EXPRESS RAIL LINK
OVERHEAD LINE SYSTEM - A STEP FORWARD

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Summary

In a new era of railway construction in Hong Kong. Express Rail Link (XRL) Project connects Hong Kong with over 20,000km National High-speed Rail Network. The Hong Kong Section of the XRL is 26km in length, with trains operating at the maximum speed of 200kph in Hong Kong, linking West Kowloon to Shenzhen Boundary and Guangzhou. It provides a safe, fast and efficient travel between Hong Kong and the Mainland. This paper introduces the new Overhead Line (OHL) technologies, in terms of designing, construction, testing and commissioning. It highlights the latest developments and the challenges encountered to ensure the seamless interface with the National High-speed Rail Network.

The design challenges included the development of functional requirements, technical standards & specifications taking into account of the compatibility and mainland interface management. During construction, various new high speed OHL installation requirements and techniques were required, which various types of new plant have been adopted to achieve the programme targets. In addition, testing and commissioning procedures for certification of the completed OHL to the test speed of maximum 217kph were different from the practice in the existing operating railway in Hong Kong. All these aforesaid challenges were finally overcome with all the collaborated efforts. XRL is targeted to open in Q3 2018 which will provide convenience to the Hong Kong citizens travelling to the Mainland and bring the Hong Kong railway network more connected.

1.0 INTRODUCTION

1.1 Project Background

The Guangzhou-Shenzhen-Hong Kong Express Rail Link is a new high speed intercity rail corridor connecting the cities of Guangzhou, Shenzhen, and Hong Kong. This is a passenger only dedicated corridor, serving short haul regional services between the three metropolitans as well as long haul operation to other Mainland cities; such as, Beijing, Shanghai, etc. The route length within the Hong Kong section is approximately 26km consisting of standard gauge dual-track mainline. The XRL trains will be running at the maximum speed of 200kph inside the Hong Kong section as shown in Figure 1.

Figure 1: XRL Alignment

Figure 2: Shek Kong Stabling Sidings

The new railway services will be provided by electrically powered multiple units (EMU) taking power from a 25kV AC overhead line traction system. An 8-car high-speed train or 16-car trains coupled together will be used to cater for the short-haul and long-haul services respectively.

2.0 HIGHLIGHTS – OVERHEAD LINE SYSTEM

2.1 Overhead Line

OHL system is to provide a reliable power with continuous 25kV single phase a.c. direct feed system to the high-speed train at the maximum operation speed of 200kph. It comprised 150mm^2 (cross section area) of silver copper alloy Contact Wire (CW) and 120mm^2 bronze Messenger Wire (MeW) with cantilever supports forming a flexible tension length along XRL mainlines. Balance Weight Anchors (BWA) with erected tension of 20kN are terminated at both ends of tension length. The maximum length was about 1.5km. Thus, the overlap of two successive tension lengths was employed to ensure the continuous power delivery to the train at all times. In order to sectionalize the electrical power supply or make fault point isolation, all trackside OHL isolators were motorised and could be remotely controlled and operated by Operation Control Centre.

Aerial Earth Wire (AEW) runs in parallel to tension lengths and connected each cantilever supports and trackforms at approximate 1100~1500m interval through the signalling impedance bonds. It also connected to the trackside earth terminals which are effectively connected to the earth mats. The schematic earthing system is shown in Figure 3.

