The Shatin to Central Link Project

Final Report

Volume 2 of 2

Expert Adviser Team

Transport and Housing Bureau

December 2020

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Background of the Shatin to Central Link Project

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Appendix 1-1

Background of the Shatin to Central Link Project

Shatin to Central Link

1. The Shatin to Central Link ("SCL") is one of the strategic railway lines recommended in the Railway Development Strategy 2000. It has a total length of about 17 km. It comprises the following two sections (***Figure 1-1-1***):

(a) Tai Wai to Hung Hom Section: This is an extension of the Ma On Shan Line from Tai Wai via Southeast Kowloon to Hung Hom, where it will join the West Rail Line. This Section is denoted as East West Line ("EWL") of the SCL.

(b) Hung Hom to Admiralty Section: This is an extension of the East Rail Line from Hung Hom across the Victoria Harbour to Wan Chai North and Admiralty. This Section is denoted as North South Line ("NSL") of the SCL.

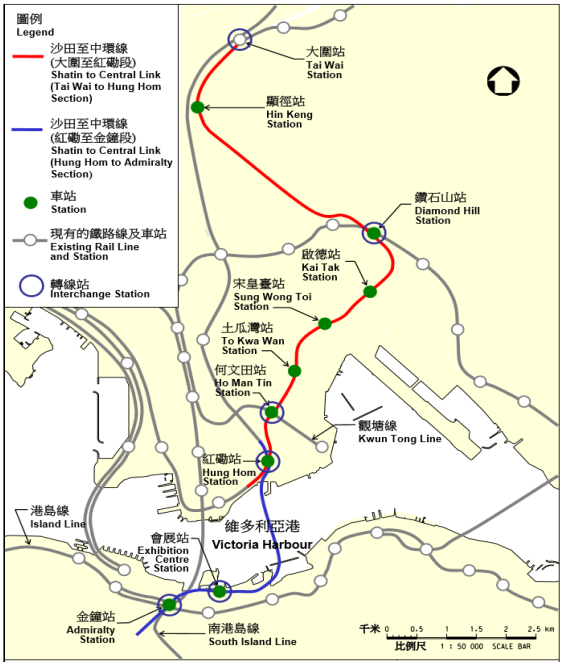

Figure 1-1-1 Alignment of Shatin to Central Link

(Source: Adapted from HyD's Drawing No. HRWSCL003-SK0465)

2. There are ten stations in the SCL. Apart from bringing improvements to the existing Tai Wai Station, the SCL Project also involves construction of new stations or extension of existing stations at Hin Keng, Diamond Hill, Kai Tak, Sung Wong Toi, To Kwa Wan, Ho Man Tin, Hung Hom, Exhibition Centre, and Admiralty.

3. The SCL is implemented under the service concession approach in which the Government funded the construction works and entrusted MTRCL to implement the project. The Government and MTRCL signed three Entrustment Agreements[1], pursuant to which MTRCL was entrusted to carry out the site investigation, design, construction, testing and commissioning of the SCL Project. According to the Entrustment Agreements, MTRCL warrants that the entrusted works shall achieve a professional and reasonable level of skill and supervision, including the assurance of quality of the works up to the required standards.

4. The construction of the SCL commenced in 2012. The completed Hin Keng Station, Diamond Hill Station Extension, Kai Tak Station and the associated railway sections have already been commissioned. Together with the original Ma On Shan Line, the entire railway from Wu Kai Sha Station to Kai Tak Station, which is officially named as "Tuen Ma Line Phase 1", was put into service on 14 February 2020.

5. After reviewing the progress as at 31 March 2020, MTRCL has set the commission of the remaining Kai Tak to Hung Hom Section in the third quarter of 2021 and that for Hung Hom to Admiralty Section in the first quarter of 2022.[2]

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[1] The first entrustment agreement entitled "Design and Site Investigation in relation to the Shatin to Central Link" was signed on 24 Nov 2008. The second entrustment agreement entitled "Advance works relating to the Shatin to Central Link" was signed on 17 May 2011. The third entrustment agreement entitled "Construction and Commissioning of the Shatin to Central Link" was signed on 29 May 2012.

[2] See LC Paper No. CB(4)646/19-20(03) "Progress Update of the Construction of the Shatin to Central Link (As at 31 March 2020)" reported in the Legislative Council Panel on Transport Subcommittee on Matters Relating to Railways in June 2020.

Instrument of Exemption and Instrument of Compliance

6. Depending on the applicability of the Buildings Ordinance (Cap. 123) ("BO"), building works under the SCL Project may fall under the purview of the Building Authority ("BA") or HyD, subject to the provision of the Instrument of Exemption ("**IoE")** and Instrument of Compliance ("**IoC**") respectively.

7. Pursuant to the Mass Transit Railway Ordinance (Cap. 556) ("MTRO"), the BA may issue the **IoE** to exempt MTRCL from part of the requirements under the BO.

8. The expansion of Hung Hom Station and the construction of Sung Wong Toi Station of the SCL Project are within the land leased to the Kowloon-Canton Railway Corporation and Government land given to MTRCL as short-term tenancy, respectively. The construction works at these locations are therefore controlled under the BO. With the consideration of the specific nature of building works related to railway construction, the BA, in accordance with Section 54(2) of the MTRO, issued the **IoE** in December 2012 to exempt MTRCL from certain requirements under the BO. The exemption is only limited to those procedures involving the appointment of Authorized Persons and Registered Structural Engineers, approval of drawings, and issuing works permits and occupation permits. The **IoE** also stipulates that MTRCL has to appoint persons possessing the appropriate experience and qualifications to be responsible for works in different aspects, and to establish Project Management Plan for the relevant works. The Project Management Plan outlines the scope of the works for the SCL Project and provides details on how this project is to be managed by MTRCL in order to demonstrate that the proposed management process will meet the exemption requirements under the BO.

9. Pursuant to the provision in Section 41 of the BO, construction works of the SCL project located in unleased land are exempted from the control of the Ordinance. In accordance with the Entrustment Agreements between the Government and MTRCL, the Director of

Highways issued the **IoC** requiring MTRCL to follow the administrative procedures and requirements as stipulated in the Instrument for carrying out building works. The objective is to ensure that the quality of the building works should not be inferior to the standards as required by the BO and its subsidiary legislations.

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Terms of Reference of Expert Adviser Team

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Appendix 1-2

Terms of Reference of Expert Adviser Team

Expert Adviser Team for the Shatin to Central Link Project
Terms of Reference

(i) ***Overall review***

(a) To review the Project Integrated Management System ("PIMS") of the MTR Corporation Limited ("MTRCL") to identify areas for improvement, as well as enhancement in communication and checks-and-balances, including, but not limited to, how hold point inspections are to be conducted by MTRCL and/or Government, possible use of smart technology for site supervision;

(b) to advise on additional management and monitoring measures to be taken by MTRCL and government departments to avoid recurrence of similar incidents in the construction of the remaining parts of the Shatin to Central Link ("SCL") project, including the platform slabs, approach tunnels and immersed tube in the North South Line from Hung Hom Station to Admiralty Station;

(ii) Hung Hom Station Extension

(a) to advise on the most pragmatic methodology for MTRCL to conduct forensic investigation to ascertain, to the maximum extent possible, what has been built inside the platform slabs and diaphragm walls at Hung Hom Station Extension and how it has been built;

(b) to review whether the load test to be arranged by MTRCL for the platform slabs at Hung Hom Station Extension could help ascertain (a) above;

(c) to explore the feasibility of partial opening up of the platform slab, and diaphragm structure to ascertain if the couplers used for connecting reinforcement bars had been properly constructed;

(d) to identify other potential tests, destructive or non-destructive, and the need for continuous monitoring of structural performance of the diaphragm walls and platform slabs of Hung Hom Station Extension;

(iii) Other Stations of the SCL project

(a) to advise on possible measures to ascertain if there are other irregularities in the construction of key structures in the SCL project (not limited to Hung Hom Station Extension).

(iv) Any other matters relevant to the works of the SCL Project

Deliverables

The Expert Adviser Team shall submit a final report in about 9 months from the date of establishment and may submit interim report(s) as necessary.

Membership

Dr Lau Ching-kwong	Senior Adviser (SCL)1	former Director of Civil Engineering
Mr Hui Siu-wai	Senior Adviser (SCL)2	former Director of Buildings
Mr Wong Hok-ning	Senior Adviser (SCL)3	former Head, Geotechnical Engineering Office

Supporting Team

Mr KWOK Kin-kuen	Senior Project Co-ordinator (SCL)	HyD
Mr POON Kwok-hin	Senior Structural Engineer (SCL)	BD
Mr CHUNG Hon-hei, Matthew	Senior Geotechnical Engineer (SCL) (until 3.5.2020)	GEO
Dr KOO Chi-hung, Raymond	Senior Geotechnical Engineer (SCL) (from 4.5.2020)	GEO

Appendix 2-1

Summary of Preliminary Recommendations

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Appendix 2-1

Summary of Preliminary Recommendations

(Source : Appendix C of the Interim Report of the EA Team)

Preliminary Recommendations (PR)	
(a) General	
1.1	The EA Team recommends that the THB arrange regular high-level meetings with the EA Team, MTRCL and other key stakeholders to address EA Team's recommendations and review the progress of the relevant follow-up actions.
2.1	The EA Team recommends that the relevant parties report the progress made and actions taken with respect to each of EA Team's recommendations, for review in the regular Project Meetings held by THB with the EA Team, MTRCL and other key stakeholders.
2.10	The EA Team recommends that MTRCL examine whether their consultants or other service providers in the Hung Hom Station Extension and in other sites of the SCL Project may have potential conflict of interest, either actual or perceived, and take any necessary actions to ensure that this will not adversely affect, or may be perceived to adversely affect, the management and delivery of the SCL Project.
(b) Hung Hom Station Extension	
1.2	The EA Team recommends that, in consultation with the relevant stakeholders, MTRCL set out the objectives of the load test and any other relevant examination and monitoring work for the EWL platform slabs of Hung Hom Station Extension, and devise a holistic plan for undertaking the test and other work for meeting the objectives. The objectives should include not only verifying the structural safety of the EWL platform slabs, but also its long-term durability and

Preliminary Recommendations (PR)	
	serviceability, and what has been built in its key structural elements. Special attention should be given to those parts without adequate objective evidence of the as-built conditions, and to those parts which were constructed before duly completing the required design amendment and endorsement processes.
1.3	The EA Team recommends that MTRCL extend the work on collection of objective evidence and other enquiries to also covering the NSL platform slabs of Hung Hom Station Extension, with a view to establishing what has been constructed and agreeing with the relevant stakeholders any necessary testing, examination and monitoring work for the NSL platform slabs.
1.5	The EA Team recommends that MTRCL compile a comprehensive list of outstanding submissions of design changes that are overdue in the Hung Hom Station Extension and in other sites of the SCL Project. These include those which are required under the Project Management Plan and other provisions of the IOE and IOC, as well as those that are required under the established internal procedures of MTRCL, e.g. the Project Integrated Management System (PIMS).
1.6	The EA Team recommends that the outstanding submissions should be made as soon as possible, and that MTRCL continue to monitor and update the list of outstanding submissions, and keep the relevant parties, e.g. HyD and BD, informed.
2.2	The EA Team recommends that MTRCL formulate a holistic strategy for agreement with the relevant government departments for assessing the acceptability of the works in the Hung Hom Station Extension, covering the EWL and NSL platforms slabs and the diaphragm walls. The strategy may include a combination of diagnoses based on the available objective records, physical inspections through opening up the structures, non-destructive tests and load tests, for assessing the

Preliminary Recommendations (PR)	
	acceptability of the structures and for establishing the key parameters that may be required for the design and implementation of any necessary remedial/improvement works.
2.3	The EA Team recommends that MTRCL and the relevant government departments consider the need for updating the scope of the work required of their independent experts and consultants, to ensure that the necessary input from the independent experts and consultants in assessing the acceptability of the works in the Hung Hom Station Extension are acquired in a holistic and timely manner.
2.4	The EA Team recommends that MTRCL and the relevant government departments review and update their assessment of any signs of distress and immediate danger in the Hung Hom Station Extension, including the EWL and NSL platform slabs and the diaphragm walls.
2.5	The EA Team recommends that MTRCL should explore other suitable testing methods to supplement the hammer test to verify the extent and severity of the honeycombing/void condition of the soffits of the EWL slabs. The possibility of presence of similar honeycombs/voids in the NSL platform slabs should be examined. The extent, severity and structural implications of the gaps between the columns and the soffits of the EWL platform slabs should also be assessed.
2.6	MTRCL should consider supplementing the ADMS with other monitoring devices, such as those that could record small structural strains and deformation, to measure and monitor the structural health of the platform slabs and diaphragm walls in the Hung Hom Station Extension.

Preliminary Recommendations (PR)	
(c) Settlement-related Issues	
1.4	MTRCL should ensure that effective mechanisms and procedures are put in place to assure the reliability and coherence of the settlement monitoring data at all active construction sites and other sensitive sites of the SCL Project, with account also taken of the latest experience gained by MTRCL from stocktaking the data.
2.7	MTRCL and the relevant government departments should ensure that all the monitoring parameters stipulated in the accepted drawings and monitoring plans are duly considered in evaluating whether the AAA Levels are breached, in undertaking the response actions in accordance with the accepted drawings and monitoring plans, and in assessing any other required follow-up actions.
2.8	The EA Team recommends that damage inspection/assessment should be carried out by MTRCL after breaching the Alarm Level, to provide a basis for establishing the need for any mitigation or other follow-up actions and ascertaining the acceptability of resumption of works.
2.9	The public should be assured that the AAA Levels will only be revised with full justifications, including the confirmation that it will not result in any safety or undue damage issues and that all practicable control and mitigation actions will be taken. This should be explicitly stated in the proposed mechanism for enhancing notification and reporting relating to the AAA Levels to minimize possible public misunderstanding.

Appendix 3-1

Construction Works in Hung Hom Site

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Appendix 3-1

Construction Works in Hung Hom Site

1. HUH Extension is an underground station constructed underneath the existing concourse of HUH, under Contract 1112 – *Hung Hom Station and Stabling Sidings*. The contract includes the extension and modification of HUH, construction of the NAT, SAT and HHS and other ancillary works.

HUH Extension

2. As far as the extension and modification of HUH is concerned, the civil engineering works mainly comprise the construction of D-walls, an upper underground platform for the EWL and a lower underground platform for the NSL. A general layout plan of the EWL platform is shown in ***Figure 3-1-1*** below.

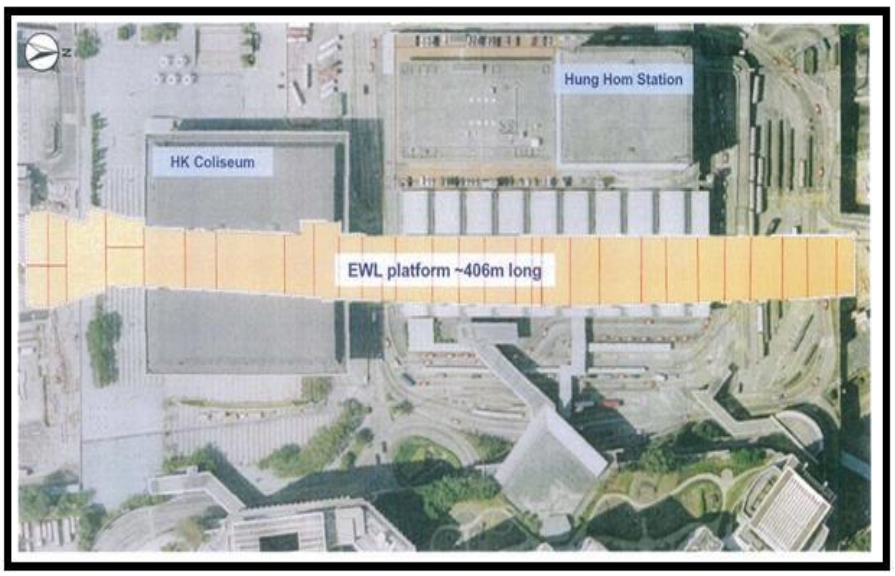

Figure 3-1-1 General layout plan of the EWL platform of the Hung Hom Station Extension

(Source : "MTRCL Report on SCL Contract 1112 – Review of the EWL Slab Construction" dated 15 June 2018)

3. The D-walls at the western and eastern sides of the station were first constructed, to serve as the cofferdam to facilitate the top-down excavation and construction of the EWL and NSL platform slabs. In other words, the EWL platform slab was constructed to provide part of the required lateral support to the D-walls, before the ground was further excavated to the NSL platform level for the construction of the NSL platform slab. As is the usual practice, the D-walls also serve as the permanent structural walls of the underground station. Two diagrammatic cross-sections of the structures of the HUH Extension are shown in ***Figures 3-1-2*** and ***3-1-3*** below.

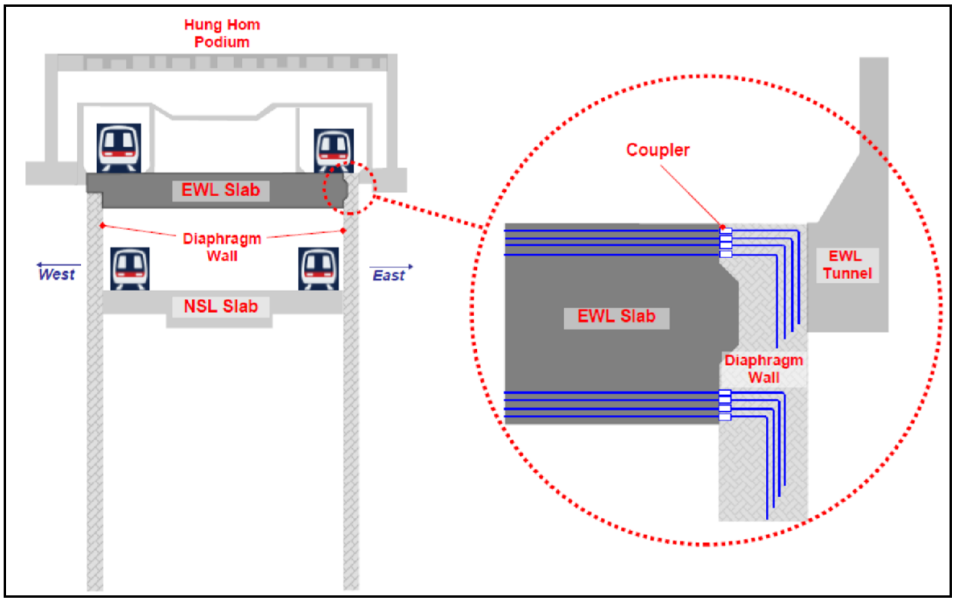

Figure 3-1-2 Diagrammatic cross-section of the platform slabs and D-walls of the Hung Hom Station Extension

(Source : "MTRCL Report on SCL Contract 1112 – Review of the EWL Slab Construction" dated 15 June 2018)

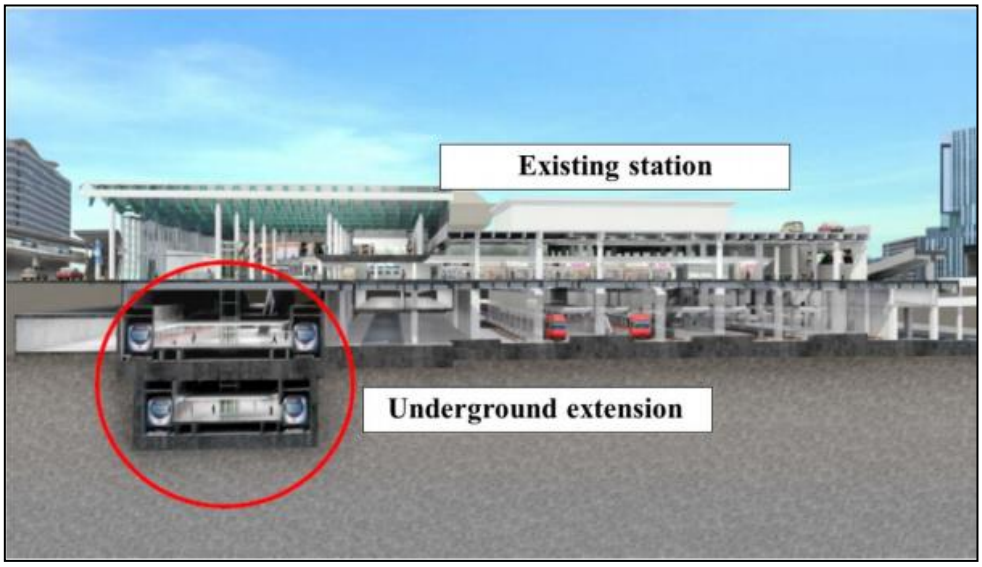

Figure 3-1-3 Diagrammatic cross-section of the structures of the Hung Hom Station Extension

(Source : Figure 2 of the Holistic Proposal)

4. The D-walls and the EWL and NSL platform slabs are cast-in-situ reinforced concrete structures. Owing to their sizeable longitudinal dimension (see ***Figure 3-1-1***), the D-walls and platform slabs were constructed panel by panel, instead of being cast in one go. Notwithstanding this, since the D-walls and platform slabs are designed as a monolithic structure, the steel bars required for reinforcing the concrete needed to continuously go through the structures (i.e. between the D-wall and the platform slab, and between adjoining panels of the platform slabs), except at specific locations where expansion joints were provided between the structures.

NAT, SAT & HHS

5. The layout of the NAT, SAT and HHS in relation to the HUH Extension is shown in ***Figure 3-1-4*** below. The structures involved are as follows:

(a) NAT – (i) an open-trough structure resting on soil for the EWL and shunt neck, and (ii) an underground box-section tunnel partly constructed on soil and partly supported by socketed H-piles for the NSL.

(b) SAT – (i) an open-trough structure partly supported by socketed H-piles and partly on soil for the EWL, and (ii) an underground box-section tunnel supported by D-walls for the NSL.

(c) HHS – (i) open-trough structures resting on soil to house 15 railway tracks, (ii) two box-section underpasses resting on soil and beneath the railway tracks, (iii) open-trough structures at the North Fan Area resting on soil and a noise barrier founded on piles, and (iv) eight single-storey accommodation blocks founded on piles.

