COMMISSION OF INQUIRY INTO THE CONSTRUCTION WORKS AT AND NEAR THE HUNG HOM STATION EXTENSION UNDER THE SHATIN TO CENTRAL LINK ("SCL") PROJECT

("THE COMMISSION")

CLOSING SUBMISSIONS OF THE GOVERNMENT

ON EXPERT EVIDENCE FOR THE ORIGINAL INQUIRY ("COI-1")

A. Overview of Investigations and Findings – Holistic Proposal

1. During the course of COI-1, MTR Corporation Limited (**"MTRCL"**) submitted to the Government a Holistic Proposal for Verification & Assurance of As-constructed Conditions and Workmanship Quality of the Hung Hom Station ("**HUH**") Extension (**"the Holistic Proposal"**) dated 4 December 2018 **[G17/12970-12999]**. The purpose of the Holistic Proposal was to verify the as-constructed conditions of the EWL platform slab to Diaphragm wall ("**D-wall**") connection and investigate workmanship quality of the D-walls, the EWL and NSL slabs to D-wall connection, concrete and steel reinforcement, for the purpose of assessing the structural integrity of the HUH Extension work **[G17/12972]**. Task groups comprising representatives from MTRCL, Buildings Department (**"BD"**), Highways Department (**"HyD"**) and the Expert Adviser Team were formed to oversee the preparation and implementation of the Holistic Proposal **[OA1/6 §58]**.

2. The Holistic Proposal was divided into three stages:

   (1) Stage 1: Desktop exercise

(a) Stage 1a: Consolidating the latest amendment drawings (as constructed) prepared by Leighton.

(b) Stage 1b: Consolidating all available objective evidence and checking the latest contractor's amendment drawings (as-constructed) with reference to the objective evidence including construction records.

(2) Stage 2: Physical examination via opening-up

(a) Stage 2a: Opening up the locations at the EWL slab (as identified in Stage 1 as being without sufficient objective evidence to show what had actually been constructed) and verify the as-constructed conditions.

(b) Stage 2b: Opening up the randomly selected areas at the respective connections between the platform slabs (i.e. the EWL and NSL slabs) and D-walls to assess the workmanship in the coupler connections by physical inspection and/or the Phased Array Ultrasonic Test (**"PAUT"**).

(c) Stage 2c: Review of construction records of the D-walls.

(d) Stage 2d: Investigation of honeycombing and gaps at wall/column/hanger wall and workmanship in shear links and horizontal construction joints.

(3) Stage 3: structural assessment of the EWL and NSL slabs and the station extension box and consideration of the need for and details (if required) of remedial works based on the verification findings in Stages 1 and 2.

3. The various stages of the Holistic Proposal were implemented from December 2018 to early July 2019. On 18 July 2019, MTRCL submitted the Final Report on Holistic Assessment Strategy for the HUH Extension (**"the Holistic Report"**) **[OU5/3229-3350]** to the Commission.

4. The key findings of the Holistic Report are as follows.

Stage 1

5. In about December 2018, upon a review of all the information and construction records available with reference to the amendment drawings (as constructed) prepared by Leighton, a total of 24 locations of EWL slab to D-wall connection were required to be opened up for further verification of the available records or evidence to demonstrate the accuracy of the as-constructed conditions shown in the amendment drawings **[OU5/3244-3245 §§2.2.1-2.3.4]**.

Stage 2a

6. It was revealed that 8 out of the 24 locations of EWL slab to D-wall connection as identified in Stage 1 were found to be inconsistent with the contractor's amendment drawings (as-constructed). It was found there were inaccuracies in the drawings which suggest deficiencies in the drawing amendment process during construction. Some site changes were not properly recorded and/or updated in the amendment drawings **[OU5/3246-3247 §§3.2.1-3.2.7]**.

Stage 2b

7. The opening up works were based on a statistical approach with random sampling to assess the workmanship of the steel bar and coupler connections between the platform slabs and D-walls. The sampling

method for coupler connections was discussed and agreed between the MTRCL and the Government under the advice of the Government's advisers, including Professor Guosheng Yin and other academics from the University of Hong Kong **[ER1/item 11.1 §8; Transcript on 24.9.2019/23:20-24:10]**. The following points should be noted:-

(1) In this regard, a sample size of not less than 84 randomly selected couplers each for the EWL and NSL slabs would give a result with 95% confidence level using binomial statistics **[OU5/3248 §3.3.1]**.

(2) 28 locations each for the EWL and NSL slabs were randomly selected and a total of 56 selected locations were therefore opened up. Layout plans showing the 56 selected locations in the EWL and NSL can be found at **[OU5/3306-3307].**

(3) A two-stage cluster sampling scheme was adopted by firstly sampling the location at random, followed by random sampling the layer of couplers at the selected location **[OU5/3249 §3.3.4]**.

(4) When the couplers were exposed, PAUT was used to measure the actual engagement length of threaded bars of platform slabs into the couplers pre-installed in D-walls **[OU5/3249 §3.3.6]**.

(5) The "best-compliant" rule was applied to the opening-up investigation, meaning that every endeavour was made to obtain the data chosen by the random selection scheme. Where there were circumstances that the selected samples could not be reached or PAUT measurement could not be carried out due to site constraints, PAUT data from the nearest layer was collected **[OU5/3249 §3.3.5]**.

8. The method for PAUT had been enhanced due to the fact that in January 2019 deviations were observed between the engagement lengths

measured using PAUT and direct measurement taken after coupler assembly was removed by cutting. After a series of on-site and laboratory validations exercise, an enhanced method for PAUT was developed and used **[OU5/3250 §§3.3.7-3.3.10]**.

9. For the purpose of this study, the proper installation requirement for the couplers were considered to be (1) there shall be a maximum of two full threads exposed (as per BOSA's installation requirements); and (2) the engagement length of the thread steel rebar inside the couple should be at least 40 mm. The allowance measurement tolerance of the PAUT equipment is however 3 mm. Hence, with an aim to provide the benefit of the doubt to Leighton regarding PAUT results, engagement lengths found to be less than 37 mm by PAUT or 40 mm by direct measurement are considered defective.

10. 25 out of 90 samples at the EWL slab and 23 out of 93 samples at the NSL slab were found defective. These 48 defective samples included 8 cases where the main reinforcement bars were not connected to couplers at all and 5 cases where the bars appeared to have been cut. Further, on the basis of the binomial analysis mentioned above, it was estimated that, with a 95% confidence level, not more than 36.6% and 33.2% of couplers at the EWL and NSL slabs respectively were considered defective **[OU5/3256 §§3.3.24-3.3.25]**, including that not more than 15.5% of couplers at the EWL slab were unconnected at all **[ER1/item 12.2/Yin's slide 11].**

11. It should be noted that the EWL slab in Areas A and Hong Kong Coliseum was mainly connected to the D-walls via capping beams. As revealed by the opening-up works, 2 out of 11 main rebars from the capping beams on top of the D-walls were not properly connected to the

couplers linking the rebars from the EWL slab, while 2 out of 7 of the connections on the side of the EWL slab are found to be defective.

12. It was concluded in the Holistic Report that the likely causes of deficiencies in coupler connections included poor workmanship in rebar fixing which was not identified during inspection of the construction works **[OU5/3235 §14]**.

Stage 2c

13. The process under Stage 2c, as mentioned above, involved the review of the available construction records to check whether or not there were irregularities in the D-wall construction. Late submission and endorsement of RISC Forms and unavailability of some coupler inspection records were identified. Upon consideration of other information including the signed shop drawings of the fabricated reinforcement cages and relevant photographs, it was considered that site supervision and inspection had generally been conducted during D-wall construction and no obvious workmanship issues were identified. Hence, the opening-up of the D-walls for further investigation was considered unnecessary **[OU5/3258-3259 §§3.4.5-3.4.12]**.

Stage 2d

14. The investigation during the Stage 2d process revealed:-

    (1) Approximately 12% of the inspected area with shallow honeycombing (i.e. less than 50mm deep) and approximately another 7% of the inspected area with deeper honeycombing (i.e. 50mm to 350mm deep) were identified **[OU5/3236 §§20-21]**.

(2) 31 gaps between the wall/column/hanger wall and EWL slab soffit were identified which were either unfilled or filled with improper materials. Reinforcement and coupler connection issues were identified in some of these gaps **[OU5/3236 §22]**.

(3) Since the investigation of the honeycombing identified irregularities in the shear links, 18 localised areas at the EWL slab soffit were selected for opening-up, taking into account site accessibility and shear stress concentration. The opening-up works revealed shear link irregularities at all 18 locations. These included missing shear links, smaller bar sizes and insufficient anchorage lengths. These irregularities did not conform to the design and also reflected construction and supervision issues **[OU5/3237 §§23-24]**.

(4) In addition, irregularities in respect of horizontal construction joints in connections between EWL slab and the D-wall were found at two out of four locations where video rigid scope investigation was carried out **[OU5/3237 §§25-26]**.

(5) Other defects found in Stage 2b included corrosion of the unscrewed threaded rebars, water seepage/ponding at some opening-up locations at the platform slabs and defective coupling works at the locations between the soffit of the EWL slab and the D-wall covered by NCR No. 157.

Stage 3

15. Under the Stage 3 structural assessment ("**Stage 3 Structural Assessment**"), two scenarios were considered, namely, the Original Design and the Updated Design **[OU5/32379 §35]**.

16. Under the Original Design scenario, the structural integrity was assessed on the basis of the original design assumptions and models with consideration of the findings of the as-constructed conditions derived from the investigations carried out in Stage 1 and Stage 2. It was based on such Original Design assumptions and models that the proposed works were accepted as achieving the safety level required in the Code of Practice for Structural Use of Concrete (**"the Code"**) prior to construction **[OU5/3273 §4.1.4]**.

17. According to the assessment based on the Original Design, further works would be required in the EWL and NSL slabs to cater for the irregularities in the coupler assemblies, including those directly connecting the platform slabs with the D-walls and connections via the capping beam, irregularities in the shear links in the EWL and NSL slabs and also the defects at the horizontal construction joint in the connection between the D-walls and the EWL slab **[OU5/3240 §37]**.

