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Wednesday, 16 January 2019

PROF YEUNG TAK CHUNG, ALBERT (on former affirmation)

(10.07 am)

CHAIRMAN: Sorry, just before we start, could I mention one thing. I have a longstanding hearing this evening in the Market Misconduct Tribunal, starting at 5.30. It's not merely a directions hearing, it's a substantive hearing, and I'll obviously have to be there. I've got the papers with me, so it's only a question of presenting myself there by 5.30. I wouldn't want to keep a room full of people waiting.

So, all being well, I would this evening ask if we could rise at quarter to five. All right? Thank you very much.

MR BOULDING: Sir, I was going to ask for leave to ask one or two further questions arising out of our reading of last night's transcript, but I understand that Mr Shieh might also have an application to reopen his cross-examination. So assuming that leave is granted, logically he probably ought to go first.

MR SHIEH: Yes. Mr Chairman, I've had a word with Mr Chow who indicated that he would be asking questions after me, and also with Mr So, representing China Technology, that I have one topic I wish to explore with Prof Yeung, arising out of one of the slides that he produced. The

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slides were produced sometime during the day yesterday and we only had time to do some detailed checking and production of graphs overnight. Therefore, for that reason, I seek leave to ask some further questions of Prof Yeung on one topic.

COMMISSIONER HANSFORD: That's fine.

CHAIRMAN: Yes. You may proceed, and Mr Boulding also, thank you.

MR BOULDING: I appreciate that.

Further cross-examination by MR SHIEH

MR SHIEH: Prof Yeung, good morning.

A. Good morning.

Q. Can I ask you to look at the transcript of yesterday's hearing at page 109.

In fact, it starts at page 108, the previous page. This is where you introduce that chart -- remember, in your slides, you produced a chart -- where you tried to plot, first of all, the tensile strength as per BOSA's table; right?

A. Correct.

Q. One thread, two threads, three threads, all the way down to ten threads; yes?

A. Correct.

Q. Reaching the figure of 1002, I think.

A. I cannot recall the exact number.

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Q. Then you tried to plot that in your graph versus the actual physical test results. That was the purpose of your chart; remember?

A. Correct.

Q. We can look at that now. Could I have shown on the screen Prof Yeung's chart. We actually sent -- we took that out of Prof Yeung's series of slides yesterday and we emailed that to the Commission. I don't know whether or not the Commission has managed to include that in the e-bundles yet.

CHAIRMAN: I think we all have them. This is the one we're talking about? (Indicating).

MR SHIEH: Yes, but for the benefit of those sitting outside --

CHAIRMAN: Yes, of course, who are sitting outside.

MR PENNICOTT: What's the question?

MR SHIEH: The question has not been asked yet because I'm trying to locate the actual graph Prof Yeung presented yesterday. It's halfway through.

WITNESS: I think it's slide number 12.

MR SHIEH: That's it, yes.

Prof Yeung, look at the description that you put -- at the bottom of page 108, you say, line 24:

"Then now you can look at the open circle. The open circles are the experimental results from the five

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ones ..."

And then over the page at page 28:

"... that we saw so far. So you can see now I try to adopt the same symbol you have seen in those reports, so 'S' stands for slipout ... 'C' stands for the failure in the coupler, and then the 'B' stands for the fracture in the bar.

When you look at this circle, look at the first one with 'S', it looks like it's very close to the theoretical calculation, but in fact now is, if you think about more detail, the solid circle ..."

Pausing here, Prof Yeung, the solid circle is what we call the calculated -- the theoretical circle?

A. The calculated value.

Q. The calculated value, yes.

"... the solid circle is based on a tensile strength of 529 and this bar may actually be, as what we've been discussing so far, 500 with a tensile strength of 625. And if you use those numbers to recalculate, BOSA's calculate, those red dots ..."

That means the solid dots; right?

A. Yes.

Q. "... those red dots ..."

Sorry, the red dots should be the open ones?

A. The solid circle.

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Q. The solid circle.
"... those red dots should be a whole lot higher because you get a higher shear strength, so for each thread get engaged, they can take more stresses."
Yes?
I'm not sure if there's anything wrong there. No.
If I may ask you to look at your graph, looking at the open circles, the first open circle appears above "Number of threads engaged", 4?
A. Correct.
Q. Now, that, according to the result, is actually 30 per cent engagement.
A. Correct.
Q. And because the BOSA calculation is based on number of threads engaged, we have to convert percentage engagement into threads engaged?
A. Actually, when I do the analysis, I did look at the picture in BOSA's letter. When they take a picture of the 30 -- what they mark 30 per cent in the picture, and I look at the picture, I actually count the threads in the picture. That's how I get four.
Q. The BOSA table, actually -- if we look at the BOSA table -- the BOSA table we can find in Prof McQuillan's report, appendix V.
So that's ten threads, based on ten threads?

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A. BOSA calculate up to ten threads.
Q. Up to ten threads, yes. Whether it's ten threads or 11 threads, a 30 per cent engagement of ten threads would be three threads, do you accept that, arithmetically?
A. 10 times 0.33.
Q. Yes, and 10 times -- even if you apply 11 threads, it would be 3.3 threads?
A. Correct.
Q. So, on that basis, would you accept that if we convert the percentage engagement into number of threads in this way, the open circle above the number 4 should be moved sideways a bit to the left, to be above 3 or 3.3?
A. In terms of research, when you try to plot the experimental data to compare the calculated data, the way you plot it is you should plot what you have actually done in the experiment. That's why I told you earlier is -- I looked at the picture that they prepared, that they denote as 30 per cent threads. I looked at that bar and I count it, there are four threads on it. They call it 30 per cent.
Q. So, basically, what you are telling us is you did not do the conversion by an arithmetical process of multiplying the percentage engagement by the number of threads, but you trusted your vision and you counted the number of

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threads that appeared on the photographs?
A. I trust the experimental record, rather than what they say to be 30 per cent, because I think they may make the thread first -- because the bar was specially made for that experiment, and you can look at it, there are only four on it, because they did it on purpose to test the bar with less number of threads than the standard number threads. Then they may do the calculation and say it's approximately 30 per cent and I would consider the accurate way to do is you look at actually what they have done in the experiment and put it on the graph.
Q. Now, I would ask you to tell me where the photographs are, because everyone can look at the photographs. They are in the bundles; right?
A. They are in the bundle.
Q. I'm going to ask you where the photographs are.
A. I think they are attached to the letter of 7 January from BOSA to BD.
Q. Yes. As I say, I'm going to look at that set of photographs with you later.
A. Okay.
Q. But I'm just trying to test with you some propositions based on pure arithmetical value and see whether you accept. You may not agree with the underlying assumption but let's leave that to one side.

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A. No, I think that's not an assumption. When you went to compare experimental data with theoretical or calculated data, you need to actually plot what has been done in the experiment. You cannot mix up the two sets of data in such a way for a fair comparison.
Q. Can I proceed to the next open circle, at -- I think it's 40 per cent engagement in the actual test -- remember? 50, sorry.
A. They denote it as 50.
Q. 50. If you apply 50 per cent to ten threads, that would give you five threads, numerically?
A. Correct.
Q. Even if you proceed on the basis that it has 11 threads, 50 per cent of 11 threads would be 5.5 threads, arithmetically?
A. Correct.
Q. So proceeding on that basis, rather than looking at the photographs, the open circle above the number 6 would have to be moved sideways towards the left, on that basis?
A. Again, as what I said, you try to mix up the theoretical and the experimental results, and that's not the correct way to research on a certain phenomena, when you perform experiment and try to check it out, how correct your theory is. Experiments are experiments.

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Q. I did say "on that basis".
A. So you are mixing up the basis.
Q. I know. You can assume that I am as wrong as I possibly can, but on the wrong basis then the circle above the number 6 would have to be moved sideways, to the left?
A. Correct.
Q. By saying "correct", I know you don't mean to accept the underlying premise that I put to you the question, but as I say I'm just putting to you the arithmetical consequences.
A. Or your logic of plotting the data.
Q. Then we come to the next dot, open dot, which is at 60 per cent engagement. 60 per cent engagement, on the basis of a ten-thread bar, would be six threads?
A. Correct.
Q. Even if it's 11 threads, it would be 6.6 threads?
A. Yes.
Q. Then, on that basis, again, that circle, that open circle, somewhere between 6 and 8, marked "B", which you intended to denote the 60 per cent breakage, would have to be moved again sideways to the left?
A. Very slightly.
Q. Slightly to the left.
Now, could I show to you what Mr Southward has done, the next slide which we submitted to the Commission this

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morning.
If you look at the screen, Professor --
A. Yes.
Q. -- this is what Mr Southward has done overnight, by replotting your graph, by applying the percentage to a thread length of ten threads; right?
A. Okay.
Q. Then the result would be, as I have just explored with you, a moving sideways to the left of the circles depicting 30 per cent engagement, 50 per cent engagement and 60 per cent engagement. You understand the logic? You may not agree with the logic but you understand this logic?
A. I understand.
Q. Then you can see that there is a pattern whereby for the theoretical line and the line represented by the actual result, the two lines are similar in shape?
A. What do you mean by "two lines"? We see only one line on the graph.
Q. If you try to look at -- because you are making a point about the comparative value between the actual result and the theoretical result, and you observe that there was something not quite right --
A. Yes.
Q. -- under the graph you plotted.

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A. Yes.
Q. But, if you replot the graphs, then you can see that the position of the circles would have changed, and the odd or strange feature that you described in the transcript no longer featured; would you accept that?
A. No, I don't.
Q. Right. Why was that?
A. Steel now -- I think Mr So would want to make a fair comparison. The tensile strength of the experimental data are based on 500 grade steel. The solid circle right now shown on the graph, on both graphs, are based on 460 steel.
Q. When you said "experimental data" --
A. No, the calculated data.
Q. Calculated data is based on 460?
A. 460, right, and the experimental data are based on 500.
Q. So there would be a gap between them, which is what you expect to see?
A. Between the two sets of theoretical data, there should be a gap.
Q. Which is there.
A. No, no. This one we are comparing experimental data to calculated data.
Q. Yes, I know, and there should be a gap between experimental, actual pulling out, and calculated,

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theoretical; correct?
A. That's right.
Q. So you would expect to see a gap between solid circle and hollow circle for each value of engagement; correct?
A. Correct.
Q. But that is what you see, for each value of number of threads engagement, you see one value for theoretical, calculated value, and one value for actual pulling-out test results?
A. When you mention you see a gap between theoretical data and experimental data, the gap can go either way. Like, for example, I can create a model myself and then I run experiment. If the experiment match my model 100 per cent, that's probably a good indicator my model is correct. On the other hand now is, the experimental data, in the usual way in research, may not match 100 per cent to your theoretical data. Then the other side we need to look at now is does my experimental data overestimate the theoretical data or underestimate?
The point I want to make yesterday is the theoretical data presented by BOSA actually overestimates the experimental data.
In this graph now, what you try to present is the experimental data is overestimating the theoretical data, because the open circles are above the theoretical

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line.
Q. The open circles represent the result of actual pulling out based on the actual steel bars used; correct?
A. Correct.
Q. And if the actual steel bars are of a higher grade, let's say 500, you would expect them to require a higher strength to be able to break them?
A. Even theoretically.
Q. But theoretically they used 460?
A. That's correct.
Q. But if in fact 500 is used you would expect the tensile strength to be higher?
A. I would expect that the solid line will be moved above, because the thread gets stronger; right?
COMMISSIONER HANSFORD: May I interject?
MR SHIEH: Yes.
COMMISSIONER HANSFORD: Prof Yeung, are you saying that if one were to plot also on this graph the theoretical line for 500 --
A. Yes.
COMMISSIONER HANSFORD: -- that would also provide a useful additional piece of information?
A. You are perfectly correct.
COMMISSIONER HANSFORD: And maybe that can be done before we hear from one of the other experts.

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A. I think that's a good idea.
MR SHIEH: We can do all kinds of replotting and all that, but as a matter of shape, if you plot -- if you look at the distance -- if you look at the shape of the three hollow lines --
A. Yes.
Q. -- if you try to plot the three hollow lines, they are almost parallel to the solid line, maybe 30 per cent higher?
A. If you are eyeballing, yes.
Q. And the difference between 460 and 500 is 8 per cent?
A. 460 and 500 is --
Q. Around 8 per cent? It's a matter of arithmetic.
A. Yes. I think you are talking more -- it's about 9 per cent, I guess.
Q. Anyway, can I ask you to refer us to the photograph that you say you looked at. I'm not going to spend any more time discussing what we can see from photographs, because we can all see what's in the photograph. I just wish the professor to let us know, when he said instead of using percentage he counted the number of threads in the actual pulling-out results, I wish you to refer us to the actual photographs so we have on record where they are.
You say they are attached to BOSA's January letter

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in response to the BD's enquiry of BOSA?
A. Right. That's what I can recall.
COMMISSIONER HANSFORD: Mr Shieh, could we have in the break this morning -- we don't need it now -- a hard copy of this graph, please?
MR SHIEH: Mr Southward's graph?
COMMISSIONER HANSFORD: Yes.
MR SHIEH: We can. Certainly. The Commission will deal with it.
Let's look at BOSA's letter, bundle H26. A letter from BOSA.
MR PENNICOTT: 221_11. Is that it on the screen?
MR SHIEH: Yes.
You are talking about page 45643? Is that the photograph that you were referring to?
A. I also saw a different set, but I think they are taking the same sample -- taking the same specimens.
Q. Because if you are talking about the letter -- the photograph attached to BOSA's letter, that is the BOSA letter attaching photographs.
COMMISSIONER HANSFORD: I'm not sure I'm very comfortable with counting threads off photographs.
MR SHIEH: I just wish to make sure that we know what the professor is talking about.
COMMISSIONER HANSFORD: Yes, I understand.

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MR SHIEH: As I say, I'm not going to engage in this tedious exercise of asking for each bar to be magnified and then we do a counting by committee. I just wish to make sure that we all know where it is and we can all observe the threads ourselves.
So this is the photograph that we can locate. Do you have in mind some other photograph that you acted on?
A. I recall I saw one is with -- a photograph of each of the specimens. But I think they are taking the picture of the same specimens.
Q. Except this one they put all five together, you are saying?
A. Yes.
Q. Anyway, we know that these are the bars that you looked at?
A. Correct.
Q. Photographs of the bars that you looked at. You are saying that there may well somewhere be individual photos of each bar?
A. Yes.
Q. Maybe bigger?
A. Yes.
Q. Which we can replicate by zooming in, maybe?
A. I think we can.

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MR SHIEH: Thank you.
Thank you very much. I have no further questions.
Further cross-examination by MR BOULDING
MR BOULDING: Thank you for allowing me to ask a few further questions, Commissioners.
Good morning, Prof Yeung.
A. Good morning.
Q. Yesterday, you will remember we were talking about figure 4 in your report. I think we probably ought to get it up. Bundle ER1, tab 8 at page 26.
A. Yes.
Q. If we could go down to page 26, please. That's the one. There we've got the "Visual inspection -- acceptable thread tolerance", and we can see that zero tolerance is acceptable, right up and including a maximum of 2 millimetres showing; correct?
A. Will you repeat the last part of the question?
Q. Yes. If we look at the red arrow below the bottom of the photograph, we can see that zero tolerance is at one end, and then the maximum tolerance is the two threads we can see there; correct?
A. Correct.
Q. Yesterday we were proceeding on the basis, were we not, that the conscientious MTR site inspector, the conscientious worker, would have this document in his or

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her back pocket to be able to check on site what was acceptable? Do you remember proceeding on that basis?
A. I recall.
Q. You'll know, won't you -- and in any event we've heard -- that at the time this check has to be carried out, first of all you've got the D-wall constructed; correct?
A. Depending whether checking for the reinforcement of the D-wall or checking on the reinforcement between the EWL slab and the D-wall. These are also used for the D-wall.
Q. Yes. Well, I'm talking about the EWL slab to the D-wall.
A. Correct.
Q. So let's proceed on that basis. So you've got the D-wall concreted; correct?
A. Correct.
Q. And you've got the couplers in the D-wall encased in concrete?
A. Correct.
Q. And one is looking to see whether the threaded rebar which goes into the coupler is adequately engaged; correct?
A. Correct.
Q. We had some evidence on this particular matter.

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I wonder if we can look at the transcript, at Day 30, page 142.
Have you had an opportunity to consider the evidence, Prof Yeung?
A. Of whom?
Q. Of Andy Wong, MTR's Andy Wong.
A. No, no.
Q. Let's have a little look together. Page 142, yes. Then line 10, and I'm asking him questions here in re-examination:
"Can you tell the Commissioners how you would check for compliance?
Answer: First of all, as I said, I would do a visual inspection, that is to see if there would be an over-exposure of threads. The correct ones would be just one or two threads. Then I would use my hand or use my leg to push it, to see if they were steady. If there was too little connection, then it would not be stable or not aligned."
So whilst he doesn't refer to it expressly, it appears to be the case, does it not, that he has in mind this acceptable thread tolerance as referred to in figure 4?
A. I agree.
Q. Thank you. Then just reading on, line 18:

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"Did you ever watch the rebar being screwed into the couplers?
Answer: Yes. Yes, I did. That is more or less part of my daily duties. If there was the coupler connection, I would watch it.
Question: I see. Is that something you did throughout the whole of your 100 metres that you covered in C2/C3?
Answer: Yes. Well, at the same time, there would be two or three teams of people. Say, for example, on that day, on 22 September, that evening there were 18 people on the night shift, so I can't say that I would have seen everything, but I would do my best. "
And I said, "Well done."
Proceeding on that basis, he sees a maximum of 2 millimetre exposed threads, two threads exposed, and he would be entitled, would he not, by reference to the figure 4 in your report, to say that's all right?
A. I think you missed the second part of what he said, because he said he also pushed on that one.
Q. That's right.
A. That's another thing. If you recall what BOSA put in for us, if they are not spliced butt-to-butt, that one will be loose.
Q. That's what I'm coming to. That's what I'm coming to.

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And it was in this context yesterday that you brought up the so-called BOSA requirement for butt-to-butt; do you remember mentioning that to the Commissioners?
A. Yes, I did.
Q. We've been through the BOSA brochures overnight that were available during the course of the contract and we cannot find anything there.
I wonder if we can look at a document together, H4056. Thank you.
A. Hang on. I haven't got the document yet.
Q. It's on the screen.
A. Okay.
Q. There we see, do we not, the MTR writing to the BD on 8 July 2013; correct?
A. 8 July, correct.
Q. They are making a submission, and we can see that they are sending the material submission of the proposed coupler for diaphragm wall reinforcement cage and slab construction at Hung Hom Station; right?
A. Correct.
Q. If we look at the document -- I think if we go on to H4142, I hope you see a BOSA catalogue entitled, "Technical and quality assurance manual ... Seisplice standard ductility coupler type A (type II -- ductility coupler)"; do you see that?