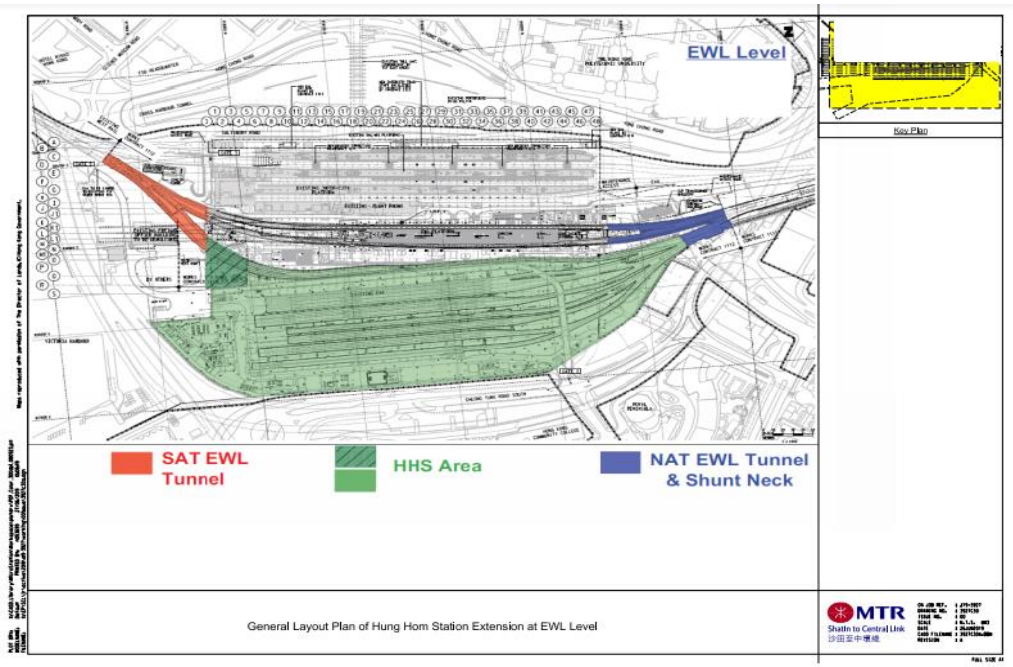

Figure 3-1-4 General layout of NAT, SAT and HHS

(Source : Appendix A of the Verification Report)

Appendix 3-2

Findings of Honeycombing Investigation at EWL Slab Soffit (as of June 2019)

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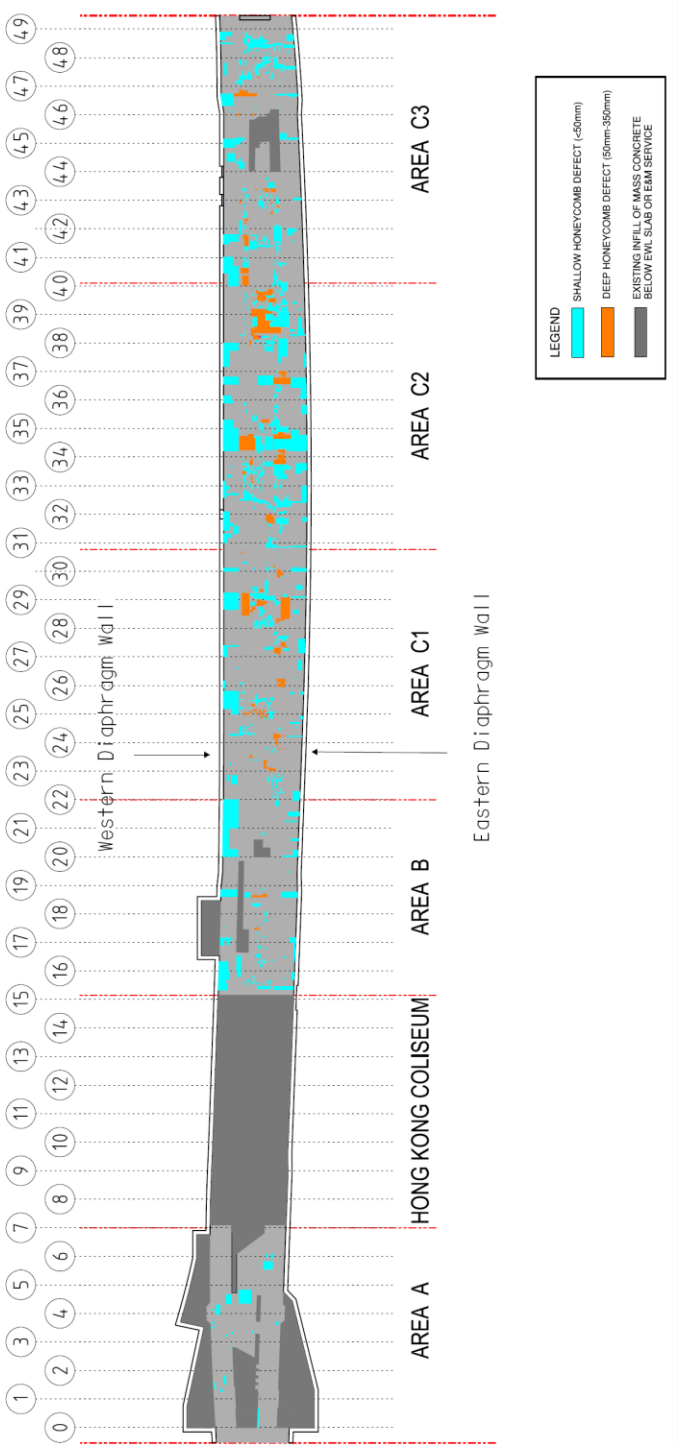
Appendix 3-2

Findings of Honeycombing Investigation at EWL Slab Soffit (as of June 2019)

(Source : Appendix B6 of the Holistic Report)



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Appendix 3-3

Findings of Shear Link Defects

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Appendix 3-3

Findings of Shear Links Defects

(Source : Appendix B8 of the Holistic Report)

EWL Slab

Type of defects	Number of locations in honeycombing inspected areas	Number of locations in additional opening-up areas
No shear link	10	6
Inadequate anchorage length	2	5
Undersized link diameter and inadequate anchorage length	1	1
Over-spacing of links and inadequate anchorage length	6	3
Undersized link diameter, over-spacing of links and inadequate anchorage length	3	3
Total	**22**	**18**

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Appendix 3-4

Summary of Defects in Gaps between EWL Slab Soffit and Walls/Columns/Hanger Walls

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Appendix 3-4

Summary of Defects in Gaps between EWL Slab Soffit and Walls/Columns/Hanger Walls

(Source : Appendix B7 of the Holistic Report)

Type of Defects	No. of Junction
(i) Unfilled gaps between slab and walls/columns/hanger walls	
a) Without observation on unconnected/ defective coupler connections and/or improper rebar fixing;	17
b) With observation on unconnected/ defective coupler connections and/or improper rebar fixing	5
(ii) Gaps filled with improper filling materials between slab and walls/columns/hanger walls	
a) Without observation on unconnected/ defective coupler connections and/or improper rebar fixing;	6
b) With observation on unconnected/ defective coupler connections and/or improper rebar fixing	3
Total	**31**

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Appendix 4-1

Implementation Progress of Suitable Measures in Hung Hom Site

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Appendix 4-1

Implementation Progress of Suitable Measures in Hung Hom Site

Type of remedial works	Description of works (Location)	Progress
(A) Structural strengthening works		
(i) Coupler connections	● Slab thickening of 20 m long x 500 mm thick with drilled-in bars (soffit of EWL in Area A) ● Slab thickening of 2.5 m^2 x 150 mm thick with drilled-in bars (VRV plant room in HHS) ● 15 strutting slabs of approx. 60 m in length (HHS) ● 17 backing walls with drilled-in bars to track slab of approx. 60m in length (HHS) ● One backing wall with strengthening at top of trough wall of approx. 4 m in length (HHS) ● One modification to trough wall close to existing column of approx. 4 m in length (HHS) ● One strutting beam of approx. 4 m in length (HHS) ● Two steel brackets at the connections fixed by anchor bolts (NAT Shunt Neck)	Completed
(ii) Shear link placement	● Slab thickening of 175 mm thick x 10 m^2 (top of EWL slab in Area A) ● Slab thickening of 300 mm thick x 42 m^2 (top of NSL slab in SAT)	Completed

Type of remedial works	Description of works (Location)	Progress
	● Slab thickening of 500 mm thick x 23 m^2 (top of NSL slab in Area A) ● Erection of 4 steel columns (between NSL slab and EWL slab in Area A) ● Installation of 21 inclined concrete struts (NSL slab in Area A)	
(iii) OTE ducts	139 sets of steel brackets with anchor bolts (Areas B & C)	Completed
(iv) Horizontal construction joints	● Eight drilled-in dowel bars with 200 mm slab thickening of approx. 11.4 m in length (EWL slab in Area B) ● 40 drilled-in dowel bars with 200 mm slab thickening of approx. 58 m in length (EWL slab in Area C)	Completed
(B) Other repair works		
(i) Honeycombing	● Approx. 324 m^2 of patching for shallow honeycomb (soffit of EWL slab in Areas A, B & C) ● Approx. 387 m^2 of grouting for deep honeycomb (soffit of EWL slab in Areas A, B & C) ● Approx. 481 m^2 of patching/grouting (soffit of EWL slab inside OTE ducts in Areas B & C)	Completed

Type of remedial works	Description of works (Location)	Progress
(ii) Insufficient concrete cover	133 locations of concrete cover remedial works (NAT, SAT & HHS)	Completed
(iii) Jagged Surface	85 m^2 of patching/grouting (soffit of EWL slab in Area A)	Completed
(iv) Column/Wall Gaps	40 locations of grouting (Areas A, B & C)	Completed
(v) Opening up Areas	● Rectification of water seepage at 25 opening-up locations, including the three locations with seepage rates that exceed the NWDSM requirement. ● Reinstatement of 79 opening-up locations with cement grout subsequently (Areas A, HKC, B & C)	Completed
(vi) Water seepage	41 locations of water seepage requiring rectification were identified as at 20.7.2020.	Rectifications at 38 locations completed as at mid-October 2020.
(vii) Voids in concrete backfilled areas in Area A	About 1,750 m^3 of voids to be backfilled with concrete	About 75% of concrete filling works completed as at mid-November 2020.

Type of remedial works	Description of works (Location)	Progress
(C) Other non-works provisions		
(i) Long-term monitoring	Draft technical proposal submitted by MTRCL to RDO on 31 July 2020 and 31 August 2020 which is under discussion between RDO and MTRCL.	Discussion is underway as at November 2020.
(ii) Water seepage preventive measures	Water seepage prevention measures with continuously monitoring for the water seepage condition will address the long-term water seepage problem as well as the corrosion problem.	Discussion is underway as at November 2020.
(iii) Restrictions and precautionary arrangements associated with *Updated Design*	MTRCL should address this issue, perhaps, through suitable provisions in the long-term monitoring programme.	Discussion is underway as at November 2020.

Appendix 4-2

Updated Design Criteria Adopted in Holistic Assessment of HUH Extension

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Appendix 4-2

Updated Design Criteria Adopted in Holistic Assessment of HUH Extension

(Source : Table 5 of the Holistic Report)

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
1. Partition Load Platforms were designed with a partition loading of 5 kPa, in addition to the passenger live load of 6 kPa throughout the entire platform.	The layout was finalized during detailed design. The partition load is now applied according to the as constructed layout with reference to the Architectural Plan.	Flexibility for future alteration works may be affected, in view of the revised loading provisions adopted in the *Updated Design*.
2. Trackform Load A superimposed Dead Load of 14.5 kPa for EWL and 20 kPa for NSL was allowed in the Station design at the time when the trackform design was uncertain on account of it not having commenced at that time.	The trackform design has been finalised and the trackform has been installed. The trackform loading can therefore be updated according to the as-built drawing from trackwork contract.	Flexibility for future alteration works may be affected, in view of the revised loading provisions adopted in the *Updated Design*.
3. Train Load A uniform live load of 50 kPa was allowed at all locations of the track area to envelope the moving loading from trains.	Train load can be applied as per NWDSM Figure 4.4.6 F1 Rev D.	May affect the alteration of train type not already covered by current NWDSM, in view of the revised loading provisions adopted in the *Updated Design*.

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
4. Column Load An additional built-in Load Factor of 1.1 for column load from existing columns.	The additional 1.1 Load Factor was removed as it is not a statutory or Code requirements to provide redundancy in the existing Column Loads.	Nil
5. Seismic Load Pseudo-static acceleration of 0.07g together with a Load Factor 1.4 was applied in the *Original Design*. This approach is also adopted in the design of other SCL stations.	Following the requirements stipulated in NWDSM. A dynamic analysis is carried out to verify the seismic loading.	Nil
6. Self-weight lock-in effect due to top down construction The *Original Design* adopted a 1.4 Load Factor for lock-in force for the EWL slab self-weight during the construction stage.	Taking into account the partial Load Factor requirements in the Code, a Load Factor of 1.26 is sufficient for the self-weight during construction while a Load Factor of 1.4 should be applied for the permanent situation, when the EWL slab is supported by internal columns and walls.	Nil

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
7. Soil Stiffness Correlation Factor An E value of 1.0 x Design SPT-N was adopted in the model.	The assessment of the stiffness can follow the Geotechnical Engineering Report ("GER") which has been accepted by relevant Government departments during the early design stage.	Nil
8. A 5m differential water pressure was applied and a load factor of 1.4 subsequently applied. This approach is also adopted in the design of other SCL stations. **Future Property Loading** A positive 20 kPa lateral pressure acting on one side of the structure, and a negative 20 kPa lateral pressure acting on another side was allowed for.	A 5 m differential water pressure is considered to be an exceptional load case in Clause 4.4.8.4 of the NWDSM. A load factor of 1.05 can be applied according to Clause 2.3.2.2 of the Code. After reviewing the site conditions around the station, the potential for future property development in the vicinity is under control of MTRCL. The application of 20 kPa acted on both sides can therefore be excluded.	Groundwater and loading conditions, say arising from future construction works in the vicinity of the site, will be controlled accordingly. Long term monitoring scheme to be further developed. This poses a potential restriction on the future usage and development in the vicinity of the site.

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
9. Modelling approach PLAXIS was modelled without considering all internal walls and barrettes. The NSL slab was assumed to be suspended during construction.	The as-constructed barrettes and some structural walls are now included in the PLAXIS model. The NSL slab was actually supported on soil during the top down construction of the station. Thus there was no locked-in stress on the D-walls during construction.	Flexibility of future alteration works may be affected, in view of the revised modelling conditions adopted in the *Updated Design*.
10. No redistribution of moment, which is the approach commonly adopted in designing railway structures in Hong Kong.	A maximum of 30% moment redistribution is adopted, i.e. for reinforcement concrete joint exceeding the structural capacity, the excess moment at the support between D-walls and platform slabs would be redistributed to the mid-span of platform slabs.	This affects the reserve capacity of the structure.

Appendix 4-3

Updated Design Criteria Adopted in Verification Study of NAT

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Appendix 4-3

Updated Design Criteria Adopted in Verification Study of NAT

(Source : Table B1 of the Verification Report)

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
1. Trackform Load A superimposed dead load of 14.5 kPa was allowed in the NAT design at the time when the trackform design was uncertain on account of it not having commenced at that time.	The trackform design has been finalised and the trackform has been installed. The trackform loading can therefore be updated according to the as-built drawing from trackwork contract.	Flexibility for future alteration works may be affected, in view of the revised loading provisions adopted in the *Updated Design*.
2. Seismic Loads Pseudo-static acceleration of 0.15g together with a Load Factor 1.4 was applied in the *Original Design.*	Following the requirements stipulated in NWDSM.	
3. Modelling approach Three separate 3-D shell or grillage models were adopted, which the structural behaviour could not be fully demonstrated especially the differential settlement at interface.	A single 3-D shell model is formed with consideration of staged construction at the stitch joint.	

Remark: The above are consistent with those adopted in the Final Report on Holistic Assessment Strategy for Hung Hom Station Extension.

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Appendix 4-4

Updated Design Criteria Adopted in Verification Study of SAT

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Appendix 4-4

Updated Design Criteria Adopted in Verification Study of SAT

(Source : Table B2 of the Verification Report)

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
1. Train Load A uniform live load of 108 kPa was allowed at all locations of the track area to envelope the moving loading from trains.	Train load can be applied as per NWDSM Figure 4.4.6 F1 Rev D.	May affect the alteration of train type not already covered by current NWDSM, in view of the revised loading provisions adopted in the *Updated Design*.
2. Seismic Load Pseudo-static acceleration of 0.07g together with a Load Factor 1.4 was applied in the *Original Design.*	Following the requirements stipulated in NWDSM.	NIL
3. Trackform Load A superimposed Dead Load of 20 kPa for NSL was allowed in the SAT design at the time when the trackform design was uncertain on account of it not having commenced at that time.	The trackform design has been finalised and the trackform has been installed. The trackform loading can therefore be updated according to the as-built drawing from trackwork contract.	Flexibility for future alteration works may be affected, in view of the revised loading provisions adopted in the *Updated Design*.

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
4. A 5 m differential water pressure was applied and a load factor of 1.4 subsequently applied.	A 5 m differential water pressure is considered to be an exceptional load case in Clause 4.4.8.4 of the NWDSM. A load factor of 1.05 can be adopted according to Clause 2.3.2.2 of the Code.	Groundwater and loading conditions, say arising from future construction works in the vicinity of the site, will be controlled accordingly. This may pose a restriction on the future usage and development in the vicinity of the site. Long term monitoring scheme to be further developed.
Future Property Loading A positive 20 kPa lateral pressure acting on one side of the structure, and a negative 20 kPa lateral pressure acting on another side was allowed for.	After reviewing the site conditions around SAT, the potential for future property development in the vicinity is under control of MTRCL. The application of 20kPa acted on both sides can therefore be excluded.	This poses a restriction on the future usage and development in the vicinity of the site.
5. Modelling approach The NSL slab was assumed to be suspended during construction in PLAXIS model.	The NSL slab was actually supported on soil during the bottom up construction of the tunnel. Thus there was no locked-in stress on the D-walls during construction.	Flexibility of future alteration works may be affected, in view of the revised modelling conditions adopted in the *Updated Design*.

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
6. No redistribution of moment, which is the approach commonly adopted in designing railway and other structures in Hong Kong.	A maximum of 30% moment redistribution is adopted. i.e. for reinforcement concrete joint exceeding the structural capacity, the excess moment at the support between D-walls and NSL slabs would be redistributed to the mid-span of NSL slabs.	This affects the reserve capacity of the structure.
7. Soil Stiffness Correlation Factor An E value of 1.0 x Design SPT-N was adopted in the model.	The assessment of the stiffness can follow the Geotechnical Engineering Report ("GER") which has been accepted by relevant Government departments during the early design stage.	Nil

Remark : The above are consistent with those adopted in the Final Report on Holistic Assessment Strategy for Hung Hom Station Extension.

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Appendix 4-5

Updated Design Criteria Adopted in Verification Study of HHS

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Appendix 4-5

Updated Design Criteria Adopted in Verification Study of HHS

(Source : Table B3 of the Verification Report)

Original Design	Updated Design	Restrictions/ Precautionary Arrangements
1. No redistribution of moment, which is the approach commonly adopted in designing railway and other structures in Hong Kong.	A maximum of 20% moment redistribution is adopted in the review of the maximum utilisation of tie beams at NFA. Tie beams were monolithically supported on pile caps and hogging moment at the supports would be redistributed to the mid-span.	This affects the reserve capacity of the structure.
2. Additional moment was allowed in the design to cater for pile construction offset tolerance of 75mm.	Additional moment due to offset of pile is recalculated based on as-constructed condition.	Nil

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Appendix 6-1

Spot-check of Spare Capacity in Original Design of EWL Slab

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Appendix 6-1

Spot-check of Spare Capacity in Original Design of EWL Slab

Considerations in Spot-check

1. The EA Team has carried out a spot-check of the spare capacity in the *Original Design* of the structural connection between the EWL slab and D-wall of the HUH Extension structure.

2. Here, "spare capacity" refers to the spare structural capacity in terms of the bending moment resistance (or cross-sectional area, where applicable) of the main rebars provided in the *Original Design*, over and above of that which was required for code compliance. The code compliance requirements may be governed by: (i) the required bending moment resistance calculated from design analysis under the *Original Design*, or (ii) other detailing requirements of the Concrete Code (see *paragraphs 3* and *4* below), whichever controls the design.

3. If the connection between the EWL slab and D-wall is to be designed as a *beam-column* connection with ductility provisions, the following requirements should be met[1]:

(a) the minimum percentage of the tension reinforcement (i.e. the main rebars in the top mat at the connection between the EWL slab and D-wall) should be not less than 0.3% of the area of the concrete section at the connection; and

(b) the compression reinforcement (i.e. the main rebars in the bottom mat at the connection between the EWL slab and D-wall) should be not less than 50% of the required tension reinforcement in the top mat at the connection.[2]

---

[1] See Clause 9.9.1.1(a) of the Concrete Code

[2] This is the 50% requirement referred to in *paragraphs 317, 327 and 330* in ***Section 6***.

4. However, if the connection between the EWL slab and D-wall is to be designed as a *slab-wall* connection, the requirements listed in *paragraph 3(a)* and *(b)* above are not applicable. Instead, 50% of the calculated span reinforcement in the EWL slab should be anchored into the connection.[3] This means that, in the bottom mat, the amount of the main rebars at the EWL slab and D-wall connection should be not less than 50% of the tension reinforcement required in the mid-span.

5. Four locations of the EWL slab and D-wall connection were selected by the EA Team for the spot-check. These included two locations in Area A (near Grid Lines 3 & 6) and one each in Area B (near Grid Line 19) and Area C (near Grid Line 39).

6. MTRCL and its DDC (Atkins) assisted in the spot-check by providing the relevant design information and jointly reviewing the findings with the EA Team. They also advised that the four selected locations, in terms of the available spare capacity at the connection between the EWL slab and D-wall based on the *Original Design*, were reasonably representative of the circumstances in the respective Areas A, B and C.

Findings of Spot-check

7. The findings of the spot-check were presented according to the following two scenarios.

(a) Scenario I – connection between the EWL slab and D-wall designed as a *beam-column* connection

(b) Scenario II – connection between the EWL slab and D-wall designed as a *slab-wall* connection

[3] See Clause 9.3.1.3 of the Concrete Code

Scenario I

8. The findings regarding the spare capacity in the EWL slab and D-wall connection at the four spot-check locations under Scenario I are summarized in *Tables 6-1-1 (a)* and *(b)* below. The spare capacity shown in the Tables is the surplus of the actual provision of the main rebars over and above the provision required for code compliance, and this is expressed in terms of the percentage of the required provision.

9. Under this Scenario, at the connection between the EWL slab and D-wall, the main rebars in the top mat at three of the four spot-check locations had a spare capacity of at least 40%. However, at the location in Area A (Grid Line 6), the spare capacity is only 10% at the connection with the east D-wall, and 23% with the west D-wall.

10. This suggests that while the main rebars in the top mat at the connection between the EWL slab and D-wall had generally been significantly over-provided in the *Original Design*, such over-provision was not consistently available throughout the whole stretch of the connection.

11. The main rebars at the bottom mat had generally been significantly over-provided. In Areas B and C, the over-provision was as substantial as 225% and 467%, respectively.

Scenario II

12. The findings under Scenario II are summarized in *Tables 6-1-2 (a)* and *(b)* below.

13. If the connection between the EWL slab and D-wall was designed as a *slab-wall* connection, the over-provision at the top mat was similar to that in the case of designing as a *beam-column* connection. However, given that a *slab-wall* connection is not subject to the requirement listed in *paragraph 3(a)* above, the over-provision of the main rebars at the top mat in Area B and Area C would become even more significant. The over-provision was 63% and 183%, respectively, if it was indeed the intent in the *Original Design* that the connection was to be designed as a *slab-wall* connection.

14. As for the bottom mat, if the connection was indeed intended to be designed as a *slab-wall* connection, the available spare capacity would be significantly less. For example, the spare capacity of the main rebars in Area B would become 10% (compared with 225% under Scenario I), and that in Area C would become 27% (compared with 467% under Scenario I).

Ambiguity in the scenario to adopt

15. There appears to be some ambiguities regarding whether the connection was designed as a *beam-column* or *slab-wall* connection.

16. During the course of the spot-check, both MTRCL and Atkins took the view that it should be designed as a *slab-wall* connection. However, the EA Team was advised by Professor Francis Au, the Government's independent structural expert, that it should be designed as a *beam-column* connection with ductility provisions.

17. In the Inquiry, all the independent experts agreed that:

> *"All agreed that an amount equivalent to 50% of the top tensile steel was required in the bottom of the EWL slab to be carried through in the [diaphragm] wall[,] i.e. less than 50% of the bottom steel at the interface was required for* ***Code compliance****."*[4] **[emphasis added]**

18. It was stated in the Final Report that:

> *"The Commission was advised by the experts that, in order to* ***comply with the Code****, the amount of reinforcement steel in the bottom of the EWL slab needed to be at least equivalent to 50% of the reinforcement steel in the top of the slab."*[5] **[emphasis added]**

[4] See paragraph 332 of Final Report

[5] See paragraph 331 of Final Report

19. The requirement referred to in *paragraphs 17* and *18* above is stipulated in the Concrete Code for *beam-column* connection, but not for *slab-wall* connection (see *paragraphs 3* and *4* above). This reflected that, in the Inquiry, the experts had taken the view that the connection was a *beam-column* connection. Furthermore, had the experts taken the connection as a *slab-wall* connection, they should not have unanimously advised the Commission that the main rebars in the bottom mat of the EWL slab at its connection with the D-wall would have such a significant spare capacity as *"less than 50% of the bottom steel at the interface was required for Code compliance"*.[6]

20. In view of this, the illustrative example given in *Figure 6-1* of ***Section 6***, which refers to the selected spot-check location in Area B, was based on Scenario I.

Over-provision of tension reinforcement at mid-span of EWL Slab

21. It was not the objective of this exercise to check the spare capacity of the main rebars provided as tension reinforcement in the mid-span of the EWL slab. However, data on this were collated since these were relevant to the application of the detailing requirements as described in *paragraph 4* above.

22. The data indicated that the over-provision was significant, both in the top mat (from 31% to 85%)[7] and bottom mat (from 32% to 147%)[8].

---

[6] According to *paragraph 14 of this Appendix*, if the connection was indeed intended to be a slab-wall connection, about 90% of the main rebars in the bottom mat at the connection of the EWL slab and D-wall in Area B would have been required for code compliance (corresponding to 10% over-provision, i.e. 100 / 110 ≈ 90%). Likewise, about 80% of those in Area C would have been required for code compliance (corresponding to 27% over-provision, i.e. 100 / 127 ≈ 80%). This means that about 80% to 90% of the main rebars in the bottom mat at the connection between the EWL slab and D-wall would be required for code compliance, which is contrary to the experts' advice to the Commission that "less than 50% of the bottom steel at the interface was required for Code compliance".

[7] See *Tables 6-1-1 (a)* and *6-1-2 (a)*.

[8] See *Tables 6-1-1 (b)* and *6-1-2 (b)*

Table 6-1-1 Scenario I (connection between EWL slab and D-wall designed as beam-column connection)

(a) Main rebars at the top mat of EWL slab

Area	Grid Line	In Mid-span			At Connection with East D-wall			At Connection with West D-wall		
		Actual Provision (kN-m /m)	Provision Required by Code (kN-m /m)	Spare Capacity	Actual Provision	Provision Required by Code	Spare Capacity	Actual Provision	Provision Required by Code	Spare Capacity
A	3	2,750	2,100 @	31%	2,750 (kN-m /m)	1,280 @ (kN–m /m)	115%	3,750 (kN- m /m)	1,800 @ (kN-m /m)	108%
					8,373 (mm^2 /m)	3,000 # (mm^2 /m)	179% (not critical)	8,629 (mm^2 /m)	3,000 # (mm^2 /m)	188% (not critical)
	6	1,850	1,000 @	85%	2,750 (kN-m /m)	2,500 @ (kN-m /m)	10%	1,850 (kN-m /m)	1,500 @ (kN-m /m)	23%
					8,373 (mm^2 /m)	3,000 # (mm^2 /m)	179% (not critical)	4,314 (mm^2 /m)	3,000 # (mm^2 /m)	44% (not critical)
B	19	9,168	5,200 @	76%	13,341 * (kN-m /m)	8,200 @ (kN–m /m)	63% (not critical)	-		
					12,559 * (mm^2 /m)	9,000 # (mm^2 /m)	40%			
C	39	17,789	11,000 @	62%	13,341 * (kN- m /m)	4,706 @ (kN–m /m)	183% (not critical)	-		
					12,559 * (mm^2 /m)	9,000 # (mm^2 /m)	40%			

Remark:

@ Based on the calculated tensile reinforcement for providing the required bending moment resistance.

