Friday, 18 January 2019

(9.34 am)

DR MIKE GLOVER (on former oath)

Cross-examination by MR CONNOR (continued)

CHAIRMAN: Mr Connor, yes.

MR CONNOR: Good morning, sir. Good morning, Professor. Good morning, Dr Glover. I have only a few questions for you this morning, and they are really questions with regard to the reports that you have issued, against the background of the evidence that you provided to the Commission yesterday.

For reference and for the record, could we just have briefly on the screen your report ER/6. That is your report of January 2019. This is your report for the Commission.

A. Yes, I have it.

Q. Thank you very much. There's just a very quick dip into the report and I'll ask you some questions about it.

So this is your report, Dr Glover, and for the sake of completeness, you will see on page 2, at paragraph 2.4, you refer to two earlier reports which you prepared and which are in the bundles. They are referred to at paragraph 2.4(a) and (b), and that is a report that's part of the holistic study, and that report is dated 9 November 2018 -- for the record, that



is B19/B25114; and secondly, a report which is described as design spot-checks for diaphragm walls -- Plaxis analysis. That is also dated 2018 and is, again for the record, B20/B26004.

Do you see those references?

A. I do.

Q. Thank you. So I need not take you further on that page at this stage.

But one understands, I believe, from reading those reports, that is the November reports, Dr Glover, that substantially your position in relation to important issues such as the integrity of the structures under consideration by the Commission has not changed between November and January, that is November 2018 and January 2019; is that so?

A. I don't believe they have. I mean, if the words say otherwise, then they would be correct. But no, that's my view.

Q. That is my understanding and I just wished to confirm that with you.

I have two brief areas of interest just to raise with you.

I should just mention for completeness, if one takes your evidence, one would also want to include reference to your PowerPoint presentation yesterday.



A. Mm-hmm.

Q. Which is again for the record ER/6.1, in which you expand on a number of these points.

A. Yes.

Q. So if we take all of that evidence together, two areas I wish to ask you some questions about are firstly the EWL slab and secondly the NSL slab.

A. Yes.

Q. But the point is really quite brief I think for these purposes and it's more by way of confirmation of my understanding of your evidence and to ensure that that is shared with the Commission.

As far as the EWL slab is concerned, you conclude in very broad terms, if you forgive the breadth of my language, that utilisation in the EWL slab as far as design and, from what one can tell, construction is concerned, is modest?

A. Correct.

Q. That it is, again very generally, no less than 50 per cent across that part of the structure?

A. Sorry, I didn't want to misunderstand what you said. Could you just repeat the numbers you used?

Q. Yes. There is a range, I think, of percentages of utilisation, depending upon Arup calculations, Atkins calculations, and indeed those by others, but it is



generally found to be no less than 50 per cent?

A. No less, no, that's not correct.

Q. Not correct?

A. No. The general level, if you were to take sort of a norm, would be about -- would be less than 50, actually. But I say generally 50 with localised higher peaks.

So I don't think that matches your words.

Q. It doesn't, but having read your report again this morning, you correctly recall your own, so thank you for that.

A. Okay, thank you.

Q. You describe it as a robust design?

A. Mm-hmm.

Q. With a comfortable measure of redundancy?

A. Correct. I think I go on further to say, to make sure that people understand what that means: there's a reserve of strength.

Q. Indeed. And fundamentally that it is safe?

A. Absolutely.

Q. As far as the NSL slab is concerned, it's a similar picture, really, as far as your November report is concerned and indeed your January report, that again generally modest utilisation levels?

A. Yes, most certainly, probably lower than the EWL, but

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again you get peaks.
Q. And fundamentally, in your view, the more you have looked at, safe?
A. Correct.
Q. The road that has taken us to that point, which you helped us with yesterday, in terms of the initial assessment of the requirements of the project, those topics that I described yesterday of the complexity, the position of the project, taking account of temporary conditions, taking account of safety, of course, and taking account of programme, have taken us to a point where all of those points seem to have been addressed, and we have fundamentally safe structures in place?
A. Is that a question or --
Q. Yes.
A. Yes, I would agree with that.
Q. Now, in your report, in January, that is ER/6 which you have in front of you --
A. Yes.
Q. -- and also in your PowerPoint which you spoke to yesterday in front of the Commission, you do go into the areas of the decisions that were made around design that has led us to the conclusions we just led, and you do touch upon certain issues as to engineering judgment?
A. Correct.

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Q. And you do that in section 5 of your report, and indeed -- and that particularly with regard to the EWL slab -- and yesterday --
CHAIRMAN: I'm sorry, Mr Connor -- I'm just wondering -- I think I may have fallen behind the race somewhere, because I have never understood it to be suggested that the fundamental design was at fault. I've understood there to be concerns with the couplers. I've understood there to be concerns with the work that was done while in progress to cut down that portion of the diaphragm wall and put in through-bars. Refresh my memory: where is it said that Atkins' design fundamentally was at fault?
MR CONNOR: It is not. You are absolutely right, sir.
CHAIRMAN: Okay.
MR CONNOR: What is touched upon -- and it is, in fairness, only touched upon -- in the report which was prepared for the Commission's purposes by Dr Glover, and that is section 5, if you would have regard to that for context --
A. Yes.
MR CONNOR: -- is a question and an observation that he makes in relation to the exercise of engineering judgment, and not to question that the product is safe, but to question whether or not, as we touched upon

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yesterday, there has been, in the preparation of that design, over-observance of the Codes of Practice, for example.
I understand where you are coming from, sir. This is a brief point. It does not, I think, impact upon the issue that will necessarily concern you, but it is a point on which it is important that there is a level of clarity provided to what Dr Glover intends by that comment, and if I can have --
CHAIRMAN: I may be wrong, and we will hear from Dr Glover very shortly, I'm sure, but I have never understood what he has said in any way whatsoever to be a criticism that the design should have been different. It was merely aspirational in the sense that Dr Glover, in his career, has looked to research cutting-edge design and the like, but he appreciates there is a different regime in Hong Kong which may constrain people like Atkins in the design of this kind to be what he considers perhaps, with his great experience, to be very conservative. That's not a criticism, that's merely a statement.
But that conservatism is prudent. That seems to be what he underlines his remarks with. Am I wrong there?
A. I think you have encapsulated it very well, actually, and I would say prudence is certainly the word to apply to the design.

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CHAIRMAN: I am only saying that in case there's a misunderstanding. I have never understood it, therefore, that he's trying to undermine the issue of design.
MR CONNOR: Therefore, Mr Chairman put your finger entirely on the point that has interested me. Dr Glover has very helpfully, yesterday and now today, confirmed that view, and really where I was going to was a question very much along your lines, and it was singularly that.
The comments and observations that, Dr Glover, you have made within your report of January, and indeed your PowerPoint yesterday, are all to be looked at in the context that the Chairman has just helpfully described, and your observations.
A. I would agree with that.
MR CONNOR: Thank you. With that, sir, that is helpful, and helpfully closes the area of interest for me and I have no further --
CHAIRMAN: In fact, may I just add to this: Prof Hansford has just pointed to me the word or the phrase "substantially over-provided", the EWL slab. As circumstances now present themselves, that is an assurance, actually. It may not have been at the design stage, if you're having to pay for it, but at this stage it really is a comfort.

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COMMISSIONER HANSFORD: This, for the record, is the first sentence of Dr Glover's 5.8.
MR CONNOR: Absolutely, and that point is well taken and well understood and you are absolutely right in your assessment that that is an assurance, sir, and if it is allied with the assurance that that is the product of a properly directed design in the context of Hong Kong and its approval regime, then I'm very happy to leave it there.
CHAIRMAN: Good. Thank you.
MR CONNOR: Thank you, sir. Thank you, Professor. And thank you, Doctor.

Cross-examination by MR TO

MR TO: Chairman and Commissioner, I have taken instructions from Prof Albert Yeung.
Good morning, Dr Glover.
A. Good morning.
Q. My name is Christopher To, I represent China Technology. I just have a few questions to ask you, that's all.
The first question I want to ask you is, in terms of research, you did mention, you did elaborate in terms of your illustrious career in terms of this area. In terms of postgraduate training, have you had any postgraduate training whatsoever in research?
A. Forgive me, I don't understand why you are asking the

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question.
Q. I'm asking the question because you did mention in the presentation yesterday about research.
A. Yes, but the research I do is related to the projects I do. I don't have to go to a university to do that. I really don't know what the question is for.
Q. No problem. Do you have any postgraduate qualifications in research?
A. No. I don't have any postgraduate --
Q. That's all for me.
Yesterday, Dr Glover, you mentioned, for example, the mechanical engineering applications in terms of bolts.
CHAIRMAN: Sorry, I don't mean this badly and I don't want to be combative, but by way of a hypothesis, that's a little bit like, is it not, when a general returns from a war which he has won very successfully, with minimal casualties, to then be questioned as to whether he actually went to Sandhurst.
MR TO: I apologise for asking that question but I've been instructed to ask it. I hope you understand.
CHAIRMAN: All right. Yes.
MR TO: My next question is to do with the mechanical engineering application. You mentioned yesterday about the bolts; do you remember that?

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A. Yes.
Q. The functions of couplers in connecting steel reinforced bars are totally different from connecting a bolt; do you agree with that?
A. No, I don't agree with that, because what I was talking about is threads and not necessarily nuts and bolts. I was using nuts and bolts as an analogy. The technology of threads is pretty universal, in fact very universal. It's all a function of the pitch of the thread -- I mean, you get -- width you get unified, and they are all for different purposes.
But the basic design of threads is well understood and they are not just singularly to do with a nut and a bolt. And indeed, if you look at the whole range of screwed connections and fixings, they all have the same basic physics. They just look different and have different applications.
So I don't see them as being different. Screwed threads are screwed threads.
Q. Thank you for that. Do you agree with me, for example, that the engagement length between a bolt and a nut is always the length of a nut, regardless of how many threads are on the bolt?
A. If you take nuts and bolts, purely, as you say, and if you look up a product, a listing of the dimensions of

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one thing and another, traditionally the diameter of the bolt is the same as the depth of the nut, and traditionally that has always been the case. Does that answer your question?
Q. That answers my question.
A. Good.
Q. The next question I want to ask you, Dr Glover -- remember you talked about hypothesis.
A. I probably did, yes.
Q. Before going into sort of a testing and research programme. Do you think it's important to have a hypothesis before you actually go into the testing and research area?
A. I think I explained -- I will repeat what I believe I said and you can challenge it. I said if you are embarking upon something, you start with a hypothesis, an idea that something is going to work. So the first thing you do is you think about that issue, and in engineering you generally do a few calculations to see whether it stands up. If it still is robust enough, you actually do a mock-up, if it's a physical thing, or if it's something you are trying to test for strength, you do an embryonic test, not really too refined but you think about it and you set it up and you see if it still works.

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If you've passed those hurdles, which is hypothesis, calculations, mock-up, prototype, you then move on to a formalised procedure whereby you can, in my terms, bring a full stop to the issue. It either works or it doesn't. And really the latter stage, you don't embark upon the more formal testing programme until you are pretty clear that you've got a hypothesis, you've got calculations and you've got a rough and ready understanding. I think in this case, when it comes to levels of engagement, if you look at the number of things that individuals have done collectively or singularly, it comes to a pretty convincing story, worth testing in terms of the formality of the research programme or closing it out with tests.

Q. Yes. The reason I'm asking that question, Dr Glover, is because there were five tests done.

A. Yes, but they would constitute -- you are referring to the BOSA test; yes?

Q. Yes.

A. But they come under my category of, "We've got a good idea, let's pull something apart, let's see whether it really does work." That I would not consider to be the full stop and never have.

Q. I understand. And yesterday you mentioned about nine samples, so you talk about from five to nine samples.

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Where do you get your hypothesis in terms of nine samples? Why not 18 or 20 samples?

A. I'm glad you asked that question. I thought I did deal with it yesterday but just in case I didn't.

Nine samples in production engineering is the standard sampling technique from a batch, whether the batch is 500 or 1,000 or 2,000.

CHAIRMAN: You did say that yesterday.

A. Yes. Nine is the number that you use. I think in this case it's potentially overkill but believe me I want to see this finished. So that's nine samples, but that's nine samples of each engagement, not nine samples. So the details actually of the level of engagement that we will test, obviously that has to be fully confirmed, but most certainly it will be 60 per cent and most certainly it will be 100 per cent, and it will be nine samples of each, and we can see the trend line. As far as I'm concerned, that would be a full stop, and I will emphasise again that testing programme should not and will not, in my terms, include any cyclic loading because it's irrelevant to the case. But you will get nine samples of each of the engagements.

MR TO: I will come back to cyclic loading in a few minutes.

A. I thought you might. That's why I thought I would pre-empt it.

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Q. In terms of, for example -- you talked about the floating force acting at the bottom of --

A. I'm sorry --

Q. The floating force acting at the bottom of the NSL slab is approximately 150 kilopascals for 15 metres of underground --

A. I see,yes. 15 metres of water for other people, yes.

Q. And the self-weight of the NSL slab is approximately 48 kilopascals?

A. Yes, I'd agree with that.

Q. Do you still agree that the bottom of the NSL slab is still under permanent compression?

A. No, I didn't say that. What I said is quite the opposite. I said at the support the bottom of the NSL would be in tension and in the middle of the span, I agree with you, that would be in compression. But where it connects into the diaphragm wall, where everybody is concerned, or I thought you were concerned, that's in tension and that's where the couplers are.

So how am I going to answer your question? Am I concerned? No, because you missed something else. And I do apologise, because you are reporting on behalf of someone else who wasn't here. I explained yesterday that the NSL slab, as you say, it doesn't equal the weight -- it doesn't counteract the hydrostatic uplift

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on its own. It has three support lines to hold it, to make sure that it is resisting it. You've got the two diaphragm walls, you've got the columns or walls between the EWL slab and the NSL slab. So as the slab tries to push up, it pushes against the greater weight of the EWL slab. And you've also got isolated barrettes sitting under the slab. So the NSL slab is supported very, very effectively.

And so it's not just the slab itself in terms of its deadweight that's holding it down, it's also mobilising the very considerable weight of the EWL slab above. Does that help?

Q. That helps. It moves on to a point I'm talking about box structures.

A. Yes.

Q. Box structures, you mentioned yesterday, survive very heavy ground movements?

A. I'm sorry, I didn't catch that.

Q. Box structures can survive very, very heavy ground movements?

A. Yes, "strong ground motion" I think I used.

Q. If you look very carefully, for example, the box structure is connected to two D-walls at the end, and barrettes, as you mentioned, at the middle. It is not only a box buried in the ground. When the box moves in

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the ground, what are the effects of the box movements on the connections between the box, the D-wall and the barrettes, do you think from your analogy yesterday?
A. Well, the ground moves as a mass, so it's not, you know -- it's not -- it doesn't move differentially between one point and another unless you've got faulting, and Hong Kong is not going to have faulting, particularly in these materials. So the whole thing moves as one and that's why you've got connections between elements. So I really don't understand what the question is about because it's a monolithic whole, isn't it, so why is one part going to move differently from another? They are connected to each other.
Q. Maybe I'll elaborate further. Yesterday Mr Southward mentioned about it was a superstructure.
A. I don't want to get into this argument, I'm sorry. As far as I'm concerned -- I will confuse it even further. In my language, there's a superstructure, a substructure and a foundation. How does that go? Does that help you?
Q. It does help me, but I just want to ask you this question: should a superstructure be above the ground?
A. In my classification, I would say substructure must be sub, below the ground. Yes, I --
Q. So the superstructure --

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A. I see three divisions, basically. You've got superstructure, let's not use "substructure" for a moment, let's say basement, and then you've got foundations that are holding it all up. So which one are you interested in?
Q. I'm referring to the superstructure, the one above the ground.
A. I think that's pretty clear, superstructure.
Q. So basically you have a different take in terms of Mr Southward in terms of the structure?
A. No, I said I wasn't going to get into that, because I've told you how I see the description. My description is what I would call engineering observation. It's not tied into codes or any definitions. I'm just -- I'm sorry if I'm not being helpful here. I'm not trying to be evasive or whatever. I really don't understand what it is you want me to answer.
Q. No problem. I'll move on to when you talked about compliance with codes.
Remember yesterday -- I won't take you to the transcript because I'll just read it out to you so you understand. It's on page 95. It says:
"... fitness-for-purpose basis. I'm not seeking to demonstrate compliance. I'm just trying to demonstrate safety, on the basis of fundamental physics and

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experience."
Do you remember saying that?
A. Yes, I'm sure I did. It sounds right.
Q. You mentioned yesterday about flag on the hill.
A. Yes.
Q. We started off with original design, in terms of this project, then subsequently it was changed. You mentioned about, for example, we do have to actually expect the unexpected, and you don't need to follow codes.
A. No, I didn't say that. I didn't say you don't have to follow codes. What I said is you have to challenge codes, you have to see if they are appropriate and act accordingly. I didn't say -- you know, that's --
Q. I apologise for that.
A. Thank you.
Q. So you said you want to challenge codes, that's what you said?
A. Yes, I want to challenge them, if they're not correct or if they're not -- more often than not, the code is not incorrect, it's just inappropriate for the application.
Q. So in terms of this project, were there any challenges towards the code?
A. I wasn't there at the outset, but I believe the code has been complied with or attempts have been made to -- so

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I can't really answer your question because it would require me to have been there at the outset, because someone can challenge something but if that challenge is not taken up, then history -- it will be lost to history, and as far as the history is concerned, what has been built has been built, and I wasn't there at the outset, so I can't help you there.
Q. But you are saying, for example, Dr Glover, that we should follow codes?
A. I think you should -- yes, you've got to follow codes, but to the extent that they exist. But if they are clearly not appropriate for the application, then it's very important as an engineer that you bring attention to that. You do have the option of just following through, and this is why I used the word "unquestioning application of the codes", because I understand that sometimes in life, time is of the essence and you are just going to miss all the other deadlines if you continue to debate the issue, whereas if you go for the safe, safe solution which is compliance, everybody is happy, except the economy loses a bit.
Q. I understand. Now, do you agree with me that codes are important in terms of standardisation, consistency and predictability?
A. That's a very interesting question. I'm afraid I'm

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going to give you a bit of a long answer. Potentially you didn't expect this one.

My generation wrote the codes. We started writing those codes from a very, very low base of technical knowledge. We used documents which were very much guidelines, very open to interpretation. And because we were very clever, people of my generation thought we'll put that cleverness into codes, and gradually the codes became more and more definitive.

So I'm apologising, really, because the more that those codes have become definitive and restrictive, the more -- when computers came along and equations could be computerised, the sophistication of those equations became such that you could no longer use them sensibly unless they were in computer programs.

So now we have reached the situation where the codes that I knew as a boy, because 50 years is a long time, have grown from guidelines into -- words have been used around here of mandatory design manuals. Worse than that, with accompanying computer suites which you can't really do the design unless you've got them. As a result, what has been lost is some of the judgment that I have talked about in the past, just yesterday -- well, it seems like the past -- yesterday and a little bit today.

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So that's why I say I didn't think you expected that. So the codes are the codes now. In the forewords, they still use the word "guidelines", but the way they are applied, they are no longer guidelines. That is very, very regrettable, and I'm almost apologising to myself and my generation for being so damned clever.

Q. Thank you, Dr Glover. In terms of, for example, earthquake, you mentioned yesterday California and Japan.

A. Mm-hmm.

Q. Can I just ask you whether that is speculative in terms of what you are saying, or do you have concrete data to back you up, in terms of Japan is much more severe than California?

A. I didn't include this on my CV but for many years I chaired the Arup committee on seismic engineering, so I know a little bit about seismic engineering, and California is less seismic than Japan.

Q. Okay. Now, in terms of seismicity in terms of earthquakes, do you think in Hong Kong we should design codes to cater for it?

A. It's like a lot of things in life. Once the genie is out of the bottle, you can't put it back again. Technically, every part of the earth is seismic, even

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the United Kingdom, and indeed we have guidelines for seismic design for particular strategic installations, like nuclear power stations, for example.

So yes, it's right that every part of the world has a degree of seismicity, and various studies have been carried out and I think you'll find the initial studies carried out on the seismicity of Hong Kong were indeed Arup's, and Jack Pappin, who is the author of that document, is a personal friend and I did look at what he produced, and I did say at the time that I thought he was taking the upper end of certain parts of the parameters, but that's his judgment and he judged it to be a bit higher than I would have done, but other authors have come along subsequently and supported those general views. I'm a seismologist so I wouldn't cast any more judgment on that, other than, yes, a level of seismicity has been assigned to Hong Kong on the basis of looking at various models, looking at past events, and coming to a view.

But it certainly isn't anywhere near the high levels of seismicity that you get south of here, for example.

COMMISSIONER HANSFORD: Towards Indonesia.

MR TO: Then we'll come to my cyclic testing. You remember, I was going to --

A. Okay, good.

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Q. The issue about cyclic testing is important, because it talks about for example earthquakes, in terms of tremors, and so on, and the MTR design manual does have provision for it?

A. Do you want me to answer that? Is that a question?

Q. You can answer it if you want.

A. Yes, it has provision, but it's -- I think I said this yesterday and I've said it in my report -- a nominal allowance, and I think a prudent one. Don't misunderstand me. I think it's right.

I could be wrong but I think there's always been a standard number in the Hong Kong bridge code for a lateral load, and that was always to take account of a nominal load. No, I think it's a prudent measure. I'm not doubting that. It's a strong ground motion which is not appropriate.

Q. So you are saying it's a prudent measure to adopt some kind of code relating to this kind of situation?

A. Yes. And for your very tall buildings, for example, here, if they are a beam and column frame, then I think most certainly you should be thinking about that detailing. But interestingly enough you should be thinking about that detailing for your wind anyway. Wind will always trump earthquakes in Hong Kong. It's an interesting -- I mean, the trouble is -- it's like

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a travelogue through life, isn't it? -- I can remember when I was designing the Hongkong Bank, Swiss Re were going to insure the building so we got this memo or telex I think it was in those days asking us how the building would perform in the event of a tsunami. I think my response was "no worse than any other building in Hong Kong". But the fact is that, the risk fact that Swiss Re have, and they still have it, is that tsunamis are a risk for Hong Kong.

Please, I'm not being facetious. In Hong Kong, earthquakes are more prevalent than tsunamis. But I'm just trying to give an example that once the genie is out of the bottle, then you've got to ask the question, like the question that's being asked of this building, is it safe, and everybody trembles; is it teetering on the brink? Well, it isn't.

Q. You are talking about in terms of liberal approach, we should have some kind of parameters to cater in the code?

A. For seismicity?

Q. Yes.

A. That's for others to judge. You've already got -- someone has already put the provisions in there anyway, which I find a little bit insidious, but that's by the way.

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Q. Can I move on? You mentioned yesterday about movement, remember about that, in terms of not getting bending movements?

A. I'm sorry, within what context?

Q. Within the context, for example, of the structure, the box area I'm talking about.

A. Yes. Not large movements -- do you mean large ground movements?

Q. Yes.

A. No, yes. Don't forget large ground movements means a differential movement between one part and another, like a large wave coming through the soil and the top and the bottom not being -- if there was a very large difference in strata somewhere, and I'm not talking about here but say California, then you would be thinking seriously in a box structure of some provision. But they have performed remarkably well.

Q. I think you are familiar with the Hong Kong construction environment, are you, Dr Glover?

A. I think that's a leading question. Could I ask you why you are asking that one in particular?

Q. The reason I'm asking this -- maybe I'll ask you the question instead.

A. Okay.

Q. Or even a statement, I'll just make it out and see

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whether you agree with me or not.

Many foundation contractors in Hong Kong assume the pile cap to be rigid; do you agree or disagree?

A. In what context being rigid?

Q. In a design.

A. Sorry, when you say "rigid", you mean it's a solid block?

Q. Yes.

A. But it can still move, can't it?

Q. Yes.

A. Yes, I mean, it's a block of concrete. Obviously if it's only 300 millimetres deep, I wouldn't think that would be -- but we're talking a substantial piece of concrete, are we?

Q. Yes.

A. A couple of metres. Okay.

Q. And there are bending movements; don't you agree?

A. What, within that solid block?

Q. Yes.

A. No. It's interesting, the discussion a few days ago about strut-and-tie, in other words you get principal -- big compressions and big tensions. Basically, that's how we -- not traditionally -- that's how we design large pile caps, by a strut-and-tie method.

Q. So the pile caps have to be heavily reinforced?

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A. Well, they are heavily reinforced as a consequence of the design. They don't ask to be reinforced. You know, we carry out a design and we put the reinforcement where it's required.