18. After reviewing the Original Design assumptions, it was considered that some of the extra provisions and flexibilities (which were initially intended to cater for the uncertainties which might be encountered during the subsequent design, construction and operation stages to cater for the design life of 120 years) could be reviewed. MTRCL and its external consultants therefore recommended a set of revised design assumptions for the Updated Design in the Stage 3 assessment and they took the view that the adoption of the revised criteria generally complies with MTRCL's New Works Design Standard Manual (**"NWDSM"**) and also achieves the safety level required in the Code. Furthermore, it was acceptable to also adopt some other changes to the Original Design assumptions for the structure provided that suitable restrictions and precautionary arrangements were put in place, e.g. future alteration works,

alteration of the train type and usage and development in the vicinity of the site might be affected **[OU5/3274 §§4.1.5-4.1.6; OU5/3280-3281 Table 5]**.

19. MTRCL eventually adopted the Updated Design as an appropriate approach for assessing the extent to which further works would be required to remedy the defects in the structure. In adopting the Updated Design, certain loading reserves and safety standard originally allowed for in the Original Design were surrendered **[ER2/item 17.1/Lau1 §50; ER2/item 17.11/Lau's slide 26; OU5/3280-3281 Table 5 (last column)]**. The works required under the Updated Design approach have been reduced when compared to those required under the Original Design approach.

20. "Suitable measures" (" **"suitable measures"** ") were therefore proposed to be carried out for the poor workmanship issues found and to achieve the safety level required in the Code for meeting the requirement of the Buildings Ordinance (**"BO"**) and the established good practice of engineering design. The NWDSM should also be complied with **[OU5/3274 §4.1.8]**.

21. Based on the Updated Design, the "suitable measures" including the installation of drill-in bars, local thickening of slabs, reinstating shear links, adding columns, grouting etc. were proposed to address the defects identified. It was estimated that it would take 4 to 6 months to design the "suitable measures" and obtain acceptance from the Government and it would take about 9 to 12 months for such "suitable measures" to be fully implemented **[OU5/3284-3285 §§4.4.1-4.4.12]**. The detailed design for the "suitable measures" have been completed by MTRCL and accepted by the Government. Execution of the "suitable measures" are being

undertaken by Leighton under the supervision of MTRCL. A summary of the progress of the works as of 8 January 2020 can be found at **[OU9/11474-11484]**.

B. Structural Engineering Evidence

B1. Background

22. In the Interim Report, the Commission, having considered the evidence available adduced in COI-1, concluded that the HUH Extension D-wall and platform slab construction works are safe **[A2/721 & 824-827]**. In the meantime, the Commission was informed of the progressive developments and findings of the Holistic Proposal, that the Stage 3 Structural Assessment would be conducted, and that the issue regarding the need for and the extent of the remedial works (if required) would also be addressed.

23. The Holistic Report and the Final Verification Study Report ("**the Verification Report**") were released in July 2019. Upon considering the contents of the reports, the Commission sought clarifications from the Government and MTRCL on various issues relating to the question of structural safety and also the need to implement the remedial works (i.e. "suitable measures") **[OU5/3356-3359]**.

24. Both the Government and MTRCL provided their replies and also answers to the Commission's Requests for Information (see Government: **[OU5/3377-3379]**; MTRCL: **[OU5/3374-3376])**.

25. By letter dated 7 August 2019 **[OU5/3354-3355]**, the Commission asked all involved parties to indicate if they would adduce structuring

engineering expert evidence on various matters including three major topics namely, coupler connection, shear links and horizontal construction joint between EWL slab and D-wall panels in Areas B and C.

26. On 7 August 2019, Messrs. O'Melveny & Myers ("**OMM**") (for Leighton) wrote to the Commission seeking to adduce structural engineering expert evidence "*to consider and make an assessment of the suitable measures proposed in the [Holistic Report and Verification Report]*" and also expert evidence from a statistician in relation to rebar testing **[OU5/3380-3382]**.

27. By email dated 14 August 2019 to the Commission, Department of Justice (**"DOJ"**) (for the Government) stated at §4 **[OU5/3426]**:-

> *"In light of the said agreement to implement the "suitable measures" as recorded in the Holistic Report, we are of the view that further structural engineering or statistical expert evidence, or arguments on the details of the assessment performed by MTRCL or the "suitable measures" proposed (which in any event are yet to be further developed) would not be necessary. In particular, further arguments on the question of whether the Station (without the implementation of "suitable measures") can generally be described as "safe" without making any reference to agreed design standards, benchmark or any statutory requirements in Hong Kong would not be helpful to the Commission or the public. Moreover, as the Government and MTRCL have agreed to proceed with the "suitable measures", the question of whether some or all of the "suitable measures" proposed are necessary in the circumstances (whether under the Contract or otherwise) would, in our view, be*

primarily a matter of civil liability, which ought to be resolved in a separate forum."

28. Hence, DOJ informed the Commission that it was the Government's view that no structural engineering or statistical expert evidence would be required on the Government's own accord, and that any expert report on the Government's part would only be responsive in nature **[OU5/3427]**.

29. By letter dated 16 August 2019, OMM informed the Commission that Leighton would be "prepared to withdraw its request to adduce expert evidence on statistics regarding coupler connections if the Commission acknowledges that the key parties have different opinions in relation to the quality of the coupler connections and allows the parties to resolve such differences in other appropriate forums (if necessary)" **[OU6/3736]**.

30. By emails dated 25 August 2019 and 29 August 2019, the Commission gave directions on the expert evidence relating to statistical matters and structural engineering respectively **[AA1/266-269; OU7/9691-9692]**.

B2. Safety and fitness for purpose

31. By letter dated 4 October 2019, the Commission wrote to all involved parties stating that in view of the fact that it was concluded in the Holistic Report and the Verification Report that "suitable measures" would need to be carried out, the Commission took a tentative view that the structural engineering experts (**"SE experts"**) should focus on whether the relevant works as constructed are safe and fit for purpose and whether the "suitable measures" are necessary for safety and statutory or code compliance and invited all involved parties to make submissions on whether this should be the appropriate focus of the structural engineering evidence **[AA1/419-420]**.

32. The Government's submissions on the issue of structural safety were filed on 10 October 2019 **[AA2/441-446]**. The key points can be summarised as follows.

(1) 'Safety' is a broad concept and can be subject to variations in different people's interpretations. However, the question of whether the relevant works as constructed are 'safe' can only be meaningfully answered by reference to some objective building standards.

(2) The Code and the BO reflect the level of structural safety expected and required to be achieved in all building structures in Hong Kong. There is no reason why another set of structural safety standards should be applied to the construction works at the HUH Extension, NAT, SAT and HHS.

(3) Hence, the Code and the BO are intrinsically linked to structural safety required to be achieved in Hong Kong and the two cannot be artificially segregated.

(4) In addition, there are other provisions contained in, for example, CS2 and the Code of Practice for Fire Safety in Buildings 2011 (in relation to concrete cover to maintain the stability of the structural elements in case of fire) which also concern structural safety of structures and all relevant codes are collectively referred to as "**the Applicable Codes**".

(5) The Government would only consider a structure to be 'safe' if both its design and construction comply with the requirements of the BO and the Applicable Codes, not only in respect of loads or strength, but also serviceability, durability, fire resistance and

robustness so as to cater for unforeseen and exceptional circumstances or adversities like fire. The same standards were adopted by MTRCL in the original design as well as the Stage 3 Structural Assessment.

(6) Upon the Stage 3 Structural Assessment and the further investigation and assessment carried out pursuant to the Verification Proposal, it is concluded that without the implementation of the "suitable measures" (although the exact details and extents are yet to be determined) the as-built structures fail to comply with the requirements of the BO, the Applicable Codes and MTRCL's NWDSM. This is common ground between the Government and MTRCL. However, it is also common ground between the Government and MTRCL that one can safely conclude that upon the implementation of the "suitable measures" the structures are 'safe' according to a set of objective standards as enshrined in the BO and the Applicable Codes.

(7) The Commission should not be concerned with the question of whether some part(s) of the "suitable measures" proposed by MTRCL may be excessive, and thus unnecessary. It is because the "suitable measures" as proposed in the Holistic Report and Verification Report will have to be carried out in any event as agreed between and jointly announced by the Government and MTRCL (and there is no reason why they should not be entitled to do so) for the purpose of ensuring that the requisite building standards are complied with and the requirements of NWDSM are met.

(8) Insofar as Leighton (who was not privy to Stage 3 Structural Assessment and the assessment work under Verification Proposal) intends to establish that the "suitable measures" are excessive or unnecessary believing that it may have an impact on the extent of its legal liability under Contract 1112, this is a matter entirely between MTRCL and Leighton, which if required should be resolved by way of civil litigation between them instead of this Inquiry.

(9) If Leighton attempts to prove that the as-built structures are 'safe' without the implementation of the "suitable measures" while making no reference to the BO and the Applicable Codes, it is submitted that such exercise does not serve any meaningful purpose because, as explained above, the Applicable Codes and the BO reflect the standards required in Hong Kong for the purpose of ensuing safety.

(10) It is not in dispute that the structures do not have any imminent risk or danger of collapsing. The Government has accepted the description in MTRCL's Holistic Report and Verification Report that '*for ongoing construction activities, the structure is safe*'. However, a structure which is capable of taking up its existing loads without any present risk of collapsing does not mean it is 'safe' for any further loads, including those under unforeseen and/or exceptional circumstances that it may experience during the lifetime of the structure. Hence, if any involved party wishes to rely on any calculations only in terms of loads or strength in the hope that it can demonstrate that the structure built is safe, the consideration of loads or strength is insufficient and it falls short of

the standards applicable to all other building structures in Hong Kong.

(11) By the same token, in order to answer the question as to whether the as-built structures are 'fit for purpose', one has to first ascertain the 'purpose' for which the structures are built. It is indisputable that MTRCL was commissioned by the Government (and Leighton was appointed as main contractor by MTRCL) to build the structures in question as part of the railway systems in Hong Kong. Hence, if the structures are not allowed to be put into use as such because they do not achieve the level of structural safety required under the Applicable Codes and the BO, they cannot be said to be 'fit for the purpose' for which they are intended.

