Monday, 6 January 2020

(10.05 am)

DR LAU CHI WANG, JAMES (on former oath)

Presentation by DR LAU (continued)

MR KHAW: Good morning, Dr Lau. I believe when we adjourned last Friday, you had just finished page 47 of your slides.

A. Yes.

MR KHAW: Please continue.

A. Page 48, I started by commenting on Mr Southward's COI 1 report. We have a number of disagreements. First of all, about the conclusion. First of all, I disagree with him -- I think there is a need for suitable measures at this point.

I also talk about entering judgment. For me, what MTRC and Atkins are doing is actually exercising engineering judgment in the stage 3 assessment report.

Next one, please. On couplers, for me, the couplers need to be butt-to-butt for it to be acceptable, because apart from static tension, a very important consideration is the permanent elongation test. We don't want the coupler to have excessive elongation at working stress. As I said, it will cause cracking in the concrete because of the elongation.

Secondly, we have no proof that partially engaged

couplers can satisfy a structural engineer the requirements of safety, deformation, crack width and durability, because at one stage the government did ask MTRC to provide certain tests about partially engaged couplers to satisfy government about deformation, crack width and durability. That was not done at all.

On defective rates, last Friday I think that the Commission was a bit worried about the figures. First of all, the EWL slab, the figure was 36.6 per cent. Despite the high value, actually no suitable measure was required according to the stage 3 assessment; there was no suitable measure for EWL slab. Similarly, for the NSL slab, the 33.2 per cent defective rate, again there was no requirement for suitable measure, so the argument is just academic. For the EWL slab in area A, there was a figure of 68 per cent, but this 68 per cent was a statistical figure, and suitable measures was required in this area, but when I look at the design for suitable measures in this area, I found that there were only 15 panels, only 15 panels required suitable measures.

Next one, please. On shear links, Mr Southward assumed that there were shear links in the critical sections or the critical positions where shear links were required, and then he carried out different analysis to show that despite the shorter anchorage

length, there is still strength in the shear links. I have no disagreement with him on this analysis. It's totally all right. But I disagree with him mainly because of my concern that there might not be shear links in the critical locations where shear links are required. This is my disagreement with him.

In fact, there are photographs of missing shear links in the honeycomb area. There were 22 locations with honeycomb area, and ten of these locations have no shear links, as well as 22 locations where opening-up investigation was carried out. In these 22 locations, six locations have no shear links. So altogether there were 16 locations without shear links out of 40 locations.

Mr Southward commented about the MTRCL's opening-up. He said that shear links could be hidden in the 1 metre by 1 metre L-shaped opening-up by MTRC. I disagree. The spacing of shear links is at most 300 millimetres, sometimes 150 millimetres or even 75 millimetres. If shear links were not discovered within the 1 metre by 1 metre L-shaped opening-up, then the shear links were not there.

In fact, Leighton has opened up one area, whereas MTRC have opened up 40 areas, so there's a big difference between the MTRC investigation and Leighton's

investigation. So, for me, the MTRC investigation is more convincing than the investigation of Leighton.

Mr Southward made comment about the higher cube strength. This is a very important point. He said that the high cube strength obtained from the cube strength should be taken as the strength of in-situ concrete for the purpose of structural assessment. For me, this should not be used. For me, the only reliable test on the concrete strength in the structure is actually the core, the structure, to find out what is the strength in the structure itself.

First of all, the cube strengths are used for quality control purposes. They are not used for your design purposes, because if a supplier gives you grade 40 concrete, you should use the grade 40 concrete strength for design purposes, because, first of all, in the cube strength -- it depends on workmanship and curing; it's very important. In the cubes, they were properly compacted by the workers, they were properly cured in the curing tank before they were tested in the laboratory, whereas in the in-situ concrete, they were placed in the structure, they may not be properly compacted, they may not be properly cured. In fact, if you look at the structure, at this particular structure in the station, there are a lot of defects: look at the

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honeycomb area. So I don't think we should use the cube strength test -- the cube strength result as the strength of the concrete structure.

There was also comment about the concrete gaining strength over time. I also disagree that he should use this, because I agree that the concrete would gain strength for the first two to three years because of, as I said last time, chemical reaction being continued. But after two to three years the chemical reaction stops and the strength of the concrete begins to deteriorate because of the accumulation of micro-cracks in the structure, because of use of the structure, and the micro-cracks will never disappear; they only accumulate. That's why the strength of the concrete can only decrease, not increase, after certain period of time.

There was also talk about arch action in the slab. Well, it depends on the depth span ratio. I showed last week that in the slab there are a lot of openings. If there are a lot of openings in the slab, there may not be arch action in the slab for the sheer calculation.

Next one, please, on construction joint. Now, we all agree that it is not a structural problem anymore; it's purely a workmanship problem on the construction joint. We only disagree on the method of suitable measures. For Mr Southward, he said that you only have

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to grout the two holes, but for me, I think we have to grout -- you have to use dowel bar and grout as a suitable measure. And according to the design by Atkins, we need this grouting action and dowel bar action on 23 panels, altogether 23 panels.

For me, the dowel bars are important because the joint is actually a fixed-end moment joint and there should not be a construction joint in the concrete. If there's a construction joint in the concrete, you can imagine that you are trying to open up the bending moment, trying to open up the joint, and the crack may propagate in the long term. So I think it is important to put in a dowel bar to stop any opening of the crack in the long term.

Next one, please. Dr Glover's COI 1 report. My disagreement with Dr Glover is this. He said the partial safety factors are meant to cover the uncertainties during the construction period. I disagree with him, because the partial safety factors are meant to cover the uncertainties during the long intended design life of the structure, which is 120 years, not for the temporary stage of the construction period.

Second point is fitness for purpose. For me, the design working life of the structure is not

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a contractual requirement. It is a durability requirement. So I think, for fitness for purpose, we should consider also the long intended design life of the building structure.

He said that the code is a "one size fits all" standard. I disagree with him on this point, because I was on the steering committee of the Hong Kong Concrete Code. In fact, the code allows different approaches to be adopted by the designer. They do not restrict you to do whatever you want. But of course if you want to do something different, then the rules inside the code may not apply; you have to do more checking. That's all.

About the combination of test data for the statistical analysis of coupler connections, I have to disagree with him about combining the test results for purpose 1 with purpose 2. I'm not an expert in statistics, but I know that purpose 2 are properly designed random samples. You should not contaminate the random samples with purpose 1 data; they should be separated.

Also, one last point I want to comment on Dr Glover is that he comments on Atkins' stage 3 assessment being too conservative. I looked at the assessment, the OAP settlement agreement and the Atkins assessment myself.

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Basically, they used more or less the same software, Plaxis, the same software, the same applied load -- the same dead load, same live load, same soil load, same water pressure load, the same -- and they should come out to be about the same in all the -- the stresses in the structure should be the same. In fact, when OAP adopt a very important parameter, which is the modulus of the soil which is E equal to 1 times N -- N is the value of the standard penetration result from ground investigation. If they use the same stated modulus, they get more or less the same result, but OAP go one step further. They also do another assessment based on a very important parameter, that is E. This time they change it to E equals 1.5 N. By doing that, the utilisation factor in the structure becomes lower, and then he criticises the Atkins result as being too conservative. This I have to disagree because the equal to 1 N is a parameter required by the Geotechnical Engineering Office in Hong Kong. All structures in Hong Kong have to be designed to E equal to 1 N, not E equal to 1.5 N. This is the main difference between the two.

Next one, please. We come to COI 2. When I look at -- in the COI 2, I understand that -- I only want to concentrate on two areas rather than all these: the

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coupler and the shear link, because these are the areas we have to concentrate on.

For the couplers, I know that there were no opening-up in the COI 2 investigation or assessment, but there were discoveries of bad coupler installation at three points. The first one is the VRV room. The second one is the three stitch joints leading to water seepage, and there was also defective coupler connection at the shunt neck.

Next one, please. So even without opening-up, the MTRC adopted a 35 per cent reduction rate, strength reduction rate, for the coupler assessment. This is a proposal proposed by MTRC. There's nothing I can do about that because I have to look at the evidence before me -- right? So I look at -- I think, still, it is okay, the 35 per cent defective rate is okay, because if you look at the -- next one, please -- if you look at the investigation report on the couplers at the VRV room as well as the stitch joint -- next one, please. Now, this is the stitch joint. You can see that the couplers are not connected at all in the stitch joint.

Next one, please. And next one, please. This is the VRV room. Again, the couplers are not connected at all. So this evidence convinced me that something must be done on the defective rate of the couplers.

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Next one, please. The structural review done by MTRC is like the COI 1 -- they compare the spare structural capacity of the structural elements and look at the extent of strength reduction required. In the case of the defective couplers, they checked the two, they checked the spare capacity against the required strength reduction, to determine if suitable measures are required, and in the case of COI 2, they found that NAT/SAT, as far as couplers are concerned, there's no need for any suitable measures, but the only suitable measure they recommended is the trough walls.

Next one. According to AECOM, MTRC's DDC, they found that the trough walls in HHS cannot safely resist the horizontal impact load from a derailed train, and as far as the SAT is concerned, they also found that because of the lack of -- the missing shear links, suitable measures would be required on the SAT as well.

Next one. Let us look at the columns. Inside the trough wall, there are a lot of columns that support the podium above. Some of the columns are very close to the trough wall itself.

Next one. You can see that the trough wall and the relationship with the columns, they are very close.

Next one. These are the proposal by -- well, this is the location of the trough wall.

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Next one, please. Next one, please. For me, I think only fully engaged couplers should be used in the structural assessment of the trough walls. The 35 per cent strength reduction rate for me is a reasonable assumption. And remember that the trough walls were designed to take collision loads in accident involving train derailment. And the assumption of no shear links is adopted in the assessment -- I think it is satisfactory.

At this stage, I would like to go back to the -- actually, let me continue. In the SAT area, again, in the SAT, because of missing shear links, suitable measure was required on the base slab of this particular -- in the SAT area. I have to point out to the Commission that the diaphragm wall, some diaphragm walls are called "hit" diaphragm walls; that means they go down to the rock. Some diaphragm walls are called "miss" because they don't go down to the rock. So there's water coming in through the "miss" diaphragm walls, so future dewatering in the surrounding area can cause ground settlement. The groundwater table actually is near the top of the EWL slab at the moment.

Next one, please. You can see that the SAT slab is not resting on rock at all; it's not resting on rock, because actually rockhead changes a lot. It changes

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from minus 7mPD to minus 50mPD. There's a big change in rock level for this project, a big change.

Next one. What suitable measures are required for the SAT area?

CHAIRMAN: Sorry, can you tell me what that means, the big change in the rock level.

A. In area A, the rockhead is about minus 7mPD, which is still below the NSL slab level. When we go down to --

CHAIRMAN: I see. You are talking about -- I understand it. Thank you very much indeed. So you are talking about the levels, the actual physical -- how wide they are when taken against the PD, the --

A. 0mPD is sea level. And in area C it goes down to minus 50mPD. It's very deep.

CHAIRMAN: All right. Sorry, just while I'm just asking questions, you say that there should be an assumption of no shear links, when we are talking about couplers and shear links.

A. We are talking about shear links. There are two problems here in this particular COI 2. The first one is couplers, and the couplers only affect the trough wall design.

CHAIRMAN: Yes.

A. And the shear links affect the SAT slab design. If you assume there's no shear link, then according to Atkins

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we require suitable measures.
CHAIRMAN: I'm with you, yes. And you make what is effectively a statistical assumption of no shear links, for purposes of deciding what work needs to be done?
A. Yes. I did not do any statistical analysis.
CHAIRMAN: No.
A. It's MTR proposed that.
CHAIRMAN: MTR's done that. Yes.
Sorry, Mr Pennicott, can I ask, when did shear links become a problem? The only reason I ask is I don't recall that right at the outset, I don't recall anything about shear links.
MR PENNICOTT: It emerged, sir, during the course of the first part of the Inquiry.
CHAIRMAN: Yes, that's right.
MR PENNICOTT: And when I show this witness some cross-examination by Mr Chow of Louis Chan [Kwan], one of the MTR's officers, we will perhaps remind ourselves of how it came about.
CHAIRMAN: Thank you very much.
A. Actually, in the SAT area, assuming that there are no shear links and the suitable measure required is shown in this blue strip, there's a requirement of thickening of the slab for about a length of 42 metres, thickening of the slab to cater for the assumption of no shear

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links in the slab.
Next one. In fact, this is a summary of the calculation by MTR, and they show where -- which part, which point of the slab is overstressed.
Next one. I go to Mr Southward's COI 2 report. He said there is no opening up of the structure by MTRC to identify defects, which I agree; there was no opening-up. For me, the only opening-up are the VRV room and the stitch joint area.
COMMISSIONER HANSFORD: What do you mean -- sorry, on here, Dr Lau, you say "which is preferred". What do you mean by that?
A. Preferred by me. If I have the chance, I would ask for opening-up.
COMMISSIONER HANSFORD: Ah, you are saying that there was no opening-up, but you would have preferred that there had been opening-up?
A. Yes, I would prefer.
COMMISSIONER HANSFORD: Okay.
A. That's why I say I agree with Mr Southward, because this is the evidence to support any design, but anyway there was no opening-up. This is a decision by MTR so there is nothing I can do about that.
Then MTR recommend a strength reduction of 35 per cent in the checking of the trough walls and the

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NAT and SAT.
Actually, for me, in view of the workmanship of the coupler connections at the stitch joints, the shunt neck joint and the VRV room, I agree that the 35 per cent strength reduction factor is a reasonable assumption.
Next one, please. In the trough walls design -- in Mr Southward's COI 2 report, the trough walls were designed to take accidental collision loads in the event of train derailment. For me, during the 120 years intended design working life of the trough walls, the accident of train derailment may or may not happen. We don't know. It may never happen. But if it happens, it can have serious consequences, because there were a lot of columns behind the trough walls.
Based on the strength reduction factor of 35 per cent, MTRC analysed the trough walls as cantilevers with the weak point at the defective coupler level, that is the kicker level. This is a conventional method adopted by structural engineers everywhere.
Next one. Mr Southward adopts a yield line analysis, and he is allowed because in the Hong Kong Concrete Code you are allowed to use yield line analysis; it is okay. But the yield line pattern proposed by Mr Southward has to be correct at the time of failure, otherwise he overestimates the strength.

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And also he did not check the shear capacity of the trough wall. I think he should check; at least he should check it. I'm not saying it will fail but at least he has to check it.
COMMISSIONER HANSFORD: Have you checked it, Dr Lau?
A. I checked it somewhere -- I tell you how I did it; I checked it in other way, I checked it, I used very simple method to check it.
He also assumed that the strength reduction was evenly distributed over the whole trough wall. I think it's okay, but that's what he did.
Next one, please. In reality, if there was strength reduction, the weak points in the trough wall will be located at the coupler level. If there is an established line of weakness in the trough wall, Mr Southward's yield line pattern would not be correct. So for me I prefer DDC's method of analysis.
Next one, please. Before I go to these shear links, let me tell you what I did. When Mr Southward was asked, I think on Friday morning, whether he checked the deformation of the trough wall at the time of collision, he said he did not, so what I did was, when I returned to my office, I carried out a very simple calculation, hand calculation, because according to his design there was a -- if you can put up his -- there's a drawing,

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he's got a drawing. Can we put it up, his slide, in his report? He did a yield line analysis; he's got a yield line analysis. He's got a PowerPoint. I think it's very interesting. I need to show the Commission what I did.

This is it. Remember there's a column behind this wall. The distance between the column and the wall is 60 millimetres. In fact the wall, there was a recess in the wall to accommodate the column. On the right-hand side, there's the so-called expansion joint, it's a movement joint, on the right-hand side, so it's free. But this is not the yield line. It should be -- next one. Yes, this is it. This is the yield line. This is the yield line pattern adopted by -- this is the yield line pattern adopted by Mr Southward (indicating). He said the wall breaks along this line as the top portion falls away from the lower portion. This is yield line.

You know that when a yield line forms, there's a plastic hinge there. That means -- and it's free, on the right-hand side, and if the wall on impact by the train, it will rotate towards the column; right?

What I did was I used very simple hand calculation. The wall is 1.8 metres high. At the midpoint, it's about 1.2, 1.3; right? Then I calculate how much rotation it needs for the wall to hit the column. The

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rotation is only 2.7 degrees. That means a very small rotation of the wall will hit the column.

So, for me, it is very important that the wall should be stopped from rotating at the point of failure, and the proposal by AECOM to strengthen the wall from behind is very important, because in case there was an accident during the 120-year design life of the trough wall, an accident happens, the column will be severely damaged by the train and something will happen to the podium.

It's not just one area; there were a lot of other columns, all along the trough walls, a lot of other columns. So this is what I did in terms of deformation.

Can we go back to ...

Shear links. Mr Southward referred to EIC's shear calculations that take into account of, first of all, the correct steel area. I agree. I think he can do that; I have no disagreement with that.

Secondly, higher in-situ concrete strength obtained from tests performed on concrete cubes prepared on site. I disagree with this point, as I said before. It depends on the workmanship in the concrete. It doesn't depend on the workmanship of the cube; right? The workmanship on the cube and the workmanship of the in-situ concrete are totally different, so I will not

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accept this at all.

He also said that there is an alleged redistribution of shear forces. I disagree with him as well, because shear failure are brittle failure and sudden failure. You cannot redistribute -- if it is bending, I can understand there is a redistribution. Moreover, in the original design, there was already a -- the so-called redistribution already taken into account. If there's a shear failure on the slab, the failure will happen first because there will not be any other redistribution because there's no support and the column will be hanging on the slab beam above. So I disagree with him that there will be a redistribution of shear forces at all.

Next one. This is a very important point because the other three experts keep on insisting that we should use the concrete strength from the cube in the analysis. First of all, I tell you, nobody in Hong Kong does that. We only use the design strength supplied to you by the concrete supplier as the design strength, just like what Atkins did. I would not use the cube strength test result in my design at all.

So what I said is that the concrete strength must depend on the design mix proposed by Leighton and accepted by MTR at the beginning of the project. The

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concrete cube strength tests are only used for quality control. As I said, the results are always higher than the strengths required by the design mix and also higher than the in-situ concrete in the structure itself.

Next. The strength of concrete supplied by the concrete supplier was not less than the design strength if on-site quality control was satisfactory. Good concrete strength also depends on -- important -- workmanship, it depends on workmanship, it depends on how you compact the concrete in the structure and how to cure the concrete in the structure. It doesn't depend on the cube strength you get; right? Of course the strength is always high because we have different workmanship on the cube strength and the workmanship on the in-situ concrete. So, for me, it is inappropriate to assume that the in-situ concrete strength is higher than the design strength. It's inappropriate, at all.

Next one. Again, I talk about that you cannot redistribute shear stresses, because it is not ductile; it is brittle failure. You cannot.

Next one. Okay, I repeat this again. I don't want to repeat this.

