

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

(formerly COMMISSION OF INQUIRY INTO THE DIAPHRAGM WALL AND
PLATFORM SLAB CONSTRUCTION WORKS AT THE HUNG HOM STATION
EXTENSION UNDER THE SHATIN TO CENTRAL LINK PROJECT)

CLOSING ADDRESS FOR THE ORIGINAL INQUIRY [COI 1]

BY COUNSEL FOR THE COMMISSION

**(in respect of the Substantive Hearings for Statistical Expert
Evidence and Structural Expert Evidence commencing on 23
September 2019 and 2 January 2020 respectively)**

References below to, for example, [ER2/#1] are references to the bundle number/tab number of the documents prepared for the Substantive Hearings, references to, for example, [ER2/2] are references to the bundle number/page number of the documents and references to, for example, [T/Day6/84:9-15] are references to the Transcript/Day 6/page 84 at lines 9 to 15.

A. Introduction

A1. General

1. These Submissions address the principal remaining matters in the Original Inquiry or "COI 1". They consider the further evidence heard by the Commission following the publication and service by MTRCL of its Holistic Report dated 18 July 2018, namely

statistical expert evidence and further structural engineering expert evidence.

2. Before addressing that evidence, however, three inter-related matters are mentioned which apply not just to the Original Inquiry but also the Extended Inquiry (or “COI 2”). These matters are mentioned because the Commission’s legal team is well aware that comments and reports from certain quarters have suggested that the Commission has not fulfilled its remit. This, it is submitted, is an entirely unfair criticism. It is submitted that the Commission may wish to make mention of the matters referred to immediately below in its Final Report.

A2. Safety, fit for purpose, execution in accordance with the Contract and code compliance

3. The word “safety” or the words “public safety” appear no less than four times in the extended Terms of Reference. As was made clear in the Commission’s Interim Report, determining whether (or not) the Hung Hom Station Extension was ‘safe’ was the paramount and overriding concern of the Commission. This unequivocally remains the position. The definition of ‘safe’ is discussed later in these submissions. ‘Safety’, however, might, if narrowly construed, be regarded as a transient state of affairs. The structure might be ‘safe’ today, but what about next week or next year or the decades to come?
4. Consequently, the Commission regarded it as appropriate to consider whether the structure was ‘fit for (its intended) purpose’,

appreciating that so far as MTRCL is concerned the structure had a design life of 120 years. The definition of ‘fitness for purpose’ is also considered further below but, in a nutshell, the question posed is whether the structure will be fit for use as an operational station for its intended life span. Addressing this question should not, it is submitted, be viewed as some sort of limitation or restriction on the Terms of Reference but rather as complementary to the safety question.

5. The Commission also expressly recognized in its Interim Report that it was mandated to ascertain whether the works that raised concerns about public safety were executed in accordance with the Contract. This, it is submitted, is the correct construction of §(a)(1)(iii) of the (original) Terms of Reference, and now also §(a)(2)(iii) thereof. On the contrary, however, the Commission was not and is not required to carry out a wide-ranging, all-embracing investigation of every potential aspect of the works, however minor or peripheral, which may not have been executed in accordance with the Contract. Accordingly, §481(1) of the Interim Report duly determined that, in material respects, the diaphragm wall and platform slab construction works were not executed in accordance with the Contract¹. Notwithstanding that determination, however, §481(2) the Interim Report rightly, it is submitted, found the structures to be safe.

6. Further, mindful of the Chief Executive’s direction that the determination of any criminal or civil liability (whether an

¹ §17 of Leighton’s COI 1 Submissions invites the Commission to withdraw that interim finding.

individual or legal entity) was outside the Commission's Terms of Reference and equally mindful that the Commission's hearings should not be used as a forum for a dry run of any future civil disputes between any of the Involved Parties (a stance that all Involved Parties agreed to), the Commission is determined not to become embroiled in detailed matters of code or statutory compliance, save insofar as the same may bear on the questions of safety and fitness for purpose. It is submitted that there is no inconsistency between the station structure being safe and fit for purpose, but nonetheless not being strictly code compliant. Indeed, it is submitted that it is not for the Commission to inquire and determine whether the station may be operated. There may well be a myriad of requirements which have nothing to do with structural safety but which, nonetheless, need to be fulfilled before the station can be opened. Ultimately, this is a matter for the Government and these requirements may well concern code compliance.

A3. Requests to the Involved Parties

7. It may seem to be a trite observation but, even though the Commission's procedures can be characterized as inquisitorial, it can only realistically inquire, investigate and call for evidence on matters which are brought to its attention. Thus, when, during the course of the evidence in the Inquiry, it became apparent that there were or might be some potentially important issues concerning BOSA couplers, the Commission itself, through its legal team, took positive steps to procure evidence (physical, documentary and a factual witness) from BOSA. If, however, a particular matter of potential relevance and interest to the Commission is not brought

to its attention by the Involved Parties or others, it is submitted that there is no basis or justification for criticizing the Commission. This point is particularly apposite to all the Involved Parties since in the initial letters of request (in both COI 1 and COI 2) they were not only requested but encouraged to come forward with information and evidence relating to the Terms of Reference. The standard wording was “...*Similarly, if there are topics not mentioned above but which Your Company considers to be relevant to the subject matter of the Inquiry, Your Company is at liberty to file witness statements covering such topics as well.*” It is respectfully submitted that, with the assistance of all the Involved Parties, the Commission has thoroughly and exhaustively looked into all matters which have been brought to its attention. No doubt any honest, respectable and responsible Involved Party with knowledge of matters potentially affecting safety (as opposed to unimportant peripheral or purely speculative matters) would have brought them to the attention of the Commission for due consideration, and the Commission should, it is submitted, make that assumption.

A4. The Extensive Investigation of the Structures

8. In §5.2 of his COI 1 Report [ER2/#16.1/8], Dr. Mike Glover (“**Dr Glover**”), who gave structural engineering expert evidence on behalf of MTRCL, stated that “*Few structures have been subjected to the degree of post-construction survey, inspection and opening up, or subjected to the sophisticated independent analysis and testing which has been carried out on the structures by a number of different parties.*” This was a view with which all

the structural engineering experts agreed, even Dr. James Lau (“**Dr Lau**”), the Government’s expert. The structures have massive reserves of strength and even adopting the most conservative assumptions only very few discrete areas require, according to MTRCL and the Government, limited so-called “suitable measures.” All of the tests and investigations carried out have generated a very high level of assurance and confidence in the structures such that even if other miscellaneous matters might be raised subsequently, there is simply no threat whatsoever to the safety and fitness for purpose of the structures.