Q. So the reinforcement is actually to prevent movement, isn't it?

A. No, no, no. No, no, no. The reinforcement is actually to resist forces.

Q. To resist forces in terms of bending moments?

A. Well, if it's a strut-and-tie, it's to resist direct forces. But the reinforcement is there to resist tensions.

Q. Tensions. Thank you.

Yesterday you mentioned about, for example, cracks; remember? You talked about shrinkage cracks and cracks caused by loading?

A. I said cracking come about from various reasons.

Q. Are they the same, shrinkage cracks and loading cracks?

A. No, they are caused by different things. Shrinkage occurs quite early on in the life of a structure, in fact in the first days and then through to the first month. It depends on the levels of constraint, because if you have a block of concrete and you put it on the desk, and it's not restrained, then you don't get any shrinkage cracks. So shrinkage cracks are a function of

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how much you hold the edge of the blocks.
So concrete shrinks. If it's restrained, you get cracking. I think that's a better way of stressing it.
Q. So in terms of crack implications -- and that's what I'm talking about in terms of the different types of crack -- the integrity of the structure will be different?
A. No. No, no. Interestingly enough, the whole principle of reinforced concrete is that the concrete cracks to -- sorry, how can I best express this? I apologise, let me think of how I can best explain this.
You have a reinforcement bar, and I think everyone knows what one of those looks like, and it's got ribs on it. The way the stress is transferred from the concrete to the steel is by bond, you know, and when we use to use just straight mild steel, which didn't have ribs on it, that process was essentially sort of almost like a chemical bond. I'm using "chemically" as a sort of incorrect term here.
COMMISSIONER HANSFORD: You mean like a glue?
A. Like a glue. It sort of just held on to it. In reality, there was a sort of friction there. But clearly, once that bond went, it really slipped, it went. So that's when you started to get the ribbed bars.

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The thing with a ribbed bar, just like a bolt, it has to take up a little bit of strain, so, as the beam bends, the concrete actually has to micro-crack to allow the bond of the ribs to take place. So concrete cracks, and it cracks naturally in reinforced concrete, but not to a huge extent, and the reason that one looks for those ribs to be mobilised is you get a crack pattern, not micro-cracks because you can probably see them with your eye but they are not large cracks.
But that's the way reinforced concrete works. I know that might be "shock horror" to people, but reinforced concrete is associated with a degree of cracking for it to work.
Q. Thank you, Dr Glover. You talked about the structures and cracking yesterday. I'm just going to elaborate further.
Do you agree with me that the structure will fail at the weakest point?
A. I think that's -- it would be illogical for me to say otherwise, wouldn't it? You would have to define what the weakest point was.
Q. So you agree with me if there's a weakest point in the structure, it might collapse?
A. No, it wouldn't necessarily collapse, but if there's a weak point in the structure, something might happen,

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it might sort of -- .
Q. The structure might fail?
A. I don't know what you're going to ask next.
Q. Following on from that, if all the failed couplers concentrate on one location --
A. Oh, yes.
Q. Not what we assume in terms of uniform distribution, do you think so this is dangerous or not dangerous?
A. I think the hypothesis you put forward -- I think you've really got to think about what you're asking, you know, how sensible or logical that question was, you know, in the light of everyday life and what we've observed in the opening-ups.
I think the likelihood of that happening is extremely remote, and even then the structure has got a huge degree of ability to spread the load elsewhere. Reinforced concrete has a wonderful property in the sense that it creeps, so if it finds a piece of weakness, it can actually span around it. So if you have a connection between a slab and a wall, like that (demonstrating with hands), coming into each other -- sorry, the other way around -- and you assume that there was uniformly supported along the whole length, and then something nasty happened at a certain portion of that, then what happens is the load goes around it, because it

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can't go there, it doesn't go there, it goes to the areas of concrete, reinforced concrete, on either side.
And because of the load factors that we use in our design and the factors of safety on materials, particularly the steel as I've shown you the stress-strain curves, this structure's got plenty of ability to bridge around different situations like that.
Q. So, from your opinion, even the weakest point, the structure will be still intact?
A. Look, I'm not prevaricating to avoid answering your question. I'm trying to help you to put the question into context, because the way you've said it, it could be the whole length of the wall, but that's not going to happen, is it? So I think I've got to couch -- I've got to give you the question you wanted to ask me and then I'll give you the answer to it. Does that help?
Q. Why not?
A. I think the question you wanted to ask me is there is a possibility of there being a concentration of mal-performing components in the structure, and what is my belief: could the structure handle such an issue? That's your question, and my answer to that would be: yes, the reinforced concrete nature of the structure that we're using has the ability to actually span around such anomalies.

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Do I believe those anomalies will exist in this structure? No.
Q. Thank you very much. Yesterday, I think you were in the room when, for example, Mr Southward was shown a diagram, or you were shown a diagram yesterday, in terms of, for example, the colours in the bars and all that, there was blue in colour; do you remember that?
A. Yes, I remember that.
Q. In the diagram, there was lapping, not a through-bar, there was lapping.
A. I don't think there was on the diagram. I'll stand to be corrected.
Q. On the photo there was lapping.
A. On the photo. You said on the diagram. On the photo? Yes. Sorry, yes, go on.
Q. So even with lapping, do you still believe, for example, with a concentration of the failures in a certain area, you still believe that the structure is safe?
A. Most certainly, yes. The lapping, interestingly enough, if those bars, the ones that you are asking me to say they've all failed, they were going to lap on to another bar, that's all. If they are not there, those bars don't work either. And the answer to the question is no, it bridges around.
Q. Yesterday, Mr Chow mentioned to you about these

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opening-up; do you remember?
A. Oh, yes.
Q. I think he gave you some figures. I actually did some calculations, that was yesterday, in terms of data. I think, for example, of the 80 tested, in terms of if it doesn't meet 40, there's 47, that comes to roughly 58 per cent. If it's 37, in terms of what we talk about minimum embedment and what is required, there are 36 out of 80, so it comes to 45.
So my question to you -- you mentioned yesterday there's no point in opening-up further, there's predictability, consistency, we know the data. But how can you tell the public out there --
A. It's quite straightforward. Is that your question?
Q. I'm not finished yet. How can you tell the public out there, for example -- how can you tell the public out there, "Don't worry about it, we've got the data, we know there are going to be more but don't worry about it, we think we have enough data now to do the testing and we think the structure is safe." How can you alleviate them and tell them: don't open up?
My second point is if the data came back and it was consistent there were no problem with the couplers, wouldn't that send a better message?
A. Okay. Is that two parts of the question?

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Q. That's two parts of the question.
A. But that is the question?
Q. Yes.
A. You and I are discussing two different things. You are discussing something I would call compliance with a manufacturer's catalogue, which is in dispute, by the way, in terms of what the interpretation of that is. So you're talking about compliance. I'm talking about safety. I've made it very clear from the outset that I'm not reviewing the structure within the context of let's call it compliance. I'm viewing it from a fitness-for-purpose basis.
So if I'm viewing it from a fitness-for-purpose basis, then I'm looking at a sensible figure to assign to a coupler strength to come to a view whether it's strong or not.
And so therefore your numbers of -- whatever they might be -- 44, 40, 37, they are not that number. We will demonstrate that a lower number, a level of engagement, which satisfies the strength requirement of the bar -- because don't forget it's a high hurdle to jump, to get to the 650 megapascals when the structure is only actually operating at something like 10 per cent of that number. But that's what we will do.
So in terms of a strength demonstration, that's what

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the research programme would be in terms of the testing. With that assurance, then the public I think will understand, particularly when we relate the level of stress that we have in the structure in comparison to the level of ultimate strength that it has. And I emphasise again the stresses in the structure as it's operating are probably around about 10 per cent of that figure, and I think the public at large would understand that ratio, between the capacity that's there and the level at which it's working.
Now to answer your other question, I think the first one really, which is to do with confidence in the statistics. When I use the word, and I don't think I did use it but if I had used it, "consistency", I'm not talking about consistency in the sense that you get the same number every time you look at something. I'm saying there's a consistent family, in other words there's a variation in that family, and I'm saying if you do even more tests, you will find that they fit within that family. In other words, the distribution that you're looking at now will not change radically.
I think I said yesterday: let's assume that you are finding, in my terms, a rate that doesn't pass my test of about 10 per cent. If you continue the research programme, that might vary in extremis to 8 or 12. But

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the difference between -- and I do apologise if the difference between 8 and 10 per cent means a lot to people in the public, but I don't think it does; I think they understand these are quite small variations -- then what's what I say. You have 80 samples now. Probably as we sit here today, there will be more, but I'm saying we should bring it to a conclusion, a sensible conclusion.

As I said yesterday, I think statisticians -- I'm not a statistician, I just use statistics -- a statistician's view, a government view, is obviously going to trump my individual views, but I'm just telling you what I believe, and that is you will not get very much variation from here on in; you'll get more of the same. You'll get some at 36, you'll get others at 45. You know, you'll get that sort of thing going on.

I hope I've answered your question. I know it took a bit of time to get to it. But "consistency" is a very bad word to use.

Q. In terms of what you just said, Dr Glover, whether for example the data will come up the same or different and all that -- at the end of the day, without doubt, there are problems with the couplers; don't you agree?

A. No. I've got to pull you back there. I've never said there are problems with the couplers. Quite the

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opposite. I've said there's variations in the workmanship that you're seeing there, and I don't think -- I think I also said, to the best of my knowledge and belief, I've not -- the work has not been done maliciously. I mean, why would someone take a bar, screw it in by 6 millimetres -- I think that's one of what I call a rogue figure -- and leave the rest sticking out, if they really meant to deceive? It doesn't make sense.

Q. Actually, it doesn't make sense to me as well, but we do see photographs of it happening.

A. But that means the workman wasn't trying to -- all right, let's assume this workman is a rogue workman or operative. He sees he can't get it in, so he takes it out -- he's not going to leave this (demonstrating) sticking out because that means he's done it incorrectly. No, he will get his saw out and cut the end off and it will look all right then. But he didn't. He took the bar and did the best he could.

Q. Maybe you're not aware, Dr Glover, we do have photographs of people actually physically cutting the bar.

A. Yes, and interestingly enough I wouldn't be surprised that there are photographs that show that. There are many reasons why you have a saw on site to cut

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reinforcement. Not all the reinforcement is threaded, by the way, as you are well aware. In fact it's quite the oddity. So I'm not surprised to see a saw on site, but I'm not saying -- I'm not giving a judgment on whether there was malpractice or not. I'm just giving you an engineering view of what I've seen and what the numbers mean to me.

Q. I understand. Now, I'm not going to take you to the BOSA letter of 10 January, but it did say, for example, that we -- I will just read it out, in paragraph 1. It says on page 3:

"We also understand MTRC has conducted various similar tests."

And yesterday Mr Boulding did clarify that, for example, those tests were not done by MTR.

A. Yes, that's correct. I was under a misapprehension.

Q. Okay. Then maybe there's some mistake in terms of BOSA's letter.

A. I'm sorry, I don't --

Q. I'm just saying.

A. Okay.

Q. In terms of testing of the couplers, you mentioned there were going to be nine more samples; you mentioned that?

A. Mm-hmm.

Q. Do you have details in terms of the hypothesis, the

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testing method, the requirements, and are these in accordance with BOSA's requirements, or have you consulted BOSA? Are you basically in a position to answer that question?

A. No, I'm sorry. I'm just telling you that those tests are going to be carried out. I don't have the specification with me, and I should imagine they will talk to BOSA. In fact I'm sure they will talk to BOSA about that. But I'm not in a position to give you any advice on the questions you've asked.

Q. Thank you.

A. And that's not because I'm avoiding it; it's just I just don't know.

Q. You did mention, for example, nine samples; yes, you mentioned that?

A. Mmm.

Q. But in terms of -- you mentioned this is a standard, isn't it?

A. It's a production engineering standard, yes.

Q. Where do you get that standard from?

CHAIRMAN: Sorry, what I've understood -- I don't want to interrupt -- but I don't think, unless I'm woefully wrong, that Dr Glover has said that this is a recognised industry standard. He has spoken about that number being used when, in ordinary day-to-day building,

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batches of rebars are received.
A. Correct.
CHAIRMAN: And it therefore becomes not an uncommon methodology. That's what I've understood.
Now, it may well be that there are in universities different levels. I don't think that Dr Glover is in any way contesting that. There may be better levels. I don't think he's contesting that. He's simply saying that this is what has been decided upon in the present case.
MR PENNICOTT: Sir, also, with respect -- I'm sure Mr Chow will confirm this -- the Buildings Department itself uses nine for batches exceeding 500.
A. Well, there you are.
MR PENNICOTT: If you go to H9/4025, you will see that.
This is one of the appendices to one of the Buildings Department's acceptance letters, and you can see the table there. So "Exceeding 500" is "9".
A. Thank you very much.
MR PENNICOTT: We have seen, if you go back to the January 2014 Pypun/Buildings Department audit, all the tests they did, I mentioned the number of 27 the other day, they did three lots of nine.
A. Thank you.
CHAIRMAN: I would be more than happy if you would like to

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put it to Dr Glover that he's badly off the mark and that in fact either academic information is to the contrary and/or industry standard information is to the contrary and/or statutory requirements are to the contrary.
But outside of that, I have a little difficulty.
MR TO: I understand.
Maybe I will rephrase it this way: do you think, Dr Glover, test samples give a reasonable indication of the performance of such a large population?
A. Absolutely.
Q. Just a few more questions. You have mentioned about the elongation -- remember?
A. (Nodded head).
Q. -- requirement of the coupler is a measurement of the product passing and not a structural integrity issue?
A. Yes, I think I said something along those lines.
Q. So the requirement indicates the performance of the coupler after installation?
A. The test is that you pull the coupler at quite a high level of stress, you release it and you measure it, and that's called the elongation. It's not -- let's call it elongation because that's what it is. But it is the width of a hair.
Q. 0.1.

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A. And it's a test of is the batch -- let's assume you've got a batch, and the concept of batch is that things are produced in a mass-produced sense. They are using the same batch of steel, et cetera. So the reason for those tests is to demonstrate that that batch passes a test. That test is to test that particular component as to whether it does what it should do. It is not then extrapolated into what happens in the structure. All it is -- it's saying that that product has passed this hurdle in terms of being made of the right stuff.
I would say to you that that measurement, which I think in Hong Kong is 0.1 of a millimetre, as I say --
Q. That's correct.
A. -- it literally is the width of a hair -- is very arbitrary, because if you were to go to Texas, for example -- I'm not suggesting you should -- you'll find that that figure is 0.25. Now, why should it be any different? It's just that they judge it as being a reasonable test of the product. But how would you extrapolate 0.1 into the structure and then Texas would extrapolate 0.25 into the structure?
So all I'm saying to you is they are a test of the quality of the product that's coming off the assembly line, and it is an error to then extrapolate that into what happens in the structure.

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Q. So do you agree with me that the performance of the coupler is very important to the performance of the reinforced steel bar being connected?
A. I would say the strength of the coupler is the thing that matters. The elongation is a cul de sac in conversation, because it is not relevant to the actual what happens in the physical structure, because the coupler is tested in open air, on its own, which is not the context within which it works.
Can I help you on this, because I think you are worried about distortion and things -- that's what you are really worried -- in structure.
Q. I am.
A. If you were to take two bars, two reinforcing bars, and apply the same load to them that you would -- in a structure that you would to a coupled connection, you will find the coupled connection will be stronger. When I say "stronger", because they've both got the same strength, stiffer.
Q. Provided they are connected properly?
A. Provided they pass what I would call the elongation test.
Q. So they are connected properly in terms of the embedment.
A. No. No. They have to be embedded sufficiently to

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generate the correct strength, and in doing so the elongation, using your word rather than mine, should not be excessive.

Now, I do not believe a number which is 0.1 is excessive. I mean, please, if you take it out, and that's a good reminder, I would even say even if it was two hairs, that would not be excessive, or even three hairs, because I don't believe the impact on the structure is significant, and my comparison with a lapped bar I hope gives you that assurance.

That's the statement, and if you knew the history of where the 0.1 came from, you'd understand why I'm quite doubtful it is a reasonable test.

Q. I understand. I read it last night, the 0.1 millimetre, so I have a fair idea.

A. It's a number and it's a hard hurdle to pass but --

Q. My last point on this. So do you agree with me that the performance of the reinforced steel bar is always a structural integrity issue in reinforced concrete?

A. Most certainly, yes. You use the word "reinforced concrete" so therefore without the reinforcement it wouldn't work.

Q. For example, then we need to follow some kind of code to ensure, for example, the performance is there -- I know you don't like the word "consistency" but remember in

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future that station might have extensions, there might be structures at the side, so if we have consistency, standardisation in place, and the diagrams are all there so that when you have extensions, that wouldn't be a problem in terms of future designers; do you agree?

A. Can I correct your use of my use of the word "consistency"? I was talking about consistency of statistics, not consistency of structural integrity. So they are two different things so please recognise that.

Yes, I mean, there have to be -- it has to have demonstrable strength and that's what we are embarking upon. We are demonstrating that the components that make up the structure will have the integrity required for strength.

Q. Now, when we talk about --

CHAIRMAN: Sorry, again, I may have been misunderstanding this -- and again, if I have, I have fallen woefully behind the race -- I have never understood Dr Glover to be saying that rules and regulation, codes and specifications, should be abandoned and that it should be some sort of "free-for-all" where creativity is all, because he hasn't said that, in my view. What he's saying is -- and perhaps there's a key phrase where he says "I come from a different world". What he is saying is that for future consideration there can perhaps be

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a culture that allows codes and regulations to be tested in the sense of advancing engineering, provided always there is the necessary internal integrity to whatever it is that is constructed so that it is safe.

So I have understood him to be saying: for the future, not for now, that kind of culture which allows a little more interplay, which doesn't simply set up rigidity of codes, that should perhaps be considered.

Now, whether we find any strength in that, or whether we reject it outright, is a matter for us.

COMMISSIONER HANSFORD: Would what you just said still work if you replace the word "interplay" with "judgment"?

CHAIRMAN: Yes, "judgment".

So he's not saying this is what should have been done. I think what he's saying is: this would be aspirationally a good way to consider the future. And I don't think he's saying in any way that the codes here were in fact ignored, other than perhaps an issue which he doesn't want to get involved in.

COMMISSIONER HANSFORD: This is quite useful to us because part of our terms of reference, in fact part (c) of our terms of reference, is to make recommendations for the future, and so that's why we're rather -- that's why we're very interested in this aspect of what Dr Glover is telling us.

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MR TO: I understand, Professor and Chairman. I agree with what you've said. What I'm trying to put forward, Chairman and Professor, is the issue about the flag on the hill -- remember that, Dr Glover?

A. Mm-hmm.

Q. In terms of codes, we do have a code, we do have the Buildings Ordinance 123; we have the full ordinance. If there are problems with the design, if there are complications, if you can't design it as it's been designed for, build for design, the chances are then you need to flag these up, you need to alert authorities, you need to alert certain people in terms of, "Hey, please stop what we are doing now because there are problems with the design and if we continue to design, there could be a problem", but unfortunately in this situation we haven't seen that.

CHAIRMAN: Sorry, I don't understand that. It's me again, I'm sure. Could we re-state that?

MR TO: Okay. Maybe there was some misunderstanding, maybe people weren't informed or certain requirements weren't followed -- "maybe", I'm saying that, "maybe" -- there could be doubts in other people's eyes in terms of whether it was followed or not.

A. Sorry, I don't know what it is that wasn't followed. What are we talking about? I do apologise. It's me.

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Q. In terms of, for example, the as-built drawings.
A. Okay .
CHAIRMAN: That's a different subject. That's an entirely different subject. I think to confuse the two misunderstands Dr Glover's evidence entirely.
He's not saying that on site there should not have been proper inspection. He's not saying that in the building of a particular matter there should or should not have been proper liaison with the Buildings Department. He's not saying that if a worker decides he's only going to put in a rebar into a coupler every fourth time, that that may be permissible. He's gone nowhere near that.
COMMISSIONER HANSFORD: Forgive me, and just to add, I don't think Dr Glover is saying that there shouldn't be as-built drawings, which is the point you have just raised there.
MR TO: So, Dr Glover, are you saying that there should be more partnering in terms of doing this project?
A. Absolutely. I'll go further than that. I would say you should not have authority without responsibility, and I think that is a very important test of any governance structure. If you look through the structure -- and this is I guess true of life but I don't want to extrapolate it too far -- but particularly in

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construction, where safety is of paramount importance, you can't have a division between responsibility and authority, and I'm afraid superficially, when I look at the governance structure on certain projects, I can see there's a case to ask yourself.
Q. The reason I'm asking you that question is because the project management expert did advocate in terms of NEC. I'm not sure if you're familiar with NEC. Do you believe NEC would be an appropriate means in terms of addressing the problems going forward?
A. That is definitely outside the remit.
MR PENNICOTT: Hugely.
A. Hugely outside. But just to put your mind at rest, yes, I've used NEC extensively, probably -- well, at least 7 billion pounds of work. I've also used FIDIC, that's probably about 3 billion pounds of work. Would I want to make a judgment for Hong Kong? No, because it's horses -- the fact that I've used both demonstrates that you've got to be very clear about the context, what you're trying to achieve.
COMMISSIONER HANSFORD: And, Dr Glover, you're absolutely right. That's, as I understand it anyway, beyond the terms that you have been --
A. I think so.
COMMISSIONER HANSFORD: But last week we had Mr Rowsell

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here, Steve Rowsell, who told us his views on NEC, but we had that last week.
A. Privately, I can tell you what mine are, but that's by the way. That's not my remit, I'm sorry.
MR TO: Thank you very much. Just for those who are not sure what the acronym "NEC" stands for, new engineering contracts.
CHAIRMAN: Is it "new" or "no"?
COMMISSIONER HANSFORD: Well, it's new engineering contract. The author of the New Engineering Contract was Dr Martin Barnes. I suggested to him the word "new" might be inappropriate because one day it would no longer be new, and he's told me, "It's not been a problem with the New English Bible, it won't be a problem with this."
A. I think that says a lot about Martin, doesn't it? I think that describes his personality.
COMMISSIONER HANSFORD: So I think we can stick with the word "new" but it's commonly just called NEC and it's currently on version 4, but NEC3 and NEC4 are both in common usage.
MR TO: I'm sure he'll agree with that.
COMMISSIONER HANSFORD: I have rather a lot of experience in this area.
MR TO: Thank you very much.
Dr Glover, just two more questions to finish it off.

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Can I take you to, for example, your report, at ER. It's page 13. Do you have a copy of it?
A. Yes, I have. I've found it. Thank you.
Q. You talk about -- I know this might not be an important issue but I just want to address you on it -- in terms of number 9, "Load test" --
A. Mm-hmm.
Q. -- I'll just read it out in terms of 9.3:
"A more worthwhile approach would be to complete the re-analysis of the structure on the basis of the rebar detailing uncovered in the opening-up works to confirm its structural adequacy."
Do you still believe this statement still holds what you have just told us?
A. Yes, I do, yes. I think it's very important to do that because there are so many pieces to be brought together, and the only way you can really bring them together is to do a comprehensive analysis.
Q. So an opening-up in terms of looking at the structure, the adequacy of, for example, the rebar detail?
A. Yes, and I think to be clear, the common language you are using in the project is purpose 1, in other words the uncovering of the top of the EWL. Yes, I think that's important.
Q. My last point to you is -- if you go to your report, in

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terms of paragraph 11.
A. Yes.
Q. I'm just looking at the word "honeycombing"; yes?
A. Yes.
Q. If you look at paragraph 11.2.
A. Yes.
Q. The last sentence, you said:
"The agreed opinion was that the concrete defects were not unusual in such a massive construction and were capable of repair."
So what are you trying to say here?
A. What I'm saying is that it is not unusual to find honeycombing in construction. There are great concentrations of reinforcement in this slab. When I use the word "massive" construction, I'm referring to its great depth, and the problem with such depth, as I think has been discussed, maybe not -- the problem with something which is 3 metres deep is you are concreting from above, and it's not a lack of diligence on the part of the operative at the top with the concrete and trying to vibrate it. The reinforcement is very tightly measured at the top. T40 is at 150, two or three levels, and he's looking down onto probably another seven layers of reinforcement, and he's trying to get his poker, the vibration poker, into those areas.