Next one, please. Let me look at Dr Glover's COI 2 report. About the 35 per cent strength reduction, I already responded, and there is no need for me to talk

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about that again.
On the strength design checks for trough walls, he said he relied on the concrete slab and the soil behind the trough walls and concluded that the structure was safe.
First of all, the soil was not relied on in the original design; it was not relied on. Secondly, you can see that if the columns are so close to the trough walls, the soil is not that important because the wall will just hit the column, in time of accident. He said that we can rely on the concrete slab between the trough walls because it was not designed for -- it was not designed like that. They were supposed to be temporary works. If you want to rely on them, you have to make them permanent, as what AECOM is doing now. They put in the soil and the suitable measures and the concrete now and that now becomes permanent work, then we can rely on it now, but not before.
He also suggested we should use a 3D model of the SAT structure to show that no requirement of shear link reinforcement in the NSL slab, but I haven't seen this 3D model. Maybe he can demonstrate to me but it is not there.
Next one. Prof McQuillan's COI 2 report. The 35 per cent reduction, I already responded.

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On the trough walls, Prof McQuillan said there would be energy dissipation into the soil fill between the trough walls. First of all, the soil is not supposed to be permanent in the original design but now, after the suitable measures, it is permanent. But remember that if the column is so close to the trough walls, the soil may not be that useful in time of accident.
Anyway, AECOM's design is an universally accepted method of cantilever analysis and it is a prudent approach.
Next one. Shear links. Professor said he disagreed about the shear link proposal by AECOM. He said there's no opening-up investigation in area A. In fact, there were three locations, but still I agree with him that if possible we should have an opening-up.
He said that the shear failure on the slab will not occur because the slab was in contact with soil which would prevent the slab from failure. Well, I cannot agree with him because the slab was supposed to be suspended slab. We have to remember that this structure is supposed to last for 120 years. We don't know what will happen in 10 years/15 years afterwards. There may not be any soil in contact with the slab because of dewatering and settlement of the soil. So it's better to be prudent, to assume that the soil is not there.

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Next one. I talked about that. As I said, the lowering of the groundwater table can increase the effective soil pressure, will cause consolidation and settlement of soil beneath the suspended slab. So I don't think we can rely on the soil beneath the suspended slab.
COMMISSIONER HANSFORD: Sorry, Dr Lau. Can we just go back one slide. Your final sentence there, what do you mean by that, "If it is punching shear"?
A. Suppose you have a raft foundation and there is a column there. The column has punching shear. There is soil underneath; you can still punch through the raft foundation. If the concrete in the raft foundation is not strong enough to support the shear, it can still happen.
COMMISSIONER HANSFORD: Okay. Thank you.
Sorry, we seem to have some confusion about what you actually said. Did you say "raft foundation"?
A. Yes, raft foundation. But this is not raft foundation here, we are not talking about, but I suppose, if it is a raft foundation, you have a column punching through the foundation.
COMMISSIONER HANSFORD: Yes.
A. There is soil beneath.
COMMISSIONER HANSFORD: Yes, and you are saying here there

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isn't.
A. But in this case, we have no -- we have to assume it is suspended slab.
COMMISSIONER HANSFORD: Okay. Understood.
A. Also, it is important to understand what happened during the construction. I'm a contractor; I know what will happen in the basement construction. When you excavate, you always excavate more, because you have to allow for drainage at the soil level, so you have to excavate more so that there's a gradient so the water can flow along the surface of the soil, so the water can be accumulated in certain sump pit to be pumped away. So you always over-excavate and then you compact the soil back, put the soil back, before you cast the slab.
So the soil will not be the original soil. The soil will be loose soil, because you over-excavate and then put it back. So we should not be thinking that there is CDG underneath the -- CDG means completely decomposed granite. It will not be CDG underneath the suspended slab. It will be fill soil underneath the suspended slab.
In Hong Kong, it is well-accepted practice in Hong Kong that for pile caps and suspended slab, the contribution of soil is neglected in the design of suspended slab, always. We always neglect the

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contribution of soil for all suspended slabs.
Next one. The end.
Before I finish, I would like to give a conclusion.
I think it's important for me to put this in. In both COI 1 and COI 2, defects and workmanship problems were found. In fact, a lot of assessment and calculations were done by different consultants. In all this analysis, we identify certain weak areas in the structure. We all agree that these are weak areas, all concerned agree that it is weak, I think including the experts agree what are the weak areas. But the difference between me and the other experts is they think, even though there are weak areas, there's no need for any suitable measures, but for me, I think we need to put in the suitable measures.
CHAIRMAN: Sorry, when you say "weak", do you mean "weaker"?
A. I'm not saying weak. Utilisation ratio is high.
COMMISSIONER HANSFORD: Okay. I think we need to be careful with the word "weak" there.
A. Sorry. These are areas we identify with high utilisation ratio and I think we need to put in suitable measures. They should be monitored in the long term as well. These are the areas we should monitor in the long term.
COMMISSIONER HANSFORD: So what you are saying is -- your

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submission is that all of the engineers involved agree that some areas have higher utilisation than others?
A. Yes, that's right.
COMMISSIONER HANSFORD: Thank you.
A. Also, don't forget --
CHAIRMAN: Sorry, just remind me again: higher utilisation means, in layman's terms ...?
A. Reaching the -- there's a limit of the strength, the strength limit. In theory, we should have the applied strength -- applied stress lower than the limit; right? If it is close, then we should be more -- we should look at that more carefully. If we have a high margin, then we are more happy; right? If the applied stress on the structure is close to the limit, then we need to be more careful about those areas, in those areas.
COMMISSIONER HANSFORD: Yes. Maybe, in layman's terms, what we are really saying is that in areas of high utilisation, the structural capacity is being used more than in areas of low utilisation.
CHAIRMAN: That's what I imagine, yes.
A. Thank you, Professor.
COMMISSIONER HANSFORD: Is that correct?
A. That's it.
The so-called suitable measures are -- I think he need to put into perspective what sort of suitable

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measures we are talking about. In COI 1, as far as the couplers are concerned, we required 15 panels for suitable measures, only 15 panels. On the CJ issue, we required 23 panels. On the shear links, we are talking about 1 per cent of the area. On COI 2, the trough wall, I think definitely we need suitable measures because it is very important to protect the columns.
Basically, as far as I understand, it is basically completed on site at the moment. The shear links in SAT area, we are talking about a strip of 42 metre long, 1 metre wide, thickened concrete. This is the suitable measure required by Atkins and MTRC.
COMMISSIONER HANSFORD: How thick?
A. I forgot how thick, sorry. I cannot answer you.
COMMISSIONER HANSFORD: That's fine.
A. But it's not a thick -- just to increase the thickness of the slab to improve the shear strength. That's all.
COMMISSIONER HANSFORD: Okay.
A. That's the end of my presentation, sir.
CHAIRMAN: Very good. Thank you very much. Thank you, Doctor.
Examination-in-chief by MR KHAW
MR KHAW: Dr Lau, perhaps there's just one minor point I would like to follow up on in relation to your PowerPoint presentation. If you go back to slide 13,

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under the heading of "Serviceability limit state design", point 4, "Cracking", there's a bracket saying "(exposure condition of the structures should not be considered as 'mild', ie not exposure condition 1)".
You recall that when you were discussing this point you told Mr Chairman and also Prof Hansford that you might come back to this point. Would you like to have anything to say on this point?
A. Okay. First of all, I hope that the Commission understand that diaphragm walls are discrete panels. They are not watertight diaphragm walls. So, actually, even though there is no seepage through the diaphragm wall joint, it is still moist. Still moist.
First of all, so I don't think it is "mild" in that sense. That means inside the diaphragm wall enclosure, it is quite moist, because of -- sometimes you will have seepage. Even though there's no seepage, it is still moist, so it is not "mild" in this sense.
Secondly, as I mentioned previously, there would be cracks on the diaphragm wall top and the soil side of the diaphragm wall, and there may be in the long term water seepage into the inside of the concrete of the diaphragm wall and it may cause corrosion of the reinforcement. So we need to be careful about all this. This is what I mean, that's why I said I need to discuss

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this point later on.
Q. Thank you. Just to complete the picture, Dr Lau, for the purpose of this Inquiry, you have produced two reports.
A. Yes.
Q. Your COI report dated --
CHAIRMAN: Sorry, I apologise. It takes me a little while to catch up sometimes.
You would not, therefore, describe the atmosphere as "mild"?
A. I would not, no.
CHAIRMAN: You would describe it, rather, as being ...?
A. I wouldn't say severe but it's definitely not mild.
CHAIRMAN: Okay. So one up from mild on the severity stakes, or more than that perhaps?
A. The worry I have is the reinforcement inside the panels. This is my worry. I'm not talking about the condition of people working inside the station. I'm worried about the condition of reinforcement inside the panel, the condition of reinforcement at the joint.
CHAIRMAN: Yes, of course.
A. This is what I worry about. And if the reinforcement corrodes, the reinforcement will expand, when it expands, it will cause spalling of concrete. This is the sort of thing I am worried about. And for diaphragm

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wall and for the joint, this may happen in the long term.
COMMISSIONER HANSFORD: Maybe to answer the chairman's point it would be helpful if we could look at -- I think it was Mr Southward's presentation where you had a table of the different exposure conditions; am I right?
MR KHAW: He has a table showing condition 1 only.
COMMISSIONER HANSFORD: Okay. Yes.
MR KHAW: Perhaps I will show Dr Lau the table consisting of all the conditions.
COMMISSIONER HANSFORD: Yes. That would be helpful.
MR KHAW: It's H8 --
COMMISSIONER HANSFORD: Thank you.
MR KHAW: -- starting from 2856. The last bit, 4.3.2.2, "Classification of exposure conditions", then we can see the following conditions.
COMMISSIONER HANSFORD: I see. So if it's not mild and it's not severe, presumably you are saying it's moderate, Dr Law?
A. Well, in our case, I think it's between 3 and 4, because remember that the diaphragm wall, outside diaphragm wall we have high groundwater table, and remember I talked about the tidal effect, I talked about --
COMMISSIONER HANSFORD: Sorry, the only reason I said that is you said you wouldn't say it's severe, so I am

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assuming if it's not severe --
A. I think it may be moderate to severe, somewhere between the two.
COMMISSIONER HANSFORD: I see. Okay.
MR KHAW: Thank you.
For the purpose of this Inquiry, you have produced two reports, the COI 1 report --
A. Yes.
Q. -- dated 10 December. If we can just have a quick look at that report. It consists of about 69 pages. If you could just identify your signature at page 49; do you see that?
A. My signature, yes.
Q. There are various appendices attached to this COI 1 report as well.
A. Yes.
Q. We can all see that.
If we can go to the COI 2 report, dated 12 December 2019. It's a shorter report, consisting of about 17 pages; do you see that?
A. Yes.
Q. At page 17 there's your signature?
A. Yes.
Q. And also there are some appendices attached to this report.

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Can you just confirm, Dr Lau, that insofar as the two reports contain factual matters --
A. Yes.
Q. -- the facts are true and correct?
A. Yes.
Q. Insofar as they contain your opinions, they contain your true and honest opinions?
A. Yes.
Q. Thank you. What will happen now is that various parties will have questions for you --
A. Sure.
Q. -- for cross-examination, and obviously meanwhile the chairman and Prof Hansford may have questions for you.
A. Sure.
MR KHAW: Thank you.
Examination by MR PENNICOTT
MR PENNICOTT: Dr Lau, good morning.
A. Good morning.
Q. I get to go first. Thank you very much for coming along to give evidence to the Commission.
A. Yes.
Q. Dr Lau, you were appointed relatively recently by the government to give expert evidence to the Commission. When were you appointed?
A. I forgot. I think it's end of September.

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Q. You say in your first report that you were joined, as it were, in the second stage of the Inquiry.
A. Yes.
Q. So that would be right. So you think it was in September?
A. Well, actually, I was consulted by the Highways Department around May. First of all, I helped the Highways Department in May, not necessarily as an expert.
Q. Right.
A. So I looked at the report around May, and then afterwards I was appointed by the DoJ to be the expert.
Q. When you say you looked at the report, what report are you referring to?
A. The holistic report and the verification report, the draft form.
Q. Why were you asked to look at those?
A. Well, as a consultant or something like that, to assist them. I don't know what, I don't know --
Q. Were you paid to do that?
A. Yes.
Q. You looked at both the holistic report and the verification report?
A. Yes.
Q. So you had some input into those reports?

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A. No. Just look at.
Q. Why did you look at them then?
A. Just to explain to the engineer at the Highways Department what's the implication.
Q. Who did you meet in the context of reviewing those reports?
A. The Chief Engineer, the senior engineer, of -- I think they have a railway division there.
Q. Of the RDO?
A. Yes.
Q. During the course of that initial review of those reports, did you have occasion to meet any of the expert advisory team appointed by the government?
A. Later on, not at the time, no. Later on.
Q. When did you first meet with the EAT representatives?
A. I think after I presented my report, the first report.
Q. Right. The first draft of your report?
A. I forgot exactly when, but maybe somewhere between the draft report and the final report. I forgot exactly when, but I did meet them.
Q. All three of them?
A. Sometimes together, sometimes not together.
Q. What was the purpose of meeting them?
A. They hear what I -- they hear my comment on -- they just listened. They just listened to what I said.

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Q. Did they influence the contents of either of your reports, Dr Lau?
A. No, no.
Q. Are you sure?
A. I'm sure. I'm an expert. I don't have to be influenced by other people.
Q. Can we just go back a moment to your review of the verification report and the holistic report. Did you meet any representatives of the MTR during that period?
A. No, not at all.
Q. When you were first appointed, Dr Lau, do you recall whether the proposed list of issues for the structural engineers was already in existence?
A. Not -- let me see. Let me try to recollect. When I was preparing my report, I think there were the issues, but they change, every now and then they change. I think there were some issues -- I looked at some of the issues, yes.
Q. Because those lists of issues came into existence in about mid-August 2019 and were the subject of directions by the Commission at the end of August 2019. And I think you've just said that you were appointed in September 2019 officially.
A. Yes, officially.
Q. Okay. And so, if that's right, then the list of issues

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would have been in existence at that point?
A. Would be. Would be.
Q. Okay.
A. But I did not look at that carefully because I was not supposed to be an expert at that time. I just looked at the report for --
Q. No, I am just talking about September now. So far as I'm aware from what you've just said, you were appointed as the expert on behalf of the government in September; is that right or wrong?
A. That's right.
Q. Okay. So you would have looked at the list of issues at that point?
A. Yes.
Q. All right. I'm sorry to press you about this, Dr Lau, but let's go back to the holistic report in May. Can you now just recall why it was you were asked to review the holistic report; let's focus on that to start with?
A. I was sent a copy of the draft report.
Q. Why? Why were you sent it, Dr Lau?
A. I don't -- well, they come to me and discuss with me, taking with them the draft report, and to give them some advice, whether the extent of investigation was sufficient or not, or something like that. There were investigations by the MTR and Atkins.

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Q. Did you provide any written advice at that time?
A. No, no, no.
Q. Was there any -- just advice given at meetings?
A. At meetings, yes.
Q. Did you keep any notes of those meetings?
A. There may be some notes. I forgot. There may be some notes, maybe.
Q. Can you recall they particular aspects that they asked you to focus on at that point, back in May?
A. Basically, whether the investigation was sufficient or not, basically, the investigation.
Q. Any particular aspect of the investigations?
A. The coupler, the shear link, the honeycomb, things like that. That's all. I did not participate very actively. They just come every now and then to talk to me about that, yes.
Q. But why you, Dr Lau? What was the initial contact? Did you know somebody who was looking into this? What was the reason they came to you; do you know?
A. They also took me to meet a Prof Au as well.
Q. Prof Au?
A. Prof Francis Au.
Q. From HKU?
A. Yes. I know Francis Au for many years previously. We talk about the particular construction joint, the

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analysis at the construction joint at that time. I think mainly they rely on my expertise on finite element analysis, to talk about the construction joint. I think the most important point is the construction joint at that time.
Q. Okay. Now, as far as the verification report is concerned, you were also asked to consider that; is that right?
A. Yes.
Q. Because the proposal, as I recollect it, in relation to the verification report, was not actually made by MTRC until the middle of May. So at what point did you look at the verification report or start looking at that?
A. When they have a draft, they sent it me to have a look. That's all. I did not participate in the report itself. They just sent it to me to have a look, every now then, when there's a draft.
Q. Does it come to this, Dr Lau: that you were sent copies of drafts of the holistic report and verification report, you had meetings with certain government officials?
A. Yes.
Q. You commented on certain aspects of those reports?
A. Yes.
Q. And whether those comments were taken on board or not

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you don't know?
A. I don't know.
Q. When you came to look at the final versions of the holistic report and the verification report, could you tell whether your observations and comments had been taken on board or not?
A. I don't think they took on board anything I said. I don't think so.
Q. All right.
A. No.
Q. We know the two reports, the holistic report and verification report, were produced on 18 July 2019. When you did you first see them in their final versions?
A. Oh, the final version were supplied to me when I actually have to write my expert report, the final version, but because I have different copies of these two reports, in the draft form, I hardly know which one was the final copy, the final version. There were so many copies. Every now and then, I was sent copies of -- they were not exactly the same.
Q. All right. We know, because they are in the files, that the final versions of both reports were produced and submitted to the Commission on 18 July 2019.
A. That I don't know, sorry.
Q. What I'm asking, what I'm trying to find out, is when

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you first saw the final versions of those reports.
A. I seriously looked at the final version when I had to prepare my expert report, actually, but before that, it was not serious. I was not appointed as an expert, so I did not do it very seriously.
CHAIRMAN: Were you appointed then as a form of adviser?
A. Before September, sir?
CHAIRMAN: Yes.
A. I don't know in what form. I don't even have a written contract with them.
CHAIRMAN: But if you are being paid and if you are being sent what appears to be a good number of copies of various drafts, that would suggest --
A. I think I have written them a letter and then they signed it back to me, saying that they want me to be sort of adviser -- I don't know whether it's adviser or what. They asked me to have a look at the report in the draft forms. That's all.
CHAIRMAN: All right.
A. At that time, I don't know what was my role, at that time.
CHAIRMAN: Sorry, I don't mean to sound facetious, but that would suggest to a cynical outsider that you were being paid for something you didn't know what you were doing, in the sense that -- obviously you knew what you were

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doing, you are an expert and you have great experience, it's not meant as an insult or a criticism in any way, but the government was saying, "We are just going to send you documents, we might ask for your assistance from time to time and we will pay you"; would that be right?
A. I think something like that, yes.
CHAIRMAN: All right. Thank you.
MR PENNICOTT: A rather loose arrangement, Dr Lau?
A. Sorry?
Q. A rather loose arrangement, it sounds?
A. I think it's a very loose arrangement. I think the actual appointment came in September when I have to act as an expert for the DoJ. That is a concrete appointment. But before that, I don't know what was my role.
Q. It doesn't sound typical of government, I am bound to say, in terms of loose arrangements so far as finance is concerned, for those of us who have experience.
A. I didn't know I have to attend this sort of Inquiry at all, at that time.
Q. Presumably, in or around September last year then, Dr Lau, you were officially engaged as the government's expert for the Commission?
A. Yes.