9. From the documentation submitted to the Commission, there is no doubt that extensive assessments, analyses and calculations have been carried out on the HUH structures by leading engineering companies in the construction industry. These reports and analyses have been reviewed, analysed, discussed and debated by the structural engineering experts appointed respectively by the parties and the Commission in this Inquiry. The Task Force comprising representatives from MTRCL, BD, RDO, the Hong Kong Police Force and the Expert Advisor Team has also been overseeing every step in the Holistic Study and endorsed the Holistic Report. For the sake of completeness, a list of the structural engineering expert reports and other technical reports and analyses which were adduced to the Commission are set out below:

(A) Structural Engineering Expert Reports

| | | | |
|-----------|--|------------|---------|
| 1. | Professor Don McQuillan President of the Institution of Structural Engineers Director of RPS Consulting Engineers | | |
| | (i) Expert Report (COI 1) | 06.01.2019 | ER1/#3 |
| | (ii) Supplemental Expert Report (COI 1) | 06.12.2019 | ER2/#15 |

| | | | |
|--|--|------------|-------------|
| 2. Professor Francis Au Professor and Head, Department of Civil Engineering, The University of Hong Kong | | | |
| | (i) Expert Report (COI 1) | 07.01.2019 | ER1/#7 |
| | (ii) Opinion and Structural Checks based on design information provided by Atkins by letters dated 20 and 22 February 2019 | 01.03.2019 | OU2/917.24+ |
| 3. Dr James Lau Managing Director and Chairman of James Lau & Associates Limited | | | |
| | (i) COI Structural Engineering Expert Report | 10.12.2019 | ER2/#17 |
| 4. Dr Mike Glover Arup Fellow (ARUP) | | | |
| | (i) Expert Report (COI 1) | 07.01.2019 | ER1/#6 |
| | (ii) Original Inquiry Structural Engineering Expert Report | 06.12.2019 | ER2/#16 |
| 5. Mr Nick Southward Executive Director of Tony Gee & Partners LLP Managing Director of Tony Gee (Asia) Ltd | | | |
| | (i) Change of Details at Eastern Diaphragm Walls and Slabs | 07.01.2019 | ER1/#5 |
| | (ii) Structural Engineering Expert Report (COI 1) | 11.10.2019 | ER2/#14 |
| 6. Dr Albert Yeung Associate Professor, Department of Civil Engineering, The University of Hong Kong | | | |
| | (i) Engineering Expert Report (COI 1) | 07.01.2019 | ER1/#8 |

(B) Other Structural Engineering Reports/Assessments

| | | | |
|------------------------------------|---|------------|-------------------|
| 1. COWI UK Limited (“COWI”) | Commissioned by Leighton to undertake an independent structural analysis and assessment of section utilisation of EWL slab to diaphragm wall connection at Hung Hom Station. The scope, basis and findings of the structural analysis and assessment of section utilisation are detailed in the “Findings Report” (referred to in item (i) below), and the “Assessment Report (Volumes 1 to 4)” (referred to in items (ii) to (v) below) is supplemental to the “Findings Report” and provides additional detail of the Assessment methodology, input and output of the structural analysis and the findings of the structural assessment of different locations: | | |
| | (i) COWI’s Findings of its independent structural assessment of the EWL Slab to Diaphragm Wall Connection | 21.12.2018 | ER1/#4.0 |
| | (ii) COWI’s Assessment Report (Volume 1) | 21.12.2018 | ER1/#4.1 |
| | (iii) COWI’s Assessment Report (Volume 2) | 21.12.2018 | ER1/#4.2 |
| | (iv) COWI’s Assessment Report (Volume 3) | 21.12.2018 | ER1/#4.3 |
| | (v) COWI’s Assessment Report (Volume 4) | 21.12.2019 | ER1/#4.4 |
| 2. Atkins | The Joint Assessment Report [(i) below] provides structural capacity checks for the EWL Track Slab/diaphragm wall joint that are supplementary to the calculations provided in the Stage 3 Assessment Report [(ii) below]. As referred to in §3.1.1 of the said Joint Assessment Report, the design methodology and detailed results of the hand calculations are presented in the Stage 3 Assessment Report [referred to in (ii) below]: | | |
| | (i) EWL Slab / Diaphragm Wall Joint Assessment Report | 15.08.2019 | OU6/ 3944-4025 |

| | | | |
|--|---|-------------|------------|
| | (ii) Stage 3 Assessment Report (Rev A)(6 Volumes) presenting the findings from the Stage 3 Structural Assessment of the Holistic Report: | August 2019 | OU6/4026+ |
| | 1. Volume 1 | | OU6/4026+ |
| | 2. Volume 2 [Appendix B] | | OU6/4274+ |
| | 3. Volume 3 [Appendix C] | | OU6/5480+ |
| | 4. Volume 4 [Appendix D] | | OU6/6110+ |
| | 5. Volume 5 [Appendix E] | | OU6/6445+ |
| | 6. Volume 6 [Appendices F, G and H] | | OU6/8207+ |
| 3. AECOM | | | |
| Commissioned by MTRCL to provide an independent design review and structural assessment of the as-constructed SCL Hung Hom Station underground structures, viz. EWL and NSL Slabs and diaphragm walls. 2 Reports were produced: | | | |
| | (i) AECOM Final Independent Structural Assessment Report (for Area A, HKC, Area B and Area C) | 20.08.2019 | OU6/9680+ |
| | (ii) AECOM's Sensitivity Study Report in respect of its Final Independent Structural Assessment Report (for Area A, HKC, Area B and Area C) | 20.08.2019 | OU6/9681+ |
| 4. ARUP | | | |
| Appointed by MTRCL in late September 2018 as the Independent Expert Consultant for the holistic study intended to verify the structural integrity of the as-constructed condition of Hung Hom Station Extension [OU6/8583/§1.2]. | | | |
| | (i) Stage 3 Assessment Report (Rev. F) | 23.08.2019 | OU6/8580+ |
| | 1. Volume 1 - Design Basis Report | | OU6/8580+ |
| | 2. Volume 2 - Assessment Report - Area C | | OU6/8753+ |
| | 3. Volume 3 - Assessment Report - Hong Kong Coliseum | | OU6/8962+ |
| | 4. Volume 4 - Assessment Report - Area B | | OU6/9122+ |
| | 5. Volume 5 - Assessment Report - Area A | | OU6/9257+ |
| | 6. Volume 6 - Integrity and Ductility of Slab / Diaphragm Wall Connections in Areas B and C | | OU6/9521+ |
| | 7. Volume 7 - Shear Strength Investigation of Slabs and Structural Safety Checks | | OU6/9606+ |
| | 8. Volume 8 - Analysis Summaries | | OU6/9664+ |
| 5. EIC Activities PTY Ltd ("EIC") | | | |
| Commissioned by Leighton and produced the following reports: | | | |
| | (i) EIC Memorandum on "Design Principles" - review of the design principles and code requirements applicable to the capacity assessment adopted in the Stage 3 Assessment of the Holistic Proposal | 23.08.2019 | OU7/9744+ |
| | (ii) EIC Memorandum on "EIC Response to MTR Holistic Assessment - Couplers" dated 29 August 2019 setting out EIC's review of the "suitable measures" proposed for coupler connections in EWL in Area A and HHS. <u>Conclusion of EIC:</u> "Based on the assessment undertaken by EIC it appears no strengthening is required for Area A couplers and a substantial reduction is possible in the HHS location." [OU7/9835] | 29.08.2019 | OU7/9829+ |
| | (iii) EIC's "Response to MTRC Recommended Suitable Measures - Shear" setting out EIC's findings for the shear requirement in the EWL, Mezzanine and NSL slabs. | 30.08.2019 | OU7/9838+ |
| | (iv) EIC's Review of the Stage 3 Assessment Reports conducted by Atkins, Arup and AECOM | 23.09.2019 | OU7/10020+ |
| | (v) Supplemental Report on "Shear Analysis" | 16.10.2019 | OU8/10717+ |