33. Upon considering parties' written submissions and oral submissions at the hearing on 11 October 2019, the Commissions gave directions on 12 October 2019 **[OU8/10561-10562]** that the SE experts should focus on "*whether the as-constructed works are safe and fit for purpose from a structural engineering perspective*" and "*the SE experts shall not be required to look into the question of whether the suitable measures (as agreed in the Holistic Report or Verification Report, or subsequently) are required for statutory or code compliance*".

34. The above directions are intended to require the SE experts to analyse the structural issues (including the issues of "suitable measures") not from a point of view of strict adherence to the Applicable Codes but from "a structural engineering perspective". Further, by email dated 25 November 2019 **[OU9/10978-10979]**, the Commission clarified that the above directions do not preclude any reference to relevant statutes or codes, in particular if such reference is necessary for the SE experts to

explain their analyses on whether the structures are safe and fit for purpose.

35. Different SE experts may analyse the above issues by adopting different approaches or from different angles. However, it is submitted that there are certain parameters which must be considered. In this regard, it appears from the evidence given by all four SE experts that they have all considered the primary factors such as strength and longevity/durability while Dr James Lau, the Government's structural engineering expert, has referred to further details on the relevant factors which should be considered. But, after all, it seems that there is no major dispute on the applicable parameters.

36. Other than the questions of whether partially engaged coupler connections should be taken into account and whether the contribution of shear links that may exist in the slabs should be ignored in the structural assessment, the main difference between the SE experts appears to lie in the minimum levels of the factor of safety which should be applied to the analysis of the issues identified in the Commission's directions. Dr Lau takes the view that in considering the level of factor of safety, the standards and requirements laid down under the Applicable Codes shall be met as it reflects the community's expectation and consensus reached among the industry practitioners taking into account of the circumstances in Hong Kong **[ER2/item 17.1/Lau1 §32-34]**. The other SE experts, namely, Mr Nick Southward (for Leighton), Dr Mike Glover (for MTRCL) and Professor Don McQuillan (for the Commission) think otherwise. They considered that lower levels of safety factor (which deviate from those required under the Applicable Codes) could be applied in the assessment.

37. The above reflect the differences between the experts in terms of the approach they have taken in this exercise. Obviously, Dr Lau's opinion is that the issues of "safety" and "fitness for purpose" need to be assessed by looking at the relevant parameters and also adopting the levels of factor of safety stipulated under the Applicable Codes because, as mentioned above, the standards required under the Applicable Codes are closely and intrinsically linked to the questions of safety and fitness for purpose. However, the other three SE experts have provided their opinions from a "forensic engineering" perspective on whether the structures are safe by applying the levels of factor of safety which they consider acceptable even though they fall short of the requirements under the Applicable Codes in Hong Kong. However, if one takes such an approach, it is important to explain how the proposed reduction could be objectively ascertained and measured. Further, a forensic engineering approach should involve sufficient field investigation and detailed examination of the structures concerned supported by systematic and comprehensive laboratory test results. Nonetheless, it appears that no detailed information regarding such investigation and examination is contained in their evidence.

B3. Are the as-built structures (i.e. without the implementation of "suitable measures") safe from a structural engineering perspective?

38. For the purpose of bringing the as-built structures up to the safety level required under the Code, the BO and MTRCL's NWDSM, "suitable measures" are being carried out by Leighton and MTRCL on site. Upon the completion of such "suitable measures", certain parts of the as-built structures will be rectified and strengthened. Hence, the present question relating to structural adequacy or safety of the as-built structures should

not affect the need for and also the actual implementation of the "suitable measures".

39. As submitted above, there is no benchmark or text-book definition for determining whether a structure is safe and fit for purpose from a structural engineering perspective. There may be variations in different people's mind regarding whether their perceived "safety" requirements have been met. Naturally, different structural engineers may have different views and they may place different levels of emphasis on the relevant parameters and/or what they consider to be the required level of factors of safety.

40. However, it is submitted that the question of whether the relevant works as constructed are "safe" can only be meaningfully answered by reference to some objective building standards. No doubt, different experts may apply a certain degree of their own engineering judgments in the analysis of safety and it is always easy to say that this ultimately boils down to "a matter of common sense" (see Southward's evidence: **[Transcript on 2.1.2020/106:5]**); however, it is inappropriate and dangerous to evaluate building safety by resorting to subjective elements of expectations and perceptions. This is the reason why different jurisdictions have their own building codes and standards tailored made and published for engineers to design structures to attain an acceptable level of safety specific to these countries and areas. Mr Southward agrees that different countries have different ways of approaching and using factors of safety (see Southward's evidence: **[Transcript on 2.1.2020/119: 17-20]**).

41. In the present case in Hong Kong, the relevant standards are the Code and the BO. The Code was drawn up by a steering committee, comprising relevant building professionals representing professional institutions and

stakeholder organisations, academia and representatives of relevant government departments, and upon formal consultation with the construction industry in Hong Kong via established consultative committees. It therefore represents the collective wisdom and consensus reached to suit the particular circumstances in Hong Kong and reflects the level of structural safety expected and required by the society to be achieved in all building structures in Hong Kong. Hence the Building Authority would only raise no objection to the certification submitted for the completion of the works in question if and only if the works are designed and constructed to achieve the level of structural safety required in, *inter alia*, the BO and the Code.

42. Dr Lau was a member of the said steering committee. He was involved in the consultation process and drafting of the Code, thus he was involved in the setting of the said minimum safety standard **[Transcript on 3.1.2020/97:14-20; on 6.1.2020/7:6-8]**. Whilst Dr Lau has identified various parameters for ascertaining the questions of safety and fitness for purpose, he takes the view that in considering the level of factor of safety, the standards laid down under the Code and the BO would need to be applied **[Transcript on 6.1.2020/48:6-11]**. In other words, a structure will only be considered safe and fit for purpose if the standards governing the factor of safety in relation to each of the relevant parameters (as set out in the Code and BO) are fulfilled **[Transcript on 6.1.2020/54:14-55:4]**. According to Dr Lau, to satisfy the fit-for-purpose requirement, one also has to comply with the requirements of the client as set out in the contract, a relevant part of which is the NWSDM **[Transcript on 3.1.2020/103:3-12; 104:13-22; 114:21-115:3]**. In fact, Mr Southward agrees that in assessing whether a structure is fit for purpose, it is

necessary to consider the purpose that the structure intended to serve under the client's requirements **[Transcript on 2.1.2020/111:19-23]**.

43. On the basis of the structural assessment done by MTRCL's designers, Atkins and AECOM, Dr Lau is of the view that the as-built structures are not safe and fit for purpose. It is because they fail to achieve at least the same level of safety required by the Code and BO. In particular, Dr Lau is primarily concerned with (a) the problem of excessive crack width that may be caused by the partially engaged couplers which would impact on the durability of the structures, and (b) the possible complete lack of shear links at critical locations where shear links are required.

44. Other experts consider that the as-built structures are safe from a structural engineering perspective by reference to different benchmarks. Dr Glover highlights the fact that some uncertainties a designer faced at design stage would be removed upon completion of the construction. Hence, a reduced factor of safety could be adopted for post-construction structural assessment, and he would therefore adopt the approach used in forensic analysis **[Transcript on 7.1.2020/163:25-164:21]**. Professor McQuillan takes a similar view that for the purpose of determining whether the as-built structures are safe and fit for purpose from a structural engineering perspective, if appropriate, one can adopt different design loads (other than those specified in design codes) and apply a somewhat lower level of factor of safety in the assessment **[Transcript on 9.1.2020/12:1-15:3]**. However, when Dr Glover was asked to comment whether it would be difficult to quantify the reduction in partial load factor in the structural assessment, Dr Glover acknowledged that it was "*on the basis of your expectation of the variation in that load going forward*" **[Transcript on 7.1.2020/165:10-25]**. Dr Glover also said that it ultimately would depend on whether the reduction was within a

reasonable range and as such the adoption of the partial factors of safety in the Code by Atkins in Stage 3 Structural Assessment is not unreasonable **[Transcript on 7.1.2020/162:4-168:24]**. This seems to further confirm that, other than verification against the Code and BO, there was no objective way to assess and quantify the reduction which should be applied in the structural assessment.

45. In any event, it is to be noted that some of the uncertainties/unknown at the design stage referred to by Arup and Professor McQuillan, e.g., in relation to load conditions and actual geometry of the structure, have in fact already been taken into account by MTRCL and its designer when the parameters for the Updated Design were developed and agreed with the Government: see Holistic Report **[OU5/3339-40 §§35, 38 to 41]**; Verification Report **[BB16/9956-57 §§12 & 13]**.

46. In the present Inquiry, the three specific structural issues being considered by the SE experts are (a) the partially engaged couplers in the platform slabs, (b) the non-compliant shear links in the platform slabs, and (c) the construction joint in the connection between the EWL slab and D-walls. They are further discussed below.

Partially engaged couplers

47. The use of ductility couplers as connection between the reinforcements in the platform slabs and diaphragm walls is part of MTRCL's design as a splicing device. MTRCL's designer did not specify any particular brand of couplers to be used, see e.g. drawing at **[H2/440]**. Relevant supervision and testing requirements were specified in the acceptance letter **[H9/3901-3904]**.

48. For construction, Leighton proposed to use BOSA's couplers – see Leighton's Quality Supervision Plan (**"QSP"**) submission in August 2013 **[H9/4265-4280]**. BOSA's couplers are not new products, they have been used in other projects in Hong Kong **[A1/654-663]**.

49. The related materials and documents submitted by Leighton through MTRCL include a QSP **[H9/4265-4280]**, the specifications on coupler installation method, measurement of thread length and guideline for visual inspection **[A1/272-282]**, and BOSA's Technical & Quality Assurance Manual (**"T & QA Manual"**) **[A1/556-684]**.