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A. Correct.
Q. If you look back at your report on page 26, one can see, can one not, in the summary, number 2:
"Please refer to our Seisplice technical and quality assurance manual ..."
That is the same document, is it not, that we are looking at at H4142?
A. Agree.
Q. Then if we go over to H4143, we've got a "Content" page, and if we look together at item 8, we can see, can we not, the "Seisplice standard ductility coupler -- coupler installation method"; do you see that?
A. Item ...?
Q. Item 8. It's on page H4143.
Do you see it? Just there.
A. Yes, yes.
Q. Then we can pick that document up at H4173.
A. Yes.
Q. Do you see, at the top of the page, the BOSA logo? Do you see that?
A. Yes.
Q. Thank you. "Coupler installation method (standard splice -- type A)". Now, the type A is the rebar that has the ten threads on, isn't it?
A. Yes.

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Q. Looking down, we can see, can we not, that the reader is being told here what the appropriate installation method is; right?
A. Yes.
Q. And step 1, "Position the 1st stage rebar":
"Ensure the coupler is fully screwed into the bar prior to being cast in concrete.
Protective cap should be fitted on coupler end to prevent ingress of foreign material."
Now, there we are talking about the D-wall, are we not?
A. Yes.
Q. Then step 2, "Connect the continuation bar". Now, here we are talking about the bar which goes from the slab into the coupler, which has already been cast in the D-wall; correct?
A. I think if you look at the letter --
Q. Which letter?
A. The cover letter of this manual. It was this set of information are attached for the diaphragm wall construction.
Q. But this also applies to the slab?
MR PENNICOTT: And slab. It says "slab".
A. Okay. I take your word for it.
MR BOULDING: And step 2, "Connect the continuation bar":

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"Position the continuation bar.
Remove both protective cap on the rebar and the coupler.
Fully engage the thread using hand to the coupler. This should develop full tensile strength of the splice once fully engaged."
Then step 3, "Lock the splice":
"Use a typical pipe wrench to tighten the splice. No special torque amount is required."
Now, it's obvious, is it not, that there's absolutely no reference to, is there, to a requirement for a butt-to-butt connection; that's correct, isn't it?
A. No, it's not.
Q. Well, where do you see it there?
A. If you follow these four steps as shown on the instruction, I think for the first one, they say the first one needs to be tightened to the end; right?
Q. Sorry, where are you looking?
A. Step number 1.
Q. Right.
A. The coupler needs to go all the way to the end of the parent bar; right?
Q. Yes.
A. How do you know you reach the end of the parent bar?
Q. Is that a question for me?

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A. No, I try to answer the question. The way you know it is because when you tighten the coupler, you are using up at the threads on the parent bar and your coupler cannot go in any more. That's the way you know you reach the end of the parent bar.
Q. Right. Then you've got the continuation bar.
A. I've got the continuation bar to come in.
Q. Absolutely, and you are allowed to have a maximum of two threads showing; correct? That's correct, isn't it?
A. You are allowed when your bar cannot go in any more.
Q. No, you are allowed to have two threads showing. That is clear from your figure 4, "Summary":
"After connection has been fully tightened, one should see a maximum of two full threads to ensure a proper installation."
A. But during construction, if you look at the last step on this page that you have just shown me --
Q. Step 3?
A. Step 3, you try to hand-tighten it, right, until the bar doesn't go in any more.
Q. Right.
A. How do you know the bar cannot go in any more? It's either this bar has -- the butt of this bar, of the continuation bar, hit the butt of the parent bar. That's why your bar cannot go in any more.

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Q. No. It doesn't say anything here about putting the continuation bar in until it cannot go any further. What it says is you position the continuation bar, you remove the protective cap on the rebar and the coupler, and you fully engage the thread using hand to coupler. "This should develop full tensile strength of the splice once fully engaged.
3: Lock the splice.
Use a typical pipe wrench to tighten the splice.
No special torque amount is required."
What I've got to suggest to you, Prof Yeung, this says absolutely nothing whatsoever about the need for a butt-to-butt connection, does it?
A. I don't think so.
Q. Good. You are agreeing with me then?
A. No, I don't. If I'm going to tell my construction worker -- I don't want to say something discriminating but in Hong Kong most construction workers are not really highly educated. I think that may apply to many parts of the world. So when I look at step number 3, what I would instruct my worker to do is, "Use your hand, keep tighten it until you cannot go in any further". Isn't that another easier instruction to give to your worker? I think that's the easiest thing I can tell them to do, "Keep tighten until it doesn't go any

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more." Then they will go on to the last step, "Put a wrench on it and put more force on it to make sure it doesn't go in any further".
If at that point they still see threads exposing from the coupler, that means the bar cannot go in, and the instruction they got is if the exposed bar is not more than two, we can accept it.
Q. That's all very interesting, Prof Yeung, but none of the instructions that you would give your worker can be found in this document, can they?
A. I can find it. It's "fully engage the threads".
Q. There, they are talking about the initial step, using your hand to put the rebar into the coupler. That's what they're talking about. That's the step you do by your hand, isn't it?
A. Fully engage?
Q. Yes, to make sure you can screw it in. Then, once you have done that, you use a typical pipe wrench to tighten the splice. So you put it in using your hand, that's a manual operation, to make sure you can screw it in. You might have to get a bit of dust out or a little bit of debris. Then once you've done that, you get the wrench, and we've seen pictures of that, and you tighten it, and when you've got your two threads showing, you can say "job done", can't you?

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A. I think you keep avoiding the word "fully" in the instruction.
Q. Well, there we are.
Let me put this situation to you. Of course, when you are screwing in this rebar, by hand or indeed by a wrench, what would happen if you hit a bit of debris there? How do you know that that wasn't the butt that you contend for? If you hit a bit of debris, you would be led to believe, wouldn't you, that you had hit the butt; that's right, isn't it?
A. That is correct, but that is not the intent, to leave a gap in there. That means you are talking about an error in the construction.
Q. We can all read that for ourselves and that's the BOSA coupler installation method.
We looked pretty hard and we can find one reference to butt-to-butt and I want to discuss it with you. If you would be kind enough to go to H4265. Here we've got the "Quality supervision plan on enhanced site supervision and independent audit checking by MTRC and RC for the installation of couplers", and we can see that they're talking there, can we not, about the type II coupler; correct?
A. Correct.
Q. Then if we go on to H4280, we've got a diagram that is

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contained in the QSP, and then there's a box below it, and we've got managed to establish where that comes from, but let's look at that together. It says:

"The tolerance established in the table above provides a lower limit on the permissible variation of the length of the threaded bar.

The larger the nominal size of the rebar, the greater the tolerance allowed."

Then there's a note:

"BOSA CNC threading machines are always programmed by default to allow a positive tolerance on the thread length. This is to ensure butt-to-butt connections can always be achieved when the rebar are spliced inside the coupler[s]."

Now, that's the only reference we can find to "butt-to-butt" at all, and it's a matter of legal submission as to what that means, but what I would suggest to you is that it's not setting out any sort of mandatory requirement, is it, that there always has to be a butt-to-butt connection so far as the two pieces of rebar are concerned?

A. Counsel, I think you have just mentioned to us this is part of a legal submission.

Q. Yes.

A. And this legal submission has been approved by the BD.

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Q. Yes.

A. And on this construction site, this instruction becomes a mandatory instruction.

Q. Well, it depends what it means, doesn't it? What I've got to suggest to you is that if you look back at your figure 4, if you look at the BOSA acceptable thread tolerance, and "After connection has been fully tightened, one should see a maximum of two full threads to ensure a proper installation", if you are allowed to have a maximum of two full threads to ensure proper installation, what I would suggest is you would never have a butt-to-butt connection; that's right, isn't it?

A. I don't agree. The number doesn't add up.

MR BOULDING: Thank you, Professor.

A. I would add one more point to the Commissioners.

I think you may have seen the TV, doing the interview, the project director of MTR can do this connection by hand, even like us in suits. So that tells you one thing. Even though you try to fit it by hand, it's very easy to fit in. There's no point for a construction worker to try to stop somewhere in between without getting into a butt-to-butt situation.

COMMISSIONER HANSFORD: I've not seen that.

MR BOULDING: Again, that begs the question as to whether, on the true meaning of the documentation we've been

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looking at, there is indeed a requirement for a butt-to-butt connection, but I think that's a matter of submission, Professor. Thank you very much indeed.

WITNESS: Thank you.

Questioning by THE COMMISSIONERS

CHAIRMAN: Sorry, Professor, can I ask you this, and I do so very much in the knowledge of what Mr Boulding has commented, namely that your suggestion of what you would say to workers on site, obviously it appears nowhere here, but if butt-to-butt connection was vital or entirely necessary to ensure integrity, speaking as a layperson, would you not have something written down saying, "Ensure there is butt-to-butt connection. Important: ensure butt-to-butt connection", or something like that, because then everybody on site knows the two threads -- whatever the mathematics of that is we will come to later -- but you have to have butt-to-butt connection, because if you don't, you could have difficulty?

A. From a practical standpoint, when you are a construction worker trying to tighten bar in a coupler, there's no way you can really guarantee you get butt-to-butt. When you think about a normal construction worker, the only thing he knows is, "I keep tightening, I clearly cannot go any further in", and then my supervisor may ask me to

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check, "If you cannot go any further, how much is left outside the coupler? If there's only two, okay, take it. More than two, take it out, do it again." The easy way to do it --

CHAIRMAN: So if you're trying to get it in and for all sorts of reasons you can't get butt-to-butt, have a look; if there's two there, you're okay. I'm the world's worst do-it-yourself person, so I have lots of experience in this. You take a screw, you try to screw it into something where the wood perhaps is a little warped or difficult and you suddenly find you've still got about three screws left on your screw but you can't get it in any further; okay? You then look and you test it and it doesn't look too good because it should really be in fully, but that's as far as you can go; you've achieved what you can. Is that not the same thing here? It doesn't say it must be butt-to-butt because (a) you can never tell if it in fact is, unless you have x-ray eyes, and we don't --

A. Yes.

CHAIRMAN: -- that's number one. But number two, accepting that, providing there's only two screws there or two threads showing, you're okay. If there are four threads showing, then you should go to your foreman and say, "Look, I don't know what I've hit here but I've got four

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threads showing."
A. Mm-hmm.
CHAIRMAN: If he comes across and says, "No, you can't count, there's two", and you say, "Sorry, yes, there's two", then everybody is happy. So there hasn't been butt-to-butt but there has been -- the tolerance level of two has been met. Now, that's on what I might call the workability basis on site.
Now, whether in fact two itself is over-engineering, I don't know. That's something else. That's like in pharmacy they say, "Only take two pills a day", but in fact, if you take three, that's okay, but they don't want to be sued if somebody's got some particular problem. Do you see what I mean?
A. I fully understand what you mean. That's exactly the condition while you are working on site. I tell my worker, "Go as far as you can, until you cannot go in any further", but if you like, what you have mentioned, you come back and say, "I tried my best, still two out there", and we understand construction is never perfect and this is the kind of thing we need to allow for, and exactly what we talk about in this Commission, I think many engineers will mention to you what a factor of safety is, and so. Those are something we try to cover, some of the imperfections in construction.

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CHAIRMAN: So BOSA must then build into their engineering of these things a situation where because maybe the angle is not 100 per cent right, because the thread perhaps is not fully beautifully honed, that you might not get fully in, so you don't have to have butt-to-butt, provided you are close enough that only two threads show; that will be sufficient?
A. Or I think another very good suggestion is by Mr Boulding, maybe you've got a small piece of debris in there, and then simply your bar gets jammed and cannot go in any further.
CHAIRMAN: Yes, but the point I'm making is assuming you've got the diaphragm wall and it's all concreted and you've used your hydraulics, and actually it presents a rather difficult situation, some are off at bad angles but a lot of them, shall we say a run of say ten of them, are not that badly off but are just a little bit off and you try to get it in, and each time you get as far as you can, two screws showing -- you know?
Now, the foreman comes across and says that's okay. You know it's okay because BOSA have told you it's okay, and you've done that on a run of say six or seven or even ten of them. None of them are butt-to-butt, but there's only two threads showing. Now, if I was an ordinary worker there, I would say, "I'm okay.

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I haven't got butt-to-butt but I've got a run of nine or ten of these which are only showing two threads."
Wouldn't BOSA say that's okay?
A. If I'm the resident engineer on site, as a resident engineer on site, although I work full-time on site, I'm not really full-time on the site because I may be in the site office, working on paperwork and other things.
CHAIRMAN: No, I appreciate that.
A. But I still inspect my site from time to time. If I encounter the hypothetical situation you have mentioned, that I got 30 bars there and all 30 bars got two threads sticking out, I would do an evaluation to see what happened.
CHAIRMAN: But you are a professor and you are involved at a much higher level. I'm talking about ordinary, everyday construction methodology. What I'm saying, I suppose, is this: surely, if BOSA demanded butt-to-butt, and they would only demand it for safety and structural integrity reasons, they would say so. But they don't, they say two threads is okay. That's not an invitation not to have two threads, because by and large if everything's lined up, you can just screw away and clunk, you've hit the butt; do you see what I mean?
A. And then two threads was caused by the tolerance,

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because that's the one mentioned about full tolerance, that means the threaded section is longer than design. So you can still maintain the ten threads in the coupler. That's what they mean by full tolerance on the right side of the figure.
COMMISSIONER HANSFORD: How do we know that? How do we know that's what they mean?
A. Because they say "maximum tolerance". That means both bars get a maximum tolerance and both bars are 48 -- the threaded section, both bars are 48mm long.
CHAIRMAN: Sorry, so you are saying -- please forgive me -- the two threads means that you still hit the butt because that's the tolerance?
A. Yes. I can give you a simple example on the numbers.
CHAIRMAN: No, no, I understand that. All right. I'm just trying to bring it down to a level that I can understand; okay? Because I'm thinking to myself, "Why say this, why not say it"; do you see what I mean? To an ordinary worker, "I've come on site, and it doesn't say anything about you've got to do butt-to-butt. It says try to get full engagement, which I understand as meaning unless you get them lined up, you can't get them screwed in." So line them up, get full engagement, and then screw them in, and when it starts to get hard, as it always does, because there's a big long rebar which

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is weighing a lot and you've got some guy at the other end holding it up, then get the wrench and you turn the wrench until you feel, "Right, I can't go any further", you can still see two threads. What you are saying is that means that in fact, even though you can't see it, you are now butt-to-butt or as close such that it doesn't matter if you're not -- you're within a tiny millimetre of not being butt-to-butt so therefore you don't have to worry -- so two threads showing means butt-to-butt?

A. Let me explain that to you in a simple way.

CHAIRMAN: No, my question, ordinary -- I'm wearing my wellies, I've got my hard hat on -- two threads showing means butt-to-butt?

A. It's still butt-to-butt.

COMMISSIONER HANSFORD: Just as a supplementary to the Chairman's question, Prof Yeung -- on page 26 of your witness statement -- can we go to it, actually?

In the summary under your diagrams, why have you underlined -- why have you got in capitals and underlined "two full threads"?

A. The summary is a verbatim copy from BOSA.

COMMISSIONER HANSFORD: So BOSA have underlined and have in capitals "two full threads"?

A. You are perfectly correct.

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COMMISSIONER HANSFORD: Thank you.

CHAIRMAN: Because, to repeat, "two full threads" means it's butt-to-butt anyway?

A. The thread get exposed because the threaded section is longer than the design value.

CHAIRMAN: That's correct, yes. But then -- again, please forgive me, I've stopped being a worker, first day on site, I'm back to being a lawyer, and I can't help but think to myself, the guy who writes the instructions, he would say, "There will always be two threads showing; that's proof that you are now butt-to-butt"?

A. If the threads are 44mm long, both will go in, you won't have any threads exposed, because 44 plus 44 is 88. The reason we got this thread cannot get in is because you've got one section with 48mm long. So once the first one goes in, there's only 40mm left for the continuation bar, and that's why the two threads gets out.

CHAIRMAN: Okay. Good. Thank you very much. That helps me.

Cross-examination by MR CHOW

MR CHOW: Good morning, Prof Yeung.

A. Good morning.

Q. I represent the government and I have a few questions for you.

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CHAIRMAN: Sorry, Mr Chow. Please continue.

MR CHOW: No problem, sir.

The first topic I would like to explore with you, again, relates to the butt-to-butt requirement.

A. Okay.

Q. You recall that yesterday, in your discussion with Mr Boulding, acting on behalf of MTRC, it was suggested by Mr Boulding that the requirement for butt-to-butt splicing is not part of the contract, and by "contract" my understanding is the contract between MTRC and Leighton. Do you recall that?

A. Yes.

Q. Do you agree that the couplers manufactured by BOSA is a kind of proprietary product of BOSA?

A. Yes.

Q. Meaning that if one used that product, one has to go to BOSA to purchase it?

A. That may not be necessary. You may get one of BOSA's distributors, if they have one.

Q. And it's a product developed by BOSA with the necessary testing data?

A. For them to get approval from the government.

Q. And the property of BOSA's coupler, the party who knows the best would be BOSA; am I correct?

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A. Yes, you are correct.

Q. And the requirement in relation to installation, to ensure that the couplers will perform as designed, the best party to define how it should be installed should be BOSA; do you agree?

A. Of course.

Q. Just now, Mr Boulding took you to look at a material submission --

A. Counsel, I want to go back to one point you mentioned earlier, whether this installation procedure is in the contract. I would say exact specific instruction may not be in the contract, but in the contract there must be something saying you need to follow the instruction from time to time as the project goes on.

So indirectly that installation procedure is part of the contract, although it may not be explicitly spelt out in the contract.

CHAIRMAN: We don't need to argue the matter, but if everything is meant to meet specifications, so you assume, if it's going to be that proprietary product it will need specifications, and you assume that it will be properly installed. I don't think you need -- provided your -- and in this case we know that BOSA gave instructions to workmen before these workmen set about their job.

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A. Correct. Because sometimes, in some contract, something -- we may not know what product to use, so that means then we use the provision in the contract called engineer's instruction.
CHAIRMAN: Good. Thank you very much.
MR CHOW: Thank you, sir.
Just now, Mr Boulding took you to look at a material submission from MTRC to the Buildings Department. Do you recall that?
A. Yes.
Q. It seems there is no dispute that the material or the use of BOSA's proprietary product is proposed by MTRC?
A. Correct.
Q. Mr Boulding also took you just now to the quality supervision plan. Can I trouble you to go to the supervision plan again, at bundle H9, starting at page 4263.
A. Yes.
Q. This is a supervision plan, again, submitted by MTRC to the Buildings Department for the Buildings Department's acceptance.
If we then turn over the page and go to page 4265. That is the quality supervision plan. At the top of the page we have Leighton's logo on the left, and on the right we have BOSA's logo as well.

