Monday, 14 January 2019

(10.02 am)

MR PENNICOTT: Good morning, sir.

CHAIRMAN: Good morning.

MR PENNICOTT: Sir, you will see around the room this morning that there are some perhaps unfamiliar faces to you. That is because we are starting the structural engineering expert evidence this morning, and I think, although I haven't counted, that most if not all of the structural engineering experts are in the room.

CHAIRMAN: Yes.

MR PENNICOTT: As you know, Prof McQuillan is sat next to me, I can see Mr Southward is there, and I think Dr Glover is at the back as well, and at the moment Prof Au is in the witness box.

CHAIRMAN: Yes.

COMMISSIONER HANSFORD: Mr Pennicott, before we move on to structural matters, can I just raise one matter of project management which is residual from last week.

MR PENNICOTT: Of course.

COMMISSIONER HANSFORD: This probably directed mainly to Mr Boulding. You will recall that Mr Huyghe's evidence and his expert report had an appendix D, which was MTR's update on their progress made on Turner & Townsend's report.

The Commission found that very useful, but what the Commission would find particularly useful would be an update on that, perhaps at the time of MTR's closing submission, so that we are up-to-date with the progress that's been made by on MTR's work against the Turner & Townsend recommendations, if that would be appropriate.

MR PENNICOTT: Obviously Mr Boulding has heard that on behalf of MTRC and I'm sure that can be accommodated. What I would say is if we ask MTR to do that, I would suggest that's outwith their 100 pages. They can do that additional to that.

CHAIRMAN: Obviously.

MR PENNICOTT: Just in case there was any concern on that front. Obviously Mr Boulding perhaps can comment.

MR BOULDING: Yes, of course I can. Mr Pennicott is absolutely correct. We will take the opportunity to update that, Professor, and provide that to the Commission, because you regard that as being useful and we want to assist you, as we made clear, as much as possible. So those behind me will pass on that message today and the necessary steps will be put in train.

COMMISSIONER HANSFORD: Thank you. Because I believe that was dated 3 January.

MR BOULDING: 3 January, it's signed off --

COMMISSIONER HANSFORD: And maybe if we could look it -- I don't know, something like 25 January; bring it as up-to-date as we possibly can.

MR BOULDING: It may well even be the case that we could take it up to 29 January. We will see what can be done and we will update it as much as we possibly can.

COMMISSIONER HANSFORD: Thank you very much.

CHAIRMAN: Good.

MR PENNICOTT: Sir, before we get to Prof Au -- good morning; we'll be with you shortly, Prof Au -- could I just mention this. I think it's a matter that has been drawn to the Commission's attention, but there have been some enquiries from the media, and in particular the Apple Daily, in relation to questions concerning the potential lack of independence of certain experts who have produced reports for the Commission on behalf of various parties.

In particular, my understanding is that so far as Leighton are concerned, Mr Scott Allan from COWI -- and I understand it's pronounced with a V although it's spelt with a W -- Mr Allan from COWI, there's a question mark regarding his independence that has been raised in fact by China Technology and the Apple Daily.

Likewise, the Apple Daily has raised some concerns with regards to Mr Southward, and also, I understand,

latterly, the Apple Daily has raised some queries in relation to Dr Mike Glover, the MTRC's structural engineering expert.

I just wonder whether it would be appropriate and perhaps more efficient if we dealt with those matters now and I understand that perhaps Mr Shieh and Mr Boulding are in a position to do so, and I certainly am as well.

CHAIRMAN: I think it's essential we deal with those matters now, because we don't want the experts sitting here with any suggestion that they may not be able to assist the Commission at the end of the day. That would be an entirely wasted exercise for them. So we do need to deal with them first.

MR PENNICOTT: Yes. I am happy to deal with them, as it were, sequentially, so if Mr Shieh would like to deal with COWI first, Mr Allan, and then obviously deal with Mr Southward at the same time, and then I'll deal with that, and then if Mr Boulding wishes to say something on behalf of Dr Glover, he can do so as well.

CHAIRMAN: Thank you.

MR PENNICOTT: Can I pass the baton to Mr Shieh on that basis.

CHAIRMAN: Yes.

MR SHIEH: Mr Chairman, Mr Commissioner, can I deal with

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COWI and Mr Scott Allan first, followed by Tony Gee and Mr Nick Southward.

In relation to COWI, the position is this. COWI had no involvement in the development and delivery of the work at Hung Hom Station. COWI's work -- now, COWI is a catchphrase to describe the expert, but what I'm now going to describe is the precise set-up. COWI's work in relation to the provision of the expert report for the Commission is being delivered by COWI UK Ltd, in particular by Mr Scott Allan and his team based in Glasgow.

That work has been undertaken independently of COWI Hong Kong Ltd and COWI Singapore Ltd.

There's a project known as the Hong Kong Express Railway twin bored tunnel project under Lam Tsuen Park. COWI Hong Kong was employed by the main contractor for that project, Kier-Kaden-OSSA JV. COWI Hong Kong did not have a contractual relationship with MTRC. The relevant people from COWI who worked on that project had limited contact with MTRC and they do not recall having any contact with the sub-contractor, Tak Cheong Civil Engineering Ltd.

COWI Hong Kong completed its work on that project before COWI UK was engaged for the present matter by those instructing me, O'Melveny & Myers on behalf of

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Leighton.

There's another project in Singapore called Singapore Deep Tunnel Sewerage System. The relevant work on this Singapore project was delivered by COWI Singapore and COWI Hong Kong Ltd. COWI's work on that project, the Singapore project, was completed before COWI UK was engaged for the present matter.

Mr Scott Allan and his team who prepared the report for this Commission were not involved in the Hong Kong Express Railway project or the Singapore project. With the exception of the present case, COWI is not performing any work for Leighton or the other parties to the Commission. Mr Scott Allan and his team who prepared the expert report have no connection to any of the parties to the Commission.

COWI A/S is an international consulting group, specialising in engineering, environmental science and economics, based in Denmark. It has been involved in more than 50,000 projects in 175 countries and has approximately 6,400 employees, including engineers, biologists, geologists, economists, surveyors, anthropologists, sociologists, architects, and we respectfully submit that Mr Scott Allan and his team are not subject to any conflicts of interest or anything which could impair their independence and no reasonable

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observer could form the impression otherwise or could suggest otherwise based on the facts I have just described.

I now move on to the question about Tony Gee and Partners. Tony Gee and Partners had no involvement in the development and delivery of the work at Hung Hom Station. In media reports, it has referred to engagements that were completed by Tony Gee and Partners many years ago. In particular, Tony Gee and Partners completed its work in relation to the Saadiyat Island in Abu Dhabi, the Brisbane Gateway in Australia, the Ampang Elevated Expressway project in Malaysia and the MTR's Airport Express viaduct projects many years ago. Tony Gee and Partners performed a discrete role for Leighton in relation to the HAECO hangar at the Hong Kong International Airport. That was completed about eight years ago.

With the exception of the work in relation to the expert report produced for this Commission, Tony Gee and Partners is not performing any work for Leighton or any of the other parties before the Commission, and Mr Nick Southward and his team who prepared the expert report have no connection to any of the parties before this Commission.

In the light of media enquiry, Tony Gee and Partners

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had conducted further conflicts check beyond what was usually required and wishes to disclose for the record that in the year 2015, a Mr Jonathan Gray from its UK office was seconded to Leighton for seven days, on the 1, 2, 4 and 7 to 10 December 2015 as a principal engineer for SCL1112. Tony Gee and Partners was not responsible for Mr Gray's work during this period of secondment for seven days.

Likewise, we submit that neither Mr Southward nor Tony Gee could be subject to any conflict of interest or anything which could impair their independence, and no reasonable observer could suggest otherwise, based on the facts I have mentioned.

Could I add two points: first, this Commission is not comparable to a conventional civil trial where a lay, untrained judge -- when I say untrained, I mean untrained in the expert discipline in question -- may need to rely upon experts solely in order to be educated on technical points. In that scenario, it may be that the court would be more vigilant to check the independence of the expert and to decide what weight to place on the expert. But in this case, the Commission has its own independent expert, and one member of the Commission, Prof Hansford, is also a qualified and respected expert in the field. In the circumstances, we

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respectfully submit that whatever facts or matters one may raise in respect of Mr Scott Allan/COWI or Mr Southward/Tony Gee should be regarded as a kind of disqualifying feature so as to rule them out completely. As a corollary to the point I have just made, I respectfully submit and suggest that insofar as the Commission remains under any lingering doubt about possible lack of independence, those are matters which could only, if at all, go to the weight to be placed on the evidence given by the expert and not amount to any disqualifying feature so as to rule them out completely at this juncture.

These are the matters I wish to say in respect of the queries made about the two experts on behalf of Leighton.

CHAIRMAN: Thank you.

MR PENNICOTT: Sir, could I --

MR BOULDING: Sorry.

MR PENNICOTT: You go first. I suggest you do.

MR BOULDING: Sir, Professor, MTR and Dr Glover welcome this opportunity to dispel any suggestion that Dr Glover's evidence to the Commission will not be completely independent. In order to achieve that, I've been authorised by both Dr Glover and the MTR to make the following statement to you. It's hoped the media are

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listening.

Dr Mike Glover, OBE, is a veteran civil engineer with a rich professional knowledge and has nearly 50 years of experience in structural engineering. He has wide, multidisciplinary project experience in major infrastructure and building structures, industrial facilities and transportation projects in the UK and overseas for public, commercial and industrial sectors. Arup's business covers engineering design, planning and architectural aspects. Arup and Dr Mike Glover, who is an Arup fellow and a fellow of the Royal Academy of Engineers, have previously performed work for MTRCL but Dr Glover confirms -- I emphasise confirms -- that this previous work does not affect his independence.

In accordance with the Rules of the High Court, all expert witnesses have to abide by the code of conduct for expert witnesses. An expert witness is obliged to help the Commission of Inquiry impartially and independently on matters relevant to his area of expertise, and his paramount duty is to the court, not to the person from whom the expert has received instructions or by whom he is paid.

Dr Glover has a high professional standing. We believe he will give unbiased professional views to the Commission based on the Commission's requirements, and

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as you will see, sir, when Dr Glover comes to give evidence, it will be clear from the way he deals with matters and his demeanour in the box that you can rely upon his evidence as being totally independent.

CHAIRMAN: Yes. Thank you.

MR PENNICOTT: Sir, can I thank both Mr Shieh and Mr Boulding for those observations --

CHAIRMAN: Sorry, Mr Pennicott, I'm just wondering as to process, whether other parties may wish to be heard and then you come at the end.

MR PENNICOTT: I'm happy for that. I don't know if anybody else wishes to say anything.

CHAIRMAN: I would like to double-check that.

MR PENNICOTT: Please do. That may well be appropriate. Thank you very much.

CHAIRMAN: All right. We will hear from the Commission -- perhaps Mr Connor?

MR CONNOR: Thank you. There is nothing from Atkins on this topic, sir.

CHAIRMAN: Thank you very much indeed.

From the government?

MR KHAW: Nothing from the government.

MR SO: Nothing from China Tech.

CHAIRMAN: Intrafor, at the back?

MR COHEN: Nothing, sir.

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CHAIRMAN: Fang Sheung?

MS CHONG: No submission on this point.

CHAIRMAN: I just wanted to double-check. Thank you.

Mr Pennicott.

MR PENNICOTT: Thank you, sir. I'll be very brief.

Obviously, the statutory backdrop to the admissibility of evidence in this Commission is to be found in the Commissions of Inquiry Ordinance at section 4(1), which provides, broadly, that:

"The Commission may, for the purpose of complying with the directions issued under section 3 [that is by the Chief Executive-in-Council] and for conducting the inquiry generally --

(a) receive and consider any material whether by which of oral evidence, written statements, documents or otherwise, notwithstanding that such material would not be admissible as evidence in civil or criminal proceedings".

So the Commission is given a very, very wide discretion as to the admissibility of evidence. However, it is right to point out that in the Rules of Procedure and Practice that the Commission published back on 24 September at the preliminary hearing, it was made clear in paragraph 11 of those rules that any expert evidence to be advanced or adduced by any of the

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parties should be independent -- and the word "independent" was used.

The media has enquired as to whether the Commission has, as it were, fleshed out the meaning of the word "independent". The answer to that is no, it hasn't, but I am about to do so.

Sir, really it comes to -- many of the points that have been mentioned by both Mr Shieh and Mr Boulding -- the reason why the word "independent" was inserted before the words "expert evidence" in the rules was to ensure, essentially, that the various involved parties didn't seek to adduce expert evidence from their own employees, from their own staff. That was really the reason why the word "independent" was there and we didn't want the government producing a senior engineer from the government, MTR producing a senior engineer from MTR, and Leighton and all the other parties likewise; we wanted people who were independent, that is independent from the parties. What does that mean? It's always a question of degree, but certainly it is not the case, it is not the law in Hong Kong, that simply because there is some historic commercial relationship between the organisation that the expert works for and the party that he is now giving expert evidence on behalf of, or indeed any of the other

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parties that are here, is sufficient to question of itself his independence. That simply isn't the position. Not only historic commercial relationships but indeed current commercial relationships.

Indeed, in the courts in Hong Kong it has been held in a number of cases that indeed employees of companies and organisations can qualify as expert witnesses. It was that that we sought to avoid here, and in my submission we have avoided it.

Sir, for all those reasons, it's certainly the Commission's legal team's position that for the reasons that Mr Shieh has set out in detail and the reasons Mr Boulding has given, that neither Mr Allan, Mr Southward nor Dr Glover can in any way be suggested not to be independent.

Sir, we are satisfied, having had advance notice of what was going to be said on behalf of Leighton and the gentleman concerned and on behalf of MTRC and Dr Glover, that they are independent; that their reports clearly should be admitted and their evidence heard by this Commission, which I am convinced will also be extremely helpful to the Commission.

I might add that I wholly endorse the point that Mr Shieh makes that of course the Commission has, in Prof McQuillan, its own independent expert, and as we

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will see and you may have seen already, if you have read the reports, there are indeed many points of agreement between the experts. They have achieved an agreement which we'll be looking at shortly. And certainly there is a lot of common ground between Prof McQuillan, Dr Glover and Mr Southward, that's for sure, as well as the other experts.

So, sir, for all those reasons, I hope that the media will be satisfied with the explanations that have been given and in my submission they certainly should.

CHAIRMAN: Yes. Thank you.

It is, in our view, quite proper that the independence of experts should have been raised as a matter for consideration by the Commission, especially bearing in mind the very real public interest in ensuring structural integrity of the station.

That said, the Commission has looked at the reports provisionally. It has looked at the curriculum vitae of Mr Allan, Mr Southward and Dr Glover. And, for the reasons already put forward, it has no doubt whatsoever that they will give entirely independent expert evidence.

It needs to be said that none of the parties represented legally today have stood up to make any form of objection or to even obliquely suggest that the

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evidence of a particular expert should be viewed with anything other than open rationality, and certainly from our point of view, although it's quite proper that the matter has been raised, we have not the slightest concern as to their independence.

Thank you very much.

MR PENNICOTT: Thank you, sir. On that basis, sir, we will -- before we come to Prof Au, can I just make one further point. It's really by way of reiteration of a point that was made during the course of my opening address some weeks ago now and also made by other parties as well, and it's this. Sir, we are aware -- you are aware, we are all aware -- that during the course of the last few weeks, from about mid-December, a process of opening up the various parts of the slabs, the EWL slab and the NSL slab, at the station, has been taking place.

For better or worse, on a daily basis, the government has been publishing, in summary form, the results of those tests, so that they have been available to the public and of course the media. That has given rise to this consequence, that there has been a running commentary in various parts of the media over the past few weeks about the results that have come to light on a day-by-day basis.

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Sir, I mention that because I reiterate this point, that this Commission will reach its findings in its report on the evidence, and the expert evidence in particular, that it hears in this room and not through any media organisation or those who have felt it necessary to comment to the media over the last few weeks. So I just thought it would be appropriate to make that absolutely clear, that it is the evidence that is to be heard over the next coming days that is vital to this Commission and its findings.

Sir, with that, I will sit down and hand over to Mr Khaw, who is going to call the first expert, that is Prof Au, unless you wish to say anything.

CHAIRMAN: Might I just add to what you have just said, Mr Pennicott. You would need to be both blind and deaf not to appreciate that the issue of the structural integrity of the Hung Hom project has raised very real concerns in the media and therefore among members of the Hong Kong public. That the media should express its concerns is quite proper in an open, democratic society, and is in all respects to be encouraged.

However, that said, this Commission has a mandate unto itself. That mandate is not to come to a decision based on any popular concern. It is a mandate to be reached upon the evidence put before it, while not

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ignoring any concerns that may be there and, where necessary, putting those concerns to the experts who will appear. That will certainly be done during the course of this week. So we are not ignoring what is out there in the public domain, but our mandate is very limited. It is clear, it is absolute, and we will pursue that mandate and only that mandate. Thank you.

(Discussion off the record)

Yes, Mr Khaw.

MR KHAW: Just to echo what Mr Pennicott said in his last sentence, I will also sit down because I will let Mr Chow discuss the structural matters with Prof Au.

CHAIRMAN: Thank you.

MR CHOW: Good morning, Chairman and Prof Hansford. With the permission of the Commission, the government would like to call our structural engineering expert, Prof Francis Au from the University of Hong Kong, to give evidence, who has actually been sitting in the witness box for some time.

Good morning, Prof Au. Sorry to have kept you waiting this morning.

PROF AU TAT KWONG, FRANCIS (sworn)

Examination-in-chief by MR CHOW

Q. Thank you. You can now sit down.

Prof Au, would you mind to give your professional

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address as well?

A. You mean the physical address of my university?

Q. Yes, please.

A. It's department of civil engineering, the University of Hong Kong, Pok Fu Lam Road, Hong Kong.

Q. I understand that you have prepared an expert report to assist the Commission.

A. Yes.

Q. And your report should be in front of you.

A. Yes.

Q. Can I ask you to take a look at page 1.

A. Yes.

Q. The report runs all the way up to page 17. Can you just quickly flip through the report --

A. Yes.

Q. -- and confirm this is your expert report?

A. Yes, indeed.

Q. After page 17, we should see a copy of your CV; all right?

A. Yes.

Q. Can I ask you to go back to page 2.

A. Yes.

Q. Would you confirm that the signature that we see on this page is your signature?

A. Yes.

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Q. Insofar as your report refers to facts, would you confirm that those facts are true to the best of your knowledge and belief?

A. Yes, indeed.

Q. Insofar as you express any opinion in your report, would you also confirm that they are your honest opinion?

A. Yes.

Q. We understand, on 18 December last year, there was a meeting among experts from various parties.

A. Yes.

Q. At the end of that meeting, a document was signed, and that is the joint expert memorandum. Do you recall that?

A. Yes.

Q. I understand that, for obvious reasons, some of the matters that you raised during the meeting were not recorded in writing --

A. Correct.

Q. -- because the joint memorandum is meant to contain areas of agreement between the experts.

A. Yes.

Q. Subsequent to the meeting, you have prepared another document --

A. Yes.

Q. -- in which you set out your comments on various matters

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mentioned in the joint expert memorandum.
A. Yes.
Q. You also recall that; right?
A. Yes.
Q. Can I ask you to go to bundle G20, page 15046.
A. Yes.
Q. The document is entitled, "Additional comments on the joint expert memorandum of 18 December 2018" --
A. Yes.
Q. -- by you, and the document actually contains three pages.
A. Yes, correct.
Q. The last page is 15048.
A. Yes.
Q. Do you confirm this is the document that you have produced?
A. Indeed, yes.
Q. Would you also confirm that insofar as this document contains any facts, they are true facts to the best of your knowledge and belief?
A. Yes.
Q. And to the extent that it contains opinions, they are your honest opinions as well?
A. Yes.
Q. You would also adopt the contents of these additional

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comments as part of your evidence to this Inquiry?
A. Yes.
Q. Thank you.
CHAIRMAN: Sorry, could I just ask -- we have no knowledge of this document at this moment.
COMMISSIONER HANSFORD: I've not seen this document either. Can I also --
CHAIRMAN: It seems to me it's not merely two paragraphs and perhaps we do need to have some knowledge of it.
COMMISSIONER HANSFORD: Can I just supplement that by: do these comments in this document -- are they covered by Prof Au's expert report of 7 January?
A. I think so.
MR CHOW: Yes, I believe the main points raised in this document are actually covered in Prof Au's expert report.
COMMISSIONER HANSFORD: Obviously we have seen Prof Au's expert report of 7 January, but neither the Chairman nor I have seen this document.
CHAIRMAN: Perhaps what we could do -- sorry, I'm cutting across you. My apologies, I didn't mean to do that.
MR CHOW: No problem.
CHAIRMAN: But while I'm now puffing along, I might as well just continue. Could we just have a copy of it, do you think?

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MR CHOW: Of course.
CHAIRMAN: Because if we are given a copy, Prof Hansford will be able to speed-read that very easily. I will be able to read it at a more plodding pace. But I think between us, without having to adjourn for a quarter of an hour or something like that, we will be able to catch up as we proceed. Thank you very much.
MR CHOW: Right. I will make sure that a hard copy will be prepared, perhaps during the break. But from my recollection --
COMMISSIONER HANSFORD: Sorry, actually, can we have it quicker than the break?
CHAIRMAN: We would like it now. Thanks.
MR CHOW: Yes. I'm sure colleagues from the Department of Justice will be doing it right now.
CHAIRMAN: All right. Thank you.
MR CHOW: May I just add that from my recollection, we should not find anything surprising from this document. They are I believe all covered by Prof Au in his expert report, perhaps even more in detail.
The next point I would like to move on to is -- Prof Au, we know that after you have produced your expert report, there were further results from the opening-up exercise.
A. Yes.

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Q. Did you have a chance to look at the latest results of the opening-up?
A. Yes.
Q. Can I ask whether these further results from the opening-up exercise would in any way affect your opinion expressed in your report?
A. Actually, the results reinforce my belief that there is a real need to continue the opening-up process to find out more, because actually the results are sort of a real concern. I remember that there are a few couplers which are unconnected. Now, that is another concern because apparently, a coupler that is not connected can be easily seen on site. So then it obviously has escaped the attention of the contractor's staff and staff of the sub-contractors and also the site supervising staff. So that is a real concern, whether that kind of thing is isolated or whether it is going to happen elsewhere.
Q. Thank you. Prof Au, you have set out in your report your opinion --
A. Yes.
Q. -- on various technical matters.
CHAIRMAN: I'm sorry. Just forgive me. A question arises from that. One is project management --
A. Right.