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As a consequence, because of that great depth, it is not unusual to find areas of -- in fact my term, call it "honeycombing" because that's the language you are using.
COMMISSIONER HANSFORD: Sorry, what language would you use?
A. I would have said "void". Honeycombing tends to me to be something that's more surface, but when you get voiding, where there is actually no concrete -- you know, the concrete has arched over -- so I guess, to me, honeycombing would be where you've got concrete but it's not actually -- you haven't got the latence in there, you've just got this honeycombing. But where you've physically got a void, that's a void to me. But they seem to be lumped together in the description.
Does that make sense?
COMMISSIONER HANSFORD: Yes, it does.
A. What I would say, and this is just a comment, I know that the concrete pours that were made used what I would classify as standard mix of 20 millimetre aggregate and I'm sure you use some form of plasticiser but I think with the concentration of reinforcement, whoever was responsible for casting the concrete should have used a smaller aggregate and should have used a super-plasticiser, and they didn't, and that has certainly contributed to the honeycombing.

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But that's a personal view. You asked me -- you asked the question, and that's a cause and effect, isn't it? You've got an effect, which is voiding. What was the cause? One of the causes was the great concentration of reinforcement, but the other one was that the concrete mix could have been different, and I think you would have got a better performance.
COMMISSIONER HANSFORD: And the capability of repair, Dr Glover?
A. The capability of repair is the superficial ones, because I think they tend to be concrete cover, I think almost like a plastering approach towards it. But the deeper ones might -- not just my preference -- I would strongly recommend that it's pressure-grouted.
I've had experience with that and I think it works very well, but there seems to be some reticence to do that, but I'm sure they will come around to it.
COMMISSIONER HANSFORD: And once repaired, then it has its full integrity, does it?
A. It has its full integrity but the stress will have been lost in those bars which lap, because obviously this bar laps with that (demonstrating with fingers) and how does it communicate? It's with the concrete in between. 90 per cent of the load is on, so those bars will only see the next 10 per cent. But there is so much

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redundancy in the structure that the bars on either size of it, and indeed above it, are taking the strength.
COMMISSIONER HANSFORD: As you've already explained.
A. Yes. So I think -- but the repair method of that pressure grouting is what's needed.
MR TO: Thank you, Dr Glover. You mentioned about the aggregate.
A. Yes.
Q. So if someone follows the specifications exactly, and all that, then clearly the specifications are wrong?
A. A specification is like a rule, going to my codes. Because it says something and you know it to be wrong, would you do it?
Q. But if the one who's pouring it doesn't know what it is?
A. No, the man who's pouring it -- it's just been delivered. No, who asks what should be delivered and who authorises it at the higher level. So leave the operative out. I think looking at the amount of concrete that was being placed and the speed it was being done, I think they were pretty diligent, actually, and when you look at the task they had of actually forming it -- no, the specification would have said whatever it said. I'm not suggesting for a moment that the specification was not applied in the works. What I'm saying is -- this is one of my examples of

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challenge. You know, there's the words, that's what has been contracted to do, but you don't just carry it through if you know it is probably not going to give you the best answer, because at the end of the day the person who is responsible for that concreting is running his own risk. In fact he's got his risk now, hasn't he? The honeycombing was only caused by the concreting man. So isn't it to his benefit to have actually challenged the specification if he thought it wouldn't give the right product, the right fitness for purpose?

Q. It would be in his position to challenge something if, for example, he was aware after it had been poured and he saw the surface.

A. No, I think if this is a competent contractor -- and I'm not challenging the competence of the contractor -- they know the challenge ahead of them, and if they did not ask the question and challenge it -- they could have challenged it, I don't know, and they could have said, "No, we are not accepting your challenge", and in that case, that's all right.

But I think in this case it would have definitely been better if you had used a -- or if they had used, whoever it might be, a smaller aggregate and super-plasticiser. And I'm not saying for a moment that the specification that was applied was not a sensible or

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appropriate one. I just don't think it was looked at for the particular circumstances.

Q. I understand.

A. Does that --

Q. It answers my question.

In terms of -- you mentioned about the void or honeycombing -- is it common in the construction industry to have voids or honeycombs?

A. Well, yes, concrete repairs are -- I'm afraid they are a way of life. What is more insidious is lack of cover to concrete. That's something that catches. Interestingly enough, honeycombing is something you can see and do something about. Inadequate cover is something that catches you out in the years to come.

But no, these are -- I wouldn't say common everyday events. You don't have a 3 metre deep suspended slab every day. But no, these aren't things that "shock horror, my goodness this has happened".

MR TO: Thank you, Dr Glover. That's all from me.

WITNESS: Thank you very much.

Re-examination by MR BOULDING

MR BOULDING: Good morning, Dr Glover. There's just one matter I would like to ask you about. You will recall having been questioned by various lawyers in the room about technical compliance matters.

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A. Yes.

Q. I have jotted down that you have emphasised on a number of occasions that you are here and you are dealing with fitness for purpose and in particular safety. Do you remember giving answer to that effect?

A. Correct.

Q. I wonder if we can just have a look at your report which is up on the screen, very happily. If we can go to 8.10, which is on page 12.

A. Yes. Thank you.

Q. There do I see your "Conclusion of considerations of structural adequacy"?

A. Correct.

Q. If we could go to page 13.

A. Yes.

Q. You say at the top:

"It is evident that so far as I am concerned that the structure of the station box has large degrees of redundancy and robustness and, consequently, a comfortable margin of safety which supports my opinion that the structure is safe for its intended lifespan."

Now, taking account of all the propositions which have been put to you over the course of the last three or four hours, is that still your professional view?

A. It still is.

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Q. Do I understand that you stand by the bullet point reasons in that paragraph as supporting that view?

A. Can I just look at them?

Q. Please do. I want to be certain about this.

A. Yes, I still accept those points. Yes, I do.

Q. You are sure about that?

A. Yes, I am. And to be doubly sure I would like to carry through with the test evidence, because I do acknowledge, and I've said that all the way through, that the test evidence points me in a direction and I want to close it out.

Q. As you said, that's to be doubly sure.

A. That to be doubly sure, yes.

MR BOULDING: Thank you, Dr Glover.

Sir, Professor, I don't know whether you have any questions.

COMMISSIONER HANSFORD: I just have one and as a civil engineer I ask this question with a little bit of trepidation.

Dr Glover, you are an eminent structural engineer, and I know Arup has both structural engineers and civil engineers. It might just assist the Commission if you could explain what is the difference between a civil engineer and a structural engineer.

A. Right. At university, I studied civil engineering.

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That's a degree. I actually practise civil engineering, but I specialised in structural engineering. As the professor will know, there is an arrogance in structural engineers, and some of us, for one reason or another, in the folly of youth, decided that we would become members of the Institution of Structural Engineers, as opposed to the civils. It was a straight choice.

COMMISSIONER HANSFORD: As opposed to the Institution of Civil Engineers?

A. Exactly. I must admit, I've been invited to join on a number of occasions but I felt I would be letting down my younger self in terms of the arrogance.

But it is important and perhaps I should correct that error of my youth and become a member as well.

COMMISSIONER HANSFORD: I'm sure the Institution of Civil Engineers would welcome you, Dr Glover.

A. Thank you very much.

So civil engineering is very wide, as a day-to-day life I practise that, but I specialise in structural engineering.

Does that help you?

COMMISSIONER HANSFORD: And the specialisation, just to differentiate it from civil engineering?

A. The specialisation, structural engineering, is to do with the mechanics of frameworks and plates.

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Interestingly enough, structural engineering, when I was younger, in our exam that we used to take, it was a day-long exam, it wasn't an interview or whatever, it was a physical exam, "Here's a problem, solve it", so it was a pretty high hurdle to pass, and we used to have an aeronautical question. So interestingly enough, structural engineering, although it is a subset, an arrogant subset, I must say, within civil engineering, it also encompassed aeronautical engineering, so it went off to the side.

COMMISSIONER HANSFORD: That's helpful. Thank you.

MR BOULDING: I have just been passed a note and it says that the calculations carried out by government, the government consultant, Mannings, were made available very late last night. Now, Dr Glover has not had an opportunity to look at those because of when they were delivered and of course the fact that he's been in the box and we've not been able to communicate with him.

So can I just point out that we are now going to ask Dr Glover to do a little bit more work and look at those calculations, and I wonder whether, if he's got any interesting observations to make on those calculations, that you would consider having him back, say, for five or ten minutes later today. Can I just make that point?

COMMISSIONER HANSFORD: Is there any -- this is possibly slightly unfair, Mr Boulding -- indication as to how long it might take for those to be considered by Dr Glover?

MR BOULDING: I am told that they are substantial in length. I think they are something like 100 pages. It would probably take me six months but of course he's got far better skills than I've got.

CHAIRMAN: Sorry, just remind me, these are calculations by Mannings for what purpose?

MR BOULDING: Carried out on behalf of government.

CHAIRMAN: For what purpose?

MR BOULDING: Into the structure, as I understand it.

COMMISSIONER HANSFORD: Sorry, Mr Boulding, as far as you are aware, are these the calculations that Prof Au was referring to on Monday or Tuesday?

MR BOULDING: I think so.

MR PENNICOTT: I may be able to shed some light on this, sir.

CHAIRMAN: Thank you.

MR PENNICOTT: Because I have actually seen the calculations.

COMMISSIONER HANSFORD: What do they say?

MR PENNICOTT: Mr Boulding is right, first of all, that they came in relatively late last evening, as far as I'm concerned. Obviously Prof McQuillan is in the same

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boat, as it were, as Dr Glover, albeit that he's not in the same witness box yet, in the sense that he's had the quickest of glances and no more at the calculations this morning.

They are bulky. They deal specifically -- what we've been given, as I understand it, is a covering letter from the DoJ, Prof Au's list of calculations that he thinks ought to be done, and then some calculations by Mannings that run, as I say, to a number of hundreds of pages.

They are all, as I understand it, focused on the debate we've been having about the shear and the construction joint and the shear plane of that construction joint.

CHAIRMAN: Yes, Prof Au said that that was an area that he felt could be dealt with by calculation.

MR PENNICOTT: Yes.

CHAIRMAN: Or initially dealt with by calculation.

MR PENNICOTT: Yes. So what we have -- we've already had the Atkins calculations that Prof Au was critical of in his report -- we now have another series of calculations by Mannings which as I say are not short, and whilst I'm not resistant to Mr Boulding's suggestion that Dr Glover has a look at them, I am very doubtful, having had a brief conversation with Prof McQuillan had morning,

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that either Prof McQuillan or, with the greatest of respect, Dr Glover is going to be able to take the matter too far, given the very short period that is available to us.

COMMISSIONER HANSFORD: I'm not sure it would serve this Commission very well to have a sort of initial view. I think it would require a thorough review.

MR PENNICOTT: Yes. I suppose there's always the prospect that they might look at them and say, for whatever reason, they are fundamentally flawed right at the outset, but that prospect I would have thought is not great.

COMMISSIONER HANSFORD: And open to challenge.

MR PENNICOTT: And open to challenge. Sir, we are due to finish the expert evidence today.

What is clear, I have to say, from the brief perusal that I've had of the calculations, is that it's quite clear that Mannings started this work way back in probably the end of October/beginning of November, and what we've got is revision 2 of a report of which there was a previous revision at an earlier date. Obviously, having not seen the first revision, one doesn't know what the changes are in the latest version.

So this is work that's been going on for some time and here we are, on the last day of the structural

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engineering expert evidence, faced with what on any analysis is a large amount of calculation.

COMMISSIONER HANSFORD: When Prof Au suggested that this work should be done, on Monday or Tuesday of this week, I don't think it was committed that the experts gathered here today would review that --

MR PENNICOTT: No.

COMMISSIONER HANSFORD: -- and be cross-examined on it.

MR PENNICOTT: No.

COMMISSIONER HANSFORD: So is that something that perhaps we could take over the next week, not for cross-examining, of course, but the review by the other parties on these calculations could be reported back to us next week?

MR PENNICOTT: Sir, that's a possibility, but I wouldn't like to commit either the Commission's team, if I can say that, and Prof McQuillan in particular, or indeed any of the other parties -- MTR, Leighton and anybody else who might be interested -- to respond to you, sir, before they've had an opportunity of actually looking at those calculations.

COMMISSIONER HANSFORD: Of course not.

MR PENNICOTT: They may say, "I'm sorry, mission impossible, we can't possibly do that for several weeks; it's going to take us some time."

What troubles me slightly is that, as I understood

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Prof Au's evidence, he seemed to be intimating that the calculations he had in mind could be done relatively quickly, over a couple of days or so.

COMMISSIONER HANSFORD: Half a day.

MR PENNICOTT: But it's quite self-evident to me that these Mannings calculations have been prepared over months. So the Mannings calculations don't appear, to me at least, to be the ones that Prof Au perhaps had in mind. But I may be wrong on that.

COMMISSIONER HANSFORD: There may be others as well.

MR PENNICOTT: There may be others. I just don't know.

CHAIRMAN: Can I ask what --

MR CHOW: Sir, if I may assist on this subject. First of all, I myself have not looked at the details of Mannings' calculation, but I tend to agree with Mr Pennicott's observation. I have some doubt as to whether it is helpful for the experts to look at Mannings' calculation at this stage. As I recall, what Prof Au said is Mannings' work was done based on incomplete and insufficient base data, and on that basis they found some problems in some of the locations, and my understanding is the set of calculations now produced by Mannings reflects what they have done on the basis of incomplete base data.

To that extent, I doubt very much that even if there

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is any comment or disagreement on the accuracy of the calculations, that it would really assist this Commission for the purpose of what we are doing now.

COMMISSIONER HANSFORD: It sounds to be of limited value at this stage.

MR CHOW: Yes, because in fact when we submitted the calculations yesterday, my understanding is that the covering letter makes it clear that this calculation was made on the basis of incomplete and insufficient base data, and the list that we served yesterday actually, as far as I understand, sets out all the base data that we think should be made available for a more accurate and meaningful calculation.

MR BOULDING: Sir, it seems as though I was correct to raise this matter, because it could well be important. Obviously Mr Pennicott is better informed than I am at the moment. But it doesn't seem as though my proposal of having Dr Glover back today is realistic in the circumstances.

So whilst we put down a marker and we'll obviously look at them and revert to you and assist you as much as possible, that doesn't seem to me to be a realistic course of action.

COMMISSIONER HANSFORD: Mr Boulding, whilst I accept what you have just said totally, and it's not realistic to

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involve Dr Glover in a response to those calculations today --
MR BOULDING: Exactly.
COMMISSIONER HANSFORD: -- nevertheless, it may be appropriate for you to be consulting Dr Glover on this work.
MR BOULDING: Of course, over the course of the next few days.
COMMISSIONER HANSFORD: Yes.
CHAIRMAN: All right. Then we will --
MR CONNOR: Sorry, if I may add, there is an additional question which we might come back to later which is that again, once we have all had a chance to read what has been submitted overnight in terms of this list that Mr Chow refers to, what is to be done with it -- is that something which Mr Chairman and the professor wish to charge individuals, experts or others, to deal with? Is it something that Prof Au is handling? Can we expect more from the government on this? I think that's an unanswered question at this stage but clearly we need clarity on it before we get to the stage of submissions to you.
CHAIRMAN: I would imagine we will discuss this over the morning adjournment.
MR CONNOR: Thank you, sir.

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CHAIRMAN: But obviously if its basis is flawed, and materially flawed, then obviously it probably is not going to be of any real assistance to us.
MR CONNOR: Absolutely. I was drawing a distinction between what Mannings may have produced or what has been produced on behalf of Mannings and separately the list that Mr Chow referred to which also has been lodged and this is what we understand to be generated further to the conversation and the evidence of Prof Au.
COMMISSIONER HANSFORD: I think that's clearly understood, Mr Connor.
MR CONNOR: Thank you.
CHAIRMAN: Thank you very much.
MR PENNICOTT: Just to assist, I have asked the Secretariat just to put up on the screen the extent of the documentation. So you will see, from item -- all this material has now been put in bundle H37, and the covering letter from DoJ you can see is at 232, and then the rest of the documentation below 232 all the way down to 239 is the extent of what we've been provided with, and that's just an index.
CHAIRMAN: So we've had --
MR PENNICOTT: It looks like that (indicating).
CHAIRMAN: I remember about 100 years we used to end geometry problems with "QED".

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WITNESS: Absolutely, wonderful.
CHAIRMAN: It's almost going back to St Custard's, for those old enough to remember that kind of prep school stuff. So we've got a gallant team who have spent three months doing all of this and QED, nothing, is that it, at the end? I feel very sorry for them if that is in fact the case. Nothing worse than a problem being well done not to be of any benefit at the end. But we'll see if that is in fact the case.
15 minutes.
Before we do so, I'm sorry, we've left you sitting there all on your own.
WITNESS: I would like to leave the room, sir.
CHAIRMAN: Dr Glover, thank you very much. It has been of very great help to the Commission, just as the other evidence has been, and may I say, without any disrespect to any of the other experts, it's been a pleasure to listen to your evidence.
WITNESS: Thank you, sir. Thank you, Professor.
(The witness was released)
(11.15 am)
(A short adjournment)
(11.34 am)
COMMISSIONER HANSFORD: Before we commence --
MR PENNICOTT: Sorry, with the greatest of respect, the

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government appear to have given up. The government aren't here. I was a little concerned before you said anything, sir.
COMMISSIONER HANSFORD: That's good. Thank you.
MR PENNICOTT: Perhaps they don't want to hear Prof McQuillan.
COMMISSIONER HANSFORD: Can I just raise one point, is this appropriate, or should we wait for the government?
MR PENNICOTT: I think we should wait for the government.
COMMISSIONER HANSFORD: Yes. Can somebody find them?
MR PENNICOTT: Someone has gone.
(Bonnie Cheng entered the room)
CHAIRMAN: Is Mr Chow coming in?
MS CHENG: I think he's in the washroom.
(Anthony Chow entered the room)
CHAIRMAN: Mr Chow, just to make your embarrassment even worse, let me say we have been waiting for you.
MR CHOW: Sorry, I was in the washroom and I have been trying to get a hard copy of the covering letter from the DoJ.
CHAIRMAN: I appreciate that. Thank you very much.
H O U S E K E E P I N G
COMMISSIONER HANSFORD: I have a question for Mr Boulding which I thought I would raise at this point if I may.
MR BOULDING: Yes.

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COMMISSIONER HANSFORD: Reference has been made extensively to these additional nine tests.
MR BOULDING: Yes.
COMMISSIONER HANSFORD: It's not clear to me yet when they are going to be done and I think it would be quite useful for us to know.
MR BOULDING: Yes, absolutely, sir. I am conscious of the fact that you asked me that question about this time yesterday, and I sought instructions and I'm still waiting for those instructions. I have emphasised how urgent it is and obviously I will get back to you as soon as I've got anything to tell you.
COMMISSIONER HANSFORD: Thank you very much. That's helpful.
CHAIRMAN: I have just one observation to make as well. Just before the morning adjournment, this question of the calculations by Mannings was raised. While we seem to be agreed that it may not be of any benefit to us, I personally would not like it to slip under the radar, so to speak, so that we would need something a little conclusive as to what we make of or do not make of these calculations, in case we need to at least make mention of it in the report. Maybe we don't but I wouldn't like it just merely to, as I've said, slip under the radar.
Mr Chow, perhaps it's a matter you might consider.

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You may even put it in final submissions or something like that, almost by way of a footnote, but I wouldn't like it forgotten.
MR PENNICOTT: Sir, perhaps I can have a discussion with the government, Mr Chow, and decide the best way of dealing with this.
CHAIRMAN: Yes. Thank you.
Yes.
MR PENNICOTT: Sir, good morning again. Before we come to Prof McQuillan, might I be permitted just to say a few words, essentially for the benefit of the public and perhaps also those reporting these proceedings, about the visits that all the experts made to the station site on 17 and 19 December 2018, and also a little bit about the meeting, joint meeting of the experts, that took place in this building on 18 December, sandwiched between the two site visits.
I say that because we've had various references throughout the course of the expert evidence so far to the site visits and to the joint statement.
Sir, by way of background, on Day 31 of these proceedings, that is 10 December 2018, the opening-up of the site started. On 11 December 2018, Day 32, both I and you, sir, the Chairman, indicated to everybody that Prof McQuillan would be arriving in Hong Kong in

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the not-too-distant future to inspect the areas that had been opened up or that were being opened up.
Sir, on that day, you extended an invitation to the independent experts appointed by the parties to accompany Prof McQuillan on his intended inspections, provided that the MTR could make the necessary arrangements.
Sir, you stressed on that occasion that the people to carry out the inspection should be the independent experts and nobody else.
Sir, after that announcement had been made by yourself, in addition to the MTR, both Leighton and the government indicated that their clients' respective experts would like to join Prof McQuillan on his proposed inspections.
Correspondence took place on 12 December in which the MTR were asked to make the necessary arrangements for the site visit, and in particular asked to make arrangements for the inspections to take place by the experts on 17 and 19 December.
The MTR, on the following day, on 13 December, informed the Commission's solicitors that the inspections could be arranged as requested, and provided information on the meeting point and the logistics for the site visits. In that communication from the MTR's

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solicitors, it was also suggested that only Prof McQuillan should be permitted to take photographs or videos during the opening-up visits, with the photographs to be made available and circulated to the parties immediately after the visits.
Sir, I can say that we thought that that suggestion from the MTR was a sensible one. It was a practical one, because at that stage we didn't want four sets of experts come along with their cameras, taking identical photographs of what they were looking at, end up with lots of sets of photographs, and also, in the process, slow the whole site visit up, and so we agreed --
CHAIRMAN: And also there would have been a safety issue with a large number of people in areas with scaffolding and steel bars and the things around.
MR PENNICOTT: Yes. That's absolutely right, sir, because we were also told by the MTR, accurately, that at least some of the opening-up locations were inside the duct and had very limited headroom, which is essentially the point you have just made.
On 14 December, the Commission's solicitors informed MTR that Prof McQuillan would attend the meeting point as requested, that's outside Mannings, the retail department store, not the engineers, and he would take his own photographs with his own camera and that the

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photographs taken would be included in the hearing bundles in due course.

Sir, importantly, in the same email of 14 December, the experts were invited to attend a joint expert meeting, which I made mention of a short while ago, on Tuesday, 18 December. That is, as I said earlier, sandwiched between the two site visits. And so it was the initiative of the Commission, one, that the site visits took place and two, that the experts should meet jointly.

Sir, at that stage, on 14 December, in the morning, we still had four parties with experts on board: the Commission, the government, the MTRC and Leighton. In the afternoon of 14 December, a Friday, we received from China Technology's solicitors a request that Prof Yeung, Prof Albert Yeung, who has given evidence before you, join the inspections that were to take place on the 17th, on the Monday. Incidentally, there was also a request that Mr Jason Poon accompany Prof Yeung on that visit. There was a very quick response from the Commission's solicitors, indicating that certainly Prof Yeung could and should attend, if he so wished, and by copying in the series of emails that I have referred to earlier, all the details of where to meet, the logistics, and so forth, were communicated to China

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Technology's solicitors, and no doubt, I assume, passed on to Prof Yeung.

Indeed, on Saturday the 15th -- sorry, I should say that not only was the indication given that Prof Yeung would attend the site visits but also would attend the joint meeting.

On the following day, on Saturday the 15th, it was confirmed by China Technology's solicitors that indeed Prof Yeung would go to the meeting point in front of Mannings and that he would also attend the expert meeting.

Sir, that is the background to both the joint site visits and the experts' meeting, and I will be asking Prof McQuillan just a few questions about what happened on the joint inspection, particularly on 17 December, and indeed on one or two aspects of what happened at the joint meeting on the 18th, and I'll do that shortly.

Sir, but before I conclude, can I just detail this point, that as arranged, on the first visit, that is on 17 December, Prof McQuillan did indeed take photographs, a number of them, they are item A1/50 in the bundle, and on 18 December the involved parties were informed that all the photographs were available to the parties on a DVD, upon collection at the Commission's solicitors. All parties, including China Technology, picked up the

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DVD of the photographs on 17 December -- picked it up on the 18th, that is, of the photographs on the 17th.

So far as the second visit is concerned, sir, slightly more detailed, photographs were taken on 19 December. They weren't in fact physically taken by Prof McQuillan, for reasons he will explain in a moment. They were taken by Mr Colin Wade who I understand to be one of Dr Glover's colleagues, but Prof McQuillan will explain why that was the case in a moment.

More importantly, following the taking of those photographs on the 19th, the parties again were informed that that collection of photographs, which is A1/51 in the bundle, were available for collection from the Commission's solicitors' offices. On 20 December, all parties collected the DVD of the photographs, save for China Technology.

For reasons which I can explain in detail but probably don't need to, despite the fact that those photographs were clearly available and made available on 20 December, China Technology's solicitors did not collect those photographs of the 19th visit -- they already had the 17th -- until 4 January 2019. As it happens, that was three days before Dr Yeung produced his report to the Commission.