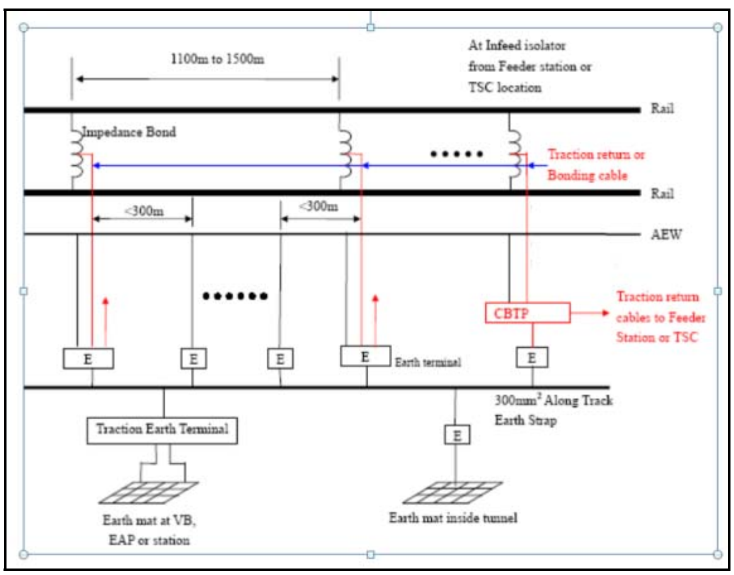


Figure 3: Schematic Earthing Diagram

3.0 DESIGN PHILOSOPHY AND CHALLENGES

3.1 OHL neutral section was designed for single phase a.c. system to electrically isolate two different phases of 25kV traction power sources. XRL adopts 6-span 2-overlap arrangement (Figure 4) for neutral section, instead of a propriety phase break assembly. It improves the transition passage through the neutral zones at high speed. The on board 25kV circuit breaker would be triggered open and re-close automatically before approaching and after leaving the neutral section respectively. XRL OHL system was electrically segregated from the Mainland OHL power source using similar neutral zone arrangement (Figure 5).

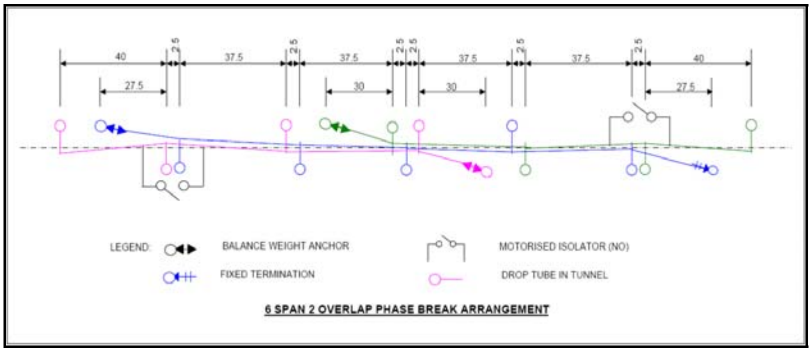


Figure 4: Schematic for OHL overlap

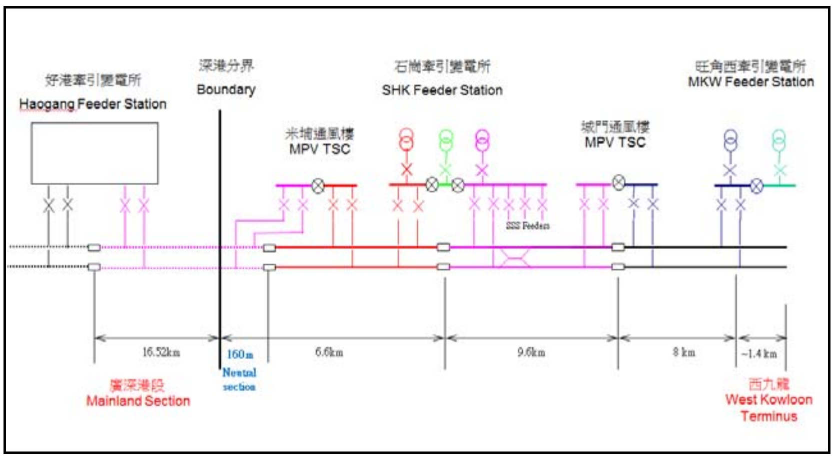


Figure 5: Schematic for power supply at the boundary

4.0 CONSTRUCTION HIGHLIGHTS AND CHALLENGES

4.1 To achieve high quality OHL performance and meet the international standards for high speed railway, OHL wires are under tension of 20kN applied on CW and MeW for XRL mainlines. The Contractor firstly introduced a special wiring work train set, named Constant Tension drum carrier (Figure 6) for stringing wires in Hong Kong.

This train set has been commonly used in high speed railway construction and corrective maintenance projects in the Mainland. The wires strung from this drum carrier are kept straight with initial tension of 6kN~12kN applied. It eliminates excessive kinks and deformed points which cause bounces and electric arcs between train pantograph and OHL contact wire. Special features for this work train include: (1) Pre-set tension (6kN~30kN) for wire stringing; (2) computerized control for operating speed and stringing tension; (3) 3-dimensional controllable stringing directions (longitudinal/vertical/lateral); and (4) automatic alarm system for over-tension alarms and sub-system faults.