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Q. And that would have been on a much more formal basis, with exchange of letters and --
A. Oh, it's formal. It's formal after that.
Q. Okay. Once that had happened, there would have been a process, I assume, of the government providing you with documentation?
A. Yes.
Q. Was that DoJ or was it Highways, or who was your main point of contact in the provision of information?
A. Both departments, Highways and also DoJ.
Q. Did it go like this, that they supplied you with documentation and then you called for more information or more documentation if you thought you needed to see it?
A. I called for more information. In fact, I called for all the design calculations, the assessment report, the report on the suitable measures. I want to know more about the project. This is my -- I always do this. I want to know more about the project.
Q. Right. So it was a two-way process: they would provide you with information and documentation, but you would also ask for more documents as you thought --
A. I always ask for more. I always ask for more. I want to understand more about the project.
Q. All right. I've seen a list of documentation you say

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you reviewed in appendix JL1-B to your COI 1 report.
A. Yes.
Q. Does that provide a comprehensive list of the material that you had seen as at the date of the reports?
A. Yes, because I did ask for all this information so that I can understand the project.
Q. To what extent had you read the transcripts of the evidence of the Commission?
A. I only -- I read the transcript of the Commission on Prof Au because I was quite interested in the construction joint at the time. Because when I was first asked to assist the Highways Department, my main concern -- at that time our main concern was the construction joint, to see analysis by different companies, Mannings, Atkins, AECOM -- at that time, that was the main concern. I don't know why, but that was the main concern at that time, when I was first appointed by Highways, just to look at the construction joint.
Q. All right. So did you have occasion to look at any of the transcripts of any of the factual witnesses?
A. Very briefly. I did not go very deep into it. Very briefly. I did not put too much attention to that. I was more interested in what happened to Prof Au during the investigation.

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Q. So you focused on Prof Au's evidence?
A. Yes. I know very well about what happened to him.
Q. I see. All right. I may need to just show you one or two aspects of the factual evidence a little bit later.
Dr Lau, do you agree that the Hung Hom Extension structure has been subjected to a significant amount of post-construction surveys, investigations and opening-up?
A. I agree, yes.
Q. Would you agree that the extent and degree of those investigations is unusual, perhaps not unique, but unusual; there's been a lot of them?
A. I agree with you. Yes, I agree.
Q. And presumably you would also agree that certain aspects of the structures have been subjected to a series of sophisticated independent analyses by a number of well-qualified people?
A. I agree.
Q. Do you agree as a general proposition that the conclusions to be derived from those investigations and analyses establish a high level of confidence in terms of the overall safety of the structures?
A. I agree.
Q. Would you agree that none of the findings and conclusions have uncovered or exposed any fatal flaws in

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the construction of the extension?
A. In terms of stability, I don't think there's any fatal flaw.
Q. Could I then just touch briefly on a topic which I think -- it might be called risk profiling.
A. Okay.
Q. You agree, I think, that at the inception, design stage of a project, despite perhaps much investigation and research being carried out, there are still inherent and inevitable uncertainties about, for example, the appropriate loadings to take when you are designing a structure; there are uncertainties about that?
A. In what sense? Can you be more specific? In terms of dead load, I think it's quite certain. Live load is also very certain. What sort of thing are you talking about?
Q. Okay. Let's just change the topic slightly. In Hong Kong, as you and I well know from previous cases, the ground conditions may not be quite as you expect them to be.
A. I know that there were a bit of problem during the diaphragm wall construction, and this is the reason why they put in some capping beams, because they cannot reach rock level properly, because you don't have capping beams everywhere, only in certain locations you

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have capping beams, and that was caused by certain unforeseen ground conditions.
Q. Yes. That's the type of thing I had in mind, that there are, when you are a designing a structure such as the Hung Hom Extension, inherent uncertainties; you don't quite know 100 per cent what you are going to face?
A. I agree, I agree.
Q. Right.
A. But that's all, but not -- as far as dead load or live load, I don't think they are quite certain. But as far as uncertainty is concerned, I think the ground level, the rock level, there were a bit of problem. That's why they need certain ground -- capping beams to bridge over the diaphragm wall. This is also the reason why they have "miss" panels and "hit" panels in the diaphragm wall.
Q. Yes. Understood. Could I ask you then to just look at one paragraph in Dr Glover's report. That's ER2, tab 16, page 8, paragraph 5.5.
What Dr Glover says -- I assume you have read Dr Glover's report?
A. Yes.
Q. "In the inception and design stages of a project, much is unknown as to the actual future construction loadings and sequence, material strengths and geometric accuracy.

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For this reason, the international codes and standards contain partial safety factors. These factors include for the extremes of the variations in the applied loads and 'ignorance' factors -- 'ignorance' factors are intended to reflect the level of uncertainties in the assumptions made in the design and the sophistication of the analysis methods to be adopted, to mitigate these unknowns ..."
Then he gives an example of a British Standard.
Did you agree generally with those propositions, Dr Lau?
A. Actually, I don't quite agree with him in this sense, because so-called partial safety factors are meant for the design life of the building rather than the construction stage. I know there are certain problems during the construction stage, if we talk about that sort of problem, then I can agree. I don't know whether the Commission is aware of what we call the locking effect or not, because there are a lot of arguments about this point during the design stage. If you would like me to explain, then I can, otherwise we can skip this point.
Q. I think we can skip the point, Dr Lau. I just want us to stay on a relatively high level, if I may, at the moment.

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Can we scroll down a bit further, please.
Dr Glover also refers to the fact that that British Standard was the code on which the Hong Kong Concrete Code was based.
A. Yes.
Q. It is right, is it not, Dr Lau, that the codes and standards, both domestic and international, are there because they contain built-in safety factors when you are designing a structure?
A. Yes. These are the minimum factors we have to adhere to in the design, yes.
Q. So what these codes are there for is to mitigate the unknowns or the "ignorance" factors, as Dr Glover calls them?
A. Yes, he's talking about the short term; I'm talking about the long term. He's talking about the construction stage but I'm talking about the 120-year period.
Q. Right.
A. So we differ in this sense.
Q. Understood. And by their very nature these codes and standards are conservative in nature?
A. In terms of factor of safety, I don't think it is, but other things, it might. I don't know. But it's difficult to say whether they are conservative or not.

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Actually, if you follow all the rules in the code, then you can skip certain checks, for example. Take for example, if you follow all the detailed rules, then sometimes you don't have to check the crack width, provided you follow all the detailed rules. So, in a way, it helps the engineer in the design stage. It helps the engineers.

Q. Dr Glover goes on at 5.6 to say:

"In my opinion, the logical consequence of the substantial reduction in risk between inception and post-construction of a project is that the basis of assessment of the structure should recognise and take account of the fact that many of the safeguards and conservative assumptions included in the original design and construction no longer apply and should be relaxed."

Do you agree with that?

A. I have to disagree with him on this point.

Q. All right.

A. That means -- this is wrong. I'm sure it is wrong. Because the factors of safety are meant for the long intended design life of the building, in case of uncertainties in the change in load or accidental load on the structure, not for the short construction period; certainly it cannot be right. It can't be right.

CHAIRMAN: I may have misread what Dr Glover says but

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I didn't read it quite the same. Perhaps wrongly, and I don't want to put words into Dr Glover's mouth, but I think what he's saying effectively is there is a difference between the assumptions you make at the design stage and the actual knowledge that you now have upon completion of a construction.

A. Okay.

CHAIRMAN: He is not saying that that doesn't take into account the long-term durability issue.

A. He is talking about -- the factor of safety relates to the load and material; right? Only load and material. So, if you try to reduce the factor of safety in load or material, after the initial design, initial construction, then it must be wrong.

COMMISSIONER HANSFORD: I'm sure we are going to hear from Dr Glover on this point in the next day or so, so --

MR PENNICOTT: The reason of course I'm putting this to you, just in case nobody else does, is because I thought this was an area where you possibly disagree with Dr Glover, so I'm giving you an opportunity to say what you want to say and then Dr Glover can respond when he gives his evidence later today or tomorrow, I imagine.

A. Because you are talking about rock level, of course there are bound to be unforeseen conditions in the rock level, bound to be, but this has nothing to do with the

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partial safety factor, nothing to do with that.

Q. But all I understand him to be saying, as the chairman says, is that once, post-construction, you've got your building, you now know what you've got, and you now can use the knowledge that you have to analyse the safety and the fitness for purpose rather than having to go back and make all sorts of assumptions about -- derived from the codes and standards and so forth?

A. But you don't reduce the factor of safety.

Q. I don't think he's suggesting that.

CHAIRMAN: No.

A. He doesn't.

CHAIRMAN: Let me put it this way. My understanding -- Dr Glover is there, probably he is getting angrier by the moment, as he listens to us mutilate his sentences.

MR PENNICOTT: That was the idea.

CHAIRMAN: My understanding is he is really saying that the loading and material strength assumptions at the inception of a project will of course include durability factors for the life of the project, the life of the building. But you don't apply those, including the durability factors, once the project is surveyed and tested post-construction, and what you look at post-construction will obviously be different because you now have an opportunity to survey it, but will also

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include the durability factor. So the durability factor stays throughout.

A. I believe that he's talking about reducing the partial safety factor, after the completion of construction. Am I right? Because I seem to understand --

CHAIRMAN: No. I think he's just saying that certain assumptions you make at the beginning, which include perhaps extra loading, et cetera, you don't have to have those extra loadings necessarily once you have actual knowledge of the post-construction stage.

A. But if I look at the design -- I looked at the design load very carefully, there's not -- I don't think there's any load called "construction load" on the design. So where do you take this away? If we do not understand something, we put in an additional load called construction load, after finishing the construction, we can take away the construction load, then I can understand it. But if I look at the full load in the design, I look at the design very carefully, there was no such a load. That's why I do not understand what he means.

But I think I know what he means. I think I know what he means. Because what happened was this structure was constructed using top-down construction; right? After you finish the top-down construction, they go in

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to put in the column and the wall inside. Now, before you put in the column and the wall inside, the heavy slab already is deformed, and put in a lot of fixed-end moments at the diaphragm wall connection. Now, the point is when they use the dead load in the design, they put in 1.4, so if you put in 1.4 with the heavy dead load, there are a lot of bending moments, fixed-end moments at the ends. So there was an agreement between Atkins and also OAP that let us not use 1.4, let us use 1.26. In fact, that's what they used, because using 1.26 they reduce significantly the bending moment at the end.

But I think this is acceptable. For me, this is acceptable. I'm not questioning them at all. But if you are talking about taking away a construction load, there was no such construction load at all in the whole site.

CHAIRMAN: Obviously Dr Glover will be given an opportunity to explain.

A. But if you talk about the locking effect, then I agree with him; you can do that.

CHAIRMAN: Okay.

MR PENNICOTT: Dr Lau, if I can just then, before we have a cup of coffee, discuss with you the definition of "safe" and "fit for purpose".

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First of all, do you agree with this, that "safe" and "fitness for purpose" is achieved provided durability and consequential longevity are not compromised; would you agree with that as a proposition?

A. Agree. This is very important. Very important.

Q. That's the way that Prof McQuillan expresses it.

What about this: safety and fitness for purpose is achieved if, as constructed, the structure is capable of being used and functions, in this case as a station, safely and without physical restrictions on its operations and as anticipated by MTRC?

A. Agree.

Q. That's the way that Dr Glover puts it.

You, however, say that the structure is only safe and fit for purpose when it is able to meet certain criteria during its intended working life?

A. I think they are the same. He's talking about longevity. Are we talking about the same? I think they are the same. We are talking about the same thing.

Q. Okay. If you are, that will be of great benefit.

So far as safety is concerned, as we've seen in your slides, you identify four primary factors: stability --

A. Yes.

Q. -- rupture of section --

A. Yes.

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Q. -- robustness --

A. Yes.

Q. -- and ductility?

A. Yes.

Q. As I understand your report and your position, Dr Lau, you have no problems, no concerns regarding stability, robustness or ductility; is that correct?

A. Now, no, because I think now they are using ductility couplers -- because ductility is very important in this structure, because we are talking about moment redistribution over 30 per cent. We need ductility in a structure to do that, very important.

Q. But, as I understand it, you have not referred to anything in your reports where you express concern about ductility; am I right?

A. I'm not concerned but I mention in my report that ductility is very important.

Q. I know. I'm sure it may be and --

A. I think there is ductility in the structure, definitely, in this structure.

Q. As I understand it, your primary concern is rupture of section?

A. Yes.

Q. That item.

A. Yes.

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Q. Because you say that there is a risk -- and this is a point you made right at the end of your presentation -- of localised overstressing of individual structural elements.

A. Yes.

Q. And your view is, if I've understood this correctly -- could we look at paragraph 44 of your report, please. That's the COI 1 report.

A. Yes.

Q. You say, under the heading, "The updated design by MTR":

"I have been provided with the updated design calculations carried out by MTR. I believe that the other experts also are in possession of these calculations. My report relies on this set of calculations. From the updated design calculations, it is clear that the as-constructed structure has no structural stability problem."

So that's why I tick the "stability" box.

A. Yes.

Q. "The only concern", you say, "is the overstressing of local areas in the structure."

A. Yes.

Q. That's as I understand your position. However, and we will perhaps discuss this a little bit more later, I think you do agree, despite having said that, that so

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far as the top of the EWL slab and the top of the east diaphragm wall is concerned, there is no evidence of overstressing?
A. Can you repeat your question? Is it shown here in my report or what?
Q. No.
A. Okay.
Q. You say:
"The only concern is the overstressing of local areas in the structure."
A. Yes.
Q. What I was suggesting to you is there is no overstressing at the top of the EWL slab and the top of the east diaphragm wall. That is correct, is it not?
A. Actually, there were overstressing, otherwise there's no need for redistribution. There was, because of overstressing, that's why the consultant recommended a 30 per cent redistribution of moment from the fixed end to the mid-span of the structure.
Q. The work to the construction joint at the top of the EWL slab and top of the east diaphragm wall is not being carried out because of overstressing, is it, the dowel bars? That's not to do with overstressing; that's to do with workmanship problems.
A. Okay. I understand what you are talking about. After

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all the analysis we agree that there is no more structural problem, it's a workmanship problem. I'm sorry, because I didn't catch what you said. I'm sorry about that.
Q. It's probably my fault, but anyway, so far as -- you refer to overstressing in local areas, but at the top of the east diaphragm wall and the EWL slab, that's not to do with overstressing, that's to do with workmanship?
A. Workmanship. Okay.
Q. All right.
A. Because actually your question is not too specific. Can I tell you what I understand? If I'm wrong, then you correct me.
Q. Yes. Please do.
A. In the original design, after discovery of all these defects, Atkins carried out an analysis. They found that the joint, the fixed-end moment, there were overstressing, so they carried out a 30 per cent redistribution, to redistribute the bending moment to the mid-span, and for that, because of that, they reduced the utilisation factor at the joint. So there were overstressing initially, but after the updated design there were no more -- no more. So, if we go this sort of step, then I can agree with you.
COMMISSIONER HANSFORD: Presumably you are saying: so

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theoretically there was overstressing?
A. Yes, okay, you can say that.
COMMISSIONER HANSFORD: Because they then redistributed. I mean, that's a theoretical concept, isn't it?
A. It is allowed -- but it is also real, it's not just theoretical. If you don't allow redistribution --
COMMISSIONER HANSFORD: The redistribution is real, but the overstressing you referred to is theoretical?
A. After the redistribution, there's no more overstressing, yes.
COMMISSIONER HANSFORD: Right.
A. But then the structure's got to be ductile, otherwise you cannot do the redistribution.
COMMISSIONER HANSFORD: Yes. I see what you are saying.
MR PENNICOTT: Just to finish on this point, could you just look at paragraph 67 of your report, please.
A. Yes.
Q. Probably we ought to find out where we are. Could you scroll up, please, just to find out what heading we are under. You are talking about the construction joint at this section of your report, Dr Lau; do you see that?
A. Yes, okay, because -- okay. Let's -- okay.
Q. Then if you go to paragraph 67, you say:
"Without the L-shaped rebars, tensile forces in the fixed moment joint had to be transferred through

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concrete. It is not desirable to rely on concrete to take tensile force. MTR's consultants then carried out analyses of the joint in question based on the updated design."
This is the point you are making.
A. Yes.
Q. "It is now found that the concrete at the construction joints is not overstressed under the updated design despite the lack of L-shaped vertical reinforcements at the top of the diaphragm wall. It is probably due to the fact that the internal stresses generated under the updated design are lower than those under the original design."
And so forth.
A. Agree.
MR PENNICOTT: Sir, would that be a convenient moment?
CHAIRMAN: Certainly. 15 minutes.
(11.38 am)
(The luncheon adjournment)
(11.59 am)
MR PENNICOTT: Dr Lau, good morning again.
Dr Lau, can we just focus for a few minutes on rupture of sections --
A. Yes.
Q. -- which is of primary concern. There are, as

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I understand it, two essential causes of localised overstressing, concerning the coupler assemblies and the shear links.
A. Yes.
Q. Those are the two primary drivers or causes of local overstressing, as you see it?
A. Agree.
Q. So far as the defective coupler connections are concerned, what that has led to in terms of suitable measures is a strengthening of the connections between the capping beam and the EWL slab at area A?
A. Yes.
Q. So despite -- and I think you made this point at the end of your presentation, quite helpfully -- all that has been said about the coupler connections and the coupler assemblies, no suitable measures, in relation to coupler assemblies specifically, are required in the HKC, area B and area C?
A. Agree.
Q. Even then, so far as the suitable measures in area A are concerned, they are just in three specific locations; is that right?
A. About 15 panels, yes.
Q. And so far as the SAT area is concerned, in one location?