\# Based on the requirement for the minimum 0.3% tension reinforcement, see paragraph 3(a) of ***Appendix 6-1***.

* A reduction factor of 0.75 has been applied in view of the presence of tremie pipes.

Table 6-1-1 Scenario I (connection between EWL slab and D-wall designed as beam-column connection)
(b) Main rebars at the bottom mat of EWL slab

Area	Grid Line	In Mid-span			At Connection with East D-wall			At Connection with West D-wall		
		Actual Provision (kN-m /m)	Provision Required by Code (kN-m /m)	Spare Capacity	Actual Provision (kN-m /m)	Provision Required by Code (kN- m /m)	Spare Capacity	Actual Provision (kN- m /m)	Provision Required by Code (kN- m /m)	Spare Capacity
A	3	2,637	1,750 @	51%	1,150	640 ^	80%	1,150	900^	28%
	6	1,850	750 @	147%	1,850	1,250 ^	48%	1,150	750^	53%
B	19	32,081	24,300 @	32%	13,341 *	4,100 ^	225%	-		
C	39	32,081	21,000 @	53%	13,341 *	2,353 ^	467%	-		

Remark:

@ Based on the calculated tension reinforcement for providing the required bending moment resistance.

^ Based on the requirement for provision of 50% of the tension reinforcement at the EWL slab and D-wall connection as compression reinforcement, see paragraph 3(b) of ***Appendix 6-1***.

* A reduction factor of 0.75 has been applied in view of the presence of tremie pipes.

Table 6-1-2 Scenario II (connection between EWL slab and D-wall designed as slab-wall connection)

(a) Main rebars at the top mat of EWL slab

Area	Grid Line	In Mid-span			At Connection with East D-wall			At Connection with West D-wall		
		Actual Provision (kN-m /m)	Provision Required by Code (kN-m /m)	Spare Capacity	Actual Provision (kN- m /m)	Provision Required by Code (kN- m /m)	Spare Capacity	Actual Provision (kN- m /m)	Provision Required by Code (kN- m /m)	Spare Capacity
A	3	2,750	2,100 @	31%	2,750	1,280 @	115%	3,750	1,800 @	108%
	6	1,850	1,000 @	85%	2,750	2,500 @	10%	1,850	1,500 @	23%
B	19	9,168	5,200 @	76%	13,341*	8,200 @	63%	-		
C	39	17,789	11,000 @	62%	13,341*	4,706 @	183%	-		

Remark:

@ Based on the calculated tensile reinforcement for providing the required bending moment resistance.

* A reduction factor of 0.75 has been applied in view of the presence of tremie pipes.

Table 6-1-2 Scenario II (connection between EWL slab and D-wall designed as slab-wall connection)

(b) Main rebars at the bottom mat of EWL slab

Area	Grid Line	In Mid-span			At Connection with East D-wall			At Connection with West D-wall		
		Actual Provision (kN-m /m)	Provision Required by Code (kN-m /m)	Spare Capacity	Actual Provision (kN- m /m)	Provision Required by Code (kN- m /m)	Spare Capacity	Actual Provision (kN- m /m)	Provision Required by Code (kN- m /m)	Spare Capacity
A	3	2,637	1,750 @	51%	1,150	875 κ	31%	1,150	875 κ	31%
	6	1,850	750 @	147%	1,850	375 κ	393%	1,150	375 κ	206%
B	19	32,081	24,300 @	32%	13,341*	12,150 κ	10%	-		
C	39	32,081	21,000 @	53%	13,341*	10,500 κ	27%	-		

Remark:

@ Based on the calculated tensile reinforcement for providing the required bending moment resistance.

κ Based on the requirement for 50% of the calculated span reinforcement to be anchored into the connection, see paragraph 4 of ***Appendix 6-1***.

* A reduction factor of 0.75 has been applied in view of the presence of tremie pipes.

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Appendix 8-1

Comparison of HUH Extension with Other SCL Stations

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Appendix 8-1

Comparison of HUH Extension with Other SCL Stations[1]

Station	Factor (a)[2]	Factor (b)[2]		Factor (c)[2]
	Construction form same as HUH Extension (Y/N)	**Main contractor**	**Steel fixing subcontractor**	**Potential conflict of interest between consultants (Y/N)**
HUH Extension	D-walls with the use of couplers for connection with the platform slabs	Leighton Contractors (Asia) Ltd	● Hung Choi Engineering Co Ltd (D-walls) ● Fang Sheung Construction Co (EWL & NSL slabs and SAT) ● Wing & Kwong Steel Engineering Co Ltd (NAT & HHS)	Yes
HIK	No	Penta-Ocean Construction Co Ltd	Cally Construction Engineering Ltd	No
DIH	Yes	Leader Joint Venture	Jiu Ji Construction Ltd	Yes[3]

[1] The SCL stations not involving major civil engineering in the SCL Project, viz. TAW, HOM and ADM, are not included in this comparison.

[2] See *paragraph 431* in ***Section 8*** of this report

[3] Under Contract 1106: "Diamond Hill Station Extension", Leader Joint Venture employed the same design consultant (AECOM) as MTRCL's DDC, mainly for part of the temporary works design of the excavation and lateral support works.

Station	Factor (a)[2]	Factor (b)[2]		Factor (c)[2]
	Construction form same as HUH Extension (Y/N)	**Main contractor**	**Steel fixing subcontractor**	**Potential conflict of interest between consultants (Y/N)**
KAT	No	Kaden - Chun Wo Joint Venture	Leung Kai Engineering Co Ltd	No
SUW	No	Samsung - Hsin Chong Joint Venture	Tin Wo Engineering Co Ltd	No
TKW	Yes	Samsung - Hsin Chong Joint Venture	Tin Wo Engineering Co Ltd	No
EXC	Yes	Leighton - China State Joint Venture	Tin Wo Engineering Co Ltd	Yes[4]

[4] Under Contract 1123: "Exhibition Station and Western Approach Tunnel", Leighton-China State Joint Venture employed the same design consultant (Ove Arup & Partners) as MTRCL's DDC, mainly for part of the temporary works design of the excavation and lateral support works and alternative designs for piling at the station etc.

Appendix 8-2

Summary of Audit by WSP on Six SCL Stations

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Appendix 8-2

Summary of Audit by WSP on Six SCL Stations

Scope of Audit

1. According to WSP, their assessment on the level of supervision and inspection carried out by MTRCL of the works is "*mainly based on the completeness, relevancy and authenticity of the documentation and supporting materials presented by MTRCL.*"[1]

2. With the exception of EXC (excluding item (d) below), the audit covered the following four types of site records:

(a) RISC forms;

(b) QSP and quality supervision documents for couplers;

(c) SSP; and

(d) NCR.

3. WSP documented the findings of the audit in the following two audit reports, which were submitted by MTRCL to HyD:

(a) Audit Report on Quality Supervision of EWL Stations dated 6 November 2019; and

(b) Audit Report on Quality Supervision of 1123 Exhibition Centre Station dated 21 April 2020.

4. Reference to the two audit reports has been made in preparing this Appendix.

[1] See paragraph 1.3 of MTRCL's Audit Report on Quality Supervision of EWL Stations dated 6 November 2019

RISC Forms

5. For RISC forms, WSP has adopted a two-phase checking process. The workflow is shown in ***Figures 8-2-1*** and ***8-2-2*** below.

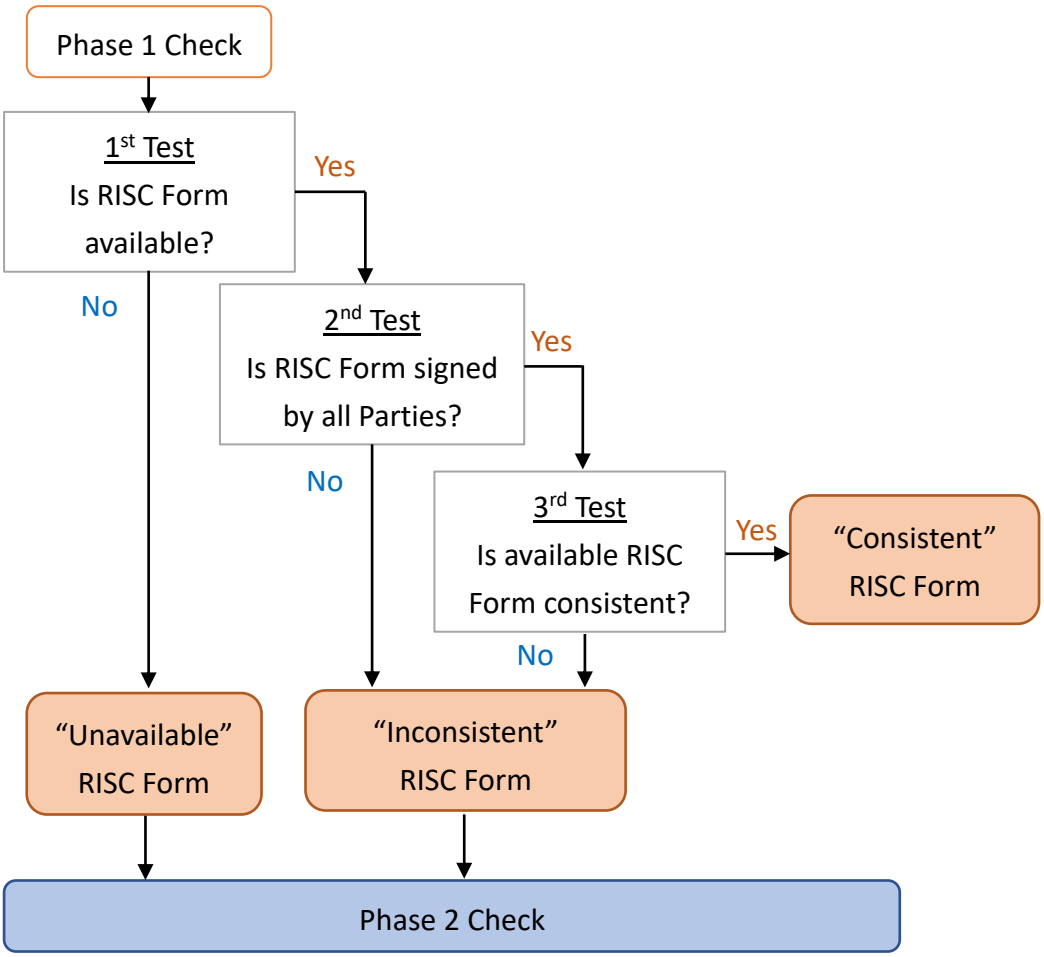

Figure 8-2-1 Audit Workflow in Phase 1 Check

6. In Phase 1 check (***Figure 8-2-1***), WSP took stock of whether the required RISC forms for the two hold points being audited were available. For the available RISC forms, WSP reviewed the following information for determining whether they were "consistent":

(a) the title, description of works and number are correct;

(b) all required parties have signed off the RISC form; and

(c) the date of concrete pouring, date of request for inspection, inspection date and endorsement date are consistent and reasonable.

7. The results of Phase 1 check for the five EWL stations are as follows:

Table 8-2-1

Stations	**Number of required RISC forms**	**Number and percentage of required RISC forms which are available**		**Number and percentage of required RISC forms which are consistent**	
HIK	631	602	95.4%	478	75.8%
DIH	560	520	92.9%	439	78.4%
KAT	804	657	81.7%	634	78.9%
SUW	1,077	1,020	94.7%	594	55.2%
TKW	751	661	88.0%	501	66.7%
Total	**3,823**	**3,460**	**90.5%**	**2,646**	**69.2%**

8. In the Phase 2 check, WSP evaluated the available supplementary materials for the cases where the RISC forms were either “unavailable” or deemed “inconsistent”, to determine whether site supervision at the relevant hold points could be evidenced (***Figure 8-2-2***). These supplementary materials comprise photographs, site diaries, drawings, WhatsApp/Email messages, test reports and piling records.

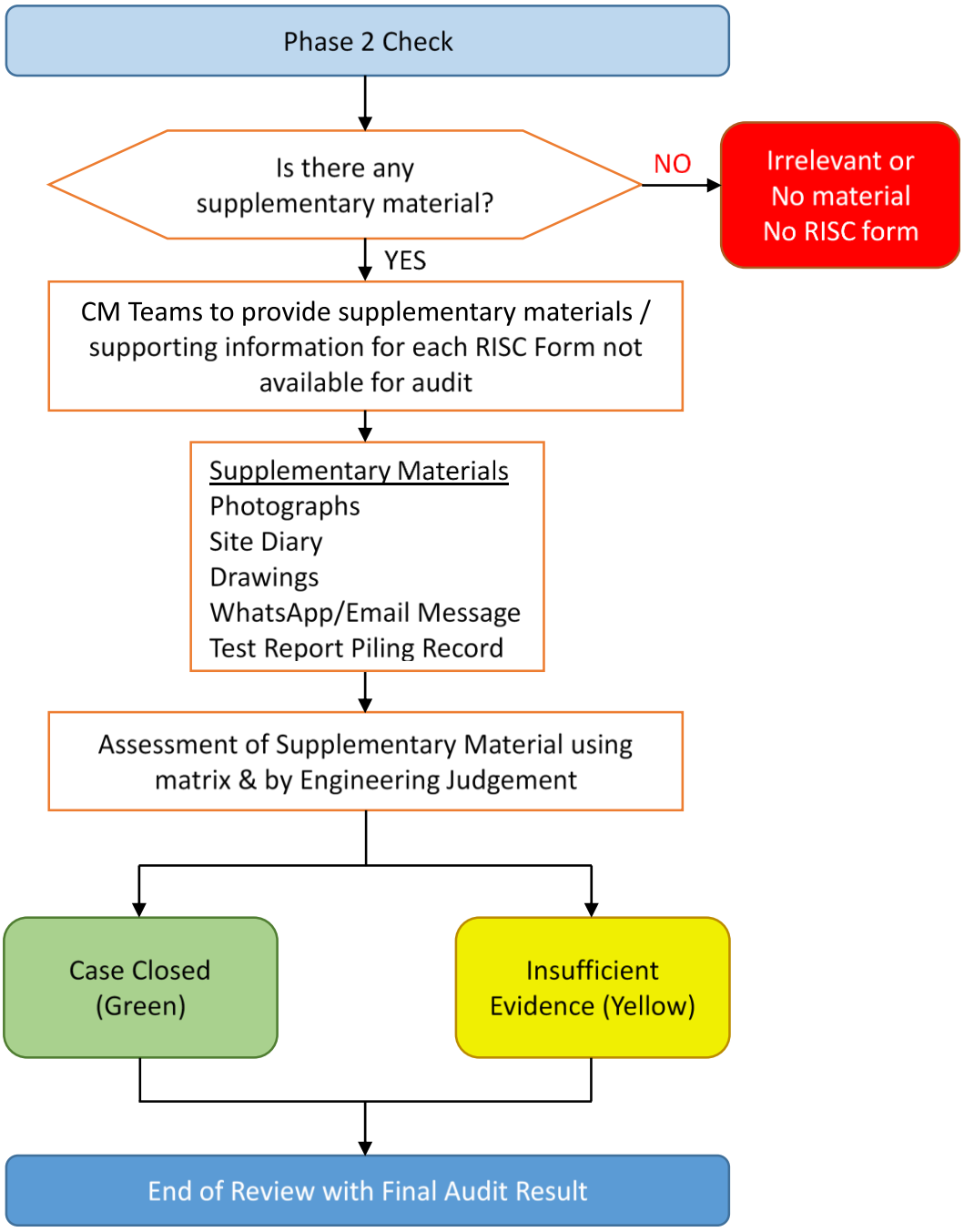

Figure 8-2-2 Audit Workflow in Phase 2 Check

9. The "closing of cases" were determined by WSP after reviewing the supplementary materials. For RISC forms found to be "unavailable" or "inconsistent" in the Phase 1 check, WSP would regard the availability of two or more pieces of supplementary materials as meeting the criteria for taking the case as "closed". Otherwise, the case was denoted as with "insufficient evidence", i.e. it was an "unclosed" case.

10. The results of the Phase 2 check for the five EWL stations are presented in ***Table 8-2-2*** below.

Table 8-2-2

Stations	**Number of unavailable RISC forms**	**Case closed**	**Insufficient evidence[2]**	**Number of inconsistent RISC forms**	**Case closed**	**Insufficient evidence[3]**
HIK	29	15	14	124	2	122
DIH	40	40	0	81	59	22
KAT	147	96	51	23	15	8
SUW	57	51	6	426	375	51
TKW	90	87	3	160	136	24
Total	**363**	**289**	**74**	**814**	**587**	**227**

11. By incorporating the results of the Phase 2 check, the overall findings are summarized in ***Table 8-2-3***:

[2] These cases have less than two pieces of supplementary materials as supporting evidence.

[3] These cases have less than two pieces of supplementary materials as supporting evidence.

Table 8-2-3

Stations	Number of required RISC forms	Number of required RISC forms which are consistent	Number of cases closed in Phase 2 check[4]	Number and percentage of required RISC forms remain not closed[5]	
HIK	631	478	17	136	21.6%
DIH	560	439	99	22	3.9%
KAT	804	634	111	59	7.3%
SUW	1,077	594	426	57	5.3%
TKW	751	501	223	27	3.6%
Total	**3,823**	**2,646**	**876**	**301**	**7.9%**

12. For EXC on the NSL, a digital RISC form system ("iSuper") was launched in February 2019 to supersede the previous paper RISC forms. Therefore, the audit results for EXC were divided into two parts to deal separately with the paper RISC forms before the implementation of the iSuper System and the situation after the iSuper implementation. The audit results are presented in ***Table 8-2-4*** below.

[4] RISC forms which are found to be consistent in Phase 1 check are not subject to Phase 2 check.

[5] This refers to the outstanding RISC forms, i.e. those which have neither been found to be consistent in Phase 1 check nor regarded as closed cases in Phase 2 check, and is expressed in terms of the percentage of the required RISC forms.

Table 8-2-4 Phase 1 & 2 checks for EXC

EXC	Number of required RISC forms	Phase 1 Check				Phase 2 Check		
		Number and percentage of required RISC forms which are available		Number and percentage of required RISC forms which are consistent		Number of cases subject to Phase 2 check	Number of cases closed in Phase 2 check[6]	Percentage of required RISC forms remain not closed[7]
Paper RISC forms	1,218	939	77.1%	377	31.0%	841	793	3.9%
iSuper forms	1,428	1,428	100%	1,428	100%	0	0	0%

13. The overall situation of RISC forms for the five EWL stations is comparable with that for EXC while the digital iSuper system has returned much better results.

14. WSP has applied a *7-day rule* which acknowledges that, if the RISC form is received within 7 days of the activity under inspection, the RISC form is deemed acceptable (i.e. not regarded as "inconsistent"). This gives the benefit of the doubt that the works schedules of the front-line inspectors might not allow them to attend office until a later time and the review of RISC form submission status by the SIOW was conducted on a weekly basis.

QSP and Quality Supervision Documents for Couplers

15. For quality assurance and supervision documentation for mechanical couplers, WSP checked if the relevant documents were in order. The audit results are presented in ***Table 8-2-5*** below.

[6] RISC forms which are found to be consistent in Phase 1 check are not subject to Phase 2 check.

[7] This refers to the outstanding RISC forms, i.e. those which have neither been found to be consistent in Phase 1 check nor regarded as closed cases in Phase 2 check, and is expressed in terms of the proportion of the required RISC form.

16. MTRCL concluded that "*audit on the delivery notes, mill certificates of raw materials, test reports, inspection records, etc. have been conducted and revealed that the majority of which are generally in line with the quality assurance and supervision documentation requirements as stipulated in the RDO/BD submissions.*"[8]

Table 8-2-5[9]

Structure[10]	**Location**	**Coupler installation record**		**Remark**
		Required	**Available**	
TKW	Mini-piles	116	116	RISCF provided instead for unavailable coupler installation record
	Dwall	165	146	
	Slab	43	43	
SUW	Station Structure	7	7	
KAT	Perimeter wall	4	4	
	Slab	12	12	
	Column	3	3	
DIH	Dwall (1106)	76	76	
	Slab (1106)	162	156	
	Dwall (1103)	48	48	- RISCF provided instead - NC Report regarding lost inspection record submitted to BD/BO team on 15-May-19
	Slab (1103)	25	25	
Total		**661**	**636 (96%)**	

[8] See paragraph 9 of the Executive Summary of MTRCL's Audit Report on Quality Supervision of EWL Stations submitted to HyD on 8 November 2019

[9] This table is reproduced from Section 3.2 of MTRCL's Audit Report on Quality Supervision of EWL Stations submitted to HyD on 8 November 2019.

[10] According to MTRCL, no mechanical couplers were used in HIK.

17. It is noted that further information on WSP's observations about the anomalies in the QSP records is given in Appendix B2 of MTRCL's Audit Report on Quality Supervision of EWL Stations submitted to HyD on 8 November 2019. For example, regarding the coupler installation records of DIH, WSP noted that in 123 out of 162 (i.e. 76%) of the records "*were identified as Lab Test Date later than Cast Date although the test results have been checked and passed.*" Regarding the coupler installation records of TKW, "*for all records found, no full name of QCS (MTR T3) and signature/date are shown in the records.*"

18. For EXC, there were inaccuracies in the contents of the 73 coupler inspection record sheets for the D-walls and base slab constructed up to February 2019. Most record sheets were identified as invalid due to late threading records, test completed dates later than coupler inspection dates or coupler inspection dates later than the cast dates, logistic check failures or lack of RISC forms for sampling coupler assembly.

19. Despite the deficiencies found of the site records, WSP concluded that "*The result found the work was generally all in accordance with the QSP requirement*."[11]

SSP

20. The checking of SSP documents includes the verification of whether the relevant documents of the required inspections are available and whether the contents therein are correct, e.g. the names of TCPs, the commencement and completion dates, and the frequency and number of inspections carried out.

21. For the five EWL stations, SSP records were found for 92% of the total number of the required inspections (i.e. 17,534 records of inspections were available out of 19,054 required inspections).

22. For EXC, the percentages of SSP records available ranged between 80% and 93%, for different types of structural works involved.

[11] See paragraph 3.2 of MTRCL's Audit Report on Quality Supervision of 1123 Exhibition Centre Station dated 21 April 2020

23. For the five EWL stations, MTRCL concluded that "*the SSP records for the five stations are about 92%. The small percentage of unavailable SSP record is mainly due to site office relocation and/or improper filing*."[12] Notwithstanding this relatively high percentage of available SSP records, WSP has discovered that the inspection records for certain grades of TCPs and certain elements of the structures in individual stations are well below this average figure of availability. For example, there was no record of the 60 required inspections by the Grade T4 TCP of the CP stream for the pile cap construction at HIK (i.e. 0% availability). In another case, only the records of 141 inspections out of the 250 required inspections by the Grade T5 TCP of the CP stream for the basement construction of KAT can be identified (i.e. 56% availability).

24. For EXC, WSP concluded that "*over 85% of the required documentation was identified during the audit. Despite the small percentage of RISCF/records that did not pass the audit requirements, the construction and supervision were generally in order and are supported by alternative evidence and/or records to conclude the findings.*"[13]

NCR

25. A total of 43 structure-related NCRs for the five EWL stations were identified. All had been closed out. Nonetheless, WSP's audit revealed different types of inconsistency in 31 NCRs. WSP had reviewed the supplementary evidence provided by MTRCL staff and considered the closing out of the NCRs satisfactory.

26. No audit on NCRs was given in the audit report for EXC.

27. In the two letters from WSP to MTRCL in June 2019 and January 2020 in relation to the audit exercises carried out to the five EWL stations and EXC respectively, WSP gave the following views:

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[12] See paragraph 3.3 of MTRCL's Audit Report on Quality Supervision of EWL Stations dated 6 November 2019

[13] See paragraph 4.1 of MTRCL's Audit Report on Quality Supervision of 1123 Exhibition Centre Station dated 21 April 2020

"Given the random nature of this small percentage of missing RISC forms across the site construction works, and the general weight of evidence that the works on site were being adequately supervised, it is not unreasonable to be confident that the same strong site inspection regime would have been applied to all elements of structure, including those with less compelling physical evidence, as was confirmed verbally by the project staff interviewed during the audit"

28. In the Conclusion of the Executive Summary of the Audit Report on Quality Supervision of EWL Stations submitted to HyD on 8 November 2019, MTRCL stated the following:

"There is no sign of any distress or structural issue which would affect safe operation of the railway. There is also no report showing any problem which would affect safe operation of the railway from any party either.