| | | | |
|--|------------|------------|--|
| 6. Professor Stephen Foster Professor and Head, School of Civil and Environmental Engineering - The University of New South Wales, Sydney, Australia | | | |
| (i) Report on “Mechanisms relating to shear strength of reinforced concrete thick one-way slabs in relation to [Hung Hom] Station, and the influence of reduced anchorage of shear reinforcement” produced as Appendix D to EIC’s “Response to MTRC Recommended Suitable Measures - Shear” | 02.09.2019 | OU7/9917+ | |
| 7. CEEK Limited (“CEEK”) Commissioned by Leighton/EIC to carry out comprehensive independent testing of partially engaged coupler assemblies | | | |
| (i) Technical Review of Coupler Testing of EWL Slab Reinforcement Couplers at Hung Hom Station and Stabling Sidings produced as Appendix A to EIC Memorandum on “Design Principles” dated 23 August 2019 | 14.06.2019 | OU7/9752+ | |
| (ii) Area A Slabs Design Review Report - Shear Capacity Review on EWL Slab | 23.09.2019 | OU8/10113+ | |
| (iii) Area A Slabs Design Review Report - Shear Capacity Review on Mezzanine Floor | 19.09.2019 | OU8/10286+ | |
| (iv) Area A Slabs Design Review Report - Shear Capacity Review on NSL Slab | 23.09.2019 | OU8/10294+ | |
| (v) Area A Slabs Design Review Report - Bending Moment Capacity (Coupler) review on EWL Slab | 09.10.2019 | OU8/10569+ | |

B. Statistical Expert Evidence

B1. Background

10. As explained in MTRCL’s Report on Statistical Analysis in relation to the Final Report on Holistic Assessment Strategy for the Hung Hom Station Extension (“**MTRCL’s Report on Statistical Analysis**”)², the need for statistical analysis arises from Stage 2b of the Holistic Proposal³. The process of such statistical analysis is summarised below.

11. The Holistic Proposal proposed using binomial statistics to analyse the overall impact of the observed coupler connections during the opening-up works. Binomial statistics allow results to be

² [ER1/#11/§§12-13].

³ [B20/26101-02].

categorised as either a “fail” or a “pass” against certain “acceptance criteria”. Samples which do not meet such acceptance criteria are treated as failures and described as defective⁴.

12. To assess the defective rate of the coupler connections with a 95% confidence level, 28 locations with a minimum of 84 samples at each of the EWL and NSL slabs were randomly selected. It was expected that, by selecting a minimum of 84 couplers at each slab (with at least three couplers being inspected at each selected location), at least 168 couplers would be inspected to ascertain the quality of the workmanship at the coupler connections⁵.
13. Prior to the opening-up works, a method statement was submitted and accepted by the Government in December 2018. The opening-up works commenced in December 2018 and all the Phased Array Ultrasonic Test (“PAUT”) were completed in April 2019⁶.
14. A total of 102 and 99 samples at the EWL and NSL slabs respectively were eventually examined. Of these samples, 90 and 93 samples at the EWL and NSL slabs respectively yielded valid results for the purpose of the statistical analysis⁷.
15. 25 out of 90 samples at the EWL slab and 23 out of 93 samples at the NSL slab were found defective as against the agreed acceptance criteria. Based on the binomial analysis, it was estimated that, with a 95% confidence level, not more than 36.6% and 33.2% of the

⁴ [ER1/#11/§14(2)].

⁵ [ER1/#11/§14(3)].

⁶ [ER1/#11/§14(3)].

⁷ [ER1/#11/§14(4)].

coupler connections at the EWL and NSL slabs respectively were considered defective⁸.

16. Insofar as the “*acceptance criteria*” are concerned:-

(1) By a Press Release dated 24 December 2018⁹, the Government stated its position that, according to the information from BOSA, the proper installation requirements of a coupler were: (a) there should be a maximum of two full threads exposed; and (ii) the embedded length of the threaded steel bar inside the coupler should be at least 40mm in length. The Government considered that the couplers should have been installed in accordance with the above requirements¹⁰.

(2) Between December 2018 and January 2019, a number of meetings were held and attended by the representatives of the Government and MTRCL to discuss the acceptance criteria for assessing whether a coupler connection passed or failed for the purpose of the binomial analysis. Having discussed the matter at length, the Government advised and MTRCL adopted an engagement length of no less than 40mm by direct measurement and no less than 37mm by PAUT as the acceptance criteria¹¹.

⁸ [ER1/#11/§14(5)].

⁹ [B21/26690].

¹⁰ [ER1/#11/§34].

¹¹ [ER1/#11/§36].

(3) Consequently, as recorded in the Holistic Report, the acceptance criteria are: “(i) *there shall be a maximum of two full threads exposed (which is stated in the manufacturer’s installation requirements); and (ii) the engagement length of the threaded steel rebar inside the coupler should be at least 40mm. As the allowable measurement tolerance of the test equipment is 3mm, equipment readings below 37mm are regarded as defective.*”¹²”

17. During the course of the opening-up works under Stage 2b, either PAUT was conducted or direct measurement was taken at the coupler connections at the EWL slab side only¹³. Such an approach did not distinguish the general coupler connections from the capping beam coupler connections¹⁴, which are mainly found in Areas HKC and A¹⁵. In particular, where a capping beam is used, the coupler connection is placed within the EWL slab (instead of at the junction between the EWL slab and the D-wall). Consequently, the two sides of such coupler connection, including the slab side and the capping beam side, would be exposed during the opening-up works.