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So do you agree that this is a document, on the face of it, jointly prepared by Leighton and BOSA?
A. I think it's more likely it's Leighton adopt BOSA's document to submit.
Q. Right.
Can I then ask you to go to page 4276. This is part of the quality supervision plan that we are now looking at, and this part talks about the installation procedure or method. Do you see that?
A. You mean the five points on the top?
Q. That's correct.
Now, paragraph 4 describes one of the steps. It says:
"Once couplers are fully engaged and tightened. Use a regular pipe wrench/chain wrench to tighten the splice."
Do you see that?
A. Yes.
Q. Just now, according to what you have told the Commissioners earlier, fully engaged, given the dimensions of the thread produced by BOSA, it actually would result in a butt-to-butt splicing condition?
A. Correct.
Q. Then do you see under section (v) it refers to a sample inspection record sheet with example as attached; do you

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see that reference?
A. No, I don't.
Q. Page 4276.
A. 4276, yes.
CHAIRMAN: Sorry, can I get back -- I'm just slightly behind you -- paragraph 4:
"Once couplers are fully engaged and tightened."
And the answer to that was?
A. That would ensure butt-to-butt.
MR CHOW: Butt-to-butt, yes.
CHAIRMAN: Then why put in "then use a regular wrench to tighten"? What that means, surely, is once the couplers are fully engaged and you actually move them in a bit, then what you do is you take your wrench to tighten the splice. So the first sentence doesn't say butt-to-butt, it just says engage it and screw it in, probably as far as is comfortable doing it by hand, and then you use your wrench to tighten; would that be correct?
A. That's normally what they do, but if --
CHAIRMAN: The reading of that instruction.
COMMISSIONER HANSFORD: And further to that, isn't it the case that if it was already butt-to-butt, you wouldn't be able to tighten it with a pipe wrench?
A. You are correct, but that's one thing you do as a check on site, because sometimes, as what the Commissioner has

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mentioned, they may not be properly aligned, so sometimes you need to use a little bit more force.
COMMISSIONER HANSFORD: Okay. But it doesn't say that.
CHAIRMAN: All right. Continue, sorry.
MR CHOW: At the bottom of that page, 4276, there is a reference to a sample inspection record; do you see that?
A. You mean the sample or just the sentence?
Q. The sentence. Under section (v), the phrase within the brackets; do you see that? It refers to a sample inspection record sheet.
A. Okay. You mean the last sentence on the whole page?
Q. Yes. So if you look at the sample inspection sheet on the next page, 4277 -- you see there a number of columns; do you see that?
A. Yes.
Q. The first column is just for putting in the bar's reference; do you see that?
A. Yes.
Q. The second column is supposed to record one of the things that you need to check and inspect, right, and this requires the inspector to make sure that the coupler is fully screwed and fitted; do you see that?
A. Yes.
Q. Then if we move on to page 4279, 4279 apparently relates

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to type I, ie the non-ductile couplers; is that right?
A. I think so, yes, because the coupler is only 86mm long rather than 88.
Q. We have a similar rectangular box at the bottom of the page, and the last line inside the box asks for similar requirement:
"This is to ensure butt-to-butt connections can always be achieved ..."
Do you see that?
A. Yes.
Q. Now, the following page is the page Mr Boulding has taken you to, so we don't need to go to that. So do you agree that "fully engage" the threaded bars and "to ensure butt-to-butt connections" actually applies to both non-ductile and ductile couplers?
A. Correct.
Q. Then, if I may, I would like you to go to have a look at the letter from BOSA dated 7 January 2019. Bundle H26, page 45640, please.
A. Yes.
Q. Prof Yeung, this letter, actually you should be quite familiar with, because you have also referred to this letter --
A. Yes.
Q. -- in your report. Just now you agreed -- you actually

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confirmed that the couplers that were being used by Leighton in this project is a proprietary product from BOSA; correct?
A. Correct.
Q. In this letter, we have BOSA telling us something very important, at least it appears to me, which relates to the specific property of its own product.
Can I ask you to go to the bottom paragraph on page 1, the first page of the letter, where BOSA said "we confirm" -- do you see that, the first line of the bottom paragraph?
"... we confirm the maximum positive tolerance is one thread or 4mm. The tolerance is always positive, and we wish to emphasise here that this is an important feature of our design to ensure butt-to-butt connections can always be achieved when the rebars are spliced together inside the coupler."
A. Yes.
Q. It goes on to say:
"Please refer to the last remark in the table at appendix A. Please note further if rebars are not spliced butt-to-butt, the coupler assembly will be loose."
Do you see that?
A. Yes.

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Q. So this is what BOSA tell us.
Then if we can move on, turn over the page, BOSA then go on to say, the first line of the first paragraph:
"... we do not have any test data on correlating partial thread engagement of coupler to its structural performance. We have no intention in conducting such tests as it should serve no useful purpose for our products. Our products are designed for butt-to-butt full thread engagement and that is what we sell."
Right?
A. Right.
Q. Then if we can jump to the second paragraph:
"Regarding your question on how a partially engaged coupler would perform in permanent elongation test, static compression and tension tests and cyclic tension-and-compression tests, it is our opinion as explained in paragraph 4 above, that it is unlikely that such couplers, without being spliced butt-to-butt and are therefore loose, will survive permanent elongation, and cyclic tension-and-compression tests."
Now, this is what the owner of the proprietary products tells us as to the property of his own product.
Now, leaving aside whether the butt-to-butt requirement is part of the contract between Leighton and

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MTRC, purely from a technical point of view, for BOSA's couplers to function properly and serve its intended purpose of splicing two pieces of rebar together, does it matter whether the butt-to-butt requirement is clearly set out in somebody else's contract, if someone decided to use its own product?
CHAIRMAN: Sorry, I have difficulty with that.
COMMISSIONER HANSFORD: Yes, I don't understand that.
CHAIRMAN: I would say I have difficulty with this letter too, because with the greatest of respect, this letter is written by January 2019, by which stage this whole thing had blown up.
MR PENNICOTT: Exactly.
CHAIRMAN: And anybody worth half an ounce of salt is going to make sure their position is secured as possible in law. So it's a defensive letter in that respect. That's not a criticism, it's a statement of common sense. So I have difficulty with the contents of that letter.
MR CHOW: Very well, sir. We can attach different weight to any of the documents.
CHAIRMAN: Yes.
MR CHOW: I just want to ask Prof Yeung, as an expert, whether from a technical point of view, given what the owner of the proprietary product tells us as to the

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property of his its product, what his view is going to be. But of course the views of BOSA are set out in a letter which was only issued recently, after all this has blown up, is something that the Commission can take into consideration.

CHAIRMAN: We will obviously do that, should this be put before us and argued on that basis.

MR CHOW: My last question on this topic is: if the measured engaged length is less than 37mm, in your opinion, is it still possible that the splicing inside the couplers is still butt-to-butt?

A. Counsel, I think you are referring to the embedment length, not the engagement length, because that's not what we measure.

Q. Okay. How about --

A. If the embedment length is less than 37, even though we take into account of the measurement tolerance of 3mm, it won't have a minimum of 40. So there's no way you can guarantee them to be butt-to-butt. Very simple mathematics we can look at it is -- because the coupler is 88mm long, if the bar, the parent bar, has a full tolerance, it will be 48mm long. So that still have 40mm for it to be butt-to-butt. If what you measure is less than 37, there's no way the threaded length into the coupler can reach the value of 40, so that means it

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won't be butt-to-butt.

COMMISSIONER HANSFORD: Sorry, Prof Yeung, can you just enlighten me, what's the difference between embedment length and engagement length?

A. Engagement length will be, when you put the thread in, the thread will engage the thread inside the coupler. And what we measure now is -- we can measure the end of the bar, and depending on how many -- from that measurement, we cannot really deduce -- we can do some deduction but we cannot guarantee how many threads are actually engaged, because we only measure how long is the bar into the coupler.

COMMISSIONER HANSFORD: Sorry, we are receiving almost daily reports of the opening-up exercise. Are we being advised -- I need to check -- of engagement length or embedment length?

A. We are measuring embedment length, because we can only measure where the end of the bar is.

COMMISSIONER HANSFORD: Right. Okay. Thank you.

CHAIRMAN: So, in very simple terms again, embedment length means it's a 10 foot bar, it's now 6 foot, so 4 feet of it's gone into the structure; that's embedment. Engagement is we've got X number of threads and it appears from our counting that six threads have actually gone in?

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A. Yes.

COMMISSIONER HANSFORD: So, just to complete this, engagement less than is always shorter than embedment length?

A. Correct.

COMMISSIONER HANSFORD: Thank you.

MR PENNICOTT: Sir, the information we are getting on the table is headed "Engagement length".

COMMISSIONER HANSFORD: That's why -- thank you. I don't know if that's helpful or not.

MR PENNICOTT: I'm just telling you, it's a fact.

COMMISSIONER HANSFORD: So the table calls it "Engagement length"?

MR PENNICOTT: It does, sir.

COMMISSIONER HANSFORD: But Prof Yeung would call that "embedment length"; is that correct?

A. That's why I'm very careful.

COMMISSIONER HANSFORD: You're being careful but it appears that those providing us with the regular tables are not. So when they say "engagement length" you would say that really means embedment length, and engagement length is something shorter?

A. Correct.

COMMISSIONER HANSFORD: Thank you.

A. I can --

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COMMISSIONER HANSFORD: No, that's -- unless you need to elaborate, I've understood that.

MR CHOW: Sir, my understanding is so far that people take the reading from the ultrasonic tests as representing the engagement length for the purpose of our discussion, but --

COMMISSIONER HANSFORD: Prof Yeung calls it something slightly different.

A. That's actually the embedment length.

MR CHOW: Thank you. Prof Yeung, I would like to move on to a new topic.

A. Okay.

Q. You recall yesterday Mr Pennicott took you to Prof McQuillan's report, paragraph 89. Can I ask you to go to the report, and I think it's in tab 1 of the bundle, at page 38, paragraph 89.

A. Yes.

Q. You have been taken to subparagraph 2; do you recall that? Where Prof McQuillan says:

"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 D-wall."

Do you see that?

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A. Yes.
Q. The part I would like you to focus on is the first two sentences that I've just read to you.
A. Mm-hmm.
Q. My question is this. Well, you have given an answer yesterday. Your answer was something like, "It depends, there may be many different loading cases"; that was your answer. Irrespective of that, do you agree with me that to be able to form a plastic hinge at the diaphragm wall below, as suggested by Prof McQuillan, there is one very important prerequisite or assumption, the joint, the connection between the EWL slab and the east diaphragm wall, is strong enough to transfer the loading. If the joint failed, then the plastic hinge under the connection may never form. Do you agree or not?
A. When you mentioned the joint failure, what is the failure mechanism of the joint, before I can answer your question?
Q. How about shear failure?
A. On the slab?
Q. No, within the joint.
A. I think without a detailed analysis I cannot definitely answer that question.
Q. All right. Thank you.

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Do you recall yesterday you mentioned that you are also of the view that the stresses inside the joint has to be checked?
A. I think I mean the construction joint.
Q. Yes, the additional construction joint?
A. Yes.
Q. So, to that extent, you agree with the opinion of Prof Francis Au; right?
A. Yes. But we are not saying it is not adequate. I think we need to check it to make sure it's adequate. Without the analysis at this point in time, we cannot say the joint is not structurally adequate. We won't make that opinion for the time being.
Q. Yes. This is also the position taken by Prof Au as well.
If I may move on to another topic, about the question of whether there is requirement in relation to the use of couplers in the 2004 Concrete Code. Do you recall that?
A. Yes.
Q. At one point, you seemed to agree with Mr Pennicott that there was no requirement in relation to couplers in the Concrete Code 2004. Do you recall that?
A. If I remember correctly, coupler is not in the Code of Practice 2004.

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Q. All right. I'm not sure that it is the true position. Let's see if I can get you to clarify. Can I first ask you to take a look at the acceptance letter issued by the Buildings Department, dated 25 February 2013. Bundle H9, page 3908, please.
A. Yes.
Q. This is an acceptance letter -- sorry, I have some problem with my iPad. Just bear with me, please. Like Mr Shieh, I cannot rotate the page.
This is the first page of the acceptance letter. If we can then now go to the relevant part, the specific requirement for ductile couplers, at page 3931, please.
You see, under paragraph 5 -- paragraph 5 is part of the requirement imposed by the Buildings Department. It relates to the various tests --
A. Yes.
Q. -- that the contractor has to perform for the use of couplers in the project.
A. Yes.
Q. Under subparagraph (a), it refers to tests specified under the American code, AC133; do you see that?
A. I think it's the acceptance criteria.
Q. Yes.
In subparagraph (c), it refers to a requirement in relation to permanent elongation of the splicing

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assemblies after loading to 0.6 of the yield strength should not exceed 0.1 millimetre in accordance with the requirements stated in clause 3.2.8.2 of the Code of Practice for Structural Use of Concrete 2004; do you see that?
A. Yes.
Q. So that is some requirement in the Concrete Code in relation to maximum elongation after certain level of loading is applied?
A. Yes.
Q. There is also reference to AC133, which you have also attached to your report. Can I ask you to go to appendix II of your report, please. Appendix II of the bundle ER1, tab 8.
A. Yes.
Q. If you go to page 3, can you confirm that the section 4.1.2 contains requirement for various tests to be performed on ductile couplers?
A. Correct.
Q. And also, if we go back to section 4.1.1, which refers to "Type 1 splice", am I right to say that "type 1 splice" referring to this American code, actually refers to non-ductile couplers?
A. Yes.
Q. Or they are different? Okay, right.

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A. Actually, they match the type I and type II of BOSA.
Q. I see. So you mean "type 1 splice" referred to in AC133, under section 4.1.1, corresponds to the non-ductile --
A. The type I of BOSA.
Q. The type I of BOSA, and "type 2 splice" referred to in paragraph 4.1.2 corresponds to type II ductile couplers of BOSA?
A. Correct.
Q. So we can see there are requirements for various tests to be conducted for both ductile and non-ductile couplers to be used?
A. Correct.
Q. Do you want me to refer you to the relevant section of the 2004 Concrete Code, just so make sure there are requirements for testing?
A. It would be good to look at it, yes.
Q. Sure. Can I take you to bundle H8, page 2852. This is the Code of Practice 2004. Clause 3.2.8.2, regarding "Bars in tension":
"The only acceptable full strength butt joint between bars in tension is formed using a mechanical coupler satisfying the following criteria".
If you can turn over the page, the first bullet point:

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"-- when a representative gauge length assembly comprising reinforcement of the diameter, grade and profile to be used, and a coupler of the precise type to be used, is tested in tension the permanent elongation after loading to 0.6 [yield strength] should not exceed 0.1 millimetre; and
-- the coupled bar assembly tensile strength should exceed 287.5 newtons per millimetre squared for grade 250, and 483 newtons per millimetre squared for grade 460."
So you confirm it's actually a requirement under the 2004 Concrete Code?
A. For couplers, yes.
Q. And this requirement actually applies to both ductile and non-ductile couplers; correct?
A. I think in 2004 they may not consider ductile coupler at that time.
Q. Okay. But the acceptance letter from the Buildings Department also sets out testing requirement for non-ductile couplers. Can I ask you to go back to the acceptance letter, bundle H9, page 3934. This is the same acceptance letter that we have just looked at, it's just that this is another page under the section for non-ductile couplers. Paragraph 3, in subparagraph (a), we can see that similar requirement in relation to

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permanent elongation also applies to non-ductile couplers.
A. Correct.
Q. So am I right in saying that irrespective of whether it is a ductile or non-ductile coupler, one has to comply with the requirement as to the permanent elongation of, you know, the maximum 0.1 millimetre after a loading of up to 0.6 yield strength?
A. Correct.
Q. And as far as you know, BOSA has not performed elongation tests to any of the partially engaged couplers?
A. You mean the tests they conducted specifically for this Commission?
Q. No.
A. No, they didn't.
MR CHOW: Sir, I think it's a convenient moment to have the morning break. I have just one more topic to go through. It will take maybe another five minutes.
CHAIRMAN: Then I think finishing your examination would be good. Thank you.
MR CHOW: Prof Yeung, the last topic I would like to explore with you --
CHAIRMAN: Sorry, just before we move on, the question and the answer that was just exchanged, it suggests that

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BOSA were not requested to do this or that BOSA failed to do it. There's quite a difference, because BOSA is not a party, and that would be a criticism of BOSA if we use the suggestion "failed". But if they were not asked to do it by way of later testing, that's a different matter.
MR CHOW: Sir, the last line of questions that I asked actually related to the test carried out by BOSA to the partially engaged couplers for the purpose of the Commission, in relation to which my instruction is that the test was carried out by BOSA without the request of the Buildings Department, and the Buildings Department was only invited on the day of the testing to send someone to witness the test.
It is not clear whether the test performed by BOSA was originally requested by MTR or not. That is something beyond my knowledge or the government's knowledge.
CHAIRMAN: All right. That puts it into context.
MR CHOW: Yes.
MR PENNICOTT: Sir, there was certainly no failure. It may be I'm in a very similar situation to Mr Chow. I'm still struggling a little bit to help the Commission in establishing where the initiative came from to do those tests, because unless I've suffered a complete memory

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failure, which is quite possible, I'm not convinced it was something initiated by the Commission itself, and if that is correct then I'm still a little bit, as I say, factually unclear as to precisely the provenance and how all that came about in the first place.

CHAIRMAN: I accept that.

MR PENNICOTT: So I certainly don't think one can categorise it as a failure. Clearly they either did it of their own initiative or somebody asked them to do it. I don't think it was the Commission and it doesn't sound as though it was the government, so the number of potential requesters are limited.

CHAIRMAN: Good. I'm sure you understand my position though --

MR PENNICOTT: Yes.

CHAIRMAN: -- that obviously if BOSA is criticised in some way, it would be quite wrong for them, not being parties, to just pick it up somewhere or other in the media at some later stage, without being given an opportunity to reply.

MR PENNICOTT: Of course, sir.

MR CHOW: Sir, can I also add this: from my recollection, Mr Glover's report also mentioned about the tests as something commissioned by MTRC. That is where I got that impression. Perhaps we can clarify with Mr Glover

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later on.

As Mr Pennicott said, at the moment it is not clear to the government as to who was the one who initiated this test, but definitely not the government.

Prof Yeung, I have one last topic I would like to explore with you. You know, when I heard about your credentials, I noticed that you are a specialist in geotechnical engineering.

A. Correct.

Q. One of the issues so far that has given rise is how we should classify the station box structure, comprising the platform slab and the diaphragm wall.

The position of the government or some of the factual witnesses -- for example, Mr Humphrey Ho of the Buildings Department considers the diaphragm wall forming part of the station structure, it should be considered as foundation; right? We also have evidence from an Atkins engineer, for example Mr Sung, who confirmed that to him the change made to the top of the eastern diaphragm wall is a change made to the foundation, and he also advised the Commission that prior consultation has to be done with BD before the implementation of the change.

We also have Mr Andy Leung, the design manager of the MTRC, telling us that as far as he was concerned,

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this kind of change has to inform the Buildings Department and get its acceptance before the implementation of the changes.