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CHAIRMAN: -- supervision and/or inspection, which may be that if there hasn't actually been any form of connection of rebar to coupler, that may go to issues of adequacy of oversight.
A. Right.
CHAIRMAN: That's one question. The next question is if there has been a level of failure to connect at all, does that go to structural integrity?
A. Yes.
CHAIRMAN: And your answer would be --
A. Of course that would affect.
CHAIRMAN: The structural integrity of the work?
A. It depends on the amount of couplers unconnected.
CHAIRMAN: Yes. Good. Thank you.
COMMISSIONER HANSFORD: Thank you very much.
CHAIRMAN: Thank you, Mr Chow.
COURT REPORTER: Excuse me, I don't want to speak out of turn, but please wait until the question has finished before you answer, because I need to get the question on the record.
WITNESS: Understood.
MR CHOW: Prof Au, I understand, to better assist the Commission, you have prepared a short PowerPoint presentation to summarise your main points set out in your expert report.

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A. Yes.
Q. If you are ready, I will hand over the floor to you, but after you finish I will still come back because I understand you would like to respond to a few matters raised by the other experts in their expert reports. So that we will do later on. But now, if you are ready with your PowerPoint presentation, you can start now.
A. Okay. Thank you.
Before I give my oral synopsis, here is a little bit about myself. I am currently a professor and head of the department of civil engineering at the University of Hong Kong. Here are some of my qualifications. I've got a bachelor's degree with first class honours, a master's degree with distinction and a doctorate degree, all in civil engineering. I'm a fellow of the Hong Kong Institution of Engineers and the Institution of Structural Engineers. I'm also a member of the Institution of Civil Engineers.
Before I joined academia around 30 years ago, I had spent seven years, roughly, in the industry, including one and a half years on site and the rest of the time I spent in various design offices.
After joining university, apart from teaching and administration, I do research, primarily on bridge engineering, concrete structures, vehicle-bridge

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interaction and structural fire engineering and so on. I work both on the theoretical side of research as well as the experimental part of research. For example, in the laboratory, we fabricate specimens of structures and we load test them to failure, to find out more, to learn more about their behaviour. So we try to observe the phenomena before failure, including for example the cracking, crushing, buckling of components or materials and in some fire tests we even observe explosive spalling of concrete.
So from that experience I knew that there are certain limitations in the calculations, so the reality can be different, so that's why there is a need to do research. From our research findings we also publish papers to propose new theories or propose new methods of calculation. I have published over 150 journal papers and over 90 conference papers. I have given over 20 invited and keynote lectures. I have won a few research awards.
Perhaps I could ...
MR PENNICOTT: The next page.
A. All right. So I start from fundamentals. I believe all of us know what a force is. If we apply a force at a distance from a pivot, we are creating a moment.
Next, please. There are materials which are brittle

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or easily broken, including glass, porcelain and concrete. There are some other materials which are ductile, they can be easily deformed without breaking, including copper and steel.
Next, please. To help you understand what happens to a concrete structure, the left diagram shows a plain concrete beam, that is a beam constructed entirely of concrete, nothing else. If we carry out a loading test, if we overload it, then sooner or later it is going to break into two pieces without any warning. Of course that is undesirable.
Next, please. Now, if we introduce reinforcing bars into the concrete beam, it becomes a reinforced concrete beam. If we load test it, of course it can carry certain loading. If we overload it, of course it is going to deform further and it will also crack. Now, the excessive deformation and cracking are not bad, because they are warning signals so that the occupants can evacuate.
Next, please. Of course ductility is something that is desirable. Now, in a construction project, the works have to satisfy various requirements. So, in the local situation, of course the Concrete Code published by the Buildings Department is one of them, and for this particular project the MTRCL's in-house design manual is

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another, and then there are later on the contract requirements.

Very often, proprietary products are used in a contract and then the supplier's requirement has to be satisfied as well.

In the design process, engineers normally consider a lot of loading combinations and then they carry out structural analysis and design. In addition, there are certain miscellaneous rules laid down in various design codes, for good reasons.

Next, please. The MTRCL has submitted a holistic proposal to the government which has been accepted. It describes a sampling approach to -- well, for two purposes, including the verification of as-built record and the workmanship. I believe that this opening-up process is necessary and pragmatic.

The binomial statistics approach adopted is considerable acceptable, simply classifying the outcome as compliant or non-compliant. However, for those outcomes which are non-compliant, ie for couplers' non-engagement with the threads, follow-up investigation for strength, elongation, et cetera, is necessary.

From the outcomes of the opening-up process, after completion of it, it can be reviewed if there is a need for further opening-up. For the non-destructive test of

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the couplers exposed, I believe that the phased array ultrasonic testing is quite reliable.

Next, please. Regarding the acceptance criteria of couplers, they are supposed to comply with the code and whatever standard. In particular, they have to satisfy the requirements of strength, deformation, et cetera, not just strength. From the visual inspection, manual or similar, of BOSA, the couplers are supposed to be fully tightened and a maximum of two full threads may be exposed. However, in another letter of BOSA dated 7 January 2019, "10 full threads" are supposed to be engaged and it should be tightened so that the bars are "butt-to-butt", otherwise the assembly may be considered "loose".

There may be some slight discrepancy between the last two bullet points.

Next, please. That is about the opening-up of the upper slab or EWL slab, adjacent to the diaphragm wall. From the calculation based on the normal load combinations, it's true that in respect of strength there may not be any need for bottom reinforcement. However, that is also required by the Concrete Code, that is 50 per cent of the reinforcement area at mid-span should be provided there and well anchored there.

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Now, this additional amount of reinforcement is not useless. It also provides ductility, serviceability, and so on. Actually, in our department, a few colleagues, including myself, have worked on the ductility of concrete structures. The compression reinforcement helps to enhance the ductility of the cross-section.

Here are two papers published over ten years ago.

Then, again, depending on the outcome, there could be further increase of random sample size, to help us understand further the workmanship, and the sequence of the actual opening-up may also be revealed.

Next, please. The case of the lower slab or NSL slab is a bit different, actually quite different. Now, because of the water pressure acting upwards on the bottom of the NSL slab, bottom reinforcement is normally under tension adjacent to the diaphragm wall. We also know that it is impractical to open up the bottom reinforcement for verification, so therefore the random samples of the top couplers will be very useful to let us have a better understanding of the workmanship of all the couplers in this NSL slab.

Also, in the rare case of future dewatering in the vicinity, the top reinforcement may also take tension.

Next, please.

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CHAIRMAN: Sorry, dewatering -- I know what it means -- what does it mean in engineering terms here?

A. All right. Let's say supposing in future there is a need to further extend the station and they have to dig downwards, so they need to pump out water, they have to dewater, and so the groundwater table would come down. So if it comes down and below the NSL slab, then the self-weight of the NSL slab take effect and it would reverse the bending moment.

CHAIRMAN: Thank you.

A. All right. Now, on the compliance of works, the MTR New Works Design Standards Manual is used, and it specifies that seismic design and ductility detailing would be required. And the original design has been accepted by the Building Authority, as far as I understand.

However, there are various issues, such as the non-compliant couplers which have been discovered from the opening-up process, the additional construction joints due to the revision of the connection between the slab and the diaphragm wall, honeycombing discovered on site, and some missing or misplaced shear links, et cetera.

So there are certain parts of the work which are non-compliant.

Next, please. The connection between the slabs and

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the east diaphragm wall. If we look at an assembly of the coupler, we understand that the coupler is essential to ensure that the assembly is an integral component that can take force. Similarly, the connection between the slabs and the diaphragm wall are very important connections. I understand that rigidity has been assumed in the analysis so far. So in case the connection is defective, then that would affect the internal forces and in the extreme case it may even affect the stability. So these are things that have to be followed up.

Next, please. To help you understand more what happens at the connection -- now, the left diagram shows a cross-section of the station. In particular, we would like to focus on the connection between the upper slab and the diaphragm wall over there, and the top-right diagram shows an enlarged view of that.

If you look at the left diagram -- it is not loaded, so it is just a platform slab over there, so the platform slab is just supporting its own weight, and you can -- if you refer back to the top-right diagram -- now, you can see that on the left of the connection, there is a moment, there are two forces acting on that face of connection. On the right of the connection, there is also a downward force and a bending moment.

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There may also be a very small horizontal force.

Now, the yellow part of the concrete which has been cast afterwards is enlarged in the bottom-right diagram. This is what we call a free body diagram. This is a simplified version of the free body diagram that is very often used by engineers to understand what happens to various parts of a structure. So you can see that on the right of that yellow block there is a tensile force acting -- sorry, on the left there is a tensile force acting, and then on the right there is a smaller tensile force acting. To ensure equilibrium or balance of force, there is a need for a shear force at the bottom, the horizontal force at the bottom; okay? So this is to ensure equilibrium, it would always behave like this.

Next, please.

MR CHOW: Prof Au, can I pause you here. Can we just stay in slide 13.

A. Yes.

Q. Earlier, you mentioned about the tensile force on the right is smaller than the tensile force acting on the left side of the free body. Could you elaborate a bit further why we have a difference in the magnitude of this force between the two sides of the free body?

A. Yes. So if you refer back to the top-right diagram, there is a bending moment acting on that interface.

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Because of that bending moment, it would create some tension in the top reinforcement; the slab is having a quite long span, and then the bending moment is also quite large, and because of that there is a need for a large tension to take up that moment.

But on the right side of the connection, in comparison the bending moment is smaller and so the tension acting on the free body is also smaller.

Next, please. If you look at the left diagram, now, in this case, the platform is fully loaded by people and trains. So obviously the bending moment and forces acting on the interface shown in the top-right diagram are all larger, in particular the bending moment and shear force.

So if you look in the bottom-right diagram, the tension caused by the bending moment must be larger as well, and because of that the shear force acting on the bottom of the yellow free body must be larger. In other words, what I am trying to demonstrate is that the internal force inside the connection varies with the loading condition. So the larger the loading applied, the larger the force and the stress inside the structure.

Next, please. Now, here shows the enlarged connection detail of one of the versions. The

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connection is something that is very important, connecting the slab and the diaphragm wall, enabling it to transfer the forces between them. Because of the change of the design of the connection, there is an additional construction joint. This is just one of them. There are more complicated construction joints. In addition, there are some other cross-sections which may cause concern. There is a need to check the stresses inside the connection, to ensure that it can act as an integral component in the structure.

Next, please.

COMMISSIONER HANSFORD: Sorry, if I can just interject, Prof Au. You say there's a need to check the stresses inside the connection.

A. Right.

COMMISSIONER HANSFORD: How long would that take? How long is an exercise to check the stresses inside the connection? How long would that take?

A. I think for someone who understands the behaviour of beam-column joints, it's very simple. But the problem --

COMMISSIONER HANSFORD: Are you talking about one day, one week?

A. I think half a day. The problem is that very often, the behaviour of beam-column joints is taught in

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postgraduate level, and very often such courses are not compulsory, so I'm not surprised that some engineers may have no knowledge of the behaviour of beam-column joints.

Having said this, there are certain requirements for the design of beam-column joints in the Concrete Code, but that is only for the more regular beam-column joints, there is a formula, and so people simply use that formula to find out the required amount of reinforcement. That's it. But then if some people try to alter that, take away something, that would be more complicated, and I'm afraid not everyone is capable of doing that.

COMMISSIONER HANSFORD: I understand. So, basically, you are telling me that it's about half a day for someone who's properly qualified to do that?

A. Yes.

COMMISSIONER HANSFORD: Understood. And somebody properly qualified would include yourself, would it?

A. Yes. Well, actually, I have two PhD students having worked on the research of beam-column joints.

COMMISSIONER HANSFORD: Who could do this sort of work?

A. I think practising engineers under the instruction of someone who knows the behaviour of beam-column joints. That's it.

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COMMISSIONER HANSFORD: Thank you.

A. All right. Here is a list of issues that we need to look at. From the outcomes of the opening process so far, over one-third of the couplers are defective. I'm afraid the effects can't be ignored. In particular, some couplers have been discovered to be unconnected. We need to find out more.

Of course, for those couplers that are not fully engaged, there is still some strength. There is a need for conducting a holistic assessment of such partially engaged couplers, not just to look at the strength but also to look at the behaviour in other aspects specified by the design code, including the ability to sustain cyclic loading and the elongation and so on. We need to look at the connection between the slab and the diaphragm wall, looking at the strength of the connection itself and also stresses at the additional construction joints, which may be critical. The honeycombing area --

CHAIRMAN: Sorry, before we move on, again -- where you are talking about no connection, any tests of course would be dependent upon the regularity of the occurrence of no connection?

A. I believe for those couplers that have not been connected, of course it cannot develop any strength.

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I think the important point is there is a need to assess through statistical method the possible, let's say, percentage of such occurrence, so that when -- I think that is stage 3 of the holistic assessment -- so that there is something to base upon to evaluate the strength of the structure.

CHAIRMAN: Okay. Thank you.

A. So the honeycombing area of the slab should be repaired, and there is also a need to evaluate the effect on the overall structure, because very often the honeycombing areas are in the most congested area where the reinforcing bars are lapping, and so these reinforcing bars are not effective anymore, and how these ineffective reinforcing bars are going to affect the structural performance I believe there is a need to assess.

There have been some calculations performed to assess the structural utilisation factor. I believe the structures have been assumed to be intact, no problem at all, no defective couplers, no honeycombing whatever. Now, it is too early to conclude. I believe more calculations should be conducted.

Next, please.

COMMISSIONER HANSFORD: Sorry, what sort of calculations, Prof Au?

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A. For example, if we know that there is a certain percentage of couplers which are found to be defective, and -- well, there are two aspects. The first aspect is on strength, which a lot of people have been talking about. So we need to carry out calculations, also modelling those parts which are affected by the defective couplers, and then we have to find out the effect of this structure with some defects, and then find out whether other parts will be overstressed or whatever. And what is more, we need to find out if there is the feasibility of strengthening so as to bring this structure up to the required level. That is the strength aspect.

The other aspect is the elongation. According to the design code, certain tests would be carried out, and afterwards we have to measure the residual elongation. So, at the location where couplers are required to connect reinforcing bars, in case there is excessive elongation at that part, there may be excessive crack width. For example, at the connection between the diaphragm wall with the lower slab -- now, it is entirely connected by couplers. In case, well, there is a higher percentage of defective couplers, there is a concern of excessive crack width over there and the groundwater may get into the reinforcement, and so on.

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Now, I'm not saying that it must be unacceptable but we need to do calculation with some scientific basis, let's say on the percentage of defective couplers, to find out how serious it is or whether it is still acceptable. There is still a chance that it may be acceptable.

COMMISSIONER HANSFORD: You talked about possible strengthening.

A. Yes.

COMMISSIONER HANSFORD: But that would only be required, presumably, if the structure was found to be inadequate?

A. Yes. But I need to add that to assess whether a structure is adequate or not, strength is of course something very important, but in addition to that ductility, serviceability and other things should also be considered.

COMMISSIONER HANSFORD: Okay. Thank you.

A. All right. So if I --

CHAIRMAN: Sorry, what does "serviceability" mean?

A. "Serviceability" means -- okay, in design of a structure, we need to consider two types of limit state, what we call -- okay, let's call them conditions. The first condition is what we call serviceability limit state; that is the working condition. Let's say, in this room, all of us are sitting over here, so there

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would be loading coming from the furniture, from the people over there, the self-weight of the floor over here, and if we try to calculate the stresses based on that, that is what we call the serviceability limit state or the working condition.

CHAIRMAN: Okay. Thank you.

A. The second bullet point. Both the strength and deformation of the couplers are important, so couplers with only six threads engaged may not be acceptable. So we need to carry out more tests with the coupler assembly partially engaged to understand more their performance not only in respect of strength but also in respect of deformation and ability to sustain cyclic loading and so on. There is a need to continue opening up the bottom of the EWL slab and the top of the NSL slab.

There are miscellaneous issues, some of them I have already covered, that should be followed up, and then the outcomes will enable a future decision to be made regarding whether there is a need for strengthening, and so on.

CHAIRMAN: Sorry, when you say that more tests need to be done to see, for example, if there's only six threads engaged or something like that --

A. Right.

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CHAIRMAN: -- are you talking about doing that away from the work site, I mean away from --

A. Yes, inside a laboratory.

CHAIRMAN: So you would take the couplers and you would conduct a series of tests at different thread engagement?

A. I understand that some tests have already been carried out using similar couplers, not those couplers taken from the works, so they have used similar couplers with some partial engagement of the threads and then they did some tests. And actually, in my report, I have also included a table showing the results from that test report. But the results are not enough. The samples are not enough. And then they have to carry out more tests -- in addition to finding out the strength, other performance attributes should also be found out.

COMMISSIONER HANSFORD: Why are the samples not enough?

A. What I mean is -- if you look in my report, so in that table, there are results of I think 100 per cent engagement, I can't remember, 80 per cent, 60 per cent, 50 per cent, whatever. Now, the strange thing is that the maximum strength occurs at 60 per cent engagement but not more. It's very strange. So I believe the results are having a very large variability. And so, for example, for the case of 60 per cent engagement,

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I would believe, let's say, ten samples like this should be tested. For every percentage engagement, there should be more samples tested, so that we can find out the mean value, we can find out the standard deviation, to understand how variable the results can be.

COMMISSIONER HANSFORD: Okay. Thank you.

A. I think I have finished my presentation. Thank you.

CHAIRMAN: Sorry, on what you have just spoken about, would this mean that you are looking to a mean average related to the strength entirely across the whole length, or are you talking about particular areas? Well, no, it would be very difficult to isolate to areas, wouldn't it, it would be impossible, without basically opening everything up?

A. No, I am not advocating taking out all of the couplers for testing. I am suggesting that similar couplers are let's say manufactured by the same company and if possible similar reinforcing bars would be employed to carry out tests inside a laboratory. So these are new samples not taken --

CHAIRMAN: I appreciate that, yes. And then?

A. So the results would help us understand the behaviour or the possible behaviour of this structure with some defective couplers.

The defective couplers still carry some loading.

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They still have some strength. So the purpose of doing this is to let us have a better estimate of the available strength and then the possible deformation, so that in future, when further calculations are carried out, we can be more realistic; we try to model the situation of the structure better.

CHAIRMAN: Thank you. How long do you think that would take?

A. I think doing the tests would take, let's say, a few weeks, if the couplers are around, if the bars are around -- I think perhaps one to two weeks, that could be done.

COMMISSIONER HANSFORD: Why would it take so long?

A. I think, first of all, I understand that the industry has been sort of experiencing a change in the use of the reinforcing bars, because previously we were using grade 460 but now people are using 500. So if we really want to find out the kind of reinforcing bars used at that time, I don't know whether we really can find them, but even though we can't find them I think anything, let's say grade 500, and if we can carry out similar tests, that would help us understand better.

CHAIRMAN: Thank you.

MR CHOW: Thank you, Prof Au.

Prof Au, on the basis of your report, it appears to

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me that the main difference between your opinion and the opinions from experts of the other parties is that you say the internal stresses in the connection have to be checked properly and numerically; is that right?

A. Yes.

Q. That is really the main difference between you and the other experts.

A. Yes, indeed.

Q. Can I ask you to go to part of Mr McQuillan's report. You will find that in I believe it's tab 3 of the same bundle.

A. Yes.

Q. Paragraphs 99 and 100 at pages 41 and 42.

A. Yes.

Q. Do you need to read the paragraphs again?

A. Yes.

Q. The diagram that we see on top of page 42, that is right above paragraph 100 --

A. Right.

Q. -- is a similar diagram that we have seen earlier --

A. Yes.

Q. -- your free body diagram.

A. Yes.

Q. In paragraph 100, Mr McQuillan made the following statement:

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"The diagram illustrates why no tension or shear can occur at the interface."

A. Yes.

Q. Do you have any response to this statement?

A. Yes, indeed. Now, actually, I believe that the amount of compression acting on that construction joint is very low. It is very low. That is because -- now, to understand how much compression exists there, we need to look at the two sides, the left side and the right side of the rectangle enclosed by the red dashed line but then inside it's blue.

We need to look at this diagram. So here is -- there is a small rectangle in blue, that is the concrete cast afterwards. To find out how much compressive force is acting on the construction joint, we need to look at the downward shear force acting on this part of the free body on the right (indicating), as well as the downward shear force acting on the left of the free body (indicating).

Actually, for someone who understands strut-and-tie action in a concrete structure, actually most of the downward forces will be acting on the bottom part, and so the upper part would have relatively small. There may still be some compression but it will not be very small. But the major concern is that there would be the

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shear force. So as shown in two slides of my presentation. So the major concern will be the shear force at the construction joint (indicating).

So that is a potential weakness. So I believe there are two possibilities. If the strength of the construction joint is good enough, spending half a day to check it, I think it would be easier to verify that numerically than to argue that it is not necessary to do so. If it is not strong enough, there is a real need to do calculations to find out the feasibility of strengthening and the extent of strengthening.

So I think there is a need to check numerically the forces and the stresses.

COMMISSIONER HANSFORD: Prof Au, that's the numerical testing that you consider can be done in half a day --

A. Oh, yes.

COMMISSIONER HANSFORD: -- by someone qualified to do it?

A. Yes.

COMMISSIONER HANSFORD: Thank you.

MR CHOW: Prof Au, a follow-up question: have you got all the data and design parameters for you to carry out such checking?