(1) It is clearly shown on the specification for coupler and threaded bar dimension that for 40mm diameter bar size, the length of the coupler is 88 mm while the threaded length of the rebar is 44mm plus a positive tolerance of maximum one thread which is 4mm, i.e. a total threaded length ranges from 44mm to 48mm **[A1/595]**. The guideline for visual inspection further states that under normal circumstances, BOSA provides a positive tolerance of half a thread, i.e. with a total threaded length of 46mm **[A1/594 §3]**;

(2) The method of installation specified by BOSA provides that (i) BOSA Fabricator will screw on the coupler by hand to one end of the threaded bar, (ii) at the time of steel fixing, the steel fixer has to ensure that the coupler is <u>fully screwed into the bar</u> prior to being cast in concrete and the protective cap is still intact and fitted on coupler end and <u>to prevent ingress of foreign material</u>, (iii) when the continuation bar is being connected, the steel fixer has to remove both the protective cap on the rebar and the coupler, <u>fully engage the thread to the coupler by hand</u>, and lastly (iv) the steel fixer has to <u>use a typical pipe wrench to tighten the splice</u> (no

special torque is required) **[A1/275;** see also T & QA Manual at **A1/590]**;

(3) Section (iv) of Leighton's QSP requires Leighton's Quality Control Supervisors to fully supervise the installation work including checking the coupler and threads for existence of concrete gal, debris and foreign material. If concrete gal, debris and/or foreign material is found, the said supervisor has to ensure that the coupler and threads are cleaned prior to installation and tightening **[H9/4276 §3]**;

(4) Hence, if the threaded length of the rebars supplied by BOSA is as specified and Leighton's steel fixers properly carried out the installation work as per the method of installation specified by BOSA, the threaded bars which is 46mm under normal circumstances would not necessarily meet at the mid-point inside the coupler, but would mostly be 2mm away from mid-point. If the threaded length of the first bar is 48mm instead, the bars would meet at a point 4mm away from mid-point.

(5) As to the number of exposed threads on the continuation bar, it again depends on where the bars meet inside the coupler and the threaded length of the continuation bar.

Threaded length of 1st bar (mm)	Point where bars meet	Space left inside coupler for continuation bar (mm)	Threaded lengths of continuation bar (mm)	No. of thread exposed
44	Mid-point	44	44/ 46/ 48	0/ 0.5/ 1
46	2mm away	42	44/ 46/ 48	0.5/ 1/ 1.5
48	4mm away from mid-point	40	44/ 46/ 48	1/ 1.5/ 2

As demonstrated in the above table, depending on the respective threaded lengths of the 1st bar and the continuation bar, if the steel fixers follow the specified method of installation, no thread should be showing on the side of the 1st bar and the number of exposed thread showing on the size of the continuation bar varies from 0 thread to 2 threads.

(6) Hence it was stated by BOSA in its guideline for visual inspection that "After connection has been fully tightened, one should see a maximum of TWO FULL THREADS to ensure a proper installation"; it is emphasized in the guideline that, "… the exposed thread, if any, always occurs at the top of the continuation bar." **[A1/282 Summary §§1 & 3]**.

(7) On the basis of the specified dimensions of BOSA's coupler and threaded bar, there is no inconsistency or incompatibility between the method of installation and the acceptance criterion stated in the visual inspection guideline, i.e. no more than 2 threads showing.

(8) It does not necessarily follow from "no more than 2 threads showing" that the connection inside the coupler is 'butt-to-butt'. Provided that the steel fixers properly follow the method of installation specified, in particular ensuring any debris or foreign materials in the couplers and on the threads are cleaned/removed and the bars are fully screwed into the couplers and tightened by pipe wrench, the connection inside the coupler would be properly secured and should be "butt-to-butt" in colloquial terms.

(9) It should be pointed out that the focus here is not about whether the connection is "butt-to-butt" but whether the threaded rebars

were properly screwed into the couplers and fully tightened on both sides in accordance with BOSA's specifications as set out in QSP (and also as taught by BOSA in the training sessions). Provided that proper supervision is carried out in accordance with the QSP, visual inspection to ensure that the exposed threads of the continuation bar does not exceed 2 in accordance with BOSA's specification is a reasonable and practical compliance check which should be carried out by the Leighton's Quality Control Coordinator.

50. Step 4 of the Coupler Installation Method states that fully engaging the thread to the coupler should develop full tensile strength **[A1/275]**. The QSP further states, "*BOSA CNC threading machines are always programmed by default to allow a positive tolerance on the thread length. This is to ensure butt-to-butt connections can always be achieved when the rebars are spliced inside the coupler.*" **[H9/4280]**. In a letter dated 7 January 2019, BOSA further confirms to the BD that its 40mm diameter Type 2 coupler (a) has a thread length of 44 mm with a maximum positive tolerance of one thread or 4mm, (b) its couplers require around 10 full threads engagement for a correct connection, and (c) it is an important feature of its design to ensure butt-to-butt connections can always be achieved when the rebars are spliced together, otherwise the coupler assembly will be loose **[H26/45479-45481 & 45640-45643]**.

51. It is submitted that, Leighton being the main contractor for the work and the proposer for the use of BOSA's splicing system, it is reasonable to expect and incumbent upon Leighton to ensure that (a) the threaded length of the rebar produced by BOSA were as specified, namely ranges from 44 mm to 48mm (which under normal circumstances is mostly 46 mm), (b) its steel fixers were properly trained for the installation work

and duly informed, and if necessary reminded, of the requirements of BOSA. During the execution of the coupler connection work, Leighton was also required to provide full time and continuous supervision to ensure that the steel fixers performed the work in accordance with the method of installation specified by BOSA in order to meet the requirements specified in the acceptance letters.

52. As to MTRCL, being the project manager of the SCL project with a responsibility to supervise the construction works on site, it is also reasonable to expect and incumbent upon it to ensure that the couplers supplied and the threaded bars produced by BOSA are in compliance with its T & QA Manual, its specification and the QSP, and Leighton (and its steel fixers) performed the coupler assembly works in strict compliance with the method of installation specified by BOSA and the requirements set out in the QSP and the acceptance letters.

Acceptance criteria adopted by the Government

53. Pursuant to BOSA's method of installation, upon tightening of the threaded bar, there would be a minimum engagement of 40mm (in the case of continuation bar, see table in paragraph 49(5) above). BOSA further confirmed to BD that its couplers require around 10 full threads engagement for a correct installation **[H26/45640 §3]**. Hence, for the purpose of assessment under the Holistic Report, the Government set the acceptance criterion for the coupler connections at 40 mm actual engagement. It is to be noted that 'butt-to-butt connection' was not part of the acceptance criteria for coupler connections under the said assessment.

54. In the Holistic Proposal **[G17/12970-12999]**, for the purpose of Stage 2 investigation, MTRCL proposed to use PAUT (which was subsequently

enhanced in March 2019) to detect the degree of thread engagement in a coupler connection. For obvious reason, actual unscrewing of the coupler connections for direct measurement is not feasible and other forms of destructive testing method are undesirable. The proposal to detect the actual engagement length by PAUT was therefore accepted by the Government.

55. However, there is a limitation in PAUT, namely there is a tolerance of 3mm in PAUT measurement. In other words, for a particular measurement by PAUT, the actual engagement inside the coupler may be + or – 3mm. Hence, for the required actual engagement of 40mm, the corresponding measurement taken by PAUT may vary from 37mm to 43mm. Adopting an acceptance criterion of 43 mm measurement by PAUT would be unfair to Leighton and the result would unlikely represent the true picture of the quality of coupler connections in the structures.

56. Upon further consideration with MTRCL, it was decided to give Leighton the benefit of the doubt and thus set the acceptance criterion at 37mm measurement by PAUT. If the PAUT measurement is less than 37mm, there can be no argument that the actual engagement length is insufficient, i.e. 40mm or less. On the contrary, any PAUT results showing an engagement length between 37mm and 43mm may still have a chance to have the actual engagement length less than 40mm. The Government and MTRCL were mindful that for a connection giving a PAUT measurement of 37mm, the actual engagement length may well be as low as 34 mm. In order to reduce the number of such extreme cases being unintentionally accepted due to the limitation in PAUT, the Government and MTRCL decided to apply a further acceptance criterion of “not more than 2 threads exposed” on the basis that if the connection work had been

properly carried out, an actual engagement of less than 40mm would likely have more than 2 threads exposed. It was for this reason that the acceptance criteria were set at (a) a minimum measurement of 37mm by PAUT and (b) not more than 2 threads exposed.

57. Although with the said acceptance criteria, a partially engaged coupler connection may also be treated as compliant coupler connection by MTRCL or the Government under Stage 2 investigation, it is submitted that it does not constitute a waiver of the requirement for fully engaged coupler connection, which is in fact the requirement of Leighton's own material supplier, BOSA. The reality is that for the purpose of determining reasonable acceptance criteria, a line had to be drawn somewhere. As discussed above, the acceptance criteria were adopted in the present case in order to take into account the limitation of PAUT and also to try to obtain results which will reflect the quality of the coupler connections (with a benefit of the doubt also being given to Leighton as a matter of fairness). It can be seen from the Holistic Report that, when the length of actual engagement can be directly measured for those exposed coupler connections that have been cut and unscrewed for investigation, the acceptance criterion remains as 40mm **[OU5/3235 §10; 3254 §3.3.20 & Appendix B3].** These factors should be carefully taken into account before one seeks to criticize the appropriateness of the acceptance criteria.

58. As to Professor McQuillan's observation that all the samples of coupler assemblies he had been provided were of threaded lengths of only 44 mm **[Transcript on 7.1.2020/136:10-24]**, it is submitted the factual evidence given by both Mr Paulino Lim of BOSA and Mr Neil Ng, the Project Manager of MTRCL, confirms that the threaded bars used on site were of threaded lengths range from 44mm to 48mm (see Paulino Lim's evidence at **[Transcript on 17.12.2018/98:22-100:3]**; Neil Ng's evidence at

Transcript on 24.9.2019/62:20-25; BOSA's letter at **[H26/45640]**). This is in line with BOSA's specification **[A1/595]**.