The issue now is what is the proper classification of the station box structure. The expert instructed by Leighton --

CHAIRMAN: Sorry, I am interrupting you again; I do apologise. This is a classification question, is it not, that may differ from one jurisdiction to another, so that in jurisdiction A -- I may be wrong here; please tell me if I am. In jurisdiction A they may say this type of working classifies as a foundation whereas in jurisdiction B it may, depending on certain things, classify as superstructure. I'm just wondering, therefore, if the professor, with due acknowledgement of all his skills, is actually in a position to determine a classification in Hong Kong of a particular form of building.

MR PENNICOTT: Also, sir, there's a rather broader question that has arisen on a number of occasions already, as to whether this is actually an issue which concerns the Commission at all in any event.

CHAIRMAN: Because I think we made it quite clear earlier on, we were not being pulled into any aspects related to the sort of thing that arises in civil litigation. You

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know, you have built to this or built to that and somebody has to determine what it is in law. So I'm a bit concerned as to whether we should really be enticed into this area.

MR CHOW: Sir, may I try to assist further on this point? The reason why I need to ask this question actually relates to one of the issues I believe that the Commission would be interested in. That is whether prior consultation with the Buildings Department before the implementation of the changes is required.

Given the experts also discuss about the implication of a practice note, PNAP ADM-19 --

CHAIRMAN: I appreciate all of that. That's why we are aware of the fact that this issue has been dealt with. I don't see it falling into our terms of reference. I can certainly see a situation arising as to as-built drawings. I can certainly see the argument being there should have been earlier consultation. And then the question is whether it was required or not. But as to whether it was required or not, that seems to us at the moment, subject to your representations in a week or so, not to be an issue for us.

MR CHOW: Okay. I take note of your --

CHAIRMAN: Sorry, I don't mean to appear rude about it, but it's just one of the things we have to be careful about

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is we stick to our terms of reference and only to our terms of reference --
MR CHOW: Very well.
CHAIRMAN: -- and we don't get enticed into other areas; all right?
MR CHOW: In that case, I have no more questions. Thank you.
CHAIRMAN: Thank you.
MR CHOW: Thank you, Prof Yeung.
CHAIRMAN: Sorry, Mr Pennicott, as counsel to the tribunal does that roughly accord with your approach?
MR PENNICOTT: It does, sir, yes.
MR SO: Sir, I have some re-examination. I'm entirely in your hands as to whether you want me to do it now.
CHAIRMAN: It's now nearly 12 o'clock, so we will allow for tea or coffee now.
MR SO: Thank you.
CHAIRMAN: Quarter of an hour.
(11.54 am)
(A short adjournment)
(12.17 pm)
MR KHAW: Mr Chairman and Mr Commissioner, just on the last point that was discussed between Mr Chow and the Commission regarding the terms of reference before the morning break -- I heard what the Commission said and

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I heard what Mr Pennicott said. I don't want to argue this point with anybody but it's just that I have a duty to point out that this may have a direct bearing on the scope of the closing submissions that our team has been working on.
CHAIRMAN: Yes.
MR KHAW: During the break, I had a look at Mr Pennicott's second opening address. In fact if I can very briefly refer to one of his sentences which in fact had been formulated as primary topics of enquiry, one of the question which has been formulated is this:
"In relation to the connection between the east diaphragm wall and the EWL slab and, in particular, the reinforcement steel arrangement in respect thereof, separately in relation to area A, area HKC, area B, area C1, area C2 and area C3 ..."
Under his (v) it says:
"Insofar as the as-built situation differs from the original design/specification, what reporting to the government ought to have been taken place, if any, when and by whom?"
I believe it is in this context that parties have put forward various arguments regarding the interpretation of this PNAP no. 19. That actually gives rise to this question in relation to superstructure,

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foundation, et cetera.
So it is actually in relation to this particular area that this issue has arisen.
I have also checked the transcript regarding this Monday. In fact when Prof Au was giving evidence, Mr Shieh also referred Mr Au to a particular passage in Mr Southward's report regarding this classification in relation to the structure.
CHAIRMAN: You are right.
MR SHIEH: That's because the government asked Prof Au a question along those lines and that's what prompted me to ask him that question.
The whole thing about foundation came about because the government witnesses made a point that whether or not consultation is needed or not needed may turn on the interpretation of that particular practice note, which then turns on whether or not the D-wall counts as part of the foundation.
CHAIRMAN: That's right.
MR SHIEH: Which is the origin of all this.
CHAIRMAN: Sorry to interrupt. I'll let you continue in a second. What has concerned the Commission is this. We appreciate the issue is one of when this decision was made or before it was implemented, should there have been representations made to the Buildings Department.

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One can look at that more holistically by saying one needs to build up a culture of cooperation and close liaison; it becomes a joint endeavour in these things. Or one can look at it, perhaps -- and I'm just giving examples at the moment -- from a much more restrictive legal perspective, which then becomes a case of saying: in order to determine whether this was a design change, as opposed to not a design change, one therefore has to determine whether what was being changed was a foundation as opposed to a superstructure. It's then required for the Commission to make a legal determination of what, under existing regulations in Hong Kong, constitutes a foundation in respect of the diaphragm walls, et cetera, et cetera.
That becomes a peculiar and particular legal issue, and I don't know that we are -- there may be occasions when it is necessary to do so, and we would be very happy to be educated on this, but that's our major concern.
Then, of course, what are we going to do -- is somebody going to appeal that on the basis that actually we've got it wrong, it's not a foundation, it's a superstructure? It becomes a peculiar legal issue that we want to try to avoid. Do you see what I mean?
MR KHAW: (Nodded head).

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MR SHIEH: In fact it resonates, from Leighton's perspective, with one observation which came from the Commission at a certain juncture where the Commission actually observed that the Commission is well aware of certain actions taken by the government in respect of Leighton prior to the commencement of the Inquiry, but the Commission is not going to enter into a determination of the civil aspects of any matters which may transpire between Leighton and the government. There may be all kinds of legal disputes subsequently arising.

CHAIRMAN: Yes, of course. Sorry, Mr Khaw, I'll let you stand in a second. We are aware that these are the issues, and we've allowed some debate on the issue, because unless we understand the issue we can't know, for example -- and this is off the top of my head -- whether something should come forward from this Commission suggesting more cooperative manoeuvres or steps in future between the Buildings Department and various contractors and the like. So we have to know something about it.

But we don't want to be taken so far into the jaws of it that we get chewed up in a legal debate which then becomes a legal decision which should really come from a court of the classic kind as opposed to a Commission

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of Inquiry.

Mr Khaw, you may want to answer that.

MR PENNICOTT: Can I just make some observations as well, very briefly?

Obviously, what was said in the opening submissions has been accurately read out by Mr Khaw and I have no difficulty with that. But what we have here is a dynamic process, and I am bound to say that when I wrote that -- and I take full responsibility for it, of course -- I have to say I was completely unaware of where all this was going to lead. I had no idea of course that all of this ultimately might hinge on the question of whether or not this was a foundation or not a foundation and all of that.

I had more in mind at the time that this was actually going into a potential project management issue as to how the MTR and Leighton on the one hand should have communicated with the government, was there a breakdown? It was more seen as a project management issue than a technical issue, if you like, that it seems to have turned into.

So, in defence of myself, if I can say so, I honestly didn't understand the technicalities that obviously have emerged as we have progressed. As I understand it, from Leighton's position -- and no

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doubt Mr Shieh can confirm this -- you will recall that on 27 November Mr Shieh and his team put in -- I think it's somewhere in the bundle; I'm not sure -- a submission on the design change issue, which as I understood it was indeed an attempt, by Leighton at least, to take the Commission away from deciding these issues.

Certainly since then, I'm bound to say I've been trying to row the Leighton boat on that particular point, that the Commission shouldn't get involved in deciding these rather complex issues which, as you've said, sir, are rather more relevant perhaps to commercial litigation or arbitration or however it may be resolved in the future, if it needs to be.

CHAIRMAN: Yes.

MR PENNICOTT: Sir, that's really how I have been approaching it since all the evidence has emerged about the construction of the provisions of the Ordinance and the contractual documents.

CHAIRMAN: Yes.

MR SHIEH: That is indeed our position. May I echo what the Chairman has said? It is one thing to say on a high level of generality at the very beginning, "Let's enquire whether or not anyone should be made known about it, et cetera, at an earlier stage." But if, as things

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transpired, the finer points of detail are no longer whether something should have been sent -- we know something had been sent -- but whether or not, on a fine legal construction, that amounted to a proper form of statutory application or consultation, that is a completely different kettle of fish and which we had suggested the Commission should stay away from.

If what the government wants is some assurance that this is not what the terms of reference require and not what the Commission is going to get into, I hope and I think the government has its answer.

But if what the government now wants is to positively press for it, then I would respectfully suggest some underlying agenda which is unknown to us. In other words, if they want assurance, I suspect they would have got their assurance by now, but if they go any further, then I hear what they say.

MR KHAW: Certainly no hidden agenda whatsoever. I just want to make myself clear, Mr Chairman and Mr Commissioner. My point is simply this. I'm not trying to encourage anyone in fact to really labour this point. This is certainly not my intention. I only wanted to make sure that we will cover everything in our closing submissions in order to assist the Commission.

Another point that Mr Shieh raised is that it's the

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government's stance that we need to have an interpretation on this PNAP no. 19. In fact we never raised it in the first place. It is Leighton who tried to convince the Commission that they did not need to report this change to the Buildings Department, ie they rely on this practice note to say it's not necessary. That is why this interpretation of the practice note came into being. It was never the government's case that this was relevant.

But since Leighton has raised this point, we have to meet this case by doing an interpretation on the practice note in relation to this narrow part regarding the classification of the structure.

Of course, if it is now Mr Shieh's case that Leighton is not going to run this argument, that "This is a superstructure, not a foundation; we are not going to rely on the interpretation of this PNAP no. 19", I'm perfectly fine with that and we don't need to actually deal with this particular argument.

But when we look at it, they actually have chosen to raise this point again in their expert report. I believe they still find it necessary to do so. That is why, just as a matter of prudence, we would like to clarify this point, because if they are going to run this point and they are going to rely on the

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classification of the structure, and if Mr Chow is now not given a chance to ask Prof Yeung this question, we may not have a complete picture regarding this narrow point on classification. That is my only concern.

CHAIRMAN: I think you can accept from us -- we have discussed this matter, so this is not an off-the-shoulder answer to you; far from it, we've discussed it on more than one occasion -- and we are of the view that it is not for this Commission to make a legal decision in this instance, which it would be, as to whether the diaphragm walls in this particular structure constitute foundations in accordance with the prevailing regulations, statutes, bylaws, et cetera, that prevail in Hong Kong.

So, that said, it's clearly a very important issue because it sets the scene and contains within its parameters the reason for a lot of dynamic happenings that have taken up the time. So we will expect from parties who believe it's relevant to their case that the issues should be there, but we will not, at the end of the day, make a decision on that limited legal point of whether the diaphragm walls in this structure constitute foundations in accordance with the law of Hong Kong.

MR KHAW: I'm very grateful for the clarification, Mr Chairman.

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CHAIRMAN: Good. Can I also just say -- I appreciate that parties have in the past and will continue to do so, that they will look to what may have been said for counsel for the Commission at the outset. That's quite proper. There's no criticism at all. However, unlike litigation of the classic kind, where the chess pieces are set up ready to be moved -- that's why whenever you take a civil case to court, it takes you so long, because the pleadings have to be prepared -- with a Commission of Inquiry which commences within a much more limited scope of time, the chess pieces make their own way onto the stage, bit by bit. It's a much more fluid, a much more progressive process. It's an inquiry, and inquiries you have to follow your nose in many respects.

Good. So what Mr Pennicott's nose tells him at one time, the combined olfactory wisdom of everybody may say shouldn't influence us at a later stage.

Good. Thank you very much.

MR SO: In that case, I wonder if Mr Chow would --

CHAIRMAN: Yes, I was just waiting. I think Mr Chow was having a brief final discussion with Mr Khaw.

MR CHOW: Prof Yeung, just before the break, I was going to ask you -- you recall about the classification of the station box structure; right? You recall that?

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A. I think we were talking about the diaphragm wall in particular.

Q. Yes. What I was going to say is that according to Mr Southward's expert report, having made reference to a foundation analysis and design textbook, Mr Southward takes the view that the station box in question should be treated as a superstructure. Do you agree?

A. I think that's not in his report. I think he's saying, if my recollection is correct, the diaphragm wall below the EWL slab is a foundation, but then above the EWL slab is not. I think that's what he said in his report. Correct me if I'm wrong.

Q. Yes. Perhaps it's easier for me to refer you to a particular part of his report, section 14.2, page 40 of Mr Southward's report.

A. I think you are referring to page 41, internal page number.

Q. Page 41 is the figure, the figure 13 referred to by Mr Southward on page 40. In page 40, under section 14.2 --

A. Yes.

Q. -- Mr Southward refers to a foundation analysis and design textbook, and in particular he refers to a sentence stated in the textbook which says:

"The foundation is the part of an engineered system

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which transmits to, and into, the underlying soil or rock the loads supported by the foundation and its self-weight."

Then he goes on to refer to the Code of Practice for Foundations 2017, which provides:

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

The term diaphragm wall is explained by the Buildings Department in the same publication as follows:

'A diaphragm wall may be used as a temporary lateral support wall for deep excavation or the permanent wall of a basement, or it may be designed for both temporary and permanent uses. It may also be used to support vertical loads.'"

Then Mr Southward continues to say:

"In the context of the SCL1112 station box structure ..."

Now, the station box structure is the one that you were just pointing out to us, figure 13, turn over the page, it's the part comprising the ground, EWL slab, the purple NSL slab and the section of diaphragm wall in between the two slabs, as the station box structure.

In the penultimate paragraph, Mr Southward concluded:

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"This element of the overall structure should be termed the superstructure."

Do you see that?

A. Yes.

Q. Do you agree with his conclusion?

A. No, I don't.

Q. How would you classify this part of the station box structure?

A. If you look at the structure itself, the weight or the load on the EWL slab will be transmitted to that part of the diaphragm wall, and through that diaphragm wall it will transmit the load to the ground. So if you look at all the definitions, that remains a foundation.

The second thing is you also see from the figure, you see the ground level. So that part, the whole box, is underground, so it cannot be called "superstructure".

Q. So how would you describe it, foundation or substructure or whatever, something else?

A. I will call this a foundation.

MR CHOW: Thank you, Prof Yeung. I have no more questions.

Re-examination by MR SO

MR SO: Prof Yeung, I have two topics --

CHAIRMAN: Sorry, I do apologise for interrupting.

So that, Professor, would reveal the point that whenever you have investigations of this kind, you are

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going to often find areas where highly respected experts may agree on definition, or may disagree on definition?

A. Not frequently.

CHAIRMAN: No, but when you've got an in-depth investigation of this kind, you may find that happening?

A. I have seldom see for one structural member get two definitions, because diaphragm wall is one single entity and it was actually built in one piece.

CHAIRMAN: Okay. Fine. Thank you very much.

MR SO: Thank you, sir.

Professor, I have two topics that I wish to discuss with you. The first one is arising out of a discussion you had between yourself and Prof Hansford this morning about the engagement length and embedment length issue.

Prof Yeung, I heard that you told us in your answers to Prof Hansford that the current tests could only measure the engagement length but not the embedment length --

A. No, it's the other way around.

Q. The other way around. Only the embedment length but not the engagement length. Can you tell us why this is so?

A. The technique we are using is actually sending an ultrasound wave into the bar. And then when the wave hits the end of the bar, it gets reflected back, and then by measuring the length of time it takes, we know

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where the end of the bar is. That's why we call it embedment length.

In between are all the threads and the threads are engaged to the coupler. So this thread doesn't tell us how many threads are engaged. So we are trying to make a deduction now is: if we know where the end of the bar is and try to -- make that to deduce how many threads are within that section.

COMMISSIONER HANSFORD: Forgive me, because I'm quite keen to understand this point.

MR SO: Sure.

COMMISSIONER HANSFORD: So in your view the difference between the embedment length and the engagement length is the chamfer; is that correct?

A. In this case, yes.

COMMISSIONER HANSFORD: And the chamfer, I think we said yesterday, was a maximum of 2 millimetres?

A. Correct.

COMMISSIONER HANSFORD: So therefore, in your view, the engagement is 2 millimetres short of the embedment length?

A. At most.

COMMISSIONER HANSFORD: At most, maximum. Okay.