18. In early May 2019, after the completion of PAUT and during the review of the investigation results of the nature and extent of the coupler engagements on the slab side under Stage 2b, it was decided by the Task Force Group¹⁶ that the exposed coupler

¹² [OU5/3252/§3.3.13].

¹³ [ER1/#11.1/§40].

¹⁴ [ER1/#11.3/Annex II/Figure 1].

¹⁵ Area B also contains capping beam detail, e.g. EH40 [OU7/9808-09].

¹⁶ Which was a working group formed in or around December 2018 comprising MTRCL, BD, RDO, the Hong Kong Police Force and the Expert Adviser Team (“EAT”) [ER1/#11.1/§8].

connections at the capping beam side of EWL slab (11 numbers in total, located at D-wall panels nos. WH35, EH32 and EH40¹⁷) should also be taken into account¹⁸.

19. Since the Holistic Proposal focused on the condition of the coupler connections at the slab side only, the binomial analysis was to be applied to assess the defective rate of coupler connections at one side only, i.e. the slab side. In May and June 2019, following extensive discussions and consultation within the Task Force Group, it was agreed that the original statistical analysis had to be modified to account for the combined effect of the conditions of the coupler engagement at both the EWL slab and the capping beam sides¹⁹.
20. In mid-June 2019, MTRCL proposed using binomial analysis to calculate the defective rate for each of the EWL slab side and the capping beam side coupler engagements, followed by a probability analysis to calculate the combined reduction factor. The Task Force Group commented that MTRCL's proposed analysis was not acceptable from a statistical perspective²⁰.
21. Eventually, the Government's statistical advisers, led by Professor Yin Guosheng ("**Professor Yin**"), suggested using a formula (the "**Formula**") to account for: (1) the combined defective rates of the coupler connections at both the slab side and the capping beam

¹⁷ Which are located in Area HKC and Area B [OU5/3440].

¹⁸ [ER1/#11.1/§41].

¹⁹ [ER1/#11.1/§41].

²⁰ [ER1/#11.1/§42].

side; and (2) the small sampling size at the capping beam area²¹. By application of the Formula, a defective rate/reduction factor of 68% was derived²².

22. Further, although no opening-up was carried out in Area A, the same defective rate/reduction factor of 68% was extrapolated thereto on the assumption of similar conditions and workmanship²³.

B2. Relevance of statistical expert evidence

23. As explained in the Opening Address by Counsel for the Commission dated 23 September 2019²⁴, statistical expert evidence is relevant in the following two situations in the Original Inquiry and the Extended Inquiry:-

- (1) The capping beam coupler connections in Area HKC and Area B (i.e. panels WH35, EH32 and EH40)²⁵ were found in the Holistic Report to have a calculated defective rate/reduction factor of 68%. Assuming the capping beam coupler connections in Area A have a similar defective rate/reduction factor, there will be an issue of safety or fitness for purpose in respect of the structures in Area A (the “**1st Situation**”).

- (2) The general coupler connections at the EWL and NSL slabs at the Hung Hom Station Extension (“**HUH**”) were found in

²¹ [ER1/#12/Section 4].

²² [ER1/#11.1/§43].

²³ [ER1/#11.1/§44].

²⁴ [OS1/#9].

²⁵ [OU7/9810]; [OU5/3306].

the Holistic Report to have a defective rate/reduction factor of 36.6% and 33.2% respectively²⁶. Assuming the general coupler connections at the NAT, SAT and HHS have a similar defective rate/reduction factor, there will be an issue of safety or fitness for purpose in respect of the structures in those areas (the “**2nd Situation**”).

24. These submissions focus on the 1st Situation. Separate submissions in respect of the Extended Inquiry are made in respect of the 2nd Situation.

25. The following experts have given statistical expert evidence:-

(1) Professor Yin on behalf of the Government, who explains the rationale behind the calculation of the defective rates/reduction factors of 68% in respect of the capping beam coupler connections, and the 36.6% and 33.2% in respect of the general coupler connections²⁷; and

(2) Dr Barrie Wells (“**Dr Wells**”) on behalf of Leighton, whose opinion differs from that of Professor Yin in various fundamental respects²⁸.

26. In addition, Dr Glover, who gives structural engineering expert evidence on behalf of MTRCL, has explained and supported in his further expert report the statistical analysis carried out by Ove Arup

²⁶ [OU5/3235/§10].

²⁷ His expert reports/presentation slides and other related analyses can be found at [ER1/##12, 12.1-12.4].

²⁸ His expert reports/presentation slides and other related analyses can be found at [ER1/##10, 10.1, 13.1 and 13.2].

& Partners Hong Kong Ltd (“**Arup**”)²⁹. According to Dr Glover and Arup:-

- (1) For a single-sided connection (i.e. the general coupler connection), the pass rate should be 88%; and
- (2) For a two-sided connection (i.e. the capping beam coupler connection), the pass rate should be 77%³⁰.

27. For the reasons set out in more detail in Section C below, it is submitted, without criticism of Professor Yin³¹, that:-

- (1) There is no proper engineering justification in the Holistic Report to adopt the acceptance criteria for the purpose of determining the defective rates/reduction factors of the relevant structures;
- (2) There is no proper engineering justification in the Holistic Report to adopt a defective rate/reduction factor of 68% in Area A;
- (3) The Commission should be satisfied that the defective rate/reduction factor in Area A is on the low side such that it does not affect the safety or fitness for purpose of the structures.

²⁹ His further expert report/presentation slides and drawings can be found at [ER2/##16.1-16.5].

³⁰ [ER2/#16.1/§7.38].

³¹ This is because the submissions are made more from an engineering perspective than from a statistical perspective.

C. The Structural Expert Evidence

C1. The Commission's directions

28. On 12 October 2019, the Commission directed that:-

- (1) The structural engineering experts should focus on whether the as-constructed works are safe and fit for purpose from a structural engineering perspective; and only if they are considered not safe or fit for purpose that such experts should then provide their opinion on whether the suitable measures (as agreed in the Holistic Report or Verification Report, or subsequently) are necessary for safety from a structural engineering perspective; and
- (2) The structural engineering 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 compliance³².

29. The focus of the structural engineering expert evidence is therefore on whether the as-constructed works are safe and fit for purpose.