59. Even if the threaded bars supplied by BOSA for the construction work were all of a threaded length of 44mm, it would still have been Leighton's responsibility to adjust its guideline for visual inspection to that of "no thread exposed" and inform its workers and supervisors accordingly.

Statistical analysis for estimating the defective rate of coupler connections

60. The binomial statistics adopted in the Holistic Proposal for the assessment of the defective rate of coupler connections was proposed by Arup **[ER1/item 11.1 §23 and ER1/item 12/Yin1 §1.2.1]**. Both Professor Yin and Dr Glover consider that the adoption of binominal analysis was appropriate in the circumstances (Dr Yin's evidence at **[ER1/item 12/Yin1 §§1.3.1 to 1.3.5 & 3.2.2**; Dr Glover's evidence at **Transcript on 7.1.2020/142:23-143:10])**. It is because for the purpose of code compliance (which was the benchmark adopted in the assessment under the Holistic Report), a coupler connection either passes or fails the "acceptance criteria" and Code requirement, there cannot be passes of different degrees.

61. The simple ratio between the number of defective couplers and the total number of samples obtained from the results of the opening-up investigation could not be applied directly for the determination of the strength reduction factor for the entire population of coupler connections. To obtain an estimated defective rate on proper statistical basis and with a confidence level of 95%, a conversion has to be done, and the mathematical formula and the corresponding conversion table are set out

by Professor Yin **[ER1/item 12/Yin1 §§1.4.1 to 1.4.3]**. Upon statistical analysis, the coupler defective rates at EWL and NSL slabs (with a confidence level of 95%) were estimated at 36.6% and 33.2% respectively. Such estimates were independently verified by MTRCL **[ER1/item 12/Yin1 §§3.1.4 & 3.1.5]**.

62. For the estimation of the coupler defective rate in Area A, as the coupler connections in question are double-sided – see diagram reproduced in Dr Glover's expert report **[ER2/item 16/Glover1 §7.25]**, a different approach was adopted to determine the combined defective rate in order to account for the condition on both sides of coupler connections, detailed explanation is given by Professor Yin in section 4.2 of his report. On the basis of the results of the opening up done in Area A, namely 2 out of 7 samples on the side of the EWL slab failed and 2 out of 11 on the capping beam side failed, the combined defective rate estimated (with a confidence level of 95%) was determined to be 68.3% **[ER1/item 12/Yin1 §4.2.6]**. Professor Yin further stated that if the overall failure rate of the EWL slab was used as the failure rate on the EWL slab side instead, the combined failure rate for Area A would be reduced to 56% **[ER1/item 12.4; Transcript on 27.9.2019/151:19-153:12]**.

63. Professor McQuillan suggested that the estimated defective rate of 36.6% for EWL slab should have been adopted for Area A because only one side of the coupler assembly will fail, if at all **[ER2/item 15/McQuillan1 §§38, 39 & 45]**. With respect, this is incorrect, as the doubled-sided coupler assembly has 2 weak points, one on each side, the chance of finding a defective coupler assembly (which may fail on either side) would be higher. The adoption of the defective rate on either one side is only true on the assumption that the other side is always properly connected. It is a matter of probability and it was agreed by Dr Glover.

In Dr Glover's assessment, he also recognized the increased chance of failure in doubled-sided coupler assemblies by calculating the combined failure rate using probability theory, although the result provided thereby would not be of a confidence level of 95%: see **[ER2/item 16/Glover1 §§7.29-7.32 & 7.38; Transcript on 8.1.2020/70:2-72:8]**.

64. It is not in dispute that partially engaged couplers fail to comply with the requirement of not more than 0.1mm permanent elongation under the permanent elongation test. Mr Southward, Dr Glover and Professor McQuillan agreed that it was due to the effect of 'bedding-in" of the threads **[ER2/item 18.3/JEM §1]**. Dr Lau is concerned with the effect of slip movement or the so-called "bedding-in" of the partially engaged couplers in the structures on the crack width of the concrete structure. He opined that the partially defective coupler connections would generate crack width in excess of 0.3mm allowed under the Code and have an adverse impact on the deflection and durability of the structures **[Transcript on 6.1.2020/1:18-2:6 & 79:12-83:21; ER2/item 17.1/Lau1 §56]**. In cross examination, Dr Glover confirmed that so far the effect of the partially engaged couplers on crack width had not been looked into or studied by any party **[Transcript on 8.1.2020/60:10-62:7]**.

65. Even if one is to consider the strength of the partially engaged couplers only, Dr Lau is of the view that the number of tests performed by MTRCL and GCE on such coupler assemblies is not sufficient to establish the strengths for structural assessment, one would need a full programme of testing **[Transcript on 3.1.2020/132:17-24; ER2/item 17.11/Lau's slide 19]**.

Non-compliant shear links in platform slabs

66. Because of the honeycombing at the soffit of the EWL slab (see location plan at **[OU5/3328]**), MTRCL noticed the shear links that were exposed fail to conform to the accepted design. Further opening up works were carried out at 18 locations of the soffit of the EWL slab for investigation. In total, inspections were carried out at 40 locations (including the 22 locations of honeycombing), the results of the investigation are summarised in Appendix B8 of the Holistic Report **[OU5/3332]**. Out of a total of 40 locations, no shear link was found at 16 of them. There are also other areas where the number of shear links observed is grossly insufficient, see for example DS 7 and DS 19 where only one shear link was observed over a large area exposed **[ER2/item 17.10/27&72]**. It is to be further noted that the honeycombing in some of these areas goes deep into the slab (up to almost 300mm), it throws doubt on the suggestion that the shear links might have been hooked to an inner layer of the bottom reinforcements.

67. In view of the questionable condition of shear links observed at the soffit of the EWL slab, MTRCL considered that it was appropriate to ignore the contribution of the shear links that may exist in the slab for the purpose of Stage 3 Structural Assessment. Dr Lau is also of the view that ignoring the contribution of any shear links (of a somewhat uncertain arrangement) in the slab is justified and appropriate in the circumstances **[ER2/item 17.1/Lau1 §§119 & 137; item 17.11/Lau's slide 28]**. In view of the fact that 16 out of 40 locations inspected are found to be without trace of shear links, Dr Lau is concerned with the risk of complete lack of shear link at critical locations where they are required [**ER2/item 17.1/Lau1 §§121, 124, 126, 135 & 137; Transcript on 6.1.2020/2:21-3:6]**. On the assumption that there is no shear links in the platform slabs, "suitable

measures" are required at locations where there are insufficient punching shear capacity **[ER2/item 17.1/Lau1 §64]**.

68. As to the use of a higher concrete strength (obtained from results of cube tests on the concrete delivered to site) for the assessment of the shear capacity of the as-built structures, it is to be noted that extensive honeycombs were discovered at the soffit of the EWL slab. According to the Holistic Report produced by MTRCL, 19% of the areas of the soffit of the EWL slab inspected suffer from honeycombing **[OU5/3262 §3.5.11]**. This is alarming and Dr Glover considers the situation "very unsatisfactory" and "totally avoidable" **[Transcript on 8.1.2020/15:3-9]**.

69. The extensiveness of honeycombs at the soffit of the EWL slab naturally gives rise to reasonable doubts as to the quality of the concreting works for the platform slabs. It is indisputable that concrete with honeycomb would not provide the same strength as designed or expected **[Transcript on 8.1.2020/15:17-21 & 19:18-20]**. Dr Lau therefore opines that one should not make use of the apparent higher concrete strength in structural assessment **[Transcript on 6.1.2020/4:3-5:3]**.

Defective construction joint at the connection between EWL slab & D-wall

70. All experts agree that it is a workmanship issue **[ER2/item18.3/JEM §3]**. The only difference between Dr Lau and Professor McQuillan is (a) whether the dowel bars proposed by MTRCL and its design consultant are necessary from a structural point of view, and (b) whether the installation of dowel bars which involves coring a vertical hole of 32mm diameter into the D-wall would accidentally cut any shear reinforcement in the D-wall and thus cause structural damage to the as-built station structure.

71. Dr Lau is of the opinion that dowel bars that are being installed pursuant to the accepted "suitable measures" would reduce the internal stress in the connection, reinstate the intactness of the joints and help to reduce cracking **[Transcript on 3.1. 2020/153:19-25, 154:1-2; on 6.1.2020/6:1-14]**. Obviously, the said dowel bars have been considered necessary, by MTRCL and its consultant.

72. In respect of the installation of dowel bars at the construction joint, Professor McQuillan expressed concern about the risk of damaging the shear links by the coring operation **[Transcript on 8.1.2020/166:2-16; ER2/item 15.3/McQuillan's slide 56]**. Dr Lau however opines that such risk is extremely low **[Transcript on 6.1.2020/118:8-120:5; item 17.11/Lau's slide 5]**. Although Mr Southward also expressed similar concerns but he accepted that if one follows the procedures set out in Leighton's method statement, the risk of damaging or cutting a shear reinforcement would be reduced **[Transcript on 3.1.2020/76:7-79:17]**. While Professor McQuillan's concern is nevertheless duly noted by the Government, in consideration of the following factors, the Government decided not to intervene at this stage but to continue to monitor the works paying particular attention at the coring operation:

(1) Installation of dowel bars and drill-in bars involving similar coring operation is commonplace in Hong Kong;

(2) Leighton has extensive experience on such operation, a lot of drill-in bars[1] with similar operation had been installed by Leighton on the surface of the D-wall where the reinforcements inside the wall

[1] See **[H14/10848, 10849, 10997, 10998, 11017 to 11020, 11130]** etc.

are even more congested[2], so far no report of accidental cutting of steel bars during the coring operation has been received;

(3) No other professionals (including MTRCL) have ever expressed similar concerns in the past;

(4) Installation of dowel bars involving similar coring operation was also approved as part of the rectification works for the original stitch joint and there was no reported incident of cutting of steel bars[3];

(5) As of 16 January 2020, 29 out of 47 core holes required had been drilled by Leighton, while steel bars were encountered during some of the coring operations, as indicated in Leighton's method statement[4], the operator managed to notice it and stopped the coring operation. So far, no shear links in the D-wall has been damaged;

(6) Professor McQuillan confirmed in cross examination that as there is no shear stress in that part of the D-wall, no shear link was actually required from a structural point of view. Hence even if a shear link is accidentally damaged during one of these coring operations, it would not give rise to any structural concern[5];

(7) Dr Glover is of the view that given the diameter of the hole which would need to be drilled, "the risk of you hitting anything important is much reduced **[Transcript on 7.1.2020/115:1-7**]; and

---

2 See photos at **[F2/1047, 1052, 1054, 1075]** etc. There are usually more than one layer of reinforcement - see photos at **[F2/1078, 1079]**.