MR SO: Thank you. Actually that's the next question I was going to ask and I'm very grateful the professor has

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helped to resolve that matter.
I will move to the second topic I wish to discuss with you. The second topic is arising out of your discussion with the learned Chairman this morning. There was a lot of debate between yourself with other counsel as to the definition of "butt-to-butt" and the stipulation where BOSA said there would be a tolerance of maximum up to two threads.
A. Yes.
Q. I remember this morning when you were trying to explain the mechanism, you want to give us some examples and the details of that.
A. Mm-hmm.
Q. I understand that the secretary has kindly prepared a pen next to yourself. Can you try to help us demonstrate graphically why butt-to-butt would be equivalent to what you have told us to be the two-thread tolerance?
A. Okay.
COMMISSIONER HANSFORD: I think you will need the microphone with you.
A. Let me draw it first.
COMMISSIONER HANSFORD: Okay.
A. (Drawing on the whiteboard) So what I draw here is on the top will be the type A bar. The type A bar was

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designed to be the threaded section, by design it's 44mm. In real-life construction or manufacturing, there's no way we can make it exactly 44 all the time. That's why, in engineering, we have something we call the tolerance. And by the design of BOSA, BOSA make the tolerance, they make sure that the threaded length is always greater than 44. Their tolerance didn't allow anything to be less than 44. Then this tolerance, they allow it to be the maximum would be 4mm.
So that threaded section will be from 44 to 48, in reality. Then the coupler itself will be 88mm.
So what it shows on that picture is if the two bar that we try to put in, both the parent bar and the continuation bar, if they are both 44, so both will get in and they butt-to-butt, 44 plus 44 equal to 88. On the other hand now, we may get a situation now is: both bars reach their maximum tolerance, that becomes the figure on the right-most, that becomes 48 plus 48. And also the installation procedure, we say the coupler needs to go into the end first, so that the parent bar will take up already 48. As the coupler is only 88 millimetres long, so the continuation bar, when it comes in, it can only go in for 40, and that's exactly why you get two threads sticking out from that side.
MR SO: Just following from what you have told us, the last

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sentence you have told us -- so if the parent bar is 48mm, so by a simple calculation we would know the remaining bar would be 40mm only into the coupler?
A. Correct.
Q. So if it takes up to 48mm in the other bar, then it will be at most two pitches; is that what you are trying to say?
A. That is if both bars are at the maximum tolerance.
Q. Thank you very much.
I would like to bring you to page OU135. I believe this is the up-to-date opening-up result.
MR PENNICOTT: The very latest is 338.
MR SO: I heard it was 338. I'm not sure which is the most updated one.
MR PENNICOTT: 338.
MR SO: Thank you. This is the 15 January opening-up result. Can I bring you to the last page of it.
A. So this is 352 then.
MR PENNICOTT: The last page.
MR SO: Yes. Thank you.
In my examination-in-chief, and of course it was also cross-examined by Mr Pennicott on this topic, regarding the opening-up results, you were asked by Mr Pennicott and also by Mr Paul Shieh, if the standard was changed, then the opening-up results would be

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different in terms of the failure rate.
Do you remember that exchange you had with Mr Pennicott yesterday?
A. I think we are talking about the acceptance criteria.
Q. Exactly. So, with your -- after your oral synopsis and with your criteria that you have proposed to this Commission, can you tell us what is the percentage of the failure rate, if using your standard?
A. So that means we start to count all the numbers here?
Q. I think we have the total numbers at the end. There are altogether 75.
A. 75, okay. Can it come down a little bit?
Q. Maybe you can be given a hard copy. I think that would be more convenient for you to count.
A. The hard copy is extremely small.
Q. I see.
A. Okay, good.
Okay, go up.
Okay, move.
Move up. Okay.
I got 45 that are less than 40. So 45 divided by 75 is 60 per cent.
Q. The last question I have for you, in light of that: in your expert opinion, and in your expert opinion in referring to the terms of reference of this Commission

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of Inquiry, it's your expert opinion that the structural integrity is now compromised, not compromised, or you have doubt?
A. We see 60 per cent of the couplers not installed properly in the sample, so by statistics that means, in the population, you may get a little bit more or less, depending on the margin of error in the sampling. But with 60 per cent not construct according to the drawing, and before I can have a chance to do a very detailed analysis on the existing conditions, the best I would say is I have doubt on the structural integrity of the structure.
MR SO: Thank you very much. I have no further questions.
CHAIRMAN: Good. Any questions arising from that? Because that sort of came out at the end.
Professor, thank you very much indeed. I think we kept you somewhat longer than intended. But thank you for all your help. It's been of great value. Thank you very much indeed.
WITNESS: Thank you.
(The witness was released)
MR PENNICOTT: Sir, I see it's about 1.50, is it?
CHAIRMAN: It is, yes.
MR PENNICOTT: Mr Southward is the next expert to give evidence. Can I suggest perhaps we break for lunch now

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and come back a bit earlier?
CHAIRMAN: Yes.
MR PENNICOTT: Perhaps come back at 2.05 or something of that nature?
CHAIRMAN: That sounds good. So we will adjourn now until 2.05. Thank you.
(12.53 pm)
(The luncheon adjournment)
(2.14 pm)
MR BOULDING: Sir, before Mr Southward is called, I wonder if I can make one or two observations on behalf of MTR as to quite where we are going now.
It seems a long time ago but when the Commission of Inquiry started, perhaps the two most important matters to enquire into was firstly the issue of the cut rebar and secondly the connection detail, and you will recall that that was the focus of the evidence over a number of weeks, and of course it was against those two matters primarily, if not exclusively, that issues of safety were to be considered.
But we have now moved on to the opening-up phase which, as I understand it, was directed initially at establishing the extent of the cut bars and secondly whether the connection detail was in accordance with the as-built drawings as prepared by Leighton and MTR, and

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handed to you I think in October.
However, and as will be apparent from the last answer that Prof Yeung gave, safety now seems to be determined by reference to the opening-up, one would have thought perhaps exclusively by reference to the opening-up, and in particular the arbitrary, we would say, pass or fail measurement of 37 millimetres which the government has imposed upon MTR; secondly, the issue of engagement or embedment, and very recently whether rebars will butt-to-butt.
We are very concerned about this because none of these matters were investigated in the factual evidence. For example, there was evidence that BOSA gave instruction courses to the workers. It wasn't investigated whether there was any direction that it ought to be butt-to-butt or whatever. But we are very concerned as to whether it's going to be suggested in some way that MTR -- Leightons must speak for themselves -- are responsible for the way the case on safety or lack of safety is now being put, whether it's going to be suggested that instead of satisfying ourselves that there was a maximum of two threads showing, we should have had some sort of x-ray machine and we should have been looking for embedment or engagement. We don't know whether it's going to be

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suggested against us. And it's not entirely --
CHAIRMAN: Sorry, suggested that you should have had some sort of technology available to you at the time that the couplers were coupled?
MR BOULDING: Exactly, whether our inspectors or supervisors should have been watching out for butt-to-butt, and if so how, and so on and so forth.
So I don't know what the answer is but I did feel it appropriate just to put down a maker at this stage because we do seem to be moving quite a considerable way from where we started.
CHAIRMAN: Yes. It's one of the dangers of an inquiry of this kind. I confess to having considerable sympathy because both Prof Hansford and myself have been burrowing away behind our closed doors, looking for example to BOSA's evidence, and going back to some of the original employees and things like that, to find out did anything arise about these issues, and at the moment it seems not.
MR BOULDING: As you will have heard this morning, you heard me refer to Mr Wong's evidence, and he was looking for the 2 millimetres.
COMMISSIONER HANSFORD: Two threads.
MR BOULDING: Two threads, I'm sorry -- and I put it to Prof Yeung that he appeared to have in mind the BOSA

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recommendation and he agreed with me.
That seems to me to be a test that we ought to have been looking for. If we found the two threads, a maximum of two threads, job done. Now it appears to be progressing somewhat from that, and I don't know what's going to be suggested at the end of the day, so far as we're concerned, and of course so far as Leighton is concerned because -- Mr Paul Shieh is obviously very competent and will be looking after their interests, but I don't know whether it's going to be suggested that Leightons were somehow in breach of contract through failing to achieve butt-to-butt on every single coupler.
CHAIRMAN: Well, butt-to-butt is brand new to us.
MR BOULDING: And to me.
CHAIRMAN: Look, this is a danger we run. We have had in progress, and still have in progress, a collateral exercise, namely one of opening up, conducted essentially independently of the Inquiry, and that collateral exercise is being judged and assessed independently. So what we have to do, I think, is just try to stay abreast of that, and if we have to recall a number of witnesses, even if, with the greatest of respect, it means calling them after normal working hours or something like that, just so we can clarify some matters, then I think we may have to do so. That's

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just off the top of my head.
MR BOULDING: Of course.
CHAIRMAN: But we share your concerns, Mr Boulding.
MR SHIEH: May I simply add that Mr Chairman had his fingers on the nub of the matter, namely that we actually have two parallel processes going on. As perhaps of a political knee-jerk reaction or whatever may be the reason, the administration appointed a Commission of Inquiry, and then as things went by, someone came up with an idea of some experts getting their heads together and then an opening-up exercise going on, when the Commission of Inquiry was actually deep into its hearings.
One of the points we may make in our closing submission is that usually, in prior Commissions of Inquiries in the past few years, one has an undisputed incident or catastrophe, such as a ship collision or lead found in drinking water, where nobody is seriously disputing what actually happened, so people can meaningfully find out why it happened, with no one having any particular axe to grind; whereas now we are obviously having a rather different animal.
The opening-up results show matters which may cut across the cutting of threads aspect, which we respectfully suggest would fall within the ambit of the

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terms of reference; it may throw up matters outside of the allegation of cutting of threads, which ironically was the only thing Mr Poon alleged at the very outset which gave rise to media enquiry, and I would add it's somewhat ironic that Mr Poon and China Tech, and the experts engaged by China Tech now see fit to have a roving enquiry on matters outside of the allegations originally made. These are all matters we will make in due course.
But in order to assist the Commission, because the Commission when it asked for the experts' evidence to be reduced into a kind of synopsis, the Commission did ask for the experts to comment on opening-up, understandably, and the experts will be commenting on that.
But it is not to be taken as somehow Leighton accepting that somehow we are to be taken as being fully equipped or prepared to deal with a hitherto unarticulated cause for concern, namely bars, albeit not cut, for whatever reason, now having been detected to be not possessing the arbitrarily imposed 40 millimetres engaged or embedded length.
As the discussion we have seen so far, we have all been trying to "interpret" in lawyerly fashion what BOSA has written back then and maybe a couple of weeks ago.

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That is unsatisfactory. All I can say is we will do our best to assist by commenting on the issues of opening-up but with an eye to ultimately addressing the issues raised by the terms of reference, which actually are referable back to allegations made way back in May, as publicised by the media.
MR SO: Mr Chairman, if I may respond.
CHAIRMAN: Yes.
MR SO: I have two points to address. First is in regards to Mr Boulding's observation as per whether there would be allegations on the part of in particular China Technology as to whether there are failures in supervisory plan.
As far as I'm concerned, I'm not trying to make submission or giving evidence from the bar table, but insofar as we read the evidence of Prof Yeung and read the evidence of Mr Paulino Lim from BOSA in collective terms, it seems that the butt-to-butt requirement would effectively be satisfied if the requirement of BOSA that no more than two threads are being exposed. So, in effect, the supervision would have been done without the need of, say, what Mr Boulding is suggesting, x-ray detection of that point. Of course this will be reserved to our closing submissions as to whether this is tenable or an appropriate interpretation in terms of

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evidence.

But insofar as the second point I wish to address, regarding whether we are shifting focus on the terms of reference, I wish to quote a small bit of transcript. If I may be so bold as to invite the Commission to look at Day 8 of the transcript, page 97, at lines 8 to 18. This is the cross-examination of Mr Pennicott, counsel for the Commission, against Mr Jason Poon.

There Mr Poon deliberately made clear that:

"For T40 table, above that T40 table, it's clear, external thread tolerance is 4mm, right, and metric thread per pitch, that means for every thread, every circle of thread, the distance is 40.5 metric times 4 millimetres. That means this table already tells you -- this is the table approved by BD, it's telling you that in the other paper of BOSA, to say that we could leave out two or three threads and that's already outside the tolerance limit, if the tolerance limit is just one thread or no more than one thread, the pitch, crest to crest, that is."

Now, of course the terminology adopted by Mr Poon is "crest to crest". As for now, we are mentioning a new term, "butt-to-butt". But I must say, this term or this allegation made by China Technology is in no way out of the blue, neither are involved parties being ambushed.

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This is clearly being revealed in the course of the evidence that this Commission has heard. Therefore, I would, in my most respectful submission, say the Commission will not taken by surprise that there is such an allegation that threads are now not fully engaged or fully threaded into the couplers. That evidence is clear there and I leave the evidence there until we make further submissions in our closing. Thank you.

MR BOULDING: Sir, I will just observe that when the phrase "crest to crest" is being used, it's being used in the context of the thread and the pitch. It's not being used in the sense of butt-to-butt.

CHAIRMAN: Yes. Thank you.

The position as I see it -- and I don't have the terms of reference directly in front of me -- is essentially and primarily that we have to conduct an inquiry in order to be satisfied that the structures which are subject of the inquiry are safe.

It is, of course, regrettable that this issue of butt-to-butt or this issue of embedment and/or engagement of the rebars into the couplers should have arisen so late in the day. It has arisen, from what we can see, because of an independent and collateral set of proceedings, entirely legitimate and very helpful in themselves, conducted outside of the Commission of

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Inquiry; that is the opening-up exercise and that has raised new issues.

I think for us to say, "Sorry, it's not really part of our terms of reference as we saw them originally" is not acceptable. The fact of the matter is the public expects us to consider all matters that are relevant to safety of the structures within the terms of reference, and if it means that we have to spend a bit more time calling back some witnesses or looking at new aspects of evidence in order to satisfy ourselves, then that we will have to do. I think the public would quite rightly believe that they had been severely let down by this Commission if we were to deal with cut rebars and despite the public concern say nothing about the opening-up issues that have arisen.

So I think I make myself quite clear there.

If it means we have to burn the midnight oil, then we will have to do that, or if it means that because the matter becomes one of central importance to this Inquiry and we ourselves are not able properly to submit our report to the Chief Executive until we are better informed on this issue of opening-up, then we will have to inform the Chief Executive of that fact. We are not going to be found wanting in our desire to give to the public a full report because the report is due in in

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a week's time when we could easily put it in in three weeks' time, for example. Quite clearly, the public will want -- they are happy to wait an extra two weeks and get a proper report.

That's our view on that.

That said, we share the concerns that this has arisen so late in the day and we will make sure that we can properly deal with it so that everybody, all the parties that appear here, are given a full and fair hearing. That includes the government and includes MTR and Leighton, as well as the sub-contractors.

So we will proceed on that basis. It may well be, of course -- and let me say this emphatically -- that while we have given absolute weight and will consider most anxiously the reports of the two experts who have already given evidence before the Commission, there are three more experts still to give evidence, and it's our duty to be able to assess all of that expert evidence, and it may well colour our view as we proceed.

One of the reasons why Prof Hansford sits on this Commission of Inquiry is because it was accepted by those who constituted this Inquiry that somebody of international eminence in engineering matters, both as to structural matters and as to project management matters, must sit with me.

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So clearly, all of these issues fall under our ambit and all will be considered. I don't think I need to say anything further. I think we all know where we stand. But we will keep a running eye on this and see how we can assist. We ourselves may wish to have somebody called back to give more evidence. We don't know.

MR SHIEH: Mr Chairman and Professor, may I next call our expert for Leighton, Nick Southward.

MR NICHOLAS JOHAN SOUTHWARD (sworn)

Examination-in-chief by MR SHIEH

Q. Mr Southward, can I trouble you to look at the expert bundle in front of you, tab 5. You can see that is a report entitled "MTRCL Shatin to Central Link contract 1112, Hung Hom Station & stabling sidings, change of details at eastern diaphragm walls and slabs"; do you see that?

A. Yes.

Q. Usually in these expert reports one looks at the signing page, and in this particular case we see that at the next page, internal page 2.

A. Yes.

Q. That is your signature there?

A. Yes.

Q. What follows is a table of contents, and all the way down to the final page, page 83, consists of your report

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and its various appendices attached?

A. (Nodded head).

COMMISSIONER HANSFORD: Page 83?

MR SHIEH: 53, sorry.

COMMISSIONER HANSFORD: It's 53 plus appendices.

MR SHIEH: 53 is the end of the report itself. 83 would be the end of everything else, so when I said all the way down to 83, I did say the report and the appendices.

COMMISSIONER HANSFORD: I understand, it's just I don't have the pages numbered after 53. They are just appendix numbers.

MR SHIEH: I'm sorry.

Mr Southward, before I ask you to formally put forward your expert report as evidence and also to deliver your synopsis orally, can I just take you to two points in your report.

First of all, can I ask you to look at paragraph 7.4.3. That's where you dealt with technical query no. 34; do you see that? It's internal page 18 of 53; do you see that?

A. Yes.

Q. In the second full paragraph, you said:

"This would have been caused by an out-of-tolerance installation of the reinforcement cage of this D-wall panel."

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Do you have anything you wish to say or change or add to the phrase "would have been caused"?

A. Yes. I think perhaps the sentence should start, "This could have been caused by an out-of-tolerance installation". So simply the substitution of "could" instead of "would".

Q. To follow up on that, in the context of the report and the purpose of the report, were you intending to be judgmental or fault-attributing in that particular sentence?

A. Absolutely not. That's not part of my brief.

Q. Next, can I ask you to look at internal page 49 of 53. Yes?

A. Yes.

Q. There is a reference at the top of the page to:

"The relationship between characteristic yield strength and ultimate tensile strength may be conservatively taken as 5 per cent."

Now, do you have anything to change or to add, to say in respect of that sentence?

A. Yes. This unfortunately is a typographic error and really it should say "20 per cent" in this context.

COMMISSIONER HANSFORD: So the 5 should be a 20?

A. So the 5 should be a 20, yes.

MR SHIEH: Does that have any consequential effect on any

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part of the numbers in this report?

A. It does, yes. So the next single line which says:

"Thus the minimum fracture load allowed for a bar coupler assembly ..."

The value should be 727, not 636.

Q. 727?

A. Yes.

Q. Thank you.

Subject to these two comments and changes, you put forward your report as evidence in this Commission of Inquiry?

A. Yes.

Q. Mr Southward, I understand you have prepared some slides and an oral presentation summarising the evidence, so may I now invite you to start your presentation.

CHAIRMAN: If we could just hear a bit about yourself.

A. I have the words.

CHAIRMAN: Thank you very much.

A. Mr Chairman and Prof Hansford, my name is Nick Southward. I am an executive director of Tony Gee and Partners and I am the independent expert appointed to the Commission of Inquiry on behalf of Leighton. I would like to thank you both for allowing me to appear before you.

I have been practising civil engineering for

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30 years, the last 25 of which I have spent in Hong Kong. I have only a small amount of publications and awards to my name because I choose to work at the sharp or pointy end of the civil engineering industry, practising real structural design for large civil engineering infrastructure projects.

I have designed personally some significant infrastructure projects in Hong Kong. I typically design structures for contractors, mainly in design and build situations, so I am skilled in preparing cost-effective, practical and buildable designs that comply with all rules, regulations and design codes.

I am a chartered civil engineer. I am a fellow of the Hong Kong Institution of Engineers. I am a member of the Institution of Civil Engineers in the UK. And I am a registered professional engineer in Hong Kong.

My primary brief has been to look at the Hung Hom Station structure and investigate whether the sequence of events that occurred during construction has had any impact on the overall structural integrity of the station structure, and to advise if, in my opinion, the structure is safe.

I can cut to the chase and advise that in my opinion the structure is safe. I will now continue to explain why.

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There are three key areas which I wish to highlight from my report.

Next slide, please. First, on the design change of the horizontal reinforcement in the EWL slab from the use of couplers to continuous rebars, my view is that the changed design is stronger and more robust than the original accepted design detail. It is compliant with all the relevant design codes, and it is structurally safe.

Next slide, please. Second, on the length of the threaded end of the rebars, my opinion is that the minimum acceptable embedded length is 26.4 millimetres embedded into the coupler, based on the results of the load tests undertaken so far.

Third, my report explains that there is significant structural redundancy in the design, or in simple terms spare capacity in the rebar connections. For the top layer of the EWL slab as it connects into the D-wall, this is 40 per cent. The bottom layer, 50 per cent. But I have to stress that this opinion is based on the findings of three separate large engineering consultancy firms and not my own calculations, as doing those calculations was not part of my brief.

COMMISSIONER HANSFORD: Sorry, and those three firms?

A. Atkins, Arup and COWI.

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COMMISSIONER HANSFORD: Thank you.

A. Next slide, please.

I'm sure you are all familiar by now with the layout of the station, but to remind, we are talking about the junction of the upper EWL slab in red and the D-wall on the left-hand side in blue. This is circled in yellow on the slide.

Next slide, please. This is a 3D graphic which is a representation of the reinforcement arrangement at the top of a typical D-wall panel. You will see that the EWL slab was to be connected to the D-wall using L-shaped T40 rebars through couplers in the top and bottom surfaces of the slab. The OTE was connected to the D-wall in a like manner.

