the area.

West Rail has nine stations and passing through six major districts, namely Sham Shui Po, Kwai Tsing, Tsuen Wan, Yuen Long, Tin Shui Wai and Tuen Mun (Fig. 1). It has interchange provision to three major railway systems. It links to the Mass Transit Railway (MTR) Tung Chung Line at Nam Cheong Station, to the MTR Tsuen Wan Line at Mei Foo Station, and to the Light Rail System at Yuen Long, Tin Shui Wai, Siu Hong and Tuen Mun stations.

In addition, West Rail has provision to link to the south and north ends of East Rail in future. At the southern end, Nam Cheong Station is provided with facility that can be connected to the future Kowloon Southern Link toward Tsim Sha Tsui direction. At the northern portion, similar provision will enable Kam Sheung Road Station to connect to the Northern Link via Lok Ma Chau and finally reaching Lo Wu of the East Rail northern terminal.

3. The 30.5km long West Rail – The physical routing
At the southern terminal, West Rail runs northward from Nam Cheong Station through a 2.6km-long tunnel, mainly constructed in at-grade box, and passing through one major traffic interchange at Lai Wan, toward Mei Foo Station (Fig. 2).

Immediately leaving the Mei Foo Station, the West Rail enters into the 3.5km-long Kwai Tsing Tunnel, where it joins the 600m-long approach tunnel of Tsuen Wan West Station at its northwest tip. Further northbound through a 500m-long approach tunnel, West Rail cuts into the range of Tai Mo Shan through the 5.5km-long Tai Lam Tunnel. Leaving the tunnel’s north portal at Pat Heung, the 3.2km-long track of West Rail runs at grade until it reaches Kam Sheung Road Station. The 32.5 hectares maintenance depot of the rail system locates in the mid-way of this section of track.

From Kam Sheung Road Station, the track of West Rail heads southeast toward the Long Long/Tuen Mun corridor on viaducts, via the Yuen Long, Long Ping, Tin Shui Wai, Siu Hong stations and finally reaches its northern terminal at Tuen Mun Station. Total length of the viaduct measures about 13.4km, and passing through a series of major traffic interchanges at Au Tau (Fig. 3), Pok Oi, Yuen Long Nullah junctions (Fig. 4), Ping Ha Road/Long Tin Road junctions, Lam Tei, Tsing Tin Road/Tuen Mun Road junctions, until it joins Tuen Mun Station at Pui To Road (Fig. 5). The final 1.6km tracks joining Siu Hong and Tuen Mun stations are built on viaduct averaged 12m above the Tuen Mun Nullah.

4. Construction of the major Tunnels

There are two major tunnels constructed in the West Rail Project. The first one is the Kwai Tsing Tunnel that links Mei Foo Station with Tsuen Wan West Station. Kwai Tsing Tunnels is a collective name for three sections of tunnelling work: the 1.7km-long Ha Kwai Chung Tunnel; the 1.8km-long Tsing Tsuen Tunnel; and the 120m Tsing Tsuen Cut-and-Cover Section (Fig. 6).

The major construction features of this tunnel can be highlighted as follow:
Two methods were employed for the construction of the tunnel; the Ha Kwai Chung section was constructed using drill and blast, while the Tsing Tsuen section was done by the use of an earth pressure balance Tunnel Boring Machine (TBM).

Three access locations, the tunnel portal at Mei Foo, an 32m dia. access shaft at Lai King, and the portal at Tsuen Wan, are provided as entrance/exit points to support the handling of materials and machineries during the tunneling process.

A very major traffic diversion at Mei Foo was carried out, where a section of 150m-long approach tunnel cut through Ching Cheung Road, a busy roadway leading to the container terminals at Kwai Chung and the Route 3 expressway system (Fig. 7).

Two averaged 24-storey tall buildings in the way of the tunnel alignment in close vicinity to the Tsuen Wan portal were demolished to allow room for the passing through of the tunnel.

The second tunnel constructed is the Tai Lam Tunnel. It is a 5.5km-long tunnel constructed using drill and blast method. It is a joint-venture project with one contractor each responsible for an equal length of the tunnel construction, until they met in the middle of the tunnel.

The major construction features of the tunnel can be highlighted as follow:

Portal to support the tunneling works were provided on each side of the tunnel; the south portal was located at the entrance of Tuen Mun Highway at Choi Wan Kok of Tsuen Wan. The north portal was at Pat Heung of Kam Tin.

A series of bored-pile foundation for the elevated Tuen Mun Highway was in the way of the tunnel alignment at the south portal. Underpinning work was carried out to transfer the load of the elevated highway to the replacing piles (Fig. 9).