3 See Note 5 and construction sequence 1 to 4 on drawing at **[DD4/2264]**.

4 **[OU9/11402-11403]**.

5 **[Transcript on 9.1.2020/31:20-33:12]**.

(8) A suspension of the works at this stage would have serious consequences on time and costs and inevitably result in further delay to the commissioning of the SCL.

B4. Are the as-built structures (i.e. without the implementation of "suitable measures") fit for purpose from a structural engineering perspective?

73. In order to answer the question as to whether the as-built structures are "fit for purpose", one has to first ascertain the "purpose" for which the structures are built. It is indisputable that MTRCL was commissioned by the Government (and Leighton was appointed as main contractor by MTRCL) to build the structures in question as part of the railway systems in Hong Kong. Hence, if the structures are not allowed to be put into use as such because they do not achieve the level of structural safety required under the Code and the BO, they cannot be said to be "fit for the purpose" they are intended.

74. There is no dispute that certain parts of the as built structures fail to comply with the requirements of the Code and/or BO. Although the SE experts may disagree on the extent and aspect of such non-compliances[6], without the implementation of any "suitable measures", the works cannot be put in operation due to such non-compliances. To that extent, they cannot possibly serve its intended purpose and hence are not fit for purpose.

75. Other than the above consideration, it is to be further noted that one of the parameters relevant to the question of whether the structure is considered fit for purpose relates to the width of the cracks to be generated under design working loads **[ER2/item 17.1/Lau1 §§38, 39, 42 & 43]**. As

6 The Commission is however not required to resolve the differences between the SE experts in this regard.

mentioned in paragraph 64 above, if the crack width generated is excessive (i.e. in excess of 0.3mm specified in the Code[7]), it would have an impact on both the durability and serviceability of the structures. In that regard, Dr Lau is of the view that, on the basis of the results of the tests performed on specimen of partially engaged couplers, due to out-of-slip movement (or "bedding in" – see **ER(COI2)1/item 14.3/JEM §1**) of the partially engaged couplers, the total permanent elongation measured exceeded 0.1mm as specified in the Code, the width of the cracks thus generated in the structure would exceed the allowable limit of 0.3mm and the deflection of the affected structural element may also be excessive, which are unacceptable **[ER2/item 17.1/Lau1 §§56 & 57]**. Also on this basis, Dr Lau opines that the as-built structures are not fit for purpose. It is to be noted that at the moment, there is no detailed study on the effect of the partially engaged couplers on the long-term performance and behaviour of the structures **[Transcript on 8.1.2020/60:10-62:7]**. Hence, the concern remains.

76. Although Mr Southward pointed out in his oral presentation **[ER2/item 14.9/Southward's slides 7-9]** that the station box structure is only subject to "Exposure Condition 1" which, pursuant to Note 1 of Table 7.1 of the Code **[H8/2928]**, the crack width would have no impact on the durability of the structure, it is submitted the station box structure in its present location could not possibly be subject to "Exposure Condition 1". Pursuant to the classification in Table 4.1 of the Code **[H8/2857]**, internal concrete surfaces exposed to high humidity, e.g. bathrooms and kitchens, are considered to be subject to "moderate" exposure (i.e. Exposure Condition 2) while structures on or near the coast have to be designed as subject to "severe" exposure (i.e. Exposure Condition 3). From the

7 Cl. 7.2.1 of the Code **[H8/2928]**.

concrete cover specified by Atkins for the concrete works of the station box structure, it is clear that Atkins did not consider that the station box in question is only subject to "Exposure Condition 1" for the purpose of the Code[8]. Further, the diaphragm walls were installed near the coast subject to tidal fluctuation between the sea and the station box and there is no reason why they would not be subject to a high level of humidity.

77. Dr Lau is of the view that the station box structure is subject to an exposure condition between "moderate" (i.e. Exposure Condition 2) and "severe" (i.e. Exposure Condition 3) **[Transcript on 6.1.2020/31:2-3]**. This is in line with the concrete cover specified by Atkins for the station box structure.

78. In the premises, excessive crack width would adversely impact the durability of the structures and thus render the same not "fit for purpose".

C. <u>Project Management – Recommended Enhancement Measures Relating to the Government</u>

79. The Government welcomes the Commission's recommendations in its Interim Report on strengthening the existing supervision, monitoring, control and management systems of the Government.

80. Since the making of the Interim Report, the Government has been proactively implementing the improvement measures suggested by the

---

8 Pursuant to Table 4.2 of the Code **[H8/2858]**, the concrete cover for grade 40 concrete required for structure subject to Exposure Condition 1 and 2 are 30mm and 35mm respectively. In Atkins' design, the concrete covers specified for the EWL top slab and 'Diaphragm Wall-Non Soil Face' are 40mm and 95mm respectively **and the crack width limit is 0.3mm for providing adequate durability [Table 5.5 at H14/19168]**, it is therefore plain that Atkins considered and designed the station box structure as a structure to be subject to an exposure condition more severe than Exposure condition 1.

Commission and Mr Steve Rowsell, i.e. the Commission's project management expert. To update the Commission on the steps taken by the Government so far in implementing those recommendations and the further steps which the Government intends to take to further strengthen its monitoring system, we have prepared two tables as follows:

(1) **Table A**: Progress Report Regarding the Commission's Specific Recommendations for the Government Set Out in the Interim Report.

(2) **Table B**: Progress Report Regarding Mr Rowsell's COI-1 Recommendations for the Government Set Out in Appendix F to the Interim Report.

81. In short, all of these recommendations are either implemented or in the process of being implemented.

82. For example, in relation to the Commission's recommendations on promotion of partnership, collaboration and communication, the Government wishes to report that HyD and MTRCL established a high-level Steering Group on Communications (**"SGC"**) for the SCL project in May 2019. The SGC aims to enhance the effectiveness of communication between the Government and MTRCL and ensure that the reporting of project matters from MTRCL to the Government is timely, with appropriate context and pitched at the right level. The SGC does not supervise the project *per se*, but focuses on promoting collaborative working relationships and culture in delivering the SCL project to achieve a quality outcome.

83. Guided by the SGC, some other recommendations made by the Commission have been implemented.

(1) First, a Senior Leadership Round-table workshop was held among the senior representatives from the Government, MTRCL and key contractors/subcontractors of active contracts under the SCL project on 10 January 2020. Senior leaders discussed the challenges in project delivery and exchanged views in such areas as cross-party collaboration, trust and reward to staff. As a follow-up, there will be a bi-monthly survey on partnering behavioural changes until December 2020.

(2) Second, a review of the three-tier project supervision structure (i.e. the Project Supervision Committee Meeting, Project Coordination Meeting and Project Progress Meeting) has been completed. With the SGC's endorsement, enhancement measures have been implemented to rationalise the arrangement for escalating issues from lower tier to higher tier meetings. PSC meetings have also been divided into two parts, with Part II, attended by a smaller number of more senior members, dealing with more strategic and sensitive issues.

(3) Third, co-location working arrangement between the Government and MTRCL has started. Since July 2019, a HyD's in-house inspectorate team is stationed at MTRCL's site offices. With first hand understanding of the up-to-date arrangement of site works, especially the critical work fronts, HyD can monitor the site works and its progress more closely and independently, i.e. without having to place excessive reliance on MTRCL's reporting. More frequent site inspections, including surprise checks, are being carried out to verify the quality of works as well as effectiveness of MTRCL's supervision regime.

84. Some recommendations made by the Commission are in the course of being implemented. For example, on rationalising and clarifying rules and requirements, BD is taking two follow-up actions. The first one is drafting a new practice note, which will consolidate various requirements relating to specific tasks and testing of materials (e.g. QSP for installation of ductility coupler splicing assemblies, on-site sampling for testing, etc.). The second one is drafting amendments to the Code of Practice for Site Supervision 2009 **[B5/2676-2795]**, which will, among others, clarify the definition of supervision, record keeping requirements and non-conformance reporting as well as strengthening the requirements on obligations of the site supervisory personnel and the communication among the site supervisory personnel to ensure delivery of design intent in the construction. BD plans to consult the industry on the two draft documents in February 2020.

85. BD is also working with MTRCL on the introduction of a fast track consultation process so that certain types of "minor changes" could be processed within a shorter period of time (e.g. within 7 days) through an enhanced communication system and working arrangement with MTRCL and its consultants/contractors.

86. The Commission's other recommendations, especially those concerning governance and monitoring and verification of railway projects, are subject to further studies and planning. The Government will commission, by the end of January 2020, a consultancy to look into the Government's monitoring and control regime, as well as delivery approach in implementing future railway projects. Specifically, it will study delivery approaches adopted in major rail infrastructure projects overseas, the pros and cons of the "check the checker" mechanism under the concession approach and the monitoring mechanism under the

ownership approach, and issues relating to establishing a new department specifically tasked to handle and supervise railway planning and delivery matters, etc.

D. Other Aspects of Project Management Evidence – "Full-time and Continuous Supervision"

87. Another issue regarding project management relates to the meaning of the requirement of "full-time and continuous supervision" **[Transcript on 8.10.2019/2:13-3:10]** that Leighton intends to re-open and re-argue.

88. This issue has already been dealt with by the Commission (*albeit* provisionally) in the Interim Report:

(1) During COI-1, the Commission heard evidence that Leighton's factual witnesses understood "full-time supervision" to mean simply that the person carrying out the supervision must be fully engaged on the project as opposed to working part-time, whereas "continuous supervision" meant no more than a normal daily supervision and inspection regime: Interim Report §282 **[A2/803]**.