Next slide, please. However, for practical construction reasons, the original arrangement of reinforcement had to be re-arranged to provide space in the middle of the panel for construction equipment to be inserted into its top. As a result, the horizontal bars at the top of the D-wall panels were re-arranged into three layers, to provide a space in the middle. Two layers of rebars, which are the magenta and green coloured bars, originally L-shaped, are no longer turned down into the D-wall but are extended to the other face of the D-wall, with a coupler at each end, and they are

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arranged in two groups of four bars, which provide a clear space in the middle.

There is also an additional layer of rebar which is the yellow bars at the bottom. This is provided so that the total number of horizontal bars per panel remained unchanged from the original design. All three layers of this rebar were planned to be extended into the OTE slab for their anchorage.

This was design change number 1 and was submitted and accepted for construction by the Buildings Department. This change to the original design had no overall effect on the global stability of the station structure.

Later, it transpired that the position of the horizontal couplers in some isolated D-wall panels were misaligned. To remedy the problem, it was proposed to trim off the top portion of the D-wall from the EWL slab -- sorry, to trim off the top portion of the D-wall so that bars from the EWL slab could be installed at the correct level. This involved removing the top layer of the coupled rebars and replacing them with continuous bars.

These incidents were the precursor for the decision taken to make a minor change to the accepted design as follows.

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Next slide, please. This shows how the top portion of the D-wall was trimmed down to expose the transverse reinforcement and the couplers.

Next slide, please. This slide shows how those bars and couplers were replaced with two continuous layers of bars which passed over the top of the D-wall from the EWL side and were anchored into the OTE slab in the same way as the change 1 design.

Now, I have to stress that this is a 3D representation. It's not meant to show the actual arrangement of the bars and the lapping that connected to them. It's just a graphic for illustration.

COMMISSIONER HANSFORD: Sure.

A. So was this change compliant with building codes? Under the Hong Kong Code of Practice for Structural Use of Concrete, both the versions of 2004 and 2013, reinforcement continuity in concrete is allowed to be provided using bar laps, welding or couplers. Such choices are present in all international design codes.

The change, however, from change 1 to change 2, was just a simple matter of substituting straight, continuous bars instead of coupled bars. So it's completely compliant with what's allowed, with what is stipulated in the codes.

Next slide, please. This is just a simple,

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side-by-side illustration of the principal effects of the change. It's just a repeat of the three previous slides but it shows clearly the order of sequence of the changes.

Next slide, please. This slide gives us a closer look at how much additional reinforcement has been placed across the joint. If you count the bars that cross the D-wall, you will see that they have increased from 24 number on the left to 36 on the right. So the 24 bars on the left are the magenta, green and yellow bars, and they are now replaced with an increased number of magenta and green bars on the right.

So what was the effect of the changes? It is my view that the change to use continuous rebars has had no effect on the design, performance, behaviour or durability of the EWL slab and the connection to the D-wall. The member sizes, sequence of construction and load parts remain the same. The top reinforcement in the EWL slab remains anchored into the OTE slab as per the change 1 design. The deletion of couplers at the top level of the D-wall has no effect on the tension forces in the bars or the manner in which those forces are anchored into the OTE slab concrete. The bending strength of the EWL slab and the OTE slab, as they connect into the D-wall, is in fact increased.

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In fact, I am of the view that the change marks an improvement to the design. It increases the amount of reinforcement that connects the slab and the wall, so the structure has an increased amount of strength, robustness, redundancy, spare capacity. The bending strength of this EWL slab connection has increased by 50 per cent from the original design.

Next slide, please. The change also eliminates the vertical construction joints at the top, between the EWL slab, the D-wall and the OTE slab. These interfaces are points of high stress. And as a matter of good practice, the Hong Kong Code of Practice for Concrete recommends construction joints are avoided in points of high stress. The top section of the joints, which you can see on the left-hand side, the top section of those joints were eliminated by the continuous or monolithic concrete pour across the EWL slab, across the top of the D-wall, into the OTE slab.

Importantly, the construction joint has now been moved to a horizontal location, embedded within the overall body of the concrete, and is at a position where the stress on that construction joint is lower than that at the original locations.

The trimming down of the top of the D-wall did not affect its integrity. Such trimming down of the top

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section is no different from the trimming of the section of the over-poured concrete above the top of the D-wall. Such trimming was finished by the use of hand-held breakers, which is the accepted practice for preparation of construction joints.

On the issue of minimum embedded length of threads, in my opinion, it is wrong to suggest that the entire threaded end of a rebar must be screwed into a coupler with no visible threads outside.

MR PENNICOTT: The next slide?

A. I'm going to say now, next slide. I wanted to say that bit first.

Here is the theoretical arrangement of an 88 millimetre long T40 coupler with reinforcement bars screwed into both ends. Theoretically, 44 millimetres of each rebar is screwed into the coupler on each side, on a butt-to-butt basis. The spacing of the threads is 4 millimetres, so each threaded end has 10/11 threads inside the coupler. That depends on the discussion we had yesterday about how much of the chamfer is present.

However, BOSA has confirmed that it usually adds a tolerance to the threaded length up to a maximum of 4 millimetres. Thus the total threaded length could be increased to a maximum of 48 millimetres.

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Next slide, please. Normally, the coupler is fully screwed on to the parent bar, that is the bar in the D-wall that the coupler is first attached to prior to the D-wall construction, as we can see from BOSA's own illustration.

Coupled with BOSA's description that a maximum of two visible threads outside a coupler is allowed for proper installation, this may result in the continuing rebar having an embedment length of 36 millimetres.

Next slide, please. This slide shows, on the left side, a continuation bar with a 44 millimetre threaded end, screwed correctly into the coupler, with two visible threads outside. It shows that the bars are not butt-to-butt. In this sketch, the gap is 4 millimetres. But if the parent bar on the right had been threaded with a zero tolerance, then the gap would be 8 millimetres.

I am not showing this sketch with the intention of discussing the number of threads engaged inside the coupler. I refer solely to the embedded length, because we could use this as a comparison for the opening-up test results, which measure embedment length, not engagement threads.

The upshot is that BOSA allowed two exposed threads in their tolerances, and because of that fact the

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minimum embedment length could not be greater than 36 millimetres.

Next slide, please. This is just a side issue but this shows the same sketch, redrawn, but the continuation bar now has a threaded length of 48 millimetres, but is still embedded by 36. This shows how it's possible to have three exposed threads showing on the continuation bar in that situation. So seeing three exposed threads cannot by itself be a reason to condemn a coupler assembly, because it could still have a 36 millimetre embedment.

Importantly, BOSA's specifications, their requirements, are not to be equated with the actual strength performance requirements.

Next slide, please. We have seen these load test results a lot in the last few days. They show that 60 per cent of the threads engaged in a coupler -- sorry, I should say -- yes, 60 per cent of the threads engaged in a coupler is sufficient for structural safety, ie 26.4 millimetres, which is 60 per cent of 44.

Prof Au expressed bewilderment, basically, that the test with 60 per cent thread engagement had the largest failure load. He said he couldn't understand why this failure load was the largest of the three tests where the bar broke. So the 60, 70 and 100 per cent tests.

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For me, looking at it from the perspective of the structural safety of the coupler assembly, I'm actually pleased to see that the largest failure load was with 60 per cent thread engagement. I say this because it proves that screwing the bar into the coupler more than 60 per cent has no effect on the strength of the coupler assembly. At 60 per cent engagement, the bar outside the coupler broke first. At 70 per cent engagement, the bar outside broke. At 100 per cent engagement, the bar outside broke first. So once the bar is screwed into the coupler by 60 per cent, the threads in that 60 per cent embedment are stronger than the bar.

This is evidenced quite clearly in calculation by the contents of appendix V of Prof McQuillan's report, which shows the BOSA thread strength calculation table. We have seen that table a lot as well.

You can see in this table that the theoretical strength of the combined threads, as you increase -- as you add more and more threads to the calculation, between six number and tend threads, the combined strength increases linearly from 601MPa to 1,002MPa. That's just the strength of the threads. But that increase in threads does nothing for the bar, which has a lower tensile strength of 529MPa and is therefore doomed to failure as soon as the number of threads are

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six and above.

We also discussed this this morning, when Prof Yeung was queried on his slide, and there was a discussion about the linear line of that graph, and if that chart was plotted correctly -- that one there -- then the experimental test results would be plotted above the line by a healthy margin. It's about 30 per cent.

So Prof Yeung said, "Look, but if the calculation is redone for 500MPa, then the strength of the threads will increase", and that is correct. The linear line, the calculation line, will increase by 8 per cent, which is the ratio of the 500 grade rebar to the 460 grade rebar.

But the tests of the bars, the failure loads of the bars, show the bars failing by -- well, I don't know the exact number, but it looks like about 30 per cent, from the graph. So there is still a very healthy margin between calculation and the experimental test results.

There's also been discussion about the fatigue loading and cyclic loading on the bars and couplers under repetitive train loadings, and there's also been discussion about the 0.1 elongation and the cyclic testing of those couplers.

Now, the variation in stress in the reinforcement bars, in the couplers, calculates to be of the order of 15 to 20MPa. This is a calculation that has been

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carried out by COWI and they have -- I asked them to tell me, when the trains go on the platform slab, what's the variation in stress in the reinforcement? The train load is insignificant compared to the weight of the slab and the pressures upon the soil and all the forces acting on that joint. So the actual variation in stress is only 15 to 20MPa.

COMMISSIONER HANSFORD: Sorry, just so we can understand what you are saying, because we then talk about cyclic loads. You are coming to that?

A. I was just about to say, yes. So 15MPa, this is a low stress. Therefore, I can't envisage that the effects of fatigue or cyclic loading will be a problem.

We also discussed this morning the BOSA letter dated 7 January, which is something that I've not seen until this morning, but one of the counsel took Prof Yeung through that and there was a comment on whether or not the couplers would be able to withstand the cyclic loading tests -- there was a comment about whether the threads should be fully engaged or not for that test.

Again, I've not studied that letter but I would just like to point out that 15MPa is only about 3 per cent of the design stress of the bar, where the cyclic testing load is 60 per cent. So what's going to happen in reality is quite different from any theoretical lab

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test.

Next slide, please. There is significant structural redundancy or robustness, or in simple terms spare capacity, in the rebar connections. Based on the calculation and assessments three of international, extremely experienced and reputable consultants -- Atkins, Arups and COWI -- there is at least 40 per cent spare capacity in the top surface of the EWL D-wall connection.

COMMISSIONER HANSFORD: Do you mean the top mat?

A. The top mat.

COMMISSIONER HANSFORD: Okay.

A. This means that 40 per cent of that rebar can be completely removed and the structure would still satisfy all relevant design codes and would still be safe.

For the bottom surface, I agree that there is no strength requirement for those bars, as the section will always remain in compression. There has, however, been much discussion with previous experts over the issue of the requirement for type II ductility couplers. The issue we discussed and agreed at the expert meeting in December was that the seismic movement or performance of the station structure would result in a situation of the D-wall failing long before the slab had a chance to develop a plastic hinge, that is exhibiting a ductile

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behaviour that would necessitate the use of type II couplers in this location.

We have done some very basic calculations to demonstrate this. These were performed in the last day, in very limited time, and use the methods stated in the New Zealand and Australian seismic design codes to calculate the yield displacement capacity. The yield displacement capacity of an element is that amount that the structural component has to deform in order to create yield stresses in the tension reinforcement. So it's calculating the physical movement.

This is the onset of when the section becomes ductile and thus when ductility couplers are needed. The yield displacement capacity is a function of the dimensions of the element, its thickness, the span between the restraints, and of course the strength of the reinforcement inside.

The New Zealand codes describe a method to do this, and these are based on a reference work which is titled, "Displacement-based seismic design of structures". This was written and published in 2007 by Priestley, Calvi and Kowalsky, and represent the state-of-the-art. The yield displacement capacity of the slab calculates to be 2.3 times that of the D-wall. Dr Mike Glover comes to pretty much the same conclusion in his report but in

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a different way.

Now, this is the start of an extremely complex method in which to determine the seismic performance characteristics of a structure. This method is not in use here in Hong Kong due to the low seismicity in the region. I am therefore not going to dwell on this any longer. My point is simply to indicate some numbers to give back into the statement that was agreed in the expert meeting in December.

But despite there being no strength requirement for rebar or ductility couplers, I believe that continuing to comply with the Hong Kong Code of Practice would be a defensible outcome. As there is at least 50 per cent spare capacity in the number of the bottom slab rebars passing into the D-wall via couplers, we could consider 50 per cent of those couplers ineffective without any implication on code compliance.

COMMISSIONER HANSFORD: What do you mean by "defensible outcome"?

A. I mean this would be a sensible idea; one that could be defended quite easily, not taking any risks or anything.

COMMISSIONER HANSFORD: So conservative?

A. Conservative, yes.

COMMISSIONER HANSFORD: Thank you. Sorry to interject.

A. That's okay.

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So the joint. During Prof Au's evidence, much discussion was given to the performance of the internal actions inside the joint, between the D-wall, EWL and OTE slabs. I had not included a checking of the joint in my report because there is no difference between change 1 and change 2, and I had already accepted the fact that the change 1 was previously accepted for construction by the Buildings Department. I have no reason to doubt their view that the joint was acceptable.

Structural engineers have many different ways of analysing and designing structural elements and details. This particular joint could be designed using any of the following methods shown.

Next slide, please. There is the clamping theory concept as discussed by Prof McQuillan. There is the Atkins calculation method, which they submitted in December, which in my opinion is extremely conservative. There is Prof Au's specialist beam-column joint method, which he did not describe to us. There is my preference in practice of using finite element analysis, using 2D plate elements or 3D solid brick elements.

COMMISSIONER HANSFORD: Which, for the benefit of lay people, is a computer modelling process?

A. This is a fairly sophisticated computer modelling

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process that calculates the internal stresses in structures.

COMMISSIONER HANSFORD: Indeed.

A. In quite some detail.

COMMISSIONER HANSFORD: Thank you.

A. And there is a strut-and-tie analysis.

The point is that there are many ways to skin a cat. This applies equally well in structural engineering as it does to any other application in life. All ways, however, will result in a design that is safe and serviceable.

Next slide, please. I have reviewed the Atkins calculation which is shown on this slide. This is an extremely conservative approach, whereby they have considered the vertical element of the D-wall inside the EWL slab to be isolated, on its own, and they have checked that for an internal shear force that is generated by the applied bending moment, and they have divided that applied bending moment by the lever arm between the compression zone and the steel reinforcement. That has given them an internal shear force.

That's a very conservative way, because there is actually a lot more material there. There is the EWL slab and the OTE slab. So it's very conservative to

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consider that shear force just acting on that wall.

COMMISSIONER HANSFORD: And this manuscript here is from Atkins?

A. This is their calculation which I extracted from the submission they make.

So there are some aspects of this calculation that I don't fully understand. It's handwritten and so clearly it would be good to have a discussion with the actual engineer by himself who wrote that. But if this is the approach they have used, then this is very conservative, and it would certainly demonstrate compliance for both change 1 and for the issue of horizontal shear stresses for change 2.

Next slide, please.

COMMISSIONER HANSFORD: Sorry, I don't wish to labour the point, Mr Southward -- can we go back to the slide? There. All of that on the right-hand side is Atkins', including the writing in red; is that correct?

A. Yes.

COMMISSIONER HANSFORD: Thank you.

A. My bit is the graphic.

COMMISSIONER HANSFORD: Yes, understood.

A. I have considered the presentation yesterday from Prof Au and his free body diagram, which is shown on this slide. So I've just extracted that from his

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presentation.

It is easy to allay his concern.

Next slide, please. Looking at a close-up detail of the yellow slice, we can see there are two layers of T50 vertical bars and two layers of T40 bars that cross this interface. So these are the vertical bars drawn in black. Two of those bars are T40 bars and two of those bars are T50 bars.

There is so much reinforcement, in fact, that the basic shear capacity of the steel bars in dowel action alone is enough to resist the tension load developed in the horizontal T40 bars at the top of the slab. So you can see the red arrow which is -- that's the tension force in the T40 bars, and that is pulling the yellow slice to the left. That pulling is basically resisted by the steel bars. The steel bars would have to be sheared. The steel bars would have to break in order for the yellow slice to move.

COMMISSIONER HANSFORD: And again, for lay people, dowel action?

A. Dowel action is exactly -- well, actually, I'll explain that.

COMMISSIONER HANSFORD: Very good.

A. So I say this, I can say it's safe, because the shear capacity of a steel reinforcement bar in dowel action is

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half of that of its tensile strength. There are four layers of vertical bars but there are only two layers of horizontal bars, and the vertical bars are bigger, they are T50, so the cross-sectional area of the vertical steel is much more than twice the cross-sectional area of the horizontal blue steel.

COMMISSIONER HANSFORD: So they are resisting?

A. They are resisting. That doesn't allow for the fact that there is 40 per cent spare capacity in this joint anyway.

To answer your question about the dowel action, I can also refer here to the last slide, Prof Yeung's presentation yesterday. If you'll remember, this showed a bolt connecting two plates, and Prof Yeung explained that the purpose of the bolt is to stop the two plates sliding apart.

COMMISSIONER HANSFORD: Was it Prof Yeung or Prof Au?

A. Prof Yeung. He explained that the purpose of the bolt is to stop the two plates sliding apart.

In our case here, the steel reinforcement bars are doing exactly that, exactly the same job as the bolts in Prof Yeung's slide. Thus the yellow free body securely anchored to the D-wall below, it cannot move or slip and there is no concern over the presence of a construction joint.

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Strut-and-tie method, which is the final method on my list, are simple ways to represent and analyse the transfer of forces from one structural element to another. They are especially useful at corner joints such as this. Indeed, use of such a method was suggested by Prof Au in his expert report. The method consists of diagrammatically representing the forces inside the joint and demonstrating a feasible load path to transfer the tension forces in the slabs to the tension forces in the D-wall.

So, in the last day, we have had a look at a possible strut-and-tie representation, in order to do the simple checking calculations referred to by Prof Au. This slide shows the base data for checking of the joint. These are the ultimate limit state moments and shears on the joint, and they are extracted from the original Atkins design calculations for a typical panel, which in this instance is EH113.

Next slide, please. This is one possible strut-and-tie system that provides equilibrium in the joint for the change 1 design. The red lines indicate zones of compression or struts. The blue lines indicate lines of tension or ties.

I stress this is just one possible strut-and-tie system, but I have chosen this arrangement to represent

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the clamping action referred to by Prof McQuillan in his report.

Next slide, please. Here, we have the strut-and-tie system that provides equilibrium in the joint for the change 2 design.

COMMISSIONER HANSFORD: Isn't it the same?

A. You will see, if we flick back and forth between the two slides -- if you could do that, please -- that there is no difference in the strut-and-tie arrangement between the two systems. By this I mean the manner in which the forces are transferred between the reinforcements in the slab and the wall.

This is because -- I'm sorry, I've already said that.