Both the south and north portions of the tunnel were constructed using drill and blast method. However, the JV contractors used different methods for spoil disposal. Dump truck arrangement was used in the south portion; while crusher/conveyor system was employed for the north portion, where the rock debris after blasting was crushed to smaller size at the spot to allow removal by an extendible conveyor system until it reached the portal exit.

A gantry-type tunnel formwork was used to form the in-situ tunnel lining. Waterproofing membrane was provided as the underlay in the lining in order to improve water-tightness as the electronic signaling system may be damaged by dampness inside the tunnel and jeopardizes the operation of the railway network. (Fig. 10).
Figure 10 – Installing the waterproofing membrane before the forming of the in-situ concrete lining

5. Construction of the station structure

5.1 Nam Cheong Station
Nam Cheong Station is provided with interchanging facility with the MTR Tung Chung Line. The station situated along the West Kowloon Expressway (Fig.11). In order to make the interchanging arrangement more convenient to passengers, part of the station structure is constructed underground and under-pass the existing tracks of the Tung Chung Line so that the interchanging platforms can be placed conveniently for passengers. Besides, connection provision to the future extension to the Kowloon Southern Link has also been made.

Figure 11 – General layout of the Nam Cheong Station. West Kowloon Expressway, with the track of the Tung Chung Line underneath, bisect the station structure in two parts.

5.2 Mei Foo Station
The station is basically an enclosed RC structure measures about 260m x 35m, partially constructed underground down to the track level of about –4m. It is an interchanging station with the MTR Tsuen Wan Line. Complicated pedestrian tunnels connecting into the MTR Mei Foo Station is provided. In addition, the station structure is bisected by the Kwai Chung Highway and the tunnel tube of Tsuen Wan Line at two points (Fig. 12). Stringent control is thus required during the entire process of construction.

Figure 12 – General layout of Mei Foo Station. Cutting across in the center is the Kwai Chung Highway. The tunnel tube of the MTR Tsuen Wan Line is located further backward from the elevated roadway, about 16m below the ground surface.

5.3 Tsuen Wan West Station
The station is mainly an underground structure, measure about 380 x 40m in size. It is constructed on a piece of newly reclaimed land, and running in parallel within 30m reach of the Tsuen Wan Bypass (Fig. 13). Almost working at the same pace, a series of complicated diversion works such as to the nearby traffic interchanges, as well to the existing storm water discharge and salt water intake systems, are to be incorporated in the construction process. The new station and the nearby approach tunnels, need to cross the box-culvert for the storm water discharge at 3 different locations, with the culvert running above and the tunnel crossing below.

Figure 13 – General layout of the Tsuen Wan Station.

5.4 Kam Sheung Road Station
The station is an elevated structure, measure about 280 x 30m in size (Fig. 14). It is connected to one end by track at grade and the other to the viaduct system heading to Yuen Long direction. Provision for future track connection to the Northern Link Line is located 300m on the west side of this station. In order to convenient passenger in the area to use the rail instead of using private vehicle, a very large parking and public transport interchanging facility is provided in this station.

Figure 14 – General layout of the Kam Sheung Road Station.
5.5 Yuen Long Station
The station is an elevated structure, measure about 420 x 40m in size. It is connected to both ends by viaduct systems, partly constructed over wetland of the Yuen Long Plain (Fig. 15). The terminal of the Light Rail is at present located about 100m from the new station. A series of re-alignment to relocate the track and platform facility of the Light Rail to convenient interchanging to the West Rail will be carried out. Besides, other public transport facilities to the nearby satellite districts will also be provided in the station.

5.6 Long Ping Station
The station is an elevated structure constructed over the Yuen Long Nullah, measure about 380 x 30m in size. It is connected to both ends by viaduct (Fig. 16). Complicated diversion arrangement is also required for there is a number of high-voltage cables and large diameter water mains running along the nullah network in close vicinity of the station. Large area of glazed panel for wall and roof are used in the station design in order to provide natural lighting and to improve orientation of station users.

5.7 Tin Shui Wai Station
The station is an elevated structure, measured about 460m x 30m, situated at the junction of Ping Ha Road & Tin Fuk Road (Fig 17). New Light Rail stop will be provided at ground level under the station concourse with track re-aligned from the nearby stops. In order to minimize the disruption so created during construction, the station structure was cast in 2 main sections, each on the side of the busy road junction.