There were regular inspections by the TCPs and site supervision team as evidenced by the TCP records. The Competent Person (CP) had also conducted visual inspection at the 74 locations where only one piece of acceptable supporting evidence is available for the unavailable RISCF on 17 and 18 June 2019. No sign of distress, concrete spalling or structural cracks was observed. Accordingly, the CP is satisfied that the quality of the works is in good order.

Although there is deficiency in documents, the audit did not reveal any major deviations or irregularities which may arise concern on the structural integrity of the stations.

Lastly, the CP declares that the documents being checked during the internal audit are in order in terms of authenticity, relevancy and adequacy."

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Appendix 8-3

Summary of Audit by PYPUN on Six SCL Stations

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Appendix 8-3

Summary of Audit by PYPUN on Six SCL Stations

Approach and Methodology

1. The following approach and methodology was adopted by PYPUN in the audit:

(a) the verification is carried out by way of sample checking;

(b) the selection of critical structural elements for the audit is based on a risk-based approach with the aim to cover critical elements (e.g. D-walls, platform slabs, pre-bored socketed H-piles, columns, and beams) that are with significant structural safety implication and with similar nature to those reported irregularities in other SCL stations;

(c) reference is made to irregularities previously reported in media reports, MTRCL's NCR and in other relevant reports on SCL projects;

(d) the sampling size of selected structural elements and their corresponding records is determined by engineering judgement of the audit team on a case-by-case basis with the aim to approximately covering different periods of the construction, different areas of the station structure, key hold point inspections, and key quality supervision procedures relevant to mechanical couplers works and site supervisions; and

(e) in principle, only the records relevant to the sampled elements are to be checked in the audit. However, if MTRCL also presents other records relevant to elements not being sampled, these records may also be checked and considered in the audit.

2. PYPUN's audit covered the following key site records:

(a) RISC forms;

(b) QSP and quality supervision documents for couplers; and

(c) SSP.

3. PYPUN documented the findings of the audit in the following eight audit reports:

(a) Executive Summary of Health-check Exercise covering SCL TKW, DIH, HIK, KAT, SUW Stations (Ref No. PKD-030P) (November 2019);

(b) Contract Review Report of Diamond Hill Station Audit (Final) (Ref No. PKD-030N) (July 2019);

(c) Contract Review Report of Hin Keng Station Audit (Final) (Ref No. PKD-030N) (July 2019);

(d) Contract Review Report of Kai Tak Station Audit (Final) (Ref No. PKD-030N) (July 2019);

(e) Contract Review Report of Sung Wong Toi Station Audit (Final) (Ref No. PKD-030N) (July 2019);

(f) Contract Review Report of To Kwa Wan Station Audit (Final) (Ref No. PKD-030N) (July 2019);

(g) Review Report of Sample Checking of Supplementary Materials for SCL TKW, DIH, HIK, KAT, SUW Stations (Ref No. PKD-030P) (November 2019); and

(h) Review Report of Exhibition Centre Station Audit (3rd Draft) (July 2020).

4. Reference has been made to the eight audit reports in preparing this Appendix.

RISC forms

5. PYPUN's audit covered about 15% of the critical elements of the stations structures on three key hold point inspections. For platform slabs, the selected hold point inspections are: (i) rebar fixing, (ii) formwork erection and (iii) pre-pour check. For D-walls, they are: (i) pre-fabrication of reinforcement cage, (ii) installation of reinforcement cage, and (iii) pre-pour check. It was found that, at the five EWL stations audited, the availability of the required RISC forms ranged between 83% and 95% (see ***Table 8-3-1*** below). This is comparable to the findings of WSP's audit.

Table 8-3-1

Proportion of the required RISC forms found to be available

Station		**PYPUN's audit**	**WSP's audit**
HIK		83%	95%
DIH		91%	93%
KAT		84%	82%
SUW		95%	95%
TKW		83%	88%
EXC	Paper form	91%	77%
	iSuper system	100%	100%

6. Sample check of supplementary materials was carried out on selected cases of missing or inconsistent RISC forms. This is aimed at verifying whether there were any objective site records to demonstrate that the required site inspection was carried out. If so, the case was taken as "closed".

7. Ten to twelve inspection cases were selected from each of the audited stations for the sample check of supplementary materials. These

amount to a total of 58 inspection cases, in which 28 cases were of missing RISC forms and 30 cases were of inconsistent RISC forms. The results of the sample check are summarized in ***Table 8-3-2***.

Table 8-3-2

Station	No. of inspection cases for sample check	No. of inspection cases closed by sample check
HIK	12	5
DIH	12	12
KAT	12	11
SUW	12	12
TKW	10	10
Total	**58**	**50**

8. PYPUN's audit of the five EWL stations revealed deficiencies in the availability of the required RISC forms. Irregularities and inconsistencies, including late submission and incomplete information in the available RISC forms, were also observed. Furthermore, it was noted that MTRCL had relied on a shared register of RISC forms, which was maintained and updated by the contractor, to monitor and control the RISC form process, instead of keeping MTRCL's independent RISC register. This is contrary to the PIMS Practice Note which required MTRCL to keep its own independent RISC form register.[1]

9. For EXC, both paper RISC forms and digital iSuper forms were audited. All the paper RISC forms of the station slabs, columns, perimeter walls and external walls were available with no irregularities noted. The availability of paper RISC forms of the H-piles and D-walls were 97% and 64% respectively. Furthermore, irregularities related to inconsistent inspection, concreting or received dates on substantial number of cases of H-piles and D-walls construction were noted from the checking of the available RISC forms.

[1] See Section 10.1.2 of PIMS/P/aa/A3 and Section 5.1.2 of PIMS/PN/11-4/A5

10. The audit revealed that MTRCL made use of an independent RISC forms register in EXC, which was regularly updated and maintained by MTRCL, to monitor the submission of the paper RISC forms.

QSP and Quality Supervision Documents for Couplers

11. The types of mechanical couplers used in the five EWL stations are shown in ***Table 8-3-3***.

Table 8-3-3

Station	Type of mechanical couplers	Manufacturer of couplers	Statutory Requirement of Supervision
HIK	N/A (no couplers were used)	N/A	N/A
DIH	Type II (ductility couplers)	Contract 1103 – Dextra Contract 1106 - BOSA	QAS & QSP
KAT	Type I (non-ductility couplers)	VSC	QAS & SSP
SUW	Type I (non-ductility couplers)	Dextra	QAS & SSP
TKW	Type I (non-ductility couplers)[2]	Dextra	QAS & SSP

12. It was found that the coupler inspection records generally met the minimum statutory requirements for inspection. However, for Contract 1103 of DIH, all the quality and inspection records for couplers were not available at the time of the audit. MTRCL explained that the records were lost possibly during the relocation of the DIH site office.

[2] All couplers actually used in TKW were Type 2 couplers. MTRCL considered that all couplers were designed as Type 1 couplers. The type of couplers to be use is not explicitly specified in the accepted drawings.

13. For EXC, the quality supervision procedures of mechanical couplers followed the accepted QSP. The quality supervision records were generally in line with the requirements in QSP.

SSP

14. The inspection records for the five EWL stations were found to have generally complied with statutory requirements for SSP. The SSP documentations were submitted to HyD for acceptance. However, not all records of TCP inspections by Grade T3 and T5 TCPs, and RSE/CP could be produced by MTRCL for checking. PYPUN noted MTRCL's claim that "*the 'lost' records were due to: a) relocation of site office; b) records not properly filed and the respective TCP has left MTRCL (records were kept by the individual members of CM Team)*".

15. PYPUN's audit in EXC did not cover the SSP documentations.

16. PYPUN concluded in its report entitled "Executive Summary of Health-check Exercise covering SCL TKW, DIH, HIK, KAT, SUW Stations" dated November 2019 that:

> *"Based on the sample checking of this health-check exercise, we observed that there were discrepancies and imperfections in MTRCL's site record keeping practice."*
>
> *"In summary, from the records reviewed by this health-check exercise, including the checking of other objective supplementary evidence related to unavailable RISC Forms by way of sample checking, and taking into account the findings and assessment of MTRCL's comprehensive internal audit, no major deficiencies or abnormalities of site work were revealed*."

Appendix 9-1

Monitoring and Announcement Mechanism for the Impact of Railway Works to Nearby Structures and Public Facilities ("Enhanced Mechanism")

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Appendix 9-1

Monitoring and Announcement Mechanism for the Impact of Railway Works to Nearby Structures and Public Facilities ("Enhanced Mechanism")

(This Appendix including the footnotes is reproduced from the document on "Enhanced Mechanism" provided by HyD)

Scope

All monitoring points within the areas affected by construction works set up under the Shatin to Central Link ("SCL") project.

Setting up of Monitoring Plan

2. The **MTR Corporation Limited ("MTRCL")** has set up a monitoring plan[1] for the construction works of the SCL project. The monitoring plan, upon consultation with and with the agreement of the Buildings Department[2] ("BD") or Highways Department[3] ("HyD")

[1] The MTRCL submitted the latest relevant information on settlement monitoring points along the alignment of the SCL to the Subcommittee on Matters Relating to Railways of the Legislative Council on 30 August 2018 (Refer to webpage https://www.legco.gov.hk/yr17-18/english/panels/tp/tp_rdp/papers/tp_rdp20180831cb4-1504-4-e.pdf for details). The information includes the types of relevant affected structures and the settlement readings under the monitoring plan.

[2] The HUH extension works and the construction of SUW of the SCL project are located on land leased to the Kowloon-Canton Railway Corporation or land under short term tenancy respectively. The construction works at these locations are controlled under the BO (Cap. 123). Having regard to the exceptional nature of building works connected with construction of the railway, the BA (i.e. Director of Buildings), pursuant to section 54(2) of the Mass Transit Railway Ordinance (Cap. 556), issued an Instrument of Exemption (IoE) in December 2012 to exempt the MTRCL from those procedures involving the appointment of AP and RSE, approval of drawings, and the of consent for the commencement of building works and occupation permits. Under the IoE, the MTRCL should appoint persons possessing the appropriate experience and qualifications (i.e. Competent Persons) to be responsible for works in different aspects, and establish project management plan for such works. The project management plan instigates an assurance system and control scheme to ensure that the management of the construction works is at a standard not inferior to that required under the BO. Also, BD has to be consulted regarding specified types of building works.

[3] Pursuant to the provision in section 41 of the BO, construction works of the SCL project which are located on Government land or unleased land are exempted from the control of the BO. In accordance with the entrustment agreement signed between the Government and the MTRCL, the Director of Highways issued an Instrument of Compliance ("IoC") in July 2013 requiring the MTRCL to follow the administrative procedures and requirements as stipulated in the IoC for carrying out building works. The objective is to ensure that the quality of building works to be not inferior to the

together with relevant government departments, includes setting up of various types of monitoring points and establishing appropriate pre-set trigger levels for temporary suspension of works (such as ground settlement, building tilting and angular distortion of underground utilities). Unless otherwise agreed by BD or HyD, the **MTRCL** shall continue with the monitoring works according to the monitoring plan.

3. The **MTRCL** shall compile and keep updating a list of the public facilities and structures related to the monitoring points for timely communication and notification.

Suspension of Works

4. Under the following situations, the MTRCL shall immediately suspend the part of works which may contribute to the problems:

(a) monitoring data, including amount of settlement or other monitoring data, verified by the Registered Geotechnical Engineer ("RGE") and confirmed by the Competent Person[4] ("CP") have reached or exceeded the pre-set trigger levels for temporary suspension of works as agreed by government; or

(b) the MTRCL, HyD or BD considers the settlement data (including settlement, tilting and angular distortion) or other monitoring data indicate that the structural safety of structures and safe operation of public facilities in the vicinity might be affected.

Deferment of Suspension

5. Under the situations set out in paragraph 4 above, some construction operations for alleviating the extent of settlement, such as the

standards as required under the BO and its subsidiary legislations.

[4] In accordance with the IoE (refer to footnote 2) and IoC (refer to footnote 3), the MTRCL shall appoint CP to take up the duties and responsibilities of the Authorized Person and Registered Structural Engineer under the BO, including coordination and supervision of the works, certification of the drawings and documents, and issue of completion certificates to relevant government departments. For the appointment of CP, the MTRCL shall obtain prior agreement from BD or HyD in regard to his/her qualifications and experiences.

installation of lateral supports for excavation, could not be suspended immediately in order to avoid posing a greater risk to the works, public facilities or structures, or worsening the settlement situations. Under such circumstances, the MTRCL shall consult BD or HyD at the planning stage in advance and obtain the department's agreement to the contingency measures for such kind of operations which could not be suspended immediately. The MTRCL shall suspend that part of works immediately once the contingency measures concerned have effectively stabilised the extent of settlement and it is ensured that the situation is not posing a greater risk.

6. During the period of suspension of works as set out in paragraph 4 above and deferment of suspension set out in paragraph 5 above, the MTRCL shall immediately deploy their Registered Structural Engineer and notify the relevant stakeholders and Government departments to inspect the structures and public facilities near the works site which may be affected to confirm the structural safety of the structures and safe operation of the public facilities. The MTRCL shall at the same time assess the conditions of the structures and public facilities which may be affected, including whether any damage has been caused by the SCL construction works. The MTRCL shall also formulate suitable mitigation measures to ensure public safety and minimise adverse impacts to the nearby structures and facilities. The MTRCL, BD and HyD shall continue close monitoring of the situations to ensure that the affected structures are structurally safe and the public facilities remain in normal operation.

Updating Trigger Levels for Suspension of Works

7. During the construction or temporary suspension of works, including the situation where the readings of monitoring points have not reached the pre-set trigger levels for suspension of works, the MTCRL may update the pre-set trigger levels for temporary suspension of works if considered necessary after detailed analysis. The MTRCL shall consult relevant stakeholders (i.e. utilities companies, Drainage Services Department and Water Supplies Department), BD or HyD in advance on the proposed pre-set trigger levels for temporary suspension of works, with the support of robust justifications to ensure that the works would not pose any adverse impacts on the nearby structures and facilities.

8. BD or HyD, together with other relevant Government departments, will vigorously scrutinise MTRCL's proposal of updating the pre-set trigger levels for temporary suspension of works and will only consider agreeing to the update proposed when it is confirmed that the MTRCL has sufficient justifications.

Resumption of works

9. When MTRCL considers that the conditions to resume works are ready, BD or HyD shall scrutinise the proposal of resumption of works submitted by the MTRCL. Upon confirming the completion of the following actions, BD or HyD will consider allowing the MTRCL to resume works:

(a) the MTRCL has re-examined the construction methods and sequences, and adopted necessary mitigation measures; and

(b) the MTRCL has completed the tasks set out in paragraph 7 above, as well as paragraphs 11 and 12 below, if updating of pre-set trigger levels for suspension of works is involved.

BD or HyD will notify the CP of the MTRCL by email and in writing its agreement to the resumption of works.

MTRCL's Communication with Stakeholders

10. For situations set out in paragraphs 4 or 5 above, the CP of the MTRCL is required to notify BD or HyD by email and in writing about the arrangement for the temporary suspension of works or deferment of suspension immediately and submit the relevant information, including relevant data of the monitoring points. The CP shall also inform BD if monitoring points of private buildings are involved.

11. Having received the notification from the MTRCL, BD or HyD will complete the inspection of the affected private buildings within the following 48 hours, and HyD will inspect the public facilities under attention (such as gas pipes and water pipes) within the same period to

confirm if they are structurally safe. If public facilities or government structures are involved, the MTRCL shall contact the relevant stakeholders to complete the required inspection in order to confirm their structural safety or that they are in normal operation. The MTRCL shall render full support throughout the process.

12. For the arrangements of suspension of works (paragraph 4 above refers), deferment of suspension of works (paragraph 5 refers), updating of pre-set trigger levels (paragraph 7 refers) and resumption of works (paragraph 9 refers), the MTRCL shall inform the relevant affected stakeholders, including utilities undertakers, owners or managers[5] of the buildings and structures as well as relevant Government departments, with reference to the list of public facilities and buildings given in paragraph 3 above within three days after the above decisions.

13. When BD or HyD together with the relevant utilities companies and government departments have agreed to the proposed updating of pre-set trigger levels for temporary suspension of works, the MTRCL shall notify the relevant stakeholders, including utilities undertakers, owners or managers[6] of buildings and structures as well as Government departments of the updated trigger levels in a timely manner and inform them the following:

(a) the justifications for the update;

(b) the update will not give rise to concerns or adverse impacts to the structural safety of their buildings and safe operation of public utilities; and

(c) the details of the control and mitigation measures to be implemented.

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[5] In the absence of incorporated owners, managers and caretakers at the concerned buildings, MTRCL shall put up notices in the common area of the buildings as an attempt to inform occupants as far as possible.

[6] Please see footnote 5.

Announcement Mechanism to the Public by BD or HyD

14. After completion of inspection of the affected structures and public facilities as per paragraph 11 above, BD (if private buildings or works covered by IoE are involved) or HyD, and the MTRCL will separately issue press releases (see press release to be issued by the government in **Annex I**), announcing the arrangement and reasons of the suspension of works or deferment of suspension of works and data of the monitoring points.

15. BD (if private buildings or works covered by IoE are involved) or HyD, and the MTRCL will issue press releases[7] (see press release to be issued by the government in **Annex II**) to announce the arrangements for the resumption of works (see paragraph 9 above) if the MTRCL's proposal of works resumption is agreed. If the updating of pre-set trigger levels for temporary suspension of works is involved, the details will be included in the same press releases.

16. The MTRCL shall present the readings and trigger levels of monitoring points, (a) where the trigger levels for suspension of works have been reached or exceeded; and (b) where trigger levels for temporary suspension of works have been updated, during the reporting period in the quarterly report to be submitted to the Subcommittee on Matters Relating to Railways of the Legislative Council. The latest arrangement of resumption of works shall also be reported.

Transport and Housing Bureau
Highways Department
Buildings Department

28 September 2018

[7] Regarding those structures and public facilities previously affected, MTRCL will confirm the structural safety of structures and safe operation of the public facilities. BD and HyD will confirm the structural safety of the private buildings. HyD will also inspect the utilities, roads and other related structures to confirm their structural or operation safety.

Annex I

Issue of <settlement> due to <Works type> at <XX Station>

During the <works type (for example, excavation works)> undertaken by the MTR Corporation Limited ("MTRCL"), the <works type> has been suspended on <date of suspension> as <the reasons (for example, the reading of monitoring instrumentation installed at <private buildings, structures, public facilities or roads> has reached/exceeded the pre-set trigger levels for temporary suspension of works)>. [The relevant trigger levels and monitoring readings are given in Annex.]

<Buildings Department ("BD")> has deployed staff to inspect the affected <private buildings> and [confirmed that these structures are structurally safe / considered part of them may have structural safety concerns, which have to be further investigated. The MTRCL has taken immediate strengthening measures, including <types of measures>*]. <Highways Department ("HyD")> has deployed staff to inspect the affected <structures, public facilities or roads> and [confirmed that they are structurally safe or in safe operation / considered part of them may have structural or operational safety concerns, which have to be further investigated. The MTRCL has taken immediate strengthening measures, including <types of measures>*.]
[*delete inappropriate part]

<BD or HyD> will continue monitoring the situations to ensure that [the safety <or safe operation> of the <private buildings, structures, public facilities or roads> concerned will not be affected / the safety issues of the <private buildings, structures, public facilities or roads> concerned will be resolved as soon as possible*].
[*delete inappropriate part]

Although the above works have been suspended, part of the mitigation measures for reducing the settlements, including <types of measures> will be continued. As soon as the settlements have become stable as a result of these measures and a greater risk will not be imposed, the MTRCL shall suspend that part of works immediately. Furthermore, <BD or HyD>

shall request the MTRCL to propose suitable mitigation measures and adopt construction methods which would have less impact to the <private buildings, structures, public facilities or roads>.

If the resumption of works is requested by the MTRCL, <BD or HyD> will scrutinize the proposal with a view to ensuring the structural safety <or safe operation> of the affected <private buildings, structures, public facilities or roads>. Besides, if the MTRCL proposes to update the pre-set trigger level for suspension of works, <BD or HyD> will also consider the comments from the relevant stakeholders of the public facilities and Government departments in vetting the MTRCL's proposal. When the resumption of works is agreed, <BD or HyD> shall inform the public on the related arrangement.

Annex II

Resumption of <works type> at <XX Station>

As <the reasons (for example, the reading of monitoring instrumentation installed at <private buildings, structures, public facilities or roads> has reached or exceeded the pre-set trigger level for suspension of works), the MTR Corporation Limited ("MTRCL") has suspended the relevant <works type (for example, excavation works or piling works)> on<date of suspension>.

The MTRCL has analysed in detail the <impact (for example settlement)> brought by the construction works and proposed appropriate remedial and mitigation measures, in order to reduce the impacts of the railway works to the private buildings, structures and public facilities in its vicinity. The MTRCL has submitted a proposal to <BD or HyD> to resume <works type> at <XX Station>. <At the same time, the MTRCL has provided the required justifications for updating the trigger levels of <monitoring parameters (for example settlement)>>.

<BD or HyD> confirm that the relevant existing <private buildings, structures, public facilities and roads> are structurally safe <or in safe operation>. Taking into account relevant comments from stakeholders including relevant departments and utility undertakers and confirmation that the works resumption <and updating of trigger levels> would not compromise public safety, <BD or HyD> has agreed to the proposal of works resumption <and updating of trigger levels>. [The updated trigger levels and their latest readings are given in **Annex**.]

The safety and quality of railway projects are always the prime consideration of the Government. Under any circumstances, we shall accord top priority to safeguard the public, construction personnel on sites, nearby buildings and facilities. <BD or HyD> shall continue to closely monitor the conditions of structures and public utilities in the vicinity of construction works to ensure the works are carried out in a safe manner.

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Appendix 9-2

Findings of Settlement Audit at To Kwa Wan Station

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Appendix 9-2

Findings of Settlement Audit at To Kwa Wan Station

The TKW Site

1. To Kwa Wan Station ("TKW") is an elongated box structure, which is about 300 m long and 20 m wide underneath Ma Tau Wai Road in To Kwa Wan. It was constructed under Contract 1109 of the SCL Project. The maximum excavation depth for the construction of the station structure is about 32 m from the existing road level. The layout plan and a typical cross-section of TKW are shown in ***Figure 9-2-1*** and ***Figure 9-2-2***, respectively.

2. The station structure was constructed in a top-down manner. The general sequence of the construction works was as follows:

(a) Stage 1 – construction of the D-wall alongside the eastern edge of the station (i.e. Eastern D-wall);

(b) Stage 2 – construction of the D-wall alongside the western edge (i.e. Western D-wall); and

(c) Stage 3 – bulk excavation of the ground and casting of the reinforced concrete slabs between the Eastern D-wall and Western D-wall in a top-down manner.

3. As the works in Stage 3 were located below the perennial groundwater level[1] of the site, dewatering by pumping of water from the excavated area was required. This might lead to excessive drawdown of the groundwater level in the vicinity of the site, in case the on-site provisions[2] for control of groundwater drawdown are not sufficiently effective.

[1] At this site, the perennial groundwater level was at 8 to 9 mPD. The bottom slab of the station structure was founded at -22 mPD, which is about 30 m below the perennial groundwater level.

[2] At the TKW site, the provisions included grouting at the toe of the D-wall, which helped reduce groundwater flow into the bulk excavation area and installation of recharge wells outside the bulk excavation area for replenishing the groundwater.

4. The settlement audit for TKW was focused on selected monitoring points on the two sides of Ma Tau Wai Road near the Eastern and Western D-walls, where notable settlements were reported to have occurred during the construction works.