Next slide, please. So the results of this strut-and-tie analysis. Typically, these types of analysis should be done by hand, and when I learned engineering I had to do strut-and-tie calculations by hand. But it's much faster to do this by a computer. So on the right-hand side are the computed strut-and-tie forces. There are two main areas of blue tension within the D-wall. There's a vertical tension of approximately 3,400 kilonewtons on the back face of the D-wall, which is easily resisted by the three vertical layers of reinforcement at this location.

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There is a diagonal tension of 450 kilonewtons in the D-wall within the depth of the OTE slab. This diagonal tension will be resisted by the horizontal shear links --

COMMISSIONER HANSFORD: Sorry, is that the 474?

A. That's the 474, yes.

COMMISSIONER HANSFORD: Thank you.

A. This diagonal tension is resisted by the horizontal shear links which are equally spaced at 150 millimetres up the D-wall.

So after resolving for the fact that those horizontal shear links aren't diagonal, they are horizontal, there proves to be 100 per cent more reinforcement than required.

Next slide, please. As of 14 January, 75 tests have been carried out. Of these 75 tests, 73 show embedment length which is greater than 26.4 millimetres, which is the number from the test, 60 per cent of 44 millimetre thread. That's 97 per cent. 51 show an embedment length which is greater than 36 millimetres, ie 68 per cent.

I am not an expert in statistics, so I can't extrapolate these results to cover the whole structure, but as the tests show that 97 per cent of the couplers can carry the design load, then we can be very confident

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that with the large margin of safety in the design of the structure, that the structure will remain adequate and will be safe.

So, to summarise, in the course of construction of MTRCL's original design of the station, some changes in the D-wall reinforcement details were implemented for ease of practical construction. After construction of the D-walls, Leighton constructed the connection using an improved detail that provided superior strength and robustness but remained practical for them to construct. The change of detail was compliant with all relevant design codes used for the design of the station structure, and the resulting structure is now stronger and more robust than the original compliant detail. The structure continues to be safe design, suitable for its intended use. These changes were part of the normal construction process and did not represent any significant or material change in the design of the structure.

The results of the testing of the bar couplers which have been opened up have shown that the significant majority have embedded lengths in excess of what's needed. Testing to destruction of the bar coupler assemblies has shown that this embedded length may be reduced to 26.4 millimetres. The independent design

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reviews of the structure all show that there is at least 40 per cent spare capacity in the design of the coupled reinforcement connection between the EWL slab and the D-wall.

It follows, therefore, that at least 40 per cent of the bar couplers could be considered to be ineffective, but yet the structural integrity of the platform slab will remain intact and the structure will remain safe and suitable for use. The bar couplers at the bottom surface are not used as structural design elements, so it would be safe to allow 50 per cent of these to be considered ineffective.

However, the opening-up test results to date do not indicate that it would be necessary to disregard as large a percentage of bar couplers as mentioned above. In fact only a small percentage are below strength requirement and are no cause for concern in terms of structural safety. The structure is, in my opinion, safe.

CHAIRMAN: Thank you.

MR SHIEH: Thank you, Dr Southward.

Perhaps I can just conclude by raising one question with you, by referring you to what was said about one of your sketches yesterday by Prof Yeung.

Can I ask you to look at the transcript of

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yesterday, at page 119. It actually starts at the bottom of 118, where at line 21 Prof Yeung looked at a slide which he incorporated into his slides, where he said:

"For the next slide, we are talking about the top of the connection between the diaphragm wall and the EWL slab, and for this picture I need to give credit to Mr Southward. I take this picture directly from his report. This report is very illustrative ..."

Now, I understand that that slide is also a part of a slide that you have just presented. It would be slide number -- either 7 or 8. Can I just trouble the Secretariat to try to locate slide number 7 or -- it's number 8. Yes.

I understand this to be what Prof Yeung was referring to, because this depicts the second change. He said, at the top of page 119:

"... you can see three different types of bars. When I went to engineering school the first thing I learned is to do engineering drawing, and the first thing I was told by my professor is even though you try to do a sketch, try to do things in scale. So I think Mr Southward may think the same way.

If you look at this one now, it's very interesting, if you look at the thickness of the diaphragm wall, it

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should be about 1.2 metres; we all know that. Then if you look at these bars now, they are probably a little bit more than 1 metre on one side and a little bit more than 1 metre on the other side. So one thing now I do not have evidence is: is this really the bar configuration? That means the bar is not really continuous but one bar with two lap lengths on the other side and then the steel from the EWL actually have a lap now with a bar sticking out from the diaphragm wall."

Could I then ask you to look at the sketch again. Can I just ask you this very simple question. By this sketch, were you intending to demonstrate the use of any laps in the bars?

A. No. The purpose of the sketch was just to show the bars going through the wall, but the lengths either side are immaterial, not part of the sketch.

Q. Could you repeat that, please?

A. The purpose of the sketch was just to show the bars going through the wall. It wasn't meant to represent the actual reinforcement arrangement in the slabs each side.

Q. Thank you. So the magenta is one layer, the green is the other layer?

A. Yes.

MR SHIEH: Thank you. Thank you very much for your

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presentation.
What happens next, as you might have seen from observing the proceedings, is that counsel for the other parties may have some questions for you. In the course of their doing so or afterwards, Mr Chairman and Prof Hansford may have their own questions for you also. After all that, I would have, if I think necessary, wrapping-up re-examination questions for you. So please remain seated while others ask you their questions.
MR PENNICOTT: Sir, appreciating that we are finishing at quarter to five this evening, would you like to take the break now? I'm going to be very short, I can tell you, no more than about ten minutes.
CHAIRMAN: Why don't you finish?
MR PENNICOTT: Absolutely. I'm more than happy to do that.
Examination by MR PENNICOTT
Q. Mr Southward, good afternoon.
A. Thank you.
Q. Thank you very much for coming along to give evidence to the Commission, thank you for your reports, and thank you for your cooperation in the joint statement as well.
As you know, I'm one of the counsel to the Commission and I just have a few questions really by way of clarification of a couple of matters that I would like to discuss with you.

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I think it's probably easiest to do that, certainly in the first instance, by reference to your slides, which are extremely helpful. Thank you very much.
Can we look at slide 9, please. This really is just a point of clarification, as I say, Mr Southward.
You refer to "Two layers of T40 bars at 150 millimetre centres, total 24 bars per panel", and then in the next diagram you say:
"Three layers of T40 bars in two groups, total 24 bars per panel ..."
That's the first change, and then the second change, to:
"Two layers of T40 bars at 150 millimetre centres, total 36 bars per panel ..."
When you say "per panel", as I understand this is just illustrative of a typical panel?
A. That is a typical D-wall panel which is maybe 5 to 6 metres long. It's drawn to scale, it's drawn from a real D-wall panel detail.
Q. So it's just taken one of the panels for a typical panel?
A. Yes.
Q. That's what I thought, because I think from recollection we know that the width of the panels varies.
A. There are lots of variations but I've just taken the

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standard, typical panel.
Q. That's fine. I understand. That's pretty straightforward. Thank you very much.
Then if you go to slide 16, which is the table of test results.
You gave some evidence earlier on, during the course of your presentation, regarding the other types of tests. This we know is a static load test, and you've described it, if I may say so, very helpfully, the way in which the bar breaks at the 60 per cent, 70 per cent and 100 per cent.
You mentioned, but perhaps did not deal with, one of the other tests called an elongation test; do you recall that?
A. Yes, I did.
Q. And that's one of, I think, the requirements of the Buildings Department.
What's your view, if you have one, about the usefulness of that type of test in the situation we find ourselves?
A. My brief has been to look at the strength side, the structural safety; is the structure safe? So that's where I've come from.
The testing of couplers to compliance to BD rules is a kind of -- is a different thing. It's testing them

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with respect to the specification requirements, so that those couplers can be used in any situation anywhere. Here we are looking at a very specific application, so I've just looked at it from the point of view of strength.
Q. So, if I've understood it correctly then, the elongation test, is it your understanding, has nothing to do with strength?
A. The elongation test is to do with how much the bar moves between the coupler. I don't think, to be honest, it would really affect the strength result, because it takes a certain load to break the bar. And, okay, there might be some movement, but you still get the strength in the bar. You still get the strength that you need.
Q. Right.
A. So you can do tests, the elongation tests, but they are to do with meeting specification requirements and not to do with the strength of the structure.
Q. Okay.
COMMISSIONER HANSFORD: Sorry, Mr Southward -- so are you saying you don't believe elongation to be relevant to this project?
A. Well -- no, no. If you are looking at it from the point of view that I was, "Is the structure safe?", then that's where I came from.

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COMMISSIONER HANSFORD: But it could be relevant for some other purpose?
A. To provide a general -- to make a coupler that can meet any use anywhere in the construction industry, I'm sure there are tests that you would have to do. And elongation and cyclic loading would be one of them, yes.
COMMISSIONER HANSFORD: I understand that, but I'm just wondering, to be satisfied with a coupler for this location, for this project -- maybe this is not something you've looked at, but is the elongation capability of these couplers of any relevance?
A. I don't believe it is because the structure has already been built, it's there. The load on the couplers is already there.
COMMISSIONER HANSFORD: Yes.
A. Okay? You've got massive forces on the wall, you've got the weight of the slab. The structure has taken up its shape. There is no sign of any distress.
So if something elongates -- if it elongates too much, you would visibly see the distress, but there is no --
COMMISSIONER HANSFORD: That distress would be visible now?
A. -- in terms of cracking. That distress would be visible, yes, but -- if there was a problem with elongation with these couplers, that distress would be

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visible now, but we've not seen any distress.
COMMISSIONER HANSFORD: Thank you.
A. Maybe if I could just add that the future loading that's going on to this structure now is really just the trains, and the trains are a very small proportion.
COMMISSIONER HANSFORD: As you have already told us, yes.
A. So the coupler has taken up its load, it's working, it's there, there's no distress, and the future load is going to be quite small.
COMMISSIONER HANSFORD: Thank you.
MR PENNICOTT: But my understanding, Mr Southward, is that the dead load is something of the order of 90 per cent or so and the live load is the remaining 10 per cent.
A. Yes.
Q. Does that accord with your understanding?
A. Around there.
Q. All right.
Could I ask you, please, to look at -- not at your slide because they are quite difficult to read from the slide -- but can we look at the test results that you have appended but I think are more easily read elsewhere. Could we therefore look, please, at OU338.
A. Okay. That's a little bit difficult for my eyesight. I'll wait until it's on the screen.
Q. They will pop it up on the screen as well. That's fine.

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338.
CHAIRMAN: I think we saw that one last time, 339.
MR PENNICOTT: 352, how about that one? I don't know what's happened to the numbering. 352. Thank you very much.
Just a general question first before we look at one or two points, Mr Southward. The government have used, it appears, a figure of 37 millimetres as a criteria. Do you have any observations about that figure?
A. To be honest, I don't understand where it came from or how they've reached it. I can't see -- I'm sure there's a rationale to it but I don't know what it is, so I can't really comment on it.
Q. Okay. I think -- I may be wrong but I think that it comes about like this, that you take a BOSA threaded rebar, you assume it has ten threads to it, to give you 40 millimetres. The phased array technology that's being used to measure the engagement or the embedment has a tolerance of 3 millimetres. And so 40 minus 3 is 37 millimetres. That's my understanding of how they get at it.
But if you haven't looked at it, don't worry.
A. Yes, okay. I understand now. Yes, I see. So they've just taken -- it's plus or minus 3 millimetres so they've taken the very worst result, as what their criteria would be?

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Q. That's my understanding. If one thinks about a couple of these results, and one sort of has that figure of 37 millimetres in mind -- can we look at, for example, number 50, item 50.
We can see that the engagement length as it's described here -- which is at the top, don't worry about it -- for 50 is 36.8 millimetres: do you see that?
A. Yes.
Q. And on the right-hand side, on the right column, the number of exposed threads is said to be one to two. So let's suppose it's one thread showing. So one has, on one view, a total length of thread of in excess of 40, 4 millimetres per thread?
A. Yes.
Q. If you take the proposition that in fact it's two threads, that would give you 8 millimetres, and so you've got a thread of something like 44 millimetres.
With that brief analysis, again, how do you see the relevance of the figure of 37 millimetres?
A. To be honest, I think they should all be being compared to what strength do we actually need, and that strength is -- so far, the tests have shown that strength is 26. There may be more tests and that's fine, but on the results of what's been tested so far, 26 is where you should go.

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MR PENNICOTT: Yes. All right. Thank you very much, Mr Southward. I have nothing further. Thank you very much.
CHAIRMAN: Good. We will have -- it's quarter of an hour until 4 o'clock. You are reminded -- you have heard it being said with others that once you are giving evidence, you must keep your own counsel entirely and not discuss your evidence until it is completed.
WITNESS: Sure.
CHAIRMAN: Good. Thank you very much.
(3.43 pm)
(A short adjournment)
(4.02 pm)
MR CONNOR: I have no questions for Mr Southward. Thank you.
MR BOULDING: None from me, sir.
CHAIRMAN: Thank you very much.
MR CHOW: Mr Chairman and Prof Hansford, the government has some questions, but before I start, can I put down a marker here? You will no doubt appreciate that during Mr Southward's explanation, by taking us through various slides, in particular the later part of the slides about the strut-and-tie models and also the New Zealand state-of-the-art design and theory, all that -- my first observation is these have not been put to Prof Au, so

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Prof Au has had no opportunity to deal with it. That's point number one.
Point number two is I have had no opportunity to get input from Prof Au. I have no intention to delay the process, so what I have decided to do is to try to deal with those matters the best I can while I'm on my feet from a relatively high level of way, but in the event that if later on I receive input from whatever sources, I may need to come back on some of the details regarding Mr Southward's evidence. So with that marker --
CHAIRMAN: Could we perhaps -- I don't know if anybody else wishes to ask questions of our witness -- on behalf of China Technology?
MR SO: We have some questions, but obviously we will appreciate if the government can go first because there might be issues arising out of the cross-examination of the government.
MR CHOW: Sir, I'm happy to do that. Actually, at the moment, honestly, I don't anticipate that it will be worthwhile to take the time for me to come back on some of these matters, but I will just proceed on the basis of what I can at the moment. So, with permission, I will just plough on now.
CHAIRMAN: I'm just a little worried that you may feel, in fact, that at the end of this afternoon you need to

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effectively start again tomorrow, you know. I'm just a bit concerned, if you feel that you need Prof Au with you, that the questions you put before you have the assistance and support of Prof Au may prove to be without much value and that you'll need to effectively start from square one tomorrow, or are you satisfied that you've got some potent questions you can put without the assistance of Prof Au?
MR CHOW: Sir, the problem is I'm not sure whether Prof Au will be available to help me tonight, so I don't want to delay the process, and perhaps it turns out to be a wasteful exercise. Honestly, I myself, I don't think it would be helpful to the Commission for me to enter into a debate on the minute details to the forces and stresses and all these values.
CHAIRMAN: No.
MR CHOW: So I have no intention to go into that. I would prefer that I will just ask questions from a high level, on a principle level, rather than to go into the details. To that extent, I don't really need detailed assistance from Prof Au.
CHAIRMAN: Good. Then I'm more than happy for you to begin. But, sorry, help me here. You are saying the diagrams prepared were not available to Prof Au?
MR CHOW: I'm referring to slides 23, 24 and 25, and

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although some of the slides before that, for example on page 22, the diagram, that actually is existing in somebody else's report, but while Mr Southward explained what he has done to it, this is something new, as far as I'm concerned.
CHAIRMAN: All right. I see the point you make. Well, good. Why don't you commence, and obviously you can reserve your position insofar as you may wish to continue tomorrow with further questions.
MR CHOW: Thank you, sir.
COMMISSIONER HANSFORD: Can I just add one point, though, Chairman? Of course, Mr Southward and Prof Au were both at the joint meeting of structural experts where presumably matters of this nature -- I know it's a without-prejudice meeting so we can't know the details -- but presumably matters of this nature were discussed.
MR CHOW: Prof Hansford, I myself have no knowledge of what has been discussed at the without-prejudice meeting.
COMMISSIONER HANSFORD: No, none of us have.
MR CHOW: That's the reason why my observation is made based on really what actually happened and what appears to me, so I really don't know whether any of this has been discussed in detail in the without-prejudice meeting.
COMMISSIONER HANSFORD: All right.

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MR CHOW: They may well be. I just have no information.
CHAIRMAN: All right. Fine.
MR SHIEH: If I may suggest, there are bound to be questions on areas that do not turn on the "new topics" raised orally by Mr Southward. So perhaps in order not to lose unnecessary time, I would endorse what was suggested by Mr Chairman. We on our part, insofar as is relevant, will obviously have no problem if, for example, overnight, instructions are taken, just as this morning Mr Boulding and myself, having taken instructions overnight, came back and sought leave to reopen. So we would absolutely have no problem with that.
CHAIRMAN: That helps. Thank you very much.
Cross-examination by MR CHOW
MR CHOW: Good afternoon, Mr Southward.
A. Good afternoon.
Q. I represent the government and I have some questions. Now we are all fresh in our minds as to what you said in relation to those slides, I would prefer to start by taking you through some of the slides and I will try to get further clarification from you, if you don't mind.
A. Sure.
Q. When we were looking at slide 3, about the key areas, you mention that you base your view in relation to redundancy by reference to the fact that three separate

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consultants have carried out some checking. So you relied on the result of those checking in coming to your view that the structure has extensive redundancy or spare capacity. Do you recall that?
A. I believe I said that, yes.
Q. You also mentioned Atkins, OAP and COWI as the three consultants, their work you have relied on?
A. Yes.
Q. Am I right to say that as far as Atkins' exercise is concerned, what you have looked at is graphical representation at various locations along the diaphragm wall as the percentage reserve in terms of capacity; is that right?
A. Yes. Yes.
Q. Atkins have not provided any supporting calculation or details of the assessment?
A. No.
Q. And as far as OAP's work is concerned, what I have found from the hearing bundles are 30 or 40-odd pages of design checking which OAP described as spot-checks.
A. Yes.
Q. Is that also what you have looked at as well? Is that all the information you have looked at and relied on; is that right?
A. And then the COWI analysis.

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Q. Now, COWI analysis, in your expert report, you mention to us that you have not checked COWI's calculation in detail. Does it remain the same position as far as that is concerned?
A. Correct, yes.
Q. So you -- we have also looked at, for myself briefly, COWI's supporting documents, which are contained in four big volumes, over 4,000 pages of documents.
A. Okay.
Q. From COWI's summary report, it also -- well, it simply lists out the percentage utilisation of bending moment and shear stress at some critical section, in particular the interface between the EWL slab and the diaphragm wall; right?
In COWI's report, under various notes, it mentioned that there are sections in which the result shows that the percentage utilisation has gone up to 167 per cent. Do you recall that?
A. Yes.
Q. And COWI takes the view that those results are unrealistic -- I think this is the word that COWI used?
A. Yes, I believe that, yes.
Q. And dismissed that being a problem, a problematic area, but COWI offered no explanation whatsoever. Is that what your understanding is as well?