A. No, I don't. No, I don't. But then, actually -- now, so a very simple calculation can be done; okay? Well, assuming -- now, we can work out the forces -- I'm

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sorry, I will do that again.
So the important part is this connection (indicating). So if we can find out the bending moments, shear forces and so on at this cross-section (indicating), and then similar forces and moment here (indicating), similar forces and moment there (indicating), I think it would be very simple; just a few hours, one can do that. So that is the basic principle of the design of beam-column joints. But I haven't done that myself.
But then perhaps I could add that some rough calculations have been worked out, but then it is not to say that everywhere it is not satisfactory but then there may be some concerns somewhere. The other thing that I may add is that checking the stresses at construction joint is a standard practice in the design of composite bridges, bridges comprising precast beams and in situ slab, at the interface it is a regular, standard practice to check the stress over there. So I don't think it is difficult.
COMMISSIONER HANSFORD: Mr Chow, we are going to hear from all the other experts this week, of course, but if this exercise needs to be done, it would seem to me that we should do it rather quickly.
MR CHOW: Prof Hansford, it all depends on the answer of

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Prof Au to my next question.
COMMISSIONER HANSFORD: Ah.
MR CHOW: Prof Au, can you explain to us what you mean by to carry out that exercise is to know that the moment, shear force and the external actual force on the free body that we looked at --
A. Yes.
Q. -- how long would it take you to gather those information for you to carry out that checking?
A. The important thing is to look at the entire -- well, I think a very simple thing to do is just to look at the typical cross-section of that station, so it is something like a frame, collecting all this loading acting on it, and then carrying out a plain frame analysis, finding out the bending moment, shear forces, axial forces adjacent to the joint, and then the rest would be very simple calculation using a calculator, based on certain assumptions that we normally use for reinforced concrete design.
Q. Let me put it this way. If you were asked to do this exercise, how long would it take to gather all this information and carry out the sort of checking that you mention?
A. I think just a few hours. That's fine.
CHAIRMAN: So if we were to ask that you come back, shall we

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say, on Thursday or something like that and let us have the results of the test, would you be able to do that?
A. I'm not sure because I do have lectures, and so on.
CHAIRMAN: Yes, I appreciate that. All right. So all else being equal and assuming you have the time?
A. Yes.
CHAIRMAN: Good. I just wanted to get an idea of the feasibility. Thank you.
COMMISSIONER HANSFORD: I think you also said that this could be done by PhD students under your supervision.
A. Yes, why not. Yes. I think for someone who knows the basics of structural engineering, that would be fine.
CHAIRMAN: All right. Thank you.
MR CHOW: Just now, you also mentioned that you have done some rough checking and there were some concerns; is that your evidence?
A. Okay. Now, so the government actually has engaged another firm to do some checking in parallel, under the supervision of myself and another colleague in my department, so they already have done some calculations. Apparently, there is some concern somewhere.
Now, of course, what they have used may not be exactly those that the designer has used; okay? But, well, if the designer checks that again, they are in a better position to check it. It shouldn't be too

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difficult.
CHAIRMAN: Sorry, you have to help me here, because that seems very vague to me. So whoever's done this has found some concern or has some grounds for concern in respect of something not identified?
A. Well, it's mainly the horizontal shear at the construction joint. So that is one thing. And the other thing is that, as pointed out earlier, there may be some other critical sections within the connection that has to be checked. So there should be more checking.
CHAIRMAN: All right. And again, all else being equal, could that be done relatively quickly?
A. Yes, I think it's very simple. The present problem is whether one is willing to do it, and if one is willing to do that I think it's a matter of just a few hours or just a few days, not difficult.
CHAIRMAN: These tests are not destructive?
A. I'm talking about calculations.
CHAIRMAN: That's right. So when you say "willing to do it" you mean ...?
A. So far, I haven't seen any sort of numerical results from the expert reports on this, apart from one from Atkins which I found to be erroneous; okay? Apparently, so far, I'm not aware of anyone having done this.

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CHAIRMAN: All right. Thank you.
MR CHOW: Lastly, can I ask you to go to Mr Southward's report in tab 5.
A. Yes.
Q. Page 40 of 83, under section 14.2 --
A. Yes.
Q. -- do you see the second-last paragraph from the bottom of the page?
A. Yes.
Q. Mr Southward basically says the platform slab and diaphragm wall structures would be treated as superstructure.
Do you have any response to that?
A. Now, I don't think that is the common use of the term. So if we consider a building with a basement supported on piles -- now, obviously the basement is not part of the superstructure. I think the part of the building above ground level can be termed superstructure. Anything below can't be called superstructure. I think if we call that a basement, fine, I have no objection. Well, certain parts of that may be part of the foundation, but I don't think that can be called a superstructure.
Q. How about substructure?
A. I think the term "substructure" is fine, really.

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MR CHOW: Prof Au, I have no more questions.
WITNESS: Thank you.
MR CHOW: I have no more questions for you, Prof Au. What is going to happen is counsel for the Commission may have questions for you, and after that there may be further questions from various lawyers acting for different parties, and meanwhile Mr Chairman and Prof Hansford may also ask you questions. After that, if necessary, I will also have a chance to ask you a few more questions by way of wrap-up.
So, if you are ready, please remain seated and take questions from the other counsel.
Mr Chairman, I understand --
CHAIRMAN: Perhaps --
MR PENNICOTT: Sir, before we do that, a coffee would be good.
MR CHOW: Certainly.
CHAIRMAN: One thing, as a warning request, not a warning order, is we have a number of suggested tests that Prof Au has spoken of. It would help us, perhaps, if at some stage, Mr Chow, you are able to come back to us and say, "These are the tests, these are their parameters, this is how long it will take to have them done, and if they are successful, this will be the result", that would help us. Because at the moment, for myself, as a layperson, it's a little bit fuzzy, and that's simply my lack of comprehension because a number of tests have been suggested quite quickly, one upon the other. All right. Would that help?
MR KHAW: We will be able to supply the Commission with such information after Prof Au finishes his evidence.
CHAIRMAN: That's what I'm saying.
Quarter of an hour. Thank you.
(11.30 am)
(A short adjournment)
(11.52 am)
Examination by MR PENNICOTT
MR PENNICOTT: Sir, good morning.
Prof Au, good morning. As you have probably realised, I'm one of the counsel to the Commission, my name is Ian Pennicott, and I have a few questions for you but first of all thank you very much for coming along to give evidence to the Commission.
Sir, can I just confirm that the pieces of paper you were given earlier are numbered G15046 to 48?
CHAIRMAN: They are.
MR PENNICOTT: Thank you. I just wanted to double-check, with the haste with which that was done, you have been given the right pieces of paper.
Prof Au will confirm this -- what happened, and I'm not making any complaint about this because I'm about to ask Prof Au questions about it, is that following the expert meeting, we received a letter from the government, with Prof Au's additional comments attached -- we can see they are dated 22 December -- four days after the meeting, so we've had them for some time and I apologise if they haven't been brought to your attention, but I'm well aware they have been there for some time.
Prof Au, that's how it happened, as I understand it; is that right?
A. (Nodded head).
Q. Good. Prof Au, can we look at the very first page of your report, please, which is in bundle ER1 at tab 7. You set out there your instructions and the matters upon which you have been asked to express a view?
A. Yes.
Q. Can I ask you this: have you read the terms of reference of the Commission?
A. Yes.
Q. You have. So you will be well aware that the key issue is safety?
A. Yes.
Q. And whether the EWL slab and the NSL slab in particular are safe?

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A. Yes.
Q. I'll come to that in a moment.
Could I ask you, please, to look at the joint statement that was signed by the experts on 18 December.
Sir, it will be found in ER1 as an attachment to Prof McQuillan's report at appendix XI. It's at page 117, the internal numbering of Prof McQuillan's report.
Prof Au, could we look at the first item, towards the bottom of that page --
A. Yes.
Q. -- which is -- there's a heading, "General code requirements"; do you see that?
A. Yes.
Q. The first bullet point is that:
"All agreed there was no requirement for ductility couplers."
Do you see that?
A. Yes.
Q. As I understand it, that's the first point upon which you have made some additional comments.
A. Yes.
Q. So if we could take page 15046 in bundle G20.
A. Yes.
Q. You say:

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"The discussion on the use of ductility couplers was mainly on seismic design of structures. I have raised the point in the meeting that, in general, ductility is a desirable quality of all structures, irrespective of whether a structure is designed for seismic resistance or not."
And then you make the point that the MTRC proposals required certain zones to be ductile.
A. Yes.
Q. Then you have also referred to the Code of Practice which also has ductility requirements in it.
A. Yes.
Q. Have you had the chance to read Prof McQuillan's report?
A. Yes.
Q. Could I ask you, please, to look at paragraphs 42 to 44 of that report.
A. Yes.
Q. Again, here we see Prof McQuillan has referred to the relevant Code of Practice, the ductility requirements that are set out in that Code of Practice. He's referred to an information note from the government, and then says this:
"Accordingly the BD currently does not have any specific design and construction requirements in respect of" --

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A. Sorry, which one?
Q. Paragraph 44.
A. Right.
Q. "Accordingly the BD currently does not have any specific design and construction requirements in respect of seismicity but requires compliance with the ductility requirements of the code, including couplers. In other words, code-compliance is deemed to provide some inherent structural resilience against seismic events."
As I understand it, you agree with all that, Prof Au; is that correct?
A. So are you referring to the second sentence?
Q. I am. Well, first and second sentences.
A. Yes.
Well, my understanding is that MTRC was designing the structure to comply with their in-house design manual as well. That in-house design manual requires the seismic resistance design, and apparently that was submitted to the Buildings Department, as far as I understand, and the Building Authority accepted that. And the requirement is the use of ductility couplers somewhere; right?
Q. Okay. That's what Prof McQuillan says a bit further on:
"I note, however, that MTRCL do include specific seismic design requirements and loading in their

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performance specifications ..."
And the reference is given. I think that's the same reference you have given us in your report.
A. Yes.
Q. So, as I understand it, in relation to those three paragraphs in the requirement for ductility couplers, there is no difference in fact between yourself and Prof McQuillan?
A. So you are referring to this particular paragraph only?
Q. Paragraphs 42, 43 and 44, 44 in particular.
A. 44?
Now, 44 is okay, but there is certain requirement from the BD regarding the use of the ductility couplers. Yes. So that is my understanding, that BD requires the use of ductility couplers somewhere; okay?
Q. Yes.
A. Because according to the older code, that was not allowed unless ductility couplers are used, and that is a specific sort of requirement in accepting the design, as far as I know.
Q. All right. Now, with that in mind, one -- or certainly I do -- ask myself the question: why did you all agree that there is no requirement for ductility couplers?
A. Yes.
Q. Could I ask you, please, to look at paragraphs, first of

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all, 89.1 and 89.2 of Prof McQuillan's report at page 38.
A. Well, actually, I need to add that the reason why I submitted later on the additional comments was that I found the record was not accurate. Actually, I wasn't given sufficient information before that date, there wasn't any agenda, and the meeting started at 11.00 and it went on until 2.30 in the afternoon.
Actually, in the meeting, I raised objection to many points already; okay?
Q. Prof Au, we have to be a bit careful here. These were without-prejudice discussions that took place between the five experts, and I don't want to get into a discussion about what was said by whom. All I'm interested in is what was signed at the end of the day and you put your name to along with the other experts. Do you understand?
A. I understand, but actually, at that time -- now, that was a very lengthy meeting and I wasn't given any idea how long that meeting would be, and I was starving, and then if I raised further objection, the meeting will prolong. Probably it would end at evening time, dinnertime or whatever. I don't think it is a proper record.
Q. You could have refused to sign it, Prof Au, but you

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didn't?
A. Yes, I know. I also knew that I would be given a chance to qualify the record -- well, provide additional comments.
Q. Can I suggest we do it this way. Could you just bear with me, please, and go to paragraphs 89.1 and 2 of Prof McQuillan's report, where he says this:
"The following summary facts inform my opinion:
1. There is no requirement for the structures to be specifically designed for seismicity provided the design is code-compliant in respect of the ductility and bottom steel continuity clauses."
Do you agree with that?
A. Now, so by code-compliant are you referring to the Concrete Code 2004?
Q. Yes.
A. Yes, agree.
Q. Right. Then, secondly, he says this:
"2. The geometry of the connection between the EWL slab and the east D-wall, however, precludes any ductility. The structural 'plastic' deformation which might occur during seismic activity will develop lower down the D-wall. Ductile-grade couplers are not therefore required where used in the EWL slab to D-wall joint."

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Pause there for the moment before I ask the question. Could you also, please, look at paragraph 4.6 of Dr Glover's report, which is in tab 6 at page 4, internal number.
A. Yes.
Q. 4.6, and then it's bullet point 4. I presume, Prof Au, you have had a chance to look at Dr Glover's report as well. What Dr Glover says is:
"Due to the disproportionately stiffer and stronger EWL slab (3,000 millimetres deep) relative to the diaphragm walls (1,200 millimetres thick), it would be impossible to develop ductile behaviour in the slab or its connection to the walls since the wall would have failed structurally under ultimate load conditions long before the rebar in the slab would have reached its yield stress, ie the slab connection would remain in the elastic range. This is clearly demonstrated by ..."
Then Dr Glover refers to an appendix in his report.
A. Yes.
Q. So do you agree with paragraph 89.2 of Prof McQuillan's report and that bullet point at paragraph 4.6 of Dr Glover's report?
A. No.
Q. What do you disagree?
A. Okay.

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Q. Why do you disagree, rather?
A. Let me explain, using something people can understand. Actually, in one of my first few slides, I mentioned that in the structural design, we do structural analysis based on some of the load combinations, some of the load cases, and then we try to find out the forces, whatever, provide reinforcement, whatever. In addition to that, there are certain rules of detailing whatever that we have to follow, for good reason.
Let me cite an example. When I drive on the road, I obey all the road signs, so the road signs are there for good reasons. I may not be aware of certain dangers ahead of me, but I obey the road signs. Coming back to the technical question, there are certain requirements for detailing. It's right that if you just look at the load cases that you have considered, under normal circumstances, that load, which is the self-weight of the structure, live load, the weight of the people, trains, whatever, it's true that over there, that slab is very stiff and then the diaphragm wall is more flexible, whatever, yes. But the problem is providing the reinforcement over there, providing ductility couplers over there, also serves certain purposes. I can give you some examples.
Now, I understand that there is no requirement to

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carry out fire design for that, for structural fire. Considering certain scenarios for fire, if there is a fire breaking out above the upper platform slab and it's confined somewhere, and then let's say the top part of the slab is heated to let's say 800 degrees Celsius, and perhaps before that, it is going to heat up the top part of the slab, and there is a so-called thermal bowing. So the top part of the slab is trying to expand, and this is going to reverse the bending moment.

So the bottom part of the slab reinforcement may be in tension, maybe. This is just one example.

If the fire goes on and then somehow the top reinforcement is affected, let's say the top reinforcement is heated to 600 or 700 degrees Celsius, the strength would be substantially affected. So even the bending resistance would come down to a very low value. If there is sufficient reinforcement at the bottom, well anchored, possessing good ductility, then it is going to save the structure. That is what we call catenary effect. So the floor may tend to deflect a lot, but then it will be hanging like a net. That is what we call catenary effect.

CHAIRMAN: And the spelling?

A. C-A-T-E-N-A-R-Y, like a cable. So the bottom reinforcement is also useful.

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Now, it is not a requirement to consider that load case, but I don't agree that such rules cannot be -- well, need not be followed.

MR PENNICOTT: I put what I thought, by reference to those paragraphs, Prof Au, was a relatively straightforward proposition which is clearly expressed by Dr Glover and Prof McQuillan that in the event of seismic activity, which we know is a low possibility in Hong Kong, to put it in layman's terms, the D-walls would go first and therefore the fact that there were or were not ductility couplers in the slab was neither here nor there. That's the basic proposition. Firstly, do you agree with that basic proposition: the walls would go first?

A. I agree with you, only for the seismic load case.

Q. Okay. All right.

The second bullet point in the joint statement --

A. I beg your pardon?

Q. Can we go back to the joint statement, please, if you can find that. The second bullet point under "General code requirements" -- I don't think there's much between us, Prof Au:

"All agreed that an amount equivalent to 50 per cent of the top tensile steel was required in the bottom of the EWL slab to be carried through in the D-wall. Ie less than 50 per cent of the bottom steel at the

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interface was required for code compliance."

You agree with that?

A. No. Now --

Q. Sorry, Prof Au, but why did you sign it?

A. That actually wasn't too appropriate, but then if I decline to sign then it is going to prolong the meeting.

The problem with that meeting is I wasn't provided with sufficient data, so --

Q. When were you first instructed, Prof Au?

A. Earlier but then --

Q. When were you first instructed on behalf of the government to give expert evidence?

A. Probably sometime in December. I can't remember exactly.

Q. Beginning of December?

A. I can't remember exactly. I need to check.

The problem is there wasn't any agenda and -- now, I expressed certain reservations regarding certain points, but unfortunately, even though I raised it several times, it wasn't accurately recorded, and at that time I found myself almost the only dissenting voice, I think for much of the time.

Q. Could you look at paragraph 2, please, of the joint statement.

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A. Yes.

Q. So we are over the page now to 118. That says:

"All agreed that irrespective of the code requirement the EWL slab does not, in theory, rely on steel at the interface, at the bottom, for flexure and shear capacity."

In other words, as I understand it, at the bottom of the EWL slab it is in compression --

A. Now, we are to be very careful --

Q. -- "yes" or "no"?

A. Wait a minute, I have to qualify that. At that time in the meeting, I have mentioned several times we should not be just talking about strength. Strength is not everything. We have to consider other things, ductility and other things. There would be other scenarios which may not be included in the standard loading cases.

Now, if we follow those requirements, then the structure would be safer.

Now, it's true that in this case, under the standard loading cases that they have considered, yes, it's true that in respect of strength, there is no need for bottom reinforcement. However, if we are also mindful of the need for ductility, the bottom reinforcement is also needed.

Q. Can I ask you, please, on this point, to look back at

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paragraph 89 of Prof McQuillan's report, page 38.
A. Yes.
Q. Where he says:
"To satisfy code requirements, part of the bottom steel requires to be continued into the east D-wall."
Do you agree with that sentence?
A. The first sentence?
Q. Yes.
A. Right.
Q. "This should be equivalent to 50 per cent of the EWL slab top tension steel (at the D-wall connection)."
Do you agree with that sentence?
A. Yes, agree.
Q. "The approved design was therefore conservative in that all four layers of bottom steel were continued through into the D-wall when 50 per cent would have sufficed."
Do you agree with that?
A. Yes, agree.
Q. "89.4:
"The bottom of the EWL slab at each D-wall is always in compression."
Do you agree with that?
A. Not necessarily. I think for those load cases considered in the regular design, yes, possible, but then there may be extreme events that may happen and

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we -- now, I think just for that, yes. So for the regular loading cases considered, yes, in compression. But then there may be some other events which we may not have foreseen, then if you provide reinforcement over there, that would be safer.
Q. All right. Then can I ask you, please, to look at paragraph 3 of the joint statement -- I'm sorry to keep jumping back and forth, Prof Au.
A. No problem.
Q. We are I think going to come back to a topic that you were discussing with Mr Chow and the Commissioners a short while ago, that is calculations and the like, but let's just take this, if we may, Prof Au, in stages.
First of all, paragraph 3 says this:
"The cutting-down of a D-wall is a normal part of the construction process with the methodology governed by the specification and is analogous to the construction of a shear key."
As I understand it, you are okay with that?
A. Yes.
Q. Then, and perhaps more controversially -- let's see how we go -- I want to look at this next part in three stages. The first stage is this:
"All agreed that the change from couplers to through-bars in the top of the east D-wall was a better

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detail and provided more steel across the interface ..."
Now, subject to the bit in brackets we are going to look at in a moment, I understand you agree with that first proposition, subject to what's in brackets?
A. No. Actually, in the meeting, I pointed out several times that there was a need to check the stresses at the construction joints.
Q. Okay. I said "subject". Now, the bit in brackets is this:
"... (subject to a review of the internal stresses at the top-of-wall construction joint relating to the 'first change' and its rebar detailing)."
A. Well, are you talking about the second change or the first change?
Q. I'm just looking at what has been agreed, signed up to and recorded in paragraph 3 of the joint statement, because I can't do anything else. It says:
"... (subject to a review of the internal stresses at the top-of-wall construction joint relating to the 'first change" ...)."
Which we all know is all to do with missing U-bars. Do you agree?
A. Now, the problem is -- so you are talking about the first sentence; okay? So the problem is -- so there are two issues. The first one is the first change, but

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apparently this is mainly related to the second change. Now, I am aware that the change has increased the amount of continuous reinforcement at the top, but the problem is when there is a change, it also introduces a weakness at the construction joint, that -- of the part of the concrete that is hacked away. Now, that can be the weakest link of the revised detail.
So whether or not it is going to be -- now, it can only as good as the original one, but it can't be better. Now, if we can ensure that it is strong enough at the construction joint, then it will be as good as the previous one.
Q. I'm just trying to understand what your position is, because I think I know what everybody else's position is. What it says here is:
"All agreed that the change from couplers to through-bars in the top of the east D-wall was a better detail and provided more steel across the interface ..."
Now, that's the second change.
A. Yes, second change.
Q. But your reservation was "subject to a review of the internal stresses at the top-of-wall construction joint relating to the 'first change' ..."
A. No, I think that is inaccurate. Actually the construction joint has been caused by the introduction

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-- or has been caused by the second change, not by the first change. So at that meeting I was referring to another --

MR BOULDING: Sir, I hesitate to intervene. My learned friend Mr Pennicott has already made the point that this witness is going in to, we would say, inadmissible without-prejudice discussions. He's signed off an agreement, we can see his signature, and in my respectful submission that should be the end of the matter. The idea that by rehearsing everything that was said before or allegedly said before and seeking to undermine this agreement is, in my respectful submission, not only outrageous but contrary to every rule of law concerning evidence that I've ever known. Once one has an agreement, one has an agreement, unless there's a principle of non est factum or something such as that.

I'm most concerned that I've been instructed to make this point because I don't quite know where we are going.

MR PENNICOTT: Sir, on this particular point, where we are going is this, that we know as a matter of fact that because of the reservation that was put in the brackets -- and we know that that was put in by Prof Au; there's no issue about that -- what then happened was

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Atkins went away and did a load of calculations to meet the point that's in brackets, and that's where I was going with the next question, because then what happened was Prof Au comes along with his report and criticises the Atkins calculations, as I understand it. That goes back to the point that you were discussing with Prof Au this morning as to, first of all, did Atkins do the right calculations; if they did the right calculations, are there errors in those calculations; if so, do we need to start the calculation process again? And that's all against the backdrop, as I understand it, of Prof McQuillan, Dr Glover and Mr Southward all saying, "Actually, you don't need to do any calculations because there's no shear stresses involved in any event."

So I'm just trying to work out what has happened as a consequence of the bit in brackets. Unfortunately, to get to the bit in brackets, you have to look at the rest of it as well. You can't just look at it in isolation.

I have to say I'm doing my best not to get into a discussion about what was said or not said at the agreement, and I agree with Mr Boulding in principle that an expert's agreement is an expert's agreement.

COMMISSIONER HANSFORD: Mr Pennicott, not that I need to understand them all myself, but have we seen Atkins' calculations?

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MR PENNICOTT: Well, they are referred to in Prof McQuillan's report and elsewhere.

COMMISSIONER HANSFORD: Okay.

MR PENNICOTT: And also in Prof Au's report.