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A. In one -- no, shear link.
Q. You think that's just to do with the shear links?
A. Shear links, not couplers.
Q. Okay. Just shear links?
A. Just shear links.
Q. Can we just look at a diagram or plan, drawing: OU9/11375.
Dr Lau, I'm not sure whether you would be aware, but every week over the last few months MTRC have been updating the Commission as to the progress of the suitable measures.
A. Okay.
Q. This is the cover sheet -- you can look at it on the screen -- it's probably going to be easier on the screen at the moment -- this is the cover sheet for the status as of Christmas Day, 25 December.
A. Okay.
Q. Have you been looking at these documents?
A. I think I have read a few of them, yes. I think I have read the latest one.
Q. There is one later than this --
A. I read the latest one.
Q. -- which I think might have just gone into the bundle, but for my purposes it doesn't matter.
Can we then go on to page 11382, please. We can see

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there area A?
A. Yes.
Q. The reason I suggested it was three areas -- two yellow and one green; do you see that?
A. Yes.
Q. And you think that's about 15 panels?
A. About 15 panels. Actually, I counted myself. It's exactly 15, yes.
Q. All right. Then, as far as the SAT is concerned, to do with shear links rather than coupler assemblies, we've got a few panels down here in the SAT area as well?
A. Yes.
Q. Okay. Of course also we know, so far as area A is concerned, that the work is being done not on the basis of any extensive opening-up in area A but by way of extrapolation --
A. Sure.
Q. -- from the opening-up that's been done in HKC, area B and area C?
A. Agree, yes.
Q. So far as the shear links are concerned, we've identified the area in the SAT, and as I understand it in areas B and C there are also some localised areas. If we look at, please -- it could be the previous page or it could be the next page -- that's the HHS, we don't

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need to worry about that for the moment. One back, please. That's the construction joint. Then one back, please. Right. Okay, here.
I think you mentioned a figure of 1 per cent in your presentation just a moment ago?
A. Yes. It used to be 2.5 per cent, used to be, but now, after they sharpen the pencil, they look at the design -- in fact, they also incorporate some of the comments from actually Mr Southward. They allow for the actual reinforcement area, so now it's tightened up. At the moment, it's about 1 per cent. It may still reduce.
Q. It may be that people with better eyesight than me can identify the areas -- is it possible to identify the areas on here?
A. I can't.
Q. I can't either.
A. My eyesight is bad as yours.
CHAIRMAN: Is it possible to do what?
MR PENNICOTT: To actually identify where the areas are on here.
CHAIRMAN: Yes, I can.
MR PENNICOTT: There's some colour in certain places, towards the left-hand end in area A, but for example -- yes, if we blow up area B, if we go along there, there's a green area there, with the hand. These are the items

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we are looking for it, is it?
A. Yes. I think they are normally coloured.
Q. But those green ones will be the construction joints, though, won't they?
A. I think these are construction joints. The construction joints, I think there are 23. I counted them.
Q. Yes, there are 23.
A. 23, yes.
Q. All right. I was going to ask you: in paragraph 70 of your report, you refer to 2.5 per cent area --
A. At the time.
Q. -- but you now -- it's gone down to 1 per cent?
A. Yes.
Q. All right.
A. I think it is what we call engineering judgment. We exercise engineering judgment. I think it's a good point, yes.
Q. You've not been involved in any of these decisions about suitable measures?
A. No, I'm just an observer, but I did check the calculations. I'm just an observer. I was not involved at all.
Q. All right.
Now, so far as fitness for purpose is concerned, could we please go back to your report at paragraph 39.

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The factors that you consider to be relevant to fitness for purpose you list out in paragraph 39.
A. Yes.
Q. So, at (a), durability -- if we could scroll down, please -- deformation --
A. Yes.
Q. -- fire resistance, cracking, vibration and fatigue?
A. Yes.
Q. It we go to the next page, please, you also bring back in seismic design under this fitness for purpose as well?
A. Yes.
Q. Can I ask you this, Dr Lau: do any of those seven factors add anything to what we've just been discussing under the general heading of rupture of section?
A. Durability, for example. I think we need to consider durability. Crack width. I think we need to consider these two points in the long term. I'm not talking about at the moment. At the moment, we just check the rupture of section, but we need to consider durability, crack width, et cetera, in the long term.
Q. Are you satisfied that the suitable measures that we've just been discussing or some of the ones we have just been discussing are going to address all these fitness for purpose factors that you've mentioned?

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A. Yes. They reduce the stress level; the main point is. This is very important, reduce the stress level so we can improve the durability and improve the crack width.
Q. I should have said, perhaps, the two factors that you emphasise in paragraph 42 of your report are durability and cracking?
A. Yes.
Q. Okay. Could we then look at a few points on the coupler connections.
A. Yes.
Q. As we've discussed already, this is the first topic relating to safety and fitness for purpose.
A. Yes.
Q. What happened was that a comprehensive coupler testing programme was carried out together with opening-up work, and do you accept that the programme -- and I assume you've looked at the results of the testing programme --
A. Yes.
Q. -- provides a basis to establish an acceptance criteria for the safety of the coupler connections?
A. Exactly what do you -- well, I know that there were tests on the couplers.
Q. Yes.
A. In particular, partially engaged couplers. I know that. I knew that. And I knew the result as well. So exactly

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what you want me to respond to your question, exactly?
Q. The two primary factors in the coupler testing programme were an engagement length of at least 37 millimetres --
A. Yes.
Q. -- and no more than two threads showing.
A. Yes.
Q. You are aware of that. And that was established through this testing programme as the acceptance criteria; do you agree?
A. Oh, I see. You are talking about the PAUT test?
Q. Yes.
A. Okay. Okay.
Q. Those acceptance criteria, the 37 millimetres and the two threads showing, did you have any involvement at all --
A. No.
Q. -- in the drawing up of those criteria?
A. No. I'm just an observer. I have no involvement at all.
Q. When you saw the draft holistic report in particular in May last year, as you told us this morning, were you asked to comment on the coupler testing criteria?
A. No, not at all.
Q. Do you have a view now about the efficacy of that testing criteria, the 37 millimetres and the two threads

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showing? Do you agree with it?
A. I have no particular view. This is a method done by the MTR. I have no particular view on that, no.
Q. One of the issues between yourself and the other experts is whether a partially engaged coupler connection should, if at all, be regarded as safe and fit for purpose; do you agree?
A. Yes.
Q. To your way of thinking, is a threaded rebar engaged to the extent of 37 millimetres into a coupler fully or partially engaged?
A. There are two issues here. The first one is we want the couplers to be butt-to-butt; right? This is the most important point. Now, according to the PAUT test, that's the only acceptance level we can have. If you don't accept this acceptance level, I don't know what sort of level we can accept.
Q. Is, to your way of thinking, Dr Lau, a threaded rebar engaged to the extent of 37 millimetres into a coupler fully or partially engaged? Please answer my question.
A. If using the PAUT, according to the test, it's supposed to be fully engaged. You know, this is the acceptance criteria. Whether it's correct or not, I can't comment on that. This is something I did not participate in. This is the test.

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Now, if you do not accept this criteria, there could be more defective couplers.
Q. Quite.
A. It could be.
Q. The reality is, Dr Lau -- we'll look at it in a moment -- if a threaded rebar has an engagement length of 37 millimetres, there's no way of telling whether it's butt-to-butt or not, is there?
A. Now, this is the failure criteria rather -- if you ask me, I would look at it as a failure criteria rather than an acceptance criteria. If you have -- in the PAUT test, if you've got 37 millimetres with a 3 millimetre tolerance, and the exposed thread is two, then it's supposed to be butt-to-butt. So I look at it as a failure criteria. I wouldn't look at it as an acceptance criteria.
COMMISSIONER HANSFORD: What's the difference?
A. Because otherwise there would be more defective couplers, in reality; am I right? Because if you are right, there would be more defective couplers. There's no end.
COMMISSIONER HANSFORD: I understand what you are saying, Dr Lau, but something that is -- if something hasn't failed, presumably it's accepted; is that right?
A. Take, for example, if you look at the appendix for the

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test, I looked at it very carefully. I try to identify what happened. If it is more than 37, according to the PAUT test, they accept it. If there are two threads -- more than two threads outside, they reject it. So this is the only way to test whether a coupler is acceptable or not.
MR PENNICOTT: Yes. But the point is, Dr Lau, they are not testing whether they are butt-to-butt. They can't be. On your analysis, they cannot be, can they?
A. Now, but the thing is --
Q. Am I right?
A. Let me put it this way. If I look at all the tests, quite often there are more than 37. In fact, in all the tests, in the appendix, quite often there are more than 37, and of course they were accepted, and if they were less than 37 they were rejected; right? And if there are two threads exposed, more than two threads exposed, they were also rejected. So this is the criteria to see whether certain couplers is accepted or not. Now, whether it is right or not, I cannot make any major comment, but this is the test accepted by all the parties at the time.
Q. Yes.
A. But if you ask me, if you do not accept this type of criteria, there could be even more defective couplers.

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Q. Could I ask you, please, to be shown one of your slides, and could we please look at 24.
A. Yes.
Q. If we look at the top diagram first --
A. Yes.
Q. -- Dr Lau -- actually, no. Let's look at the bottom one first, the 48 millimetre. So this is assuming, the bottom diagram, that the thread on both pieces of rebar is 48 millimetres.
A. Yes.
Q. If I've understood this correctly, Dr Lau, what you are assuming is on the left-hand side, the 48 is, as it were, fully engaged to all 48?
A. Yes.
Q. So there's nothing showing on the left-hand side. If that's the position, then because we know the coupler is 88 millimetres long, of necessity there will be two threads showing, 8 millimetres, on the right-hand side?
A. Yes.
Q. In your report -- we don't need to look at it -- you refer to the fact that you were given seven couplers, and I imagine some pieces of threaded rebar.
A. Yes.
Q. Did you measure -- who gave you those samples?
A. I asked Highways Department to send me all these

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couplers so that I can fit around. I want to understand all this concept about -- I just want to test it. In particular, what I want to do is I want to test whether, if it is not fully butt-to-butt, what will happen.
Q. Did you measure the total length of the thread on any of those seven that you were given?
A. Yes. Yes.
Q. What was the answer?
A. They vary from 44 to 48.
Q. Right. How many 48s were there?
A. Maybe one or two.
Q. So, going back to your diagrams, the next one up, you illustrate a position where you've got a 44 millimetre piece of rebar on the left-hand side, as it were --
A. Yes.
Q. -- and 48 on the other, and that would give you one thread showing, in that situation?
A. Yes.
Q. Then, perhaps the more interesting one, you've got the 44 millimetre coupler on the left-hand side fully engaged?
A. Yes.
Q. And you are assuming this time that the 44 millimetre on the right-hand side was also fully engaged?
A. Yes.

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Q. So, going back to the question I asked you just now, if that coupler on the right-hand side was only engaged up to 37 millimetres, it could not, by definition, be butt-to-butt, could it?
A. Agree.
Q. And so, going back to the acceptance criteria, 37 millimetres and two threads, you simply do not know and cannot be sure whether or not butt-to-butt has been achieved?
A. Based on that particular test limitation, yes. Based on the test limitation, that's all that we can do, based on the PAUT test. But if we do not accept that as acceptance criteria, then the point is there would be even more defective couplers.
Q. Yes.
And so if we could look at appendix B3 to the holistic report, please, so that's OU3309 in OU5. There are several sheets, Dr Lau. I expect you have looked at these.
A. I have looked at these quite a number of times.
Q. All right. We can take a number of these by way of example. Let's scroll down to the next page and take item 29, towards the foot of the page.
So what we have here --
A. Yes.

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Q. -- Dr Lau, is a position where the enhanced PAUT engagement length is 39.9 millimetres?
A. Yes.
Q. And the number of exposed threads is zero?
A. Yes.
Q. One simply wouldn't know whether that is a butt-to-butt joint or not?
A. If we do not accept that, that would be -- because you accept this as acceptable.
Q. Yes.
A. This is the problem. If we do not have this sort of criteria, we don't know how to accept it. There would be a lot of defective couplers. So we have to draw a line, because below the limitation of the PAUT test there would be a 3 millimetre tolerance, and that's --
Q. So that could go either way.
A. Well, in fact I look at this and give this a lot of thought myself, because if we do not accept this, simply that there are too many defective couplers, so we need to draw a line, and this line, I can accept that, because --
Q. There would only be too many defective couplers is your starting point is they've got to be butt-to-butt?
A. But at the same time, I do have a lot -- I do have seven couplers in my office. I tested so many times. If they

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are not butt-to-butt, it would be slack, and I do not want this slack coupler in the structure. Because even at very low stress level, the structure starts to crack, the concrete starts to crack, this is bad. As an engineer, I cannot accept that.
Q. Dr Lau, you are aware, and I'm not going to dwell on all those results, but there are very, very few bars of 48 millimetres, they are the exception rather than the rule. There are quite a number at 44 or thereabouts millimetres. As we've just seen, there are quite a lot less than 44 millimetres. There's clearly no silence, absolute silence, in the production of these threads, the threaded rebars, is there?
A. I think they are all over 44 millimetres. That's how I understand. It's between 44 to 48. I don't think any -- well, if it's less than 44 millimetres, there would be a problem, and I think the whole idea by the manufacturer is that they make sure that it is more than 44, up to 48.
Q. How can that be the case, Dr Lau? The one I've just showed you was engaged to 39.9 with no exposed threads.
A. But this is a PAUT result. This is not the true result.
Q. Right.
A. I think we have to be very careful. This is the PAUT result. We don't know exactly what happened inside.

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Of course, we do not know. But the PAUT has a tolerance of 3 millimetres, so we've got to draw a line in the acceptance criteria of the PAUT result, and if we do not accept that, there would be a lot of unacceptable couplers.

Q. All right. You are aware that the other three experts are all agreed that if there's a minimum engagement length of about seven threads or 32 millimetres, the coupler connection should be regarded as having sufficient strength to pass all the necessary strength tests?

A. Strength tests, yes.

Q. Do you agree?

A. But not fit for purpose. When we talk about fitness for purpose, we talk about elongation as well. The two have to go together.

Q. Let's taken it in stages. The other three experts agree that if there's a minimum engagement of seven threads/32 millimetres, the coupler connection will have sufficient strength to pass all the strength tests. Do you agree with that as a proposition?

A. For the -- this is the case, as far as the test is concerned. There were 54 tests so far. I accept that this is the case.

Q. Right. And that opinion is derived by the other experts

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on the basis of the partial engagement test that has been carried out by MTR?

A. I know, yes.

Q. So you agree that if you are only looking at strength, they are right?

A. Yes.

Q. However, as I understand it, your point is they won't pass the elongation test?

A. Agree.

Q. So your main concern is not strength at all but rather the consequences of the failure to pass the elongation tests?

A. Agree, yes, because the two things have to go together, strength and fit for purpose.

Q. If you look at paragraphs 94 and 95 of your report -- I think this is --

CHAIRMAN: Sorry, could you help me, Mr Pennicott. The answer given by Dr Lau was:

"Agree, yes, because the two things have to go together, strength and fit for purpose."

MR PENNICOTT: Yes.

CHAIRMAN: Strength I obviously understand. I'm not quite sure how that fits in with fit for purpose. Do you see the points I make?

MR PENNICOTT: That's where I'm about to go. We might get

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an explanation; we might not. I don't know.

CHAIRMAN: Thank you very much.

MR PENNICOTT: This is part of your report, Dr Lau, where you are discussing various aspects of Mr Southward's report.

A. Yes.

Q. You refer at paragraph 94 to elongation tests, and then you say:

"My comment: This is the main concern of MTR." I think it's your main concern as well.

A. Yes.

Q. Because that's what you say. Then you say:

"Failure to meet this requirement [the elongation test] has implication on ductility, crack width, durability and deformation which are parts of the requirements in respect of 'fitness for purpose' including safety."

Do you see that?

A. Yes.

Q. So, as I understand it, you say that if the coupler assemblies, the coupler connections, are incapable of passing the elongation tests, then it gives rise to a risk of crack width, durability and deformation?

A. Yes.

Q. And that's your point. Okay.

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You are aware, presumably, that the completed structures at the COI -- that we're concerned with in COI 1 and COI 2 have been completed for a number of years now?

A. I know. About two years, yes.

Q. I think a bit longer than that, actually, for some of them. Have you seen any evidence on any of your visits or have you seen any photographs, any other evidence, that there are such cracks?

A. If there are cracks, they will be inside the concrete, yes, because --

Q. You have seen no external evidence of any such cracks?

A. I have not inspected the structure myself anyway. I assume that there is no such crack appearing at the moment, because they all appear in the joint; right? And I mentioned that looking at the finite element analysis provided by all the consultants, there would be cracks -- even without this sort of elongation in the couplers, assuming that the reinforcement is all perfect, there are still cracks on the top of the diaphragm wall and on the soil side of the diaphragm wall. Assuming there's no problem with the reinforcement, there are still cracks on the outside, and you can't see them because they are on the soil side of the diaphragm wall and on the top of the diaphragm

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wall.
If we have this sort of partially engaged coupler used in the assessment, there would be even more cracks in the structure. I tell you, cracks, once you have cracks, you cannot recover. They only accumulate. They can only accumulate, they cannot recover. So, with the passage of time, there will be even more cracks in the future. This is what I worry about for durability.
Q. You are worried about -- you are speculating, Dr Lau.
A. I'm not speculating.
Q. You are speculating.
A. No, I'm not speculating.
Q. You haven't seen any evidence of any cracks at all.
A. I tell you, my speciality in my research is crack propagation in strain-softened material which is concrete and rock, and I've done so much analysis on this sort of material in the laboratory and under the computer. I know what will happen, you know, according to my theory, I know what will happen.
Q. Do you agree with this, that the highest loading of the structures was actually during the construction stage rather than the permanent stage?
A. Why? I disagree.
Q. The answer to your question is that in the permanent stage there is intermediate support for a lot of these

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structures, whereas during the course of construction they were not? And I think all the other experts agree and have agreed in the past that the highest loading was during the construction stage, not in the permanent stage. Do you agree or disagree?
A. I disagree because in the updated design, they analyse the structure as it is now -- as it is now -- and according to Atkins, we still require the suitable measures, as it is now. We take account all the moment redistribution, we take in account the 1.26 partial safety factor, which should be 1.4. Despite all this, Atkins still found that we need suitable measures.
Q. What suitable measures do you say are addressing the particular problem of the failure to pass the elongation tests?
A. To reduce the stress level in the joint. That's what they are doing at the moment. To lower the stress level in the joint.
Q. Can you point to anything specific that is being done by way of suitable measures to address the failure to pass elongation tests?
A. They are increasing the thickness of the slab locally. They increase the thickness of the slab locally, to reduce the stress inside the joint. That's what we are doing. That's what Atkins is doing at the moment.