(2) The Commission rejected such understanding and accepted the contrary interpretation advanced by Mr Rowsell, i.e. the Commission's project management expert, in that:-

(a) The requirement that the quality supervision should be full-time and continuous was because it was recognized that the process would be technically difficult with a high risk of problems being encountered;

(b) Full-time and continuous supervision means that Leighton's supervisor needs to be present at all times where mechanical coupler works are underway. The objective is to ensure that the work is done properly in accordance with the specifications and any problems are resolved without delay;

(c) This obligation also means that Leighton's supervisor needs to be present at the site of the work activity rather than being present elsewhere on site or in the site office carrying out other tasks. Clause G3.9.1 of the General Specification **[C3/2040]** requires that the work shall be arranged so that the works are supervised at a minimum ratio of one supervisor to no more than 10 workers. Therefore, if the number of workers involved in the coupler works is greater than 10 then there should be more than one supervisor in attendance.

(Interim Report §§281-293 **[A2/803-806]**)

89. In the course of hearing evidence on project management in Part 2 of the Inquiry, Leighton's expert witness, Mr George Wall, argues that:

(1) There is a difference between the standard of "full time and continuous" supervision and the allegedly lower standard of merely "full-time supervision". The "continuous" requirement is allegedly only applicable if the coupler works are subject to a ductility requirement as determined by the working drawings made available to Leighton by MTRCL **[ER(COI2)1/item 5/Wall §75]**.

(2) It is not practical to have an engineer present on site looking at the coupler works all of the time that the works are being carried out **[ER(COI2)1/item 5/Wall §74]**. Instead, the fact that the engineers supervising the coupler works tended to spend approximately 70%

of their day on-site supervising the works (i.e. 3 to 4 hours in the morning followed by a further 3 to 4 hours in the afternoon) is broadly in line with industry practice on construction sites in Hong Kong, and such practice would purportedly fulfil the requirements of "full-time and continuous supervision" **[ER(COI2)1/item 5/Wall §76]** .

(3) The supervision ratio of 1:10 as specified in Clause G3.9.1 of the General Specification allegedly relates only to health and safety and not quality assurance matters **[ER(COI2)1/item 5/Wall §73]** .

(4) It has also been repeatedly mentioned by counsel for Leighton that the requirement of "full-time and continuous supervision" does not mean "man-marking" **[Transcript on 4.10.2019/114:13-16; on 10.10.2019/38:15]**.

90. In response, Mr Rowsell again expressly rejected the interpretation of the phrase "full-time and continuous supervision" put forward on behalf of Leighton:

(1) The supervision requirement flows from BD's Acceptance Letters (see e.g. **[H9/3901-3903]**) and the QSP which MTRCL submitted to BD **[H9/4265-4280] [Transcript on 10.10.2019/37:12-23]**.

(2) For situations where there are ductile couplers, QSPs are required and those QSPs required full-time and continuous supervision, but where there are couplers without the ductility requirement, there is still a need for full-time supervision **[Transcript on 10.10.2019/37:23-38:2]**.

(3) "Full-time supervision" and "full time and continuous supervision" mean the same thing. "Full-time" would mean the full-time

presence of the supervisor on site. "Continuous" would be indicative that those supervisors should be dedicated to a supervision role **[Transcript on 10.10.2019/38:4-14]**.

(4) While the requirement does not mean man-marking, what is required is a continuous presence of the supervisors. Under the General Specification there is a requirement of a minimum of one supervisor for every ten workers. In a working area, one supervisor can probably quite easily see generally what those 10 workers are doing, whether they are working in a safe manner, and whether they are generally following the quality procedures **[Transcript on 10.10.2019/38:16-39:14]**.

(5) Ultimately, it is a simple, pragmatic view that the supervisor needs to be there full-time and continuously supervising, in view of the need to ensure that in those high-risk areas, the works are properly built and properly supervised **[Transcript on 10.10.2019/39:15-40:2]**.

(6) It is not correct for Leighton to suggest that the ratio stipulated in Clause G3.9.1 of the General Specification **[C3/2040]** does not cover quality assurance matters. The provision is clearly about site supervision, and is included there because one of the aspects of supervision is to ensure that all works on site are carried out safely **[Transcript on 10.10.2019/54:9-55:11]**.

91. The Government agrees with the observations of Mr Rowsell. Ultimately, the applicability and the meaning of the supervision requirements must accord with common sense.

92. As the Commission rightly observed, the requirement of "full-time and continuous supervision" should be understood in the context that the

objective of such supervision is to ensure that "*the works are carried out in a way that, when they are presented for inspection, they will pass that inspection*" **[Transcript on 10.10.2019/45:6-15 & 47:21-48:8]**. Mr Rowsell's understanding of the requirements will ensure that such fundamental objective will be achieved. In practice, such requirement can be complied with by assigning a supervisor (with proper training and knowledge of the requirement of BOSA couplers) to station at the work area where coupler connection works are being carried out. According to the factual evidence adduced in Part 1 of the Inquiry, different parts of the platform slabs were constructed in phases (EWL: **[B17/24198-24199** and NSL: **[B5/2903]**), and the area covered in each phase was not particularly extensive. With the presence of a supervisor, there can be no cutting of threaded bars on site. Any problems encountered can be timely resolved and any non-conformities can be readily identified and rectified.

93. The Commission would also recall that Mr Ho Hon Kit, Assistant Director of BD, explained the rationale behind the requirement of "full-time and continuous supervision" as follows, namely to deter non-compliant / corner-cutting activities **[Transcript on 18.12.2018/93:3-21]**:

> *"I believe that as long as the quality control coordinator, during the process of bar fixing, including screwing in of rebar with couplers, as long as the supervision was done within his line of sight -- well, perhaps it was at a time when some bars, they may be ordinary bars or threaded rebars, that had been lifted onto the site -- during the continuous supervision, the coordinator could conduct visual inspection on the length of the thread, to see if they were shorter. At the site, no one could do anything like cutting the threaded rebar. At the same time, the coordinator could supervise on bar fixing and the installation of coupler with rebar. The*

coordinator was fully aware of the situation. As I said, as soon as he knew that the screwing in was completed, he would go over to conduct compliance check to ensure that it was fully screwed in. In the entire process, he has met the requirement of full-time and continuous supervision."

94. In any event, as Leighton's expert witness Mr Wall acknowledged, as a matter of fact Leighton failed to provide full-time supervision of the coupler works **[Transcript on 4.10.2019/118:12-119:2]**.

Dated 17 January 2020.

Richard Khaw SC

Anthony Chow

Martin Ho

Ellen Pang

Counsel for the Government

Department of Justice

Solicitors for the Government

Table A

Commission of Inquiry into the Construction Works at and near the Hung Hom Station Extension under the Shatin to Central Link Project

Progress Report Regarding the Commission's Specific Recommendations for the Government Set Out in the Interim Report

Item	Reference (Interim Report §)	Recommendation	Actions taken / to be taken
(1)	442, 444	Government sponsorship of rail enhancement projects – there should be the establishment of a single point of responsibility within the Government. To critically address the way in which the Government executes its multiple roles in relation to railway enhancement projects, active consideration should be given to creating an overall Government "sponsor" role for all individual projects to take responsibility on behalf of the Government.	- To be implemented subject to findings of a consultancy which looks into the Government's monitoring and control regime, as well as delivery approach in implementing future railway projects ("**the Consultancy**"). - The Consultancy will be commissioned in January 2020 and is expected to complete in a year. - The Government would take the consultant's findings into account when considering the structure and composition of any new department specifically tasked to handle and supervise railway planning and delivery matters.
(2)	451	Foster collaboration – there should be created a more collaborative (as opposed to adversarial) culture between the Government, MTRCL and contractors, with a leading role taken by the Government.	- Implemented. - HyD and MTRCL established a high-level Steering Group on Communications ("**SGC**") in May 2019, aiming to enhance the effectiveness of communication between the Government and MTRCL and ensure that the reporting of the Shatin-to-Central Link ("**SCL**") Project matters from MTRCL to the Government is timely, with

			appropriate context and pitched at the right level. It also focuses on promoting collaborative working relationships and culture in delivering the SCL project to achieve a quality outcome. - HyD directorate officers have started meeting with senior representatives from the MTRCL construction team, the Monitoring and Verification ("**M&V**") consultant, contractors, sub-contractors and suppliers of construction materials during their regular visits to sites at key construction stages.
(3)	452	The Buildings Department may work much more closely with MTRCL and its designers and contractors in order to facilitate dialogue on all engineering matters.	- Implementation underway. - BD is working with MTRCL on the introduction of a fast track consultation process so that certain types of "minor changes" could be processed within a shorter period of time (e.g. within 7 days) through an enhanced communication system and working arrangement with MTRCL and its design consultants/contractors.
(4)	454	There should be the introduction of new contract forms such as NEC3 and NEC4 and the introduction of collaborative initiatives such as partnering and alliancing.	- Implemented. - The adoption of collaborative approach (by NEC form) in the procurement and management of public works projects has been an established Government policy. Up to 2019, more than 180 NEC works contracts have been awarded.

			- As regards rail projects, while the project manager should determine the most appropriate contract form and contract package, HyD organised an experience-sharing session with MTRCL on the implementation of NEC contracts in public works projects under HyD's management on 13 December 2019.
(5)	454	Building Information Modelling ("**BIM**") should also be utilised to improving trust and performance on performance delivery.	- Implemented. - The Government set out in end 2017 the requirement to use BIM technology in major capital works projects (exceeding $30M) to enhance project management. It is also exploring wider use of BIM through trial projects to facilitate off-site prefabrication, site supervision, asset management and integration with geospatial data for smart city planning. - Insofar as public works projects are concerned, as at end December 2019, 224 consultancy agreements/works tenders with BIM adoption have been invited and 162 consultancy agreements/works tenders have been awarded. - For future railway projects, HyD will impose the use of BIM as a standard requirement. Additionally, HyD organised an experience sharing session with MTRCL on the implementation of BIM in projects under HyD's management on 6 December 2019.