CHAIRMAN: We would just like to discuss a couple of things, if we could. We will let you know when we are ready. It shouldn't be more than four or five minutes.

MR PENNICOTT: Certainly.

(12.23 pm)

(A short adjournment)

(12.28 pm)

MR PENNICOTT: There are one or two participants missing, but never mind.

CHAIRMAN: Thank you very much. We just wanted to have a brief discussion about this matter. We are very concerned that the methodology by which a without-prejudice agreement was reached should now become subject to discussion.

The fact is the agreement was reached, and I think in respect of expert evidence it's open, Professor, to you to say, "Since reaching that agreement I have certain personal reservations." That I think is a matter that we believe you can discuss, and you can discuss matters that may concern you as a consequence of that agreement; for example, Atkins carrying out certain

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mathematical calculations.

But to go into the methodology and what was said, how it was said, who agreed to what during the course of that very lengthy meeting I think would not assist anybody at all. The fact is, from what we can see, that we had a group of eminent engineers who spent a deal of time together, debating the issue, as we encouraged, so they were free to say what they wished to say, they were free to put their reservations in, and to enter into no doubt very robust argument when necessary, and they did come to an agreement to which all of them put their signature. I think that's an important issue, and equally important, of course, Professor, if you have since had concerns, that's another matter.

Thank you. That's the reason we wanted to have a brief discussion.

Mr Pennicott, I don't know how that assists or does not assist you.

MR PENNICOTT: It assists in some ways and doesn't in others, in the sense that I am trying my best to avoid getting into a debate with Prof Au as to what or wasn't said at the meeting, and let's try to avoid that going forward, as it were.

On the other hand, I am trying to unravel, if I can, the one express reservation that I know Prof Au had,

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which is the bit in brackets in paragraph 3, because there clearly was a reservation in those words and I have no problem with that and I imagine nobody else has a problem with that.

So what I was endeavouring to do was to, as it were, identify for the Commission what followed on from that reservation.

CHAIRMAN: That's fine.

MR PENNICOTT: And that's fine. The only problem that we then ran into was that it appears, if I've understood Prof Au's position correctly, that he's now saying, actually, when it says "the first change", in his mind it really should say "the second change", or perhaps both, I don't know.

A. May I -- I think there is some inaccuracy in the part within brackets. As far as I know, the first change is related to the omission of the L-bar and U-bars. It doesn't create any additional construction joint.

Q. Correct.

A. Now, it says "subject to a review of the internal stresses at the top-of-wall construction joint relating to the 'first change' ..."

So the construction joint is not caused by the first change but by the second change. It's inaccurate.

Q. That's why I say I think what is now being said by

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Prof Au is that this is related to the second change. The construction joints, I agree with Prof Au, clearly can only relate to the second change --

A. Yes.

Q. -- not the first change?

CHAIRMAN: All right. Good. So that's looking back on the agreement, that is a patent error, in your view, a common error, and you are saying it should relate to the second change?

MR PENNICOTT: Well --

COMMISSIONER HANSFORD: Just as a consequence of that, can I just ask a question: was the additional work done by Atkins related to the second change or the first change?

MR PENNICOTT: My understanding was that it was both.

COMMISSIONER HANSFORD: Both?

MR PENNICOTT: But I will --

COMMISSIONER HANSFORD: If it's both then I'm satisfied.

MR PENNICOTT: I think that's right but I may need to double-check that. Can I just have a moment?

Sir and Prof Au, can we look at paragraph 101 of Prof McQuillan's report, page 42.

A. All right, yes.

Q. That's under the diagram that you were taken to earlier, Prof Au. Prof McQuillan makes the point that I repeated earlier in paragraph 100 that the diagram illustrates

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why no tension or shear can occur at the interface. However, at paragraph 101, it's recorded by Prof McQuillan that:

"Atkins subsequently produced design calculations for the first and second changes which demonstrate ..."

And then bullet point, bullet point, and several more bullet points. The reference is given there. Those calculations were provided on 31 December, so, as I say, postdating the joint statement. If one looks at the covering letter to the calculations -- that's at J6/4556, if we can get that up on the screen; this is Mr Blackwood writing on 31 December, the Commission having requested the calculations:

"We refer to your email of 19 December 2018 requesting calculations to demonstrate that the internal stresses at the construction joint ... are within acceptable limits for the 'first change' necessitated by the missing U-bars at the top of the D-wall. Similar calculations in relation to the 'second change' were also requested.

The requested calculations for both the 'first change' and 'second change' are enclosed."

So, sir, to answer your question, both have been supplied. That's where we've got to.

However, as I understand it, Prof Au has

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reservations about those calculations.

Is that right, Prof Au?

A. Yes.

CHAIRMAN: About both or ...?

A. About both.

MR PENNICOTT: Prof Au, when you were having a discussion with Prof Hansford earlier this morning, and he was asking you about some calculations that could be done, as I understand it the focus will be on those calculations, the Atkins calculations, and to your way of thinking at least -- I'm not sure everybody else agrees with you -- but if your criticisms of those calculations are accepted, then essentially what you are saying is that those calculations should be redone --

A. Yes.

Q. -- in a proper way?

A. Yes.

CHAIRMAN: Has that been done? Has there been an exchange --

A. I'm not aware of any.

MR PENNICOTT: That's where I was going next, because in your evidence this morning, when you were answering questions from Mr Chow and Prof Hansford, I thought that you had indicated to the Commission that some calculations perhaps had been done by -- I think you

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mentioned some other consultants engaged by the government, but I'm afraid -- perhaps you could tell us a bit more about those calculations? Have they been done? Are they available? Do they address this particular point that we are looking at?

A. Let me qualify my earlier statement. I'm not aware of any calculations submitted to perhaps COI or the government from, let's say, MTRC or Atkins or whatever. But then the other firm that is assisting Highways Department has done some checking.

Q. Who are they?

A. Mannings.

Q. Do you know whether they have done some calculations on this particular topic that we are debating at the moment?

A. Yes.

Q. They have? Okay.

CHAIRMAN: Have you seen those calculations?

A. Yes.

CHAIRMAN: What is your view of them?

A. Well, actually, in some of the design variations, there may be problem.

CHAIRMAN: Sorry, my fault. Do you agree with the accuracy of those calculations, mathematically?

A. Okay. Actually, we have gone through a certain learning

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curve, because those engineers were not too familiar with that. So actually, in the process, we were tutoring them; okay? And, at the end, we came up with some calculations.

I need to further elaborate because what I mentioned earlier this morning, that it takes half a day or whatever, that is simplified calculations. If we would like to do very sophisticated calculations, it may take months. I'm not talking about this kind of calculation, but just simple calculations. So they have done some calculations and I am satisfied that they are trustworthy, at least based on those input data, it indicates that there is a need for further checking, numerically.

CHAIRMAN: Does that mean trespassing into the area of highly complex mathematical calculations that could take months?

A. Well, I'm not -- yes, it's true, because some of my research students are really doing something like this, but I'm not talking about this kind of sophisticated calculations but just simple calculations; perhaps a few days, that would be good enough.

COMMISSIONER HANSFORD: So, Prof Au, when you answered me this morning that it could be done in half a day --

A. Yes, simple calculations. Simple calculations, not the

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sophisticated one.

COMMISSIONER HANSFORD: Sorry, is that half a day the same as what you said just now, which was a few days?

A. Something like that, yes. Well --

COMMISSIONER HANSFORD: Which? Is it half a day or a few days?

A. The problem is there are so many design variations, so there is a need to check each and every one. So what they have done is just to check a few of them; okay? But to check all the design variations, perhaps it would take a few days or whatever.

CHAIRMAN: Okay. The Commission's concern is structural integrity.

A. Yes.

CHAIRMAN: Safety.

A. Yes.

CHAIRMAN: That's the public's concern. So if it's going to require esoteric mathematical calculations over several months, then that's what it will require, but I think you are saying, as interesting as that may be, one doesn't need to go into that area --

A. No, not really.

CHAIRMAN: -- more simple calculations will be sufficient --

A. Yes.

CHAIRMAN: -- to ensure safety or to ensure that it is safe?

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A. Yes.

CHAIRMAN: Okay. Thank you.

COMMISSIONER HANSFORD: Which could be done over a few days?

A. Yes. Well, provided that there are available numbers of the internal forces, whatever, not necessary to build from square one.

CHAIRMAN: Provided the base data?

A. Yes, yes, yes.

CHAIRMAN: I understand.

MR PENNICOTT: Presumably the base data is there, otherwise these calculations wouldn't have started already?

A. So I believe the consultant firms of MTRC should have the base data.

Q. All right. I won't pursue that.

COMMISSIONER HANSFORD: Sorry, you mean Atkins?

A. Atkins.

CHAIRMAN: Or Mannings?

A. Well, Mannings doesn't have all the base data --

MR PENNICOTT: That's why I'm querying the position.

CHAIRMAN: Thank you.

MR PENNICOTT: Because if you are saying that Mannings, who have been apparently doing some calculations, don't have all the base data, I'm really not quite sure how useful that's calculations are going to be, but anyway. I mean, we will see if anybody else wants to take this

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further or if the Commission does, because there is this overarching point, sir, that you may hear from other experts to say you really don't need to trouble yourself about these calculations for reasons they will give.
CHAIRMAN: I appreciate that, but from my point of view --
MR PENNICOTT: But obviously we've got Prof Au here and we need to get his views, I understand that.
CHAIRMAN: Myself and Prof Hansford need to know what the position is for the various expert parties.
MR PENNICOTT: Correct.
CHAIRMAN: And my understanding is that Prof Au is saying there are some calculations that can be done within a limited period of time, subject to the base data being made available, and that base data should already be available, even though it may need to be checked. So these calculations and the results of them will confirm the view already held that the structures do have an integrity that makes them safe.
A. Yes.
CHAIRMAN: That's what you are looking for; you are looking for confirmation?
A. Yes.
CHAIRMAN: That's my understanding of the professor's position at this moment in time. So it's feasible and could be done before we have to bring out our report.

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COMMISSIONER HANSFORD: That's our concern.
MR PENNICOTT: Yes. All right.
CHAIRMAN: I notice Prof Au is nodding his head, so that seems to accord with his view.
A. (Nodded head).
MR PENNICOTT: Yes, that's right. Going back to the debate we were having about the joint statement just now, of course, I was going to the last sentence in paragraph 3 which again, there it is. One can see what the experts have agreed. So notwithstanding all of what's preceded it, they have all agreed that the outcome would not show the construction joint to be problematic. So I'm not going there. That's what's been agreed. The calculations may be of great interest to some, but obviously read subject to that last sentence which has been agreed.
Prof Au, can I just ask you some questions about the holistic proposal and the opening-up and some questions about that particular topic.
A. Yes.
Q. Can we first of all focus on the EWL slab.
A. Okay.
Q. Top slab.
A. Yes.
Q. As I understand it, the basic parameters of what we are

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discussing are reasonably clear, and that's this, that the top mat of steel in the EWL slab is in tension and essentially that's the critical rebar and the connections with which we are concerned. There may be others but that's the really important one?
A. Yes.
Q. So far as the top of the west diaphragm wall is concerned, because of its different design and configuration, vertical couplers, we are not concerned with the top of the west diaphragm wall?
A. Agree.
Q. So far as the top of the east diaphragm wall is concerned, essentially, because of the second change --
A. Yes.
Q. -- the vast majority of the top of the east diaphragm wall, I think something like 95 per cent or so, does not have couplers in the top rebar, because it now has through-bars?
A. Yes.
Q. Therefore, in terms of couplers at the top mat of rebar, we are only talking about a small number of panels or sections?
A. Yes.
Q. And it's those that, as I understand it, and, Professor, your understanding as well, are being focused on so far

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as the holistic proposal is concerned?
A. You are talking about the top one?
Q. Yes.
A. Purpose (i)?
Q. Yes, purpose (i), indeed.
So far as the top mat of rebar is concerned, the potential problem areas, subject to the discussion we've just had about the calculations of shear and so forth --
A. Yes.
Q. -- the potential problem so far as couplers are concerned is in a very limited area?
A. Yes.
Q. So if there is a problem that's discovered, it will necessarily be very localised, so far as the top mat of rebar is concerned?
A. Yes.
Q. And so far as the bottom mat of rebar is concerned, as I understand it, the connections both on the west and the east diaphragm wall are essentially the same?
A. Mm-hmm.
Q. But they are subject to the 50 per cent requirement in the code?
A. Right.
Q. So when one comes to look at the results that the opening-up is giving us, one has to bear all those

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different factors in mind; do you agree?
A. Yes.
Q. Because it's not just a question of whether the couplers are screwed in sufficiently, it is also rather important to know where those couplers are?
A. Yes.
Q. As I understand it -- and perhaps you can help me with this, Prof Au -- in your PowerPoint slides this morning, you referred I think to one-third of the couplers being -- I'm not sure what word you used "problematic" --
A. Over one-third.
Q. Over one-third non-compliant couplers, over one-third?
A. Yes.
Q. As I understand it, your definition of "non-compliant" is less than 37 millimetres; is that right?
A. Yes. Yes. I think that is the criterion used in the holistic proposal; right?
Q. 37 millimetres engagement into the coupler?
A. Yes.
Q. Okay. It's against that criteria that you've reached your one-third assessment or over one-third assessment?
A. I think that is the result published on the net.
Q. And that figure, one-third, is simply by reference to the 37 millimetre figure that government are using, and

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does not take into account the tests that have been done at the various percentages of engagement that you discussed briefly this morning?
A. So when I mentioned over one-third are non-compliant, I was referring to the results published. I haven't referred to the test.
Q. Indeed, because, in a nutshell, we've seen reference to 60 per cent engagement, which is equivalent to about 25 or 26 millimetres engagement, and with the results that we have from the tests done by BD, BOSA and CASTCO, they show, on one view, that 26 millimetres engagement is good enough for safety. Do you agree?
A. No.
Q. On one view, that's what they show, because you can see the figures on their face, Prof Au: 60 per cent, and they are perfectly strong enough.
A. Okay. So I have mentioned several times that the acceptance criteria do not just contain strength but also deformation; okay? Now, it is necessary to carry out more tests to find out the performance of these non-compliant couplers, I mean similar couplers, how they behave.
Q. Right.
A. And then the data must be sort of made reliable, because right now the data don't appear reasonable, having

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a maximum value at 60 per cent.
Q. So to assist the Commission, Prof Au, as I understand it, what you are saying is, "Okay, I've seen these tests that have been done by BD, BOSA and CASTCO back in November 2018. I see what they say, but I don't think those tests are sufficiently robust or sufficient in number"?
A. Yes.
COMMISSIONER HANSFORD: Just to help me, Mr Pennicott -- you refer to BD, BOSA and CASTCO.
MR PENNICOTT: Yes.
COMMISSIONER HANSFORD: Is that three lots of tests?
MR PENNICOTT: No. BD, CASTCO and BOSA did these joint tests back in November.
COMMISSIONER HANSFORD: Thank you very much.
MR PENNICOTT: It was an exercise that was done by the three parties. I think the BD, rather like the Commission, has asked BOSA to assist it on occasions, and I understand that BOSA invited BD to be present at the tests, and so forth. We have the results, we've seen the table, I think it's just about in -- everybody's expert report refers to the table that BOSA came up with.
COMMISSIONER HANSFORD: So the testing laboratory was CASTCO?

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MR PENNICOTT: Correct, that's right, sir. The independent laboratory was CASTCO.
So you have Prof Au's position. As I understand it, we will hear from the other experts on what they conclude from those tests, but Prof Au's position is that more needs to be done.
However, Prof Au, can I just look at the latest set of results that we have, just to ask you a couple of questions. They are in the OU bundle, OU314.
As of Friday, 11 January, Prof Au, I don't know whether you've come back up to date -- you've looked at this sheet -- you've got 67 results. Does that accord --
A. I have seen some results just this morning, but I'm not sure it's exactly the same.
Q. Anyway, my understand at the moment, subject to being corrected by somebody else, is that as of 12 January, which was Saturday, these are the results that we have, and they are at OU314, no results having been done yesterday, on the Sunday.
Can I just ask you to -- we can all do the exercise, but just so that we've got a bit of an understanding of what's on this sheet -- first of all, Prof Au, there are two rather blindingly obvious rogue results. That is at number 5, where one has an engagement length of

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6.22 millimetres; do you see that?
A. Yes.
Q. And number 22, where one has an engagement length of 9.4.
A. Right.
Q. So they are completely out of kilter with all the other results.
A. Oh, yes, right.
Q. And I think not shown on this sheet is another piece of rebar --
A. Yes.
Q. -- near the West Wall, I understand, which is not connected at all and is not shown on this sheet. So, on one view, we have 68 results, but 68 is not shown on here.
A. (Nodded head).
Q. Thank you. Okay.
Can I just ask you, first of all, to focus on the NSL, that's the lower slab, and you will see that there are five results at 32 to 36; do you see that?
A. Yes.
Q. And save for number 36, which is 0.64 out, they are all compliant with the 37 millimetre criteria?
A. I beg your pardon, are you referring to 36?
Q. Number 36, yes. It's 36.36.

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A. Yes.
Q. So it hasn't quite achieved 37, it's 0.64 off?
A. Yes.
Q. But the others meet the 37 criteria?
A. Yes.
Q. Then if you go down a bit further to 43, 44 and 45, three more NSL results?
A. Yes.
Q. And they all meet the criteria?
A. Yes.
Q. Then more recently we've got 59, 60 and 61, which are on the NSL but they are on the West Wall; do you see that?
A. Yes.
Q. They all do not meet the 37 criteria?
A. Correct.
Q. Then lastly, so far as the NSL is concerned, the last three results, all back on the East Wall this time, all comfortably meet the requirement?
A. Right.
Q. And that's the way we are to read this table --
A. Yes.
Q. -- I've just focused on the NSL. And the overall summary, so far as the NSL is concerned -- and of course, with the NSL, we know all the results are on the top, not the bottom --

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A. Yes.
Q. -- is that there are 14 results in total, three of which are under 37 millimetres -- sorry, four of which are under 37 millimetres but one only just?
A. Right.
Q. Okay. But if one looked at -- if one applied the strength requirement derived from the tests that we were discussing earlier --
A. Right.
Q. -- and you looked at 35 and 36 millimetres, rather than 37, they would all pass?
A. Strength, yes.
Q. All right.
Prof Au, can I just ask you this. You have looked at a lot of evidence, a lot of material, for the purposes of preparing your report and coming to give your evidence today.
A. Yes.
Q. Taking your academic hat off for one moment and applying some engineering judgment, practical engineering judgment, and perhaps, dare I say, some practical engineering common sense, but based on all that evidence that you've seen and heard, including the evidence of your fellow experts, do you agree that the most likely position is that the EWL slab is safe for its intended

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purpose?
A. Well, now, I think some more investigations should be done, such as checking of the stresses. But my impression is that even though there are problems, they should be solvable, my impression.
Q. And so -- I will put it again -- you believe, despite the fact that there are problems which need further investigation, I will put it my way, the most likely position is that the EWL slab will prove to be safe?
A. Well, after doing the necessary strengthening works or whatever.
Q. But we haven't reached that stage yet.
A. Yes, wait and see.
Q. Let me put it again --
CHAIRMAN: Sorry, I don't wish to interrupt you, but I think what Prof Au is saying is he cannot agree that the most likely result at this moment in time is that the EWL slab is safe and fit for purpose.
A. Yes.
CHAIRMAN: However, he believes that further investigation will resolve that issue and it may be necessary to add some extra reinforcing measures in order to make it safe.
A. Yes.
CHAIRMAN: Would that be right?

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A. Yes.
MR PENNICOTT: And it's a "maybe" required in terms of additional work or reinforcement?
A. Yes.
Q. I asked the question specifically in relation to the EWL slab, and would you agree the same applies as far as the NSL slab is concerned, probably even more so because there seemed to be, with respect, a lot less problems with the NSL slab?
A. I think that is reasonable because of the order of construction, the workers should have gone through the learning curve so when they came to the NSL slab they should be more experienced. So I'm glad to see that the results for the NSL slab are better than those for EWL slab.
Q. Right.
CHAIRMAN: All right. Could we approach it more on an engineering basis rather than "workmen getting better"? I don't mean to say that in a disparaging or condescending way, but it may be -- we don't know what our findings will be -- that the standard of workmanship remained the same or perhaps even got worse. So I'm a bit concerned as to dealing with a result on an assumption of improving work quality, absent some compelling evidence that that was taking place.

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COMMISSIONER HANSFORD: So, therefore, it would be helpful if the answer was revisited, ignoring the possibility of learning curve.
A. I agree.
COMMISSIONER HANSFORD: So perhaps Mr Pennicott can ask you the question again. Could we have the question based upon engineering?
A. Apparently, from the findings of the opening-up, it supports that kind of, well, argument. So the NSL slab results are better.
MR PENNICOTT: Yes.
CHAIRMAN: Okay. Good.
Is that an opportune moment?
MR PENNICOTT: Sir, it is, and subject to any thoughts over lunch, I have probably finished for now.
COMMISSIONER HANSFORD: Is there time for one question from me?
CHAIRMAN: Yes.
COMMISSIONER HANSFORD: Prof Au, in your paragraph 8.1 of your witness statement, it's your last paragraph, your very last paragraph, your witness statement, you refer to -- well, you say:
"It may be desirable to install a long-term structural health monitoring system to monitor the variations of displacements and deformations at key

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locations of the structure, which will help to assess the structural performance."
What sort of long-term structural health monitoring system did you have in mind?
A. Well, actually, in Hong Kong, the first structural health monitoring system was installed on the Lantau Link, Tsing Ma Bridge and so on, over 20 years ago. The system consists mainly of accelerometers, displacement sensors, temperature sensors, whatever. I think for this particular station, probably some displacement sensors and accelerometers will be sufficient. I don't think we need a very extensive monitoring system. I think just placing certain instruments at certain key locations, to provide data, I think that would boost the confidence of the public.
COMMISSIONER HANSFORD: And fibreoptics or would that be too much?
A. Well, actually, it is very common. I think using fibreoptic sensors for measurement of strength, I think we did that over ten years ago. It's not too expensive.
COMMISSIONER HANSFORD: And you would be advocating that here as part of what you regard is sensible long-term structural health monitoring system?
A. Yes. I think it would be cheaper than doing a loading test.