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Q. But that's all to do with calculations based on the failures, not anything to do with elongation tests at all.
A. No, no, no. They try to reduce the stress level in the joint so that the elongation would be smaller. So I do not agree with you.
Q. All right.
CHAIRMAN: So, Doctor, it would be your position that if there is no butt-to-butt connection in the coupler, then that assembly is going to fail an elongation test?
A. Elongation test, yes.
CHAIRMAN: Okay. And that failure will give rise to a real risk of the various matters to which you have already referred?
A. It gives rise to at least cracks in the concrete, because the amount of elongation is large. Actually, it's large. Because concrete will crack even at very, very small strain. Very small strain. At the moment, we are talking about 0.24 up to 0.25 millimetres just on one particular coupler. This is going to crack the contract.
CHAIRMAN: Again, returning to -- I don't know if you were the witness last week, when I referred to what I might call straightforward, simple language given to the workers, just like in the military, you know, you give

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straightforward directions to your soldiers and so you do here to workmen who are not as qualified as you would be, for example.
I don't recall anything where there's any emphasis placed by anybody in a position to do so on the real importance of ensuring butt-to-butt connection, because otherwise there will be a failure of the assembly to meet an elongation requirement, and that will render the area of the assembly unsafe for various reasons you've given. It seems to me to be quite important, you know. It's a bit like saying, you know, to a soldier, when you've still got a bullet up the barrel of your gun, don't drop the gun on the floor; you are likely to shoot someone by mistake. This is the same sort of thing, is it not? You've got to be really careful here because if you have a number of failures to ensure butt-to-butt connection, then you are rendering each assembly of no benefit at all and in fact you are endangering the entire structure.
A. In the long term, yes.
CHAIRMAN: Well, in the long term -- in 40 years or 60/70 years you might get bad cracking --
A. Yes. That's what --
CHAIRMAN: -- a requirement for urgent repairs, et cetera.
A. Actually, this 0.1 millimetre permanent elongation very

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strict by government. If a coupler fails this particular requirement, they wouldn't allow you to use it. This is very important.
CHAIRMAN: Again, you will have to help me, because my understanding was that that testing, the elongation test, was done on the coupler prior to its sale, if I can put it that way. In other words, you have to go to government and say, "Here's what we intend to supply." They check it for elongation and all the other tests and they say, "That's fine." What you are saying is that that unit which has already passed that test, unless it's assembled butt-to-butt, you've still got a failure of elongation?
A. Yes. The whole idea that we want the 0.1 millimetre limitation was to stop all these cracks forming in the concrete. Now, as far as the site is concerned, it's up to the individual contractor as to how to enforce the assembly, to make sure there is no permanent elongation.
CHAIRMAN: All right. And can you tell me: how is that done on a simple, straightforward manner where you've got workmen doing an awful lot of these in conditions where the light is not necessarily that good, where it's dusty, where the units are dirty? How do you ensure that in a clear and definitive manner?
A. Because in Hong Kong there is what we call the quality

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supervision plan, and these sort of couplers are supposed to be inspected by the technically competent person. It's specified in the approved plan in Hong Kong.
CHAIRMAN: All right. But how does -- because what I remember is things like the PAUT test, we were suddenly having to come up with a lot of high technology to judge whether it was butt-to-butt inside, and I can't imagine people walking around with a sort of back-loaded PAUT test which they kind of use on each individual one, so it has to be something more simple, does it not?
A. That's why BOSA have a drawing or the picture showing that the maximum threads exposed is 2 millimetres. And you are supposed to look at that particular -- remember there are four couplers with zero threads exposed, one, and then eventually there are two threads --
CHAIRMAN: All right.
A. -- and the technically competent person has to check the couplers installed against that particular picture.
CHAIRMAN: Okay. I understand that. But have you found any document, in looking through BOSA's or MTR's or Leighton's documentation, that in clear, unambiguous terms, makes quite clear to a dodo like myself, and I would be a dodo down there, what has to be done in ensuring butt-to-butt? Because the document you've

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shown me is far more subtle than that. I'm talking about something where you can say to the workmen, "There it is, now all of you, it doesn't matter what your level of education, you can see quite clearly what is absolutely required."
A. I do not know what happened on this site, but in other sites there were proper training by people like BOSA to the workers.
CHAIRMAN: Okay.
A. I don't know what happened on this site.
CHAIRMAN: So the answer is you haven't seen any actual document like that?
A. I haven't seen any, but in theory the BOSA people will train the workers on site to ensure that it is butt-to-butt, because it's a very important point.
CHAIRMAN: All right. Then also, on your basis, the inspectors and engineers who were responsible for checking these things, of the MTR and of Leighton, they would have known or should have known --
A. They should.
CHAIRMAN: -- as qualified persons that there was a critical matter that they had to ensure in each and every respect of each and every assembly of couplers, namely butt-to-butt?
A. Actually, there's a quality supervision plan issued by

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Leighton or the MTR to BD, telling BD what they are going to inspect. The same thing happens to every other site in Hong Kong.
CHAIRMAN: I appreciate that. It doesn't quite answer my question.
A. Okay.
CHAIRMAN: Because I'm a layperson and I'm speaking to you as an expert. As a layperson I'm saying have you got -- would it be correct to say that each qualified person responsible for inspection would have known that there was one central critical issue to ensure, and namely that was butt-to-butt assembly?
A. They should. They should. I don't know what happened on this site, but they should.
CHAIRMAN: Okay. Thank you.
MR PENNICOTT: Could we please see slide 23 of Dr Lau's presentation, please. That's the one before this one. It's the one immediately above it. I don't know whether it is possible to get two slides on the screen, this one and the next one.
Dr Lau, on the left-hand side --
A. Yes.
Q. -- we have a document generated by BOSA?
A. Yes.
Q. It is headed, in large letters, "BOSA acceptable thread

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tolerance"; do you see that?
A. Yes.
Q. In the summary it says:
"After connection has been fully tightened, one should see a maximum of TWO FULL THREADS ...", in capital letters; do you see that?
A. Yes.
Q. "... to ensure a proper installation."
A. Yes.
Q. And thinking about the installation process, we have the diaphragm wall and the couplers have been installed into the end of the rebar in the diaphragm wall and they are essentially sticking out after they have been jet-sprayed, and Leighton's sub-contractor is coming along to put his threaded rebar into the couplers; yes?
A. Yes.
Q. And two or three guys, a 6 metre long piece of rebar with a 44 millimetre thread on the end?
A. Yes.
Q. And they start screwing the rebar into the coupler. They get so far and they've got four threads showing, but they can't go any further. What do they do? Answer, presumably: unscrew it.
A. Unscrew, yes.
Q. Take it out, clean up the thread perhaps, have a look

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inside the coupler to make sure it's all clean. Right. Having done that, have another go. This time they screw in and they get to a situation where it's fully tightened but there are two threads showing. That's perfectly acceptable, according to BOSA, and by definition cannot be butt-to-butt. Do you agree?
A. If it is 44, there should be no thread showing. It's only when it is 48.
Q. But you are allowed to have two threads showing, provided it's fully tightened. That's what it says.
A. This is -- actually, you know --
Q. We can't go any further.
A. -- this particular drawing, what they are saying is if you have 44, there should be no thread showing, but there's --
Q. Where do they say that? Where do they say that?
A. Anyway --
Q. Where do they say it?
A. Anyway --
Q. It doesn't say that, with respect.
A. Okay, okay. I don't know what BOSA is going to teach or train the workers. If they train the workers, they should tell them what to do. I don't know what. I'm not on site. I have no evidence about all this. But anyway, the whole idea is that if it is 48 millimetres,

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there would be two threads showing. This is what it shows on this particular picture. And it's the duty of BOSA to go and train the workers on what to do.
CHAIRMAN: All right. We appreciate your point. I think the point you are making, Doctor -- and thank you very much, it's been of assistance -- is that however you may read this particular document and any other documents, your understanding, both as an expert and as a contractor, is that it must be butt-to-butt?
A. Yes.
CHAIRMAN: And if it's not butt-to-butt, the risks which you have already described will be present?
A. Yes. That's all that I can say.
CHAIRMAN: Yes, and you cannot say what BOSA may or may not have done.
A. I can't. I'm not the BOSA man. I'm not the manufacturer. I don't know how they train the people.
CHAIRMAN: All right.
A. But BOSA said it's got to be butt-to-butt and in fact all the tests show that if it is not butt-to-butt, there will be permanent elongation. This is something I don't want, I don't like. That's all. That's all I can say as an expert.
CHAIRMAN: Thank you very much.
MR PENNICOTT: Sir, a very last point on this.

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CHAIRMAN: Yes.
MR PENNICOTT: Can we look at the transcript for Day 36 of the Original Inquiry. I think it's page 82.
A. Can you make it bigger?
Q. We will, don't worry.
Sorry, I should have said this is during the cross-examination of Mr Paulino Lim from BOSA.
A. Okay.
Q. Prof Hansford will see he asked the question at the top of the page:
"I'll ask it at this point rather than later: and how important is it for them to be butt-to-butt? What does that do?"
Then the answer was this:
"When you are -- if you -- because some of -- the requirement for a type 1 coupler is you -- there's two testing required."
I'm not sure what all that meant.
"The first one is an elongation test, where the sample is loaded to 0.6 FY, and in between you've got a gauge that actually checks to see how much of the rebar, once the stress has been released, how much movement is within that connection, and if it exceeds 0.1mm then it's deemed as a failed sample. Butt-to-butt ensures that you actually would not have a problem.

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Commissioner Hansford: I see. Thank you."
That's your understanding, is it, Dr Lau, of where this butt-to-butt requirement comes from; is that right?
A. And also from their literature.
Q. Right.
A. Their literature also required butt-to-butt.
Q. Could we scroll down a bit, please.
A. Actually, I did not read this transcript.
Q. You haven't read this before? Okay. Can we scroll down a bit more, please; I'm not sure where it is. Keep going. Sorry, can we go back up again, up above where we were just now. Keep going up. Up further, please. Scroll down a bit, please.
Sorry, sir, there is a piece of the transcript where you were asking Paulino Lim what happens when it was fully tightened, and the answer was, "It is assumed to be butt-to-butt", and I was trying to find that and I can't.
COMMISSIONER HANSFORD: Is that the extract we were looking at on Friday --
MR PENNICOTT: I think it was.
COMMISSIONER HANSFORD: -- that I think comes before this.
MR PENNICOTT: It's around there somewhere but I can't find it.
COMMISSIONER HANSFORD: It comes before this, I think.

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MR PENNICOTT: There it is. Thank you very much. "And when one or two threads are exposed" -- do you see that, Dr Lau?
A. Yes.
Q. -- "am I right in saying it's therefore butt-to-butt?"
Then the answer from the witness was:
"It is assumed to be butt-to-butt", and then and so forth and so on.
The point being, once it is fully tightened, even if you have threads showing, it is assumed to be butt-to-butt?
A. Okay. I tried myself many times. Actually if you tighten it even by hand, you can't have any slip in the assembly. Of course I'm talking about by hand.
Q. All right.
COMMISSIONER HANSFORD: Sorry, can I just be clear?
A. Sure.
COMMISSIONER HANSFORD: Were you referring then to threads that were 48 millimetres long?
A. If it is 48 millimetres long -- because one end is always threaded in, the other end, if it is 48 millimetres, there would be two threads outside, but if we tighten it, there will be no slip at all.
COMMISSIONER HANSFORD: But if it was less than 48 millimetres long and there were two threads exposed,

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then what?
A. Always slip or movement, always.
CHAIRMAN: Always ...?
A. Even by hand, you can see that there's a movement. If you tighten it, there will be no movement. If you don't tighten, there will be movement.
So for all partially engaged couplers, there is bound to be movement.
CHAIRMAN: So that's how you can tell whether or not, if you have less threading, it isn't butt-to-butt?
A. If it's not butt-to-butt, there is bound to be movement in the assembly, bound to be. I tried so many times using different types of bar and coupler in my office. I like to try to see what happens and there's bound to be movement if it's not butt-to-butt.
CHAIRMAN: Again, please forgive me. Coming back down to the ordinary workman trying to do his job under some pressure to get as much done in a day as possible --
A. Sure.
CHAIRMAN: -- you are holding onto a rebar that's how long? 6 metres? You've got it in and maybe there's a little clip or something, there's dirt inside the coupler which is already -- we are talking about a horizontal coupler now. Will they always be able to discover some sort of movement or rattling?

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A. If it's stuck there, you mean?
CHAIRMAN: Yes. You are looking at a very long rebar. You are putting it in. There's a little bit of difficulty. I think Mr Pennicott gave an ideal example earlier. You can't get it in at all, you pull it out, clean something off, put it in again. It's now got two threads showing but it's, you know, a 6 metre thing, it's stuck. How do you do the rattle test, if I can call it that? You probably can't; it's stuck there.
A. If it is stuck because of, say for example, a piece of sand inside -- it's possible, right -- there would be a problem because when the structure is loaded later on, it may crush this piece of sand and there would still be movement.
CHAIRMAN: But that's the point. I suppose what I'm trying to do is -- because as part of a Commission, one's looking not only to what happened and why but how you may improve matters generally for the future.
A. Sure.
CHAIRMAN: I suppose in my rather lame way I'm looking all the time for something that is clear to the average hard-working man down on the floor there who has to do the fitting of the rebars.
A. I agree.
CHAIRMAN: And it doesn't seem to be clear, unless you've

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got a qualified guy standing right next to you the whole time, which is another question, of course.
A. Yes, I think the BOSA people must train the workers properly on site. This is proper training, I think. It has to be done properly. If it is so important, then it must be done properly.
CHAIRMAN: But you yourself have just said this is the problem because if you've got some sand in there or something like that, a long, 6 metre bar, it gets stuck, there is no rattling, it's solid.
A. Then you look at the number of threads exposed.
CHAIRMAN: And you see two threads exposed?
A. If it's 44 millimetres and two threads exposed, then it's not good enough.
CHAIRMAN: That's right. But you haven't measured the number of threads, so there are going to be occasions, therefore, when without any lack of competence on your part you just haven't got it butt-to-butt?
A. Then this is supervision problem and training problem. I think it's also training problem by the manufacturer.
CHAIRMAN: Yes.
A. Because if they know that -- if the manufacturer knows that butt-to-butt is very important, they should ensure that it is butt-to-butt.
CHAIRMAN: Good. it seems to be 1 o'clock.

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MR PENNICOTT: Can I just -- actually, no, I think perhaps --
CHAIRMAN: If you'd like to finish something off so that we round it off.
MR PENNICOTT: I was going to go to mild, moderate and severe and so forth next but perhaps I will leave that until after lunch.
CHAIRMAN: Good. Thank you. 2.30?
MR PENNICOTT: Yes, sir.
(1.01 pm)
(The luncheon adjournment)
(2.34 pm)
MR PENNICOTT: Dr Lau, good afternoon.
A. Good afternoon.
Q. Can I just try to finish a couple of points off on the couplers. As we've already discussed, the only area that the coupler issue has given rise to the necessity, so it is said, to carry out suitable measures, is in area A at the EWL slab level.
A. Yes, that's right.
Q. I think I showed you a wrong drawing this morning and I'll put that right a little later or shortly. That's on the basis that in the other areas, the holistic report found those areas to have sufficient reserve capacity.

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A. Yes.
Q. As I think we've already discussed, at the time of the holistic report suitable measures were proposed for about 65 metres of slab length in area, and that has now been reduced by something of the order of 20 metres or so?
A. I don't know. I just know that it is 15 panels. I think there's some reduction. Exactly how much, I did not know.
Q. Right. And as I understand, your principal concern, as we've discussed, regarding the couplers, and therefore that suitable measures work, is the elongation tests and the failure of those tests --
A. Yes.
Q. -- according to you. What I'd like to do first of all is try to identify precisely where it is that these works were being carried out, because I then want to try to ascertain your views about the mild and moderate and severe conditions.
A. Okay.
Q. Because they seem to be somehow linked, but at the moment I'm in a state of confusion as to where these works precisely are being carried out.
Can we start by looking at OU6/8590. I think we can just focus on the top diagram, please, which is

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a cross-section through area A; do you see that, Dr Lau?
A. Yes.
Q. It would be quite helpful if you now were given a hard copy of OU9 so that we've got two things to compare, at page 11379.
Can we have that cross-section drawing back up, please. Looking at the cross-section on the screen, Dr Lau, and if you've got the plan in the hard copy --
A. Yes.
Q. -- can you identify for us where you believe the suitable measures are being worked on, on the cross-section?
A. On the underside of the corner.
Q. Somebody will give you a gadget to point to it.
A. On the underside of this -- you see the underside of the corners.
Q. When you say the underside --
A. They thickened the slab, concrete slab, and then put in U-bars.
Q. Can you give me the gadget.
So you say -- is it here (indicating)?
A. Yes.
Q. What about over here (indicating)?
A. I think the same.
Q. Now look at the plan.

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A. This is the west side; right?
Q. Yes.
A. The west side, some of the west side, sometimes it's also for the shear.
Q. Is it here (indicating)? Is it here (indicating)?
A. Around that sort of area.
Q. So that's the west side?
A. That's also west side, as well, not just on the east side.
Q. Dr Lau, I'm with you on the west side. We can see that there.
A. Yes.
Q. It looks as though there's a little bit of work there (indicating).
A. Yes.
Q. I don't see anything on the east side.
A. I think there are also -- on this drawing, you cannot see it properly, but there's another better drawing just for the suitable measures.
Q. All right. Let's just focus on the west side that we can see there, and then going back to the cross-section. That must be about there (indicating), is it?
A. Yes.
Q. So it's inside the diaphragm wall?
A. Inside the diaphragm wall, yes. You cannot get -- you

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cannot do it outside.
Q. Okay. So it's just inside the diaphragm wall, before whatever the other column is there (indicating), yes, that bit? So it's about where the hand is now?
A. Okay.
Q. Is that the area you have been describing as somewhere between I think severe and very severe; is that right?
A. Yes, because the whole structure is submerged in water. The whole structure is submerged in water, and the water table actually fluctuates due to tidal variations, so for me they are contaminated by salt water, and the diaphragm wall itself --
Q. Despite the fact that we've got 1.2 metres of diaphragm wall in the way?
A. But the diaphragm wall are not impermeable, because to construct a diaphragm wall has joints in between them, and they allow water to come in. Because diaphragm walls are not watertight.
Q. Okay.
A. So if you feel the diaphragm wall from the inside, it's always wet.
Q. Okay. Thank you for that, Dr Lau. At least I now know precisely where it is we are talking about. I was unsure about that to start with, but I think I now understand it, and we can obviously hear from other

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experts about that.
Dr Lau, I'm not going to go over with you the 68 per cent reduction factor and how it's been derived and utilised in area A, and so forth, or statistical --
A. I can't answer you those questions. I'm not the expert.
Q. -- matters.
A. Not my expertise.
Q. All right.
Now, so far as the coupler issue is concerned in the COI 2 areas --
A. Okay.
Q. -- we are concerned with the HHS area and the trough walls.
A. Yes.
Q. And you've explained your position with regard to, essentially, the protection of the columns in particular.
A. Yes.
Q. You say you -- I think you explained in your presentation this morning you've done a hand calculation and you worked out that the deflection that would be required to potentially harm the columns is quite small, 2.7 degrees, I think you said?
A. Agree, yes, 2.7 degrees.
Q. Is that deflection, of that magnitude, is that going to

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be prevented by the suitable measures that are being carried out?
A. Yes.
Q. All right. And again those works are being carried out on the footing that a 35 per cent reduction factor is applicable, and that again is derived from the calculations that have been done in relation to the other areas that have been tested?
A. Yes, that's right.
Q. I think we can see from recent reports from MTR that something of the order of 90 per cent of that work has been carried out?
A. I think basically they are all completed by now, yes.
Q. Okay. Have you been back to inspect any of that work?
A. I cannot go in. I can't go in at all. I'm not allowed to go in.
Q. I thought they would let you in! Right.
As part of Mr Southward's analysis in relation to the trough walls, as we've seen already a couple of times, he carried out a yield line analysis?
A. Yes.
Q. And that's something that you criticise on the basis of, as I understand it -- is this right -- a misapplication of the American Association of State Highway and Transportation document?