So the position is those photographs were available

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on 20 December to everybody but, so far as China Technology is concerned, they did not collect them until 4 January.

I mention that because you may have seen, and I did ask Prof Yeung a question about this -- there seemed to be an implicit complaint that he hadn't seen the photographs of the 19th. I have just explained what happened, and I'm afraid, with the greatest of respect, if anybody is to blame, it's not the Commission, it's those instructing my learned friends for China Technology. They had the opportunity to get them on 20 December, they had them on 4 January, and they don't appear to have found their way to Prof Yeung.

Sir, that is the history of the matter. As I say, I will ask Prof McQuillan a few questions about certain aspects of those in a moment.

CHAIRMAN: Thank you. As you have raised these various issues for the information of the public, perhaps you might just say something about the fact that when you have a number of experts who are on behalf of different parties looking essentially to the same issue, it is today not uncommon but is in fact recommended that if possible those experts should get together, share their knowledge, debate issues in contest, and should if possible come to a joint opinion.

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MR PENNICOTT: Yes. Well, sir, indeed, that is right, and as I say the initiative for the joint meeting came from the Commission, and I think the hope, if not the expectation, was that if the experts were able to produce a written joint statement, signed by them all, that that would be extremely useful to the Commission.

Sir, as we have seen with one or two of the experts -- and I'm going to show, obviously, the joint statement to Prof McQuillan in a moment -- that is indeed what happened. A joint statement, albeit brief, was prepared. It seems to me and I know to other involved parties -- and I think to yourselves, sir -- to be a very useful, helpful document, which just on two or three sheets of paper encapsulate some key points that you will need to consider.

So, sir, that's right, and it seemed to me that throughout the course of that process there was no obvious complaint from anybody and that the experts very much worked together and discussed matters at length and came up with this joint statement. Sir, that is, as you rightly say, the normal course of events in standard litigation and arbitration, whether of a construction nature or something very different to that. But that is the procedure that is adopted in Hong Kong on a daily basis in litigation and arbitration, that experts of

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like discipline should meet and set out what they are able to agree, to assist the court, the arbitrator, or in this case this Commission. And, sir, that is what has happened, following pretty standard practice.

COMMISSIONER HANSFORD: Indeed. That's the same practice that's followed in the UK.

MR PENNICOTT: Yes, sir.

CHAIRMAN: If I might just add one final thing to that, and I made mention to Prof Hansford who sits here as a member of the Commission but obviously has fulfilled other roles in the past, and he himself, as an expert, has attended this kind of meeting, where there is energetic debate, where opinions are expressed, all in an attempt to reach, insofar as it is possible, some agreed approach on matters that relate to the expert evidence.

I say that because it would not, therefore, for any of the experts who have appeared, have been a novel, unexpected experience. They would have been expected to get together, to discourse, to debate, to hold their ground where they thought it proper, and to agree where they thought it proper.

MR PENNICOTT: Yes. Sir, I wholly endorse those observations. As I say, it's a process that is recognised and has been recognised for many years in

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this jurisdiction and, as Prof Hansford has indicated, in other jurisdictions, in the UK in particular, and it's obviously of enormous help, as it's proved to be here, we would suggest.

CHAIRMAN: Yes. Thank you.

MR PENNICOTT: Sir, with that, could I then -- good morning or good afternoon, Prof McQuillan.

PROF DON MCQUILLAN (sworn)

Examination-in-chief by MR PENNICOTT

Q. Could I ask you, please, to be given your expert report, which is in file ER1, behind tab 3.

Prof McQuillan, is that the front sheet of your report on the screen?

A. It is.

Q. If you could go, please, to page 11. Is that your signature?

A. It is.

Q. And this report was prepared and at least dated by you on 6 January 2019?

A. Correct.

Q. And the report itself runs from page 12 through to where the appendices start at page 49?

A. Correct.

Q. One of those appendices, Prof McQuillan, is the joint statement of the experts, the agreed expert memorandum.

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That's at appendix XI, which is at page -- let me start with the manuscript -- 120.

A. (Nodded head).

Q. First of all, Prof McQuillan, can I just ask you this -- I will come back to a few more questions about it in the moment -- is that your handwriting?

A. It is, for reasons I shall explain later, and I do apologise for the legibility of it.

Q. Right. On page 123, do we see the signatures of yourself and all the other experts?

A. That is correct.

Q. We can see, if we go back to 117, the transcript or the typed-up version of the joint expert memorandum?

A. Yes.

Q. Now, Prof McQuillan, insofar as your report and the joint expert memorandum contain matters of fact, do you believe those facts to be true to the best of your knowledge and belief?

A. Absolutely.

Q. And insofar as your report and the joint memorandum contain matters of opinion, are those opinions honestly held by you?

A. Those are my personal opinions.

Q. Now, just on the question of the joint -- first of all, I'll deal with the joint inspection, if I may,

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Prof McQuillan, on 17 December; Monday, 17 December 2018. Can you just briefly explain what happened in terms of arriving at the meeting point to the time that you left the MTR office and went to the site?

A. Sure. I was taken to the meeting point at the said kiosk by one of the legal team acting for the Commission. We were met -- as far as I recall, there were two MTR members of staff waiting. It was, as I understood, on a first come, first served basis. My recollection, and it might be wrong, is that Colin Wade and Mike Glover were there; Prof Au and Prof Yeung were not there at that stage; one member of the MTR staff took us up to the main meeting room, and within a couple of minutes, as I recall, Prof Yeung and Prof Au arrived, I can't remember if they came together.

What then happened was that Neil Ng, if I'm pronouncing it correctly, N-G, of MTR, sat us all down and gave us a briefing, primarily on health and safety, because we were entering an area of the works. He also exhibited the graphics that are now very familiar to us all, in the daily results, showing us where the proposed locations were going to be implemented, and described progress so far that had taken place.

We were then issued with our protective equipment, and there were several, quite a number of MTR staff,

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accompanied us. Initially, to go down to whatever level it was, we had to group into two lifts, so we were put into two groups, and when we finally made it down into the tunnel, we were all basically clustered together.

Q. Right. So can you just confirm that all five experts, as it were, rendezvoused, met up in the MTR office?

A. That's correct, and introductions were obviously made.

Q. So there was no question of one expert going off to the site before another; you all went together?

A. Absolutely, because that would be breaking the rules.

Q. All right. Can I then switch to 19 December, when you had another inspection, and I think it's common ground that on this occasion Prof Au was not in attendance but the rest of you, the four of you, were in attendance?

A. That is correct, and in addition we had a member from the legal team who wished to accompany us just out of curiosity, more or less.

Q. Okay. That's the Commission's legal team?

A. Correct.

Q. On that occasion, on the 19th, as I understand it, you didn't take the photographs as you had done on the 17th; is that right?

A. Not strictly correct. I took the photographs on the upper side of the EWL slab. We then went down, and when it came to getting into the air duct, you must remember

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it's a pretty dusty environment, I was dressed for flying home that evening to Dublin. I would have had no opportunity to change my clothing beforehand, and so, because Prof Yeung and Colin Wade were both going down into the intake, I asked Colin would he mind taking the photographs. So there was a witness to those. Using my camera, I might add.

Q. Okay. Thank you very much.

Now, one day earlier, the meeting, the joint meeting of the experts, took place, and we've looked at the manuscript version of the joint memorandum. First of all, I understand that there was no agenda for that meeting; is that right, Prof McQuillan?

A. That is quite deliberate because it has been my experience that in a forum like that, different people, different experts, will have different issues that they wish to raise, depending on their scope. So, for example, Mr Southward had a more restricted scope, it turned out, than perhaps Dr Glover and myself.

What then happened was because I was representing the Commission, and because it had been the Commission's initiative, I offered to act as the informal chair, because for those who aren't aware of the process, there isn't really a formal chair in a meeting of experts. In our jurisdiction, it's normally the expert for the

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plaintiff, for example, who will fulfil that function. This was a fairly neutral environment, so I offered to just chair informally on behalf of the Commission, and in so doing I offered to write the illegible minute that you have seen, if minutes were to be produced at all. Okay?

So I explained the process, in case every there was unaware of it, I stressed the importance of being able to discuss freely and without prejudice anything that anybody wished to raise. I also mentioned the fact that it would be of benefit to the Commission were we able to produce an synoptic note covering the issues agreed. I stressed that we could walk out of there without any sheets of paper or we could walk out with a signed memorandum. There was no objection to any of those points, and so we proceeded.

My recollection is that probably Mike Glover took the lead. It ended up as we discussed matters that there were a lots of issues in common that were raised, and at the end of each issue I simply asked those present to help me formulate the key note that is recorded into the memorandum, and they all inputted into that. The only reservation was at item 3 -- and this has been drawn attention to -- where there is a note in brackets. Prof Au felt he would not be at liberty to

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sign it as we had originally drafted unless that particular caveat was inserted.
Q. All right. I think that's probably as far as we need to go on that particular topic.
CHAIRMAN: I just want to ask one question.
MR PENNICOTT: Of course, sir.
CHAIRMAN: The meeting where the memorandum was signed was held where?
A. It was held in an annex to the court here, in one of the meeting rooms.
CHAIRMAN: Over the lunch hour?
A. No. We started, from recollection, at maybe 9.30 or 10.00, but it proceeded well over the lunch hour.
CHAIRMAN: Were you offered any food?
A. We were, but the feeling was that we should just push on to completion.
CHAIRMAN: That was a general consensus, was it?
A. There was no objection to that.
CHAIRMAN: All right. Thank you.
MR PENNICOTT: Thank you. Now, Prof McQuillan, that's all I have to ask you, but in accordance with what's happened with all the other experts, I understand you would like now to make a presentation, a synopsis of your evidence, and so I will sit down and hand over to you.

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A. Okay. Presumably you wish me to say a little bit about myself, which I'm reluctant to do.
MR PENNICOTT: You are.
CHAIRMAN: I'm afraid you are under instructions.
A. That is a different matter.
So I graduated from Queen's University Belfast in 1975 with a first-class honours degree. I immediately joined a local consultancy practice and have actually been with that same company under different guises now for 44 years. It became -- although we were a private practice, we were acquired by RPS, who are a plc group, in 2004. And I have operated at partner/director level now for 30 years, that is since 1989. So that means, if you are doing your maths, I have 44 years' experience, specialising in a broad range of stuff, maybe primarily as structural engineering but specialising in structural, civil, bridge and some marine engineering, and latterly in forensic engineering, and have been investigating and assessing defects and failures in buildings and other structures arising from design and construction and extraneous sources such subsidence, explosions, quarry blasting, et cetera.
In terms of professional qualifications, I am a Royal Academy of Engineering visiting professor of engineering design at Queen's University Belfast. I am

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a fellow of the Irish Academy of Engineering. I am a fellow of the Institution of Structural Engineers, the Institution of Civil Engineers, the Institution of Engineers of Ireland, and the Institution of Highways and Transportation, and also the Association for Consultancy and Engineering. In addition to that, I am a member of the Association for Project Managers and I am a member of the Academy of Experts.
I am currently senior vice-president of the Institution of Structural Engineers, and God willing, in 2020 will be their 100th president. So I look forward to visiting Hong Kong next year on the annual visit.
I am also the current chairman of the engineering leadership group in the Institution of Structural Engineers, which is their overarching technical committee. I am also on the editorial board of the journal of the Institution of Structural Engineers, which is called "The Structural Engineer". In fact I joined it way back in 1993 and have been on it ever since and served as chairman from 2000 to 2011.
Finally, in respect of my professorship, you will be pleased to note that I do not intend to give the class a lecture this morning, but rather, as I do at university, to bring some practical engineering experience and judgment and indeed a bit of technical

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common sense, as I call it, to the table, primarily to assist the Commission by focusing on the relevant issues and breaking down complex technical material into easy-to-understand concepts.
I would just like to stress, I am not an academic, I've never been an academic, and really I never want to be an academic, and no disrespect to the other experts who've gone before me who have been higher up the batting order, but I say that to emphasise that I have lived and breathed structures all my professional life, and as a result probably know a little bit about how they behave and work in practice.
One point I want to stress: very often, a structure is still standing even though theoretical calculations suggest that it should have fallen down. There are two reasons why this may be. Firstly, most structures will have reserve load capacity in varying degrees. Secondly and more significantly, the discrepancy will always lie in the calculations and more so the assumptions underpinning the analysis.
One of my older practice partners many years ago, he was a very experienced but a very practical and yet a brilliant structural engineer, one day he was embroiled in an argument with Building Control -- in your jurisdiction it's called Buildings Department --

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and they were giving him a hard time on a minor item of code compliance. John looked at them sagely over the end of his reading spectacles and then came up with the immortal words: "Gentlemen, the building does not know which code it was designed to, and no one will be any the wiser unless it falls down."

With that, could I have my first slide, please. It goes without saying that I would encourage the Chairman and Commissioner to feel free to interrupt me if something is unclear in my summary evidence. It's very important, I feel, that there is no ambiguity in what I am about to say.

So the second slide. No pun intended but two issues need to be decoupled and then prioritised. The first one: are the works safe in accordance with the Commission's terms of reference? And here the consideration I put to you is whether or not failure might or will occur. If the evidence is clear-cut, a definitive opinion can be given rather than just one premised on the balance of probability.

A secondary issue then is that of serviceability and durability, et cetera. Here, the consideration is whether or not the completed works will be able to function as intended, without causing distress or damage to itself. My understanding is that this is a secondary

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issue in respect of the Commission's terms of reference and has been more thoroughly investigated and actioned under the remit of the holistic proposal.

So we need to be clear about what we are dealing with today. Let I say a few things by way of introduction, and this really governs the approach I took to writing my expert report. Number 1, it is a fundamental principle of forensic engineering that one needs to understand the bigger picture before focusing in on the detail, and in this case one needs to know how the overall structure behaves before the criticality or otherwise of its components can be determined. That's a key point.

My evidence, therefore, as contained in my report, begins with an explanation of how the extension structure, principally the D-walls, diaphragm walls, the EWL slab, the NSL slab, et cetera, were designed and constructed, including the temporary works. And you've heard a little bit about that from some of the other experts.

In conjunction, I take into account the Hong Kong Codes of Practice and other performance specifications which govern the design. Then I outline the research, and that includes practical experiments which were carried out in respect of the couplers and threaded

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starter bars which is where this whole Inquiry focused and began and was in fact precipitated.

The invasive investigations are a work in progress, and since opening-up began I have reviewed the results on a daily basis, as have the other experts, and to that topic I will return in a moment.

In that context and in accordance with my brief, I then deal with three principal issues. Firstly, the reserve load capacity of the overall structure and its components, otherwise referred to as utilisation which is a term you have heard frequently. I call it reserve load; others have called it spare load capacity. It's all the same thing. That includes the recently issued COWI report, which corroborates the findings of Arup, who in turn have corroborated the work of Atkins, and the COWI report yields even lower utilisation values, which equates of course to a greater reserve of strength.

Secondly, the criticality or otherwise of the defectively coupled connections.

Then the third principal area I look at: the as-built amended detail of the junction of the EWL slab and the top of the east D-wall.

To these I will again return in a moment.

I also deal with miscellaneous workmanship and

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buildability issues, but not in much detail because, as you have already heard, these are all deemed to be reparable using normal techniques. These defects of course include the slab soffit spalling and honeycombing/voiding, they include, for example, the misaligned shear links, gaps at the tops of the columns and piers which were retro-constructed to support the EWL slab.

And can I stress for the Commission's benefit, these are not safety issues. These are the secondary serviceability and durability issues to which we have made reference.

I then comment and give my opinion on MTR's government-approved holistic proposal and also on the load test which was proposed. I recommend instead that performance monitoring using more sophisticated instrumentation be implemented, even though we do not expect any meaningful results. It's more a calming measure in terms of public concerns about the safety of the works.

In respect of the opening-up works, there have been a few rogue examples of coupled connections uncovered, and for reasons I will explain, the one recorded in the bottom of the EWL slab at the east D-wall -- and there is another at the west D-wall -- is however of no

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structural significance. Neither is the one which was found to be unconnected. I'll explain why.

The one recorded in the top of the EWL slab, however, could be critical, is of structural relevance, and the situation, although in my opinion unlikely to prove problematic, will need to be further investigated and checked.

COMMISSIONER HANSFORD: Sorry, just to interject on that point -- that one will need to be further investigated/checked and potentially require some remedial action; is that right?

A. It may not. As Dr Glover has indicated, phase 3 of the holistic approach will be -- on the basis of all the evidence uncovered will be to do a re-analysis of the whole structure.

COMMISSIONER HANSFORD: Yes.

A. Because of the high levels of reserve strength, et cetera, it may be that it's just passed by, of no relevance; okay?

COMMISSIONER HANSFORD: Okay, thank you.

A. The one point that has not come out in all of this -- well, someone mentioned it but I will stress it -- the top of slab situation where couplers have been used, applies to a very limited number of panels, in fact ten if I'm correct.

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Those are the only ones that were constructed with D-wall couplers, or coupled to the D-wall with couplers, if you like. The greatest majority of the panels throughout the works on the east D-wall are connected using through-bars.

So I'm pausing for emphasis here to let the message deliberately sink in: the top of wall coupler installations are only -- and I stress "only" -- safety critical in those ten panels. We must keep that in context.

I move on to the phased array ultrasonic testing. The results themselves are extremely difficult to interpret. I would refer you -- you don't need really to refer to it and it's too small to put on the screen -- I would refer you to the spreadsheet which has been circulated. You will probably need your A3 hard copy if you want to refer to it.

What I've done: I've simply reorganised the data into the relevant groupings, and as you will see a more meaningful picture is beginning to emerge. Has everybody got those?

COMMISSIONER HANSFORD: Thank you.

A. How can readings have a tolerance of plus or minus 3 millimetres and yet be given to two decimal points, I ask? Dr Glover explained yesterday how the external

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measurement is rather crudely done by marking two lines on the bar and then using a simple tape measure. What's wrong with using, for example, a calibrated vernier with a much higher degree of accuracy? So to me, as an engineer, it does not inspire a lot of confidence in the accuracy of those results.

Then how can one or two results, for example, test 44 be greater than 49 millimetres, bearing in mind that the bar end length is only 48 millimetres? Does that mean, for example, that when the tolerance is added on, the bar could actually be 52 millimetres? I simply make that point facetiously because I'm making a point.

I've not attempted to analyse the table but the variability and inconsistency is there to be seen, and the results are very much open to interpretation, and Chairman and Commissioner, if I may be so bold as to give my opinion: these results are potentially unhelpful and misleading to the public at a time when public concern needs to be alleviated pending the outcome of this Inquiry. I pause for effect.

COMMISSIONER HANSFORD: We understand.

A. The table shows, for example, using my groupings, 46 of the 70 results have an average thread engagement exceeding 39 millimetres. A further 32 have an engagement length, according to these results, of

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34 millimetres, and what is possibly striking is that 58 out of the 70 results have 0 to 2 exposed threads, which is what one would expect to see during a site inspection.

Can I just explain, sorry, that when I've calculated the figures used on the spreadsheet, where it's say 0 to 1, I've given the benefit and taken the more conservative figure of the average, so I've taken half a thread where it says 0 to 1. Where it says 2 to 3, for example, I've taken 2.5 threads instead of going to the 3.

Then if you look at the 0 to 3 exposed threads, there are actually 68 out of 70, and it would not be unreasonable, in my opinion, on site for an inspector to look at three threads and say, "That looks about right".

And then of course only two exposed threads in the 3 to 4 millimetre range, only two out of 70, and I think that speaks for itself.

Another thing, the phased array ultrasonic testing readings do not generally give to me any indication that the threaded bar ends have been cut, because if you look at the spreadsheet the average bar end length average values exceed 42 millimetres. Dr Mike Glover has already explained, and I take it from what I've listened to him, he's a bit of a psychologist as well: it would

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be incongruous to believe that anybody would actually take the end of the bar and cut two threads, even three threads off it, and then put it into a coupler, because they are not saving time. In fact, they are more than doubling the length of time it would take to complete the installation.

Then the results also show -- and this is just an interesting little point which I cover in my report -- that uncut type B bars have also been used in lieu of type A bars, which perhaps supports my opinion on the famous or infamous photograph which you find at D1/228, found at page 45, paragraph 108 in my report -- I don't think that bar or that picture is indicating that a type A T40 bar has been cut, because a type A bar starts off with 10 to 11 threads and the one you see in the photograph has 13 threads, so if it has been cut then it must have been a longer bar to start with.

COMMISSIONER HANSFORD: Perhaps when we get to your report, which I'm sure will be later this afternoon, we can look at that.

A. Thank you. I have set the marker, as someone has previously said.

Could we move on to the next slide, please. If a coupled connection is in tension, as in the top of those ten panels that I have referred to, and only the

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top of those ten panels -- I'm ignoring the fact that there is the NSL slab at the moment, and for it, it would be the connections right at the very bottom of it would be in tension, the couplers -- a 60 per cent thread engagement, that is six threads, gives a safe result, as demonstrated, for a fully stressed rebar.

It must be highlighted again, however, that the actually working stress levels in the EWL slab and rebar at the D-wall connections -- and this is based on the low utilisation rates which you have heard so much about -- those stresses are relatively low. That means that the 60 per cent coupler engagement, or what we're talking about really is the rebar threaded into the coupler to 60 per cent or six threads, becomes an even safer test result and an even safer criterion.

There has been a lot of criticism and debate in this forum about the fact that apparently only one sample of each partially threaded bar was tested to failure.

I need to explain something here by way of background which no one has touched upon yet. That is basically to describe how the threaded bar end has been prepared by BOSA. The bar end is initially crimped. It is put into a machine with huge pressure which effectively squashes the ribs, and in effect that, for any of you that know anything about mechanical

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engineering, and I'm not an expert, but that process actually, in squeezing the end of the bar, it's called a process of strain hardening, which actually increases the strength of the bar overall.

Then, unlike some of the cheaper installations that use to come out of China mainland, and I don't say that by way of any disrespect, the threads are not cut. The threads are actually -- again, using a high-pressure machine, they are actually rolled. So the end of that bar is, if you like, reworked under very significant pressure to actually produce rolled threads.

The key thing to remember here from the BOSA tables is that the root diameter, that's not at the tip of the thread but at the valley, the root diameter of the thread is 40.5 millimetres, compared with the nominal diameter of 40 millimetres of the bar itself.

That means that the type T2 or the type 2 coupler is always going to be stronger than the rebar that is inserted into it, even if fully engaged.

Let's return to the BOSA CASTCO test, experimental test. There has been criticism that the results are dubious and do not tally with the predicted results based on the fact that apparently only one bar was tested. I do not accept that. Remember, please, that it was not the coupler which was being tested. It was

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the coupler assembly comprising the coupler and rebar that was being tested -- and I stress -- for different degrees of thread engagement. It wasn't about testing the coupler. It was about testing how the rebar would survive in terms of partial engagement.

Just to encapsulate that, at 60 per cent engagement the coupler held and the bar broke. In other words, the bar was the weakest link, as intended. At 70 per cent engagement, the bar was still the weakest link, and increasing the thread engagement was never going to increase the load at which the bar broke, very importantly. So the bar broke again. Likewise, at 100 per cent, the bar was still the weakest link and it broke at approximately the same load as the other two.

So the point I'm making is the coupler stayed intact for 60 per cent, 70 per cent and 100 per cent, and it was the bars each time which broke. So although not the ideal nine samples that Dr Glover has been mentioning, we have in fact three samples. And if you wanted to, and I'm not proposing we take the time to do it, if you call up Prof Yeung's very helpful graph which showed the experimental results versus the actual, you will actually see in that horizontal band which he has drawn those three, if I remember correctly, hollow circles that he has drawn. Those give you three sample results

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for a bar. So please don't tell me that there was only one sample tested. And those three bars actually broke at an average or a mean value at 864 kilonewtons, which equates to 67 megapascals.

Actually, Prof Au's record, when asked, he helpfully confirmed -- and you will find this, if you want to, I'm not proposing you turn to it, but the transcript of Day 41, page 28, lines 9 to 15 -- that a minimum of three samples was deemed to be acceptable. I put it to the Commission that the test is therefore reliable. Dr Glover has given his opinion on that.

So what about the other two coupler tests demanded by the QSP, for example, the quality supervision plan? The permanent elongation test relates only to serviceability. I stress again, if you keep my opening slide in context, it's not a safety issue, it's simply a serviceability issue, and we have to, again pardon the pun, decouple both of those.

To put it into context, what 0.1 millimetre looks like -- and I wrote my script before I heard Dr Glover; he likened it to the width of a human hair -- it's actually less than the width of a sheet of normal paper. That's the width of crack you're talking about if it were to form.