30. According to the Holistic Report³³ and as agreed by all the structural experts³⁴, despite the various defects discovered, the as-constructed structures of the HUH are generally safe and fit for

³² [OU8/10561-10562].

³³ [OU5/3229-3350].

³⁴ [ER2/#19.2].

purpose. The exceptions are, at worst, limited to the following locations:-

- (1) The coupler connections at the top of the EWL slab in Area A;
- (2) The shear links at the EWL and NSL slabs in Area A; and
- (3) The construction joints at the EWL slab in Areas B and C.

31. It is at these locations that suitable measures are required according to the Holistic Report. It is to be observed, however, that the extent of the remedial measures anticipated by the Holistic Report has diminished quite significantly over time³⁵.

32. The experts below have given structural engineering expert evidence:-

- (1) Mr Nick Southward (“**Mr Southward**”) on behalf of the Leighton³⁶;
- (2) Dr James Lau (“**Dr Lau**”) on behalf of the Government³⁷;
- (3) Dr Glover on behalf of MTRCL³⁸; and

³⁵ [ER1/#11.1/§48].

³⁶ His further expert report/presentation slides/drawing can be found at [ER2/##14.1-14.10].

³⁷ His expert report/presentation slides/drawings can be found at [ER2/##17.1-17.13].

³⁸ His further expert report/presentation slides/drawings can be found at [ER2/##16.1-16.5].

(4) Professor Don McQuillan (“**Professor McQuillan**”) on behalf of the Commission³⁹.

33. In summary, while Mr Southward, Dr Glover and Professor McQuillan agree that all the structures in the HUH are safe and fit for purpose, Dr Lau has a measure of disagreement⁴⁰.

C2. The meaning of safety and fitness for purpose

34. Although different experts may express the meaning of safety and fitness for purpose in slightly different terminology, there does not seem to be any material disagreement between them⁴¹. With regard to safety and fitness for purpose, the Government appears to agree that “*there is no major dispute on the applicable parameters.*”⁴²

35. In short, a structure such as the HUH should be considered safe and fit for purpose if it is capable of being used and functions as a station safely and without any physical restrictions on its operations and as anticipated by MTRCL during its intended design life (i.e. 120 years in this case).

36. As explained by Dr Glover⁴³ and Professor McQuillan⁴⁴, safety and fitness for purpose can be demonstrably distinguished from code

³⁹ His supplemental expert report/presentation slides can be found at [ER2/##15.1-15.3].

⁴⁰ [ER2/#19.2].

⁴¹ See the formulation of Dr Glover at [ER2/#16.1/§5.8]; the formulation of Professor McQuillan at [ER2/#15.1/§50]; and the agreement of Dr Lau with them [Combined T/Day 9/53:23-54:19].

⁴² §35 of the Government’s COI 1 Closing Submissions.

⁴³ [ER2/#16.1/§§5.9-5.11].

⁴⁴ [ER2/#15.1/§§50-51].

compliance. This position is consistently maintained by the MTRCL⁴⁵ and Leighton⁴⁶.

37. The Government, however, contends that Mr. Southward, Dr. Glover and Professor McQuillan consider that “*lower levels of safety factor (which deviate from those required under the Applicable Codes) could be applied in the assessment*” and that they have reached their opinions on ‘safety’ 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.*”⁴⁷ With respect, however, the Government fails to identify any part of the Applicable Codes which the experts have ignored and which as a matter of proper engineering analysis can be demonstrated to ‘lower’ the factor of safety. The Government has made no attempt to analyse and quantify the extent to which the factors of safety have been allegedly ‘lowered’ by the experts. The two primary matters identified by Dr. Lau, namely, (a) excessive crack width and (b) complete lack of shear links at critical locations are at best speculative but, by reference to the evidence, most likely wrong.

C3. Coupler connections at the top of the EWL slab in Area A

38. To be more specific, the locations which require suitable measures and therefore raise an issue of safety and fitness for purpose are shown in blue at **OU9/11478**.

⁴⁵ [Combined T/Day 6/27:3-4].

⁴⁶ [Combined T/Day 6/49:23-25].

⁴⁷ §§36 and 37 of the Government’s COI 1 Closing Submissions.

39. The principal differences between the experts (Mr Southward, Dr Glover and Professor McQuillan on the one hand and Dr Lau on the other) are:-

- (1) Whether, from an engineering perspective, the acceptance criteria are justified?
- (2) Whether, from an engineering perspective, the defective rate/reduction factor of 68% applied to the coupler connections in Area A is justified?
- (3) Ultimately, whether the structures in Area A are safe and fit for purpose?

40. As submitted in Section B2 above, the correct answers are:-

- (1) No.
- (2) No.
- (3) Yes.

C3.1 Whether the acceptance criteria are justified

41. During February and April 2019, MTRCL carried out a series of partial engagement tests on coupler connections⁴⁸. On the basis of the test results, all experts⁴⁹, including Dr Lau under cross

⁴⁸ [OW1/87-119, 230-268].

⁴⁹ [ER2/#18.3/§1].

examination⁵⁰, agreed that if there is a minimum engagement of 7 threads (32mm), a coupler connection will have sufficient strength (ie. satisfy the strength criteria). The real issue raised is whether “butt-to-butt” engagement is required because otherwise, a coupler connection would fail the permanent elongation test.

42. That said, it appears that the Government accepts that even if Leighton’s steel fixers properly carried out the installation work in accordance with the BOSA guidelines, “butt-to-butt” would not necessarily be achieved. The Government says that the focus is not about whether the connection is “butt-to-butt” but whether the bars were fully screwed in and fully tightened⁵¹. The Government further acknowledges that a “butt-to-butt” connection was not part of the acceptance criteria for coupler connections in the Stage 2b assessment⁵². The Government’s position appears to distance itself from the rather extreme position adopted by Dr. Lau on the “butt-to-butt” issue and, it is submitted, rightly so.

43. As explained by Mr Southward, Dr Glover and Professor McQuillan, the failure of the permanent elongation test is irrelevant in the present context. This is because:-

(1) The failure of the permanent elongation test in the laboratory is due to the initial embedment of the coupler assemblies causing a “slack”. The test results are indicative of such

⁵⁰ [Combined T/Day 9/77:6-79:25].

⁵¹ §49 of the Government’s COI 1 Closing Submissions.

⁵² §53 of the Government’s COI 1 Closing Submissions.

“slack” rather than the permanent elongation i.e. stretch in the unit⁵³.