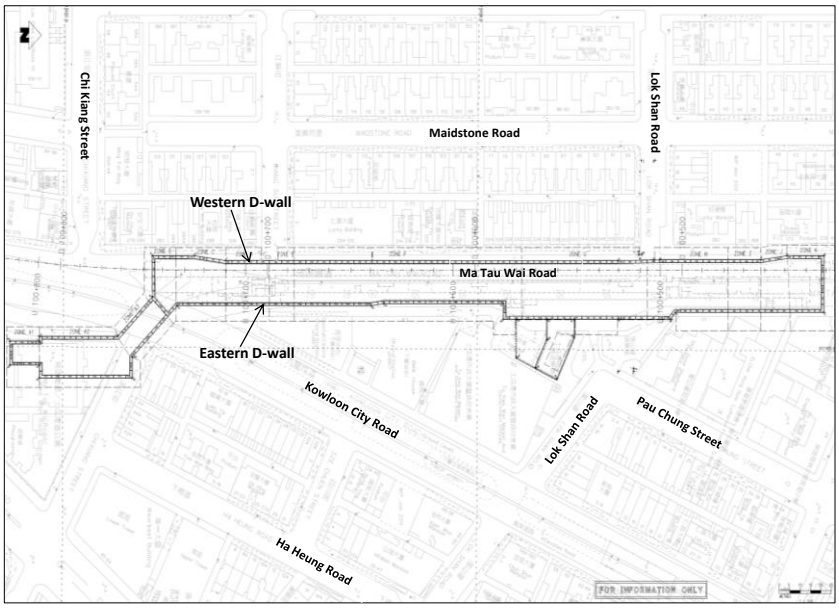
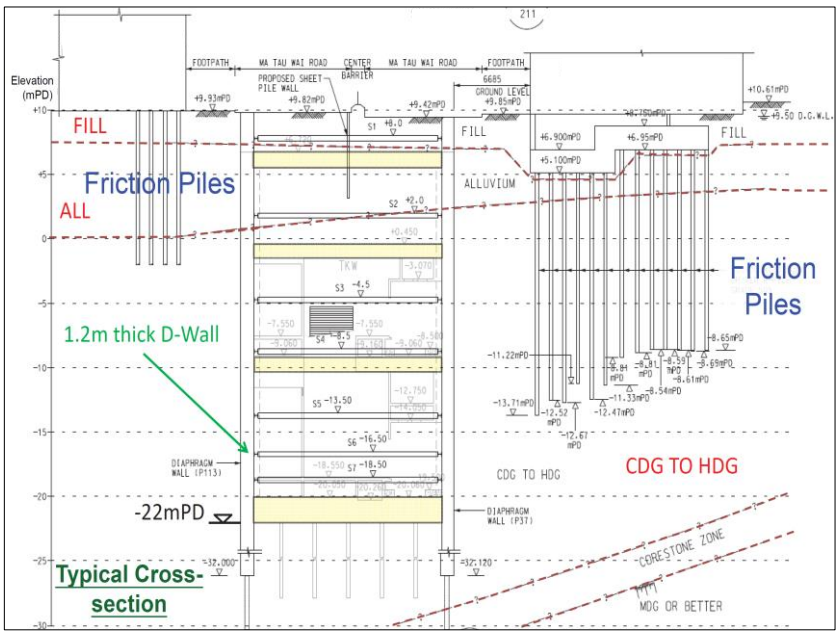


Figure 9-2-1 Layout plan of TKW

(Adapted from: Drawing No. 1109/W/TKW/MMH/SK/250 provided by MTRCL)



Note: ALL is alluvium, CDG is completely decomposed granite, HDG is highly decomposed granite and MDG is moderately decomposed granite

Figure 9-2-2 Typical cross-section of TKW

(Adapted from: Design submission provided by MTRCL)

Monitoring and Control System

AAA Levels accepted in January 2013

5. The first adopted set of the AAA Levels for TKW was specified in the drawing which was accepted by HyD in January 2013.[3] The *Alarm Levels* are shown in ***Table 9-2-1***.

Table 9-2-1 Alarm Levels stipulated in the accepted drawing of January 2013 for TKW

Type		**Construction Activity**	**Alarm Level**
Ground settlement		Due to construction of D-wall[4]	10 mm
		Cumulative for all works	25 mm
Utility	settlement	Cumulative for all works	25 mm
	angular distortion		1:300
Groundwater drawdown from the lowest historical groundwater level		Cumulative for all works	1 m
Tilting of existing building		Due to construction of D-wall	1:500
		Cumulative for all works	1:500

Note: Building settlement was not included as part of the AAA criteria.

6. In the relevant design submission of MTRCL[5], it was assessed that the ground settlement which would be induced by the works would exceed 45 mm in the vicinity of the Eastern and Western D-walls. This exceeded the *Alarm Level* of ground settlement stipulated in the accepted

[3] Based on HyD's information, the first accepted drawing stipulating the monitoring plan was entitled "Geotechnical Monitoring and Instrumentation for TKW Station – General Notes" dated 20 December 2012 (Drawing No. 1109/W/000/MMH/C01/237, Revision B1), which was accepted by HyD on 21 January 2013.

[4] This applied to cumulative ground settlement due to construction of both the Eastern D-wall and Western D-wall.

[5] See MTRCL Design Submission entitled "Diaphragm Wall Panels at Zone A3 to Zone K, Report No.: 312757/SCL1109/003E" dated December 2012.

drawing. This predicted level of settlement was neither proposed by MTRCL, nor agreed by HyD, at the time as an acceptable level of ground settlement.

7. In line with the normal practice, it was stipulated in the accepted drawing that suspension of the construction activities was required in the event of exceedance of the *Alarm Level*. The relevant requirement given in the accepted drawing is extracted as follows:

> *"On reaching the "Alarm Level" or any undue settlement or damage to adjacent roads, buildings, structures and utilities are observed, the Contractor shall notify the Engineer immediately. The Contractor shall implement emergency response actions including suspend all construction activities within 50 m of the instruments, unless otherwise agreed by the Engineer. The Contractor shall provide a report detailing the full history of movements and remedial measures adopted in relation to the actual construction sequence. The report shall be reviewed and interpretation of the events given to the Engineer with recommendations for enabling work to proceed. Work may only resume upon the written instruction of the Engineer."*

8. In the accepted drawing of January 2013, tilting of buildings was included as part of the AAA Levels for the TKW site. However, building settlement was not included as part of the AAA criteria for the TKW site. Yet, since the commencement of works, in all monthly T5 reports[6] submitted by MTRCL between January 2013 and April 2014, monitoring results on building settlement were presented.

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[6] Provision of T5 supervision and submission of T5 report are typical requirements recommended by GEO for diaphragm wall works and ELS works. Details of T5 supervision are given in Technical Memorandum for Supervision Plan 2009 and Code of Practice for Site Supervision 2009. T5 is a registered professional engineer with minimum 5 years of relevant experience. The T5 under the Registered Geotechnical Engineer's (RGE) stream is responsible for *"Checking that site works comply with the approved plan, design requirements including those of the method statements, precautionary and protective measures" and "Dealing with non-conformities by making referral to the RGE's Representative"*, among other duties. The T5 shall submit regular reports of the findings and recommendations to the RGE. RGE shall formally submit these reports (denoted as "T5 Report") to the HyD and copy them to the GEO concurrently at monthly intervals or more frequently.

9. Furthermore, in the T5 Reports, the building settlement monitoring results were compared with a set of AAA Levels[7] due to D-wall construction. It was also acknowledged in the T5 Reports that the *Alarm Level* of building settlement had been exceeded since June 2013. The EA Team could not find any documentary records about why the monitoring results of building settlement were dealt with in this manner in the T5 Reports. MTRCL explained that, at the time, building tilting was considered the relevant criterion to be adopted for building-related monitoring and control, and that the monitoring results on building settlement were presented for reference only.

Predetermined Action Plan of May 2014

10. Following the commencement of the Eastern D-wall construction, notable settlements[8] were recorded. As a provision for enhancing the monitoring and control system for D-wall construction, MTRCL formulated the "*Predetermined Action Plan*"[9] ("PAP"), which was accepted by HyD in May 2014.

11. In the PAP, buildings in the vicinity of TKW were categorized into four classes. Each class of buildings was assigned a specific set of AAA Levels of building settlement due to D-wall construction. The PAP also stipulated the required response actions in case of exceedance of the AAA Levels on building settlement, e.g. carrying out site inspections and raising the slurry level[10]. However, suspension of construction activities was not specified as a required response action, even in the event of exceedance of the *Alarm Level* on building settlement.

12. No changes were made in the PAP to the requirement for suspension of works in the event of exceedance of the *Alarm Level* of

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[7] The AAA Levels on building settlement due to D-wall construction given in the T5 Reports are as follows: *Alert Level* of 6 mm, *Action Leve*l of 8 mm, and *Alarm Level* of 10 mm.

[8] These included the exceedance of the *Alarm Level* of ground settlement at the Monitoring Point No. G141A at the southern end of TKW since August 2013, during construction of the Eastern D-wall.

[9] The accepted drawing entitled "General Notes - AAA Action Plan" under the submission "Proposal for Additional Instrumentation and Monitoring Points for Diaphragm Wall Construction at Western Side of To Kwa Wan Station" was denoted by MTRCL as "*Predetermined Action Plan*".

[10] The slurry was used in supporting the excavated trench of the D-wall prior to concreting.

ground settlement, utility settlement, utility angular distortion, groundwater drawdown and building tilting. Also, no changes were made to the AAA Levels of ground settlement, utility settlement, utility angular distortion, groundwater drawdown and building tilting stipulated in accepted drawing of January 2013.

13. In summary, the principal change made by the PAP to the monitoring and control system was the inclusion of building settlement due to D-wall construction in the AAA criteria.

Specific Action Plan of August 2015

14. Due apparently to the sustained concern about construction-induced settlements at the site, MTRCL formulated the "*Specific Action Plan*" ("SAP"), which augmented the PAP, to further enhance the monitoring and control system for bulk excavation. The SAP was accepted by HyD in August 2015. At that time, construction of the D-wall was completed.

15. In the SAP, the AAA Levels of building settlement and building tilting in the vicinity of the site, together with the required response actions in the events of their exceedance, were refined. Consequentially, the AAA Levels on building settlement were revised. However, suspension of works in the event of exceedance of the *Alarm Level* of building settlement was not stipulated.

16. While the SAP was accepted by HyD in consultation with GEO, there appeared to be an unresolved view about the lack of inclusion of suspension of works as a response action. In its reply to HyD on the SAP, the GEO commented that, for the vulnerable buildings identified, an additional set of control level on building settlement which called for cessation of works as a response action in the event of exceedance should be proposed. This comment was transmitted to MTRCL by HyD in August 2015. MTRCL had provided its response on 4 November 2015, advising that "*the ultimate allowable tolerance of individual building will be at 1:500*". However, GEO considered the additional set of control level on building settlement should be proposed. A reminder on this was made by HyD to MTRCL in December 2015. There were no records of any follow-up action taken to further address this comment.

17. In summary, the SAP resembled an updated version of the PAP, with the AAA Levels of building settlement and building tilting revised. No changes were made in the SAP to the requirement for suspension of works in the event of exceedance of the *Alarm Level* of ground settlement, utility settlement, utility angular distortion, groundwater drawdown and building tilting. Also, no changes were made to the AAA Levels of ground settlement, utility settlement, utility angular distortion, and groundwater drawdown stipulated in drawing originally accepted in January 2013. Despite GEO's comment, suspension of works was not specified as a response action in the event of exceedance of the *Alarm Level* of building settlement.

Revision of AAA Levels in late 2018

18. No further changes to the monitoring and control system, nor to the AAA Levels, were made until substantial completion of the station structure construction in mid-2017.

19. In late 2018, in connection with and prior to the implementation of the *Enhanced Mechanism*, a revised set of AAA Levels on building settlement in TKW was proposed by MTRCL and accepted by HyD. The revised set of AAA Levels replaced those stipulated in the SAP for selected buildings where the *Alarm Level* of building settlement had been exceeded for some time. Only minor outstanding works, e.g. shallow excavation and cutting down of the top part of the D-wall, yet to be carried out at the time were subject to these revised AAA Levels. These revised AAA Levels were unrelated to the bulk excavation and construction of station structure at TKW. Hence, they were not considered in the settlement audit.

Incidents of Exceedance of Alarm Level

20. Six monitoring points in the vicinity of TKW were selected for audit. These selected monitoring points and their applicable *Alarm Levels* are listed in ***Table 9-2-2***. Monitoring Points No. G506, 11202/SCL-DH060SP and 1623/B171A are located on the western side of Ma Tau Wai Road, i.e. near the Western D-wall. Monitoring Points No. G128, U125 and 1673/B166A are located on the eastern side of Ma Tau Wai Road, i.e. near the Eastern D-wall.

Table 9-2-2 Selected monitoring points and applicable Alarm Levels

Monitoring Point No.	Type	Alarm Level (applicable period)
G506	Ground settlement	10 mm due to D-wall construction (from Jan 2013 onwards)
		25 mm due to all works (from Jan 2013 onwards)
G128	Ground settlement	10 mm due to D-wall construction (from Jan 2013 onwards)
		25 mm due to all works (from Jan 2013 onwards)
U125	Utility settlement	25 mm due to all works (from Jan 2013 onwards)
11202/SCL-DH060SP	Groundwater level	6.4 mPD, i.e. corresponding to 1 m drawdown from the lowest historical groundwater level, for all works (from Jan 2013 onwards)
1623/B171A	Building settlement[11]	15 mm due to D-wall construction[12] (from May 2014 onwards)
		49 mm due to all works[13] (from Aug 2015 onwards)
1673/B166A	Building settlement[11]	47 mm due to all works[14] (from Aug 2015 onwards)

[11] Prior to the introduction of the PAP and SAP, an *Alarm Level* of 10 mm for building settlement due to D-wall construction was adopted in the T5 Reports from January 2013 to April 2014. However, this was not part of the accepted AAA criteria (*see paragraphs 8* and *9 in this Appendix*).

[12] This *Alarm Level* was included under the PAP of May 2014. It applied to the cumulative settlement due to the construction of both the Eastern D-wall and Western D-wall. The Eastern D-wall was substantially completed at the time.

[13] This *Alarm Level* was included under the SAP of August 2015. It applied to the cumulative settlement due to all works, which was inclusive of that due to D-wall construction.

[14] This *Alarm Level* was included under the SAP of August 2015. Unlike in the case of Monitoring Point No. 1623/B171A, no *Alarm Level* of building settlement due to D-wall construction was set here probably because Monitoring Point No. 1673/B166A was located on the other side of Ma Tau Wai Road at some distance from the Western D-wall, which was being constructed at the time. The Eastern D-wall, which adjoined Monitoring Point No. 1673/B166A, was substantially constructed when the SAP were introduced.

21. The available records indicated that regular monitoring was conducted on the selected monitoring points as stipulated in the monitoring plan, and that the monitoring results were presented in the monthly T5 Reports. The T5 Reports were submitted by MTRCL to HyD and copied to GEO concurrently.

Table 9-2-3 Incidents of exceedance of Alarm Level at the selected monitoring points

Incident No.	Date	Monitoring Point No.	Type	Alarm Level
1	Nov 2013	G128	Ground settlement	10 mm due to D-wall construction
2	Jun 2014	G506	Ground settlement	10 mm due to D-wall construction
3	July 2014	1623/B171A	Building settlement	15 mm due to D-wall construction
4	July 2015	G506	Ground settlement	25 mm due to all works
5	Nov 2015	U125	Utility settlement	25 mm due to all works
6	Nov 2015	11202/SCL-DH060SP	Groundwater drawdown	6.4 mPD, i.e. 1 m groundwater drawdown, due to all works
7	Jan 2016	G128	Ground settlement	25 mm due to all works
8	June 2016	1673/B166A	Building settlement[15]	47 mm due to all works
9	Jan 2017	1623/B171A	Building settlement	49 mm due to all works

[15] T5 Reports indicated that the *Alarm Level* of building settlement (10 mm) due to D-wall construction was exceeded at the Monitoring Point No. B166A as early as in June 2013. However, the EA Team did not take this as an incident of exceedance of *Alarm Level,* in view that building settlement was not formally included as part of the AAA criteria in the accepted drawing of January 2013. See *paragraphs 8* and *9 in this Appendix*.

22. The *Alarm Levels* were exceeded in nine occasions at the selected monitoring points during the construction period. These incidents are listed in ***Table 9-2-3.***

23. While the *Alarm Levels* of ground settlement, utility settlement, building settlement and groundwater drawdown had been exceeded notably at TKW, there were no records of exceedance of the *Alarm Level* of building tilting throughout the construction period.

Construction Activities Related to the Exceedance Incidents

24. The sequence of the main construction activities relating to the nine incidents of exceedance of *Alarm Level* is summarized in ***Table 9-2-4***.

Table 9-2-4 Exceedance of Alarm Level and the related construction works

Period	Construction Works	Incident No.
January 2013 to May 2014	**Construction of the Eastern D-wall** From January to April 2014, grouting was carried out in selected areas for controlling building settlement that might be caused by the Western D-wall construction.	**1** – Exceedance of the *Alarm Level* (10 mm ground settlement due to D-wall construction) at Monitoring Point No. G128 in November 2013
March 2014 to January 2015	**Construction of the Western D-wall** In September 2014, additional grouting works were carried out at the fronting of the relevant buildings.	**2** – Exceedance of the *Alarm Level* (10 mm ground settlement due to D-wall construction) at Monitoring Point No. G506 in June 2014 **3** – Exceedance of the *Alarm Level* (15 mm building settlement due to D-wall construction) at Monitoring Point No. 1623/B171A in July 2014

Period	Construction Works	Incident No.
February 2015 to March 2017	**Bulk excavation and construction of major station structure** In May 2015, additional grouting works were carried out in the vicinity of the relevant buildings. From December 2015 to April 2016, additional recharge wells were installed for controlling drawdown of groundwater levels. Bulk excavation was completed by December 2016.	**4** – Exceedance of the *Alarm Level* (25 mm ground settlement) at Monitoring Point No. G506 in July 2015 **5** – Exceedance of the *Alarm Level* (25 mm utility settlement) at Monitoring Point U125 in November 2015 **6** – Exceedance of the *Alarm Level* (1 m groundwater drawdown) at Monitoring Point No. 11202/SCL-DH060SP in November 2015 **7** – Exceedance of the *Alarm Level* (25 mm ground settlement) at Monitoring Point No. G128 in January 2016 **8** – Exceedance of the *Alarm Level* (47 mm building settlement) at Monitoring Point No. 1673/B166A in June 2016 **9** – Exceedance of the *Alarm Level* (49 mm building settlement) at Monitoring Point No. 1623/B171A in January 2017

25. For the six selected monitoring points on ground settlement, utility settlement, groundwater drawdown and building settlement, the development of the recorded settlement or groundwater drawdown with time has been examined. All the monitoring points exhibit a notable trend of increasing settlement or groundwater drawdown with time as the construction works proceeded. For example, the typical trend may be illustrated by the timelines of the recorded ground settlement at Monitoring Point No. G506 and groundwater drawdown at Monitoring

Point No. 11202/SCL-DH060SP shown in ***Figures 9-2-3*** and ***9-2-4***, respectively.

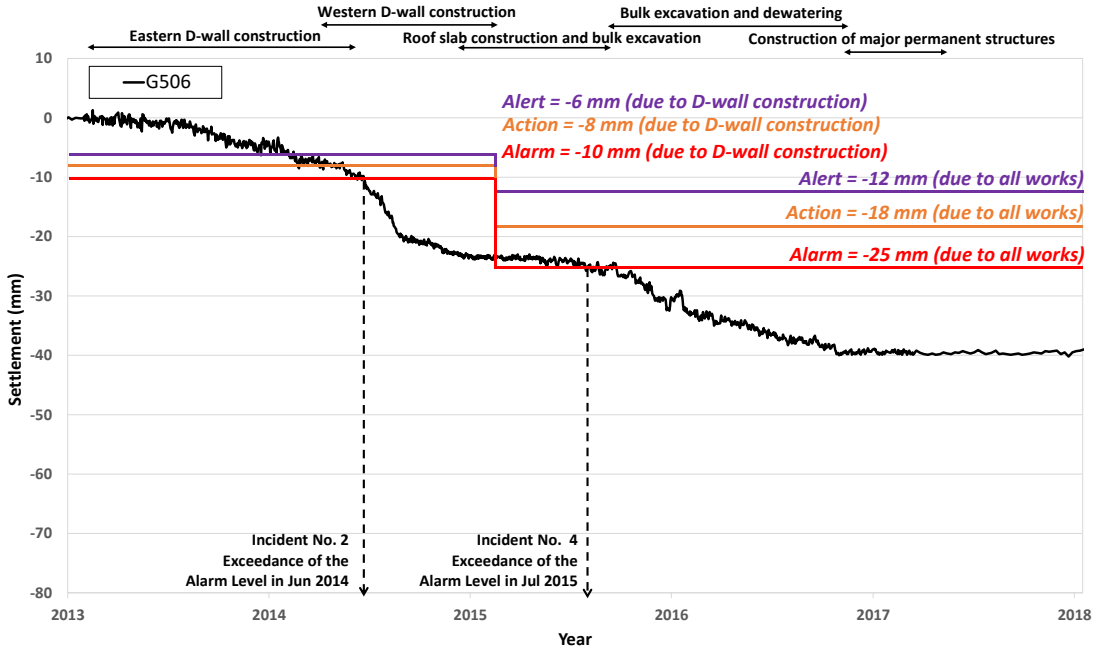

Figure 9-2-3 Ground settlement at Monitoring Point No. G506

(Source: Data provided by MTRCL)

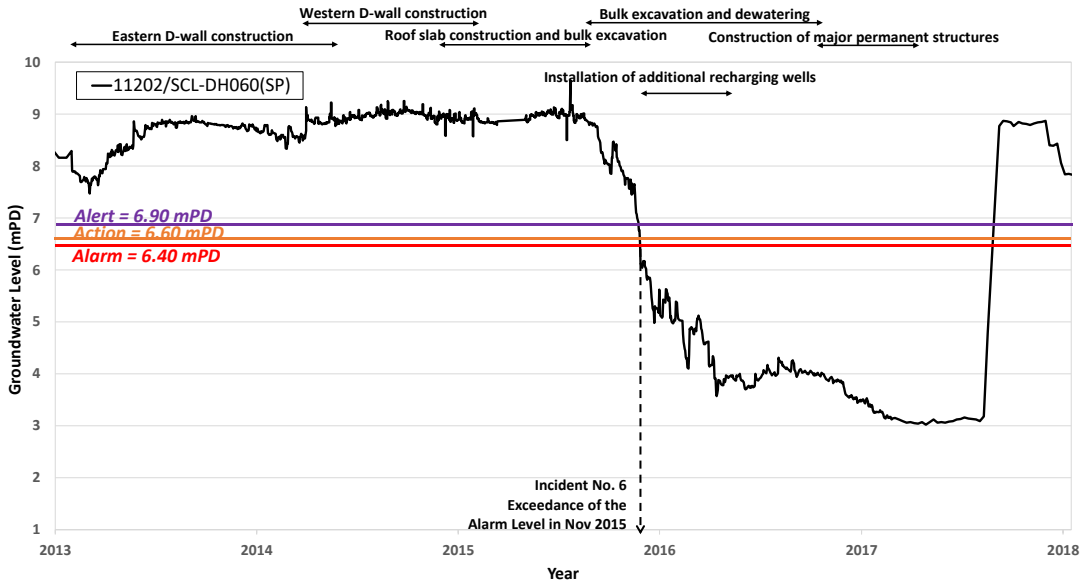

Figure 9-2-4 Groundwater level at Monitoring Point No. 11202/SCL-DH060SP

(Source: Data provided by MTRCL)

Spatial Extent of Exceedance

26. The spatial extent of the exceedance of the *Alarm Level* was appraised by checking the distribution of the relevant monitoring points in TKW where the *Alarm Level* was exceeded, in the following three time slots:

(a) February 2014 – when the Eastern D-wall was substantially completed, and after occurrence of Incident No. 1 (in November 2013) in the vicinity of the Eastern D-wall;

(b) September 2014 – when the Western D-wall was under construction, and shortly after occurrence of Incident No. 2 (in June 2014) and Incident No. 3 (in July 2014) in the vicinity of the Western D-wall; and

(c) March 2017 – at an advanced stage of bulk excavation and construction of major station structure, and after implementation of the SAP (in August 2015), and after occurrence of Incidents No. 4 to 9 (from July 2015 to January 2017).

February 2014

27. In February 2014, the *Alarm Level* of ground settlement was exceeded in a total of 12 monitoring points on the eastern side of the site in the vicinity of the Eastern D-wall. At this time, many other monitoring points on ground settlement, including points on the western side of the site adjoining the Western D-wall which would next be constructed at the time, also recorded the exceedance of either the *Alert Level* or *Action Level*.

28. The monitoring points which recorded the exceedance of the *Alarm Level* formed apparent clusters, which involved a considerable spatial extent. This implied that the exceedance of the *Alarm Level* of ground settlement at the time covered a sizeable area, and was not confined to the selected Monitoring Point No. G128 (i.e. Incident No. 1).

29. The distribution of the monitoring points with exceedance of the *Alarm Level* also suggested an apparent relationship, both spatially and temporally, between the recorded settlement and the Eastern D-wall construction.

30. The recorded exceedance of the *Alert Level* and *Action Level* at the ground settlement monitoring points on the western side of the site was notable. These monitoring points revealed that the ground on the western side of the site might be responding, in terms of settlement, to the effects of the construction of the Eastern D-wall despite they were at some distance from the Eastern D-wall. This in turn suggested the possibility of more serious ground settlement that might arise when the Western D-wall was next to be constructed in their close proximity. In EA Team's opinion, this is a vivid illustration of the intended purpose of the AAA mechanism in continuously tracking the effects of construction works on the nearby facilities, so that the required control and mitigation actions are timely taken. The effectiveness in achieving this purpose hinges not only on duly carrying out the monitoring, but also on implementing the required response actions following the AAA mechanism.

September 2014

31. By September 2014, the Eastern D-wall was completed and construction of the Western D-wall was in progress. Incidents No. 2 (exceedance of ground settlement *Alarm Level* of 10 mm in June 2014) and No. 3 (exceedance of building settlement *Alarm Level* of 15 mm in July 2014) had occurred.