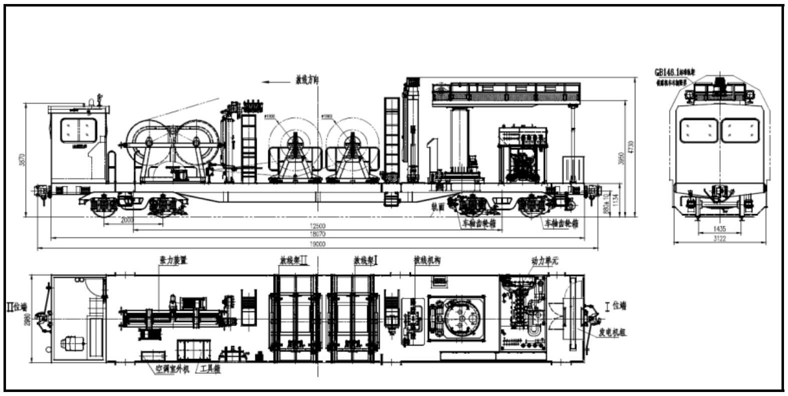


Figure 6: Constant Tension Drum Carrier

5.0 SPEED VERIFICATION OF OHL SYSTEM – TESTING AND COMMISSIONING

5.1 There were two stages for the speed verifications. The first stage test was conducted by a test train hauled by high speed Dongfeng (DF 11 diesel locomotive for test speed up to 140kph (Figure 7). It was to confirm the OHL geometry parameters in compliance with the standards at low speed. The second stage test was integrated with other systems, including Track and OHL, Communication and Signalling. The Comprehensive Inspection Train (CIT) used by China Academy of Railway Sciences Institution (CARSci) for verification of operating speed up to max 217kph in bi-directional movements (Figure 8). Mainland standard TB10761-2013 was adopted for the dynamic condition check.

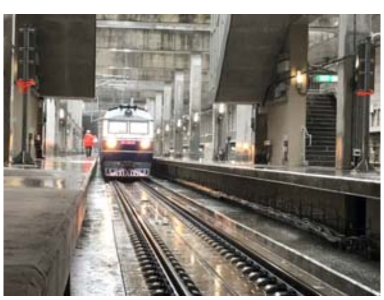


Figure 7: 140kph speed verification by DF11

Figure 8: Max 217kph speed verification by CIT

5.2 There are dynamic measuring requirements to verify the OHL performance and quality of current collection of the contact wire/pantograph interface. It required a special test train fitted with measurement instrument on the pantograph and data transfer processors (telemetry and optical system) to convert the information into graphic display and reportable formats (Figure 9).

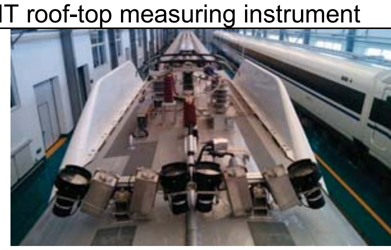
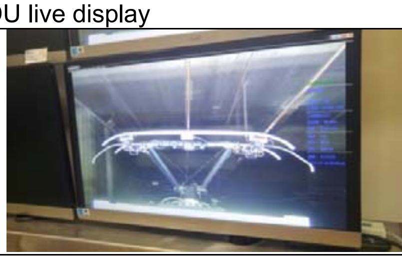
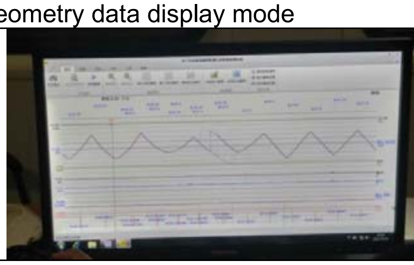
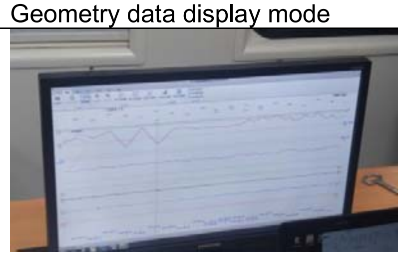
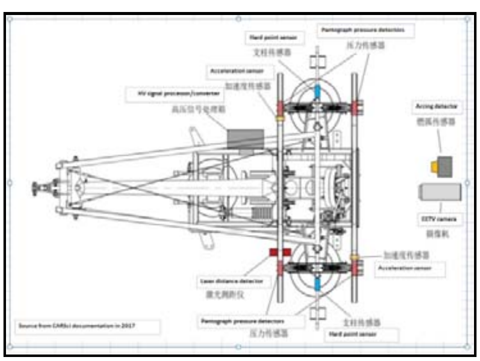
1st stage up to 140kph	**2nd stage upto 217kph**
GRC roof-top measuring instrument	CIT roof-top measuring instrument
	
VDU live display	VDU live display
	
Geometry data display mode	Geometry data display mode
	

Figure 9: OHL equipment and display for DF11 and CIT testing trains

The general features for the dynamic testing train are highlighted in Figure 10. The results were shown in live video images and graphical display inside the testing train. Testing engineers can immediately analyze and make decision for subsequently test train arrangement.