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CHAIRMAN: And in fact, just so we can confirm that, the agreed expert memorandum, paragraph 5, actually says:
"All agreed that a load test was unnecessary because it would yield no meaningful result ..."
And then, and I emphasise:
"... and long-term monitoring would be a better approach to allay public safety concerns."
A. Yes.
CHAIRMAN: So presumably a very doable, presumably financially feasible way of putting in monitoring things to ensure public safety and that people can have confidence in using that station in the future?
A. Yes.
CHAIRMAN: Thank you.
MR PENNICOTT: Sir, if I can say, just to add to that, that is one thing that clearly the Commission's expert Prof McQuillan also agrees with; see paragraph 113 of his report, where he says:
"To allay public concern ... the EWL slab should ...
-- have more sensitive instrumentation, eg a fibreoptic system, installed.
-- have its structural performance monitored in terms of deflection ..."
So that point is certainly agreed and puts a bit of flesh on the bones of paragraph 5.

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CHAIRMAN: Yes. Thank you very much. Good. It's 10 past one.

Sorry, Mr Chow.

MR CHOW: I hope I'm going to be helpful to the Commission. Just now, my learned friend Mr Pennicott referred to the test results carried out by CASTCO and BOSA. My instruction is BD did not or was not part of the test. BD only witnessed the test. Subsequent to that, what is more important is that subsequent to that, there was correspondence between the Buildings Department and BOSA. I will probably take Prof Au to those correspondence. In fact one of those correspondences has been referred to by Prof Au in one of his slides.

If I may at this point give the Commission the page references, just in case the Commissioner, sir, you have time over lunch time to take a look at those correspondences because that is highly relevant to the interpretation and the validity of the test results.

The first letter is from the Buildings Department to BOSA dated 28 December and it's bundle H26 from page 45479 to 45481. And then we have the response from BOSA on 7 January this year, same bundle, H26, 45640 to 45643. Then we have a further letter from the Buildings Department to MTRC dated 10 January 2019 at bundle H26, 45853.

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I hope that will make the position clearer.

COMMISSIONER HANSFORD: I think that's useful, Mr Chow, and I'm sure our Secretariat will provide us with copies of those over the lunch break.

MR CHOW: That's what I expected, if I may.

CHAIRMAN: Thank you all very much. 2.30.

(1.11 pm)

(The luncheon adjournment)

(2.30 pm)

MR SO: Good afternoon, Mr Chairman. Good afternoon, Professor. There are some questions from China Technology.

CHAIRMAN: Yes.

Cross-examination by MR SO

MR SO: Good afternoon, Professor. I represent China Technology.

I heard you this morning on no less than one occasion -- that you have mentioned that when looking into the strength of the thread, you would have to carry out more tests; correct?

A. Are you referring to the couplers?

Q. Yes.

A. Yes.

Q. I wish to take you to one document. That is in bundle C1, C114.

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A. Yes.

Q. Prof Au, I see that you have a hard copy in front of you.

A. Yes.

COMMISSIONER HANSFORD: Hold on, Mr So. We don't have it in front of us yet.

MR SO: Thank you.

Prof Au, this is appendix VI, as you can see, of the QSP.

A. Yes.

Q. Can I trouble you to C116, that you can see paragraph 5 of that.

A. Yes.

Q. If that can be blown up a bit.

Sorry, I'm afraid there is a technology issue.

CHAIRMAN: It's done now. Thank you.

MR SO: In paragraph 5, there mentioned -- if you focus on paragraph 5(b), there is a mention of static tension test.

A. Yes.

Q. I believe that is the test actually being done currently by the collaborative effort of BOSA and the laboratory; correct?

A. I believe so.

Q. If you can focus on paragraph (a), there is

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an experiment on permanent elongation, and in paragraph (c) there is a static compression test.

A. Yes.

Q. And in paragraph (d) there is a cyclic tension and compression test.

A. Yes.

Q. Professor, are those tests that you have referred to there further tests that should be taken in order to ascertain the full picture of the couplers?

A. Yes, correct.

Q. If you can go back to the same document, paragraph 5(b), there it mentioned the tensile strength of the bar, and there is a mention of grade 460.

A. Yes.

Q. And, as you have just mentioned to us this morning, those are the common types of tensile strength bars used at the time when the Hung Hom Station was actually built?

A. Correct.

Q. So one expects, if a test is to be conducted in terms of the tensile strength, then a reasonable test specimen would be using the grade 460 threads; correct?

A. Yes, correct.

Q. Can I bring you to your expert report, which is at paragraph 2.4.

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A. Yes.
Q. In paragraph 2.4, you have referred to the experiment in which the test results were actually incorporated in page 44521 to 44525; correct?
A. Yes.
Q. So far, we haven't taken a look at the actual test report itself. We are often referred to the table. Can I just trouble you to go to the actual test result that was actually produced by CASTCO. It is in bundle H26. This time, I want you to focus on page H44526.
MR PENNICOTT: That's H25.
MR SO: I do apologise. It should be bundle H25. Thank you. If that could be blown up slightly. Yes, thank you.
Prof Au, this is page H44526.
A. Yes.
Q. I understand that this particular page of the report was not included in your expert report.
A. Yes, I believe so.
Q. If we can focus on the box that writes, "Specified yield strength of bar", where it writes "900 Megapascals".
A. Yes.
Q. Can you kindly explain why in this test a grade 900 bar was used?
A. I believe that is mainly to test the strength of the

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coupler itself.
Q. Right.
A. Because in the other cases, very often the reinforcing bars themselves broke.
Q. So, in other cases, they would not use the grade 900 bars?
A. No.
Q. They would use grade 460 bars?
A. Yes, correct.
Q. You have told us this morning, in answering to Prof Hansford's question, it might take some time to gather grade 460 bars nowadays?
A. I believe so.
Q. Can I then bring you back to the results that have actually been used and incorporated in your expert report. They are in H44521 to H44525.
A. Yes.
Q. Again, can I ask you to pay attention to the box of "Specified yield strength of bar".
A. Yes.
Q. Can you kindly assist us, why is that actually crossed out with two dots above?
A. Well, I am not aware of the reason. It looks very strange.
Q. Why is it looking very strange to you?

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A. Because normally, in a laboratory, there should be some qualified people, including the authorised signatory, and so on, that should be looking at all these tests, and I believe -- now, the other strange thing is that the number 900 has been typewritten, whereas the other numbers have been handwritten. It looks strange. So it looks like the worksheet has been designed for testing of assemblies having strength of 900 Megapascals.
Q. But as you have just told us, Prof Au, these tests should be for grade 460 instead?
A. Yes, of course.
Q. Can I then trouble you to go to H45861. This is a photograph which shows the specimen itself and also it was typewritten with the test results on it.
A. Yes.
Q. You have told us earlier this morning, and I don't need to trouble you to go to the transcript -- it was in [draft] page 43 of today's transcript, when Prof Hansford asked, "Why are the samples not enough?", and you said there was a strange thing in that the maximum strength occurs at 60 per cent engagement but not more, and you say that's very strange.
Can you kindly explain more about what is the strange thing about that?
A. Well, in coupler, having different lengths of

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engagement, normally people would expect that the longer the length engaged, the higher the strength, but actually it is not proportional, because I have recently read a paper offered to me by a colleague, and the paper described a very sophisticated finite element analysis by advocates showing all the variation of stresses in the threads or whatever. Actually not all of the threads are taking equal loading. So the first few threads are taking a lot higher loading.
That's why, when we have different lengths of engagement, some of them look quite similar, but the problem is there may be some other issues. For example, for smaller engagement length, then its ability to survive fatigue damage could be an issue.
I wonder if I need to explain what I mean by "fatigue". I'm talking about the fatigue failure of a metal.
CHAIRMAN: Yes.
A. Because it is caused by the cyclic loading. So, in a railway structure, normally cyclic loading is an issue. Now, if the structure is very bulky, it may not be very serious, but if it is quite slender, whatever, that can be an issue.
Now, when I look at the results, I felt very strange in that the maximum value appeared at 60 per cent

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engagement. It may be caused by the large variation, but it looks strange. So that's why just testing one sample definitely is not enough.
COMMISSIONER HANSFORD: Prof Au, the structural elements here are not slender, are they; they are bulky?
A. Yes, correct.
COMMISSIONER HANSFORD: And you said just now that if they are bulky, it may not be an issue?
A. Correct.
MR SO: Just to pause there, Prof Au, when you just mentioned cyclic loading, that's the cyclic loading we have just seen in the QSP; correct?
A. Correct.
Q. In light of this photograph and in light of the test sheets I have just given to you, would it be a fair comment to say, at least on the face of these worksheets, we cannot be sure the threads that were actually tested for these readouts were 460 grade threads?
A. Well, I don't know, but -- now, I think it is reasonable for people to cast doubt on it, because the worksheet used doesn't appear to be for general purpose. I think the major problem is with the very strange trend of the results. I think that is a major problem. I find that very strange.

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Q. In any event, you would accept that there were nowhere whatsoever mentioned in this worksheet that the threads being tested are grade 460 threads; correct?
A. Well, the worksheet appears to have something scribbled there. I'm not sure whether that's 460 --
Q. We can take a look at that, Prof Au. H44521 and if you wish, 44522 and 44523.
A. So that is a signature -- the initial, probably. That is not 460. It looks very strange.
Q. But there was certainly nothing there saying it was 460?
A. Yes, correct.
Q. Thank you.
Now I want to move to another issue that I want to discuss with you. I know this report was prepared by you on 7 January 2019, this year; correct?
A. Yes.
Q. I want to show you a letter that was sent by BOSA to the Buildings Department. This was at bundle H26, H45858.
Prof Au, have you had an opportunity in reading this letter before you come to give evidence?
A. Yes, I should have read that, because I can recognise "butt-to-butt", "loose", these terms.
Q. Thank you very much. I want you to cast your eye to paragraph 3 in particular.
A. Yes.

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Q. Paragraph 3:
"In response to paragraph 2(a)(i) of your letter, please note that our couplers are designed to the specifications provided in our manual as per your enclosure at appendix A, and for a 40mm diameter type 2 coupler, the threaded length is 40mm. Please note this threaded length includes 2mm chamfer at the tip and 2mm exit thread at the tail ...", et cetera.
Prof Au --
A. Yes.
Q. -- I want to cast your mind then to another piece of document you have been shown this morning by my learned friend Mr Pennicott. This is the document at OU314.
Can I trouble the Secretariat to blow it up at the top, where we have the titles of the columns.
Prof Au, all along in the phased array test, we are testing the engagement length.
A. Yes.
Q. We know that from BOSA's response that in the end of the coupler there is something called a 2mm chamfer at the end.
A. Yes, correct.
Q. That 2mm chamfer is, if I put it graphically, is 2mm chamfer and then the couplers, the threadings and then the 2mm tail; is that correct?

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A. Yes.
Q. And that 2mm chamfer, structurally speaking, is of no structural function; can I say that?
A. Well, it is not having the full structural function. Perhaps it has a little bit.
Q. But when we are talking about the phased array result, that engagement length would have included that 2mm chamfer; correct?
A. Yes, correct.
Q. Can I suggest that if we merely look at the engagement length, when we are talking about the 37mm -- where we call the passing benchmark, should we actually add in that 2mm chamfer or should we deduct that 2mm chamfer?
A. Well, now, it actually depends on the acceptance criteria of the supplier. So if the supplier has spelled out certain acceptance criteria and we know that this chamfer is already there, I would be happy to accept that. But having said that, what is the effect of the chamfer on the strength of the coupler assembly? I think that can be reflected in the test results.
Q. Thank you very much.
COMMISSIONER HANSFORD: Sorry, in what say, Prof Au, can it be reflected in the test results?
A. In the test results, the bars, the couplers, already have certain chamfers, the threads, and so on. So, when

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we test it, then the results should have already taken into account the features.
COMMISSIONER HANSFORD: I see.
A. So, in that case, I would have accepted that, provided that it is proved by test results.
COMMISSIONER HANSFORD: I see.
MR SO: Thank you. When you were actually engaged to complete this expert report, was it brought to your attention that in SCL project there were certain practices of planting dowels into the diaphragm walls?
A. Do you mean at the bottom?
Q. Yes.
A. I have seen some sketches of that. I think perhaps that applies to some of the diaphragm walls.
Q. And do you understand that when planting dowels, they are in substitution of what we call T40 bars?
A. That I'm not aware of.
Q. Can I bring you to a transcript of our hearing. It is in Day 20 of the hearing, page 40.
Mr Chairman and Professor, this is the evidence of Mr Andy Ip.
Can I bring you to page 40, line 16 onwards.
A. Yes.
Q. That is when Mr Andy Ip was being examined by counsel for the Commission, when he was asked about planting

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dowels in the diaphragm walls. Just for the benefit of everyone and for completeness, it reads:
"When the starter bar was at the correct level but installed in the incorrect direction (that is not perpendicular to the face of the diaphragm wall), in some instances the starter bar (T40) was bent to the intended alignment and one additional T25 starter bar drilled and fixed using Hilti chemical resin HIT-RE500 adjacent to the existing T40 starter bar."
Now, Prof Au, insofar as I understand, T40 and T25 are concerning the diameters of bars; right?
A. Yes.
Q. Would it be structurally anything compromising by using a T25 starter bar to substitute a T40 bar?
A. I don't fully understand whether it means that the T25 bar is replacing the T40. Now, I think if it is really the case, there is some concern, because the strength of T25 is less than that of T40.
Q. Right. Maybe I can help you. Can we turn to page --
COMMISSIONER HANSFORD: I'm sorry, actually, before we move on, can you read the next couple of lines on that transcript.
MR SO: Of course.
COMMISSIONER HANSFORD: Because I think Mr Ip goes on to say he wasn't aware of that ever being used.

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MR SO: If we go to page --
COMMISSIONER HANSFORD: No, on the page you are on, line 25.
MR SO: "Again, Mr Ip, are you aware of that type of remedial work measure having been carried out?
Answer: This one, yes, I think at the time we did submit what we call TQ [technical query], that is the engineering department submitted that to the consultant company and asked whether it could be done this way. At the end, drilling was done to add the T25 bar. That's the remedial measure that was taken at the end."
COMMISSIONER HANSFORD: Thank you. That's helpful.
MR SO: Thank you very much, Professor. I have no further questions.
Cross-examination by MR CONNOR
MR CONNOR: Thank you, sir.
Good afternoon, Prof Au. I'm Vincent Connor, I represent Atkins China Ltd, and I have a few questions for you this afternoon.
A. Right.
Q. Could you have before you, please, your report, which is ER1/7 in the bundle.
A. Yes.
Q. You note in that report, in the first line after the word "instructions" --

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A. Yes.
Q. -- that you "have been instructed to provide your opinion in respect of the following issues".
A. Yes, correct.
Q. You then narrate eight issues at that point; do you see that?
A. Yes.
Q. You mentioned, I think, in response to questions from Mr Pennicott this morning that you received instructions in December. Do you recall when?
A. It's very complicated because at the very beginning I was invited by the Highways Department to act as adviser, but then later on -- well, the date wasn't too clear. Later on, I was asked to -- so I was invited to meetings, and then later I was asked to come up with some report. Then much later I was invited by the DoJ to serve as expert witness and I received that quite late. Yes, so I think probably that was sometime in December, so that's the second one.
But then -- well, when I helped the Highways Department, I wasn't sort of told to serve in that capacity, so I was only asked to give some comments or whatever.
Q. Thank you. That's helpful. So if we understand it then, your instructions for the purposes of this report

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came in December?
A. Yes, I believe so.
Q. But that you had some involvement prior to that point, giving some advice to the Highways Department?
A. Yes.
Q. Thank you. That's helpful.
So, in fairness to you, and I say that given the depth of the questions that you've received so far, you don't come to this Commission of Inquiry with the benefit of many months or indeed years --
A. No, no.
Q. -- of involvement in the design of these structures that we've been discussing?
A. You mean design of the structure of the station?
Q. Indeed.
A. I wasn't involved.
Q. No.
A. No.
Q. Nor do you come with months or years of involvement in checks or calculations --
A. Of this structure?
Q. Of that structure, yes.
A. No.
Q. And listening carefully to your evidence, as I have been so far, would I be right in really assessing this of

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what you are sharing with us --
A. Yes.
Q. -- that your primary concern in this report and the evidence that you've given to the Commissioners so far is less about, shall we say, a criticism of what has been done by way of checking and calculation so far, but more a view that more needs to be done to satisfy your personal interest and concerns?
A. Not my personal interest and concern, no.
Q. Then if I adjust that last part: but that is principally your view; it is that what has been done is okay, but more needs to be done to satisfy concerns as to the integrity of the structure that we have discussed?
A. Yes, correct.
Q. And so to the extent we have heard evidence already from those who have had an in-depth involvement in calculations and checking, and indeed we may hear more, because of the limited nature of your involvement, you would obviously respect those views of such persons?
A. Yes, in terms of the involvement, yes, they have been involved much longer, it's true, yes.
Q. And as far as they have an involvement in the detail of the checking of the calculations, you would, to a very large extent, as we all do, defer to them and rely on them in relation to such calculations and checking?

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A. Well, now, normally, yes, but then in case there are problems -- for example, I understand that the expert reports from various parties contain the strength utilisation factors and there are variations, and in some cases fairly large variations.
Q. Let's come to the perceived problems in just a moment, if we may.
A. Yes.
Q. Before proceeding further, you will recall you were asked some questions by Mr Pennicott in particular as regards the joint statement.
A. Yes.
Q. Which you agreed just before Christmas. If you would be good enough to have in front of you the expert report of Prof McQuillan, which is ER3, and in particular the appendix XI, where the agreed expert memorandum is set out, from page 117 onwards; do you see that?
A. Yes.
Q. In particular, if you turn to page 118, article 3, I'd like to ask you a question about that.
A. Yes.
Q. In view of our discussions this morning and the comments from the Commissioners, you will understand that to some extent we will for legal purposes regard this as a document upon which the Commissioners will have views

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in due course. But we did understand, I think, from you that the words in brackets in section 3, part 3 of this, were derived from your own concern; yes?
A. I believe that is the concern not only of me but also of the government.
Q. We are only asking you questions just now, Professor.
A. Yes, it's my concern, it's my concern.
Q. So if we can stick to your concerns at this stage.
The paragraph I have in mind is the second paragraph.
A. Yes.
Q. "All agreed that the change from couplers to through-bars in the top of the east D-wall was a better detail and provided more steel across the interface ..."
And then there follow some words in brackets:
"... (subject to a review of the internal stresses at the top-of-wall construction joint relating to the 'first change' and its rebar detailing)."
Then it goes on to say:
"Notwithstanding, all agreed the outcome would not show the construction joint to be problematic."
Do you see that?
A. Yes.
Q. So the part I'm asking you about is that which appears in brackets. Mr Pennicott asked you some questions

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about this, and the purpose of my question, and perhaps as much for your comfort as it is for the learned Commissioners, is not to question what's set out here, but do we understand that with the benefit of reflection that your evidence to the Commission is that in fact your concern -- as expressed in those brackets -- was not particularly with regard to the first change but with regard to the second change?
A. No. Actually, in the meeting, I raised both.
Q. Yes.
A. I raised both. So that is shown in one of -- well, I think the third figure of my report, showing different cross-sections. The labelled cross-sections -- I raised both. So one of the cross-sections is a potential problem arising from the first change, and I believe that has caused the error of mixing the two together. So the additional construction joint has been caused by the second change.
Q. Yes.
A. So actually I raised two concerns.
Q. And today what is your position?
A. Still --
Q. Do you remain concerned about both changes?
A. Yes.
Q. So when I proceed to ask you some questions about the

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calculations and the checks that you see as being important, as we move forward, you have in mind a need for checks and calculations in respect of both the first change and the second change?
A. Yes, correct.
Q. That's helpful because that will help us frame what we look at as we go forward.
Now, putting that document to one side, please, and returning to your own report -- would you turn, please, to paragraph 6.4.1.1. For the record, this is document ER1/7, and it begins at the foot of page 9, that is where the heading of the section is set out, "Issues related to connection between the EWL slab and the east diaphragm wall"; do you see that?
A. Yes.
Q. Your opening paragraph here, if I can put it this way, sets the scene for what you go on to comment on in more detail in the rest of this section; is that so?
A. Yes.
Q. What you say is as follows:
"In the structural design, it has been assumed that the EWL/NSL slabs are rigidly connected to the diaphragm walls. The diaphragm walls serve both as the foundation supporting the station as well as the retaining structure to support the soil outside the station

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structure."
Do you see that?
A. Yes.
Q. You go on to say:
"If the slab-wall joint cannot perform as a rigid joint as expected, the internal forces may be different from those predicted from structural analysis based on the rigid joint assumption."
A. Yes.
Q. "In particular, the mid-span bending moments in the slabs will increase."
A. Yes.
Q. "If the slab-wall joint is improperly detailed and/or poorly constructed, the stiffness of the slab-wall joint will be reduced. In this unfortunate case, not only will the mid-span bending moments in the slab increase, but the structural stability of the station may also be affected, eg excessive side-sway of station structure."
Do you see all of that?
A. Yes.
Q. Just against this background -- and we'll come to look at these words in a little bit more detail, Professor -- I'd like to just understand this. It's not your position that when one designs a structure such as the one under discussion, that one needs to design for

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extreme events, beyond those that the codes require, is it?
A. Sorry?
Q. It is not your position that one should design for extreme events, beyond those that the codes, et cetera, anticipate?
A. Normally, in our design, we would consider certain load cases required, but there are rules and the provision of these rules would help in -- well, helping the structure to survive extreme events.
Q. You certainly don't design or expect to design for unforeseeable events which are not provided for within the applicable codes?
A. Now, put it -- well, I think I need to clarify. That is, there is one part which is based upon calculations; okay? To do calculations, normally an engineer would consider a list of load combinations; okay?
Q. Mm-hmm.
A. But it is possible that there could be some scenarios not covered in all of these scenarios. So the other rules -- the rules of detailing or whatever will provide additional safety measures.
Q. Assuming when one goes through the relevant codes, the relevant standards, as imposed through, for example, a consultancy agreement for the purpose of the design of

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a structure of that which is under discussion, one doesn't have to start designing for things that are not allowed for within there?
A. Correct. I hope that you understand my point. What I'm saying is that there are certain rules laid down by the design codes, such as provision of certain reinforcement that normally is not required because of the calculations.
Now, I can give you one example.
Q. Please do. One will be fine, thank you.
A. Okay, just one. Very often, the provision of reinforcement provided at locations not deemed necessary may help in providing certain robustness. Actually, one of my awards, in the year 2016, was from a paper on the robustness of concrete bridges. So it would help.
Q. Where you describe in this paragraph, the sentence beginning "If the slab-wall joint cannot perform as a rigid joint as expected, the internal forces may be different from those predicted from structural analysis based on the rigid joint assumption" --
A. Yes.
Q. -- your statement there is not based upon any particular evidence that has been put before you that the slab is behaving in that way?
A. No. It's a structural engineering sort of concept.