32. At this time, the *Alarm Level* of ground settlement (10 mm due to D-wall construction) was exceeded at most of the monitoring points throughout a 250 m strip of the ground adjoining the Western D-wall. On the eastern side of the site, the spatial extent of exceedance of *Alarm Level* of ground settlement had also enlarged, in comparison with that in February 2014 before the construction of the Western D-wall.

33. The spatial distribution of the exceedance of the *Alarm Level* of building settlement due to D-wall construction in September 2014 has

also been examined. This *Alarm Level* was introduced in the PAP in May 2014. By September 2014, it was exceeded at 14 settlement monitoring points at the buildings adjoining the Western D-wall.

34. The PAP did not stipulate the application of this *Alarm Level* to buildings that adjoined the eastern side of the site. Had the *Alarm Level* been adopted also for these buildings, it would have been exceeded at some of the buildings.

March 2017

35. By March 2017, the bulk excavation and dewatering works had been carried out for some time. Incidents No. 4 to 9 (from July 2015 to January 2017) had occurred. These involved the exceedance of different types of *Alarm Levels*, including 25 mm ground settlement, 25 mm utility settlement, 1 m drawdown of groundwater level, and the limits of building settlement stipulated in the SAP.

36. At this time, the applicable *Alarm Level* of ground settlement was 25 mm, which replaced the previous value of 10 mm due to D-wall construction. Despite this change, the spatial extent of exceedance had significantly enlarged, in comparison with that in September 2014 before the bulk excavation and dewatering works. This is due to the substantial increase in the magnitude of the recorded ground settlements. The profound effect of the bulk excavation and dewatering works on ground settlement was apparent.

37. In comparison with that in September 2014, the spatial extent of exceedance of the *Alarm Level* of building settlement is similar although the magnitude of the recorded building settlements had increased considerably. This is due to the relaxation of the *Alarm Level* of building settlement introduced by the SAP of August 2015.

38. Notwithstanding this, the exceedance of the building settlement Alarm Level formed apparent clusters, which involved a considerable spatial extent by that time.

Other Response Actions on Exceedance of Alarm Level

39. The available records and supplementary information provided by MTRCL indicated that the response actions stipulated in the AAA mechanism were generally undertaken by MTRCL in the various incidents of exceedance of the *Alarm Levels*. These included the response actions stipulated in the accepted drawing of January 2013 and those given in the PAP of May 2014 and the SAP of August 2015 (which replaced the PAP). A notable exception to this was suspension of works, which will be discussed in *paragraphs 42* to *50* below.

40. As far as precautionary and mitigation works are concerned, these were typically carried out on site according to the AAA mechanism. The EA Team was aware of the effort made by MTRCL and the relevant Government departments in such follow-up actions as conducting reviews, preparing the PAP and SAP for enhancing the monitoring and control of building tilting and settlement, increasing the frequency of monitoring, carrying out ground treatment, inspecting buildings for confirmation of structural safety, ensuring road safety via inspections and repairing pavements when found necessary, and liaising with the affected parties. The response actions undertaken in these aspects in TKW were comparable to those which would normally be provided in other sites of similar complexity.

41. The EA Team did not conduct an in-depth diagnosis of the causes of the recorded settlements and their inter-relationship with the construction works and with the suspected damage. It was outside the scope of this audit to evaluate the adequacy and effectiveness of the precautionary and mitigation works that were implemented. However, the EA Team found no cause to doubt that due attention was given by MTRCL and the relevant departments at the time in attending to and ensuring structural safety at TKW.

Suspension of Works on Exceedance of Alarm Level

42. Among the required response actions in the event of exceedance of the *Alarm Level*, a distinct item regarding suspension of all construction activities within 50 m of the monitoring point which recorded the exceedance (see *paragraph 7* of this Appendix) was not complied with.

43. For Incidents No. 1, 2, 4, 5, 6 and 7 (see ***Table 9-2-3***)[16], which involved exceedance of the *Alarm Level* of ground settlement, utility settlement and groundwater drawdown, suspension of the construction activities in the vicinity of the monitoring point was stipulated in the accepted drawing of January 2013. However, in none of these six incidents were the relevant construction activities suspended. There were also no records showing that the Engineer had given any written instruction to the Contractor for the works to be resumed, as stipulated in the accepted drawing in the event of the works having been suspended upon the exceedance of the *Alarm Level*. MTRCL acknowledged that the relevant construction activities were not suspended in the incidents.

44. The EA Team considered this an important deviation from the requirements of the AAA mechanism during the implementation of the accepted monitoring and control system.

Breakdown of AAA mechanism after exceedance of Alarm Level

45. The lack of suspension of works after the exceedance of the Alarm Level has another adverse implication, which is noteworthy.

46. When the *Alarm Level* is exceeded, and if the AAA Levels are not timely revised and agreed, continuation with the construction works without suspension will imply that such works will be carried out without an applicable AAA mechanism. Since the *Alarm Level* is the maximum limit of control in the AAA mechanism, exceedance of the *Alarm Level* would, effectively, break down the existing AAA mechanism. Even

[16] For Incidents No. 3, 8 and 9, which involved exceedance of the *Alarm Level* of building settlement, no requirement for suspension of construction activities was stipulated in the PAP and SAP. Although the relevant construction activities were not suspended in these three incidents, this did not contravene the accepted AAA mechanism.

though the ongoing works are continually to be monitored after exceedance of the *Alarm Level*, no provisions are available in the existing AAA mechanism specifying the required response actions for controlling the works, given that the worst level (i.e. *Alarm Level*) under the existing AAA mechanism has already been breached.

47. Suspension of works is an obvious example. If suspension of works in the event of exceedance of the *Alarm Level* (say, 25 mm ground settlement) is stipulated in the AAA mechanism, the works should have been suspended after the exceedance. If the works continue without suspension and when the original *Alarm Level* becomes more and more seriously exceeded (say, ground settlement increases to 40 mm), how will the works be controlled? Who is to decide under what other circumstances the works should be suspended? Who is to decide whether the precautionary and mitigation measures stipulated in the existing AAA mechanism remain adequate to cater for the ongoing works? Without the revised and accepted set of AAA criteria in place, the ongoing works will, in practice, be carried out without subjection to the control of an applicable and accepted AAA mechanism. In EA Team's view, this deviates from the established good practice of the monitoring and control system.

48. The ongoing works which were continued to be undertaken in TKW at the time of each of the nine incidents of exceedance of the *Alarm Level* are listed in ***Table 9-2-5***. These "ongoing works" were the construction activities in the vicinity of the respective monitoring point at the time of the exceedance of the *Alarm Level*. By the nature of these works, it is known that they might result in adverse impacts on the nearby facilities. Hence, they were required to be monitored and controlled under the AAA mechanism. Information is also given in ***Table 9-2-5*** on whether or not the AAA Levels in each of the incidents had been revised and accepted, after the exceedance of the *Alarm Level*.

Table 9-2-5 Ongoing works after exceedance of Alarm Level

Incident No. (Date)	Alarm Level exceeded	Ongoing works (i.e. not suspended) after exceedance	Acceptance of revised AAA Levels, if any
1 (Nov 2013)	**10 mm ground settlement** due to D-wall construction	D-wall construction	Nil (up to completion of D-wall construction in about Jan 2015)
2 (Jun 2014)	**10 mm ground settlement** due to D-wall construction	D-wall construction	
3 (Jul 2014)	**15 mm building settlement** due to D-wall construction	D-wall construction	Nil (up to completion of D-wall construction in about Jan 2015). However, a revised set of AAA Levels of building settlement under the SAP was accepted in August 2015.
4 (Jul 2015)	**25 mm ground settlement**	Bulk excavation and dewatering	Nil (up to completion of bulk excavation in Dec 2016 and dewatering works)
5 (Nov 2015)	**25 mm utility settlement**	Bulk excavation and dewatering	
6 (Nov 2015)	**1 m groundwater drawdown**, i.e. groundwater level at 6.4 mPD	Bulk excavation and dewatering	
7 (Jan 2016)	**25 mm ground settlement**	Bulk excavation and dewatering	
8 (Jun 2016)	**47 mm building settlement**	Bulk excavation and dewatering	
9 (Jan 2017)	**49 mm building settlement**	Station internal structure and dewatering	

49. It can be seen that in all of the nine incidents of exceedance of the *Alarm Level*, the relevant AAA Levels which had been exceeded were neither revised nor accepted for the remaining period of the works. For Incident No. 3, a revised set of AAA Levels of building settlement was specified and accepted as part of SAP, but this revised set of AAA Levels was not for application to D-wall construction. In fact, when the SAP was introduced, D-wall construction had already been substantially completed.

50. Hence, in all the nine incidents of exceedance of the *Alarm Level*, the relevant construction works had continued to proceed for a considerable time until their completion, but without a revised and accepted AAA Levels in place.

Follow-up actions by the relevant Government departments

51. The available information indicated that, in the nine incidents, HyD and GEO were aware of the exceedance of the *Alarm Level* at the time. The EA Team obtained the following responses from HyD and GEO regarding their follow-up actions taken.

52. HyD advised that:

> *"RDO noted the exceedance in AAA values during the construction period and kept reviewing and monitoring the situation. Some precautionary measures and remedial works were carried out by MTRCL/Contractor. e.g. increase the frequency of monitoring and submit monitoring report to RDO/BO Team, ground treatment works, modification of ELS design. RDO had kept monitoring the AAA level of sensitive receivers and weekly update of AAA summary provided by MTRCL. Pending the update of the AAA values, various actions were taken during these periods and the situation was under close monitoring. During these periods, RDO proactively liaised with MTRCL for review of the proposed action plans (e.g. meetings with MTRCL/RDO/GEO on 22.4.2015 and 29.4.2015*

regarding the Specific Action Plan, which was subsequently submitted on 30.6.2015) the related ELS/ground treatment consultation submissions, reviewed allowable settlement, etc.

RDO/BO Team also requested the CP to take corresponding actions in accordance with the Specific Action Plans in case AAA response value exceeded as stipulated in the reply letters for monthly RGE's T5 reports."

53. GEO advised that:

"GEO issued reminders to RDO from time to time to request the CP/RGE to undertake appropriate actions as per the monitoring plans; to review, investigate and carry out mitigation measures as per the monitoring plans; to investigate the possible causes of the undue settlement; and review the Contractor's construction method and implement necessary preventive and mitigation measures to arrest further settlement. Please also be advised that without any statutory or contractual role, GEO only plays an advisory role to BO Team/RDO, including comments on ELS design, ground movement analysis, site supervision reports & observed site irregularities and it is up to BO Team/RDO to decide how to implement GEO comments and advice. GEO does not monitor how BO Team/RDO to exercise their statutory or contractual role."

54. Furthermore, the EA Team had also received the following responses from BD regarding their role in the incidents:

"Please be advised TKW is located at unleased land which falls within the control mechanism stipulated in the IoC issued by HyD. BD has no statutory role to play in respect of the works at TKW. However, in response to reports concerning the safety of private buildings affected by the construction works at TKW, BD will deploy staff to inspect

the buildings in question and make referral to HyD and MTRCL for follow-up in parallel. BD will, according to the structural safety condition of the buildings inspected, take appropriate follow-up action on building safety issues in accordance with the BO. In fact, in response to the incident of exceedance of highest pre-set trigger level of settlement at the TKW site in August 2018, BD inspected the affected buildings nearby and no obvious structural safety problem was found."

Audits by M&V Consultant of HyD

55. HyD's M&V consultant was tasked to conduct public safety audit of the works of TKW once every year. HyD advised that *"the audit covered MTRCL's compliance to [with] the procedures on monitoring key risk elements with public safety implications such as settlement due to construction works"*. The scope of audit was described in the consultant's audit reports as follows *"The audit consists of Process Compliance and Technical Compliance on public safety related issues of Contract 1109 [which covered the TKW site]"*. It was also indicated in the audit reports that, under the category of *"Technical Compliance"*, *"Review of procedures when instrumentation recorded exceedance of the AAA values"* was one of the items to be audited. Any non-conformances identified, among other findings, were included in the audit reports[17].

56. From 2014 to 2017, i.e. during the period of occurrence of the six incidents of exceedance of the *Alarm Level* which required suspension of works, the non-conformance with this requirement in none of the six incidents was reported by the consultant in the audit reports. Instead, the following findings were stated in the June 2014 and June 2015 reports: *"When an exceedance of the AAA Level occurred, the procedures as per MTRCL Procedures had been followed"*. In the May 2016 and May 2017 reports, it was stated *"When an exceedance of the AAA Level occurred, the procedures as stated in the PS [Particular Specifications] and construction drawings had been followed"*.

[17] Entitled "Public Safety Audit for SCL Works – SCL Contract 1109 Sung Wong Toi and To Kwa Wan Station and Tunnels".

57. It is apparent that the consultant's audits were ineffective in identifying the non-compliance with the requirement for suspension of works after exceedance of the *Alarm Level.* Furthermore, the EA Team was concerned that the audits might have given a misleading assurance that there was no non-conformance in this respect.

Audit by MTRCL

58. Regular internal audits were conducted by MTRCL on the site works. However, MTRCL advised that, over the period when the incidents of exceedance of *Alarm Level* occurred in the audited sites, *"there were internal audits but no touching on AAA exceedance"*.

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Appendix 9-3

Findings of Settlement Audit at Exhibition Centre Station

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Appendix 9-3

Findings of Settlement Audit at Exhibition Centre Station

The EXC Site

1. Under Works Contract 1123, large-scale underground excavation supported by earth retaining structures was carried out in the Exhibition Centre Station (EXC) site, for the construction of the station structure and the associated cut-and-cover western approach tunneling works. A plan showing the layout of the works under different contracts of the SCL Project in Wan Chai North is given in ***Figure 9-3-1***.

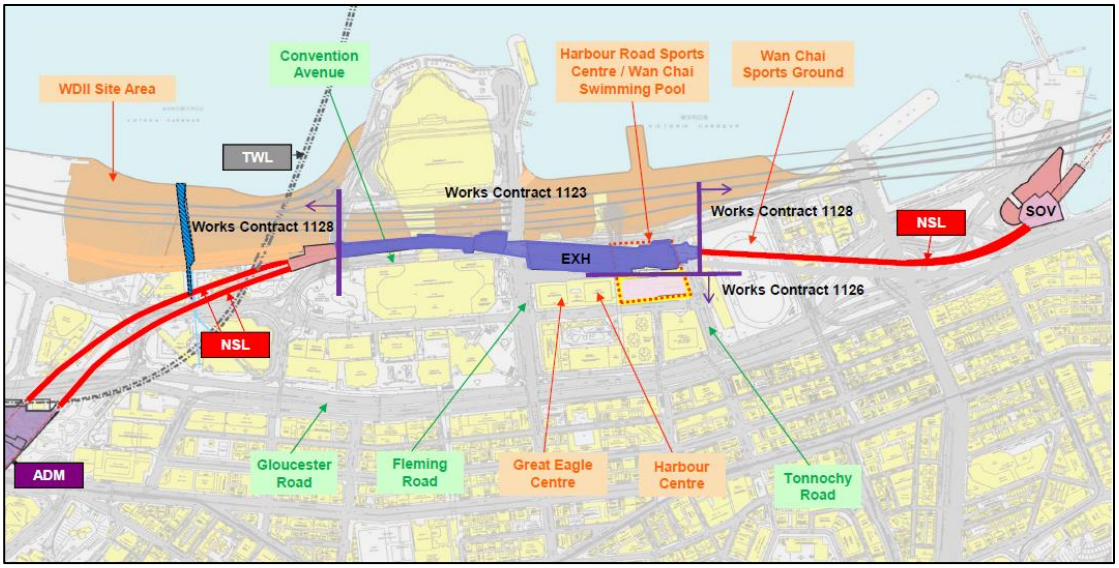


Figure 9-3-1 Layout of SCL works in Wan Chai North

(Source: Plan provided by MTRCL)

2. The layout plan of EXC is shown in ***Figure 9-3-2***. The 280 m long station structure was divided into Zone 1 to Zone 4 during construction. The associated section of the cut-and-cover tunnel, denoted as the Western Approach Tunnel (WAT), was about 320 m long. It encompassed Areas A, B, C1, C2 and E. There were concurrent construction activities in the area adjacent to EXC, e.g. the Wan Chai Development Phase II (WDII) managed by the Civil Engineering and Development Department.

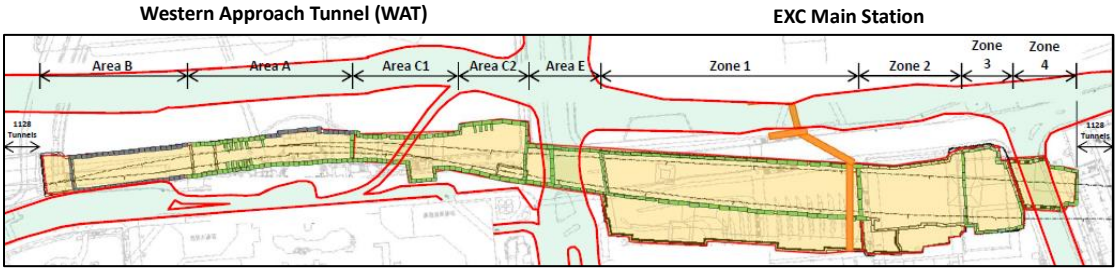
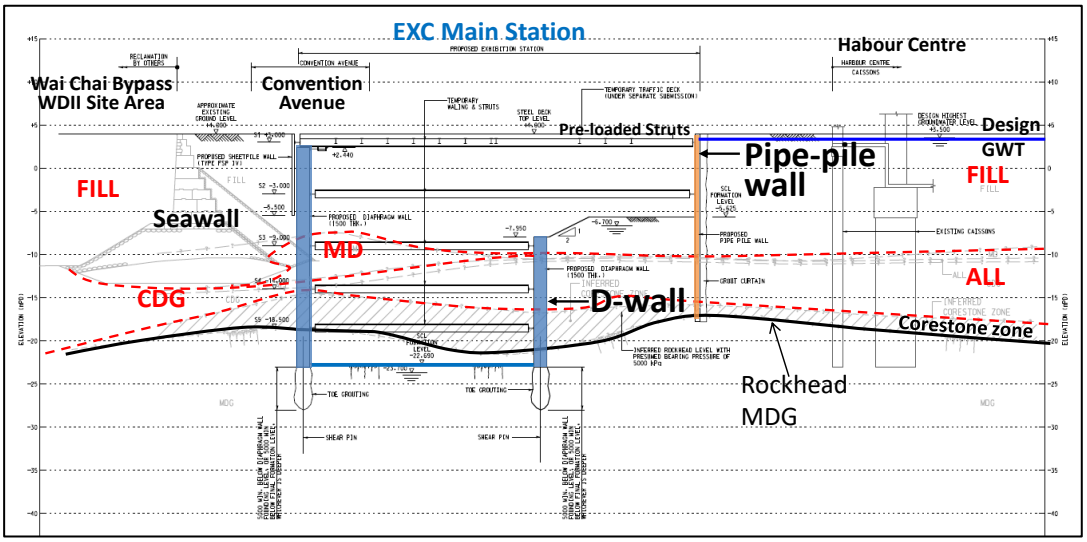


Figure 9-3-2 Layout plan of EXC

(Source: Plan provided by MTRCL)

3. The station structure is about 45 m wide, with a maximum excavation depth of about 32 m from the existing ground level for its construction. The WAT is about 18 m wide. Its construction involved a maximum excavation depth of about 30 m from the existing ground level. Both the station structure and WAT were constructed in a bottom-up manner.

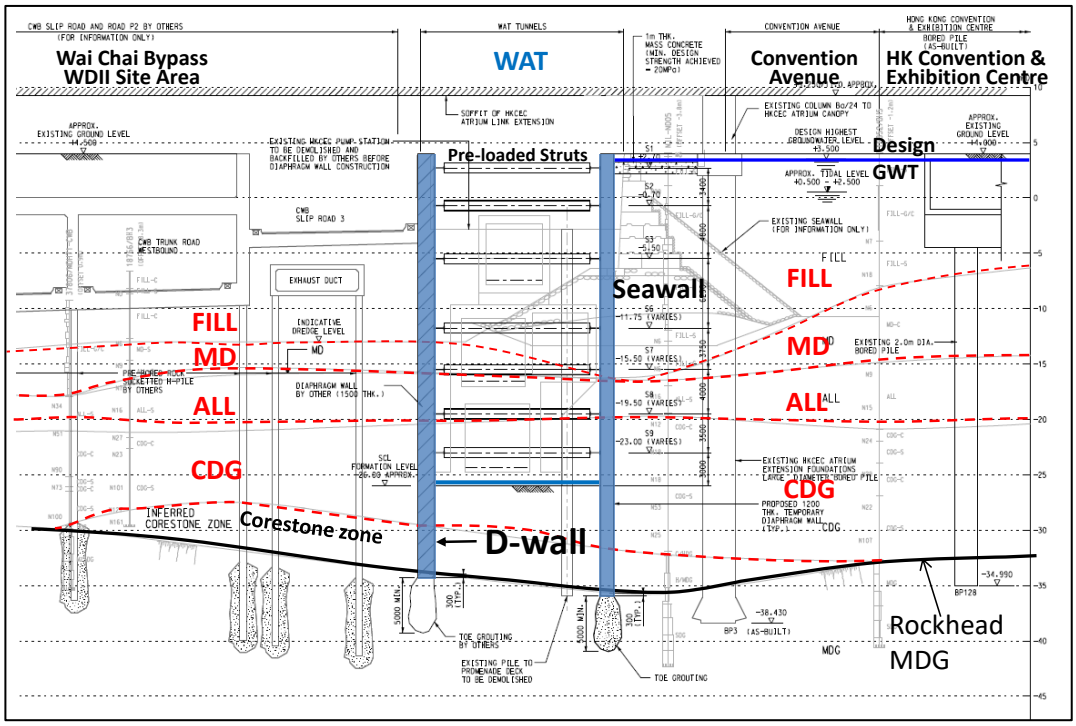
4. Typical cross-sections of the station structure and WAT are shown in ***Figure 9-3-3*** and ***Figure 9-3-4***, respectively.



Note: GWT is groundwater table, MD is marine deposits, ALL is alluvium, CDG is completely decomposed granite and MDG is moderately decomposed granite

Figure 9-3-3 Typical cross-section of excavation for construction of station structure

(Adopted from: Design submission provided by MTRCL)



Note: GWT is groundwater table, MD is marine deposits, ALL is alluvium, CDG is completely decomposed granite and MDG is moderately decomposed granite

Figure 9-3-4 Typical cross-section of excavation for construction of WAT

(Adopted from: Design submission provided by MTRCL)

5. The general sequence of the construction works was as follows:

(a) Stage 1 – construction of the earth retaining structures, viz. mainly D-wall and partly pipe-pile wall, alongside the boundary of the excavation;

(b) Stage 2 – bulk excavation of the ground to the final formation level, with installation of temporary steel struts for supporting the earth retaining structures; and

(c) Stage 3 - construction of the permanent station and tunnel structures in a bottom-up manner, removal of the temporary struts and backfilling.

6. As the works in Stages 2 and 3 were located below the perennial groundwater level[1] of the site, dewatering by pumping of water from the excavated area was required. On-site measures[2] for controlling the groundwater drawdown outside the bulk excavation area were provided.

7. As of August 2020, the bulk excavation works were completed and about 88% of the EXC station structure and 99% of WAT structure were constructed as reported by MTRCL.

Monitoring and Control System

8. The first adopted set of AAA Levels for EXC was specified in the drawing which was accepted by HyD in August 2015.[3] The *Alarm Levels*, in respect of building settlement, ground settlement, utility settlement, groundwater level, and building tilting, are shown in ***Table 9-3-1***.

9. In the relevant design submissions of MTRCL for EXC[4] and WAT[5], it was predicted that the ground settlements which would be induced by the works would be much greater than the *Alarm Level* of 25 mm specified in the accepted drawing. The predicted ground settlements at many of the monitoring points were assessed to be over 100 mm. This predicted level of settlement was neither proposed by MTRCL, nor agreed by HyD, at the time as an acceptable level of ground settlement.

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[1] At this site, the perennial groundwater level is at about 3.5 mPD. The final excavation level of EXC is generally about -22.7 mPD (except that the deepest excavation level for sump pit at Zone 3 is about -27.7 mPD), which is about 26 m below the perennial groundwater level. The final excavation level of WAT is generally about -26 mPD, which is also well below the perennial groundwater level.

[2] At the EXC site, the measures included grouting at the toe of the D-wall for reducing groundwater flow into the bulk excavation area and installation of recharge wells outside the bulk excavation area for replenishing the groundwater.

[3] Based on HyD's information, the first accepted drawing stipulating the monitoring plan was entitled "General Notes for Monitoring" dated 26 May 2015 (Drawing No. 1123/B/399/LCS/C06/301 Rev. A). This was accepted by HyD on 5 August 2015.

[4] See MTRCL Design Submission entitled "Exhibition Station (EXH) – Zone 1 Excavation and Lateral Support (ELS) Works Stage 1 & 2 Design Submission" dated June 2015.

[5] See MTRCL Design Submission entitled "West Approach Tunnel (WAT) – Area C2 Excavation and Lateral Support Works Stage 1" dated April 2016.