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A. Yes. I believe they've done a finite element analysis of the slab. The interpretation of these results can be at times tricky. If the modelling is not 100 per cent, or sometimes even if it is 100 per cent, you will get discontinuities between changes in section, and those discontinuities can throw up isolated spots of very high or very low results which don't make any sense and which couldn't happen in reality, when you compare to the pieces of concrete immediately adjacent to that particular spot.
So it's not uncommon to get areas of -- to get isolated areas that have results which are not meaningful. So if it's not a meaningful result, then it's not a result to use.
Q. From my recollection, those stresses which according to the result of COWI's analysis, that amount to 167 per cent utilisation, are shear stress; correct?
A. I have to say I can't remember.
Q. Perhaps I can take you to COWI's report. I believe it's in tab --
MR PENNICOTT: 4.
MR CHOW: -- 6.
MR PENNICOTT: Tab 4.
MR CHOW: Sorry, yes, tab 4, internal page -- for example, 34.

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Yes, page 34 is a table showing the shear force range of utilisation; do you see that?
A. Yes.
Q. And under notes 6 there is a note saying:
"Panel WH128 has a utilisation of 161 per cent. However this shear is at the extremity of the model and not considered realistic."
If we go to page 44, the last page of the main body of the report, again it's a table setting out the shear force range of utilisation. Under note 3, it is recorded:
"The utilisation of 161 per cent occurs at panel WH128."
This overstress, if I may use that term, according to the result of the analysis, relates to shear stress, not bending moment; right?
A. Yes.
Q. Do you agree that failure by shear is a brittle failure, without any sign?
A. Yes, failure by shear would be a brittle failure, yes.
Q. Actually, one of -- we have prepared a list of questions and I believe it has been sent off to COWI for COWI's clarification. One of the questions, I hope -- I would like you to tell us whether you have any view on that.
A. I have not read those questions, so I can't have a view.

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Q. I will let you know. One of these questions is this: given the computer calculation has shown some what COWI describe as irregular result or unrealistic result, and it happens that those so-called unrealistic result seems to suggest that there were overstress in the structure -- now, COWI dismissed those as reliable results. Our question to COWI is that if the same computer calculation showed part of the result which are unrealistic, how can we be assured that results for other locations are reliable? Would it suggest that the modelling itself has some problem?
A. Well, they've only modelled -- they've modelled three discrete areas of the station, so in that, in those three discrete areas, there are only going to be specific parts of that model that are going to give realistic answers.
You've seen it says that there was one failure which was a shear failure in an end panel in their model. Because it's an end panel, it's at the boundary, so the results in that would be completely unreliable.
Q. Why is that?
A. Because there's a complete discontinuity in their model. They've modelled this structure and then -- right at the end (demonstrating), and there's no structure in their model on the other side. So, at that point, the 3D

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behaviour of the wall and the slab is not being represented properly in the model, because there is no other side, so the results could not be realistic.
COMMISSIONER HANSFORD: So, Mr Southward, obviously it's for COWI to answer the government's questions.
A. Indeed.
COMMISSIONER HANSFORD: However, that's an explanation, but you're saying -- I think you're saying --
A. I think they say -- yes, they've said that it's at an end panel, so that would be my interpretation of the reason why it's overstressed.
COMMISSIONER HANSFORD: So is it the case, Mr Southward, that any computer model is only as good as the assumptions in that model and they may or may not fully represent reality?
A. Only as good as the assumptions made, how it's modelled, how the results are interpreted. It's one big melting pot and you've got to work through it very carefully to get the results.
COMMISSIONER HANSFORD: It's like a consultant interpreting medical results.
A. Luckily, I've not had much experience of that.
COMMISSIONER HANSFORD: I've had a little bit.
But, you know, these questions on this subject from Mr Chow are very valid and important questions for COWI

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to answer.
A. Indeed.
COMMISSIONER HANSFORD: But they have actually given their conclusions, I see, on page 39 of their report, and indeed they address shear in items 2, 3 and 4. But that doesn't invalidate Mr Chow's questions that they need to address.
A. Yes.
COMMISSIONER HANSFORD: Would you agree with that?
A. Yes, sure.
MR CHOW: Thank you, Prof Hansford.
I would like to move on to another slide, page 16, please, where you talk about the test result.
I recall what you said is -- at one point you said there is only one sample tested; you would welcome that if more samples should be tested, then the result may be more reliable. Do you recall that?
A. I can't recall exactly what I said. I don't think I said that.
MR PENNICOTT: I didn't hear that either.
A. I just said, "These are the tests."
CHAIRMAN: Sorry, where --
MR CHOW: You said something like, "I'm pleased to see a larger sample", something like that.
CHAIRMAN: Sorry, where did Mr Southward say this? Because

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I've missed it.
COMMISSIONER HANSFORD: I didn't hear that.
A. I can't recall.
MR PENNICOTT: I didn't hear it either.
MR CHOW: That's fine. Perhaps I have ...
MR SHIEH: He might have said something like more tests can be done but it was not specifically as to whether or not they should be done. He was simply observing, "maybe you can always do more tests", something like that. I'm checking the transcript.
MR CHOW: Sorry, my apologies. Something like that.
Can I ask you, then. The fact is only one sample was tested for each percentage of engaged length; right?
A. Yes.
Q. Do you think it would be better and make the result much more reliable if more samples of the same percentage of engaged length are being tested?
A. Well, I mean, of course, the more you test, the more confidence you get. Although I said I wasn't an expert in statistics, I think that's what statistics is about. But, you know, if you want to do more tests, you could. That's not a problem. That doesn't change the results of what we see.
Q. Okay. I appreciate that you are not an expert in statistics. Can I also ask whether you are an expert in

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the behaviour of couplers?
A. I have used couplers in my structural design, so from the point of view of the structural design, the application of the use of couplers in infrastructure works, yes, of course. I'm not an expert in the metallurgy inside couplers, no.
Q. When you say you use couplers in your design, am I right in understanding that by doing so, you relied on the catalogue or the strength data published by a particular coupler manufacturer, and you made use of those data in your design, and then you specified certain type of couplers to be used in the design drawing? That is how you so-called make use of couplers?
A. Yes, that's how industry works.
Q. So if the contractor fails to comply with, for example, the way a particular brand of coupler should be installed, then you are not -- you don't claim any expertise in trying to extrapolate and to form any opinion as to how, under those circumstances, the couplers would behave?
A. No. I think that's kind of straying into the whole specification side and the project administration side.
All I'm saying is that some tests have been done, and these tests demonstrate a significantly large spare capacity compared to the design strength of the bars

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that we need in the design. So that indicates to me that that coupler assembly is adequate.
Q. All right. Okay.
Now, this morning, when I asked Prof Yeung questions on the test requirements set out in the American code, AC133, and also 2004 Concrete Code in Hong Kong, in particular the elongation test -- do you recall that?
A. Yes.
Q. So you know that that is a requirement under our Hong Kong Concrete Code 2004, for elongation test, and it's about the maximum allowable residual elongation of not more than 0.1 millimetre after the coupling assembly is subject to a load up to 60 per cent of the yield strength; you are aware of that?
A. Yes.
Q. In the American code, AC133, there are other tests, static compressive test, static tensile test, cyclic load test. You are also aware of those tests as well?
A. (Nodded head).
Q. Do you know the reason why those tests were required?
A. I believe all these tests go towards making a specification that is watertight so that that product can be used in any application in the civil engineering industry. So you can use that coupler anywhere, I mean in any application.

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So I'm not saying that those tests are not relevant for a coupler that you want to take off the shelf and use anywhere.
Q. So is that what you guess or you know as a matter of fact those are the reasons behind those requirements?
A. I wasn't involved in drafting the AC133, I wasn't involved in drafting the Hong Kong Code, so the reasons for these tests -- I mean, they're all to do with ensuring and guaranteeing the performance of the coupler --
Q. I see.
A. -- for use anywhere.
Q. Okay. So you would not suggest to this Commission that the elongation test is wholly unnecessary?
A. If I wanted to use the coupler, say, at the base of the Nina Tower, that coupler would be subjected to very, very high tension and compression stresses because of wind loading, earthquake loading, you know. So if I wanted to use a coupler there, I want to make sure that coupler can meet all of the criteria, all of the loading, that is put to it.
So yes, those tests in that case, certainly I'm sure they are valid.
Q. But how about in our structure in question. I'm interested in the platform slab, the box structure.

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Now, the designer, Atkins, specifies the use of those couplers. There is a requirement for elongation test in the Concrete Code. Are you suggesting that for the purpose of our structure that the Commission is considering, it is wholly unnecessary to carry out those elongation tests?
A. Well, I'm saying you've got to look at it from the perspective of where are we now. We are in a situation that the structure is in the ground, it's been built, it's standing up, it's holding its load. The load has been taken up by all of the couplers. The structure is there. It's working. There's no sign of distress. What is the future loading going to be on the coupler? The future loading -- sorry, the future change in loading, that change in loading is actually going to be very small because it's only the live load of the trains on the platform slab, which is almost on top of the diaphragm wall, so the incremental stress change is very small, which is a completely different situation to a coupler at the base of the Nina Tower which is going to experience very large stress reversals.
Q. Can I move on to the next slide, please, where you set out various possible methods to determine the internal stress inside the connection.
A. Sorry, which slide?

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Q. Slide 18, I think.
Now, you list out possible methods or acceptable methods, and you also told us that the one you usually use is a finite element analysis using two-dimensional plate elements or three-dimensional solid brick elements.
Am I right in thinking that for the joints that we are interested in, you have not carried out any really numerical checking to satisfy yourself that under the most critical load cases, the connection as-built is strong enough to take those loading?
A. Before yesterday, no, I had not done any calculations.
Q. And how about today?
A. Yesterday, after hearing the conversations on Monday about how simple the joint calculation was, I thought let me have a look at it, let me see if I can do a simple calculation. So I asked for the representative loads, and these were extracted from the calculations, and I did a very simple, very quick, extremely quick, strut-and-tie analysis to see if the joint could work.
So this was very, very quick. Clearly, I said my preference, out of -- my preference in engineering design is to do a finite element analysis, using 2D or 3D elements. If I'd had a few weeks, I would certainly have done that, and -- you know, a finite element

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analysis is a good tool because if modelled correctly and if you can understand the input and the output, you can look at the flow of the stresses through the joint, and that flow of stress, the lines of principal stress, are very useful in determining how that joint behaves.
But I didn't have that time so --
Q. I appreciate that.
A. And I wasn't --
COMMISSIONER HANSFORD: Can I just ask, in your experience, does the how does the output from a finite element analysis correlate to the output from a simple strut-and-tie analysis?
A. Okay. So if you took a bridge pier, you know, a bridge column that had two bridge bearings on top and then the load of the bridge above, so you've got two point loads on the top of this column, and you did a 2D plate analysis, finite element analysis, of that column, you would see the lines of principal -- compressive test and principal tensile stress. You know the graphics that were in COWI's --
COMMISSIONER HANSFORD: Yes.
A. If you've seen those. So you would get similar graphics showing the flow of compression and tension stresses, and you could use something like that to verify a strut-and-tie analysis, because the point of

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a strut-and-tie analysis is to show where the compression struts are and where the tension ties are. So you do your strut-and-tie and then you could check it by doing a 2D finite element analysis.
COMMISSIONER HANSFORD: I understand that, but my question is, in your experience, are the results usually similar?
A. Finite element analysis will give you a better result.
COMMISSIONER HANSFORD: What's the order of magnitude of "better"?
A. It depends. It depends vastly on the application and the situation. I could say 10 per cent, maybe 20, maybe 30; it really depends on the situation, because strut-and-tie analysis is just a 2D thing, whereas finite element analysis can be completely three-dimensional. So you are modelling the effect of that force going everywhere.
COMMISSIONER HANSFORD: So, if you get sufficient confidence from a strut-and-tie analysis, would it then be unnecessary to do a finite element analysis?
A. I think a strut-and-tie analysis is more conservative. I mean, I've been in situations where we have produced a design of bridge piers and we've done nice three-dimensional finite element analysis, and I've had a checking engineer say, "That looks great but I want to see the lines of force, I want to see a simple

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strut-and-tie, to demonstrate that your computer wizardry is correct." But that strut-and-tie analysis does sometimes give you a more conservative answer -- sorry, will give you a more conservative answer.
COMMISSIONER HANSFORD: So therefore, if a strut-and-tie analysis gives you confidence or proves, to your satisfaction, that the structure is adequate, the finite element analysis would give you --
A. It would improve the result.
COMMISSIONER HANSFORD: It would improve the result?
A. Yes.
COMMISSIONER HANSFORD: And in improving the result, it would give you even further confidence?
A. Correct.
COMMISSIONER HANSFORD: Thank you.
CHAIRMAN: So, in other words, the two are on a plane together? It's not as if you are going to have the strut-and-tie saying, "No, this is going to fail", and you're going to have the other one saying, "Yes, it's going to be fine"? It will be the question of the strut-and-tie will give you a result, quite conservative, and the other test, the computer test I'll call it, will give you a more refined test, but essentially on the same -- a rising plane?
A. That does depend on where you've started. If you've

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started from a finite element analysis, and you have designed it very efficiently and very tight and, you know, you really have made it meet all the rules exactly, then if you use a strut-and-tie, you might find the tension force is a little bit larger than the tension stresses in the computer analysis.
CHAIRMAN: Put it this way, a better way than the rather clumsy way I put it earlier -- my apologies -- they complement each other, the tests?
A. Yes.
COMMISSIONER HANSFORD: In some areas, in some professions, I might suggest, reference is made to a quick and dirty analysis, if you can excuse that term.
A. That's fine.
COMMISSIONER HANSFORD: Therefore, would an overnight strut-and-tie analysis constitute a quick and dirty?
A. It would be, yes.
COMMISSIONER HANSFORD: Thank you.
A. And I have to stress that there are lots of different ways you can draw out a strut-and-tie. You know, what I drew, I don't say that's the absolute -- the way it works. It's just a representation. And the point is that in a finite element analysis, it's elastic --
COMMISSIONER HANSFORD: Yes.
A. -- and it will show you the first order of response to

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the structure. It will show you the first way that the structure wants to behave. And if that structure then -- because it's made of reinforced concrete, that structure might then crack a bit, and it cracks, which is perfectly okay -- reinforced concrete cracks, that's okay -- the structure cracks and then the load will redistribute inside the section, and it will then go into its second response, the second way it's taken up its load.
So when you do a strut-and-tie, if your strut-and-tie is the same as the first order of response, then it's exactly -- it models exactly how the structure will behave first. But if it's not, if it's a different strut-and-tie, the structure might have to crack a bit and the load redistribute, and then the load goes into the second response.
COMMISSIONER HANSFORD: Okay.
A. Do you follow?
COMMISSIONER HANSFORD: I do follow, but in order --
A. So that's why there are many different ways of doing strut-and-ties. So I'm not saying this is "the way". I'm just saying it is one way that was, as you said, quick and dirty.
COMMISSIONER HANSFORD: That's very helpful. In order not to alarm anyone that might be listening to this

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conversation, those initial cracks are not cracks of concern?
A. No, absolutely not. No, no, no, of course not.
COMMISSIONER HANSFORD: Thank you.
MR CHOW: Thank you, Prof Hansford.
Mr Southward, just now you told us that yesterday you have carried out your checking for the first time. Is it the 23rd slide -- or the 25th slide, is that right, where you set out the result?
A. Yes.
Q. Now, I have a few questions on this.
First of all, the bending moment that you use for your strut-and-tie analysis, if you look at the bending moment on the left side, left-hand side, it's 10,406 kilonewtons/metre width; right?
A. Yes.
Q. If you look at Atkins, the section -- the Atkins calculation, on the manuscript page, page 19, the bending moment used by Atkins is 14,000.
A. Yes.
Q. Then why don't you use Atkins' bending moment for your strut-and-tie analysis?
A. Because I guess those are for two different panels. I was just trying to do an illustrative -- I was just trying to do a quick calculation in the time that I had.

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I asked for the typical bending moment and it came to me. There wasn't really time for me to go back and say, "This is different to what Atkins had."

So that is the bending moments for panel EH113, so I have checked panel EH113.

Q. Okay. So you are only -- well, on the assumption that your calculation is correct, all that you can say is the panel that you have checked is safe?

A. Well, that's correct, yes.

Q. I see. Okay.

A. Prof Au did say that there were lots of different panels.

Q. Yes.

A. So there are. I don't dispute that.

Q. The force diagram that you show, have you checked whether the resistance inside the connection is able to take up those forces? For example, the inclined force, the tension force which runs diagonal between -- from the top, on the left-hand side, down to the right of the lower part, the blue line with arrows, that represents the tension; is that right?

A. It does, yes.

Q. I can't find any reinforcement to resist that tension?

A. There are horizontal shear links. There are horizontal shear links in the diaphragm wall that are referred to

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in the Atkins calculation of December. In the back of that, there are diagrams showing the diaphragm wall panels and there are shear links.

Q. Have you checked the dimension or the cross-sectional area of the shear links to satisfy yourself that --

A. I believe the shear links are T16.

Q. Have you checked? This is my question.

A. Yes, I looked at the drawing and I saw that the shear links were T16.

Q. Have you checked numerically, determined the cross-section of the shear link and then compared it with the tension force that you have found, to satisfy yourself that there are sufficient shear links to resist the tension force?

A. Yes.

Q. Can you produce the details of your calculation?

A. Well, to be honest, I have done -- yes, of course I can, if you want.

COMMISSIONER HANSFORD: I just make the comment at this point that I think it unwise that lawyers get too much into structural calculations, but that's just an observation.

MR CHOW: Thank you, Prof Hansford.

Mr Chairman, I note the time. According to my watch, it is 4.45.

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CHAIRMAN: That's excellent. Thank you very much. Then we will adjourn for the day, a quarter of an hour earlier, for the reasons I gave earlier.

Tomorrow morning, 10 o'clock. Thank you.

You are reminded again, Mr Southward -- thank you very much -- about keeping your own counsel now until the completion of your evidence.

WITNESS: Yes.

MR SHIEH: Can I just clarify that Mr Southward is supposed to do the calculation and produce it on a piece of paper tomorrow, because I don't want people to get confused as to when he's going to produce the calculation?

COMMISSIONER HANSFORD: If that's something he could readily do, it might be useful.

MR SHIEH: I just want to clarify, in order not to waste time tomorrow, not to have any misunderstanding as to what Mr Chow is asking for.

CHAIRMAN: I'm not sure exactly what was being asked for.

COMMISSIONER HANSFORD: I'm not sure we need it, actually. I'm not sure we need it. You asked Mr Southward whether he had done that calculation.

MR CHOW: That's right, yes.

COMMISSIONER HANSFORD: He has said he has.

CHAIRMAN: Good. Thank you very much.

(4.48 pm)

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(The hearing adjourned until 10.00 am the following day)

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