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Q. To what extent does your view of that possible performance of the slab depend upon, for example, the nature of a hinge within the structure?
A. Could you say that again?
Q. The nature of a hinge within the structure.
A. I don't see any proper hinge in the structure. There is no hinge so far.
Q. That is fine. So you and I are in agreement that there is no hinge in the structure.
A. Correct.
Q. But what we do have, as has been observed by Prof McQuillan in his report, has been discussed between you and Prof Hansford, 3 metre thick slab that's heavily reinforced?
A. Yes.
Q. So if there is, as you conclude at the end of this paragraph, the potential, I think you were saying, for, for example, excessive side-sway of the station structure, to bring that set of circumstances about, one would have to have a hugely significant and unexpected turn of events, would one not?
A. That is a very extreme case.
Q. Thank you. And if it were the case that such side-sway were to happen, you would need some very significant external forces to bring that about, would you not?

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A. Yes.
Q. And if it were to come about, then significant distress would self-evidently be apparent from the slab concerned?
A. I believe so.
Q. There would, for example, be cracking on the top of the joint?
A. Now, the problem is --
Q. Sorry, if you could caveat that, and I will come back to you explaining your problem, but if we can deal with this point by point -- there would be cracking visible on top of the joint?
A. Not necessarily. The problem is --
Q. Okay, please --
A. -- in the joint there are certain parts, primarily the reinforcement, taking tension, and concrete is taking compression. The problem with concrete -- well, relying a lot on the compression of concrete is that the behaviour is brittle, just like two of my slides showing brittle failure and ductile failure.
So the problem with the joint is that in case anything goes wrong, it could be brittle, so we may not be able to see anything prior to its failure.
Q. So your position is side-sway, as you alert us to as being an example of what might arise here, would have to

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arise as a result of excessive and unusual circumstances?
A. It would be unusual, yes.
Q. But one would not necessarily see evidence in the form of cracking of the concrete until it happened?
A. No. Cracking is just one form of distress.
Q. What other forms of distress would one expect to have seen if this were to happen?
A. Crushing of concrete. That would be immediate. So that is the cause of brittle failure.
Ah, yes, one more. Shear failure also is very brittle.
Q. And what would be the physical manifestation of that?
A. So, actually, in some of my slides, I have shown some of the vertical forces acting on one section of the slab. That is a shear force. If the shear force is excessive, and if the shear strength is not sufficient, for example insufficient shear length, then the failure would be brittle, yes.
Q. Pausing at that point, and I ask the point not for anything other than to confirm the position, there is no evidence so far of any of these things coming to pass?
A. Not yet, no.
Q. Can you help the Commission with precisely what checks and tests you say must be carried out to ensure that one

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is satisfied that this risk of extreme failure arising from unusual forces is excluded?
A. Sorry, I beg your pardon.
Q. Let me break that down a little bit.
A. Yes.
Q. And, sir, in asking this question, I'm not at all ignoring the Chairman's point of this morning that it may be helpful after Prof Au's evidence to have a list of those tests, et cetera, that he considers may be helpful, but if you will permit me it's probably important as we go through on a point-by-point basis to understand where he's coming from in terms of those likely checks and tests. Thank you.
So if I break that down a little bit, Professor, in fairness to you.
A. Yes.
Q. In the situation that you have described in 6.4.1.1 --
A. Yes.
Q. -- and in particular to anticipate and to deal with, and indeed confirm that your concerns are not well placed as regards, for example, excessive side-sway of the structure arising, what checks or calculations do you commend or require be carried out to satisfy us that this is not going to happen?
A. I'm going to recommend, okay, certain checks. So,

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first, check all the stresses along the additional construction joints. And the other concern is that the detail -- can I go on, please?
Q. Yes. If we just take it slowly, your first thing is check all the stresses along the additional construction joints -- sorry, if I may just pause there. To make sure that I at least understand that, these are those additional joints that arise from the so-called "second change"?
A. Yes.
Q. I know you have more to say so I will come back to that in a moment, but in response to questions from the professor earlier on, I think perhaps before lunch, the professor was asking you to draw the distinction between those checks and calculations which were simple and therefore capable of being carried out within a few hours to a half day, and those that were sophisticated and would take many months.
A. Yes.
Q. Is what you just described something that would be in the former category, namely the simple one?
A. Yes.
Q. Thank you. Now, I cut you off and I didn't mean to. You were going to go on to a second check or calculation.

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A. Yes. The second concern is that the detail right now is not one of those standard details, because of the first change. So the problem is that there can be some critical shear planes within the joint, and I think there is a need to change -- sorry, a need to check the stresses along such critical shear planes. There may be several.
Q. Again, that check that you've just described is within the simple category that you described to the professor?
A. Yes, simple.
Q. Thank you very much.
COMMISSIONER HANSFORD: So, therefore, that's all part of the same numerical process that you've referred to?
A. Yes. Now, the reason why I feel that there is a need to check is that because of the first change, because of the omission of the L-bars, U-bars or whatever -- now, if you look up those design manuals for structures, normally there would be such details. If we omit some of these bars, that's not to say it must be unacceptable, but then one has to check whether or not there are problems.
MR CONNOR: Thank you.
Professor, does that answer the question you had in mind?
COMMISSIONER HANSFORD: Yes.

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MR CONNOR: Thank you.
When you describe -- and forgive me because I'm a layman for these purposes asking you the question -- critical shear planes, can you explain what it is that you say has to be checked and how?
A. May I draw it over here, please (indicating whiteboard)?
CHAIRMAN: Sure, absolutely.
COURT REPORTER: You need to speak into the microphone though. Can it move?
A. (Drawing on the whiteboard) Now, here is one example. I'm not saying this is the only critical shear plane. Note that there are several layers of very big bars, 40, 50 millimetres, whatever. Then they are supposed to be anchored within this slab; okay?
Now, perhaps for each of them anchorage may not be a problem, but the major problem is that at the end of the bars, because of the lack of lapping, the stresses at the end of that must be zero, effectively zero; okay? Here is a very large tensile force acting downwards, and if we isolate that as a free body, there will be a downward shear force acting, which is shown here (indicating). We are just looking at that part.
So if we consider that as the free body and considering just vertical equilibrium, vertical balance of forces, there must be a very large shear force acting

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on this joint. So that is within the joint.
Now, we need to check the stress over here, whether it is excessive or not; okay? So that is the major problem. In case the original design has been just marginal, in case, adding another construction joint is going to harm it further. So the problem is if we have two changes, two possible weakening, the total effect may not be just the sum of the two. It may be more.
That's why if we are aware of any of these possible weaknesses, we have to check.
MR CONNOR: Thank you very much.
COMMISSIONER HANSFORD: Just as a question of process, it's very useful to have these drawings on these flip charts. Is there a way we can bring these into evidence; will we be taking photographs of these and then including them somewhere in the bundles?
MR PENNICOTT: We can do that, sir.
COMMISSIONER HANSFORD: Thank you.
MR CONNOR: Thank you very much. Thank you for that helpful explanation, Professor.
Again, so I understand, at the very least, the two areas of checking and calculation that you've described, can you help the Commissioners with against what standards or codes these checks are to be carried out? Because you will understand that the idea of numerical

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checks and calculations and so on is a little bit lacking in detail, with no disrespect. So precisely what codes and standards do you say must be applied in relation to the checks that are to be carried out?
A. This is a very difficult question. So that is why normally engineers would follow standard details. At the joints, they have certain bars, L-bars, U-bars, whatever. If they follow such details, then normally there would be no problem, but if they modify, they omit something, it would be very difficult.
Now, the major -- now, if we do that, that's simplified check. If we discover that the stresses are very low, no problem. But then if they are high, let's say 5 megapascals, the next question is what is the acceptance criteria. There is no simple answer.
Q. Let's pause at that point, because I don't want us to get too far ahead of ourselves. You have described to the Commissioners the simple tests that may be done, and you quite rightly say, of course, if certain things are found as a result of those, then there's, if you will excuse the colloquial expression, a deeper dive that may have to be done in that regard.
A. Yes.
Q. But that's for the future. Initially, for these checks, can you help us with precisely the codes and standards

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which would require to be referred to to provide the checks and the numerical calculations that you have described as necessary?
A. Yes, this is a difficult question. So what people normally do is to -- when they do the design, they would look at a certain region, what people call the D region. I mention that. Then people normally use the strut-and-tie model, to arrive at the arrangement of reinforcement satisfying that the concrete can take the stresses, whatever, without problems.
Now, if we, let's say, modify something, and then we try to do a back analysis to check whether it is okay or not, it is not that simple. It would be very involved; okay?
Now, using this approach, if the stress turns out to be very low, there is no problem, but then if it is higher, then just doing that would not be sufficient.
So normal design codes would not tell you how much is acceptable in this rather unusual scenario.
COMMISSIONER HANSFORD: So what would? If normal design codes would not tell you what is acceptable, what would tell you what's acceptable?
A. People normally -- there are some standard situations, normal beam-column joints like that -- so a beam and a column like that. So for this very standard case,

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people can refer to the Code of Practice, and there is a formula for people to work out the required amount of reinforcement.
But for some other more complicated cases, then it would be difficult and people would have to do the design from first principles, and normally people would try to, first of all, come up with the forces, look at what happens inside the connection and then provide sufficient reinforcement.
If we reduce some of the reinforcement, if we omit some of the bars, would that be acceptable? This question is more difficult to answer. Then people can, for example, use three-dimensional finite element to do that. Even for a reinforcing bar we are not treating that as a bar but a lot of small elements, volumes, it's very complicated. Normally, people doing research, postgraduate level, would do that, so things would take several months or whatever. It would be very complicated.
MR CONNOR: Professor, if I may.
COMMISSIONER HANSFORD: Thank you.
MR CONNOR: You will forgive me if I push you a little bit further on the question, Professor.
A. Yes.
Q. Because we are not in the complicated area yet. We are

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not in the many months of sophisticated calculations. We are in the simple zone in terms of these. If you cannot help us with this, please just say, but I would like to come away from your evidence, subject to the learned Commissioners allowing me to do so, with an understanding of what you demand.
A. I'm not demanding.
Q. Well, I'm sorry, you are.
A. I'm just raising certain concerns.
Q. Professor, bear with me. If you say that the checks and calculations carried out by others who have been steeped in this design and construction for months and years are not acceptable but you want more things done, you do have to say to us what precisely it is that you require to be done, and if you are not in a position to do so then simply say that and we can move on to another question.
A. Now, allow me to say so. So far, I'm not aware of any design calculations of the joint were submitted. I may have overlooked something.
Q. I'm not testing you on your memory here, sir. I'm asking you a question. You've told the professor this morning that you believe there is a series of simple checks that should be carried out. You have told us we'll check along the shear planes, that we'll look at

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the new design details and we'll look at the second change. What are the tests, Professor, and by reference to what codes or standards or otherwise? Because if you do not tell us, then we are none the wiser as to what you think is important to allay your or the government's concerns about this matter.
CHAIRMAN: I think -- sorry I'm interrupting.
MR CONNOR: Of course.
CHAIRMAN: My approach, which is not a criticism of your approach, earlier was to say to Mr Khaw, and Mr Khaw agreed, that it would help us if, at the end of his evidence, we could then have from Mr Khaw, when he's able to discuss matters more fully with Prof Au, what tests, in accordance with what criteria and the like. I'm just wondering if on the hoof, so to speak, the professor is able to tie it all into codes and various things like that. I may be wrong. I just mention that in case it helps.
MR CONNOR: I had your comment very much in mind, as you may recall a few moments ago, sir, where I referred to that idea that after the professor's evidence there would be such a list. I probed it a little bit and I think I have taken it as far as I can really with Prof Au.
You will understand, I'm sure, both of you, sirs, that the concern here is that we close Prof Au's

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evidence and we are none the wiser about what it is that he thinks is required, and then out of discussion we get a list. I don't know how long that list will be. I don't know if it will be in the simple zone or the sophisticated.
CHAIRMAN: I see your point.
MR CONNOR: I think you both have it.
Professor?
COMMISSIONER HANSFORD: I think we do, but my understanding, unless I've missed something -- my understanding is that the only calculations and tests that Prof Au has been suggesting today have been, one, related to the stresses in the construction joints at the top detail of the diaphragm wall, and two, further tests relating to partially engaged couplers.
I have not registered any other tests or calculations that Prof Au is suggesting. Perhaps I can just check: am I right?
A. Well, actually, there could be some potential weakness, as shown in the vertical red line over there (indicating the whiteboard).
COMMISSIONER HANSFORD: But that's also related to the change in detail at the top of the diaphragm wall?
A. Yes.
COMMISSIONER HANSFORD: Therefore the point I'm making is

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what I understood is that you are recommending further numerical tests relating to this detail which is the detail between the EWL slab and the diaphragm wall?
A. Yes.
COMMISSIONER HANSFORD: And you are recommending some further tests relating to partially engaged couplers.
A. Yes.
COMMISSIONER HANSFORD: And I don't think I have heard you recommending any other tests or calculations.
A. Not really, no.
COMMISSIONER HANSFORD: When you say "not really", is that "not"?
A. "Not".
COMMISSIONER HANSFORD: Thank you.
MR CONNOR: Thank you, Professor. I take that "not", thank you.
Let's move on then, Professor, to paragraph 6.4.2.2 --
A. Yes.
Q. -- of your report. It is in there that you say as follows:
"The revised details in the drawings [and you then cite various drawings, B19/25487 to 9 and B19/25491] show the formation of additional construction joints at the connection. As the additional construction joints

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introduced by breaking out part of the completed diaphragm wall may create potential surfaces of weakness, they should be checked by proper structural calculations to ensure that the internal stresses generated at these joints would not be excessive."

Just pausing at that point, I think that aligns with your last response to Prof Hansford?

A. Yes.

Q. "Apparently, no such calculations have been provided by MTRCL to the Building Authority so far. If the stresses at the actual locations of construction joint are excessive, remedial works may be needed."

Just pausing at that point and to test it -- you will recall this morning that Mr Pennicott referred you to Prof McQuillan's opinion, and in particular paragraphs 98 and those following it. For the reference, this is ER3.

A. Yes.

Q. In Prof McQuillan's report at paragraph 98 and in those paragraphs following it, he's dealing there with the amended EWL slab to east D-wall connection, and he goes on -- in paragraph 98, he talks about, in his opinion, the amended detail, as represented by the first change to second change, is superior. You have given your view on that already.

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Then at paragraph 99 he says the following:

"Intuitively, and from experience, the shelf joint is superior to the butt joint in terms of its ease of construction and rigidity."

He then goes on to make reference to a schematic diagram below, which illustrates, as he says in line 4 onwards, "how the trimmed-down D-wall is encapsulated and 'clamped' by the EWL slab bending away in one direction, the OTE bending away in the opposite direction, and the self-weight of the integral 'block' of reinforced concrete (coloured in blue) which bears down on the top-of-wall construction interface. The 'block' is prevented from splitting above the D-wall by the embedded tension rebar. In my opinion the 'clamping' action compensates for the lack of 'U' bars in the top of the D-wall."

Do you see that?

A. Yes.

Q. He continues at paragraph 100, where he says:

"The internal stresses at the top of wall construction joint are all of a compressive nature. The diagram illustrates why no tension or shear can occur at the interface. Any tendency for a shear force to develop across the interface would be resisted by the 'clamping' action of the EWL and OTE slabs which bear against the D-wall."

Do you see that?

A. Yes.

Q. Do you not recognise and agree --

A. I don't agree. Well, actually, in my presentation this morning, there were two slides showing why we have shear stresses, and when there is a change in the loading the internal forces, the stresses will all change. So, in particular, over this additional construction joint, there would be shear forces. There would be.

Q. Professor, you have helped with that view already. But the short position is this, is it not, that the clamping action as described by Prof McQuillan is exactly what is to be expected, given the make-up of the slabs that he has described? The weight of the structure is such that the vertical forces which are being deployed create a bending moment which compresses the slabs. It is reinforced to a very, very large extent, and therefore the risk of anything of the type that you are concerned with arising is simply not realistic.

A. No, it's incorrect. It's incorrect. We always look at the mechanics and find out the forces. That is not the correct way.

Q. So you take the view that therefore what Prof McQuillan has described ignores the likelihood or at least the

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risk that something might arise?

A. I believe so.

Q. And by that "something", we see the application of forces such that there is some significant distress that will be found within the structure?

A. Now, the --

Q. Please answer the question. Prof McQuillan has got it wrong and actually you say that because of the evidence that you have given to this Commission, there is a risk, perhaps no higher than that; there will be a failure in the slab?

A. I'm not saying that there will be a failure. I am just saying that at the construction joint there will be shear. There will be shear.

COMMISSIONER HANSFORD: But you are not saying about the expected consequences of that shear?

A. Well, it depends on the magnitude. It may not be very big. I think there may be marginal problems over there. So I'm not expecting -- well, it really depends on the result of the checking.

MR CONNOR: So if -- sorry, I will let you finish your point.

A. If you are talking about clamping, there is one way to mobilise this clamping action. That is to do post-tensioning. Probably Prof Hansford would

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understand that. So if we provide some tendons and do post-tensioning, then there will be clamping action, but if we just cast it in situ, there won't be any clamping action that is useful.

Q. Thank you. Just going back to your comment of a moment ago, so we understand the extent of this risk that troubles you, I think you say at best here of course it depends upon the tests that you have told the Commissioners should be carried out, but as you say:

"... it depends on the magnitude. It may not be very big. I think there may be marginal problems over there. So I'm not expecting ..."

You are not expecting much, are you?

A. Not really. If we have to check -- we have to check. There may be certain issues over there, so the horizontal shear stresses may exceed what we normally accept. Well, in the normal design process, when the horizontal shear stresses are exceeded, then we need to provide additional reinforcement, perhaps in the form of some additional dowel bars or whatever. It's quite common.

Q. Okay. Moving on then to paragraph 6.4.3.3 -- in this paragraph, you refer to the submission of calculations by Atkins, and these are the calculations to which you have made some reference in your evidence already. Do

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you see that?

A. 6.4.3.3?

Q. Yes, paragraph 6.4.3.3.

A. Yes, yes.

Q. Now, at the time when these calculations were requested, do you know what the purpose of those -- pardon me, if you would allow me to correct that question for the purposes of the professor.

The report that you have referred to has been produced in response to a request on behalf of the Commission to Atkins.

A. Yes.

Q. And you are aware that that request was borne of a discussion that you and the other experts had on or about 18 December?

A. Say again, please.

Q. Let's just unpack that a little bit. When you sat down to look at the Atkins report that you refer to at paragraph 6.4.3.3 --

A. Yes.

Q. -- did you know for what purposes it had been produced?

A. I believe that -- well, that should be a concern raised on the stresses at the construction joints, additional construction joints, so that's why Atkins has come up with some additional calculations.

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Q. I think I can probably help you with that, Professor, because that's not the point.

If you have regard to the letter which accompanied these, which I think you will find in exhibit J6/28; do you have that?

COMMISSIONER HANSFORD: Can we have it on the screen?

MR CONNOR: Yes.

That is a letter, which is at J6/28 from Atkins to the solicitors for the Commission.

MR PENNICOTT: That's it.

MR CONNOR: Thank you very much.

MR PENNICOTT: We looked at this this morning.

MR CONNOR: Yes, quite right, Mr Pennicott. This is to Lo & Lo:

"We refer to your email of 19 December 2018 requesting calculations to demonstrate that internal stresses at the construction joint (cut-down wall top interface) are within acceptable limits for the 'first change' necessitated by the missing U-bars at the top of the D-wall. Similar calculations in relation to the 'second change' were also requested.

The requested calculations for both the 'first change' and 'second change' are enclosed."

Do you see that?

A. Yes.

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Q. Then you will see, if you go on to the next page, please, J6/28.1, which again I think Mr Pennicott took you to this morning, which begins as follows:

"The Commission's expert, Atkins were asked to make the following request".

I think perhaps there might be a glitch in the grammar of that, but if we go to the second paragraph:

"We refer to the 'first change' necessitated by the missing U-bars at the top of the D-wall."

This is a quote, I think, from the request that is made on behalf of the Commission.

A. Yes.

Q. "We should be grateful if your client [and for these purposes read Atkins] could produce calculations to demonstrate that the internal stresses at the construction joint (cut-down wall top interface) are within acceptable limits. Similar calculations in relation to the 'second change' should be provided as well."

Do you see that?

A. Yes.

Q. Just pausing at that point. When I asked you a few moments ago, did you understand, when you looked at the Atkins report, the purposes for which it had been provided, is this what you understood?

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A. Yes.
Q. So it didn't arise from a concern, it arose from a question that had been posed of Atkins to provide some calculations?
A. Yes.
Q. Thank you. So what you then go on to say, returning to your report, if you look at the second sentence, is:
"In Atkins' report only some calculations for a typical slab-wall joint are provided ..."
And you go on to say:
"... it is certainly not enough."
If we pause at that point, the typical slab-wall joint that Atkins address in their report, J6/4557 and those pages following it, are indeed the same as those that you address in your figure 6.4.3.3.1; is that right?
A. Yes.
Q. So in fact both you and Atkins --
A. Sorry, are you referring -- okay. So are you referring to this?
Q. I'm referring to the figure that is set out at the bottom of page 11 of your report.
A. Yes. Yes.
Q. So when you say that Atkins have provided some calculations for a typical slab-wall joint, it is the

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same typical slab-wall joint that you yourself focus on in your report; okay?
A. Yes.
Q. Your complaint about this typical slab-wall joint -- well, you say "it is certainly not enough" -- do I understand really that where you are coming from there is in your professional view, to become comfortable with the concerns that you express in your report, you wish to see more construction joint details covered by calculations similar to this one?
A. Yes.
Q. So it is not a criticism of the use of that as a typical detail; it is that you would like to see them all covered?
A. I think to ensure safety it is necessary to check all of them.
Q. I understand what your sentiment is there, Professor, but simply so we understand it --
And is that series of checks, if carried out in respect of the other slab-wall joints, within the category of simple checks that you described to the Commissioners this morning?
A. I think simple checks should be done first. If there is problem or if there is doubt, then either one goes for very sophisticated checks or to do retrofitting.