The rebar working stresses are relatively low

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because the utilisation is low and you've heard that to effect the elongation test, you actually have to stress the bar up to 0.6, if I'm not correct, of its characteristic value. So that's quite a large level of stress. The bars in this installation are working nowhere near to that level.

COMMISSIONER HANSFORD: When you say you have to stress it up to 0.6, if you are not correct.

A. I'm going from memory, sir. I'm merely sure --

COMMISSIONER HANSFORD: You mean if you're correct?

A. Yes, the --

COMMISSIONER HANSFORD: What if you're not correct?

A. The elongation test, from memory, is 0.6 of the characteristic --

COMMISSIONER HANSFORD: Sorry, Mr McQuillan, I may be picking you up on a little bit of Irish there, because you said "if I'm not correct". You meant if you were correct, did you?

A. All right. I was expressing doubt, sir, as to whether I was remembering 0.6 correct, whether it's 0.6.

COMMISSIONER HANSFORD: Now I understand.

A. The point I'm simply making is that to perform that test, you stress the bar to a fairly high level, and because of the utilisation values in this job, the bars will never be subjected to that level of stress, so they

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are never going to strain to 0.1 of a millimetre.

COMMISSIONER HANSFORD: That's clear.

A. Thank you. Then even if such cracking were to take place on site due to elongation, Dr Glover has explained that the tests are done in the open. When the couplers are encapsulated in concrete, they don't actually behave that way, but even if 0.1 millimetre were to occur, that cracking would be evident, and you've heard from the other experts that they have inspected the structure, like me, and to me, I have seen no evidence of any cracking.

The other thing to keep in mind is that even if cracking did occur, it's in a dry environment, and so it doesn't become a durability or a serviceability issue. Might I say, every structure, every house has cracks. It doesn't mean that they give any rise for concern whatsoever.

So I'm suggesting that elongation testing and partially threaded coupler assemblies is not really relevant in context.

That brings us to the issue of the cyclic loading test, and I think there has been a good deal of misunderstanding on this point. It's not a matter of subjecting the coupler assembly to a fluctuating load, as occurs with any structure and which will occur with

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the passage of trains. Rather, it's very important to point out that it involves load reversal. So it's not a matter of the stress going from A to B and up to C and down to A again. What we are talking about here is the bar is being subjected to alternate cycles of compression and then tension. So you are pulling the bar, then you are squeezing it, and then you are pulling it again and then squeezing it again, and then you take it to destruction.

So, you know, to me, as I understand it, this is a test against fatigue failure. Let me explain the concept of fatigue. If you take a wire coat hanger, I don't know if you have them anymore, but if you go into a laundry or a laundrette, they will give you your shirt back or whatever it is sometimes on a wire coat hanger. If you take that wire coat hanger and simply bend it back and forth, bend it back and forth, there comes a point when all of a sudden it snaps. That's called fatigue failure. It occurs when the specimen is subjected to first of all compression and then tension, compression/tension, so it's not that the stress is fluctuating, it's actually reversing.

Again, it needs to be highlighted that for the 3 metre thick slab -- I'm going to stand here -- I'm just under 2 metres tall, so put another half of me on

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top, that's 3 metres. It's a huge, enormous slab. To experience that sort of load reversal, that huge, thick slab has to bend upwards against its own self-weight, and that simply will never happen. Please do not try to tell me in theory that it might.

You have heard Dr Glover's evidence that underground structures have proved to be little effected in seismic events, and in addition I again stress that the levels in the rebar are relatively low and will never approach yield value.

So in relation to the coupler issue the arguments of whether or not 60 per cent is an acceptable criteria are therefore irrelevant from a structural perspective.

I could use the 60 per cent criterion, but significantly, of the 14 tests done to date on the top EWL slab -- and I'm stressing again that's the only key area in which I'm interested from a structural safety perspective -- the lowest embedment is actually 80 per cent. So instead of just taking the minimum acceptance criteria of 60 per cent, which is six threads, I've actually just taken that lower-bound value of whatever it was, 32 millimetres engagement rather than -- sorry, of 32 millimetres embedment. So what I've done is taken off the two threads for the chamfer and I've ended up at my acceptance criteria -- sorry, it

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was 34 millimetres, if you look at the bottom, which I call the safe criterion, I took off the 2 millimetre thread and have ended up with 32, which I'm saying is 75, and very arbitrarily -- because the Highways Department have chosen theirs arbitrarily at 37 -- I'm just conservatively choosing my criterion, to make the point, of 75 per cent.

COMMISSIONER HANSFORD: But you are telling us, are you, Prof McQuillan, that it could be lower than that?

A. 60 per cent I'm quite convinced, for reasons already stated, is safe. I'm just making the point that to go a little safer, let's see what happens.

COMMISSIONER HANSFORD: At 75 per cent?

A. At 75 per cent.

Perhaps we could move on to slide 4, please. Remember I'm focusing here on the safety-critical tension bars and only the ten panels. Maybe the operator could scroll it down so we are just hiding the bit that says "compression".

Under the government criterion of 93 per cent, those safety-critical bars -- leave it like that; we have made the point -- the government are only experiencing two failures in the 14 samples tested. Using my safe criterion, all 14 pass, and of course that means that the minimum 60 per cent criterion also passes. That

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of course is very good in context.

The one rogue value at the top slab has been discounted, because it is atypical, for reasons explained.

Then the table also shows that up to 14 January this year, for couplers in compression, but they will be deemed to be in tension for code compliance -- we will come to that in a moment -- on my conservative estimate, 55 pass and five fail. On the minimum criterion, 59 pass, one fails. But the government's very conservative value, they get this 50 per cent failure ratio, that's in the compression couplers, and you can see the tally, the total, at the bottom.

Now, if I were to include the results of 16 January which arrived too late for my script, just keep an eye on those figures on the chart, on my conservative 75 per cent criterion, this time it's 60 pass and five fail; on the minimum criterion, 64 per cent but one fails; and on Highways Department criterion, 43 pass and 22 fail.

I'm not a betting man but if I was, I would put a bet on the fact that the more results become available, it will only get better, from my perspective.

I'm nearing conclusion. My evidence concludes that the structures have a high reserve capacity and are

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generally only working at less than 50 per cent, as you've heard. In such situations, workmanship and other minor defects tend not to be of any structural concern, safety concern. Under normal loading, the zones at the bottom of the EWL slab -- and of course, as I've said, that applies to the top of the NSL slab -- so at the junction with the D-walls, those connections or those zones are always in compression.

Maybe we could turn to my famous slide 5, please, which has already been used. So what we're looking at, at the bottom left and bottom right, are what I call the slab bottom compression zones. Bear in mind this slab is never going to reverse, the stresses are never going to reverse, so those zones are always and only going to be in compression.

From purely a structural performance perspective -- and by that I mean catering for bending and shear -- in the EWL slab, no rebar is therefore required at the bottom, where it interfaces with the D-wall connection. You could sever the reinforcement and the slab would still carry the load as intended. It wouldn't exceed its bending capacity; it wouldn't exceed its shear capacity.

So it follows, therefore, that if no rebar is required from a structural performance point of view, in

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that zone and across the interface, then no couplers are needed. This is a very key message. In other words, every coupled connection in that zone could either be defective or missing. And again I'm pausing to let that sink in. You don't need any couplers there for the slab to perform structurally.

However, there is the question of code compliance and we must never forget that. The code requires that some 50 per cent of the rebar -- requires 50 per cent of the rebar continuity across the interface from the slab bottom into the D-wall. It also, therefore, follows that only 50 per cent of the coupled connections could either be defective or completely missing. Let me repeat that by way of emphasis. To comply with structural safety and slab performance, you need zero connectors running across that interface, you need zero couplers, but to be code compliant you need 50 per cent of what's there at the moment.

Bearing in mind that those couplers are always in compression, the ones that are there, and you've seen the results, it speaks for itself.

I would also make the point, and it already has been made, that there is an over-provision of bottom steel reinforcement. So even though at the moment there are three or four layers carrying through, it only -- it

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could have been a lot less, actually.

Could we move on to slide 6, please, and we are starting our sequence now on the as-constructed top of D-wall detail. Again, I concur with the opinion that you've heard from at least two other experts that the amended as-built connection at the top of the EWL slab and east D-wall is as good as, if not better, than the original detail in terms of both the amount of tension rebar and also the ease of construction.

I want to make a very important observation here. The connection has to be in equilibrium, otherwise it fail. It would have failed previously if it wasn't in equilibrium. It's a basic scientific principle and one that is not easy to grasp. We are all sitting on chairs at the moment. The fact that our backsides are not on the floor is because the chair is in equilibrium. It's simple. We are all moving from hip to hip, backwards and forwards when we stand up, we are subjecting the chair to different internal stress levels. But it doesn't collapse because the whole system is in a state of equilibrium. I hope that message has filtered through.

This connection is performing as intended, otherwise it would have failed. So although U-bars were not installed in the top of the D-wall, it should be noted

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that the vertical D-wall or rebar still remains and projects through the CJ interface as shown.

Next slide, please. This shows one of the very first photographs that we witnessed. I think this one was on the 19th, and I obviously took that one. It's at the top of the EWL slab at location E44, and please ignore the fact that couplers are shown here; it could equally be through-bars.

It's an interesting photograph, I'll diversify for a moment, because the one rogue bar, as we call it, on the top, as shown on the left, where nine threads are shown, and you will see quite obviously from the shininess that they were damaged. So the implication is that they must have been pouring concrete and they couldn't get this one screwed in and so they just left it. That's my explanation.

It also, by way of diversification, shows another interesting feature. You will see at the bottom two of the lapping bars, and they are actually stopping short of the inside wall of -- the inside face of the D-wall, and what you are seeing -- and we will go to the next photograph, please -- are three of the near wall of the diaphragm wall, you are seeing three of those vertical bars. Those actually appear to me as being T50 bars and they are at 150 centres.

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What you can't see, obviously, are the multiple layers of vertical bars sitting further back at the outside face of that D-wall.

Next slide, please. This is a schematic of what the blue concrete tries to do, and those of you who have read my report will note the IKEA analogy, the IKEA furniture analogy. The concrete block in blue is trying to rotate because of the imbalance of the loading, is trying to rotate off the top of the D-wall. Prof Au has explained this in a different way using his free body diagrams, and likewise Mr Southward came at it and he had a different way, but this to me is logical.

Next slide, please. However -- and this I think is a criticism of some of the other ways of looking at it -- the EWL and OTE slabs are locked into the D-wall by virtue of their bottom rebar. So you see the continuity of the bottom reinforcement in each of those slabs locking into the very intense reinforcement cage of the D-wall.

So those two, that block of blue, cannot rotate because in order to rotate, the right-hand slab has to try to lift and the bottom slab has to try to go down as per the previous diagram.

Next slide, please. The bottom -- the block of concrete sitting on top of the D-wall -- the interface,

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by the way, represents the construction joint -- the block of concrete is effectively locked against sliding sideways. It cannot slide, unless of course you shear the vertical bars or the bearing pressure between the bars and the concrete becomes really excessive, in which case the concrete block would burst.

So what's happening is, because that block is locked, the two slabs, if they were not reinforced, would try to rotate as shown, and tension cracks would develop at the two upper interfaces.

Go to the next slide, please. That is prevented from happening by virtue of the fact that the top rebar pulls the whole lot back and prevents the two independent pieces of slab from trying to fall apart. What I'm really drawing attention to is the fact that the vertical rebar is acting as a dowel, to prevent this sideways slippage of the blue block sitting on top of the red block. Very helpfully again, I'm quoting Prof Au -- you don't need to turn to it but the reference is transcript of Day 40, page 145, lines 16 to 21 -- he actually proposed the retro-installation of dowel bars, vertical dowel bars, as a remedial measure to prevent the sliding happening if he found the shear stresses were excessive.

So I put it to the Commission --

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CHAIRMAN: Sorry, if he found the shear stresses to be excessive -- his first way of determining that would be by way of mathematical calculation --

A. Yes.

CHAIRMAN: -- in terms of the systems that he will or has proposed?

A. Yes, and then if he found those stresses to exceed the permissible levels, he recommended that one way of remediating that would be to retro-install these vertical dowel bars. So I'm putting it to the Commission that there are ample steel dowel bars already existing to resist the potential for slippage across that interface, in other words the construction joint. I put it to you that there is therefore no residual concrete stress at the CJ interface.

COMMISSIONER HANSFORD: Does it therefore follow that if Prof Au's calculations were to show the need for dowel bars, they are already there?

A. They are already there. That's the point I'm making. You have this single layer in the front face and I think there's three layers in the back face.

COMMISSIONER HANSFORD: Yes. Consequently, if his calculations demonstrate that there's a dowel action necessary, there's no remedial work required because it's already there?

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A. Correct.

COMMISSIONER HANSFORD: Thank you.

A. What I understand his calculations are not doing is taking into account the dowel effect of the rebar in the bottom of each of those slabs locked into the D-wall to prevent them from lifting. So the only way -- I know it's a difficult concept to understand -- that the block of blue on top of the D-wall can be subjected -- or the interface can be subjected to any type of stress is if the rotational movement actually begins to occur.

So you could get -- if we could go back to the previous slide for a moment. What would happen, that little block of blue -- and I'm pointing at a screen that's not meaningful, but at the right-hand side, it would try to lift, the left-hand side adjacent to the EWL slab would try to compress, and so the concrete at that little corner of the red bit would be subjected to high compressive stress, which is I think what he's talking about, and of course it would try as it's lifting to try to slide on the interface as well.

COMMISSIONER HANSFORD: Yes.

A. So the secret is you've got to hold down that block.

Now, the point has been made during cross-examination that there is not adequate anchorage length in the right-hand bar to prevent the blue block

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lifting at that side. Well, go to my next and then the next slide, please. That one, which is the famous one you have seen as well.

What I'm putting to you is that that blue block, adequately reinforced, is actually being held down by virtue of the horizontal dowelling, it's prevented from doing anything sideways by virtue of the vertical dowelling, and therefore I'm using the expression the top of the D-wall is actually capped. "Encapsulated" would be a better word. Prof Au misinterpreted that, using a different concept we use in structural engineering, and he thought I was referring to the need to post-tension it, which is actually inducing compression into it, to hold it together.

Okay. It again needs to be emphasised that the EWL slab, by the way, has a dead to live load ratio of approximately 90 to 10. So 90 per cent dead load that it's already been subjected to. And in fact, as Dr Glover has emphasised, the situation is now actually better, because originally the big 3 metre slab was free-spanning. Now, because internal walls and piers have been introduced which are taken down to the NSL slab and hence into foundations, the situation is actually vastly improved and I think we mustn't lose sight of that fact; it's even safer.

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It has been functioning now for some three years, and it's even carried trains under test conditions, under commissioning. If it was going to fail, it would have already failed, is my postulation, and if the internal stresses are so high as claimed, there would be signs of distress and cracking very evident. No sign of slippage or bearing overstress, by the way, was evident in the photographs we saw and in the actual site inspection at location E44.

You'll pleased to know I'm on my final page. On the basis of that, I also put it to the Commission that this call for calculations is therefore both pedantic and unnecessary. It has been apparent that the two experts who have gone immediately before me are of the same opinion. It reminds me of the quip: if you ask an accountant what is the result of 2 plus 2, the answer that the accountant might give you, "What would you like the answer to be, sir?"

COMMISSIONER HANSFORD: I used the same quote to the Chairman earlier, but I actually used the term "a management consultant" rather than an accountant. But I think it's the same.

A. We can group both breeds together for the purpose.

I know it sounds a little bit flippant but the point I'm trying to make is it all depends on the assumptions

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you make and that's how I started my presentation today.

You have all understood or begun to understood a little bit about the complexity of this joint mechanism and also the complexity of the arguments which I don't even pretend to understand in full. So I put it to the Commission even more importantly that if the Buildings Department -- if the government feels that this is an issue they have to put to bed, if they seriously doubt the safety of this connection -- and none of the rest of us do -- I suggest that they bite the bullet and instead of going endlessly in circles, issuing calculations and the rest of us trying to review them and analyse them, let the government commission a proper finite element modelling analysis of this joint. That's the only way it's going to please everybody, it's the only way it's going put the issue to bed, and because they are the ones with concern, let them pay for it.

Personally, I consider it to be a complete overkill and a total waste of resource, and I'm happy to declare my opinion is the connection is safe.

Next slide, please. My summary conclusions. The structures as-built, despite the specific coupler non-compliance issues and the more general workmanship defects, are safe and overall structural integrity has

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not in any way been compromised. That is the key message.

Next slide, please. Moreover, code compliance has been met in terms of the serviceability requirement.

Next slide, please. Based on the test results to date, it is highly unlikely -- in fact I would even score that out now and I would write it is highly improbable -- that further opening-up will alter my opinion.

The last slide, please. However, I feel very strongly that public safety concerns should or might be allayed by performance monitoring. I have already explained that because of the juxtaposition of the structure and the railway lines running on it and all those things, and the fact that it has already been significantly loaded under deadweight, we do not, as experts, anticipate that any meaningful results will arise out of this monitoring. But I think to tell the public that it's there and being done and to let them know that we don't expect a great degree of significance in the results, I think that is as much as we can do or the Commission or the government can do to try to alleviate public concern.

COMMISSIONER HANSFORD: And that point on structural monitoring I think is common amongst the experts, and

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I think the point about -- the caution, if you like, with any structural monitoring, being clear that no movement is expected to be shown has been made very strongly by Dr Glover already.

A. I think I also press the message home that if the government persists in carrying out a load test, I think again it's a total fallacy and waste of resource. I think this is a much more effective way of dealing with it, and I opine that in my report.

So that concludes my summary evidence. Thanks very much for listening.

CHAIRMAN: Good. Thank you.

MR PENNICOTT: Sir, I just have one question or one small topic that I wanted to discuss with Prof McQuillan. It won't, I think, take more than a couple of minutes, and it might be probably fair to everybody else if I finish the examination-in-chief, as it were.

CHAIRMAN: Yes.

MR PENNICOTT: So that if anybody wants to pick up on this last point -- it is actually something that Prof McQuillan touched upon in his presentation and Prof Hansford posed a question but without going to the photograph itself.

Prof McQuillan, in paragraph 108 of your report, that's at page 44 of your report --

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COMMISSIONER HANSFORD: Ah, yes.
MR PENNICOTT: -- you make mention of the photograph at D1/227 and 228, the photographs at those pages -- just in case nobody else asks you about it, I'll ask you about it -- you have appended, and I don't know if this is good enough, at appendix IX of your report, that's at page 107.
Prof McQuillan, can you just explain by looking at the photograph and I think the annotations that you have put on there the point you are seeking to make?
A. Yes. It's quite simply this. The allegation has been made that that demonstrates that a T40 type A bar was being cut. First of all, the point I'm making is that a type A rebar has only 10 to 11 threads. The other point I'm making is that the blade of the band saw, the hacksaw, is actually below the level of the axis of the bar and even the bottom of the bar. So it demonstrates to me that if the bar has been cut, it has already been cut, it's not about to be cut, and it has to mean, by implication, that that is a type B rebar, T40, which has 20 threads on it, and for some reason, whatever reason, someone has actually decided to cut it to use it for a different purpose.
So my postulation is that it has been cut from 20 threads down to 13. It cannot have been a type A

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rebar which only starts with 10 to 11 threads. Have I made my point?
MR PENNICOTT: Yes, you have.
COMMISSIONER HANSFORD: And while you are there, in your paragraph 108, you go on and you say --
A. Could we have that back, please?
COMMISSIONER HANSFORD: Yes. I think that last phrase of your paragraph 108, perhaps you'd just like to explain that as well. At the top of the page --
A. Is that at the top of the next page, 45?
MR PENNICOTT: That's it.
A. Yes. So what I'm saying is if that was going to be used, for example, to be screwed into a normal coupler, there would be no structural compromise, because you would have more threads showing than normal.
But I was actually here in the back room listening to Mr Paulino Lim giving his evidence. He was stressing that it's not in accordance with their quality procedures. That's the only point I make.
COMMISSIONER HANSFORD: I think what Mr Paulino Lim said -- and of course we can go back to the actual words -- was that it's not recommended but nevertheless it would not cause a problem.
A. Okay. Then he's concurring with what I just said.
COMMISSIONER HANSFORD: I can be corrected on that if the

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transcript says something slightly different.
A. I think you are correct, sir, because I have taken the same meaning from what he said.
COMMISSIONER HANSFORD: Thank you.
MR PENNICOTT: Sir, that was my only point. So after lunch, I think it's just -- certainly the government and China Technology, and Leighton, who wish to ask Prof McQuillan some questions.
CHAIRMAN: Good. Sorry, give me -- it's government, China Technology and Leighton?
MR PENNICOTT: Yes.
MR SHIEH: We will reflect on whether we now still need to ask any questions, given the very helpful presentation by Prof McQuillan. So there's a real probability that we won't be asking anything.
CHAIRMAN: Thank you. And Mr Chow, could I ask you?
MR CHOW: Sir, at the moment I'm thinking about close to one hour of questioning, because I need to clarify with Prof McQuillan on a few aspects.
CHAIRMAN: Good.
Yes?
MR SO: Sir, I would be very surprised if I exceed 30 minutes, but of course it's subject to what Mr Chow has, what transpires.
CHAIRMAN: So we are looking at probably two hours.

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MR PENNICOTT: Sir, on that basis, I think we can probably take the lunch break until 2.15.
CHAIRMAN: All right. So we will adjourn until 2.15, on the basis that if we are going to overrun a little, we already have a warning order for 6 o'clock.
MR PENNICOTT: And Prof McQuillan will be given the usual --
CHAIRMAN: Yes, Prof McQuillan, please forgive me. I didn't mean to leave you stranded either. Of course, now that you are giving evidence, you are not entitled to discuss that evidence until it is completed.
WITNESS: Fully understood.
CHAIRMAN: -- with any other third party.
WITNESS: Understood, sir.
CHAIRMAN: Thank you.
(1.08 pm)
(The luncheon adjournment)
(2.18 pm)
MR BOULDING: Good afternoon, sir. Good afternoon, Professor. I am happy to say I am now happy to respond to Prof Hansford's query relating to MTR's proposed testing programme.
The intention is to carry out a testing programme the objective of which will be to establish fitness for purpose as opposed to code compliance.
The intention is to carry out nine tests on

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60 per cent engagement of the rebar into the coupler, and the proposed timetable is as follows.

The testing procedure is currently under development, but on or before 28 January the intention is to issue the test proposal to Highways, Railway Development Office and government, for review and comment. It's hoped that they will come back quickly so that the test proposal can be finalised by 31 January; that's the ambition. On that basis, on 1 February, the tests will be conducted in both the MTR laboratory and an independent laboratory, and government will be invited to witness the tests. On that basis, it is anticipated that by 4 February 2019, the tests will be complete and the laboratory test reports on those tests available.

I hope that has answered your query, Professor.

COMMISSIONER HANSFORD: It has, thank you very much. Just a clarification. You said in MTR and an independent laboratory. Does that mean some in one and some in another? It may be a detail I don't need to know.

MR BOULDING: Those behind me will have heard that and no doubt I will get another note.

COMMISSIONER HANSFORD: Actually, I'm satisfied with the answer.

MR BOULDING: Thank you.

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MR PENNICOTT: At some point, not necessarily now, perhaps Mr Boulding could take some instructions on whether the tests are being done on a 460 or a 500 bar.

COMMISSIONER HANSFORD: Yes.

CHAIRMAN: While we are on that subject, will we learn whether what was actually installed were 460 or 500? Because I still remain a little confused as to --

MR PENNICOTT: Yes.

COMMISSIONER HANSFORD: We think that's a question probably for Leighton and possibly for Intrafor, don't we?

MR PENNICOTT: Yes. Obviously the two parties can speak for themselves. It is the case that Intrafor have given us some further documents, not many, I hasten to add, just one or two documents, which suggest, so far as the rebar in the diaphragm walls is concerned, certainly the requisition orders that I have seen -- there are only a couple of them, not very many -- refer to 460.

That of itself is perhaps not definitive but it's certainly an indication.

CHAIRMAN: Of course.

COMMISSIONER HANSFORD: It's what they ordered.

MR PENNICOTT: It's what they ordered. Whether it's what they got or what they put in, I have no idea.

COMMISSIONER HANSFORD: Okay.

CHAIRMAN: Thank you.

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Yes?

MR SHIEH: Some questions from Leighton.

CHAIRMAN: Sure.