5.8 Siu Hong Station
The station is an elevated structure, measured about 440 x 55m in size and constructed over the Tuen Mun Nullah (Fig. 18). It was built on a suspended deck by the use of a set of gantry formwork system in repeated sections (Fig.19). The station located at a densely populated zone thus demand for public interchanges are enormous. It is designed as a major interchanging station with the Light Rail. In addition, elevated public transport interchange concourse is also provided at either end of the station.
5.9 Tuen Mun Station
The station is an elevated structure measured about 370 x 50m in size and constructed over the Tuen Mun Nullah (Fig. 20). Tuen Mun Nullah locates at the downstream of the flood plain of the nearby area. Seasonal diversion to the nullah by temporary concrete-block type cofferdam is therefore required during the construction period. To allow room to provide a public transport interchange to the station, a 30-year old public housing estate (the San Fat Estate) was demolished for the purpose. Besides, other interchanging facilities such as terminals and passenger platform will also be provided for linking the Light Rail to this station.

5.10 Common construction features of the stations
Though the nine stations located within the alignment of the West Rail differ from each other somewhat in design, functions or method of construction, they bear quite a lot of commonality in terms of construction feature, such as:

- All the stations are very large structure in term of building volume (average 400000–500000 m³), therefore very complicated phasing and sectioning arrangements are required during construction in particular when the usual unfavourable physical site conditions (e.g. complicated diversion, stages of handing over etc) are taken into account (Fig. 21).

- Highly non-repeated nature in the station layout thus makes the construction arrangement such as the use of formwork and other resources scheduling consideration become very difficult.

- Usual high headroom in the station design require the provision of very expensive and complicated falsework (Fig. 22).

- Station generally in long span design with very deep beams and other transfer or suspending members (Fig. 23), resulted again to the requirement of complicated falsework provision or the introduction of large number of tensioned members.

- Most of the station structures are with large area of in-situ RC walls and therefore large-size panel shutter is a common formwork being used (Fig. 24).
Figure 24 – Large panel-type formwork is used intensively in the construction of the station structures.

6. Construction of the Viaduct

A section of about 13.5km rail track of the West Rail stretching from Kam Sheung Station to Tuen Mun Station is constructed in the form of viaduct. One of the reasons for the choice is that the area is constantly susceptible to flooding (Fig. 25). Besides, construction in the form of viaduct working on elevated position will minimize interruption to ground traffic.

Figure 25 – Viaduct crosses susceptible flooding area especially around the Kam Tin-Yuen Long Plain. (Photo from Chun Wo)

The viaduct adopts a common design using twin column piers with typical span averaged around 30m - 32m. Launching equipments, in the form of under-slung girder (Fig. 26) and longitudinal steel support beam (Fig. 27), were used to lift and erect the girder segments onto the deck level to form the viaduct between a typical span. Each span is composed of 14 to 16 numbers of precast segments, glued and post-tensioned in position.

Figure 26 – Under slung launching girder for the erection of the precast box-girder viaduct.

Figure 27 – Erection using Longitudinal steel support beam

7. Environment Issues

A 3-tier approach to ensure the compliance of the required environment standards during the design and construction stages is employed for all the West Rail projects. First of all, KCRC undertook a comprehensive West Rail Environmental Impact Assessment on the overall project with the findings incorporated in all the West Rail contracts. After the award of the contracts, contractors were required to submit an Environmental Management Plan for approval, and effective mitigation measures would be complied. Meanwhile, the KCRC Environment Team, together with an independent Environmental Checker, would monitor all the activities closely throughout the contract period.

Major mitigation measures to control and reduce potential environmental impacts include issues on noise, air and water quality, as well as the preservation of natural and rural environment along the alignment of the rail. The following photos (Fig. 28 to 32) show some of the existing environmental conditions around the areas.

Figure 28 – Overlooking of the environmental sensitive areas along the Kam Tin-Yuen Long corridor where the alignment of the West Rail cutting through.
8. Conclusion

It is almost impossible to tell a detail story about the construction of the $46 billion West Rail within a conference paper with length confined to 6 to 8 pages. However, with the highlight of the construction features and the first-hand, carefully selected photos as shown in the above pages, the writer should be able, at least, to show to colleagues working in the engineering field how such a sophisticated project is built under so difficult urban and environmental sensitive area as in Hong Kong. There is no perfect solution, after all, Hong Kong still manages to have the project being designed, constructed and operated within time and budget, and achieving the stringent technical and environmental standards ever prescribed. Tribute is of no doubt given to all who have dedicated their expertise, time, energy and enthusiasm in the participation in the job. I am prove to be one of them.

9. Reference


West Rail – The Way Ahead, Kowloon Canton Railway Corporation, 2001


Hong Kong Engineer, Hong Kong, page 13-31, January 2001.


Asian Architect & Contractor, Hong Kong, page 11-38, Vol. 29, Issue 11