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Q. We understand what your position is on this, but your position, firstly, as I understand it, is that there is a range of simple checks that you would like to have done --
A. Yes.
Q. -- and your position is that this should be done now for all of the amended joint details?
A. Yes.
Q. How many of those are there, sir?
A. Well, there are so many. If you look at the drawings, there are many, many different details, or some details with very complicated construction joints.
COMMISSIONER HANSFORD: Sorry, when you say there are "many, many", are we talking about five?
A. No, more than that.
MR PENNICOTT: Four basic ones.
COMMISSIONER HANSFORD: Is four "many, many"?
A. Well, the drawings show many, but then some of them may be having similar characteristics, perhaps a bit different to reinforcement. In terms of the shape, I think they can be categorised into just a few.
MR CONNOR: Precisely. So what you are requiring is not "many, many" checks to be done; you would like four types of detail looked at?
A. It depends. It depends.

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Q. What does it depend on?
A. Because for a certain shape, there may be different reinforcement, and then for different cases, yes, of course, there is a need to check.
Q. Professor, please can we hone this down to an understanding of what your position is. You have said in this report, lodged for the purposes of the learned Commissioners, that:
"Calculations must be carried out on all design variations of slab-wall joint to ensure their safety."
A. Yes.
Q. Are we speaking now of four or five?
A. Actually it depends on the final design that is adopted by the contractor. So if there are many, then there is a need to do many checks.
Q. Professor, subject to such direction from the learned Commissioners as they choose to give me, I am pressing you a little bit here to help us, and it doesn't help us, with respect, if you simply raise another conundrum from a question that otherwise needs to be answered.
We have said to you, I have said to you, we are talking about four typical details that might be considered in these simple checks. Another view might be that there are five. Do you agree that that is in the order of the numbers that require to be considered?

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A. I have seen many different details but I am not yet in a position to classify them into just several.
Q. Thank you. If we have a look at a drawing which is B25487, in B19.
MR PENNICOTT: That's it.
MR CONNOR: Thank you very much. Thank you, Mr Chairman and Mr Pennicott.
So, Professor, you have in front of you --
A. Yes.
Q. -- there B25487. Does this help you in assisting the learned Commissioners on the number of details which would sensibly be checked as part of the simple checks that you are commending?
A. Perhaps, let's say, in this structure, how many -- well, different types of slabs are there; okay? So probably, even for the design of the slab, there may be many different types.
Now, in this drawing -- now, there are several types, but the detail may appear at different locations, and at different locations the bending moment, shear force, whatever, may be different.
Now, of course, if one tries to look at all of them and tries to come up with the most critical one, just do one check, fine, and if it is found to be acceptable, fine. But then if that is not the case, then there will

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be many different cases.
Q. Of course. But that's helpful I think, sir, because if we take this in stages, as regard the simple checks that can be done within a half-day or so, then I think what you are helping us is, "Yes, Mr Connor, you are probably right, it's four or five for those initial simple checks", but of course always subject to your qualification that "if I find something there that I don't like which causes further investigation, then that will have to be done"?
A. Yes.
MR CONNOR: Thank you very much. Just close that over then.
Sir, Professor, I do have more. I'm conscious of the time. I'm very happy to plough on but I think I will be at least another 15 or 20 minutes with the professor.
CHAIRMAN: All right. We will have the afternoon adjournment now. Thank you very much. 15 minutes. Thank you.
(3.51 pm)
(A short adjournment)
(4.12 pm)
MR CONNOR: Chairman and Professor, thank you.
Prof Au, thank you. We were looking just before the break at paragraph 6.4.3.4 of your report, which begins

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at the top of page 12.
A. Yes.
Q. Do you have that?
A. Yes.
Q. It's there that you refer, in the first sentence, to "Atkins attempts to calculate the horizontal shear stress", and you go on to refer to the calculation which was used.
You recognise the calculation, I take it?
A. Yes, this one?
Q. Yes. When you read the report, you recognised the calculation that had been deployed?
A. Yes.
Q. And you recognised it as one which was used, as you put it, "for evaluation of shear stresses in a homogeneous beam under shear due to flexure at elastic state"?
A. Yes.
Q. You accept, do you not, that part of the assessment of shear, that that is a perfectly proper equation to use?
A. Yes.
Q. Your point is that you would like more done?
A. Well, now, I believe that what the designer or whoever is trying to do is to find out the horizontal shear stress inside the joint. But that equation doesn't give the shear stress inside the joint. It is within the

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beam, outside the joint.
Q. So, as you would say, it applies to a beam theory situation?
A. Yes, not within the joint. It's outside.
Q. But it would be sufficient, would it not --
A. No.
Q. Sorry, if you bear with me, please. It would be sufficient, would it not, as a calculation, an equation to be deployed, to check, in the situation where the designer knows the make-up of the structure involved, he is familiar with the extent of reinforcement, for example?
A. I don't understand your question.
Q. I put it to you that given that this designer, in carrying out that calculation and deploying that equation, is familiar with the nature of the structure, the extent of reinforcement deployed in it, the weight of the structure, the thickness of the structure, that to provide an estimate as to shear stress, this is a perfectly appropriate equation to deploy?
A. Actually, what the designer is trying to calculate is the shear stress, the horizontal shear stress, inside the connection; okay? But in his equation, he has just made use of the vertical shear force at the end of the beam.

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Now, in order to find out what's going on within the connection, we have to know a lot. The bending moments at the two sides -- actually, the most important would be the bending moment rather than the shear force, the vertical shear force -- that is totally wrong.
Q. It is not wrong, Professor. It is a start. Your view is that more needs to be done; is that right?
A. No.
Q. You say it's wrong, full stop?
A. It's wrong. So what he has calculated is the shear stress inside the beam, not within the connection, and that is only for the elastic state.
Q. So what should he do?
A. Sorry?
Q. What should he do?
A. Well, I think he has to learn beam-column joint theory. It's totally wrong.
Q. Let us put your personal assessment to one side because what I'm really asking you is, if it's not that equation, what equation is it, Professor?
A. Well, are you trying to ask me to again explain to you?
Q. No, I'm asking you a very straight question, Professor. You say wrong equation used. I ask you what one should it be then?
A. There is no simple equation. We have to look at the

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free body, go to the basics, go to the first principles. Actually there is a section in the Concrete Code on beam-column joint, but the problem is that it only gives the equation so that people can apply to find out the required reinforcement without giving the basics. So that's why some engineers may not understand the basics. So, in this case, without knowing the basics, there is no way to calculate that.
Q. So you go to that point in the final sentence of 6.4.3.4, when you say that equation 6.19 of the Concrete Code is normally used to estimate the shear stress of beams and slabs at ultimate limit state and the behaviour is assumed to be inelastic.
A. Now, mind you -- so in this sentence I'm talking about shear stress of beams and slabs, not within the connection. So what I'm saying is that he has used a wrong equation to calculate, and that equation only gives the shear stress within the beam, and even within the beam the normal practice is not to use this equation. It is the other equation.
And we are now trying to work out the shear stress within the connection. This is totally wrong.
Q. Do you propose that equation 6.19 of the Concrete Code is the appropriate --
A. No.

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Q. -- equation? Well, why do you mention it, Professor?
A. I'm just saying that even for calculation of the shear stress in the beam, it is not correct.
Q. So 6.19 of the Concrete Code you cite at the end of that paragraph doesn't help us at all?
A. No.
Q. Why do you refer to it then?
A. It's just to show that this original equation that he has used is inappropriate. It is not used at all in the design of reinforced concrete structures.
Q. So, as far as 6.19 of the Concrete Code is concerned, you would accept that it's not an alternative to address your concern because it also assesses the shear across the whole section?
A. Equation 6.19 is for calculation of shear stress within the beam.
Q. Yes.
A. I think probably I need to explain. Let's say if that is a beam (holding a marker pen) and if let's say this is -- well, the connection (holding a water bottle), what that equation -- let's say the equation that that designer has used to calculate would be the shear stress within this (indicating marker pen) at elastic state. But it is not acceptable. To evaluate the shear stress of that at the ultimate limit state, we have to use

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6.19, to find out what's over here (indicating water bottle), to find out the horizontal shear stress over there -- sorry, these two equations would not help.
Q. No. Well, 6.19 won't help, will it, Professor? Because it also relies upon similar considerations as apply in the equation which was deployed. So again I have to ask you the question, if it's not the calculation and approach that was used, what do you propose to this Commission is the appropriate step that should be taken?
A. Well, it's just to consider the free body. Perhaps I can draw that again. (Drawing on the whiteboard).
Q. I wonder if for the purposes of this note -- I will be guided by Mr Pennicott -- are you happy on behalf of the Commission that this be on the same drawing?
MR PENNICOTT: Yes, I think the same.
MR CONNOR: Thank you, sir.
COMMISSIONER HANSFORD: It may subsequently require a bit of annotation, but we can deal with that later, I'm sure.
A. All right. What I'm trying to demonstrate is that again looking at the bending moment on this side, it is possible for us to come up with the tension carried by this, by this group of reinforcement, and then looking at the bending moment on the other side (indicating), it is also possible for us to work out the tension carried by the group of reinforcement.

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Now, if we look at this free body, in particular the horizontal balance of force or equilibrium, it is possible for us to work out the horizontal shear force or horizontal shear stress.

So neither of the equations would help. We have to consider this equilibrium.

Q. Okay. Let's come to look at that in a moment. Just so we have it for the record, you don't see the equation being deployed by Atkins as relevant at all to helping the assessment --

A. It's irrelevant.

Q. In your view?

A. Yes.

Q. And you do not even see it as part of the exercise?

A. Sorry?

Q. Part of the exercise of assessing and reporting upon the structure in the way that Atkins were asked to do.

A. So this part of the calculation has calculated something else, not something within the connection.

Q. You then move on to talk about, as you say, the free body.

A. Yes.

Q. In 6.4.3.5, which is the next paragraph of your report, that is where you refer to Atkins' report in the lower half of the page 3 of 5.

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A. Yes.

Q. "... to a cross-sectional diagram of the revised joint (which is reproduced ... below) claiming that the pink down-stand part of OTE wall can act as a shear key to help resist the horizontal shear stress at the additional construction joint."

Yes?

A. Yes.

Q. Then you say:

"However, no calculation has been provided by Atkins to substantiate this claim."

Do you see that?

A. Yes.

Q. Just pausing at that point, before you get to your comment about the lack of calculation to support it, as a proposition do you agree that the pink down-stand part of the OTE wall can act as a shear key to help resist the horizontal shear stress at the additional construction joint?

A. It depends very much where the weakest section is.

Now, allow me to do a demonstration. Supposing I'm holding a weight of 10 kilograms (indicating water bottle). If I hold it like this, very close to my body, then my body essentially is carrying axial load. The problem with a down-stand is there is an eccentricity.

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If I try to hold like this the 10 kilograms (holding water bottle away from body), I don't think I can hold it for ten minutes because of this distance. That is what we call eccentricity. This is going to create a moment. So in addition to the axial force, I have to carry that moment as well.

The problem is there is a need to check the strength of the part of -- the pink part of the concrete above the diaphragm wall.

Q. Very good. But that last part of your evidence I think reveals really where you come from on this, consistent with what you have said earlier on this afternoon, namely this, that you do not quarrel with the proposition that, if I put it this way, it might be the case that the pink down-stand part of the OTE wall acts as a shear key to help resist the horizontal shear stress at the additional construction joint; it's simply that you want more evidence that that's so.

A. Let me explain.

Q. Sorry, we'll come to your explanation in a moment. Please answer my question, under direction, if need be, from the learned Commissioners. If you go back to my question -- you say it might be the case that the pink down-stand part of the OTE wall acts as a shear key to help resist the horizontal shear stress at the

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additional construction joint, but you want more evidence of that. Is that so? Do I understand you correctly?

A. The problem is whenever we look at a structural component, we always look at the weakest part, because the strength is governed by the weakest part. Apparently the designer hasn't checked the strength of the pink part of the concrete above the diaphragm wall. That is the concern.

Q. So you have a concern?

A. Yes.

Q. And you want more checked; yes? In fact, if you would be good enough to dip back into Prof McQuillan's report, at a paragraph you have looked at already, in ER3, paragraph 100 -- in fact, you were kind enough to look at this earlier this afternoon -- he says:

"The internal stresses at the top of wall construction joint are all of a compressive nature. The diagram [which is the one he refers to above] illustrates why no tension or shear can occur at the interface. Any tendency for a shear force to develop across the interface would be resisted by the 'clamping' action of the EWL and OTE slabs which bear against the D-wall."

In fairness to you, you have already told the

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Commissioners you don't agree with that.
A. No.
Q. But it is the case, I have to put to you, Professor, that Prof McQuillan is right, the proposition from Atkins is right, and in fact no calculation is actually required, given how self-evident the position is applying these engineering principles?
A. It is similar to the case when we are talking about a chain. If there is a weak link in the chain, no matter how we claim -- now, the strength is governed by the weakest link. Actually, it violates the basic principles of mechanics.
COMMISSIONER HANSFORD: Sorry, in what way?
A. Well, we always look at free bodies. We always look at equilibrium. So if we isolate a certain part as a free body, we have to satisfy ourselves that equilibrium can be satisfied, strength is there. Otherwise -- well, I think it's just -- I think for an engineer that understands the basic -- well, the basic behaviour of a joint like this, and when the engineer looks at the free body, then the engineer should be able to understand what is happening to that part.
So actually, there would be a lot of tension, and there must be shear, must be, because -- so one argument that I put forward earlier is that the stresses depend

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on the loading applied. It is not possible, it is impossible, to have zero shear stress there all the time. There may be one instance but then when you vary the loading, obviously that will change; there will be some shear stresses.
MR CONNOR: Using your word of earlier on, Professor, the risk of that is marginal in the circumstances.
A. Well --
Q. Let's pause at that point. Don't go on to say "well". Your word of earlier on was the risk is marginal; yes?
A. Well, in some cases, yes.
Q. Thank you. Let's proceed down paragraph 6.4.3.5 of your report. You say "Apparently" --
CHAIRMAN: Sorry, I'm interrupting there. It's a question where I can be assisted later, no doubt, but one of the issues of course that arises in my mind as a layperson is when you talk about marginality is I'm sure engineers would have their own tests for when are you able in respect of any structure to disregard certain risks because they are simply not feasible in respect of that particular structure and the stresses and dynamics that that structure must deal with over its lifetime. If that comes up at any stage -- and it may already be in a report that I've missed -- but because the argument may be I think that -- what the professor is suggesting

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maybe are issues which go beyond that limit of marginality.
Does that make any sense?
MR CONNOR: It absolutely does, sir, and I think it maybe just allows me to clarify with Prof Au where he is on that, but I think we have it already -- that really, Professor, as far as the assessment of the marginality, as we put it, of that risk is concerned, we go back to the simple checks that you discussed with Prof Hansford, because, as I understand your evidence, if those are carried out, and if the results are as one would hope and expect, then we are within hopefully the area of what would be acceptable to you and other experts.
A. Mmm.
MR CONNOR: Thank you, if that helps.
CHAIRMAN: That does. Thank you.
MR CONNOR: Thank you. We were just looking -- if I may, sir -- just at that last sentence of 6.4.3.5, where you were saying:
"Apparently, the top reinforcement has not been designed to resist the combined tension and bending moment. It is uncertain if the horizontal shear resistance at the additional construction joint and the bearing resistance at the down-stand can indeed act together but not fail progressively. It should be

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demonstrated by calculations and/or experiments."
Just a short question there. Would I be right in understanding, just looking at your diagram, 6.4.3.5.1 --
A. Yes.
Q. -- of course what we have here, if I'm right, Professor, is a strut-and-tie configuration?
A. No.
Q. You disagree with that? How would you describe it?
A. You mean this detail?
Q. Yes.
A. It's a rather unusual detail, to be honest.
Q. Can you give it a description beyond the expression "rather unusual", in engineering terms?
A. So are you referring to the construction joint or are you referring to the reinforcement?
Q. We have here a situation where there is force being deployed horizontally.
A. Yes.
Q. There is force being deployed vertically into the joint; yes?
A. Yes.
Q. There must, therefore, be a greater force that as a result of that action is deployed diagonally into the structure?

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A. Okay. So which part are you talking about? The pink part or the white part?
Q. In the pink part, where you have a circle with a blue arrow pointing to it, to the left.
A. Yes.
Q. Are you with me?
A. The problem is when we look at the white part, that is not -- well, in this case, in this argument, this is not the critical part. The critical part is the pink part above the diaphragm wall.
Now, there are other problems associated with the white part of the connection which we have discussed earlier.
Q. Yes, we have discussed that.
A. Yes.
Q. So you don't agree that subject to there being sufficient anchorage that goes into the D-wall, that the combination of those horizontal forces and those vertical forces, the creation then of the diagonal force into the joint, together with the T40 bars that we see along to the left-hand side of the pink area, all adequately --
A. No.
Q. -- will deal with the forces being deployed on that structure?

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A. The major --
Q. Sorry, is that no?
A. No.
Q. Or no subject to the calculations and/or experiments that you would like to have done?
A. Okay, yes, you are right. Now, but the problem is -- the problem is -- so if you are talking about the top part of that connection, especially just -- I think the top 1 metre or so, so the vertical reinforcing bars may not have sufficient anchorage. Again, checking.
Q. And again those checks are within the parameters of the simple checks --
A. Yes, simple checks.
Q. -- that you commend?
A. Yes.
Q. Then moving on to 6.4.3.6.
A. Yes.
Q. You say:
"... Atkins has not considered the stresses inside the slab-wall joint using the principles underpinning the design of common beam-column joints as described in section 6.8 of the Concrete Code on standard beam-column joints."
A. Right.
Q. Do you still have that view?

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A. Yes, still, of course.
Q. But I think you told us already, you told Prof Hansford this afternoon and you told Mr Pennicott I think this morning, that as far as the Concrete Code is concerned in these regards, it of course is -- in terms of beam-column joints -- of greater relevance in terms of those columns that we find in buildings rather than in large civil engineering projects?
A. Now, well --
Q. Do you recall that evidence?
A. Well, actually --
Q. Sorry, let's unpack it a little bit, Professor. Do you recall your evidence?
A. Can you say that again, please?
Q. Yes, of course. So you told Prof Hansford this afternoon and I think you told Mr Pennicott this morning --
A. Yes.
Q. -- that as far as the application of the Concrete Code is concerned, its relevance insofar as columns and the joints required within them is greater in relation to, shall we say, structures which are more slight in their nature than heavy diaphragm walls and slabs which are heavily reinforced in civil engineering projects?
A. Well, the slab and wall joint here behaves like

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a beam-column joint, although it is not the standard type of beam-column joint.
Q. The Concrete Code, section 6.8, is of very limited application in a situation such as we have here, where we have a structure, Professor, that is adequately reinforced to deal with all the forces being deployed upon it; correct?
A. Well, with certain qualification.
Q. Okay. Let us have your qualifications now, but I will take your affirmative answer.
A. Yes.
Q. Please can you help the Commissioners with your qualifications.
A. The beam-column joint section in the Concrete Code doesn't spell out all the fundamental principles, it just gives the equations for calculation of reinforcement. But unfortunately that equation may not apply to unusual cases like this. But the basic principles would be the same.
Q. So a criticism that is articulated by reference to not deploying the terms of section 6.8 of the Concrete Code is not really fair in these circumstances; do you agree?
A. Say that again, please.
Q. A criticism which you make by reference to the terms of a particular part of the Concrete Code is, in the

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circumstances that even you have just described, hardly fair; do you agree?
A. Well, the same principles should be applied, the same principles.
Q. Let us assume that the principles being deployed have taken full account of the fact that this is a heavily structured, heavily reinforced, heavy structure in itself, and for all the reasons covered by Atkins and for all the reasons covered by Prof McQuillan in his report, there is no significant risk of there being shear in the nature that you describe.
A. I don't agree.
Q. You do not agree with that --
A. We have to check.
Q. Thank you. Just to close on that, what I understand, from the dialogue that we had between the Commissioners and Mr Chow and yourself this morning, that the checks that you consider we ought to require, the simple checks, are going to be capable of being pulled together by you in a table and advised to this Commission so that we know what it is you say needs to be done and how long it should take and who is going to do it; am I right?
A. I can probably recommend a textbook and a certain section, so that people can follow.
COMMISSIONER HANSFORD: Actually, sorry, Prof Au, a textbook

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might be of interest, but I think we need somebody to do the calculations, because I don't think we can be relied on to follow the textbook properly.
A. Well, that is a fairly advanced one, but that was written by Park and Paulay who are experts.
MR CONNOR: I may not thank you for an advanced textbook on this, Prof Au, but I appreciate, Professor and Mr Chairman, that we are straying here into dialogue that perhaps counsel will have with you.
But perhaps if I can close the point in this way. If it be the case, Prof Au, that government agrees on a suggestion by the learned Commissioners that there should be produced a very clear list of the tests, the calculations, the numerical working-out that you say needed to be done, within the context of the simple checks, if that is to be produced, that we understand is something to which you will willingly contribute?
A. That is something that is extra. Of course, if time allows, I will be happy to do that.
Q. You mentioned Mannings in response to questions I think just before lunchtime.
A. Yes.
Q. Can you help the Commission with their brief and what they have looked at in relation to the calculations we have been looking at in the last couple of hours?

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A. Last couple of hours?
Q. I know it won't feel that way but this afternoon.
A. Well, I --
Q. Let me unpack it to help you.
A. Yes.
Q. You told the learned Commissioners that you haven't carried out any of these simple calculations yet, you haven't looked at coming up with the simple tests, but you think Mannings have; yes?
A. Well, Mannings actually did the work under the supervision of a colleague and me, yes.
Q. What was their brief?
A. I think you have to ask the Highways Department. That is to help in coming up with certain background calculations to help us understand more about the structure.
Q. Perhaps we should unpack it a little bit because I think you told the Commission earlier that your involvement as an expert and the preparation of your report really began in December.
A. Yes.
Q. When did the Mannings work take place?
A. Probably late November to December.
Now, the problem is, at the very beginning, it's very unclear, and then when I was sort of confirmed to

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be asked to appear over here, I think that was sometime in December, but then in the adviser capacity, I have also made suggestions.
Q. Let me deal with this briefly, because it may be it can be dealt with very briefly.
A. Okay.
Q. You talk about problems; let me share a problem with you.
A. Yes.
Q. The problem here is that you've told us that Mannings have carried out some calculations which might be relevant and might be similar to those which you have discussed with the Commissioners already -- you understand?
A. Yes.
Q. And you have hinted that the fact that maybe having carried those out, the results have not been terribly helpful. Do you remember?
A. Well, some of them, yes.
Q. Against that background, that is why I am asking you what is to be done under your direction, what have they applied in terms of codes or standards, and what have they found. But in fairness to you, if you can't help the Commissioners with this, then we can draw a line under it and move on, but if you have evidence, it's

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important, I think, that you clarify it.
A. They have done some work to countercheck the strength utilisation factors, but the problem is that they don't have all the background data, so they just work from the raw data, whatever. They also did some work on the joints, the connections, and then they did find some of the joints to be problematic.
So that's why we are of the view that it is better to carry out further checking. Now, what they have used are reasonable, but then whether they are really accurate, we are not 100 per cent sure.
Q. So, as I understand, your point is that they don't have the base data and if you want to come up with accurate results, you need to have that?
A. Yes.
Q. And that's the base data that Atkins will have?
A. Now --
Q. Sorry, that is the base data that comes from the designer?
A. Yes.
Q. So if we want to have the right answer, we had better get that data?
A. It would be better, but an experienced engineer will be able to come up with some typical parameters which are useful. Okay?