MR SHIEH: Can I just deal with the question about which grade of bars were used? We have been taking instructions but the reason why we have not formally responded is because, as the Commission will know, the period in question is a period of transition, and therefore there would be a good deal of people maybe thinking, "We thought we were doing it as per grade 460 but it may well be that 500 is really provided" and people would have to get down to not just by reference to what they think they are building but what in fact has been supplied, which is a different factual question, and we don't want to shoot until we are ready.

CHAIRMAN: Yes. Thank you.

Cross-examination by MR SHIEH

MR SHIEH: Good afternoon, Prof McQuillan, I represent Leighton and I just have a few questions to explore with you.

The reason why I ask these questions is because so much has been written or publicised about the incident in the station out there to the lay public, and this really is the first time that the public, and more importantly the media who report these proceedings to

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the public, have had a proper chance to hear from what the Commission's expert has to say.

I know you paused on numerous occasions for effect, obviously thinking that it is important that the message that you are trying to convey gets properly absorbed so that anyone who wants to report what you say actually understands what you are trying to say. This is what I am trying to do, trying to make sure that I have understood what you are trying to convey properly and correctly.

This morning, at transcript [draft] page 99 -- I don't think we need to turn it up -- but you said -- you referred to the results, the day-to-day opening-up results, that have been released, and in your words:

"... if I may be so bold as to give my opinion: these results are potentially unhelpful and misleading to the public at a time when public concern needs to be alleviated pending the outcome of this Inquiry."

Then you said, "I pause for effect".

Can I just suggest to you a few propositions as to why we believe that you are saying that the results could be misleading, and you can then maybe say whether it is a correct understanding or whether you have anything to add; all right?

By "the results", am I correct in understanding that

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they mean the results released regularly, on a daily basis, by the government as to the test results of opening-up released by the government?

A. Yes, because as I understand it the government issue a daily bulletin as well, and that is accessible to the public.

Q. Yes. The key points in that release of results would include the number of bars being examined, let's say up to a couple of days ago it was 75, for example. So the key data would be number of bars examined, it would include which location, it would include how many millimetres embedded or engaged -- for present purposes, I don't think we need to distinguish between embedded or engaged -- and number of threads visible on the outside, and also whether the government regards it as pass or fail by applying 37 millimetres pass criteria.

Will that be a fair summary of what you mean by "the results"?

A. That is correct, and I think, as of the latest count, we now have 80.

Q. Yes. Can I just suggest to you what I understand to be the misleading features in this way of presenting the results. First of all, it applied a pass benchmark of 37 millimetres imposed by the government, when, as you have explained this morning, if one were to apply safety

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or some other criteria as the benchmark, the pass mark could very well be different. That is one aspect in which the results could be misleading; is that a fair way of putting it?

A. That is correct.

Q. Because there is no magic in a figure chosen by the government. The government could well be too stringent in terms of safety; do you accept that?

A. I think their benchmark is too stringent.

Q. Thank you. The next aspect in which the results as presented -- and very often I daresay by the media and picked up by the politicians -- is that the results draw no obvious distinction between precisely which stress regions the bars are located, specifically whether or not the bars are located at a location where couplings are material or important or essential?

A. I think that is the vital message, the vital point, because if the results were presented in the form of my little table, it would become very obvious which are the safety-critical ones and which are the non-important ones.

Q. Non-important ones, I would repeat, would be the bottom mat of the east-west link, because design-wise and as a matter of physics, that part is always in compression, namely there would be no attempt by the D-walls really

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to pull out of the slabs or to disengage the D-wall from the slab?

A. You have understood that correctly, yes.

Q. I hope I put it layman-like enough for everyone listening to be able to understand it.

Another area where the couplings may not be material would be the west diaphragm wall; would that be correct?

A. At the same location in the bottom, yes, because, let me explain, they only occur at the bottom on the west side.

Q. Thank you. Of course we know that on the top mat of the east diaphragm wall, there are not many couplers left after the design change using continuous rebars?

A. That was the point I wished to emphasise in my evidence. It's only a limited number of panels.

Q. Thank you. And therefore blandly looking at total number of bars and looking at total number of fail rates, applying the government's stringent criteria, you say is not discerning enough and also too stringent?

A. Correct, but even on that stringent basis, as I pointed out, they only have recorded two failures in those safety-critical tests, out of 14.

Q. Thank you. Now, again, talking about the public, rightly or wrongly, the results as published by the government had been reported by the media and some politicians have picked that up. Without commenting on

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whether they are themselves trying to mislead or whether they have themselves been misled, it has been suggested by some public figures that the figures show that the whole station or whole slab has to be demolished, bound to be demolished. What do you think to that suggestion? You can be as frank and brutal as you want.

A. I have already stated my conclusion that the station is safe. Further results as they become available should support my view that they will continue to show an improvement in terms of the overall ratios, and as it stands the compression, the tests on the compression couplers, are completely irrelevant, and all we have to go on in the safety-critical zone is two failures, according to the government, out of 14, or as we say all 14 have passed.

Q. Thank you.

COMMISSIONER HANSFORD: Prof McQuillan, notwithstanding that, is demolition even possible?

A. It depends what one would have to demolish, because if you have looked at my report, at the diagrams of the way this was constructed, there was a significant amount of temporary works involved in getting down to construct the bottom slab. So to deconstruct a box structure of that magnitude would have to be a very carefully thought-out process and the temporary works implications

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would be very complex.
COMMISSIONER HANSFORD: And very expensive.
A. And very expensive. And if one tries to -- one would first of all have to dewater below the bottom slab, which means drilling through it, and that in itself is a major technical operation because of the water pressure.
COMMISSIONER HANSFORD: Yes. That's something I want to ask you about a little later. I won't interrupt Mr Shieh's cross-examination for that point.
A. But just to repeat, I'm of the opinion, I think two other experts are of the opinion, that all we're talking about here is simply standard remedial works on a job of this nature.
CHAIRMAN: I think also -- and I stand to be corrected -- but Prof Au himself was talking not about any need to destroy everything and start again but the possibility maybe of some extra reinforcing of critical points.
A. I think that's what he was saying. I think he also qualified his concerns about the adequacy of the connection. So if he can satisfy himself as to that connection -- the rest of us are satisfied -- well, then, there are no concerns, basically.
CHAIRMAN: Yes. While I'm standing -- I apologise; it's an excellent way of proceeding, thanks very much, it

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helps us -- but I just want to confirm, and I'm rather making a statement and asking you to agree or not to agree, and I think you will agree because you said it yourself earlier on, but it would be cold comfort indeed, I think, to the Chief Executive and to the government if we were to say as a Commission, "On a balance of probabilities, we are satisfied this is safe." That doesn't really help anybody. It's a bit like saying, "Well, it's a 51 per cent you'll be okay if you cross the bridge; on the other hand, it's 49 per cent you won't."
COMMISSIONER HANSFORD: I thought you were going to mention Brexit for a minute!
CHAIRMAN: But I think you start off by saying that what is required is a definitive opinion; that would be correct?
A. That's correct.
CHAIRMAN: This is your definitive opinion.
A. I think I was saying by way of introduction -- there are two options, you can either give an opinion based on the balance of probability, but it's much better if you can arrive at a definitive opinion, and in my opinion it is definitive.
CHAIRMAN: Good. Thank you.
Mr Shieh, sorry we have cut across you.
MR SHIEH: Prof McQuillan, some politicians, in fact it

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might be the same politician, suggested that different experts are putting forward different numbers as being the pass criteria. I think the analogy he used was it's almost like bargaining in the market. People pay experts to put forward different numbers, trying to whitewash.
What do you have to say to that, in respect of your opinion as to the numbers you have put forward?
A. I go back to this muddying of the waters in terms of just grouping all the test results together because to the layman that is a totally meaningless and potentially harmful operation. I think we've got to get the message across that there is a distinction between couplers in the safety-critical zones and couplers in the zones which are of no consequence.
Q. How about in relation to the pass mark, 37, 32 or 20-whatever; are you trying to bargain the government?
A. No, we are not. I'm actually endorsing the opinion of the previous two experts by saying that I believe -- and I've put forward the fact that we actually have three tests, three sample tests, to prove it. It may not be as good as nine, I accept that, but three is better than one, and one is better than none. So I'm quite happy to say that the 60 per cent threshold benchmark is perfectly safe and I've made the point earlier that

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because the stress levels in the rebars and the EWL slab are much, much lower than one would normally expect, we have an even greater safety margin.
Q. Thank you. Can I then move on to the next and hopefully final topic, and that is apart from strength, the other two parameters or qualities which experts or BOSA have been talking about, which require checking or testing also, elongation, and I think cyclic loading.
A. Mm-hmm.
Q. Again, trying to put things in as simple a way as I possibly can, am I correct to understand that in an ideal world, if you want a coupler assembly which can be used for all possible purposes anywhere in the world, then in theory you need to pass these two, but for the purpose of being used in this particular station in this particular way, these two tests are more or less immaterial?
A. I would almost have used the word "irrelevant" but your term is probably better, yes.
MR SHIEH: Thank you very much.
I have no further questions.
CHAIRMAN: Thank you.
Cross-examination by MR CHOW
MR CHOW: Good afternoon, Prof McQuillan. My name is Anthony Chow and I represent the government.

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Just now, you had a discussion with counsel for Leighton, Mr Shieh on the question of the passing mark of 37 millimetres; right? At the same time I recall that earlier, when you did your presentation, one of your slides sets out the various acceptance criteria, and I recall -- if I am wrong, please correct me -- that you referred to the 37 millimetres value as an arbitrary --

A. Can we just go back to it, just to refresh ourselves? I think it was slide number 3 or 4.

Q. Slide 3, yes. Right.

Do you know why the passing mark of 37 millimetres engagement length was taken at the moment as the acceptance criteria? Do you know the reason behind?

A. I was told that but it didn't -- actually, I'm a little unclear as to why, and I'm less clear about the 3 millimetres tolerance.

Q. If I may also for the benefit of the Commission and the public at large explain why, at the moment, the value of 37 millimetres is taken as the acceptance criteria for the present purpose.

The brand of the couplers that were used in this project is proposed by the contractor, Leighton, and through MTRC to the government. The government, on the basis of the documents received from MTRC, was advised

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by the manufacturers of the couplers that for a proper installation of the couplers that they supply, there has to be an engagement of ten threads, and the government, at the same time, was advised that on the basis of a pitch of 4 millimetres, a total of 40 millimetres engaged length has to be ensured for a proper installation of the type of couplers used by the contractor, Leighton.

Then, because of this matter, because of the publication of the possibility of impropriety in the installation of these couplers on site, MTRC and the government, after discussion, decided to adopt a non-destructive testing method to ascertain the length of the threaded bar engaged within the couplers, and the test proposed by MTRC is phased array ultrasonic testing.

The government was advised by expert in this kind of testing, saying that the accuracy that the measurement can provide is only up to plus or minus 3 millimetres.

A. Mm-hmm.

Q. Now, on the basis of the information provided by the manufacturers of the couplers proposed by Leighton, which is 40 millimetres engaged length, in view of the accuracy of the measurement by the kind of test again proposed by MTRC of plus or minus 3 millimetres, to give

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the benefit of the doubt to the contractor, Leighton in this case, the government adopted an acceptance criteria for the present purpose of 37 millimetres.

In other words, so long as the measured length as provided by the test attains 37 millimetres, we assume the actual length would have 40 millimetres, that satisfies the requirement of the manufacturers.

Now, the requirement of 40 millimetres engagement length is not something set by the government initially. It is something set by the manufacturer of the couplers chosen by the contractor, and it is also clearly set out in the quality supervision plan submitted by the contractor, and that is the reason behind the acceptance criteria of 37 millimetres. It is not an arbitrary value picked by the government.

Now, earlier, when counsel for Leighton --

MR PENNICOTT: Sorry, is that a question, is Mr Chow actually putting to Prof McQuillan that because of the explanation he has given, it's not arbitrary? Is that a question or is it a statement? If he wants to put to Prof McQuillan whether that explanation is not arbitrary, that should be -- a question should be put not in the form of a statement, which is what has just been said: the acceptance criteria, "it is not an arbitrary value".

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CHAIRMAN: I take it that what Mr Chow is doing is saying, "Let me give to you what I understand the background to be, which you may not be aware of or have forgotten, and then can you please comment as to what you feel about arbitrariness or otherwise." Would that be correct?

MR PENNICOTT: As long as the question is coming.

MR CHOW: Yes. Thank you, Chairman.

MR BOULDING: May I just say that we don't actually accept the accuracy of the whole of that statement.

COMMISSIONER HANSFORD: Can I also make an observation that if the accuracy of the measurement -- of the equipment that was used is plus or minus 3 millimetres, it's slightly odd that the results are presented to two decimal figures.

MR CHOW: I'm afraid, on this front, I'm not in a position to advise.

COMMISSIONER HANSFORD: No, it's an observation.

A. It's a comment I made earlier.

COMMISSIONER HANSFORD: Okay.

CHAIRMAN: That is right.

MR CHOW: But obviously it's a kind of testing that both MTRC and the government, after thorough discussion, agree that this is the most appropriate test to carry out to ascertain the conditions within the couplers.

As to why --

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CHAIRMAN: So what would be your proposition to Prof McQuillan?
MR CHOW: Actually, my question -- the reason why I did not ask Prof McQuillan as to whether, given the background, the assessment criteria of 37 millimetres is arbitrary is because given the background, it's self-evident it is not arbitrary.
My question, actually, what I intended to ask Prof McQuillan, arising from that is because this morning -- sorry, it's not this morning -- just now, when Prof McQuillan had this exchange with Mr Shieh, it was put in the context that the result of the testing now being published by the Highways Department on a daily basis is misleading.
My question that I would like to ask, Prof McQuillan, is when the word "misleading" was used, I suppose that, Prof McQuillan, you are not suggesting that the Highways Department, by publishing the test results, and at the same time adopt a passing threaded length of 37 millimetres, is trying to mislead the public? I suppose this is not what you mean?
A. No. What I mean is that the acceptance criteria given by the government, which is what is informing the public at present, is really an ideal world, where you are actually trying to assess what the manufacturer's

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quality manual suggest you might do. We are where we are with this investigation, and what we are now focusing on is what is there safe. I and other experts are basically saying that the 60 per cent engagement gives a safe result.
CHAIRMAN: Certainly we didn't take the word "misleading" as in any way to mean intentionally misleading. Equally the word "arbitrary" is I think expressed in its scientific context, not in its social context.
MR CHOW: Thank you, Mr Chairman.
The next question is somehow related to the subject we just looked at. I recall, Prof McQuillan, you mentioned earlier you don't want to hear people saying only one sample was used. Do you recall that part of your --
A. I do, yes.
Q. Please forgive me. I am obliged to raise this subject again.
This morning, when you said in actual fact there are three samples that support the adoption perhaps of a more lenient or less stringent requirement -- now, the way I understand those test results, the three samples that you refer to, the first sample is the one with 60 per cent engagement; right?
A. Mm-hmm.

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Q. That's the one sample. The second sample is the one with 70 per cent engagement.
A. Yes.
Q. And the third sample is the one with full engagement, 100 per cent.
A. Yes.
Q. If someone has to advocate to adopt a 60 per cent engagement length as an acceptable criteria, the sample which is able to support that is not the sample where there was 70 per cent engagement or 100 per cent engagement. Because we want to lower the acceptance criteria, and the only sample which is available to support the change of the acceptance criteria, as far as I am concerned, remains as one. There is only one sample with 60 per cent engagement length and showed a tensile resistance of up to the required value. Am I correct?
A. With all due respect, sir, you are not correct. It might be helpful if we could flag up Prof Yeung's very helpful little graph.
Q. Yes.
A. It's contained in his PowerPoint presentation. That's the one.
So what happened -- let's go back. Let's reverse the order just for a moment. So on the extreme

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right-hand side, against the "B" and the open circle, you have a bar -- and remember it is the bar which failed -- at 100 per cent engagement; correct?
Q. Yes.
A. Move left to the next little circle. That is the bar which failed at 70 per cent engagement. The coupler still was intact.
Move left again, and where the "B" intersects with the diagonal line, that was the 60 per cent failure. The coupler held in every case. It was the bar that broke.
What I'm saying to you is that what you have there are three representative samples, and the scatter in the breaking load is not all that inconsistent.
In fact, in my report, and I gave it to you this morning, I have calculated the main breaking load for those three samples. So you don't have one sample. You have three samples of the bar that broke. The coupler -- if I can just describe it like this. Leave the coupler out of the equation. The coupler is just acting like the jaws of the testing machine holding a bar; okay? And whether it's 60 per cent engagement, whether it's 70 per cent engagement, whether it's 100 per cent engagement, the bar is still being clamped, and it's being tested to failure, and what you have here

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are three reasonably consistent failure results.
Q. Right. That part I understand. But what I don't understand is -- the way I say it, the three sample results that you have just mentioned shows the strength of the bar, not the couplers; is that the point?
A. That is the whole reason -- the reason why BOSA carried out this test. If you look at their little chart, it's entitled something like "Thread calculation".
Q. Yes.
A. So it's not testing the coupler. It's testing the number of threads engaged in the coupler which will allow the bar to go to breaking load.
Q. Exactly, yes.
A. We have three breaking loads here.
Q. Yes. But what I'm saying is the three breaking loads shows the breaking load of the reinforcing bar, and it also shows -- it also demonstrates that the couplers were strong enough to enable the bar to break at its breaking load.
A. In which case your point is completely lost on me, I'm sorry.
Q. Maybe I'm too slow but I still want to be educated on it.
Now, the sample to the extreme right tells us that if there are ten engaged threads, the coupler and bar

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assembly are able to provide an attachment so that the bar can manifest or achieve its breaking load. We no problem about that because we have ten threads engaged.
A. Okay. At the other end of the scale, 60 per cent does exactly the same thing.
Q. Exactly, but there is only one sample that shows that.
A. No, no, there's three samples of the same bar there, three different tests on three different bars, one at 60 per cent engagement, one at 70 per cent engagement, one at 100 per cent engagement. So you have three samples which broke.
Q. Yes, but only one sample which demonstrates that with only 60 per cent engagement, it is strong enough, and it is only that sample one can rely on to convince the public that now we don't need ten threads engaged, we only need six threads engaged. It is to this extent that when I raised my question to the other expert, suggesting to them there is only actually one sample, and it is not reliable because one would expect that at least we should have more samples with 60 per cent engagement and yet still able to support a loading or an attachment between the couplers and the bar, to enable the bar to fail at its yield strength.
A. I think we are splitting hairs, really.
Q. Very well. So you still maintain that there are three

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samples --
A. I do.
Q. -- which demonstrate or prove that 60 per cent engagement would be adequate?
A. Yes, because the coupler -- I've made the point this morning that the coupler is not the thing that's going to break. It's the bar that's going to break. Okay?
Q. I will move on then.
Can I ask you to go to your expert report, paragraph 26, at page 21, please. In paragraph 26, you explain the assumption that you made, and you list out a number of features that you have not taken into account in forming your view. Do you see that?
A. Yes.
Q. What I am interested in is the fifth item. You set out that:
"Columns supporting the existing Hung Hom Station podium and roof had their loads transferred to the new EWL slab ..."
So am I right in understanding that in your analysis, you have ignored the loading from the existing Hung Hom Station; is that --
A. I have not carried out any analysis. I have simply reviewed the work of others. The thing about that particular bullet point is that provision has been made

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for transferring existing loads onto the EWL slab and hence down onto the NSL slab and hence into the foundations.
Q. Yes. Mr McQuillan, you have just confirmed my next question, actually. The way I read your report, I have not seen any calculation, albeit a simple calculation, and am I right in understanding that in coming to your final view on the issue of safety, you have carried out a kind of qualitative assessment in the sense that you exercise your engineering judgment by looking at what was built, the configuration of various structural elements, and you come to your conclusion that there is no safety concern; is that correct?
A. No, that's grossly incorrect, because if you read my report carefully you will see that I have relied very heavily on particularly the work of Arups and also the work of Atkins, and more latterly I have had a brief review of COWI's work. But I wasn't concerning myself too much with COWI's because they come up with even better utilisation values than do Arups.
Q. So you relied on the result produced by Atkins and the result produced by Arup?
A. Yes. That was my brief.
Q. It's not a criticism at all, I just want to clarify so that the Commission will be able to assess your --

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A. I think you have to realise that to carry out a full analysis in the way that Atkins and Arups have done is a very time-consuming and costly process.
Q. I'm not suggesting that you should carry out the kind of calculation as a consultant would have done.
A. In which case, I'm baffled about your question or your comment.
Q. I just want to clarify so that everybody knows the basis of your opinion. That's all. It's not a criticism, as I have made clear earlier.
A. Okay.
Q. Can I now refer you to paragraphs 106 and 107 of your report, please, page 44, where you talk about the NSL slab. Do you agree that as far as the NSL slab is concerned, the bottom reinforcement are always in tension?
A. Could you flag up the slide in my presentation, please, where I show my schematic bending moment?
Q. Yes. Page 5, I guess. Is that the one that you --
A. Yes. No, ignore the diaphragm walls, and imagine you can flip that through 180 degrees.
Q. Right.
A. Okay? So it's probably not easy -- can we do it on the slide? Can we rotate it through 180 degrees? Maybe not.

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COMMISSIONER HANSFORD: Turn it upside down.
A. Yes, turn it upside down. Go right the way around. Keep going. Nearly.
COMMISSIONER HANSFORD: I can't see any cracks yet!
A. That's it. Just bring it around. Brilliant.
Yes, more or less, the diaphragm wall bending moments are not correct, but you now can see that below the black line, which is on the underside of the NSL slab, the couplers are in tension in the red zone, on both sides, but on the top of the NSL slab the couplers are in compression, if you can read that upside down.
MR CHOW: Right.
A. But the tension in the NSL slab is on the top of the slab, in the middle.
Q. The tension, sorry?
A. Let me say it again. On the underside of the NSL slab, at the zones adjacent to the D-wall, the couplers and the rebar are in tension. Dr Glover explained that to you this morning.
Q. Right.
A. Between those points -- so we are still talking about the underside of the slab, the bottom steel, the rest of the bottom steel, is in compression. When you move to the top surface, in the zones adjacent to the D-wall, the couplers and the rebar is in compression and it's

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the centre portion above the slab that is in tension.
Q. Yes. Now I understand. So as far as the bottom steel of the NSL slab is concerned, it is essential that a proper connection is to be provided between the NSL slab and the diaphragm wall?
A. I made that clear in my presentation. That is safety-critical in the same way as the EWL is critical on the top of the D-walls, yes.
Q. So do you agree with me that there is a need to find a way to ascertain the quality of the installation of the couplers for those reinforcement at the bottom of NSL slab?
A. In all seriousness, that is not a probability -- that is not possible. Do you want me to say why?
Q. I accept that it is not -- sorry.
COMMISSIONER HANSFORD: No, I'd like to hear why.
A. Right. Because you've already heard about the very significant waterhead, the hydrostatic difference. If you start to cut down into -- that's only a 2 metre slab, still quite significant -- if you cut down, you're going to have to cut through all the layers of rebar, which is going to cause enormous damage to the slab. When you get near the bottom, at some stage, the water is going to come through and you are going to create a Yellowstone National Park, geysers everywhere.

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COMMISSIONER HANSFORD: And how could that be stopped?
A. I don't know that technology, I'm sorry. You call in Red Adair.
COMMISSIONER HANSFORD: You can't just put a plug in?
A. No.
COMMISSIONER HANSFORD: So that would be very dangerous?
A. Very dangerous, and I think I pointed that out somewhere in my report.
COMMISSIONER HANSFORD: You have. I wanted to hear it.
A. That actually forms part of the holistic proposal in its first draft and I pointed out that danger.
MR CHOW: Prof McQuillan, in fact, on these particular points we are in agreement. It is almost impossible to open up the bottom of the NSL --
A. To then answer your question, you've got to go back to the evidence that Dr Glover gave. I'm even less of a statistician than he is. So you've got to satisfy yourself generally that the integrity of the couplers is fairly consistent.
Q. In fact the reason why I ask this question is what I was getting at when I asked this question is there is actually a need of opening up of the other area, like the top of the NSL slab, in order to get a better picture of the general quality of the couplers' installation work.