- (2) In the laboratory the permanent elongation test was carried out in “free air” and unrestrained. In reality, however, any thread “slack” would be taken up post-installation because of the self-weight of the starter bar⁵⁴.
- (3) Further, in practice the workmen would try to screw in the rebar as much as possible. Any slight misalignment of the coupler assemblies, whether before engagement, during engagement or post-engagement, means that the threads cannot be slack⁵⁵.
- (4) CEEK have also conducted a trial and proved that if a coupler contains grit and the rebar is only partially engaged but rotated to refusal (which better reflects what happened on site), it will pass the permanent elongation test⁵⁶.
- (5) In the circumstances, “butt-to-butt” connection or the coupler “slack” is not an issue. This is consistent with the fact that there has, to date, been no evidence of any cracking caused by such “slack” even though the slabs have experienced most of the loading⁵⁷.

⁵³ [ER2/#18.3/§1][ER2/#15.1/§21].

⁵⁴ [Combined T/Day 12/8:1-20].

⁵⁵ [Combined T/Day 12/10:9-17].

⁵⁶ [ER2/#15.1/§§25-27][OU7/9764].

⁵⁷ [ER2/#15.1/§§2, 21][Combined T/Day 12/10:18-11:25].

44. In any event, insofar as the Original Inquiry is concerned, only the coupler connections at the top of the EWL slab in Area A are in dispute. The location of those couplers is, however, within an internal environment⁵⁸. Therefore:-

- (1) Even if any crack occurs, it will not cause rebar corrosion⁵⁹.
- (2) The location is not accessible to the public and it is within exposure condition 1 (mild exposure) under the Code of Practice for Structure Use of Concrete 2004 (the “**Concrete Code**”)⁶⁰. As acknowledged under Note 1 of Table 7.1 of the Concrete Code, for exposure condition 1, any crack developed has no influence on durability⁶¹. As the location is not accessible to the public, there is no issue as to appearance either. Consequently, there is no issue of safety or fitness for purpose in this respect.
- (3) Dr Lau during evidence-in-chief suggested a classification of exposure condition between moderate and severe⁶². He however clarified during cross-examination that he was referring to the “outside” of the structures in contact with the soil⁶³, which is irrelevant to any crack caused by the failure of elongation test of the coupler connections at the top of the EWL slab in Area A.

⁵⁸ [OU6/8590/Figure 3.4].

⁵⁹ [ER2/#15.1/§21].

⁶⁰ [H8/2857/Table 4.1].

⁶¹ [H8/2928/Table 7.1].

⁶² [Combined T/Day 9/27:23-31:3].

⁶³ [Combined T/Day 9/163:23-165:24].

45. For the reasons above, the acceptance criteria of (1) a maximum of two full threads and (2) a minimum of 37mm engagement length are not appropriate. In our respectful submission, an engagement of 7 threads (32mm) should be considered to be safe and fit for purpose, as agreed by Mr. Southward, Dr. Glover and Professor McQuillan.

C3.2 Whether the defective rate/reduction factor of 68% is justified

46. First of all, as explained in Section B above, the calculated defective rate/reduction factor of 68% was derived from a very limited number of samples (11 on the capping beam side and 7 on the slab side) in Area HKC and Area B⁶⁴. The representativeness of such a small sample size is in doubt⁶⁵. In this regard, in particular, of the 12 samples found in Area A/HKC obtained for purpose (i)⁶⁶ (i.e. to verify the as-constructed rebar connection details), apart from 1 sample that was discarded because a PAUT reading could not be obtained, the remaining 11 samples all passed the 37mm engagement⁶⁷.
47. Secondly, although no opening-up was carried out in Area A, the same calculated defective rate/reduction factor was extrapolated thereto on the assumption of similar conditions and workmanship. Such assumption is problematic in that the works at Areas A, HKC and B were carried out at different times. For example, the rebar fixing works at Area HKC and Area A were carried out about 1

⁶⁴ [OU7/9810].

⁶⁵ [ER2/#16.1/§7.11(xi)].

⁶⁶ Which were not taken into account for purpose (ii), i.e. the statistical analysis.

⁶⁷ [ER2/#16.1/Annex 2].

year apart⁶⁸. In such circumstances, the workers carrying out the works might have been different. The time pressure put on them might also have been different.

48. Thirdly, the substantially higher defective rate/reduction factor in Area A than Areas B and C is inconsistent with the undisputed fact that the working conditions for capping beam coupler connections were much better than those for the general coupler connections⁶⁹. As accepted by Dr Lau:-

“According to the evidence received during the hearing of the Original Inquiry, the coupler assemblies connecting the platform slabs to the diaphragm wall were originally cast in the diaphragm wall by Intrafor. They were subsequently exposed by Leighton with high pressure water jets. It was then discovered that some of the exposed couplers were disoriented or damaged. These caused a lot of difficulty in the subsequent screwing in of threaded bars and ensuring proper alignment of reinforcement by the steel fixers. Whereas in the case of the coupler connections at the capping beam, the couplers had never been cast in concrete, these coupler assemblies were therefore not damaged and without any issues of misalignment or disorientation...In such a perfect working condition, one should not have (or would not expect) any difficulty to properly connect the threaded bars to the couplers.”

49. Fourthly, Professor McQuillan suggested that the estimated defective rate of 36.6% for the EWL slab should have been adopted

⁶⁸ [B5/2902].

⁶⁹ [ER2/#17.1/§53].

for Area A because only one side of the coupler will fail, if at all. It is submitted that he is clearly correct. Leighton also agrees with his analysis⁷⁰. It is noted that while the Government now contends that Professor McQuillan is incorrect⁷¹, it chose not to cross-examine Professor McQuillan on the point.

50. In summary, it is submitted that the adoption of the defective rate/reduction factor of 68% in Area A is speculative and unwarranted. It does not sit at all well with the factual and engineering evidence adduced in the Inquiry.

C3.3 Whether the structures in Area A are safe and fit for purpose

51. As the acceptance criteria are not justified and no opening-up works were carried out in Area A, it is submitted that it would be inappropriate for the Commission to rely on the existing statistical expert evidence to derive any definitive defective rate/reduction factor in respect of Area A.

52. Notwithstanding, it is submitted that the Commission should be satisfied so as to be sure⁷² that the structures in Area A are safe and fit for purpose in respect of the coupler connection issue on the basis of the following considerations:-

- (1) The relevant structures at the HUH, including Area A, have been completed for several years. Test trains have also run

⁷⁰ §§26-28 of Leighton's COI 1 Closing Submissions.

⁷¹ §63 of the Government's COI 1 Closing Submissions.