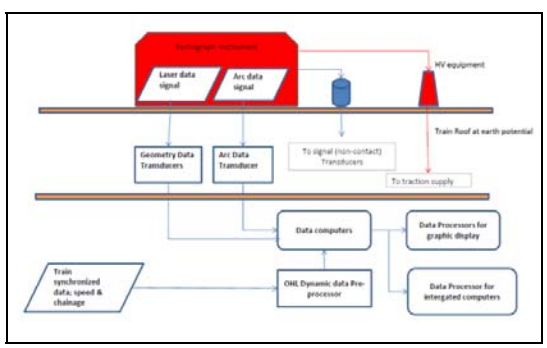


Figure 10: Equipment setup and data transfer & collection schematic

The major requirements in both Mainland Standard TB10761-2013 and BSEN 50317 are as summarized below;

OHL dynamic performance index:

Train speed,V (km/h)	V<160	160≤V<200	200≤V<300
Hard point, AV (m/s^2)	<490	<490	<588
CW height, 2A (mm)	<200	<150	<150

Remarks:
Hard point - Measured from vertical acceleration of Contact Wire
Contact Wire height - Height difference (with respect to rail top level) in the successive supports (Hmax-Hmin)

Percentage of arcing:
Equation 1- Maximum Arcing Time, Tmax <100ms
Equation 2 - Arcing rate, μ<5%

Formula: $\mu = \frac{\sum t_{arc}}{\sum t_{total}} \times 100\%$,

Where, $\sum t_{arc}$ – the duration of an arc lasting longer than 5ms
$\sum t_{total}$ – measuring time of traction current

Typical results (against time & chainage locations) in graphic display are shown in Figure 11. The imperfect records were summarized to the contractor for rectification after each round of testing. The final verification test was conducted and confirmed all OHL performance which was compliant with the standards.

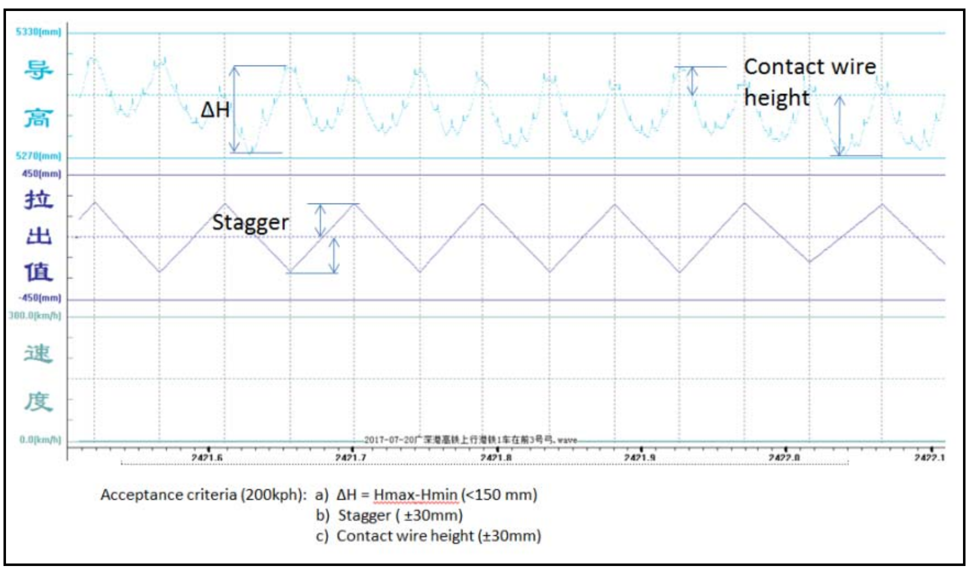


Figure 11: Typical OHL graphical display output

6.0 CONCLUSION

This is a first step to achieve the high speed railway technology in Hong Kong. The success of XRL project would be a remarkable milestone not only to connect the Mainland railway networks to enrich the commercial activities, education, tourism and financial partnership, but also to share the good practices and experiences amongst all specialists and professionals in the world. We are looking forward to receiving more share opportunities and exchanging knowledge and skill in the forthcoming years.

Figures

References:

TB10621 - Code for Design of High Speed Railway
TB10761 - Acceptance Criteria for Dynamic Condition Check for High Speed
BSEN 50317 - Requirements for and validation of measurements of the dynamic interaction between pantograph and OHL

Abbreviations:

Aerial Earth Wire	AEW
Balance Weight Anchors	BWA
Comprehensive Inspection Train	CIT
Contact Wire	CW
Electrical Powered Multiple Units	EMU
Express Rail Link	XRL
Messenger Wire	MeW
Overhead Line	OHL
Shek Kong Stabling Sidings	SSS