Table 9-3-1 Alarm Levels stipulated in the accepted drawing of August 2015 for EXC

Type	Construction activity	Alarm Level
Building settlement (for the "particular buildings"[6])	Due to construction of retaining wall	5 mm
	Cumulative for all works	10 mm
Building settlement (other than the "particular buildings")	Cumulative for all works	25 mm
Ground settlement[7]	Cumulative for all works	25 mm
Utility settlement	Cumulative for all works	25 mm
Groundwater drawdown from the lowest historical groundwater level	Cumulative for all works	1 m
Tilting of building (for the "particular buildings"[6])	Due to construction of retaining wall	1: 1000
	Cumulative for all works	1: 500
Tilting of building (other than the "particular buildings")	Cumulative for all works	1:500

10. In line with the normal practice, it was stipulated in the accepted drawing that suspension of the construction activities was required in the event of exceedance of the *Alarm Level*. The relevant requirement, which was stipulated in the accepted drawing, states as follows:

> *"On reaching the "Alarm Level", all construction activities within a minimum distance of 50 m radius of the instrument of where the Alarmed values was reached shall be suspended."*

[6] The "particular buildings" are buildings on piles founded on rock or sensitive buildings, as denoted in the "Instrumentation and Settlement Management Plan" of August 2015. Most of the buildings in the vicinity of EXC are on pile foundation, i.e. they are denoted as "particular buildings" in the Plan.

[7] Unlike in the case of the TKW site, the *Alarm Levels* of ground settlement adopted in the EXC site applied to the cumulative values from all the works, without further breakdown for the construction of retaining wall.

Before Implementation of Enhanced Mechanism

Incidents of exceedance of Alarm Level

11. Prior to September 2018 when the *Enhanced Mechanism* was implemented, no revisions were made on the AAA Levels specified in the accepted drawing of August 2015.

12. The majority of the buildings in the vicinity of EXC are supported by piles which are founded on rock. These buildings are less vulnerable to settlement which may be induced by the works. There were no reports of excessive settlement and tilting of buildings during the works, except that the *Alarm Level* of building settlement was exceeded at some structures with shallow foundations. However, these structures were either temporary or designated for demolition after the completion of the SCL Project. In view of the temporary nature of these structures, the EA Team did not include them in this settlement audit.

13. There were also no reports of excessive groundwater drawdown during the works. As EXC is in close proximity to the seafront, it is less susceptible to extensive groundwater drawdown due to the dewatering.

14. A total of seven monitoring points, on either ground settlement or utility settlement, in different parts of EXC and its adjacent area were selected for audit. These selected monitoring points and their applicable *Alarm Levels* are listed in ***Table 9-3-2***.

15. The available records indicated that regular monitoring was conducted on the selected monitoring points as stipulated in the monitoring plan, and that the monitoring results were presented in the monthly T5 Reports. The T5 Reports were submitted by MTRCL to HyD and copied to GEO concurrently.

16. The *Alarm Levels* specified in the applicable AAA criteria were exceeded at the seven selected monitoring points during the construction period. These incidents and the relevant construction works at that time of the exceedance are listed in ***Table 9-3-3***.

Table 9-3-2 Selected monitoring points and applicable Alarm Levels prior to September 2018[8]

Monitoring Point No. (Location)	Type	Alarm Level
1123-Z1-GSM-27, and its replacement 1123-Z1-GSM-27-A since June 2016 (Zone 1 of main station section)	Ground settlement	25 mm due to all works
1123-Z1-GSM-09-A (Zone 1 of main station section)	Ground settlement	25 mm due to all works
1123-Z2-GSM-14 (Zone 2 of main station section)	Ground settlement	25 mm due to all works
1123-Z3-GSM-02 (Zone 3 of main station section)	Ground settlement	25 mm due to all works
1123-AB-GSM-01 (Area B of WAT)	Ground settlement	25 mm due to all works
1123-AC-GSM(USM)-04 (Area C of WAT)	Ground settlement	25 mm due to all works
1123-AE-USM(FW)-02-A (at a fresh water main, Area C of WAT)	Utility settlement	25 mm due to all works

[8] This set of *Alarm Levels* was stipulated in the accepted drawing on 5 August 2015 and were applicable up to September 2018. In September 2018, some of the *Alarm Levels* were revised and accepted, for use after the resumption of the suspended works in connection with the implementation of the *Enhanced Mechanism*.

Table 9-3-3 Incidents of exceedance of Alarm Level at the selected monitoring points

Incident No.	Date	Monitoring Point No. (Location)	Type (Alarm Level)	Relevant Construction Works
1	Nov 2015	1123-Z1-GSM-27 (Zone 1 of EXC)	Ground settlement (25 mm)	D-wall and pipe-pile wall construction
2	Sept 2016	1123-Z3-GSM-02 (Zone 3 of EXC)	Ground settlement (25 mm)	D-wall construction
3	Jun 2017	1123-AB-GSM-01 (Area B of WAT)	Ground settlement (25 mm)	Bulk excavation and dewatering
4	Jul 2017	1123-AC-GSM(USM)-04 (Area C of WAT)	Ground settlement (25 mm)	Bulk excavation and dewatering
5	Jul 2017	1123-AE-USM(FW)-02-A (Area C of WAT)	Utility settlement (25 mm)	Bulk excavation and dewatering
6	Jan 2018	1123-Z1-GSM-09-A (Zone 1 of EXC)	Ground settlement (25 mm)	Bulk excavation and dewatering
7	May 2018	1123-Z2-GSM-14 (Zone 2 of EXC)	Ground settlement (25 mm)	Bulk excavation and dewatering

17. For the seven selected monitoring points on ground settlement and utility settlement, the development of the recorded settlement with time has been examined. All the monitoring points exhibit a notable trend of increasing settlement with time as the construction works proceeded. For example, the typical trend may be illustrated by the timelines of recorded ground settlement at Monitoring Point No. 1123-AB-GSM-01 and utility settlement at Monitoring Point No. 1123-AE-USM(FW)-02-A shown in ***Figures 9-3-5*** and ***9-3-6***, respectively.

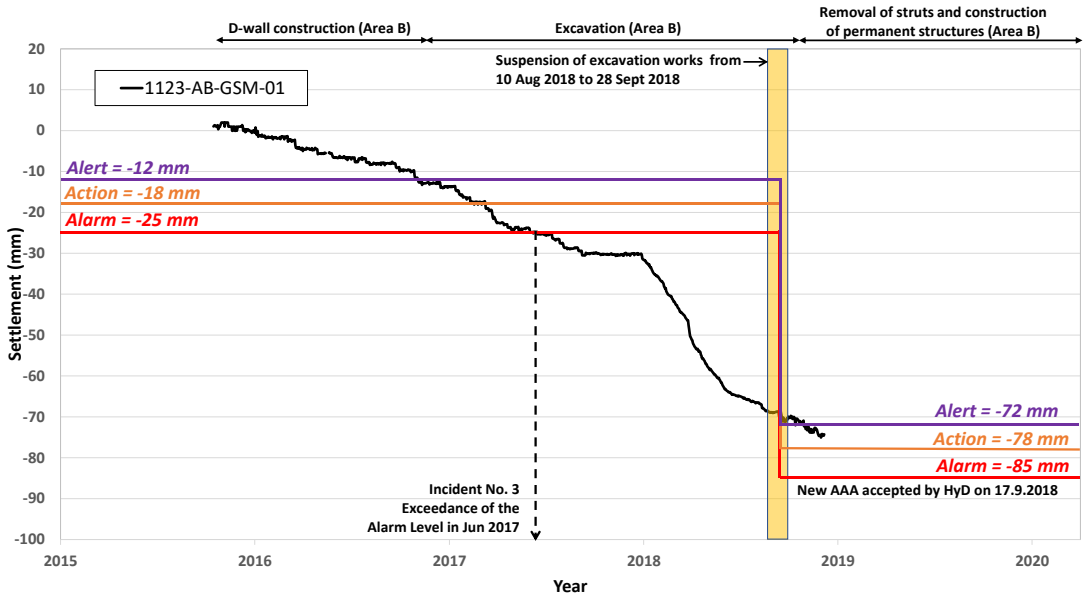

Figure 9-3-5 Ground settlement of Monitoring Point No. 1123-AB-GSM-01 (in Area B of WAT)

(Source: Data provided by MTRCL)

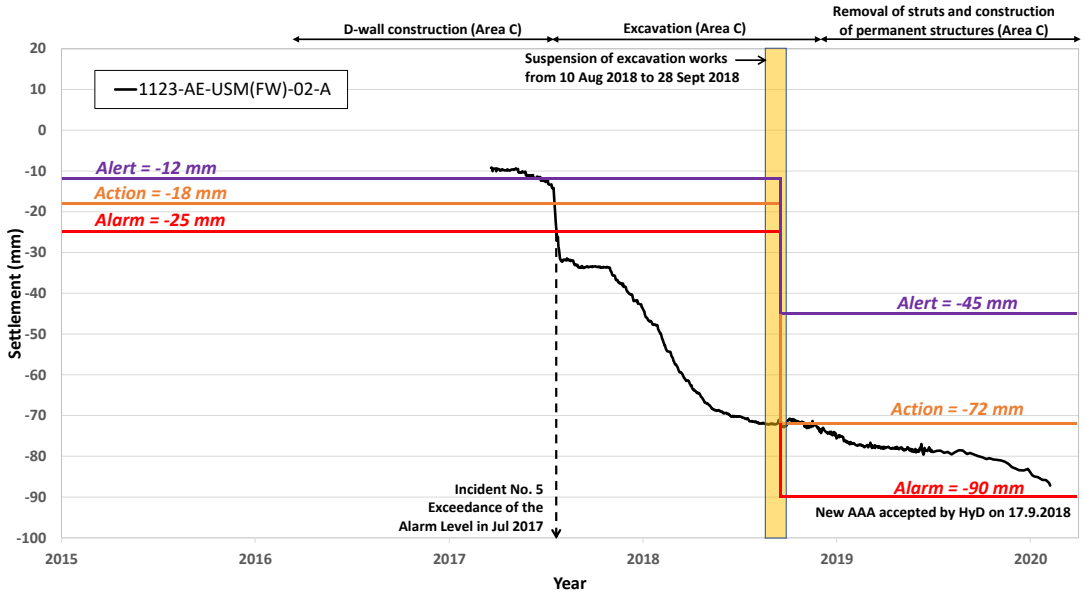

Figure 9-3-6 Utility settlement at Monitoring Point No. 1123-AE-USM(FW)-02-A (in Area C of WAT)

(Source: Data provided by MTRCL)

Spatial extent of exceedance

18. The spatial extent of the exceedance of the *Alarm Level* was appraised by checking the distribution of the relevant monitoring points of ground settlement in EXC where the AAA Levels were exceeded, in the following two time slots:

(a) May 2017 – when the D-wall construction works in Zone 1 and Zone 3 of EXC were about to complete[9], and after occurrence of Incidents No. 1 (in November 2015) and No. 2 (in September 2016), and

(b) August 2018 – at an advanced stage of bulk excavation after occurrence of Incidents No. 3 to No. 7, prior to the implementation of the *Enhanced Mechanism*.

May 2017

19. Notable ground settlement was recorded on Convention Avenue at the northern side of Zone 1, after the commencement of the D-wall construction. Incidents No. 1 and No. 2 occurred in November 2015 and September 2016, respectively. The D-wall construction works were continued without suspension until their completion, and the Alarm Level was also not revised.

20. In May 2017, a total of 10 monitoring points in the northern part of Zone 1, Zone 2 and Zone 3 had recorded ground settlement exceeding the *Alarm Level*. This indicates that the exceedance of the *Alarm Level* of ground settlement at the time covered a sizeable area, and was not confined to the two selected monitoring points involved in Incidents No. 1 and No. 2.

21. The ground settlement recorded at individual monitoring points adjoining the D-wall had recorded a lower ground settlement than the other monitoring points which were further away from the D-wall. For example, the recorded ground settlement at Monitoring Point No.

[9] The construction of the D-wall at Zone 1, Zone 2 and Zone 3 was completed in August 2017, February 2018 and May 2017, respectively.

1123-Z1-GSM-31A was 30 mm, and 83 mm was recorded at Monitoring Point No. 1123-Z1-GSM-12 located further to the north of Zone 1. This might be due to the difference in the ground conditions. There might also be the possibility that the observed ground settlement was partly due to other concurrent construction activities, apart from the D-wall construction. At that time, the concurrent construction activities in the vicinity included reclamation and excavation works under WDII and other works of SCL Contract 1123.

22. In the relevant T5 reports prepared at the time, it was noted that *"settlement possibly caused by combined effects from other contractors' reclamation & ELS works and also mini-pile work of SCL1123"*. However, further investigation had not been carried out to ascertain the significance of the effects, if any, of the concurrent construction activities on the observed settlement, nor was the monitoring and control plan updated to cater for such effects.

August 2018

23. The bulk excavation works commenced in November 2016, starting from Area B and then proceeding to other areas. The *Alarm Levels* at the other five selected monitoring points were exceeded in turn (see ***Table 9-3-3***). In all the incidents of exceedance, the relevant works (i.e. bulk excavation and dewatering) were continued without suspension. It was not until 10 August 2018 that the works were suspended. By that time, the settlement at a total of 49 monitoring points in EXC had exceeded the *Alarm Level*. These included 31 ground settlement and 18 utility settlement monitoring points.

24. The spatial distribution of the ground monitoring points with exceedance of *Alarm Level* as at August 2018 for WAT and EXC has been examined. The spatial extent of the exceedance of *Alarm Level* had enlarged, in comparison with that in May 2017 before the bulk excavation. It is evident that the exceedance of the *Alarm Level* at the time was not confined to the seven selected monitoring points, but covered a sizeable area.

25. The recorded ground settlement had increased substantially during the bulk excavation works (e.g. see ***Figures 9-3-5*** and ***9-3-6***), and consequentially a large number of monitoring points in many parts of the area had registered exceedance of the *Alarm Level*. There is an apparent relationship, both spatially and temporally, between the recorded settlement and the bulk excavation works. It was considered that the ground settlements recorded at the time were related to the bulk excavation with possible cumulative effects of the construction activities of other projects.

Response actions on exceedance of Alarm Level

26. The follow-up actions stipulated in the accepted drawing of August 2015 were generally undertaken by MTRCL in the various incidents of exceedance of the *Alarm Levels.* A notable exception to this was suspension of works, which is described in *paragraphs 28* to *30* below.

27. As far as precautionary and mitigation works are concerned, these were typically carried out on site according to the AAA mechanism. The EA Team was aware of the effort made by MTRCL and the relevant Government departments in such follow-up actions as conducting reviews and safety inspections, increasing the frequency of monitoring, and developing and implementing plans on mitigation measures in local areas, such as provision of additional support to utilities, ground improvement and repair of pavements.

Suspension of works on exceedance of Alarm Level

28. In all of the seven incidents of exceedance of the Alarm Level at the selected monitoring points, the construction activities (i.e. D-wall construction and bulk excavation) were not suspended. Instead, the works were continued for a considerable period of time without a revised and agreed set of AAA Levels in place. This was not in line with the accepted drawing, nor with the established good practice for monitoring and control in major underground construction works.

29. While acknowledging that, in the seven incidents, the construction works were continued without a revised and accepted set of AAA Levels in place, MTRCL noted that "*there were two occasions of local suspension after the exceedance of AAA Levels*".[10] Given the sizeable spatial extent of the exceedance of the Alarm Level, it is evident that the suspension of *"all construction activities within a minimum distance of 50 m radius of the instrument of where the Alarmed values was reached"* as specified in the accepted drawing should be much more extensive than two *"local suspension"*. In addition, without arriving at a revised and accepted set of AAA Levels, the suspended works should not be resumed.

30. Therefore, for the purpose of this audit, the EA Team did not consider that the *"two occasions of local suspension after the exceedance of AAA Levels"* as stated to have been made by MTRCL would have met the requirements for suspension of works stipulated in the accepted drawing in the seven incidents. HyD shared this view. GEO advised that they *"do not have any relevant information of the local suspension as claimed by MTRCL"* and *"do not have any record of suspension of works related to exceedance of AAA Levels until August 2018"*.

Follow-up actions by the relevant Government departments

31. The available information indicated that, in the seven incidents, HyD and GEO were aware of the exceedance of the *Alarm Level* at the time. The EA Team has obtained responses from HyD and GEO regarding their follow-up actions taken.

32. HyD advised that:

> "*The exceedances were reported in the T5 reports. In response to these exceedance, RDO/BO Team/GEO provided comments for MTRCL's follow up, such as investigation, review of proposed preventive & mitigation measures and submission of detailed action plan (DAP) to report the actions taken/proposed works to be taken.*

[10] The two occasions of local suspension of works were excavation of D-wall panel from 13 to 21 July 2016 and installation of pipe pile wall from 10 to 25 October 2017.

CP/RGE/MTRCL are required to ensure DAP are compatible to the consultation submissions.

RDO/BO Team also requested the CP to take corresponding actions in accordance with the specific action plans in case of AAA levels exceeded as stipulated in the reply letters for monthly RGE's T5 reports."

33. GEO's responses, which apply also to TKW, are given in *paragraph 53* of ***Appendix 9-2***.

34. BD provided similar responses as those for TKW, which are given in *paragraph 54* of ***Appendix 9-2***.

Audits by HyD

35. HyD's M&V consultant was tasked to conduct public safety audit of the works of EXC once every year. HyD advised that *"the audit covered MTRCL's compliance to the procedures on monitoring key risk elements with public safety implications such as settlement due to construction works"*. The scope of audit was described in the consultant's audit reports[11] as follows *"The audit consists of Process Compliance and Technical Compliance on public safety related issues of Contract 1123 [which covered the EXC site]"*. It was also indicated in the audit reports that, under the category of *"Technical Compliance"*, *"Review of procedures when instrumentation recorded exceedance of the AAA values"* was one of the items to be audited. Any non-conformances identified, among other findings, were included in the audit reports.

36. From 2015 to 2018, i.e. during the period of occurrence of the seven incidents of exceedance of the *Alarm Level* which required suspension of works, the non-conformance with this requirement in none of the seven incidents was reported by the consultant in the audit reports. Instead, the following findings were stated in the November 2015, November 2016, October 2017 and March 2018 reports: *"The settlement readings were monitored closely. When an instrument recorded*

[11] Entitled "Public Safety Audit Report for SCL Works – SCL Contract 1123 Exhibition Station and Western Approach Tunnel".

exceedance of the AAA values, the procedures stated in the instrumentation and settlement management plan were followed".

Audit by MTRCL

37. Regular internal audits were conducted by MTRCL on the site works. However, MTRCL advised that *"there was no internal audit regarding the exceedance of the AAA Levels for instrumentation monitoring before the launching of the Enhanced Mechanism for both 1123 and 1128."*[12]

After Implementation of Enhanced Mechanism

38. In August 2018, the construction works in the EXC site were suspended by MTRCL. MTRCL also disclosed to the public that the *Alarm Level* had been exceeded at 49 settlement monitoring points of the EXC site.

39. In connection with and prior to the implementation of the *Enhanced Mechanism* and resumption of the works in September 2018, the AAA Levels for the EXC site were revised by MTRCL and accepted by HyD. Since then, and until the time of preparation of this report, none of the monitoring points have recorded further exceedance of the *Alarm Level*.

40. After implementation of the *Enhanced Mechanism*, there were incidents of exceedance of the *Alert Level* and *Action Level* at some of the monitoring points in the EXC site. Overall, no notable non-compliances with the required response actions specified in the accepted drawing were found in the audit. Suspension of works was not part of the required response actions in the event of exceedance of the *Alert Level* and *Action Level*.

41. Both MTRCL and HyD advised the EA Team that the *Enhanced Mechanism* was serving useful purposes and its implementation was satisfactory.

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[12] Contract 1128 covered the TBM tunneling works passed underneath the Fleet Arcade, see ***Appendix 9-4***.

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Appendix 9-4

Findings of Settlement Audit at the Fleet Arcade

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Appendix 9-4

Findings of Settlement Audit at the Fleet Arcade

The Fleet Arcade

1. The Fleet Arcade is located at No. 1 Lung King Street, Wan Chai, which is about 250 m to the west of the EXC site. It comprises a cluster of low-rise buildings. These include the Main Building (comprising Lower Roof, Upper Roof and Extension), the Four Storey Building, the Post Office Building, the Sub-station, the Canopy Building and the Steel Canopy (***Figure 9-4-1***).

2. The Main Building is a single storey, reinforced concrete structure. It was originally built in 1970, but was partially demolished for the construction of the Four Storey Building in 1986.[1] The Main Building is founded on piles. The other buildings are founded on shallow foundations.

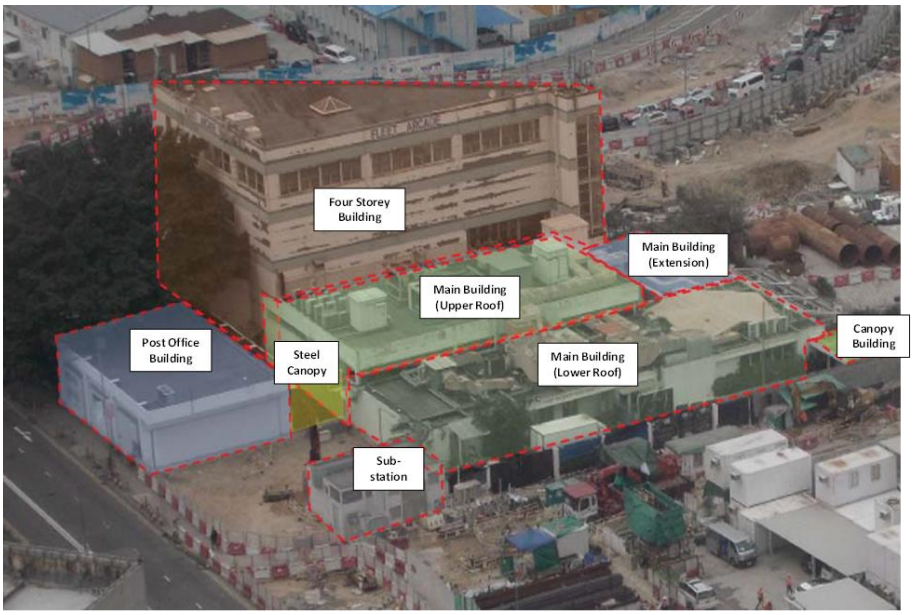


Figure 9-4-1 Buildings of the Fleet Arcade

(Adopted from: Building Impact Assessment Submission - Building Impact Assessment of Fleet Arcade with Tunneling Effect provided by MTRCL)

[1] The first occupation permit (Permit No. H100/70) of the Main Building was issued by the Building Authority on 25 July 1970 and the occupation permit (Permit No. H25/94) of the Four Storey Building was issued by the Building Authority on 3 March 1994.

NSL Western Bored Tunnels

3. The NSL Western Bored Tunnels traversed the southeast corner of the Fleet Arcade at about 30 m deep (see ***Figures 9-4-2*** and ***9-4-3***). The Tunnels comprise an up-track tunnel and a down-track tunnel, which were constructed by tunnel boring machine ("TBM") under Works Contract 1128 of the SCL Project. Each tunnel has an external diameter of about 7.5 m.

4. The TBM tunneling works in the area were carried out in two periods of time. The first TBM drive for the excavation and construction of the up-track tunnel between EXC and Admiralty took place from 8 March 2017 to 25 May 2017. The second TBM drive for this section of the down-track tunnel was carried out from 12 September 2017 to 19 November 2017. The TBM drives for the up-track tunnel and down-track tunnels passed underneath the Fleet Arcade (i.e. within about 50 m plan distance from the Fleet Arcade) in April and October of 2017, respectively.