(6)	455, 471	There may also be established a Senior Leadership Forum, comprising the Government, MTRCL, its contractors and leaders of major sub-contractors in order to monitor working relationships and cultural aspects of service delivery and to agree ways of developing collaborative working.	- Implemented. - A Senior Leadership Round-table, with participation of senior representatives from the Government, MTRCL, contractors and major subcontractors, was held on 10 January 2020. Senior leaders discussed the challenges in project delivery and exchanged views in such areas as cross-party collaboration, trust and reward to staff. - A bi-monthly survey on partnering behavioural changes will be carried out from March to December 2020.
(7)	460	Ongoing monitoring of station structure – the east and west diaphragm walls and EWL and NSL platform slabs should be instrumented to detect movement during the operational phase of the station, by way of fibre optics or other approved measures.	- Implementation underway. - To allay public concerns, we remain supportive of the Commission's recommendation in its Interim Report in relation to long-term monitoring. In fact, Preliminary Recommendation No. 2.6 in the EAT's Interim Report No. 1 is consistent with the Commission's recommendation, namely that "*MTRCL should consider supplementing the automatic deformation monitoring system 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.*" The same idea of long-term monitoring was also proposed by MTRCL in the Final Holistic Report and Verification Report - It is incumbent on MTRCL to propose the suitable form and details of the monitoring system, taking into account the latest expert evidence. The proposed system should minimise disturbance to the railway operation while providing reliable

			information and an alert system on any signs of abnormal structural behaviours. As regards the potential false alarm due to high sensitivity, it could be minimised by calibration. - In addition, in view of the concern on poor workmanship, the Government has asked MTRCL to provide additional quality assurance and/or undertakings in respect of the structures.
(8)	473-474	Ensure competence of personnel – the Government should review the "competence" requirements for personnel engaged in project management/sponsorship roles and should review checks and procedures to ensure ongoing competence of project-related staff. Effective measures should also be in place to reduce the risk of failure.	- Implementation underway. - The Railway Development Office ("**RDO**") of HyD is reviewing the competence requirements for its project-related staff. Subject to the results of the review, a framework for the required qualification, working experience and training requirements will be promulgated for RDO professionals. HyD is also preparing new operation procedures and/or work instruction to regularise (i) staff competence review and (ii) training for RDO professional staff, so as to ensure their ongoing competence. - HyD has been holding quarterly experience-sharing sessions for its project management staff. The experience in relation to Hung Hom Station Extension incident will be included in future experience-sharing session(s) upon the conclusion of the present inquiry. HyD will also ensure that Government site and non-site supervisory staff will receive integrity training regularly.

(9)	475	The Government should address the way in which it executes multiple roles in relation to railway enhancement projects, in particular its role as “client” and its role as “sponsor”.	See Item (1) above in relation to the Consultancy.
(10)	476	A Project Board should be established for future railway enhancement projects to provide strategic direction, comprising appropriate Government officials as board members, supported by external non-executive members from specialist backgrounds.	See Item (1) above in relation to the Consultancy.
(11)	477	Consideration should be given as to whether rail projects should remain within the portfolio of the Director of Highways, or whether a new distinct Director of Rail Development role should be established.	See Item (1) above in relation to the Consultancy.
(12)	478	Consideration should also be given as to the appropriate model to be fused for future projects, i.e. whether there should be used the “Concession” model, “Ownership” model, or the creation of a “Special Purpose Vehicle” approach with a dedicated Board and delivery organization.	See Item (1) above in relation to the Consultancy.

Table B

Commission of Inquiry into the Construction Works at and near the Hung Hom Station Extension under the Shatin to Central Link Project

Progress Report Regarding Mr Steve Rowsell's COI-1 Recommendations for the Government Set Out in Appendix F to the Interim Report

Item	Reference (Appendix F §)	Recommendation	Actions taken / to be taken
(1)	6	Review communication channels and reporting lines – the Government should review how it manages its interests in railway projects, with an aim to provide greater clarity in communication and reporting lines and more efficient project controls.	See Items (1)-(3) in Table A.
(2)	7	Clear summary of relevant requirements – the relevant requirements in relation to the Buildings Ordinance and the consultation process could be pulled together into a clearer and more precise description.	- Implementation underway. - BD is preparing a new practice note to consolidate various requirements relating to specific tasks and testing of materials (e.g. quality supervision plan for installation of ductility coupler splicing assemblies, on-site sampling for testing, etc.) imposed under the Buildings Ordinance when granting approval (or specified in the acceptance letter under the Instrument of Exemption) with a view to providing clearer and more precise description of the requirements and responsibilities. - BD plans to consult the industry via the Authorized Persons, Registered Structural Engineers and Registered Geotechnical Engineers Committee

			("**APSEC**") and the Building Sub-Committee ("**BSC**") of the Land and Development Advisory Committee in the next joint APSEC and BSC meeting scheduled for February 2020. - Also see Item (3) in Table A.
(3)	8	Extend role of M&V consultant – the role of the M&V consultant should be extended to provide a wider "eyes and ears" role to help protect Government's interests, and should provide high level monitoring of the operation of the project quality assurance systems, and also cost and programme issues. The M&V role could be developed into a Government's Project Representative role that works more closely within the MTRCL organisation.	- To be implemented subject to findings of the Consultancy (as mentioned in Item 1 in Table A). - The Consultancy will review the pros and cons of the "check the checker" mechanism under the concession approach and the monitoring mechanism under the ownership approach. The Government will then consider how the existing duties of the M&V consultant can be extended to help protect the Government's interests during project delivery. - For the SCL Project, owing to contractual limitations, HyD has since July 2019 deployed in-house inspectorate staff on various sites serving as the Government's "eyes and ears" to carry out site inspections and audits, including those surprise (unscheduled) checks. The Government has also encouraged more proactive involvement of the M&V consultant since mid-2018, such as inviting the M&V consultant to join all of the three-tier project supervision meetings and increasing the number of site visits and on-site record checks.

(4)	9	Develop working arrangements with MTRCL – working arrangements should be made such that Government staff would be integrated within MTRCL teams on a regular basis to help ensure common understanding of requirements, improve communications, undertake joint forward planning and to resolve issues more efficiently.	- Implemented. - For the SCL Project, HyD has since July 2019 deployed in-house inspectorate staff to station at MTRCL's site offices. Similar arrangements have been extended to HyD's engineers, who commenced working together with MTRCL staff at a site office initially for half a day at monthly interval since December 2019.
(5)	10	Review Project Supervision Committee ("**PSC**") – the Government should ensure that PSC operates as intended, as a high level committee focusing on strategic issues and performance, and that the reporting arrangements provide PSC with reliable performance data.	- Implemented. - For the SCL Project, starting from September 2019: (i) PSC meetings has been divided into two parts, with Part II, attended by a smaller number of more senior members, dealing with more strategic and sensitive issues; and (ii) the escalation of issues from Project Progress Meeting to Project Co-ordination Meeting ("**PCM**") and from PCM to PSC has been formalised. - On HyD's request, MTRCL has been submitting performance data on site supervision and communication, and other issues relevant to works quality, project cost and progress for review and monitoring at the PSC meetings.
(6)	11	Review Building Department's Code of Practice ("**CoP**") – the CoP should be reviewed to give clarity on the definition of supervision, record keeping requirements and non-conformance reporting. It should also set out requirements of the communication of the supervision plan and associated obligations. The overall	- Implementation underway. - BD will make amendments to the CoP with a view to further enhancing its clarity on the definition of supervision, record keeping requirements and non-conformance reporting, strengthening the requirements on obligations of the site supervisory personnel and the communication among the site

		supervisory arrangements should provide an adequate role for the designer to give assurance that the intent of the design is delivered in the construction process.	supervisory personnel to ensure delivery of design intent in the construction. - BD plans to consult the industry on the proposed amendments to the CoP in the next joint APSEC and BSC meeting scheduled for February 2020.
(7)	12	Develop a conflicts of interest policy.	- To be implemented in future contracts. - There is established policy on conflict of interest for civil servants. - HyD has requested and MTRCL has agreed to review their policy on conflict of interest. Subject to legal advice and negotiation with MTRCL, this requirement will be added to the relevant entrustment agreement or project agreement of future railway projects.
(8)	13	Review the lump sum contractual arrangement used to employ the M&V consultant – the Government should consider options which would provide a more effective incentive to the M&V consultant to be proactive in the execution of its duties.	- To be implemented subject to findings of the Consultancy (as mentioned in Item 1 in Table A). - For future railway projects, taking into account the findings in relation to the role of the M&V consultant under the Consultancy, the procurement approach and remuneration arrangement of the M&V consultant will be reviewed. - For the SCL Project, additional services would be ordered from the M&V consultant if such services are necessary and justified under the M&V agreement. -
(9)	14	Clarify requirements in M&V consultants' brief – clearer requirements should be stipulated in relation to site audits and surprise checks.	- To be implemented subject to findings of the Consultancy (as mentioned in Item 1 in Table A). - For future railway projects, taking into account the findings in relation to the role of the M&V consultant

			under the Consultancy, HyD will ensure that the requirements related to site inspections, audits and/or surprise checks are clearly set out in the M&V consultants' briefs. - For the SCL Project, HyD will continue discussing with the M&V consultant at their monthly meetings the requirements and details of site inspections and audits, such as the frequency, location and scope.
(10)	15	Ensure sufficiency of resources of M&V consultants – the Government should ensure that companies appointed to M&V roles have access to the necessary levels of resource if the level of monitoring by the M&V consultant has to be increased due to concerns about poor performance.	- Implemented. - HyD would continue monitoring the level of resources of the M&V consultant to ensure it has sufficient resources to deliver its tasks. A standing item for reviewing the level of resources of M&V consultant has been included in the monthly progress meeting since October 2019.
(11)	16	Consider options of recovering M&V audit costs – consideration should be given to recovering M&V audit costs from the defaulting party if poor performance by the contracting parties resulted in additional audits being required.	See Item (8) above in relation to the Consultancy.