⁷² The higher standard of proof referred to at §40 of the Interim Report.

on them. No sign of distress or abnormal deformation have been identified during structural inspections and continuous monitoring⁷³.

- (2) The stage of critical loading has passed. This happened during the construction stage rather than the permanent state of the structures. This is because in the former, the slab was in full span whereas in the latter, there is intermediate support⁷⁴.
- (3) The relevant structures survived the critical loading during the construction stage without any sign of distress. The increase in the future loading during operation will not be significant⁷⁵.
- (4) There is no direct evidence showing any defective coupler connections in Area A. The calculated defective rate/reduction factor of 68% is not justified from an engineering perspective.
- (5) Coupler connections of 7 threads (32mm) will be safe and fit for purpose, which means that the partial engagement issue is largely overstated. Although it is, as submitted above, inappropriate for the Commission to derive any definitive defective rate/reduction factor in respect of Area A, from the factual and engineering evidence adduced in the Inquiry, it should be satisfied that such defective rate/reduction factor is

⁷³ [OU6/4119/§14.1.1][ER2/#16/§8.12].

⁷⁴ [ER1/#3/§38].

⁷⁵ [ER1/#3/§33][J4/3330].

on the low side, and should not prevent this Commission from finding that the relevant structures are safe and fit for purpose.

C4. The shear links at the EWL and NSL slabs in Area A

53. The locations which allegedly require suitable measures and therefore raise an issue of safety and fitness for purpose are shown in pink at **OU9/11474, 11477-11478** and **11481**.

54. The principal differences between the experts (with Mr Southward, Dr Glover and Professor McQuillan on one side and Dr Lau on the other side) are:-

- (1) Whether the shear links should be disregarded in the structural assessment? and
- (2) Ultimately, whether the structures in Area A are safe and fit for purpose?

C4.1 Whether the shear links should be disregarded in the structural assessment

55. Defects in shear link placement were first discovered when the shear links at the EWL slab soffit were exposed during the honeycombing investigation in August 2018⁷⁶. Atkins conducted inspections between September 2018 and June 2019 at the EWL

⁷⁶ [H7/2207/§72][H19/39706].

slab soffit and identified 22 locations, in the areas inspected for honeycombing, with defects in shear link placement⁷⁷.

56. In the meantime, 18 further additional locations at the EWL slab soffit were opened up for investigation in April 2019⁷⁸.

57. On the basis of the investigation results of the aforesaid 40 locations, the Holistic Report proceeds to disregard completely the shear links in its structural assessment⁷⁹. As a result, the locations referred to in Section C2 are found to be overstressed. Otherwise, however, it is not disputed that the shear links provided in accordance with the original design are sufficient and most of the areas only require nominal shear links⁸⁰.

58. As shown in Mr Southward's powerpoint slides⁸¹, there are clearly shear links in various locations where no shear link is assumed in the Holistic Report, including Area A. The problem of the previous investigation, as pointed out by Mr Southward, is that the opening up area was too small and was limited to the bottom layer (whereas the workers might have installed the shear link to the upper layer)⁸².

59. There is also factual evidence in the Original Inquiry and the Extended Inquiry that shear links were generally installed and checked:-

⁷⁷ [OU5/3264/§3.5.24].

⁷⁸ [OU5/3264/§3.5.26].

⁷⁹ [AA2/563/§10.8][ER2/#14.1/§7.3].

⁸⁰ [ER2/#15.1/§§125, 128].

⁸¹ [ER2/#14.9/ Slides 22-26].

⁸² [ER2/#14.1/§§7.1-7.4].

- (1) MTRCL's Construction Engineer at HHS Kong Sebastian Sai Kit said he checked the arrangement of shear links (if any) according to the most up-to-date working drawings during the hold point inspection⁸³;
- (2) MTRCL's Construction Engineer at EWL Slab Louis Kwan said that he had checked shear links in his formal inspection of rebars⁸⁴;
- (3) Leighton's engineer of EWL and NSL slabs Man Sze Ho also said that he checked the depth, length and spacing of shear links⁸⁵;
- (4) Leighton's engineers for SAT EWL area Raymond Tsoi, Sean Wong and Saky Chan confirmed that all formal joint inspections for rebar fixing and pre-pour checks were carried out and approved by MTRCL in the areas they were responsible for⁸⁶.

60. It is therefore submitted that there is no proper engineering justification to disregard the shear links in the structural assessment⁸⁷.

⁸³ Paragraph 9 of the witness statement of Kong Sebastian Sai Kit [BB8/5244-5245].

⁸⁴ [B1/373/§3][COI1/T/Day 29/61:22-63:5].

⁸⁵ [C27/20660/§4] [COI1/T/Day 22/42:4-24].

⁸⁶ Para. 4 and para. 23 of Raymond Tsoi's witness statement at [CC6/3790] [CC6/3796]; para 3 and para. 22 of Sean Wong's witness statement [CC6/3799] [CC6/3806]; para. 3 and para. 22 of Saky Chan's witness statement at [CC6/3838][CC6/3845].

⁸⁷ A conclusion shared by MTRCL (§88 of MTRCL's COI 1 Submissions) and Leighton (§59 of Leighton's COI 1 Closing Submissions).

C4.2 Whether the structures in Area A are safe and fit for purpose

61. It is submitted that the Commission should be satisfied so as to be sure that the structures in Area A are safe and fit for purpose in respect of the shear links issue on the basis of the following considerations:-

- (1) The factual evidence shows that shear links were generally installed and checked. There is no proper evidence to indicate otherwise. The investigation referred to in the Holistic Report was too limited to be relied upon to show the contrary.
- (2) Further assurance can be gained from the fact that the requirement of shear links in the structures is generally very low and limited to a few locations only⁸⁸. There is also no serious issue that other minor defects such as anchorage length⁸⁹, size and spacing of rebar⁹⁰ will cause a concern. It is therefore highly unlikely that shear links will be a factor affecting safety or fitness for purpose of the structures.
- (3) To put the issue to rest, Dr Glover and Arup have demonstrated that if one assesses the shear requirement using more realistic loading and material strength, there is actually no requirement of shear link in any part of the structures⁹¹.

⁸⁸ [ER2/#15.1/§§125, 128].

⁸⁹ [ER2/#14.1/§7.5][OU6/9612/§3.2][ER2/#17.1/§126].

⁹⁰ [ER2/#16.1/§8.9].

⁹¹ [ER2/#16.1/§§8.10-8.12].

- (4) The reality check reinforces the views expressed by Mr Southward, Dr Glover and Professor McQuillan.