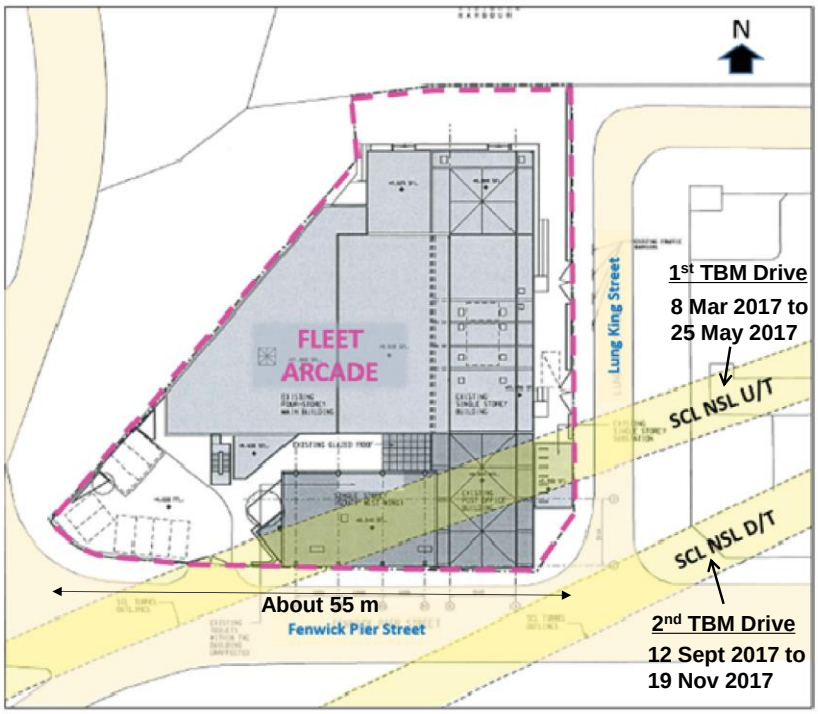
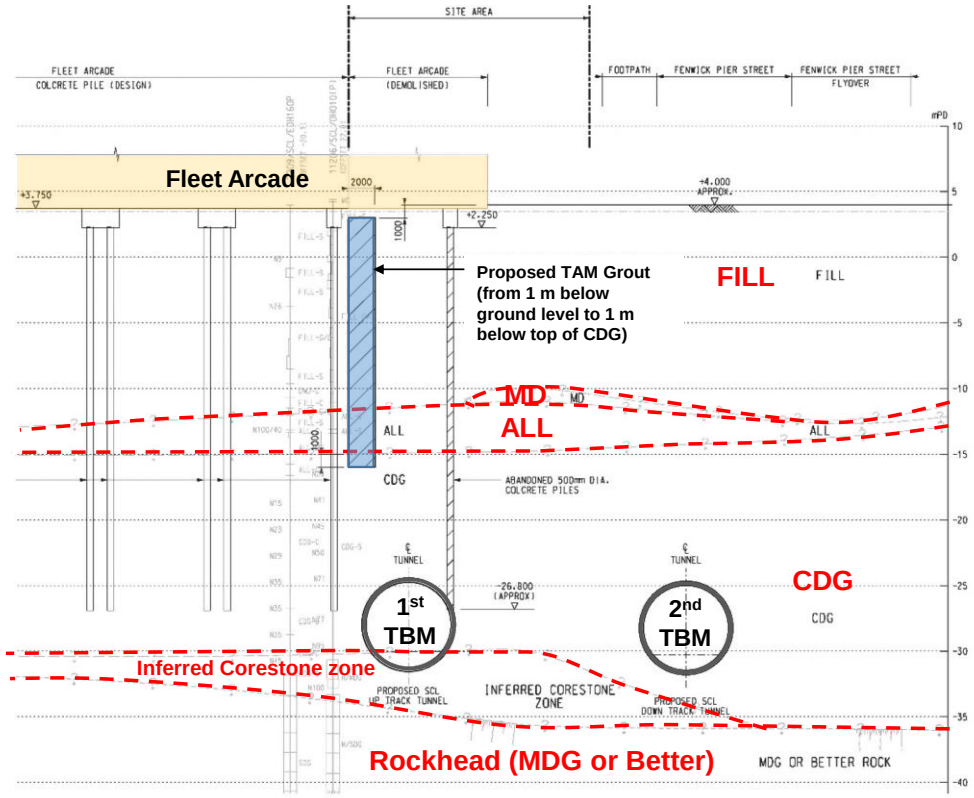


Figure 9-4-2 Layout plan of the Fleet Arcade and Western Bored Tunnels

(Adopted from: Building Impact Assessment Submission - Building Impact Assessment of Fleet Arcade with Tunneling Effect provided by MTRCL)



Note: MD is marine deposits, ALL is alluvium, CDG is completely decomposed granite and MDG is moderately decomposed granite

Figure 9-4-3 Typical cross-section of the Fleet Arcade

(Adopted from: Building Impact Assessment Submission - Building Impact Assessment of Fleet Arcade with Tunneling Effect provided by MTRCL)

Predicted Settlements and Assessment of Acceptability

Condition survey at the Fleet Arcade in May 2016

5. Prior to the TBM tunneling works, MTRCL's consultants carried out a condition survey of the existing structures of the Fleet Arcade in May 2016. While some defects (e.g. cracks) were observed at the buildings, overall the buildings were found to be in an acceptable structural condition. The condition survey concluded that *"from the recent site inspections, the structural performance of all buildings within Fleet Arcade are currently considered to be fairly acceptable. No sign of major structure distress was observed at the time of site visit. The survey results indicate that the Single Storey Main Building and Four Storey Steel Building have appeared tilting towards the north and west respectively."*

6. MTRCL's monitoring data available at the time showed that building settlements were occurring at the Fleet Arcade from mid-2014 to mid-2016, prior to the TBM tunneling works. In the period, 40 to 49 mm of settlement was recorded at the northern part of the Fleet Arcade. At the southern and western parts of the Fleet Arcade, 2 to 6 mm was recorded. MTRCL's consultants found that *"two external walls with fins at north and east side of the Single Storey Main Building appear to have experienced excessive movement and deboned, which may be induced by the other site at north-east area in close proximity of the Fleet Arcade"*. At the time, active construction activities in the vicinity included the construction of box culvert under Wan Chai Development Phase II (WDII) and removal of pile heads under SCL Contract 1128.

7. Before the TBM tunneling works commenced, MTRCL provided protective measures at the Main Building. These included grouting of the ground between November 2016 and January 2017, and erection of temporary steel frames adjacent to two non-load bearing walls between February and April 2017.

Building Impact Assessment in October 2016 for first TBM drive

8. In October 2016, MTRCL submitted a Building Impact Assessment report on the Fleet Arcade, including the proposed monitoring and control plan together with the AAA Levels for the first TBM drive. In the assessment, the settlements which would be induced by the first TBM drive were predicted. The acceptability of the predicted settlements, in addition to the settlements that have been recorded from mid-2014 to mid-October 2016, was evaluated based on analysis of the structural integrity of the Main Building with pile foundation.

9. It was concluded that *"The structural behaviour of Main Building was assessed by some structural analysis models with different scenarios and the integrity of the building is further checked to comply with the requirement of current Hong Kong Code of Practice, the structural integrity of the building is found to be fairly acceptable to cater the received settlement up to mid of October 2016 and the settlement due to the proposed tunneling works [i.e. the proposed first TBM drive for the*

up-track tunnel]". In the assessment, no account was taken of any additional settlements that might be further induced by the other concurrent construction activities in the vicinity from mid-October 2016 onwards.

10. In assessing the acceptability of the AAA Levels for the TBM tunneling works, consideration was given primarily to building safety, via analysis of structural integrity.

Building Impact Assessment in July 2017 for second TBM drive

11. After the completion of the first TBM drive, in July 2017, MTRCL submitted an updated Building Impact Assessment report, including the revised AAA Levels, for the second TBM drive. The approach adopted was similar to that of the Building Impact Assessment for the first TBM drive.

12. It was concluded that *"the structural integrity of the building is found to be fairly acceptable to cater for the recorded settlement up to now and the settlement due to the proposed tunneling works [i.e. the proposed second TBM drive for the down-track tunnel]"*.

Accepted AAA Levels

13. The AAA Levels adopted for the Fleet Arcade in respect of building settlement and ground settlement were specified in the accepted drawings since March 2017 for the first TBM (up-track) drive, and since September 2017 for the second TBM drive (down-track).[2] The *Alarm Levels* were based on the predicted settlements, which were found to be acceptable by the Building Impact Assessments as described in *paragraphs 8* to *12* above.

[2] Based on information provided by HyD, the accepted drawing stipulating the monitoring and control plan for the first TBM drive is entitled "Geotechnical Instrumentation and Monitoring Layout Plan - TBM Excavation Under Fleet Arcade" dated 15 Feb 2017 (Drawing No. 1128/B/399/OAP/C06/048 Rev. D), which was accepted by HyD on 13 Mar 2017. That for the second TBM drive has the same title and is dated 13 Jul 2017 (Drawing No. 1128/B/399/OAP/C06/048 Rev. E). This was accepted by HyD on 4 Sept 2017.

14. The *Alarm Levels*, in respect of ground and building settlements, and building tilting, specified in the accepted drawings are shown in ***Table 9-4-1***.

Table 9-4-1 Alarm Levels at the Fleet Arcade

Type	**Construction Activity**		**Alarm Level**
Ground settlement	First TBM drive (up-track tunnel)		15 mm
	Second TBM drive (down-track tunnel)		40 mm
Building settlement[3]	First TBM drive	Zone 2 & Zone 3	10 mm
		Zone 4	15 mm
	Second TBM drive	Zone 2	10 mm
		Zone 3[4]	15 mm
		Zone 4	25 mm
		Zone 5	30 mm
		Zone 6	35 mm
		Zone 7	40 mm
Tilting of building	First TBM drive	Main Building	1:967
		Four Storey Building	1:500
		Sub-station	1:500
		Post Office Building	1:500
	Second TBM drive	Main Building	1:967
		Four Storey Building	1:500
		Sub-station	1:500
		Post Office Building	1:500

[3] The affected area of the Fleet Arcade was divided into different zones according to their distance from the tunnel alignment. Each zone was assigned its specific *Alarm Level*.

[4] Except that the *Alarm Level* of the Monitoring Point No. WCSP-BSM-006 is 25 mm.

15. It was stipulated in the accepted drawings that suspension of the construction activities was required in the event of exceedance of the *Alarm Level*. The relevant requirement given in the accepted drawings is extracted as follows:

> *"On reaching the "Alarm Level", the Contractor shall suspend all construction activities within a minimum distance of 50 m radius of the instrument of where the Alarm value was reached."*

Selected Monitoring Points for Audit

16. Four monitoring points, including three on building settlement and one on ground settlement, in the vicinity of the tunnel alignment at the site were selected for audit.

17. The selected monitoring points and their applicable *Alarm Levels* are listed in ***Table 9-4-2***. The reference point for settlement monitoring for the TBM tunneling works was "reset to zero" on 1 April 2017 (about three weeks after the commencement of the first TBM drive), i.e. the AAA Levels for the Fleet Arcade were applied to the settlements recorded since 1 April 2017.

Table 9-4-2 Alarm Levels at the selected monitoring points

Monitoring points (Location)	**Type**	**Alarm Level**	
		First TBM drive	**Second TBM drive**
WCSP-BSM-011	Building settlement	15 mm	35 mm
WCSP-BSM-010	Building settlement	15 mm	40 mm
WCSP-BSM-017	Building settlement	15 mm	40 mm
WCSP-GSM-024	Ground settlement	15 mm	40 mm

18. The available records indicated that regular monitoring during the tunneling works was conducted on the selected monitoring points as stipulated in the monitoring plan, and that the monitoring results were presented in the monthly T5 Reports. The T5 Reports were submitted by MTRCL to HyD and copied to GEO concurrently.

Incidents of Exceedance of Alarm Level

19. The *Alarm Levels* were exceeded in seven occasions at the selected monitoring points during the TBM tunneling periods. These incidents are listed in ***Table 9-4-3***.

Table 9-4-3 Incidents of exceedance of Alarm Level at the selected monitoring points

Incident No.	Date	Monitoring Point No. (Location)	Type	Alarm Level
1	April 2017	WCSP-BSM-017	Building settlement	15 mm, due to first TBM drive
2	April 2017	WCSP-GSM-024	Ground settlement	15 mm, due to first TBM drive
3	April 2017	WCSP-BSM-011	Building settlement	15 mm, due to first TBM drive
4	April 2017	WCSP-BSM-010	Building settlement	15 mm, due to first TBM drive
5	Oct 2017	WCSP-GSM-024	Ground settlement	40 mm, due to second TBM drive
6	Oct 2017	WCSP-BSM-010	Building settlement	40 mm, due to second TBM drive
7	Oct 2017	WCSP-BSM-017	Building settlement	40 mm, due to second TBM drive

20. In April 2017, soon after the commencement of the first TBM drive, the *Alarm Level* was exceeded at all of the four selected monitoring points (i.e. Incidents No. 1 to 4 in ***Table 9-4-3***).

21. The AAA Levels were revised for the second TBM drive. In October 2017, soon after the commencement of the second TBM drive, the revised *Alarm Level* was exceeded in three of the selected monitoring points (i.e. Incidents No. 5 to 7 in ***Table 9-4-3***).

22. At the time of occurrence of Incidents No. 5 to 7, the cutterhead of the TBM had just been advanced to a location which was slightly more than 50 m from the relevant monitoring points. It might be argued that the requirement for suspension of *"all construction activities within a minimum distance of 50 m radius of the instrument of where the Alarm value was reached"* was no longer applicable to the TBM cutterhead, even though the recorded settlement was related to the TBM works. However, since the *"50 m radius"* is a *"minimum distance"* specified in the accepted monitoring and control plan, in EA Team's view, it should also be applicable to construction activities beyond 50 m from the instrument if the exceedance of the *Alarm Level* at the monitoring point is related to the construction activities. While there is some ambiguity, the EA Team considers that, strictly speaking, the requirement for suspension of works should also be applied to the TBM works which were only marginally beyond 50 m from the monitoring point at the time.

23. The development of ground and building settlements at the four selected monitoring points with time has been examined. All the monitoring points exhibit a notable trend of increasing settlement with time as the construction works proceeded. For example, the typical trend may be illustrated by the timelines of the recorded ground settlement at Monitoring Point No. WCSP-GSM-024 and building settlement at Monitoring Point No. WCSP-BSM-010 shown in **Figures *9-4-4*** and ***9-4-5*** respectively. There is an apparent temporal relationship between the TBM tunneling works and the recorded settlements that resulted in the exceedance of the *Alarm Level*.

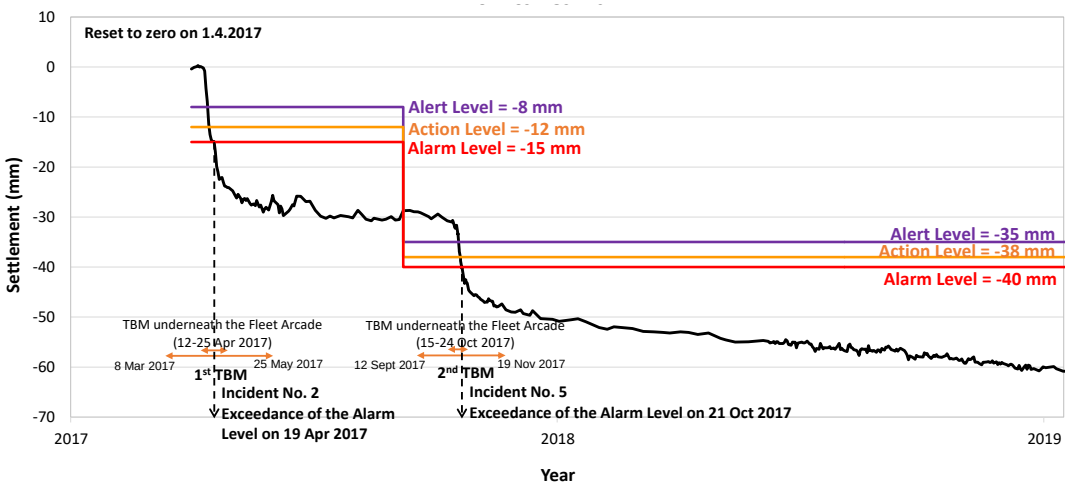


Figure 9-4-4 Ground settlement of monitoring point No. WCSP-GSM-024

(Source: Data provide by MTRCL)

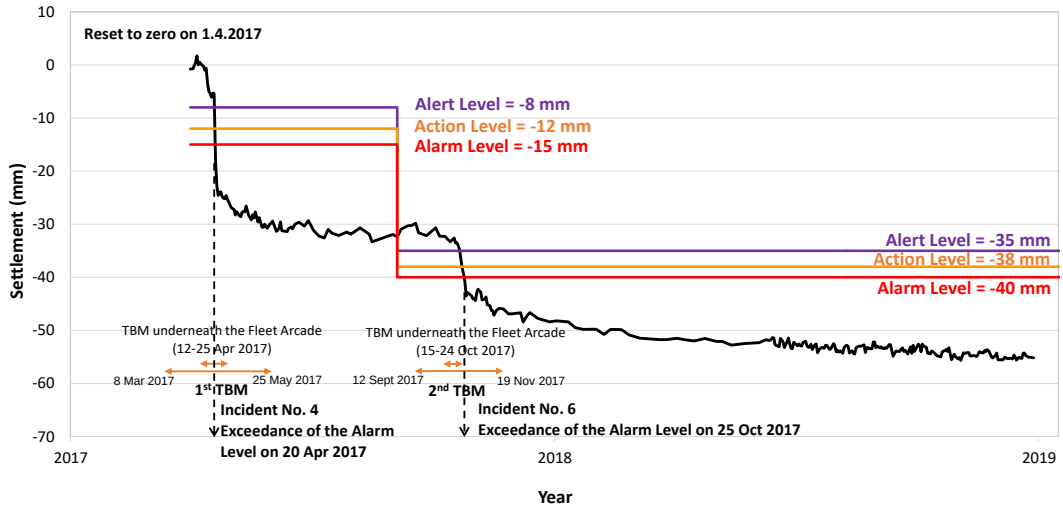


Figure 9-4-5 Building settlement of monitoring point No. WCSP-BSM-010

(Source: Data provide by MTRCL)

Spatial Extent of Exceedance

24. The spatial extent of the exceedance of the *Alarm Level* was appraised in the following two time slots:

(a) April 2017 – during the first TBM drive for the up-track tunnel, after occurrence of Incidents No. 1 to 4, and

(b) October 2017 – during the second TBM drive for the down-track tunnel, after occurrence of Incidents No. 5 to 7.

April 2017

25. In April 2017, the *Alarm Level* of ground settlement was exceeded at a total of seven monitoring points[5] in the vicinity of the first TBM drive at the southern part of the site.

26. The seven monitoring points which recorded the exceedance of the *Alarm Level* involved a sizeable area. Hence, the exceedance of the *Alarm Level* of ground settlement at the time was not confined to the selected monitoring point (i.e. Monitoring Point No. WCSP-GSM-024).

27. The spatial distribution of the exceedance of the *Alarm Level* of building settlement in April 2017 has also been examined. The *Alarm Level* was exceeded at a total of ten building settlement monitoring points[6] in the vicinity of the first TBM drive. This involved a sizeable spatial extent. The exceedance of the *Alarm Level* of building settlement at the time was not confined to the three selected monitoring points.

28. It is noted that, at the monitoring points where the *Alarm Level* was exceeded, the recorded ground settlements and building settlements are comparable. The relevant building settlement monitoring points

[5] The seven monitoring points are WCSP-GSM-002, WCSP-GSM-003, WCSP-GSM-004, WCSP-GSM-018, WCSP-GSM-019, WCSP-GSM-024 and WCSP-GSM-029.

[6] The ten monitoring points are WCSP-BSM-007, WCSP-BSM-008, WCSP-BSM-009, WCSP-BSM-010, WCSP-BSM-011, WCSP-BSM-013, WCSP-BSM-016, WCSP-BSM-017, WCSP-BSM-025 and WCSP-BSM-030.

were installed at the external building walls, which are founded on shallow footings. These walls might have settled with the ground. Few monitoring points were installed in the internal building structures which were founded on piles. Otherwise, this may provide better data for assessing the differential settlements at different parts of the building with account taken of the foundation condition.

29. The distribution of the monitoring points with exceedance of the *Alarm Level* suggested an apparent relationship, both spatially and temporally, between the recorded settlements and the first TBM drive.

October 2017

30. In comparison with the up-track tunnel, the down-track tunnel is located further away from the Fleet Arcade. Despite this and the revision of the *Alarm Levels* for the second TBM drive, the revised *Alarm Level* was still exceeded at three ground settlement monitoring points[7] and four building settlement monitoring points[8] in October 2017.

Suspension of Works on Exceedance of Alarm Level

31. The response actions stipulated in the AAA mechanism were generally undertaken by MTRCL in the incidents of exceedance of the *Alarm Level*. A notable exception to this was suspension of works.

32. In the first four incidents of exceedance of the *Alarm Level* (i.e. No. 1 to 4) at the selected monitoring points, the construction activities (i.e. TBM tunneling works) were not suspended. This did not comply with the requirements specified in the accepted monitoring and control plan. Also, after the exceedance, the TBM tunneling works were continued without putting in place a revised and accepted set of AAA Levels for controlling the works.

[7] The three monitoring points are WCSP-GSM-004, WCSP-GSM-024 and WCSP-GSM-029.

[8] The four monitoring points are WCSP-BSM-009, WCSP-BSM-010, WCSP-BSM-016 and WCSP-BSM-017.

33. MTRCL advised that the TBM tunnel excavation at the site was suspended in one occasion. The following information was provided by MTRCL:

> *"For the Up-track TBM tunnelling in close proximity of Fleet Arcade in April 2017, one no. of AAA Exceedance Notification Form (i.e No. 221) was received with exceedance of the Alarm Level of the external wall tilting (1:820) for the monitoring point Nos. WCSP-CG-001-V and WCSP-CG-008-V at Main Building of The Fleet Arcade on 13 April 2017. As a result, the TBM tunnelling excavation was suspended between 14 April 2017 and 17 April 2017. The TBM tunnelling work was resumed after the concerned external wall was inspected by RSE team and the associated safety precautionary works were carried out. As the TBM tunnelling work advanced forward and steadily moving away from Fleet Arcade, three no. of AAA Exceedance Notification Forms were received (i.e No. 222 ,228 & 230) due to some residual settlement effect. Site inspection by RSE team were conducted and the concerned building was in a safe condition in general. Structural Assessment with proposal of revised AAA level were submitted to RDO for review and the approval of these revised AAA levels was obtained before commencement of the Down-track TBM tunnelling work."*

34. The EA Team noted that this was a brief occasion of suspension of works, which was during the Easter public holiday, in response to the exceedance of the *Alarm Level* of building tilting recorded at two other monitoring points at the time. The suspension was to deal with the recorded building tilting at that particular location. It was unrelated to, and was not addressing the audited incidents of exceedance of the *Alarm Level*, which involved building and ground settlements recorded at the four selected monitoring points. As the TBM works were continued, no provision was made in the revision and acceptance of the *Alarm Levels* which were exceeded in respect of the building and ground settlements at the selected monitoring points.

35. In the last three audited incidents of exceedance of the *Alarm Level* (i.e. No. 5 to 7), there is some ambiguity about the applicability of the requirement for suspension of the TBM works, as explained in *paragraph 22* above.

36. Regarding the TBM tunneling works being not suspended in the three incidents, MTRCL also noted that "*we have reviewed the situation and considered it was safe to continue with TBM operation as suspending the tunnelling work ahead would not be beneficial to the residual settlement condition. At the same time, inspection by RSE was conducted to ascertain the concern structures in Fleet Arcade was in a safe condition"*. While ensuring safety is important, the EA Team would iterate that the AAA mechanism should serve not only to ensure safety but also avoid damage to properties.

37. The issue about the "residual settlement", which is related to the delayed response of the observed ground and building settlements induced by the TBM tunneling works, calls for further attention. There is also a question about whether suspension of the TBM works would serve much useful purpose, particularly in view of the observed delay in the response of ground and building settlements. These, in the context of monitoring and control of TBM tunneling works, are addressed in ***Section 9*** of this report.

Other Response Actions

38. As in the other audited sites, apart from the lack of suspension of works in the event of exceedance of the *Alarm Level*, MTRCL was generally responsive in carrying out the other precautionary and mitigation actions, such as conducting reviews, enhancing the monitoring and control, carrying out ground treatment and other mitigation works, inspecting buildings for confirmation of structural safety, and liaising with the affected parties.

39. The EA Team did not conduct an in-depth diagnosis of the causes of the recorded settlements and their inter-relationship with the construction works and with the suspected damage. It was outside the scope of this audit to evaluate the adequacy and effectiveness of the

precautionary and mitigation actions that were implemented. However, the EA Team found no cause from the audit to doubt that due attention was given by MTRCL and the relevant departments in attending to and ensuring structural safety.

Follow-up Actions by Relevant Government Departments

40. The available information indicated that, in the seven incidents, HyD and GEO were aware of the exceedance of the *Alarm Level* at the time. The EA Team has obtained responses from the HyD and GEO regarding their follow-up actions taken. The responses, which apply also to EXC, are given in *paragraphs 32* and *33* of ***Appendix 9-3***.

41. BD provided similar responses regarding their role as those for TKW and EXC, which are given in *paragraph 54* of ***Appendix 9-2.*** BD also advised that they "*had inspected the affected buildings and no obvious structural safety problem was found*". It should be noted that BD's inspection was not carried out at the time of occurrence of the incidents of exceedance of *Alarm Level*, but in 2018.

Effects of Concurrent Construction Activities

42. In the Fleet Arcade site, views were raised before and during construction that the excessive settlements recorded might be partly attributed to concurrent construction activities of other projects in the vicinity.

43. In June 2018, after the completion of the TBM tunneling works, MTRCL submitted a final Building Impact Assessment report of the Fleet Arcade. In the report, it was stated that "*based on the observations from the condition survey together with assessments, the structural integrity and performance of all buildings within Fleet Arcade are currently considered to be still acceptable, even though some buildings were affected by surrounding construction activities at different times*". This report was accepted by HyD on 2 May 2019.

44. The EA Team appreciated the possibility that the concurrent construction activities, apart from the TBM tunneling works, might have contributed to the recorded settlements. The EA Team was concerned about the apparent lack of detailed investigation to ascertain the effects of the concurrent construction activities and insufficient coordination to cater for their further effects in combination with those due to the proposed TBM tunneling works on the nearby facilities.

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