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A. I would not say that. I would not say that.
Q. How do you put it?
A. What I said was that he should have carried out more checks. That's all. I think, if he carried out those checks, maybe it is okay.
Q. Right.
A. All that I said is he did not check the shear. That's all. I'm not saying that it is wrong. I said that that particular line may not be the critical shear -- yield line. That's all. I'm not saying it is wrong.
Q. Okay.
A. In fact I appreciate that he has done this sort of calculation.
Q. All right.
This may be not a straightforward structural engineering issue, Dr Lau, but I'll ask you to comment because others have. You're aware that the steel fixing work in the HHS trough areas --
A. Yes.
Q. -- were carried out by a different sub-contractor to the one that carried out the steel fixing works elsewhere on the structure?
A. I know that.
Q. So leaving aside the statistical point about whether it's appropriate to apply this 35 per cent reduction

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factor, does the fact that the work was carried out by different sub-contractors -- is that of importance, do you think, in the applicability or the use of that reduction factor?
A. It has some impact, definitely.
Q. What sort of impact would you say it has?
A. Well, it depends on: is it better than the other contractor? Secondly -- what shall I say? The best thing, as I said, like Mr Southward, is to open up. If we can open up, then it solves all the problems, but unfortunately there was a decision not to open up. That I can't help. So, in that case, we have to lead with certain assumptions, and that assumption is to have a 35 per cent strength reduction. I think that's the best one can do.
Q. Right.
CHAIRMAN: The assumption is based on a previous statistical analysis of a different area --
A. In area A, yes.
CHAIRMAN: -- carried out by --
MR PENNICOTT: A different sub-contractor, yes.
A. As I said, the best thing is to open up and have a look.
CHAIRMAN: I appreciate that.
A. Unfortunately, there was no such opening-up, and we have to live on the assumption.

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CHAIRMAN: So work on the basis that the failure rate, if I can misdescribe it, would have been about the same for these new contractors?
A. Yes, at the moment, yes, but luckily -- I don't know whether it's lucky or what -- but anyway, apply this reduction rate to NAT and SAT, there's no need for any suitable measure. So the only suitable measure required is on the trough walls at the moment.
MR PENNICOTT: Yes. I think you were perhaps here on Friday when Mr Southward described the very different nature of the works to the trough walls compared to the coupler work in the slabs, and so forth. Did you hear all that?
A. I heard.
Q. Do you agree with what he said: it's very different type of works, different conditions, a lot easier in the trough walls?
A. Easier, but on the other hand, if you look at the VRV room and the stitch joint is even more easier, and yet we have this sort of problem. So we have to balance, take some sort of balance. I'm not saying that there is definitely a coupler defect, but I think it's better to be prudent because those walls are very important in case of an accident.
Q. Okay.
A. For me, I think it's a prudent approach.

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Q. Understood.
Dr Lau, shear links, a few questions about shear links.
A. Sure.
Q. That's obviously the second topic that we are focusing on. The issue regarding shear links arose during the course of the first part of the Inquiry as something of a side wind, because what had happened was various areas of honeycombing, honeycombed concrete --
A. Yes.
Q. -- were discovered, and when certain locations were opened up, that led to a consideration of whether or not the shear links were there, whether they were correctly spaced, and so forth.
A. Yes.
Q. You are aware that's all how it came about?
A. I'm aware, yes.
Q. Clearly you have now seen, presumably, a lot of photographs showing in-situ shear links, many, many shear links in many areas; is that right?
A. You mean Mr Southward's photographs?
Q. Yes.
A. At the top?
Q. Yes.
A. Okay, yes, I agree.

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Q. So it appears that there might be certain areas where there are no shear links. I think you've referred to 40-odd locations that have been looked at --
A. Yes.
Q. -- some of which appear to show no shear links.
A. Yes.
Q. Is this right, that, however, in terms of suitable measures, the whole analysis has been approached on the basis that there are no shear links?
A. Yes.
Q. And that's unreal, isn't it?
A. Sorry, can you repeat?
Q. It's unreal, is it not?
A. Let me put it this way. I looked at the opened-up area, in particular the honeycombed area where it was opened up. When I looked at -- in case when there was shear links, I saw there was no steel wire tying them together. I think this is the main problem of the shear link issue on this particular site. The sub -- the contractor should tie up all the reinforcement at the intersection. If they tie it up, when they do the concreting and do the vibration, they will not displace the reinforcement. I have the feeling that what Mr Southward showed us must be right, it must be right. The problem is they were not tied up. When I looked at

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the photographs, it seemed to me they were not tied up. Maybe they were not at the stage to tie them up. But normally you put the steel -- reinforce there, you tie up right away. You will not leave them there and go back to do the tying up; right?

So with all this reinforcement being placed there, and when they do the concreting and vibration, if you don't tie it up, they go everywhere. In fact, when I looked at some of the opened-up and honeycomb thing, there are a lot of so-called abandoned reinforcing bar on the base of the concrete. How come there were so many abandoned reinforcement on the base of the slab? Obvious, they may be previous shear links. I don't know what they are. There should not be any abandoned steel reinforcement at the base of the EWL slab.

So I have the feeling that because they did not tie them up properly, when you do the concreting they go everywhere.

Q. With respect, Dr Lau, can I just ask you to pause there for a moment. Up until your last answer, I thought that there were three potential problems with the shear links. One, they were simply missing.
A. Yes.
Q. Two, that instead of going all the way down, as it were, from the top to the bottom of the rebar, they stopped at

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a particular point in time, presumably because physically they couldn't get them through the rebar, in fact so not full-length shear links. So missing, not full-length. And the third point I thought was not correctly spaced, ie there but not correctly spaced. I thought that was the third possibility.
A. And also the fourth is the wrong diameter.
Q. Okay, wrong diameter. Now you seem to be adding in another one.
A. No, I'm not adding in.
Q. What are you doing then?
A. What I'm trying to do is -- I saw Mr Southward's photographs. They showed the shear links there, but at the bottom, when they opened up, there were no shear links. Where did they go? I don't know, honestly.
Q. Okay.
COMMISSIONER HANSFORD: Is it possible to go back to one of Mr Southward's photographs? Because I think you made the point, Dr Lau, that you could see they weren't tied properly.
A. If we look at them --
COMMISSIONER HANSFORD: I don't recall seeing that.
A. Shall we have a look?
MR PENNICOTT: I think around about 22.
A. Actually, I'm not suggesting new thing. I'm just trying

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to give some explanation.
COMMISSIONER HANSFORD: Yes, I understand. It will be useful to see what makes you think that.
A. I think there is another photograph showing the bend at the top. Shall we have a look?
MR PENNICOTT: There's one there. What about the next one, 23?
A. I can't see it properly.
Q. Next one? What about this one?
A. Look at the one closer to us.

Look at this one, for example (indicating). That doesn't seem to have steel wire tying them together; right?
Q. Can we blow that up?
COMMISSIONER HANSFORD: Yes. I can't imagine how they would stay in place if they weren't tied, but maybe that's your point.
A. I don't know. Because actually, what they should do is, as soon as they put the steel there, the link there, they should tie it up right away.
COMMISSIONER HANSFORD: Of course. I have some experience in steel fixing.
A. If you look at this, I don't think it is tied at all, none of them.
MR PENNICOTT: Okay. It seems to us that they do have some

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ties --
A. I hope that's right, because my eyes are not that good.
CHAIRMAN: Can I ask -- looking at how ordinary workmanship would proceed, and I may be wrong here -- it's a question, it's not an implied statement -- when you stick those shear links in, wouldn't you then tie each one as you go, rather than doing 100 and then go back and tie them?
A. You wouldn't do that. You would just tie it right away.
CHAIRMAN: Tie them right away. So there would have to be a complete break in normal procedure, wouldn't it?
COMMISSIONER HANSFORD: It would be extraordinary.
A. I think this perhaps explains why we missed the shear links at the bottom, because when you try to vibrate the concrete, they go anywhere, all these shear links.
CHAIRMAN: But I'm talking about, you know, it would be, as Prof Hansford has said, if you can see the shear links put there, and if the quite compelling presumption is, unless you've got a very odd way of working, to tie them at the time you insert each one, and to do anything other than that would be extraordinary, surely the mere fact that a serial of shear links are shown would imply, absent really compelling proof to the contrary, that they must have been tied?
A. They should be tied, yes. Well, I don't know, maybe --

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CHAIRMAN: An attempt must have been made to tie them?
A. Maybe they come back to do the tying later on, I don't know. But looking at this photograph, they were not tied, that's all. I'm not implying anything.
COMMISSIONER HANSFORD: Sorry, that's the bit I'm struggling with. How does this photograph show they are not tied?
A. Sorry?
COMMISSIONER HANSFORD: You said, "But looking at this photograph, they were not tied".
A. Yes.
COMMISSIONER HANSFORD: Where can you see that?
A. If they are tied, you should see -- for example, here (indicating), you should see a steel wire tying them together. You should see steel wire tying them together.
COMMISSIONER HANSFORD: Presumably the link then goes vertically downwards?
A. Yes.
COMMISSIONER HANSFORD: Giving the opportunity to tie it to the transverse horizontal bars?
A. I don't think they -- I believe, only "I believe"; I'm not introducing new evidence at the moment -- but when I looked at the photograph from the bottom, I did not see the wire there either. I did not see any wire tying the beams there either.

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COMMISSIONER HANSFORD: Okay. We can leave that point.
A. Maybe they come back to do it later; I don't know.
MR PENNICOTT: Okay.
Sorry, can we just have a look -- we'd better try to just make sure we don't miss something -- C13, an Original Inquiry bundle, 8605.
I'm not sure that you will be familiar with these documents, Dr Lau, but the Commission has seen many of these. They are the cast in-situ concrete quality control checklists that Leighton had to fill in at various stages of their works.
A. Okay.
Q. This was just one we found at random, but if you go down, please, to number 5, the reinforcement fixing, you will see one of the things that has to be ticked and signed off is:
"Size, number, length and spacing of bars, lap lengths, starter bar lengths and levels, cover, tying wire (ends turned in)" -- do you see that?
A. Yes.
Q. "... rigidity, surface condition ...", and so forth.
So one might indeed expect the wires to be tied in and therefore not necessarily entirely visible on the photographs, because they would be tied and tied in; yes?

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A. Well, I am not making any new evidence. I'm just trying to say, looking at the photograph if doesn't seem to have wire. Maybe they are coming to do it later, I don't know.
Q. You would also expect, for example, MTR's construction engineers and inspectors to check that the work had been done as well?
A. Yes, they should.
Q. You haven't seen, presumably, the evidence of Louis Kwan -- I think I might have called him Chan this morning, for which I apologise -- Louis Kwan's evidence about his inspection of the shear links?
A. They should be inspected. Anyway, as an engineer, as a contractor, this sort of thing is very important. They should be inspected. That's all. I'm not implying anything.
Q. Okay. I'm not going to take you to it but for the transcript, the relevant evidence was at Day 29, pages 60 to 63.
Just, as I say, to correct something I got wrong this morning, can we just go back to OU9, and looking at page 11375. That's the report of 25 December. 11382. I think this morning, Dr Lau, I may have suggested to you that this work or at least some of it was a consequence of the couplers. This is the shear link

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work, as I understand it, at 11382; is that right?
A. Yes.
Q. Okay.
Now, you've given some evidence, Dr Lau, about a gap opening up underneath the NSL slab; do you remember that?
A. Okay.
Q. The soil settling and a gap opening up; do you remember that?
A. Yes.
Q. As I understand it, this is also associated with the shear link issues?
A. For the slab itself, yes.
Q. Am I right in saying that the depth of the slab that we're talking about is something like 16 metres below ground level?
A. Something like that, yes.
Q. Would you really expect a gap to open up at that sort of depth in this location in Hong Kong?
A. Yes, because if there's a dewatering -- if there's dewatering going on for the next 120 years -- remember, we are talking about the design life of the building -- maybe in 10 years' or 20 years' time, because of dewatering, the ground will settle; right? And the settlement will not recover. Once it's settled, it's

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settled. It cannot return to the original level.
In fact, as I said, I involved in quite a lot of --
Q. Have you ever demolished a box structure such as we are talking about here at this sort of depth?
A. No, not this sort of depth, no. But consolidation theory is applied to ground level as well as 60 metres down, the same theory.
Q. Just one further question on the construction joints.
A. Yes.
Q. So this is the dowel bar issues that we're -- part of the suitable measures that have been carried out to 23 panels.
A. Yes.
Q. You've expressed the view, as I understand it, that drilling what we understand now to be a 12 millimetre hole followed by a 16 millimetre hole, if the driller were to hit a piece of rebar, he would know it?
A. He would know it.
Q. Because presumably, what, the drill bit would jump back or what?
A. No. It's the noise.
Q. It's the noise?
A. It's the noise.
Q. Okay. But what happens when the 32 millimetre coring exercise is done, Dr Lau?

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A. The same. Same noise.
Q. Are you sure?
A. The same noise, the same sort of drill bit.
Q. When it gets to depth, is there really going to be an indication that there's a difference between the rebar and the concrete?
A. Of course there's a difference. When I do ground investigation, if I hit reinforced concrete, even though it's 10 metres, 20 metres down, when I hit the rebar, I know right away. I will know right away. Because also, it takes a long time to drill through a rebar; it takes a long time. You don't cut it in one minute. It may take hours to drill through the rebar, because you are using steel to cut steel, the core part.
Q. I'm distinguishing or seeking to distinguish two situations. You've got the 12 millimetre drill, the 16 millimetre drill, but now you're doing a 32 millimetre core.
A. The same. The drilling bit is the same. They have a drilling bit there and then they have carbide steel bite at the end, and that is used for you to cut through the rock, but if it's steel -- this is steel, right, high-strength steel? When they cut the rebar, you have steel cutting steel. You know right away because of the noise.

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Q. All right. Prof McQuillan doesn't agree with you on that, Dr Lau --
A. Sorry. We can have different opinion.
Q. -- and I've given you a chance to explain.
A. I'm a contractor so I think I know better.
MR PENNICOTT: All right. Thank you very much, Dr Lau, I have no further questions. Thank you very much.
CHAIRMAN: Thank you.
Cross-examination by MR SHIEH
MR SHIEH: Dr Lau, good afternoon. I represent Leighton.
A. Yes.
Q. I have a few topics to pick up with you.
First, I'd like to explore further this idea of butt-to-butt connection.
A. Okay.
Q. Now, you would accept that threaded ends differ in length, and you have said that they range from 44 to 48 millimetres; is that right?
A. Yes.
Q. As a kind of crude arithmetic, a coupler is 88 millimetres in length; yes?
A. Correct.
Q. If you have a 48 millimetre threaded bar which is screwed in completely on one end --
A. 48?

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Q. 48, yes -- that would leave 40 millimetres inside the coupler; correct?
A. Yes.
Q. Then if you have another 48 millimetres threaded end bar screwed in from the other end, completely filling up the 40 millimetres inside, butt-to-butt, you would leave 8 millimetres outside; correct?
A. Yes.
Q. 8 millimetres would be equivalent to two threads; correct?
A. Yes.
Q. I suggest to you that if you want there to be butt-to-butt connection and also two threads visible on the outside, then a necessary precondition would be that you need two threaded bars with 48 millimetres each. With any other combination, you cannot achieve butt-to-butt plus two threads visible on the outside?
A. Yes.
Q. As a matter of pure arithmetic?
A. Yes.
Q. In real life, we know that not all threaded bars are 48 millimetres; you have accepted that?
A. Yes.
Q. And in real life, as I think Mr Pennicott asked this morning, when workers tried to screw in a threaded end,

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sometimes he would feel he got somewhere stuck halfway through and he saw, "Oh gosh, four threads remaining", so he takes it out, cleans it, screws it in further, until he couldn't screw in any further, but would you agree that the fact that you couldn't screw in a threaded end any further may be due to reasons other than the fact that it's already achieved butt-to-butt?
A. What other reason are you suggesting?
Q. A misalignment, maybe, you would accept --
A. Yes.
Q. -- misalignment? Because these are very heavy bars, you would accept. To achieve a very smooth screwing-in, it really had to be pushed in at a very precise angle; would you accept that? So, if there is a slight tilt, there could be misalignment; do you accept that?
A. Could be.
Q. We operate in a real world.
A. Yes.
Q. Therefore -- let me give you a numerical example -- let's assume that you have a 44 millimetre rebar, threaded end, 44 millimetres.
A. Okay, 44.
Q. Say 44.5 or whatever; it doesn't matter. The 44 screwed in completely on the one hand, leaving 44 space on the other.

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A. Yes.
Q. Workmen try to screw in the threaded bar from the other end. Let's say he got stuck somewhere before it's completely screwed in and it got stuck when it's, say, 40 millimetres embedded, 44 on one end, but on the other side, despite pushing in to the best of their ability, misalignment or whatever reason, got stuck, so there leaves 4 millimetre gap inside; right?
A. Yes.
Q. But then, on the outside, the workmen would see a 4 millimetre thread exposed outside; right?
A. Okay.
Q. Because assuming the thread to be 44, you have 40 millimetres in and you have 4 millimetres that is one thread exposed outside, so the workman would think to himself, "I have pushed in as best as I could, I don't have x-ray eyes so I couldn't see whether it's butt-to-butt. I know I have done my best. I can see one thread outside." So according to the two-thread criteria, he would pass that particular job.
A. The two-thread criteria is for the maximum. If you are using 44 threads, there should be zero threads exposed; yes?
Q. Yes, but the poor workman, when he pushed it in, he would not know whether it's 44 or 48. He would just

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know, as a rule of thumb, I push in until I see a maximum of two threads, so one thread is below two threads, he would pass it; do you agree?
A. To pass it has to depend on the supervisor. The supervisor will know because, as I said, for 44 millimetre thread, there should be zero threads exposed. It's only when you have 48 millimetre threaded bar then you have two threads exposed, that is the maximum.
Q. Yes. We are talking about on a theoretical basis, if you have two exposed threads, then if it's butt-to-butt it has to be 48?
A. There is also a device, according to the instructions, that you use the pipe wrench to turn the steel bar, but if you turn the steel bar, maybe you can get in further.
Q. Maybe.
A. I don't know, but this is supposed to be the method statement. The method statement is you should thread it, thread the bar in. If it is 44 millimetres, there should be zero threads exposed; right? If, for example, it is not zero threads exposed, you are using 44 millimetre threaded bar, you use a pipe wrench to tighten it.
Q. But my point is the poor workman would not have been told to measure the length of the threaded end before

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trying to screw in the threaded end.
A. I think this is the responsibility of the supervisor, the foreman.
Q. Are you seriously suggesting that there should be some kind of instructions, in a busy construction site, dark and dusty, to measure the length of the threaded ends so that the poor worker could then say to himself, "Ah, this is 46, so I do some mental math so that it would be a thread and a half"?
A. The worker wouldn't do that, his supervisor should do this for him.
Q. Okay. You told us on Friday that you would tell your workers always to screw in butt-to-butt.
A. Yes.
Q. On BOSA threads?
A. Well, only one or two jobs, but most of the other jobs I use other types of -- like a Lenton coupler, other types of couplers.
Q. Lenton maybe has a tapered end so let's leave Lenton to one side.
A. But let's stick to BOSA.
Q. Let's stick to BOSA. You have experience of BOSA?
A. Yes.
Q. Good. We are on the same wavelength. You would tell your men to always screw in butt-to-butt?