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A. Yes, I have no objection to that. I just think the acceptance criteria is incorrect.
Q. Yes. That we have noted.
CHAIRMAN: Can I just jump in -- I'm just interested in -- it's all been in place now for about three years.
A. Yes.
CHAIRMAN: And from what we've heard, the dead loads make up about 90 per cent of whatever stress these structures are going to have to face, and then you say adding an extra 8, 9, 10 per cent is not really going to change anything. Well, that's what is being said generally, it seems; correct?
A. That is correct, sir, but only in relation to the upper slab.
CHAIRMAN: Right.
A. In relation to the lower slab, at the moment, ignoring the trains which have been used for commissioning and testing, that slab from a very early stage, once they recharge the water table and let it regain equilibrium, that slab has more or less been -- well, it has been constantly loaded, apart from some very minor variation. So it has been subjected to the same quantity of load for that duration. There has been no evidence of any distress of any kind.
COMMISSIONER HANSFORD: Indeed, on that slab, unlike the EWL

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slab where there is 8 per cent or 10 per cent of load still to come, on that slab any live load from the trains or passengers would actually be reducing the load of the water pressure, would they?
A. That's a correct observation. It's mitigating -- so the top slab was at its worst immediately after construction. So was the bottom slab. So any trains that run on it, any additional load that's put on it, is actually alleviating the bending moment, the upward --
COMMISSIONER HANSFORD: That's what I thought but I expressed it as a civil engineer and not a structural engineer.
A. No, you're quite right. I'm a civil engineer as well.
CHAIRMAN: The point I was going to make is that perhaps having been brought up, when I was in my 20s, I think, on a diet of these disaster movies, these great buildings that collapsed and everybody jumping out of windows and stuff, one gets an image there of these couplers lying embedded in concrete, year after year, and perhaps this is what the public thinks, and then suddenly one goes clink and breaks, and then nobody notices and another one goes clink -- however you translate clink, I don't know -- and then that one breaks. Do you see the point I'm making?
A. Yes.

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CHAIRMAN: So perhaps the ordinary member of the public, and that includes myself, may think, fine, three years is okay, but what guarantee is there that over a longer period of time, perhaps the stresses on the couplers are such that slowly, slowly, one doesn't do what it should do, another doesn't do what it should do, and then you get a slow degradation which may only make itself known in, say, a dozen years?
A. I can answer that question on two fronts. The first one is that those couplers and the rebar are subjected to the same level of stress from day 0 to where we are now. Prof Hansford is right, once the trains start running, it will actually lower the stress levels. That will be a fluctuating load. So if they haven't broken now, then they won't break in the future. That is like let's go back to the test where you put a partially engaged rebar into a coupler. If you just stress it -- if the breaking load is 600 and you just maintain it at a stress of, say, 100, it's never going to break. It's never going to pull out of the coupler.
But the other thing that was raised yesterday in evidence -- Dr Glover was asked about this -- the one way in which failure might occur is if the couplers and the rebars inside them were able to corrode. But that is not going to happen because the way it was

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constructed was there was very careful -- the waterproofing laid on the prepared surface, and that was actually dressed into the diaphragm walls, there's evidence of that in the construction photographs, and therefore, assuming the integrity of the waterproofing is okay, the couplers are never going to deteriorate due to corrosion.
COMMISSIONER HANSFORD: And I think the point was made there's no oxygen at that level, which is also needed for corrosion?
A. Absolutely, yes. You need steel, you need oxygen, and you need the water.
COMMISSIONER HANSFORD: Yes.
A. Sorry, all three --
COMMISSIONER HANSFORD: I understand. Just on that point -- and you've made a very helpful -- you've given us a very helpful description of how, if all the couplers have been demonstrated to adequately take the load so far, it's not going to get any -- it's not going to change or not going to get any further loading.
A. Mm-hmm.
COMMISSIONER HANSFORD: Is the same observation true with a load test? And I know we haven't gone to load tests much because none of the experts are advocating a load test, in fact quite the reverse, but isn't it the case

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that if you do a load test, the load goes on at that point, but that just gives you the behaviour at that particular point and that doesn't change in a few years' time.
A. It's a snapshot in time.
COMMISSIONER HANSFORD: It's a snapshot.
A. That's one of the reason why personally, and if you ask the other experts they will probably concur, it's of limited value and very expensive to do, a load test.
CHAIRMAN: Just so that we follow this up, because I'm looking -- it helps me, and I think the public at large may not have the knowledge that you have, but when you're talking about -- you took the example of the coat hanger that you get from the dry-cleaner, fatigue. Fatigue would I think be the nearest that the average person would look to a biological being holding something up above their head and saying, "I can do this but I can't do it for more than 24 hours because otherwise I'm just going to drop dead", but metal doesn't work that way. So it can be there providing it can take the stress forever.
A. Mm-hmm.
CHAIRMAN: So what would therefore be the forms of metal fatigue, if any, that could change that situation?
A. Let me explain. What would create conditions for

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a fatigue to occur would be for that -- let's take the bottom slab to be moving up and down, for the load to be reversing on it, which can never happen, and the same applies at the upper slab, it can only bend in one way, it's never going to go the other way.
What I tried to explain in the QSP test, the cyclic test, is that the material like the coat hanger is first of all pulled and then compressed, then pulled and then compressed (demonstrating with hands). That is analogous to bending the coat hanger and there's a point where it snaps. None of these couplers are ever going to be subjected to load reversal and therefore fatigue will never happen.
CHAIRMAN: Thank you.
A. The other thing about fatigue -- fatigue depends on two things and it's a peculiar curve, a typical curve. First of all, it depends on the level of stress reversal, in terms of the magnitude. It also depends on the number of cycles that are experienced. So there's your coat hanger analogy, you maybe bend it six times with no problem, but there comes a seventh and it breaks.
MR SHIEH: I have a paper clip here, perhaps there can be a demonstration of how it can broken.
A. We'll let you do that, Mr Shieh.

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COMMISSIONER HANSFORD: I think we've all done that exercise for ourselves, Mr Shieh.
MR CHOW: I have done that myself.
CHAIRMAN: Thank you. I appreciate they are almost insultingly simple questions for you, but I think there are members of the public out there who kind of think, "What about slow, slow fatigue?", et cetera, and I think that links in actually to the suggestion made by all the experts that in order to allay public concerns, even though you as experts know it's not a concern, something like an electronic monitoring system is there to allay the sort of fear I've expressed.
A. Absolutely, yes. They are difficult concepts for people without an engineering background, I admit that.
MR CHOW: Prof McQuillan, I would like to move on to the next subject, which is whether ductile couplers are actually required in this project.
Could I refer you to paragraph 89.2 of your report at page 38, please. In subparagraph 2, you said:
"The geometry of the connection between the EWL slab and the east diaphragm wall, however, precludes any ductility. The structural 'plastic' deformation which might occur during seismic activity will develop lower down the diaphragm wall. Ductile-grade couplers are not therefore required where used in the EWL slab to

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diaphragm wall joint."
Now, I have explored with Dr Glover yesterday on a similar subject. However, what I'm now interested in is in the connections between the NSL slab and the diaphragm wall. Am I right in thinking that for that connection, it is not as obvious, because, first of all --
A. Sorry, which slab did you mention there?
Q. NSL.
A. The lower one?
Q. The lower one, because NSL slab is thinner, only 2 metres, and at the same time NSL slab framed into a continuous diaphragm wall of 1.2 metres. So if we are talking about relative stiffness, it is not entirely clear that if plastic hinge is ever to be formed, it will be on the diaphragm wall. It may well be on the NSL slab?
A. No, I'm afraid not, because it's not just a linear relationship. It's probably a squared relationship. So if you have a 1.2 metre diaphragm wall and you have a 2 metre deep NSL slab, it's like in the ratio of 4 to 1, something like that, in terms of stiffness.
Q. But in terms of stiffness, should we consider the diaphragm wall, contiguous diaphragm wall, one portion of it is above the connection and the other is below the

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connection and they have to be counted twice for the purpose of distributing the moment in the connection?
A. Sorry, I don't understand the point you make.
Q. Let's move on.
A. I will answer your question in a different way.
Q. Good.
A. In the event of seismic activity, it is inevitable, because again of the stiffness, the relative stiffness of the slab, to the D-wall, that any deformation will take place in the D-wall. So I would agree that in the D-wall it is necessary to put in your ductility couplers.
But the point is, even though we make a statement like that, it's just to make a certain point. The truth of the matter is that everywhere in this job, they have used ductility couplers, so there's no argument.
Q. Well, not everywhere.
A. Sorry, well, in the slabs they have.
Q. Yes, in the slabs, but in the diaphragm wall we have non-ductile couplers.
A. Yes, I appreciate that. But that was carefully designed and implemented.
Q. I think I will move on because I don't have expert opinion to support what I was going to put.
I would like to move on to another area. It's in

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relation to whether there is a need to check the stress inside the connection.
The way I see it, the main difference between Prof McQuillan, you, and Prof Au is that whether -- well, as far as you are concerned, there is no need to carry out any calculation to verify the stress generated inside the connection, whereas Prof Au said he has some concern and he thinks there is a need to do that exercise.
A. I'm not the only one who suggested there isn't any need to do it. The other two experts as well have concurred with my view that -- one already has demonstrated using a different method that it's not necessary.
Q. I'm conscious of that. I try to summarise the difference between you and Prof Au. That is really the main difference, because as far as I understand Prof Au's evidence, he is not saying that there is definitely a problem in the connection. He is just advocating that there is a need to check, to do some calculation to make sure.
A. Can I answer your question a different way for the benefit of the Commission?
Q. Sure.
A. Can I draw?
Q. Yes.

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A. Thank you.
There are two issues behind all of this, and one issue is being used to obfuscate the other. It's like a smokescreen. So let me first of all -- and this is where my sketching will be shown quite inferior to Mr Southward and Dr Glover, but bear with me.
(Drawing with a black marker) Okay. I want to establish, first -- you know, pin down the evidence that was presented yesterday.
COMMISSIONER HANSFORD: Yes.
A. That the construction joint in that zone (indicating), if properly formed, is of no consequence; right? So if a construction joint is properly formed and the wall is reinforced properly, it could shear anywhere, if it was going to shear.
(Drawing with a red marker) So a construction joint can be anywhere, wherever you want it to be. It doesn't affect the shear of that wall; okay?
The next thing I want to do is really to draw on that what normally happens. Bear in mind my slide -- in fact, if you call it up, I think it's slide number 9, would you, please, where the whole block is trying to rotate; that's the one. So it's trying to rotate like that (demonstrating with hands).
(Drawing with a green marker) How that is resisted

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is that you put in an L-bar which laps with the vertical rebar in the wall, and then you put in another L-bar which laps with that, and in practice you combine the two L-bars into the form of a U-bar. So we'll just do away with that, we'll call that a U-bar.
(Drawing with a blue marker) Now, what happens is that as this block, as I call it, is trying to rotate, this bar on the outside is taking tension, so it's going to go into tension like that, and I'll mark this with a T.
On the other hand, the stresses are then being distributed around the U-bar, and this bar here is going to go into compression, and we'll call that C.
Are you with me so far?
COMMISSIONER HANSFORD: Yes.
A. Good.
What I'll do is turn over the page because I don't want to be stripping down, and I'm going to draw that situation yet again.
(Drawing with a black marker) I hope I have picked the same colour. Was it green?
COMMISSIONER HANSFORD: I think it was green.
A. Okay, let's stick with the green.
(Drawing with a green marker) What happened was that when the U-bars were deleted, you are left with

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a situation like that; okay? And that in fact doubled up with what we call the first change, and from memory -- well, I know for a fact that that still relied on the reinforcement bar with the couplers cast into the wall; okay?

COMMISSIONER HANSFORD: Yes.

A. Now, the Buildings Department approved that detail (drawing a green tick).

What the designers then did was simply develop that and extrapolate it, and what they decided to do, because of the reasons that you've heard, was to chop that down to there (drawing with a red marker). It's perfectly logical, perfectly legitimate, and because the first change had been approved it didn't raise any hairs.

What happens now is that -- and it was referred to yesterday -- if you still think of this whole mass trying to rotate (drawing with a blue marker), it relies -- if there are no other influences acting, then this bar here, this one (drawing with a black marker), above the level of the joint, is relying on its bond, its grip in the concrete, to stop the whole lot lifting off. Are you with me?

COMMISSIONER HANSFORD: Yes, that's actually part of the long bar.

A. Yes, this is part of the long bar, but it's only that

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bit above the construction joint (drawing with a blue marker) which is actually relying on its bond. As was alluded to yesterday, that clearly won't work. It has to be an L-bar to give it the anchorage. So you've got to have some other mechanism to stop this whole lot rotating.

What I'm gathering from this and the more I've thought about it is -- it appears to me that the Buildings Department, despite having approved the first change, are now having concerns about that approval. It appears to me, and I might be wrong, that they are using the issue of the construction joint to fudge that issue; right? Because if you go back to this diagram --

COMMISSIONER HANSFORD: What makes you think that?

A. Because the first one was approved without any difficulty; okay?

COMMISSIONER HANSFORD: Okay.

A. In other words, if you ignore the construction joint (indicating), and the construction joint is as good as any -- could be anywhere -- there's still the tendency, if you don't have a construction joint, if you don't pull down the top of the wall, trim it down, you are still going to have a tendency for that to run out of bond. And I think, reading between the lines, that is Buildings Department's concern.

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So if you go back to my diagram -- sorry, the next couple, maybe. Go to the next one. Yes, that's the one.

So what I'm saying is I'm relying on a different mechanism to hold that slab from rotating.

(Drawing with a green marker) I'm relying on the rebar going into the bottom here, providing the dowel action which means that it cannot lift up, and relying on the dowel action going in here to prevent that from moving down and therefore you cannot have the thing rotating. It will rotate as a mass but it will not lift off the top of the wall.

So I thought the Commission needs to know that fact because that's what I'm beginning to thinking about it all.

Thank you.

MR CHOW: Thank you, Prof McQuillan. What actually I intended to ask you was on those diagrams that you prepared on your slide, and I can see that you are basically explaining it again on your sketch.

A. Yes.

Q. This is really what I'm interested in, because what I can do at most, as a layman, is to try to understand it, how it works.

Can I refer you to slide number 9 first, because

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I understand this is the first slide that you started to explain --

A. Yes.

Q. Am I right in understanding that what you are trying to do is to show to the Commission that assuming the blue block of concrete, if it fails, then first of all it has to kind of tilt up?

A. Yes.

Q. And your approach is, in order to stop it from tilting up, we have reinforcement coming in from the bottom of the EWL slab, and we also have reinforcement coming in from the bottom of the OTE slab, that stops it from tilting up.

Am I right in thinking that -- well, perhaps before that, I would like to, if I may, try to establish a few common grounds on a matter of principle and then I can ask questions on that basis. Am I right that a structure, for example a structure that we are looking at, the box station, in reinforced concrete, actually can be designed in more than one way to make it work?

If I can give an example, for example, the connection that we are looking at, it can be designed as a hinge joint or it can be designed as a fixed joint. Are we --

A. No, in a box structure like this, you would never be

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able, from a practical detailing point of view, to make it work as a hinge.
Q. Right. Perhaps it's not the best example. What I'm trying to say is we can make a structure behave differently, and insofar as we decide on a particular mechanism that is going to work, then we carry out our analysis accordingly?
A. That's lost on me, I'm afraid. Are you speaking in the context of this joint?
Q. Yes.
A. So let's just go through it again. What we've had is Prof Au's approach. You have Mr Nick Southward's approach. You have my approach. It all depends on the basic assumptions that you make. I have stated my assumptions. Mr Southward has stated his. I'm afraid Prof Au's is much too technical and theoretical for me to understand. That's why I suggested to the Commission we could all go around in circles on this, we are all going to stick to our posts and our opinion. If the government is really serious and thinks that that joint is defective, according to Prof Au's calculations, go ahead and commission a finite element model and analysis, because that's the only fair way to put the matter to bed.
Q. Perhaps we don't need to go into that high level of

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technicality, not typical of --
A. Then I suggest it needs to be dropped because it's just everybody stating their own opinion and we can all back our own opinions.
Q. Can you just help me to understand your reasoning, just for the moment; right?
A. The reasoning is to stop that rotating.
Q. Okay.
A. And because --
Q. Sorry, yes.
A. I've already demonstrated that the problem is that once you do away with the U-bars on top of the wall, you do not have sufficient anchorage in the vertical bar to actually hold it down.
Q. Yes.
A. You need some other way of holding that down.
So when you go to my next slide, please, it cannot rotate because the U-bar coming in from the right-hand side is locked into the D-wall, which is a massively reinforced piece of structure, and the bottom of the EWL slab likewise is locked into this massive D-wall reinforcement.
So it cannot move. The whole thing -- sorry, the whole thing has to move as an entity, in which case we revert to Atkins' calculations and they have

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demonstrated that if one considers that the breakage point is at the bottom of the EWL slab, as would be logical, it is amply reinforced to cater for that possibility.
So Atkins have pre-empted that.
Q. I'm just trying to understand. You mentioned that the whole thing has to move as an entity. Am I right in thinking that at least we have to make sure that the reinforcement inside that entity, for example, the blue blocks, remain intact, for it to turn as one piece?
A. Mmm.
Q. So someone has to do the calculation to make sure that the reinforcement inside the blue block would be able to keep the block as intact and allow it to move in your diagram, like in your diagram.
A. Go to my next slide, please. Sorry, that's how it would actually -- that's the failure mechanism --
Q. Yes, but we have to ensure that when it fails, it manages to remain in that shape.
A. Sure. Please go to the next one. So that is how the block is reinforced. I put it to you that for that to now turn -- and it will tend to turn, because the EWL slab is heavier and more massive, so there will be a tendency for it to turn, and that's where the very heavy bending moment comes into play -- but what happens

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is the D-wall then has to deflect for the whole -- it's as if you take a T and try to twist the T, the stem has to twist with it, so the D-wall has to turn as an entity and then it goes to sort of a catenary -- or a deflective mode.
Q. Perhaps I can ask another question then. When you say we have reinforcement coming into the diaphragm wall from the EWL slab, do we need to check whether the quantity of the reinforcement is adequate, or we just tell our clients, say, "Because we have some reinforcement there, don't worry about it, don't even check"?
A. If you want to check it, check it, but the thing is functioning as intended so why go to the trouble of checking it. We all as engineers, practical engineers, intuitively know that the thing is performing as intended. You have at the moment four layers of rebar coming in from the EWL slab. Go ahead and do the check. It's acting as it should.
Q. I'm fine with your answer. So you also believe it is worthwhile to do a check to ensure the quantity is adequate to make it perform like you describe?
A. If you ask me to do the check, I would tell you it's a waste of time and money. The thing is functioning as intended at present. You've got to use engineering

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judgment.
CHAIRMAN: Mr Chow, forgive me if I'm wrong, but are you saying that what needs to be -- because at the top of the diaphragm wall is a matter for the as-built drawings, and there's some concern as to the as-built drawings, that there's therefore some concern as to exactly what the reinforcing is?
A. This is not exactly the point I'm trying to make.
CHAIRMAN: Okay, so --
A. At the moment, there is a difference in expert opinion between Prof Au and the other three experts.
CHAIRMAN: Yes.
MR CHOW: And the difference stems from the fact that Prof Au believes that someone has to do the calculation, just to make sure, to verify, that the connection is strong enough.
CHAIRMAN: No, no, I appreciate that.
MR CHOW: However, what we have heard from Prof McQuillan is that, "No, no, no, it is not necessary. According to my professional experience and applying my professional judgment, it is so obvious because we see we have reinforcement coming in from the bottom of the EWL slab and we have reinforcement coming in from the bottom of the OTE slab. So that is so obvious that it's adequate; we don't need to do calculation."

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CHAIRMAN: Okay, so the point --
COMMISSIONER HANSFORD: With respect, we have also heard that from Mr Southward and we've also heard that from Dr Glover.
MR CHOW: Yes.
CHAIRMAN: And the point I'm making is if there is no debate as to what's actually in there, in the sense that the necessary through-bars are there and the other bars that are shown, and we are all agreed that, so it's really a case of, is it not, and as the professor has put it very well, he has his basic scientific assumptions and he stands by the fact that it's a perfectly proper and long-lasting structure. He's supported by two of the other experts. Prof Au, however, has concerns. He doesn't say it's going to fail. He's saying, "I'd like to double-check", and he's got certain mathematical calculations that can be carried out to ensure that takes place.
COMMISSIONER HANSFORD: Which he thinks he can do in half a day.
MR CHOW: Or a couple of days.
CHAIRMAN: And we are not going to say, I doubt, "Don't do that", because (a) we can't stop him from doing it and (b) we can't stop the government from saying to him, "You know what, that's a very good backstop insurance."

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But what's being said at the moment is not, "I am telling you, the government, how you should act out of caution"; "I am saying to you: I don't think it's necessary. That's my professional opinion. What you wish to do with that, because other opinions are perhaps a little different, that's a matter for you." That's as I've understood it.
A. Can I also add, sir -- that if, Mr Chow, you are relaying this back to Prof Au, I think he needs -- because I've seen no evidence of it -- I think he needs to take the horizontal dowel action into account when he's doing his analysis.
MR CHOW: No doubt I believe that Prof Au, if he is instructed to carry out that exercise, he will take whatever he thinks is appropriate, including the dowel bar or the dowel action.
CHAIRMAN: We may well recommend -- we haven't been able to discuss or reach any agreement; we haven't even finished the expert evidence yet -- we may well recommend out of an abundance of caution and in order to satisfy that what appears to be a reasonably simple set of mathematical -- let me rephrase that, probably bewilderingly difficult and complex mathematical calculations, but nevertheless achievable in a short period of time -- should be carried out.