C5. The construction joints at EWL slab in Areas B and C

62. The locations which require suitable measures and therefore raise an issue of safety and fitness for purpose are shown at **OU9/11480**.
63. The original concern was that as a result of the Second Change, the top of the D-wall was trimmed and recast together with the platform slab and OTE slab. Consequently, a horizontal new construction joint was formed. Professor Au, the former structural engineering expert for the Government, expressed reservations about whether the new construction joint would be overstressed⁹². He recommended further checking on the new construction joint⁹³.
64. Subsequently, 4 holes were cored for inspection. At D-wall EM94, a gap was observed at the concrete interface between the slab at one of the core-holes and D-wall, and remnants of a hessian sheet were observed at another core-hole⁹⁴.
65. In addition, detailed calculations were carried out as recommended by Professor Au, including simplified hand calculations and more complex finite element analyses. After various reviews, there is no longer any issue of overstress at the construction joint⁹⁵. All four

⁹² [ER1/#7.0/§6.4.3.5].

⁹³ [ER1/#7.0/§6.4.3.11].

⁹⁴ [OU5/3265-3266/§3.5.33-34][OU6/9525/§2.2.3; 9577-9590].

⁹⁵ [ER2/#17.1/§142].

experts are agreed that the issue is only one of workmanship⁹⁶. Nonetheless, the Holistic Report recommends the carrying out of “suitable measures”, namely, the installation of vertical dowel bars into the top of 23 east D-Wall panels. Professor Au himself is of the view that such measures will eliminate any residual concerns of overstressing⁹⁷.

66. A separate concern of Dr Lau is that the gap found between the slab and the D-wall may create a path for ingress of water and lead to corrosion of reinforcement, i.e. a question of durability⁹⁸.
67. With respect, it is submitted that Dr Lau’s concern is not justified because the construction joint was encapsulated⁹⁹. The risk of water seepage and corrosion of reinforcement is unreal.
68. On the other hand, as pointed out by Mr Southward¹⁰⁰ and Professor McQuillan¹⁰¹, the proposed suitable measures themselves (i.e. coring holes and putting in vertical dowel bars into the construction joint) do raise a concern of safety. In particular, the coring process might cut through or damage the rebar within the concrete. Professor McQuillan was very firmly of the view that the dowel bars should not be installed and that nothing should be done¹⁰². It is difficult to reach a definitive conclusion on this issue. The dowel bar installation works have not yet progressed too far

⁹⁶ [ER2/#18.3/§3].

⁹⁷ [OW1/295] DoJ’s email dated 22 July 2019.

⁹⁸ [ER2/#17.1/§146].

⁹⁹ [OU6/9529].

¹⁰⁰ [ER2/#14.1/§8.7].

¹⁰¹ [ER2/#15.3/Slides 56-57 at pp.28-29].

¹⁰² [Combined T/Day 12/30-31:16].

(14/15% by 8 January 2020)¹⁰³ and presumably could be stopped. On the other hand, assuming the works will continue then it might be expected that MTRCL and Leighton (and their sub-contractor) will proceed with caution so as to limit the risk of disturbance and damage to the existing rebar and it is to be hoped that, as MTRCL submits¹⁰⁴, the latest Method Statement¹⁰⁵ will have the effect, if properly implemented, of addressing the concerns expressed by Mr. Southward and Professor McQuillan.

D. Conclusion

69. For the reasons above, taking into account all the factual, statistical and structural evidence available to the Commission, it is submitted that there can be no reasonable doubt and the Commission can be satisfied so as to be sure that the as-constructed structures at the HUH are safe and fit for purpose.
70. Subject to the suitable measures for the construction joints at EWL slab in Areas B and C as explained in Section C5, there is no dispute that the other suitable measures, once implemented, will only improve and not compromise the structures.
71. Looking forward, Dr Glover, with whom Professor McQuillan agrees, has recommended regular visual inspections of those areas with the highest assessed stress levels (instead of installation of any monitoring system such as fibre-optics or the like, which was

¹⁰³ [OU9/11476].

¹⁰⁴ §122 of MTRCL's COI I Submissions.

¹⁰⁵ [OU9/11402].

previously recommended to the Commission¹⁰⁶, because its highly sensitive nature may trigger many false alarms) to assuage any residual public concerns¹⁰⁷.

72. It is submitted that the Commission should adopt such recommendation, with which MTRCL agrees¹⁰⁸, with particular emphasis on its implementation to the construction joints at the EWL slab in Areas B and C as a result of the concern raised by the execution of the suitable measures.

E. Points arising on the Interim Report

73. The Commission will no doubt review Leighton's invitation to withdraw its interim finding at §481(1). Whilst the Commission is in the best position to re-evaluate its interim finding, it is submitted that, for example, there appear to have been clear findings as to Leighton's non-compliance with the QSP.

74. In the context of "*The first change*" (§§100 to 105) and, in particular, (a) §102, the Commission may feel it appropriate to mention that one consequence of the first change was the clash between the EWL rebar and the D-wall rebar because the D-Wall rebar arrangement was changed from 2 to 3 rows to 4 rows (so as to permit the use of a 300mm tremie pipe). Further to TQs raised by Leighton in 2015, one option considered by MTRCL and Atkins was the use of approximately 4,000 T25 drill-in bars across the D-Wall in substitution for the T40 coupler connections. However, this

¹⁰⁶ [ER2/#16.2/Slide 35].

¹⁰⁷ See the Interim Report, §§386-388, 391-392, 459-462.

¹⁰⁸ §§124 to 126 of MTRCL's Further COI 1 Submissions.

option was abandoned in favour of a monolithic construction of the top of the east D-wall, the EWL slab and the OTE. All of this is explained in detail at §§59-64 of the witness statement of James Ho [B1/338-339] and (b) §105, it is noted that ultimately BD gave approval to the change [H11/5724-5727].

75. With regard to Leighton's contentions concerning the QSP and the ductile couplers (§§269 to 276), this is dealt with in the Extended Inquiry submissions.
76. As to §76 (b), given its relevance to a number of matters discussed above, the Commission may wish to record that the thickness of the slab in Area A is 1m only.
77. Chapter 7 (The Collateral Tests) (§§ 250 to 265) will presumably need to be largely re-written in the light of the recent statistical and structural engineering expert evidence.
78. With regard to §301, whilst the evidence of Mr. Aidan Rooney was tendered in the context of the subject matter of COI 1, it may need to be reviewed in the light of the missing RISC forms investigated at length in COI 2. See similarly §402.
79. The "Opening-up" detail at §§ 361 to 369 will inevitably need to be revisited.

80. As to §386, which deals with future monitoring, this is reconsidered in §71 above.

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