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A. Yes, and my supervisor knows exactly what I want.
Q. Right. Let's leave the supervisor to one side. Let's look at the poor worker.
A. Okay.
Q. How would the poor worker know whether or not, when he couldn't push in any further, it's because it has already reached butt-to-butt or it's because of some misalignment or some mishap that he couldn't push any further? How was he to know?
A. He has to tell his supervisor and let him decide, let the supervisor decide.
Q. But every time he couldn't screw in further he tells his supervisor, but every bar at some stage he would reach a dead end, so every bar he couldn't screw any further he tells his supervisor?
A. I tell you, it's not that difficult to fit in the threaded bar into the coupler. It's not as difficult as you said. It's not difficult. I tell you. We are sitting in this courtroom and imagining that it is very difficult, but it's not that difficult, I tell you. Most of the workers can put it in quite easily. On my site there's no problem. Here we are talking about an ideal condition saying you can't do this or you can't do that.
Q. I know, but let's just imagine the scenario that we were

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looking at just now. Let's say if the poor worker, he tried to screw it in to the best of his ability and he reaches a dead end, how is he to know that he has already accomplished his mission? He couldn't push it in any further.
A. Usually, for a batch of threaded bar, after delivery to site, the supervisor will measure the threaded length. He will tell the workers that these are all 44 millimetre bars.
Q. Each and every one of them?
A. Very often the supervisor will do. This is done by the supervisors, not by the workers. If the worker cannot thread it in, he has to tell the supervisor. And actually it's not difficult to thread the bar into the coupler. It's not difficult at all.
Q. Bearing in mind the length and the weight of a rebar?
A. Yes. It can be done quite easily by workers.
Q. Let's rewind. When a batch of rebars arrive on site --
A. Yes.
Q. -- a supervisor would have the responsibility of measuring the threaded ends?
A. Yes.
Q. Which would range from 44 millimetres to 48 millimetres; that's what you are saying?
A. Most of the bars are 44 millimetres, in most cases.

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Most of the bars are 44. But there's a tolerance there. Particular 48 is supposed to be the maximum tolerance. They aim for 44 millimetres; okay?
Q. Yes, but 44 is what they are called. They call them notionally 44 but there's a tolerance.
A. Yes.
Q. The tolerance, as we know, is a kind of a buffer, an allowance.
A. Yes.
Q. But it's not a binomial situation where it's either 44 or 48. It could be 45 or 46 because when they come out of the factory, the length could differ; right?
A. Yes, that's why the maximum tolerance is two threads outside. That's why. Normally, it should be less than two threads. If anything more than two threads, then there must be something wrong. The worker will discuss with his foreman about this and let them sort this out. The bar should be 44.
Q. So let's say a poor worker screws in until he couldn't reach any further. He still sees, let's say, half a thread outside.
A. Okay.
Q. He couldn't push in any further. Half a thread outside. What judgment does he form on the spot?
A. He then uses a pipe wrench to try one more time. If we

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use a pipe wrench to try it one more time, there's a chance it would be butt-to-butt.
Q. A chance?
A. Most likely it would be butt-to-butt, because the coupler is designed to be like that. We use the pipe wrench to tighten it, it will be butt-to-butt. Lock it and it will be butt-to-butt. The important word is "lock it".
Q. But you are saying in every case, in every case --
A. Supposed to be, yes.
Q. -- it would be like this?
A. Yes.
Q. Until you screw in completely, there won't be any chance of a gap remaining inside?
A. There wouldn't be any gap inside.
Q. Okay. Let's say, for whatever reason, that a gap remained inside. Let's rewind. And let's look at the poor inspector. The inspector is there to make sure that there is quality control; correct?
A. Yes.
Q. Because however much you instruct the poor worker to use a pipe wrench, he may or may not completely fulfil the instructions; correct? That is why you need an inspector to check --
A. Okay.

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Q. -- that it's properly done.
The poor inspector, he would go and see a whole array of rebars with ends screwed in, some completely screwed in, some with one thread outside, some with a thread and a half outside, some with half a thread outside, some with two threads outside. All would be within the tolerance limit --
A. Yes.
Q. -- instructed by BOSA. How was he to tell whether or not, deep inside, it was actually butt-to-butt?
A. He will ask the workers to use the pipe wrench to try it once more. If you try it once more and you cannot go in anymore, then it will be butt-to-butt.
Q. So whenever he sees some threads exposed, he would say to himself, "Let me ask the guy to show to me, to screw it in using a pipe wrench. I want to be assured."
A. Yes.
Q. So that is how you expect the inspector to carry out his task of inspecting?
A. Yes.
Q. Not just visually?
A. Visually as well as using the pipe wrench to do the job properly.
Q. So any inspection protocol which merely involves external visual inspection of two threads, according to

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you, would be defective; correct? Potentially failing to spot non-butt-to-butt connections.
A. There should be -- if they are using 44 millimetre, there should be zero threads exposed. If there's maybe half a thread exposed, then the best thing is for the inspector to ask the worker to use the pipe wrench to do it once more. If he cannot go in, that means it is butt-to-butt. If they expose one and a half, again they use it, if it cannot go in, that is butt-to-butt as well.
This is very important. Apart from the tolerance, also use the pipe wrench to try it.
Q. Let me ask you one more time. According to what you have said just now, any inspection protocol, whether on the site for the inspector or government or holistic report protocol which merely says, "Two threads visible on the outside, I pass", that would be an invalid method of inspection?
A. It's visual inspection, yes, for visual inspection, but to be sure, you use a pipe wrench to do it properly. The pipe wrench is -- because we want it to be locked. The important point is "locked". You use the pipe wrench to try and if it is locked then it is locked.
CHAIRMAN: Sorry, I think the question was that if the inspector was to look and say, "Two threads outside,

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I pass", that I think, Mr Shieh said, would that be not a full and proper inspection?
A. You can call it a pass inspection, but if I were the inspector, I would at least try one or two of those two threads exposed bars and use a pipe wrench to try it. I think using a pipe wrench is the only way to ensure butt-to-butt. That's the only way.
MR SHIEH: I'll try one last time. You are aware of the protocol adopted for the opening-up exercise conducted by -- opening-up for the purpose of the holistic report?
A. Okay. Are we talking about couplers still?
Q. Yes. You are aware that it did not involve screwing in with a wrench pipe?
A. Agree.
Q. Would you suggest that that is potentially defective because it would have failed to capture situations when it is not butt-to-butt?
A. It can't use the pipe wrench in this case, because there's not enough space for you to use the pipe wrench anyway. That's why they are using the PAUT test, but that's the best they can do, in the opening-up exercise that's the best that they can do.
Q. PAUT is 37 millimetres?
A. Yes, I know.
Q. Plus the 3 millimetres allowance, it would be 40?

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A. Yes.
Q. We have seen that if the threaded end on the other end, let's say, is only 46, let's say, if you have 44 inside -- if you have 40 inside, leaving, let's say, 40 visible outside -- you understand what I mean? A 88 millimetre coupler with, let's say, 46 millimetres embedded on the D-wall side, that leaves 42 millimetres space; yes? 88 minus 46 would be 42; yes?
A. Okay.
Q. You have a threaded end which you try to screw in on the other end.
A. Okay.
Q. Let's say there's a gap of 2 millimetres.
A. Inside?
Q. Inside.
A. Okay.
Q. So only 44 millimetres would be embedded; yes?
A. Yes.
Q. It would have passed the 38 millimetre PAUT test; correct?
A. But you are wrong. I tell you why. On the other side, if you have a 48 millimetre threaded bar, the maximum you can get in is 44; you still have two threads outside, on the other side. So what you said cannot happen, because at the centre -- because I try it every

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time, you screw it in one side, that's the maximum you can go in. The other side, there's also a maximum you can go in. You know, if you have 48 on the other side, the maximum it can go in is 44, and then you have two threads outside.
COMMISSIONER HANSFORD: Why is that?
A. I don't know, because when I screw in from one side, after certain tightening, you have to stop. That's the maximum you can go in. So on the other side, if you try to put it in, when it meets the other side -- so if it's 48, in fact you should have two threads outside, on the other side.
MR SHIEH: We are deep into the afternoon. Let me just give you some basic numbers. I've just written out some. 88 millimetre coupler. On one side, the side of the D-wall --
A. Yes.
Q. You have a 46 millimetre threaded end, you screw it in completely, so all 46 millimetres inside the coupler; correct?
A. Yes.
Q. Simple arithmetic tells us that 88 less 46 would be 42 millimetres left on the slab side; yes? 42 left; correct? Let's say some poor workman tried his very best to

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push in or because he's lazy or whatever, he pushed in, let's say, 44 millimetre length threaded end rebar. He pushes in but only to the extent of 40; yes? He pushes in only to the extent of 40. So inside the coupler there would be a 2 millimetre gap; yes?
A. Okay.
Q. 88 less 46, less 40, which would leave us a 2 millimetre gap, so not butt-to-butt, not locked. Let's say he's lazy. But 40 inside, according to the PAUT test, it would pass, because it's more than 37.
A. (Nodded head).
Q. Then on the outside, one thread would be visible; correct? Because if you assume this to be 44, 40 has gone in, so 4 millimetres are visible on the outside, so there's one thread remaining?
A. Okay.
Q. According to the test devised for the purpose of the opening-up, it passes both criteria: less than two threads visible and 37 millimetres according to the PAUT test.
A. Okay.
Q. But it would not achieve butt-to-butt; correct?
A. Okay. But the thing is, just like I talked to Mr Pennicott this morning, in that case there would be more failed couplers.

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Q. Yes. That is why --
A. The number of failures would be even higher. So I think, for the purpose of this particular test, somebody has to draw a line for acceptance. So this 37 millimetres plus 2 millimetres on the outside is an accepted criteria --
CHAIRMAN: Sorry, that I don't understand, because if a coupler which is -- a threaded coupler is not butt-to-butt, then according to you it's of no value whatsoever, so there should be a simple test: is it butt-to-butt or not? Because if it's not butt-to-butt, then it's not doing its job.
A. But the PAUT test, you can't do that,because -- you can't do anything about that for the PAUT test.
COMMISSIONER HANSFORD: So why have a PAUT test?
A. But this is something agreed in the investigation.
MR SHIEH: But it would be completely valueless. Drawing a line which leaves the real risk of a gap remaining inside is a completely valueless protocol; would you accept that?
A. But you see -- I'm not going to comment on the PAUT test because it was done before I came in.
CHAIRMAN: No, you weren't part of it, and we are not asking you to do a critique of the test as such, but --
A. In fact, I looked at that particular defect, how to

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classify as acceptance and defect. I had this sort of doubt to myself in the beginning, but somehow somebody has to draw a line to say this is acceptable, this is not a defect, this is acceptable; somebody has to draw the line.

COMMISSIONER HANSFORD: I thought you had drawn the line --

A. I did not.

COMMISSIONER HANSFORD: -- that butt-to-butt is acceptable.

A. Yes, butt-to-butt is -- well, I did not draw the line. It's drawn the line by the manufacturer. This butt-to-butt is required by the manufacturer, not by me.

COMMISSIONER HANSFORD: Yes.

MR SHIEH: Perhaps we can take the mid-afternoon break here and then we'll look at what the manufacturer says. Would it be an appropriate moment?

CHAIRMAN: Yes, certainly. Thank you very much. 15 minutes.

(3.39 pm)

(A short adjournment)

(3.59 pm)

MR SHIEH: Dr Lau, before I take you to the BOSA materials, can I round up your evidence about the drawing of a line. Would you say that according to your evidence, in particular the importance of butt-to-butt, that the line has been drawn wrongly?

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A. I don't -- I didn't say so.

Let me put it this way. Government only want, strength-wise, it can satisfy the strength, and then we also want permanent elongation to be less than 0.1 millimetre. That's all the government wants. And then BOSA said, to do so, it needs to be butt-to-butt. Government did not want it to be butt-to-butt. All that we want is strength and permanent elongation to be less than 0.1 millimetre. That's all that we want.

It happened that BOSA said to get this permanent elongation requirement, it's got to be butt-to-butt. That's all.

Q. I don't understand.

A. Now --

Q. Go ahead.

A. -- in fact government wants two things: strength and permanent elongation being less than 0.1 millimetre. It doesn't matter what coupler you want, it doesn't matter what coupler we are using. You have to satisfy two criteria: strength and permanent elongation. That's all.

Now, it happened that BOSA said if it is butt-to-butt, then you can satisfy both. In fact, it does, as demonstrated by all the tests. In fact, at one time, government did ask MTR to provide evidence that

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the partially engaged coupler can satisfy strength and permanent elongation, and asked them to provide a programme of tests to demonstrate that the partially engaged coupler can satisfy these two criteria. But there was no response.

So, in that case, we have to stick to the butt-to-butt. Government never asked for butt-to-butt. Never, we never. We just asked for strength and permanent elongation requirement. That's all.

Q. But according to you, no butt-to-butt means failed permanent elongation test?

A. In fact it shows, by all the tests, that when it is not butt-to-butt, it failed permanent elongation, not by me but by all the tests shown.

Q. So looking at the matter now -- listen carefully -- you now know or you now say no butt-to-butt means fail permanent elongation; yes?

A. The tests show that, yes.

Q. You now know; yes? We now know, according to the tests --

A. We now know, as well BOSA also tell us so.

Q. Forget about what BOSA tells you. We have yet to get to what BOSA tells you. Don't bring in BOSA. You have said in your report --

A. Yes.

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Q. -- in your opinion, according to whatever test you have done, no butt-to-butt means fail permanent elongation?

A. For BOSA type, yes.

Q. We have also established that according to the protocol designed for the holistic report, the protocol --

A. Yes.

Q. -- it would fail to capture a situation where there's a small gap inside and yet have 37 millimetres on the PAUT test with two threads visible; it would not have failed that?

A. Yes.

Q. So it would inevitably follow that this test is defective in capturing a non-butt-to-butt scenario?

A. I think the government --

Q. Would you say that, according to what you now know?

A. Yes and no. I tell you: because the 3mm is only a tolerance. They were given the benefit of the doubt here.

Q. I know. So 37 could mean 40?

A. Yes.

Q. But from the example we worked on just now, even if it's 40 inside, it would still not be butt-to-butt? There could be a situation where, even if it's 40 millimetres inside, it is not butt-to-butt?

A. Could be.

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Q. Could be?
A. Yes.
Q. So let me ask you once again: this protocol, according to your very strict requirement of "must be butt-to-butt", is defective?
A. I cannot answer you this, because for me, we want -- all that we want is simple: strength and permanent elongation; right? And we were told that only butt-to-butt can meet this requirement. That's all.
Q. Okay. Dr Lau, can I be very blunt and brutal about it here. You were really caught between the devil and the deep blue sea here. You wanted to hang on to this very strict and unrealistic requirement of butt-to-butt, and yet you dare not actually criticise the protocol adopted for the holistic report. That's why you have to sit on the fence and say "yes and no".
A. I don't know how to answer you as far as this is concerned. For me, we are trying to get a dividing line of what being acceptable and what being not acceptable, and this 37 millimetres plus two threads outside is the only -- is the dividing line. That's all.
Q. Thank you. Let's look at what BOSA says.
Can you look at H25, in COI 1 bundle H25, at 44527.1. Here you have the thread strength calculation table, and the system specified thread length was stated

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to be 44; do you see that?
A. Yes.
Q. So that lays the groundwork because, as I said earlier, everyone has been referring to this type of threaded ends as 44 millimetres; right?
A. Okay.
Q. We've established that.
Then let's look at bundle A1 at page 575. This is BOSA technical and qualitative assurance manual, and we see it set out the type A dimensions.
A. Yes.
Q. On a simple basis, 2t is the length of the coupler and t is the length of each threaded end?
A. Yes.
Q. Do you see that?
A. Yes.
Q. So it tells us, what we already know, that if it's a 44 millimetre threaded end, so the coupler would be 88; yes?
A. Yes.
Q. Then let's look at BB2, page 1230. This is the same as what we have just seen; yes?
A. Yes.
Q. There is one more document which Mr Pennicott had shown you earlier. It's in bundle C10, page 7016.

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A. Yes.
Q. "After connection has been fully tightened, one should see a maximum of TWO FULL THREADS to ensure a proper installation."
Do you see that?
A. Yes.
Q. So what BOSA tells people is length of the coupler is 2t?
A. Yes.
Q. And when you screw in, you can have a degree of tolerance, and if you look at the diagram, it could be from zero tolerance to maximum tolerance?
A. Yes.
Q. But there's no fixed, rigid tolerance. There's no fixed, rigid length, because obviously, as we established, if it's a tolerance, it could vary?
A. Okay.
Q. It could be from zero to one thread?
A. Yes.
Q. Or two threads; do you accept that?
A. Yes.
Q. Now I am going to show you what some witnesses have described --
A. Can I also point out to you, number 1:
"After connection has been fully tightened ..."

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Q. Yes.
A. This is a very important point.
Q. "Fully tightened", but as we have established, whether you do it by hand or use a pipe wrench --
A. Pipe wrench.
Q. -- there's no assurance or guarantee as to the reason why you couldn't go any further. You could well not be able to go further because something got stuck or because of misalignment; do you accept that?
A. If it is fully tightened and if there are more than two full threads, then definitely it is -- in fact it is not good enough. Do you understand what I'm talking about?
COMMISSIONER HANSFORD: Sorry --
A. If it is fully tightened, if we have three full threads outside, certainly this is not acceptable; am I right?
MR SHIEH: Yes, you are right, but you are not answering my question. My question is the fact that it's fully tightened may not mean it has already reached a butt-to-butt state, even with the help of a pipe wrench?
A. That's the best we can do on site. That's the best.
Q. Let me show you some witness evidence. Look at COI transcript Day 21, page 17, at line 24. This is the evidence of a gentleman called Edward Mok from Leighton. At line 20 he said:

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"To check the coupler connection, primarily it's a visual inspection. I have to see how many threads are exposed. For normal connection, we shouldn't be able to see any threads.

Let me give some background. Why is it I would know what the criteria were? Because, when I first joined in 2013, BOSA, the supplier of couplers, provided training. I attended the training. So that's why I know what the criteria were for acceptance. Now, it was mostly visual inspection, that we were told there could be an allowance of one to two threads that may be exposed. So that's about it."

So that's what one witness said. He's not a worker who screws in; he inspects.

A. Okay.

Q. Also an MTRC witness, Mr Kobe Wong, COI 1 transcript, Day 30, page 20, line 18:

"... I had seen the installation of the couplers in that area, because for the training given by BOSA to us ... under the QSP, when inspectors went to see -- went to check whether the coupler installation passed or not, we would check whether there was a maximum tolerance of 1 to 1.5 pitch of the thread."