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COMMISSIONER HANSFORD: I think bewildering to laypeople and even laypeople that may have a degree in civil engineering, but they are not bewildering to someone of the calibre of Prof Au.
MR CHOW: Then if I may move on to my last question. It's about your conclusion, paragraph 126, Prof McQuillan, page 49. I just want to clarify what you meant, because it appears to me you have put in a number of qualifications. What you said is:
"In conclusion, on the basis of all the evidence available, I am satisfied and in no doubt that the structural integrity of the EWL slab has not been compromised as a result of changes of detail and substandard workmanship incidents, and that there are no safety issues or concerns."
Am I right in understanding that you come to that conclusion first of all on the basis of the evidence available up to 6 January, that is the date of your report, and by that I mean the opening-up, the result of the opening-up?
A. It wasn't. When I talked about substandard workmanship incidents, I was also referring, as I said in my presentation, to the honeycombing, voiding, the spalling, those other things.
Q. Okay. So the substandard workmanship incident, you are

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not simply referring to the five bar cutting incidents that have been the subject matter of --
A. The five bar what, sorry?
Q. From the factual evidence -- we spent a lot of time --
A. Sorry, yes, the NCRs.
Q. So you are not referring to those incidents only?
A. No, because as I understand it they were rectified, or some of them were.
What I'm referring to is -- there's two groupings here. There are those issues with the concreting themselves, and then there's the issues with the couplers, and that has really been a work in progress. So the longer that goes, I think I've said earlier, the more and more and more satisfied I am becoming that there isn't a problem.
MR CHOW: I have no more questions for you, Mr McQuillan. Thank you very much.
WITNESS: Thank you.
CHAIRMAN: Thank you, Mr Chow.
MR SO: Some very short questions.
CHAIRMAN: Yes, Mr So.
Cross-examination by MR SO
MR SO: Professor, can I draw your attention to paragraph 56 of your expert report, please. Professor, there you have raised, presumably, a rhetorical question, as to

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when you were invited to give expert opinion as to the cutting rebar incident, and there you have asked the questions that one must ask oneself when considering this evidence:
"What are the advantages, if any, in cutting a threaded bar because, intuitively, it will take time to do it?"
I wish to show you a photograph. I think this photograph might have been brought to your attention already when you were compiling your expert report. That is in bundle C12, page C8138.
Professor, is this photo familiar to you?
A. It is.
Q. A lingering question that this Commission might have would be, as you rightly put it, if there were no advantages, why cut a threaded rebar, and based on your expert opinion -- no doubt we have factual evidence showing that there was cutting of the threaded ends -- so what are the reasons?
A. I can't answer why one would do it. All I know is that occurred -- after those particular incidents that led to NCR -- what was it, 157?
Q. Yes, 157.
A. Those were actually rectified. So I would assume that the whole supervision from Leighton and MTR would have

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improved after that. They would have been on the lookout for such things happening.
Q. With respect, Professor, that's not quite my question. My question was: you give us expert evidence on the one hand that you see no advantages in cutting it.
A. Yes.
Q. But on the other hand there are undisputed factual evidence that they were in fact being cut. So how can these two be reconciled?
A. I can't deny there were incidents of cutting. In fact, one of the current tests -- and I haven't details of it -- showed there was a cut unconnected bar in the West Wall or something. I don't know, I haven't seen the details of it. So yes, it happened, but those must have been very limited, sporadic incidents.
Q. Professor --
A. Sorry, just to finish that -- I think earlier I was trying to make the point from my very simple analysis of the results to date that there isn't any evidence there of bars being shortened.
Q. Thank you.
The other point that I wish to clarify with you is in paragraph 115 of your expert report. In paragraph 115, that is what you opined, and you said it is in your opinion that the proposal, that is the

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holistic proposal and the opening-up, "is an 'overkill' in terms of its scope. My main issue is with the nature and extent of the invasive investigation work currently being carried out. In my opinion it is unnecessary, pointless and a waste of time and resources to continue with opening up the EWL slab soffit at the east diaphragm wall."
Just to summarise your expert opinion so that I do not get it wrongly, so is it -- let's just put aside the code requirement for the time being. In terms of your expert opinion and in terms of structural integrity, is it your evidence that the EWL slab soffit simply does not require reinforcement bars there in order to ensure the structural integrity?
A. I stated that fairly emphatically in my opening presentation and actually paused to repeat it.
Q. So in other words -- I'm not trying to be rude or blunt in any way -- if they are not reinforcement bar, simply there's nothing inside, or if we put bamboo inside, it would still not affect the structural integrity; is that your evidence?
A. You have correctly understood it, yes. I think also that comment there was discussed at the meeting of the experts, and is minuted. I think all the experts agreed it was a waste of resource, continuing to explore the

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soffit of the EWL slab.
Q. Let me put that another way. So the Fang Sheung workers building or installing those rebars in that EWL slab soffit would be simply a waste of both effort and time and money; is that your evidence?
A. I don't get your question, sorry.
CHAIRMAN: I don't know. I think one has to be careful here. I don't mean this critically, Mr So. But I understand what Prof McQuillan is saying is that in purely engineering terms, when looking to the integrity of the structure, you don't need -- as you put it quite dramatically, they could well be made of bamboo; it wouldn't have made any difference.
That, however, is a very different question from one of what has been agreed to be built --
A. Yes.
CHAIRMAN: -- what is required by the various standards and the code to be built, and therefore should be built.
MR SO: That's exactly my point, sir.
CHAIRMAN: Of course. That's absolutely right.
So it's not a waste at all. It's the same as Dr Glover earlier on, when he gave his evidence, spoke of research and development and he spoke of creativity in engineering, elegance in engineering, and that is the way to go, obviously. But equally, much more

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conservative engineering, putting in a wall that's twice as thick as it should be doesn't mean that the workers are wasting their time. It just means that they are working to ensure the integrity of a more conservative design.
MR SO: I think my point is already picked up by the Commission. That's exactly my point.
I have no further questions. Thank you.
Questioning by THE COMMISSIONERS
COMMISSIONER HANSFORD: I have just one or two, in fact probably three or four, i's to dot and t's to cross which I thought perhaps if I could do them now, it might be helpful.
MR PENNICOTT: Please, sir.
COMMISSIONER HANSFORD: Just going to your report, and it's to help me really. The first one is in your paragraph 54, Prof McQuillan, on page 28, and the first sentence:
"It should also be highlighted, as previously mentioned, that the cutting down of D-walls is a normal construction event."
Can you say a bit more about that? I mean --
A. It's qualified by the next sentence, I would suggest.
COMMISSIONER HANSFORD: Okay.
A. In other words, when the D-wall is formed, the process

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that I have described, just for benefit, in my report and the appendix -- when the trench is dug and the reinforcement cage is placed inside that trench, it's done in an environment where the trench is completely filled with bentonite. The concrete, as it is being pumped in, being slightly denser than the bentonite, displaces it from the bottom up, and when the concrete finally gets to the top, you actually overcast it above the formation level, because there will be contamination by way of soil material. You will also get a weaker grade of concrete. And that all comes up to the top. That's what I refer to as the top sacrificial part. So it's necessary to chop that off and get down to the proper formation level and sound concrete.
COMMISSIONER HANSFORD: And that's quite normal?
A. Quite normal.
COMMISSIONER HANSFORD: I would emphasise that in asking these questions, in some cases I perhaps do know the answer but I want to make sure the Commission fully understands.
A. Sure.
COMMISSIONER HANSFORD: The second one is on paragraph 69, your last bullet, on page 33, and in the last sentence you talk about heat scorching of the bar. To the extent we need to understand that, can you explain?

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A. I think if we went to the photograph, you can see that. These were photographs taken at the CIC.
COMMISSIONER HANSFORD: So we go to your appendix, do we?
A. Please.
COMMISSIONER HANSFORD: Appendix VI, one of those photographs, 19 onwards.
A. Yes.
MR PENNICOTT: That's on page 94.
COMMISSIONER HANSFORD: Page 94?
MR PENNICOTT: I think so. Maybe not. Hold on.
A. Yes, go on, because this is the start of -- yes, go on a little bit again. Yes. Sorry, go back.
So I think if you blow up that photograph, if you enlarge it -- you see the little cutting to the left?
COMMISSIONER HANSFORD: Yes.
A. And you can see it's like of a shade of blue. That's the cut end, that has been heat scorched.
COMMISSIONER HANSFORD: What I want to get to is what's the significance of heat scorching?
A. I'm not a metallurgist but if you heat the steel up too much, it will alter its properties.
COMMISSIONER HANSFORD: That's the point you're making?
A. That's the point I'm making.
COMMISSIONER HANSFORD: So the point you're making is a portable electric disc cutter or grinder could alter

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the properties?
A. Could, could. I'm not an expert in that field.
COMMISSIONER HANSFORD: That covers that point. Thank you. Bear with me.
Then paragraph 121, perhaps a similar point -- well, not a similar point -- paragraph 121 on page 48. You talk about welding. I think this is the first time we've had this in this Commission so far. You say:
"... if this is an isolated incident and there are no adjacent rebars similarly compromised, the coupled joint can be left as is or welded."
Then you go on to say about the disadvantages of welding.
A. Mm-hmm. So if you -- I think it's in the Code of Practice 2004. So you are allowed actually to lap the rebar. You are allowed to use couplers, or you are allowed in some instances to weld it.
COMMISSIONER HANSFORD: Right. And you are saying that could be done but there are potential drawbacks --
A. My own feeling is you would lose some of the strength of the bar, but I could be wrong.
COMMISSIONER HANSFORD: But in any event, I think you've clearly told us it's not necessary?
A. Well, what I said earlier was that I'm sure that Arup, in implementing phase 3 of the holistic proposal, will

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be checking whether anything needs to be done with this particular coupler or not.
COMMISSIONER HANSFORD: Dr Glover has previously told us about how the structure can bridge over isolated incidents.
A. Sure, and if that is the only isolated incident, I would not have any qualms at all.
COMMISSIONER HANSFORD: Thank you. On the same page, paragraph 124, you say in your second -- well, the whole -- let's read the first two or three sentences:
"One thing which is becoming apparent is that full 100 per cent engagement of the threaded bars into the couplers was seldom achieved, if at all. Although this is of no structural relevance, for reasons explained herein, it suggests there were site factors, which in my opinion may not constitute poor workmanship, which prevented the rebars from being fully screwed into the couplers."
What do you mean by that?
A. As well as dabbling in DIY I would do a bit of motor mechanics.
COMMISSIONER HANSFORD: Aha!
A. There are occasions -- when you are screwing a thread or a stud into an engine block, for example -- if you lubricate it slightly first to reduce the friction, it

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goes in a lot easier.
COMMISSIONER HANSFORD: Yes.
A. What we are dealing with here are couplers which have been cast into a D-wall, and when they are inspected there could still be some residual dust or contamination, or whatever it is; I don't know. Plus the fact that these are heavy starter bars with threaded ends, they would go in a lot easier if they were lubricated is my proposition.
COMMISSIONER HANSFORD: All right.
A. They reach a point, and I think Paulino Lim actually mentioned this, that there comes a point where they meet resistance and even the coupler will try to turn an extra thread or two.
I'm only postulating that. I think there could be practical reasons why.
The other obvious thing that has been discussed is if the site -- if the standard quality was to achieve two threads, that might be all they did.
COMMISSIONER HANSFORD: Okay.
A. If it was deemed to satisfy.
COMMISSIONER HANSFORD: I don't think I want to go there --
A. No.
COMMISSIONER HANSFORD: -- but in hindsight, perhaps a little spray of lubricant might have helped.

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A. It would, actually, from a practical point of view, it would have made the couplers -- engaging the couplers would have been an easier process.
COMMISSIONER HANSFORD: Thank you. My final point, I don't know if it's a t to be crossed or an i to be dotted -- on page 119, which is the joint statement of experts, you have this second sentence to paragraph 6, which says:
"Moreover, it was noted during the site inspection that the EWL soffit slab openings were creating safety hazards for the staff on site."
A. Yes.
COMMISSIONER HANSFORD: You then go on to say that's one of the reasons why you all as joint experts felt that shouldn't be continued. Can you just explain that "safety hazard"?
A. On the first site inspection, which is on the 19th, I think --
MR PENNICOTT: 17th.
A. -- the 17th, I'm sorry, we were actually taken into one of the exhaust ducts above the line. Pretty cramped conditions so we were all on what was effectively a large skateboard and sliding ourselves along until it we got to the right location. There were no workmen in action at the same time, but we tried to visualise --

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and the MTR staff were explaining to us how difficult it was -- in fact they could only work 15 minutes at a time, because of the position they were in, the limited headroom, the difficulty and the dust.
COMMISSIONER HANSFORD: Sort of like painting the ceiling in the Sistine Chapel.
A. It just wasn't a happy experience for them.
COMMISSIONER HANSFORD: Is this still continuing?
A. That I don't know. That was one of the reasons we advocated shifting attention from the soffit of the slab and doing more meaningful investigation up top.
COMMISSIONER HANSFORD: So your joint expert opinion was this was a bit of a safety hazard?
A. There was absolutely no dissent on that point.
COMMISSIONER HANSFORD: However, if MTR felt they wished to continue with this and no doubt introduce appropriate safety measures, that's up to them?
A. Well, I think we as experts were actually discussing the thing with the MTR people on staff. I don't think they were happy about it either.
COMMISSIONER HANSFORD: So it would be better not to do it and it's not needed?
A. It may well all be done at this stage anyway.
COMMISSIONER HANSFORD: It may all well be done so let's not labour it. Thank you very much. My sentence is all

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joined up.
MR BOULDING: Sir, may I just point out that it wasn't MTR who felt they wished to continue like that, it was government. I made it clear to you and indeed the Chairman in the little meeting we had just before Christmas that I was going to get on the phone immediately, in the light of that, because as we have just heard it was a dangerous environment, the workers were using oxygen, and we wanted to stop that immediately.
CHAIRMAN: All right.
Anything arising at all?
MR SO: Can I just ask one question arising out of Prof Hansford's questioning?
CHAIRMAN: Yes, of course.
Further cross-examination by MR SO
MR SO: When you were giving the opinion in answering Prof Hansford's question as to the opening-up is not necessary, when you say "not necessary" do I understand it correctly that it is not necessary in terms of structural integrity concerns, it is not necessary; is that your evidence?
A. Just repeat exactly what you mean, would you, please?
Q. Of course. When you answered Prof Hansford's question and you expressed the opinion being that the opening-up

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is not necessary --
COMMISSIONER HANSFORD: This particular opening-up?
MR SO: Sorry?
COMMISSIONER HANSFORD: Sorry to interrupt you, but the point was about the soffit slab --
MR SO: Yes, I'm referring to the opening-up of the soffit. When you say it's not necessary, do you mean not necessary in terms of structural integrity concerns, it is not necessary?
A. Correct, and I think we have enough samples that already have been done, because don't forget, you are still continuing to look at the top of the NSL slab which is exactly the same condition as the underside of the EWL slab. You are getting more and more and more samples which are proving and Dr Glover has been telling you on a statistical basis the implication of that. It's all looking very rosy.
So we are actually over-providing for an area which is not safety-critical but is just code-compliant.
MR SO: Thank you. No further questions.
CHAIRMAN: Good. Professor, thank you very much indeed. I'm so sorry.
MR PENNICOTT: I have no re-examination.
CHAIRMAN: My apologies, Mr Pennicott.
MR PENNICOTT: Not at all, sir.

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CHAIRMAN: Prof McQuillan, thank you very much indeed. As with all the other experts, it's been of immense help to us. We do appreciate just how much work you have put into this, in all sorts of ways. Thank you very much indeed.
WITNESS: Thank you.
(The witness was released)
H O U S E K E E P I N G
CHAIRMAN: The next step I think is presentation of written submissions.
MR PENNICOTT: Yes.
CHAIRMAN: I think you mentioned something to me --
MR PENNICOTT: Sir, at the moment, I think, unless somebody behind me stands up and makes an application, we are sticking, as far as I'm concerned, with plan A, which is the written closing submissions from all parties, all involved parties, are due on Monday evening, close of business on Monday. We will serve those --
CHAIRMAN: This coming Monday?
MR PENNICOTT: Yes, sir. And obviously you have already made directions regarding the number of pages and so forth that everybody's got to try to stick to.
CHAIRMAN: Yes.
MR PENNICOTT: The only caveat to that being that the MTR have been asked by the Commission to update us on

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ongoing implementation of management issues.
COMMISSIONER HANSFORD: The Turner & Townsend issues/recommendations.
MR PENNICOTT: That's right. So that's the position.
Then the Commission's legal team will serve our closing submissions on Wednesday, close of business, and then we will re-convene for oral closing submissions next Friday, and then those submissions will continue the following Monday and Tuesday.
As I say, that is subject to anybody standing up behind me and saying they want to do something different, but that's the current state of play.
Can I just say, if there's any doubt or ambiguity about it, that in terms of the oral presentation, my understanding is that when you read out how long each party was to be given for their oral presentations, that was also the order in which they should be made. So that means, as I understand it, the government will be going first, followed by MTR, followed by Leighton, followed by Intrafor, followed by China Technology, followed by Fang Sheung, followed by Atkins, Pypun and ourselves.
So, sir, that is the menu.
There is one procedural matter which was raised with me at lunchtime which I'm afraid I have not had

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an opportunity of taking instructions on, nor speaking, if I may, to the Commission, but I'm going to raise it now, just in case anybody else has any views.
Sir, you will be aware that all involved parties, pursuant to the Rules of Practice and Procedure that were made, have had an ongoing obligation to provide the Commission with documentation that comes into existence, and it is the case that certainly -- let's, if I may, use the government as an example: they have been assiduous in giving us further documentation every seven days, normally on a Friday, so that we can have a jolly weekend. And the issue that has been raised with me, of course, is: now we've got to where we've got to, the end of the evidence, both factual and expert, is that an obligation that needs to continue?
Sir, so far as the opening-up records are concerned, it seems to me pretty obvious that that needs to continue, that we need to receive from the MTR or whatever channel it is that we are receiving the material on the opening-up, that that needs to continue. What I need to take instructions on is whether anything other than the opening-up needs to continue.
The problem I guess we have is that -- on the one hand, the Commission might like to be informed of any relevant material that is coming into existence as we go

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forward. On the other hand, the problem is, of course, none of the other involved parties will have an opportunity -- they will see it because it will be uploaded in the usual way, but nobody will actually have an opportunity of saying anything about it if they wish to do so. So I'm caught in a bit of a quandary here, and I raise it just in case anybody else has a view.
(Commissioners conferring)
CHAIRMAN: Yes, we're agreed that it should stop, in the sense that obviously we don't need general documentation to come in. Obviously if something of real importance comes in that may well be material to the final report, that would be a different matter, so common sense is always used, and obviously we would need to be kept informed of the various opening-up records.
MR PENNICOTT: Yes. So if, sir, the ongoing -- I am really trying to assist the involved parties, and if I may so particularly the government, who are the ones who normally are the party giving us more and more information. To give a degree of certainty about the situation, if we can say now, "Right, draw a line in the sand, no more documents are required from anybody, apart from obviously the opening-up material."
CHAIRMAN: And anything of very real materiality that just has to be brought to the attention of all the parties.

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MR PENNICOTT: Sir, you've said it and put it on the transcript. Perhaps I could invite you to make some form of direction so the parties are clear on that. We can probably draft something and agree it.
CHAIRMAN: Yes, certainly.
MR PENNICOTT: So that everybody knows where they are.
CHAIRMAN: Yes, certainly. Thank you very much.
MR PENNICOTT: Apart from that, I have nothing else to say at this juncture.
MR SHIEH: Mr Chairman, two things. First in relation to the grade of steel bars that were used, I now have instructions. Up to around May 2016, grade 460 was used, and from around May 2016 onwards, grade 500 was used.
CHAIRMAN: Thank you.
MR SHIEH: The second point --
COMMISSIONER HANSFORD: Sorry, that's very helpful, although there must be a little fuzziness as to when the 460 all ran out and when the 500 started to be used.
MR SHIEH: There could --
COMMISSIONER HANSFORD: I have to say, to be fair to you, you had said "from around".
MR SHIEH: "From around", yes. I am told -- this could mean further checking, in terms of the time line -- which particular bit would have used 500, subject to further

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checking of the time line, it's only the Hong Kong Coliseum part that would have used grade 500.
COMMISSIONER HANSFORD: Just the Hong Kong Coliseum?
MR SHIEH: Yes.
COMMISSIONER HANSFORD: On the NSL slab, or both?
MR SHIEH: That I need to check. Perhaps we can communicate with the Commission in writing.
COMMISSIONER HANSFORD: That would be helpful.
MR SHIEH: Perhaps we can check it in greater detail and then communicate that to the Commission's solicitors in writing.
COMMISSIONER HANSFORD: That would be helpful.
MR SHIEH: The second point is I've had a word with Mr Chow for the government. We both would wish the indulgence of an extension of time for the filing of written closing submissions, for the simple reason that we have just finished the expert evidence today, and while, as the Commission may see, the number of people appearing inside this hearing room are dwindling, because other people are working back in chambers or in some other parts of the world; if we could have an extra day or two to compile our written closing, we just believe that we would be able to incorporate a fuller set of transcript references and submissions to assist the Commission.
In terms of the amount of time needed, we know we

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are operating on a very compressed timeline, Mr Chow told me that the government would wish to obtain a one-day extension. For my part, I initially thought we would wish to have another two days but then I overlooked the fact that the Commission also needs to file our written closing after we have. We asked until Wednesday, so they would only have one day to digest our written closing and to file there's, and then Friday we come back immediately. That would be unfair to everybody.
So I think on reflection we would ask for a one-day extension as well, and then thereafter the Commission may file theirs on Wednesday or Thursday so that we could still be back on Friday.
MR BOULDING: Sir, can I just make two points. One is to deal with Mr Shieh's point. First of all, Professor wanted to know the grade of steel that we propose to test, and it's grade 500.
The second point is that we've obviously been working harder than most of the other lawyers in the room because we think we can make Monday evening as ordered, but if it be the case that extensions of time are granted, we would certainly like to have the extension as well. I wonder whether, if you are to grant extensions, one way of dealing with it would be to

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put all of the oral submissions into the Monday and Tuesday, I think that's the 28th and the 29th.
COMMISSIONER HANSFORD: We have an absolute cut-off of Tuesday evening.
MR BOULDING: Of course.
CHAIRMAN: At about what time?
COMMISSIONER HANSFORD: I think my flight is about midnight, actually.
CHAIRMAN: That was meant to be sotto voce.
MR BOULDING: Sir, that's our position.
MR PENNICOTT: Sir, I wasn't, when I uttered those words earlier, seeking to encourage anybody to make an application, but I thought I had a hint that it was coming. I also had a hint that the point Mr Boulding has just made was also coming. And on the basis that "here's one I prepared earlier", I have tried to work out a timetable to see whether it would be feasible to hear the oral closings just on the Monday and Tuesday of the week after next, ie abandoning next Friday.
I've reached the view that provided I was to sacrifice perhaps half an hour or so of the three hours allotted to the Commission, and provided -- and this is quite an important proviso -- everybody sticks exactly to the amount of time that they have been allocated, it would be possible to squeeze it into two days. But

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there simply won't be any latitude, I'm afraid. It's going to be really tight.
(Commissioners conferring)
CHAIRMAN: We are both in agreement that the extensions or the new timetable should be granted. By way of very brief reasoning, I am aware, after so many witnesses have given evidence, after so much evidence has been received by the Commission, some of it quite complex and a lot of it in opposition, and being aware of just how many links there are, if you excuse the sort of pun, that have to be -- the various links of evidence that have to be joined together into a coherent whole, I am particularly aware of just how important final written submissions are. In fact, they are critical.
So, from my position, that's 100 per cent acceptable.
As far as the Monday and Tuesday are concerned, we will do that, but we will start that much earlier. I'm not talking about a dawn patrol or anything but I think we could start at 9.30.
MR PENNICOTT: If the Commission is in agreement that we don't sit next Friday, the timetable that I had worked out goes roughly like this, that we start at 9.30 on the Monday, the government goes first and has an hour and a half, until 11 o'clock. We have our 15-minute break.

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The MTR has 11.15 until 12.45. We have lunch. Leighton has from 2 o'clock to 3.30 -- and those are the three parties that have got the hour and a half each.

It would then be Intrafor -- we would have the break, Intrafor come on at 3.45, and they have an hour, and we would be able to finish on that hypothesis of 4.45. On that Monday, there is therefore a little bit of leeway, I think.

Then if we pitch up again at 9.30 on the Tuesday, it would be China Technology to go first on the Tuesday, from 9.30 to 10.30; Fang Sheung, 10.30 to 11.30, we have the break; Atkins, 11.45 to 12.45, we have lunch; Pypun 2 o'clock to 3 o'clock; and then I would -- in theory you have given me three hours but I will try to truncate that to two and a half, but we would also need the 15-minute break. So I'm afraid it's the Tuesday night we would be slightly later, but still would be over by 5.30 to 5.45, on that basis, if that's satisfactory.

COMMISSIONER HANSFORD: Speaking for myself, that Tuesday overrun is fine. I'm not sure I would encourage a shortening of the Commission's closing report because although all of the closing submissions are very important for the Commission's report I think we feel counsel to the Commission's closing will be particularly

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useful for us, and so I'm not sure we suggest that's curtailed unless it has to be.

MR PENNICOTT: Sir, that's noted. I will give it some more thought to see if there's any way of re-jigging this.

The alternative would be, I have to say, to have a much longer day on the Monday --

COMMISSIONER HANSFORD: Yes.

MR PENNICOTT: -- and perhaps not even finish until 6 o'clock on the Monday.

COMMISSIONER HANSFORD: And move China Technology --

MR PENNICOTT: To last on the Monday.

CHAIRMAN: Absolutely ideal, yes.

COMMISSIONER HANSFORD: That would be better from my point of view.

MR PENNICOTT: Sir, perhaps I will have a word with those instructing me and some directive will go out to the involved parties on that basis. That's fine.

CHAIRMAN: Yes.

MR PENNICOTT: My understanding is, therefore, the involved parties will serve their written submissions on close of business Tuesday and we will also push back a day and we will serve our written submissions close of business on Thursday.

CHAIRMAN: All right. Good.

MR BOULDING: Sir, just an observation. Obviously the

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parties must have the time that's been allocated, but it occurs to me that when the parties put their submissions in and revisit how long in reality they require, it may well be that some of the parties who have been allocated an hour might think that they don't quite need that long, in which case, if they were to inform my learned friend Mr Pennicott, it may well be that the timetable could be re-jigged, say, Thursday of next week, to take that into account.

CHAIRMAN: It also may be the case that we may think, having read their written submissions -- and we would be very cautious about this, of course, because we don't want to restrict the ability of counsel to make their addresses -- that we don't perhaps need as long as is suggested.

MR BOULDING: Of course, sir.

MR PENNICOTT: I wholly endorse that. That seems to be a highly helpful constructive suggestion. Since Intrafor haven't said anything for about eight weeks, perhaps they could be first to indicate how long they need.

CHAIRMAN: Thank you. So a directive will be prepared, simply to avoid any ambiguity as to the timetable ahead, and that directive will contain periods of time.

Many, many years ago I had the pleasure of sitting

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at the back of a Federal Court of Appeal in Miami, and in Florida, along with a number of other states, as you step up to the rostrum to commence your address, the clerk of the court presses a button and a green light goes on, and at the end of your 20 minutes a red light goes on, and you then have to ask for permission to continue, and on the one occasion that I was there, it went on for 20 minutes and the red light went on and counsel said, "Can I have permission to finish my point?", to which the answer was no.

So I don't intend to be as draconian as that, but obviously the Court of Appeal didn't think much of the points that had been made in the 20 minutes, but if we can keep to that timetable that would be excellent.

Is there anything further?

MR PENNICOTT: No, sir. Thank you very much.

CHAIRMAN: Thank you very much indeed.

(4.21 pm)

(The hearing adjourned until 9.30 am on Monday, 28 January 2019)

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