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Q. But you have nothing of detail in this regard to share with us this afternoon?
A. No. So that's why I am not saying that certain details are unacceptable, but just propose whatever parties to follow up with checking.
Q. And therefore, when we get to the end of your evidence, we can look forward to clarity as to what those checks should be?
A. Yes.
MR CONNOR: Thank you. Sir, Professor, I have no further questions at this stage. Thank you.
CHAIRMAN: Thank you.
MR SHIEH: A few questions from Leighton, if I may?
CHAIRMAN: Certainly.
Cross-examination by MR SHIEH
MR SHIEH: Professor, I represent Leighton. Let's talk about this question of the new construction joints --
A. Yes.
Q. -- under the latest design change, what we call change number 2, which you say may cause problems; all right?
A. Yes.
Q. Because, as I understand it, you accept that under what we call the second change, there are more rebars --
A. Yes.
Q. -- across. You say that's not necessarily better

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because you have to also consider potential problems caused by the new construction joint; correct?
A. Correct, yes.
Q. That, if I understand you correctly, is the horizontal joint --
A. Yes.
Q. -- between the concrete poured at the place where the D-wall was chipped off; correct?
A. Yes.
Q. That would be the horizontal joint?
A. Right. That's one of the cases, because there are some other, more complicated cases.
Q. Right. Before I go further, I know you are a very distinguished professor, accustomed to teaching very learned people, but I wish you to understand there is a public interest dimension in this hearing.
A. Yes.
Q. And you are not only addressing people who know what you are talking about.
A. Yes.
Q. So sometimes it may not be entirely helpful to address professors and doctors. In particular, you have to remember there are journalists outside who are not as learned as you are who may, some of them, genuinely want to understand what's going on and write something about

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it. You understand what I am saying?
A. Yes.
Q. Could I respectfully ask that when you give answers, try your very best -- I know it may be quite some time ago, but try your very best to imagine that you are speaking to an intelligent five-year-old.
I'm not going to look at detailed plans, but I'm looking at Tony Gee's report. Can I ask you to look at the expert bundle, tab 5, internal page 27.
A. Yes.
Q. The bottom diagram, that is an attempt to present schematically -- forget about dimensions, et cetera, but in a rough and ready way --
A. Yes.
Q. -- the situation before the second change; yes?
A. Yes.
Q. Now, the left-hand side, the burgundy part is the EWL slab?
A. Yes.
Q. The middle part, the blue part, is the D-wall, and the right-hand side, the green part, is the OTE; right?
A. Yes.
Q. Under the previous design, which was -- under the previous design, rebars would go through, forgive my layman-like language -- imagine the rebars coming in

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from the left, through the EWL, and get connected by couplers to the blue bit in the middle.
A. Right.
Q. And on the right-hand side of the blue bit, again, there will be couplers; right?
A. Yes.
Q. And then connected to the OTE on the right-hand side; correct?
A. Yes.
Q. If you look at this, you agree that on this depiction, it correctly shows two construction joints vertically?
A. Yes.
Q. Can you turn to the next page then.
A. Yes.
Q. This is a depiction of the change the -- of the situation after change number 2; right?
A. Yes.
Q. We have seen different attempts to present this change, but since Tony Gee, and in particular Mr Nick Southward is my expert so I'm using this diagram presented in his report; all right?
A. Yes.
Q. What I am going to ask you is this. Even though, as depicted, you can see the joint --
A. Yes.

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Q. -- the horizontal joint --
A. Right.
Q. -- meaning the horizontal line between the burgundy part on top and the blue part in the bottom --
A. Right.
Q. -- the final product, once concrete is poured, is one lump of concrete; do you accept that?
A. You mean including all the areas of different colours?
Q. Yes.
A. Yes.
Q. It's one lump of concrete.
A. It's one lump of concrete.
Q. One lump of concrete?
A. Yes.
Q. Of course there will be forces within that lump of concrete, but there's nothing special about that line, the notional line between the burgundy and the blue; is that correct? Do you accept that?
A. I think to someone outside the engineering profession, that may be the view, but then for -- well, engineers, then they have to look at what happens at the construction joints.
Q. Right, which is what I am now going to ask you to do, because I am not an engineer.
Explain to me and those in the room who are not

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trained in engineering how this structure is ever going to break because of what you call the shear force in that notional line between burgundy and blue. Forget about diagrams, forget about equation; just describe physically how it's going to break at the line.
A. You mean the horizontal line?
Q. Correct.
A. Well, if the shear strength is really insufficient and so much below the shear force applied there, then the upper part of the concrete is going to slide towards the left, and then the other thing is the part -- well, the down-stand part of the OTE whatever is going to perhaps fail in flexure. There will be bending failure, yes.
Q. You mean the burgundy part on the right-hand side --
A. Yes, could fail in flexure, depending on -- well, of course, one has to do checking.
Q. Thank you. But I'm sure academics thrive in asking questions, but if you look at the previous page, again, if you forget about the colouring --
A. Yes.
Q. -- if you forget about the colouring, it's one lump of concrete?
A. Yes.
Q. So for an outsider, for a layman, the shape of that lump of concrete, between this and the next page, is again,

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forgive my loose language, roughly similar?
A. Yes.
Q. So if there is a force, a very strong force, pulling the whole thing to the left, if it doesn't fail, if it doesn't result in the breakage of the structure at the bottom of page 27, a layman would be forgiven for thinking that it should not break for the structure over the next page; do you accept that?
A. I beg your pardon -- now, because engineers normally explore how a structure failed, and there are different failure mechanisms.
Q. Yes.
A. We need to look at a lot of different things, and for each of them there is a possible failure mode, and for combinations of them there would be another failure mode possible.
So, for this particular case, just looking at that -- now, that may not be the location of failure. The structure may be failing elsewhere. So it's hard to answer that question just picking that part of the structure.
Q. But this is the part of the structure that I think everyone is most interested in --
A. Yes.
Q. -- in relation to what we call the revised design; do

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you accept that?
A. Yes, indeed.
Q. So that is why I am asking. So what you are saying is if a force -- looking at the diagram at page 28, what you are saying is if you apply a strong enough force by pulling the burgundy part on the left, you pull that to the left --
A. Yes.
Q. -- it may be that the right-hand side part of the burgundy structure will bend or fail or crack; that is what you mean?
A. Actually, when you look at that, if you are really serious in exploring the possible failure modes -- so, actually, there are many possible failure modes. Failure along the horizontal construction joint (indicating diagram on page 28) is a possibility, and then perhaps some cracking over here (indicating) is another possibility. Some cracking over there is another possibility; okay? Some shear cracking over here is also a possible failure mode.
So we have to check all this to find out which one would be the failure mode to appear first. So all these are possibilities.
Q. You mentioned the first possibility, that is to say you pointed at that horizontal line on the left?

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A. Yes.
Q. That's got nothing to do with the vertical line. Can you hold up that sheet for me?
A. Yes.
Q. You first of all pointed at that vertical line on the left-hand side between the burgundy and the blue; is that right? Not the horizontal one but the vertical one.
A. This one?
Q. Yes, the vertical one. You say there may be failure there, it may --
A. A possibility? Yes.
Q. But that possibility has nothing to do with the horizontal new joint; correct?
A. Well, now, again, one has to --
Q. The problem is --
A. -- checking.
Q. I thought you were going to say "the problem is".
A. Yes, the problem is if -- now, when we look at -- if there is sliding over here, then there will be tearing, possible tearing, over here, and the force taken by this part could be bigger, could be.
Q. Thank you. But there is a line between burgundy and blue.
A. Yes.

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Q. Because we know that concrete was poured there. But after concrete is poured, that is one lump of concrete; do you accept that?
A. Yes.
Q. So there should not be any sliding because it is not two blocks of concrete, it is one piece of concrete; do you accept that?
A. I can tell you, in Hong Kong, there are many composite bridges. Island Eastern Corridor and I think Canal Road Flyover, they are composite bridges and they are constructed by precast beams together with in situ slab; okay? One lump of concrete. But we still need to check the horizontal shear stress. That is a must.
Q. Yes. But whether you need to as a matter of caution or as a matter of --
A. No, it is a requirement.
Q. I'm talking about structural safety.
A. Yes, it is related to structural safety too.
Q. But that is why I wanted to know how that horizontal line could contribute to failure.
A. Now, okay. So if this horizontal construction joint is very strong, indeed it acts as a whole piece, then there will be a certain distribution of internal forces. In case it is very weak and sliding starts to occur over there, then the internal forces will be different and

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certain parts may be overstressed, perhaps leading to some other modes of failure.
So there is no simple answer.
Q. Can I ask you how there could be sliding on this configuration, by coming back to a point put to you previously, because there was clamping on both sides by the burgundy part, so I am struggling to understand how there could be sliding.
A. Now, first of all, imagine the construction sequence. So when the contractor casts the EWL slab, after casting, the slab was still supported by the ground. So the concrete inside carried zero stress; okay? Well, virtually zero stress. Then people started to excavate and then the self-weight of the slab will begin to take place. This is going to extend -- this is going to extend that (indicating diagram on page 28), and this part is going to elongate. Depending on the strength against shear, then there may be something happening. If the strength is sufficient, then it can act as a whole piece. But if the strength is insufficient, then some horizontal shear cracks will start to appear. Then perhaps some parts will be overstressed.
Q. Physically how would that manifest itself along that line, a crack appearing in the middle on that notional on line.

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A. That normally will be accompanied by some other cracking. There can be some other cracking.

Actually, in the behaviour of reinforced concrete beams, very often there are cracks appearing just at the middle, shear crack. Engineers will understand that. Shear cracks normally would appear at the middle -- not the flexural cracks, the cracks caused by bending -- it would start from the bottom -- but shear cracks will be appearing at the centre of a beam. Say a beam like that (demonstrating with hands), normally the shear cracks will be closer to the supports.

So having a crack somewhere at the middle is nothing new. It's quite common actually. We actually see a lot of such cases in our laboratory.

Q. You are saying that there could be a crack --

A. Yes.

Q. -- caused by, you know, a bad joint, appearing where that horizontal line is now appearing?

A. Possible, yes.

Q. Only there, without -- Professor, let me just suggest to you again from a layman's point of view what I have in mind and see what you say about it.

A. Yes.

Q. After chipping off the top part of the D-wall, and after concrete is poured on top of -- you know the way the

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revised design is done?

A. Yes.

Q. Concrete is poured monolithically?

A. Yes.

Q. So the top of the EWL slab, the top of the D-wall, the top of the OTE poured at the same time and monolithically, so there's one lump of concrete up there?

A. Yes.

Q. Forming, again, a monolithic structure --

A. Yes.

Q. -- together with the D-wall down there?

A. Right.

Q. You can talk about forces going in (demonstrating with a sheet of paper), et cetera. If you apply strong enough force, the whole thing can collapse.

A. Yes.

Q. But what I suggest to you is that has nothing to do with the appearance of that notional joint line buried in there, in this diagram. Do you accept that?

A. No. This is something that we have to check. Now, so if you are interested in what happens if it is not strong enough -- now, there can be sliding crack over here (indicating diagram on page 28), that part may develop a crack. That part may also develop a crack.

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So that is possible.

Q. As I say, applying strong enough force, I'm sure cracks can appear everywhere, but I'm saying cracks or failures caused by the appearance of that notional line in the middle.

A. Yes.

Q. I'm suggesting that that by itself doesn't cause any failure.

A. Well, one has to check. Now, we are discussing that qualitatively. We need to quantify what is going to happen. So we have to do calculations.

Q. You see, but as I've told you when I started my questioning, for laymen and for the public to be able to visualise or understand why we are concerned about this, they have to be able to visualise how that added joint contributes to any failure, because there's no point saying if you apply a strong enough force the whole thing collapses. It may well do. But you can't blame it on that joint. Do you understand my point?

A. I understand your point.

Q. What you are saying is there is something about that joint in the revised design that is causative of something bad, and I want to explore with you to explain to laymen how qualitatively that would happen.

A. Okay. Let's say -- now I get a few sheets of paper.

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Now, you can imagine that -- so now we have a few sheets of paper. If I bend it, it's very easy, but if I put glue between them, it would be stiffer. We can imagine that.

If when I mentioned about the example of the composite bridges, precast beam and in situ slab, we have to make sure that the interface between them is strong enough. If it is not strong enough, they can slip. So you can see that it is weaker; it can deform a lot more. I think that would help people to understand the strength of construction joints. To explain that would be very difficult. I think for those interested, they had better do a degree.

CHAIRMAN: Can I ask this, assuming procedurally everything went in accordance with the Building Code, the Buildings Department was approached, and assuming that the through-bars are actually there and everything was done. Do you think that there would have been any reason for the Buildings Department to say no?

A. Possible. Now, I think certainly they would ask the competent person to demonstrate that there is no problem within the construction joint, there is no problem within the connection at other places. I think they probably would demand that.

CHAIRMAN: All right.

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MR SHIEH: Because doing the best I can, again, as a layman, if you pull the whole thing to the left --
A. Yes.
Q. -- and what you are saying is if that joint between the burgundy and the blue is not, let's say, glued properly and there is sliding, then it could somehow drag the right-hand side burgundy together with it --
A. Yes.
Q. -- and therefore all kinds of things can happen to the right-hand side burgundy?
A. Yes.
Q. Again forgive me. If the right-hand side burgundy is as thin as a hair-pin, then I can understand if you have a little bit of sliding then the vertical hair-plain will break. But if you, again using language of my learned friend for Atkins, take off a scholar's hat and put on a common-sense hat, looking at this depiction, is it really realistic to suggest that, oh, with the chunk of -- because basically you are saying that the OTE slab would crack?
A. Well, it is possible. If something happens, let's say if it fails at the construction joint, then there can be some other cracks. It is not surprising at all, if it occurs.
Q. We have had enough discussion about qualitative

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layman-like matters. I may revisit it tomorrow morning but can I just move on to another small topic.
I can see that it's 5.10. I know we started a little bit late but I am going to move on to the next topic so maybe it would be an opportune moment.
CHAIRMAN: Prof Hansford has a conference call at 5.30. I don't know how counsel feel. I'm more than happy to continue on to, say, 5.20. I don't know if that achieves anything for you, Mr Shieh.
MR SHIEH: Yes, I can finish probably the next topic, if not the one after next, and then maybe I'll call it a day and then see if I have anything else after the evening adjournment. If not, then maybe --
CHAIRMAN: Let's do that. Good. Thank you.
MR SHIEH: Can I ask you to look at your report, at paragraph 3.1.1.
A. Yes.
Q. Here, you deal with the codes.
A. Yes.
Q. You say:
"Whilst provision of flexural strength for hogging moment at the EWL slab adjacent to the connection between the EWL slab and the east diaphragm wall ... does not necessarily require bottom reinforcement, provision of bottom reinforcement is a mandatory

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requirement under the Code of Practice for Structural Use of Concrete ..."
Then you gave the reference to the code; do you see that?
A. Yes.
Q. H8/2818.
A. Yes.
Q. So can I ask you to look at H8/2818.
A. Yes.
Q. That's the first page of the Concrete Code.
A. Yes.
Q. If I ask you to look at 2821.
A. Yes.
Q. That's the foreword.
A. Yes.
Q. Look at the penultimate paragraph.
A. Yes.
Q. It says:
"Although this Code of Practice is not a statutory document, the compliance with the requirements of this Code of Practice is deemed to satisfy the relevant provisions of the Buildings Ordinance and related regulations."
Do you see that?
A. Yes.

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Q. First of all, I wish you to confirm that it is indeed your understanding that it is not a statutory document; correct?
A. Correct.
Q. So no statute actually says that Buildings Department or whatever department, Highways Department, can promulgate a code which must be complied with; it's not statutory?
A. Correct.
Q. It actually only has the status of a "deemed to satisfy" document, in the sense that if you do what the code requires you to do, then basically the government can't make life difficult for you, they can't reject, because you are deemed to have satisfied the requirements?
A. Right.
Q. Whatever requirements there are.
A. Right.
Q. So it is not mandatory in the sense that if you fail to comply with it, then you are forever and ever doomed because the government would then be able necessarily to say you failed, therefore you are rejected; do you accept that?
A. Let me explain. Now, yes, it's true that compliance with that code will be accepted by the Building Authority. It is also possible for the competent person or the registered structural engineer to come up with

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an alternative design which doesn't follow that, but then it is the responsibility of the competent person to demonstrate that it is not inferior to the requirements over here.

There are two possibilities. First, in respect of a certain requirement, it is exactly the same. Second, it exceeds it. And because of that, in a sense, it is mandatory, because it would very often be more costly, more time-consuming, to come up with an alternative design which doesn't comply with that but which can provide the same or even better performance.

Now, if we are talking about a very large project and a certain part of the structure is repetitive, many, many times, that may be worthwhile. So I think, in this sense, saying that the requirements here are mandatory is reasonable.

Q. "Mandatory" has one meaning. "Compulsory" must follow. But you are not in any way suggesting that the requirements must be followed?

A. Now, I understand that the requirements are set down over here. You can come up with alternatives which are not inferior to what is required here.

Q. Thank you. I think I know what you mean. I'm not going to get bogged down in the meaning of "mandatory". We can all form our own conclusions.

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My next point that I want to explore with you before we break for the day is the question about foundation.

A. Yes.

Q. Can I ask you to look at the page in Mr Southward's report, tab 5, at page 40, which you were asked to look at by Mr Chow when he examined you in-chief this morning. You remember you were asked questions about whether or not the D-wall amounted to foundation; do you remember that?

A. Yes.

Q. That discussion as to whether or not the D-wall amounted to part of the foundation takes place in a certain context?

A. Yes.

Q. Because obviously, if you simply look at the word "foundation", it can carry different shades of meaning, depending on context?

A. Right.

Q. You apply to university, there's a foundation course, but obviously we are not talking about that kind of foundation; right?

A. Yes.

Q. I don't think we need to actually bother you about why there is a need to touch upon the meaning of the word "foundation" for present purposes. It suffices to note

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that our discussion takes place within the context of the Foundation Code promulgated by the Buildings Department --

A. Right.

Q. -- which is in the middle of page 40 of the report.

A. Yes.

Q. "That part of a building, building works, structure or street in direct contact with and transmitting loads to the ground."

Do you see that?

A. Yes.

Q. Can you look at the diagram on the next page.

A. Yes.

Q. That describes, again pictorially, the way what we call the box will look; right?

A. Yes.

Q. You know what I mean by "the box"?

A. Yes.

Q. "The box" is that part enclosed by the burgundy?

A. Yes.

Q. That's the box. The top burgundy is EWL; the bottom burgundy is NSL.

A. Yes.

Q. Do you see that?

A. Yes.

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COMMISSIONER HANSFORD: I think it's magenta in mine, for the NSL.

MR SHIEH: The box, yes.

I will move on relatively quickly. The point I would put to you is that the foundation for the purpose of the definition of the code that we have looked at is the D-wall below the NSL slab, because it is that part of the D-wall which transmits load to the ground and which supports the box on top of it. Do you accept that suggestion?

A. If you are talking about the middle part, yes, but then the east and the west diaphragm walls I would consider them as foundation as well. They are also taking loading. They are transmitting the loading to the ground. They are in contact with, well, the ground, the soil. The east and west, yes, they are also part of the foundations.

Q. But there's a little bit of a conundrum I need you to help us. You know about hit and miss?

A. Yes.

Q. You know the hit and miss panels in this case?

A. Yes.

Q. So even within the D-wall, not all the panels are in direct contact with the bedrock or the soil?

A. I'm talking about the ground. I'm talking about soil.

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If you are talking about the hit panel, then it is sort of touch being the bedrock. The miss would not be touching. But at the back, it still in contact with soil.

The other thing is that what we assume in calculation may not be exactly the same as its behaviour; okay? So it's true that probably in calculation we assume all the loading to be taken by the hit panels. However, those miss panels may also take some loading because underneath there is still soil, although the loading carried by that may not be as big as those hit panels.

So I would consider all of them part of the foundation.

MR SHIEH: Would it be an appropriate moment to take the adjournment now?

CHAIRMAN: Yes, it would.

MR SHIEH: I would wish to reflect on whether I need to test Prof Au any further, but I have covered most if not all the topics I wish to explore with him.

CHAIRMAN: Good.

COMMISSIONER HANSFORD: Mr Chow is on his feet.

CHAIRMAN: Sorry, Mr Chow, I didn't see you behind Mr Shieh, the imposing figure of Mr Shieh there.

MR CHOW: Because he is much grander. I just want to flag

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up at this point that I understand Prof Au has some teaching commitments tomorrow afternoon. I don't anticipate that we will need to go into tomorrow afternoon, but I just think perhaps it is good for us to flag it up at this stage.

CHAIRMAN: All right. I'm sure, Professor, we will be able to let you go in good time to go back to your students.

WITNESS: Thank you.

CHAIRMAN: Could I mention one thing, and I omitted to mention it earlier for the luncheon adjournment. Even though you are an expert, you are giving evidence at the moment, and when you are giving evidence you are an island unto yourself; do you understand?

WITNESS: I understand.

CHAIRMAN: You are not allowed to discuss matters with other people. They can't come up to you and say, "Oi, what about this, what about that?"

WITNESS: I understand that.

CHAIRMAN: I thought you did but I forgot to mention it earlier.

We will adjourn until tomorrow morning at 10 am. Thank you.

(5.21 pm)

(The hearing adjourned until 10.00 am the following day)

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