So this witness actually said 1 to 1.5 pitch; do you see?

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A. Yes.

Q. So there's a witness from Leighton who said visual two threads maximum; MTR, 1 to 1.5, and we have seen the BOSA manual.

What I am suggesting to you is this. From the evidence we have seen, from the BOSA literature and from witness testimony as to what BOSA taught the relevant personnel, it's all based on visual inspection of a certain number of threads visible on the outside --

A. Okay.

Q. -- with no requirement of butt-to-butt. Do you accept that?

A. If they are tightened, this is good enough. If it is tightened -- well, if they tighten the bar into the coupler, and with 1 to 1.5 or 2 pitch, that will be good enough, according to the BOSA specification.

Q. Okay. The one to two threads tolerance or try to screw in as best you could may be an admirable aspiration to push it in as far as possible, or even an aspiration or attempt to reach butt-to-butt, but it is not the same as a requirement that it must be butt-to-butt. Do you accept that?

A. If it is not butt-to-butt, simply it cannot satisfy the requirement of permanent elongation. That's all. In fact, as far as government is concerned, they don't mind

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what coupler you use, but you should satisfy tension strength, tensile strength, as well as the permanent elongation requirement.

Q. Now I'm going to move away from butt-to-butt. I'm going to move on to the question about test requirements for couplers be, whether it's 575 or 529.

Now, can I ask you to look at some requirements --

A. Sure.

Q. -- as to strength tests.

A. Okay.

Q. Let's look at bundle H9, page 4044. This is a Buildings Department acceptance letter setting out the requirements for mechanical couplers --

A. Yes.

Q. -- without ductility requirement.

A. Okay.

Q. Without.

A. Okay.

Q. Can you then turn to the next page, at 4045, at paragraph 4(a):

"Strength tests of the mechanical splice should satisfy the following criteria".

Permanent elongation should not exceed 0.1mm. Tensile strength should exceed 287.5 for grade 250 and 529, that's megapascals, for grade 460.

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Do you see that?

A. Yes.

Q. So relevantly for our purposes, if it's non-ductile couplers, the relevant strength to be reached, minimum, is 529 megapascals; correct?

A. Okay.

Q. If it's couplers without ductility requirement; do you see that?

A. Yes.

Q. We then turn to couplers with ductility requirement. We look at the same bundle, at 4040. This is mechanical couplers for steel reinforcing bars for ductility requirement. So this sets out the requirement for couplers with ductility requirement.

Turn over to page 4042, paragraph 5(b). It sets out the static tension test. Now, the permanent elongation test, it says 0.1 millimetre; you can see that?

A. I agree.

Q. At (b):

"Static tension test: The splicing assemblies must develop in tension the greater of 100 per cent of the tensile strength of the bar ... and 125 per cent of the specified characteristic strength of the bar."

Do you see that?

A. Yes.

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Q. So transposed to our case, it would mean that if it's couplers with a ductility requirement, then the strength to be achieved would not be 529 but 529 times 1.25; yes?
A. Yes.
Q. Which would be 575; correct?
A. Yes, correct.
Q. So the difference between a test limit or a minimum strength of 529, on the one hand, and 575 on the other, is whether the coupler in question is subject to a ductility requirement; correct?
A. I agree.
Q. Because I think in cross-examination of Mr Southward, certain figures were put to him on the basis of a test limit of 575, but we have now looked at the documents. 575 is the limit. The higher strength requirement only applies if the couplers are subject to a ductility requirement; do you accept that?
A. I agree.
MR KHAW: Sorry, just one clarification. I think 575 is not 529 times 1.25; it's 460 times 1.25.
MR SHIEH: Sorry, yes.
A. Yes, that's right.
Q. Of the characteristic strength, I'm sorry.
A. That's right.
Q. But it's the higher --

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A. I know what you mean.
Q. It's higher than 529 --
A. I know what you mean anyway.
Q. Thank you, Mr Khaw, for correcting me.
Whether or not certain couplers or assemblies are subject to a ductility requirement is a different question from whether in fact ductile couplers were used; correct?
A. Okay.
Q. You accept that?
A. I accept that.
Q. Because there may or may not be -- there may be no requirement but people for whatever reason may choose to use ductile couplers; do you accept that?
A. I agree.
Q. Whether or not there is a requirement for using ductile couplers is a matter pre-determined by looking at the drawing, design drawing; correct?
A. Okay. You can say that. But it depends on the design principle. The principle is more important. For example, here, if there is no moment redistribution, there may not be any requirement for ductile couplers.
Anyway, I take your point, yes.
Q. Because when a contractor builds a structure, he has to ask himself what are the requirements, and he's dictated

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by whatever design drawings he is given --
A. Okay.
Q. -- by whatever consultant who is responsible; correct? Do you accept that?
A. I thought the drawing showed ductile couplers, am I right, when I looked at the drawings?
Q. I'm not going to go through the tedious process of going through all the drawings, because we can all see the drawings by ourselves.
A. Okay.
Q. But there are one or two big principles that I want to put to you. Within the EWL slab, none of the couplers were subject to a ductility requirement, do you accept that, within the EWL slab?
A. You mean according to the drawing or --
Q. According to the drawings.
A. According to the drawings, it seems to be the case, yes.
Q. So if that is the case, it would follow that couplers installed in the EWL slab only needed to fulfil the load requirement of 529 megapascals?
A. If there is no requirement for moment redistribution, yes, I agree.
Q. No, if there is no requirement of ductility, then according to the documents we have seen from the BD perspective, the test to be reached is 529?

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A. I agree. When it was originally designed, there was no anticipation of moment redistribution in the original design. It's only in the updated design that moment redistribution was required.
Q. I was told it's not the case under the 2004 Code.
A. The 2004 Code, I tell you --
Q. By reference to which it was designed.
A. Anyway, that's a long story. According to the 2004 Code, you are not supposed to have coupler located in front of the diaphragm wall. You have to be 1.5d away; right? Because of that, that's why if you use the 2004 Concrete Code, BD always give you an additional letter; "If you want to place the coupler within the 1.5d, you need ductile coupler." So in the 2013 Code, this has been put correct. This is all I want to say. Normally, if you use 2004 Code, if you want to put the coupler right in the diaphragm wall, BD always give you an additional requirement in the form of a letter. But nowadays this is formalised in the 2013 Code.
I can tell you this because I was involved in the drafting of the first edition of the code.
Q. So you are saying -- can I remind you that we are talking about suitable measures being proposed for area A of EWL slab.
A. Yes. Okay. You are talking about now?

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Q. Yes.
A. Okay.
Q. Because the only suitable measures recommended, resulting from problems with couplers, are confined to EWL slab area A?
A. Agree. I totally agree.
Q. You say BD always gives you an additional letter that if you want to place whatever, you need ductile coupler.
A. They always give you an additional letter.
Q. So it is all dependent upon -- so whether there is ductility requirement depends on whether there is or is not this BD letter saying you should use ductile coupler?
A. Because BD will look at the location of your coupler. If it is placed within the 1.5d area, then they give you an additional letter. This is the practice in Hong Kong. This is the practice in Hong Kong.
Q. So if BD has not written such a letter, then there's no such requirement?
A. Agree.
Q. I probably don't need to take you to the underlying opening-up results, but do you accept that adopting 529 megapascals, that is the no ductility requirement limit --
A. Okay.

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Q. -- 529 megapascals, coupler assemblies with six threads passed this test?
A. I know.
Q. You know?
A. I know. You don't have to take me to it. I know.
Q. Whereas even if you were to adopt 575 megapascals as the test limit, all six thread assemblies, except one, passed the 575 megapascal test.
A. I know. You don't have to show me. I know that.
Q. So do you accept that on a 529 megapascal basis, six thread coupler assemblies were enough for the purpose of carrying load, because it passed --
A. Strength-wise.
Q. -- strength-wise; you accept that, yes?
A. Yes.
Q. You have no dispute with that?
A. No dispute.
Q. Can I now then move on to -- in which case, at the stage 3 analysis, structural analysis, there's no basis to disregard partially engaged coupler assemblies as if they have no contribution to load bearing; correct?
A. But as I said in my report, we want strength as well as permanent elongation, and this is for durability purposes or serviceability requirement.
Q. Can I deal with permanent elongation immediately, now

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that you have raised it.
A. Yes.
Q. Can I show you what Prof McQuillan said in COI 1, transcript Day 44, page 106. That's Prof McQuillan giving evidence, commenting on the relevance of elongation tests.
A. Okay.
Q. Starting from line 11. I don't know whether you've read it, but --
A. I did not.
Q. Let's have a look at what Prof McQuillan said. It's Day 44, page 106, line 22. This is what Prof McQuillan said:
"The point I'm simply making is that to perform that test, you stress the bar to a fairly high level, and because of the utilisation values in this job, the bars will never be subjected to that level of stress, so they are never going to strain to 0.1 of a millimetre."
Then he moved on:
"... Dr Glover has explained that the tests are done in the open. When the couplers are encapsulated in concrete, they don't actually behave that way, but even if 0.1 millimetre were to occur, that cracking would be evident, and you've heard from the other experts that they have inspected the structure ... I have seen no

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evidence ..."
If you move on:
"... if cracking did occur, it's in a dry environment, and so it doesn't become a durability or a serviceability issue. Might I say, every structure, every house has cracks. It doesn't mean that they give [rise to any] concern whatsoever.
So I'm suggesting that elongation testing and partially threaded coupler assemblies is not really relevant in context."
Have you seen this?
A. Yes.
Q. So I'm suggesting to you that because of the reason given by Prof McQuillan, permanent elongation test is not relevant in the context of where these couplers are going to be encapsulated.
A. I disagree. I disagree.
Q. Because?
A. First of all, even at very low stress, the coupler has already got the elongation because of the slack we are talking about, and this elongation is sufficient to crack the concrete. So I cannot understand why Dr Glover said if they are enclosed in the concrete nothing would happen. On the contrary, because they are enclosed in the concrete, the elongation in the coupler

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will cause a lot of cracks in the concrete. That's what we are worrying about. And the cracks will accumulate. They will not go away, they will accumulate for the rest of the life of the structure, because this sort of elongation we are talking about, they occur at very low stress level. They are not occurring at the 0.6fy level, they are occurring at the low level, because they are slack of fit.

Q. Now, there's one more element in play and let me try to describe it verbally. It's tempting to use gestures but in order to make it, you know, on record, let me try to explain the matter verbally.

A. Yes.

Q. These rebars are very long.

A. Okay.

Q. You accept that?

A. I accept that.

Q. Each rebar is I think 6 metres long?

A. Yes.

Q. Plus lapping, it could be obviously longer than 6 metres?

A. I agree.

Q. If they are attached on one end onto a coupler --

A. Agree.

Q. -- the risk of an incompletely attached coupler assembly

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would be there would be lateral movement. If it's not locked in properly, there will be movements laterally; right?

A. Yes.

Q. Moving in and out. But in reality, imagine one end being screwed in to the extent of 44/48 millimetres, but on the other hand you have a gigantic raft of mass, 6 millimetres worth of metal or even more, pressing down, there is simply not going to be that ease of movement for an incompletely attached coupler connection to laterally move around --

A. I disagree with you.

Q. You disagree?

A. Because now you have the reinforcing bar inside. Suppose there's no coupler. You load the beam, there would be tension in the bar, and the bar will elongate, and when it elongates, it will cause cracks in the concrete. Some cracks in the concrete anyway. Suppose you have a coupler inside the beam, in the bar. When you load the beam again, a lot more deformation will occur at the location of the coupler, as in our case here, and this elongation will cause a lot of cracks at that particular location with the coupler. And this sort of crack will accumulate for the rest of the life of the structure.

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So I disagree with what the professor said here.

Q. But this scenario is what I am putting to you, because elongation presupposes ease of movement sideways, laterally; right?

A. Along the bar.

Q. Along the bar. Basically, there's a tendency to be able to pull it out because if it's not locked properly, you would be able to pull it out easily, relatively easily; right?

A. They will not pull out but just --

Q. There will be movement, sorry, slight movement, if it's not locked properly; correct? That's the idea behind it?

A. And the coupler is located at the joint; right? So that means, at that particular joint, there would be a lot of deformation because of this movement of the coupler, and the deformation will cause cracks at the joint. This is what we are worried about.

Q. The point I'm putting to you is there won't be that kind of slight sideways movement --

A. What do you mean by "sideways"? Longitudinal movement?

Q. Longitudinal movement, yes. There won't be that slight longitudinal movement in the context of the present case --

A. Why?

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Q. -- where you have one end screwed in to the extent of 48 millimetres, let's say, but the other end with a 6 metre long bar pressing downwards?

A. What do you mean by pressing downwards?

Q. The weight of it plus the concrete around it.

A. No, no, no. You totally misunderstand. It's a reinforced concrete structure, at the joint, when you apply bending moment to it -- we are talking about bending moment to the joint -- the bar will be subjected to tension, and that tension will try to move the bar out of the coupler, and that means at that particular joint there are a lot of tension, tensile strain and stress, in the joint, causing cracks in the joint. This is what I'm worried about in the long term.

Q. If there are to be cracks, the cracks would have shown themselves already; correct?

A. Actually, you cannot see it now because it's inside the concrete at the moment, they are inside the concrete at the moment.

Q. What is there to dictate that the cracks must appear inside the concrete?

A. Because they are placed inside the concrete. The couplers are placed inside the concrete at the moment.

Q. They wouldn't manifest themselves by --

A. Eventually, yes, but not now.

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Q. Let me just test you further about the classification of the environment inside that concrete structure.
A. Okay.
Q. 1, 2 or 3. Mr Pennicott debated this with you. I'm not going to revisit the definition of conditions 1, 2 and 3, but can I just take you to that drawing that you have looked at with Mr Pennicott.
A. Okay.
Q. In the OU bundle, page 8590.
A. Yes.
Q. Can you zoom in. Just now, you looked at this drawing with Mr Pennicott; remember?
A. Yes.
Q. You see the EWL slab?
A. Yes.
Q. The green, and you see capping beams?
A. Yes.
Q. You see that arrow pointing all the way towards the left?
A. Yes.
Q. That is where the couplers were located; right?
A. Yes.
Q. But you can see from this drawing that the EWL slab was above sea level?
A. Yes, okay. Above, you should be saying above the

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groundwater table, rather than sea level.
Q. Above the ground, yes.
A. Groundwater level.
Q. Above groundwater level.
A. Okay.
Q. Just now, when you gave evidence, you talked about the D-wall inside would be wet and all the rest of it, but if we are talking about the EWL slab, it's above groundwater level, so where would -- there's no way in which the wetness could have got to the EWL slab.
A. Even if the wetness goes into the fill below, it can still affect the structure. When we talk about the so-called environment, we are talking about the effect of environment on the concrete and the reinforcing bar inside the concrete. This is what we are talking about. The diaphragm wall itself is not continuous. It's discrete. Water and seepage and moisture can go inside the building through the diaphragm wall joint; right? And if the water -- well, even though it is clean water, groundwater, it still affects the quality -- the durability of the concrete in the long term. They are permanently underwater. The diaphragm wall is permanently underwater.
Q. I ask one more time: the EWL slab and in particular the capping beams inside the EWL slab are not on the same

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level as the groundwater. They were above the groundwater.
A. You have fill, and the fill is wet just below the capping beam. That means the environment is good enough to cause corrosion of the reinforcement inside the slab in the long term.
Q. But there's no air inside. Where is the air?
A. Of course there is air. How come there's no air? Of course there is air. What do you mean by "no air"? What do you mean by "no air"?
Q. That's soil inside.
A. Soil has air.
Q. Compacted. It's compacted soil.
A. Even though it's compacted soil -- well, if that's the case, there's no need to have thick concrete for the diaphragm wall or the concrete cover, nor thick concrete cover for the pile.
Q. Can I look at the definition of condition 1 with you.
A. Okay.
Q. Look at bundle H9 at 2857. This is the 2004 version of the code.
A. Yes.
Q. You have said that you would have classified that area as between 2 and 3?
A. Yes.

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Q. 2 would be internal concrete surfaces exposed to high humidity, for example bathrooms and kitchens.
A. Yes.
Q. So that gives you an example of the kind of exposure --
A. Yes.
Q. -- needed. But on the drawing that we have seen, you are seriously suggesting that the EWL slab face is similar in its exposure to humidity --
A. On the outside. On the outside I'm talking about.
Q. EWL slab, we are talking about the EWL slab.
A. Yes, on the outside.
Q. That's what you say.
A. On the joint. The side in contact with the soil as far as the diaphragm wall is concerned has all the cracks, as demonstrated by the finite element model.
Q. But the suitable measures are conducted on the inside.
A. It's conducted on the inside in order to reduce the stress level in the joint, at the joint, because in the long term we have to consider whether the reinforcement will be corroded in the long term. I'm not talking about five years, ten years. I'm talking about the long term. If the reinforcement is corroded in the long term, the reinforcement will expand and cause spalling of the concrete. And you cannot inspect the outside of the diaphragm wall. You cannot inspect, nor can you

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inspect the top of the diaphragm wall -- you cannot inspect them, because on the inside they are always in compression. Even if there's cracks, you can't see it, because it's in -- this is the joint (demonstrating with hands)), we try to bend it this way, on the outside we have all the cracks.

Draw? Okay.

(Drawing on the whiteboard) This the joint. You are trying to bend the joint this way. We have all the cracks on the outside, but compression here. On the inside, there are compression.

So you are telling me that to inspect the crack on the inside, you cannot see it. Of course you cannot see it. But if you are on the outside, you can see all the cracks, but you cannot see it here, because it's soil, and here (indicating), it's covered by the track concrete.

So, in the long term, there's a worry, because as demonstrated by all the finite element models, by OAP and also by Atkins, we have all the cracks on the outside, not inside, and if you have all the cracks on the outside, we have durability problem in the long term.

I can sit down.

Q. Coming back to the question -- yes, please be seated --

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of strength, do you accept, having seen all the consultants' reports and calculations, that the structure is typically utilised to the extent of only about 50 per cent?

A. In general, yes. In general.

Q. Cyclic tension tests. If I ask you to look at what Prof McQuillan said on Day 44 of COI 1, page 107. Day 44, line 21. He said:

"That brings us to the issue of the cyclic loading test, and I think there has been a good deal of misunderstanding ... It's not a matter of subjecting the coupler assembly to a fluctuating load, as occurs with any structure and which will occur with the passage of trains. Rather, it's very important to point out that it involves load reversal. So it's not a matter of the stress going from A to B and up to C and down to A again. What we are talking about here is the bar is being subjected to alternate cycles of compression and then tension. So you are pulling the bar, then you are squeezing it, and then you are pulling it again and then squeezing it again, and then you take it to destruction.

So, you know ... as I understand it, this is a test against fatigue failure."

Then Prof McQuillan talked about a wire coat hanger, the example, and bending it back and forth:

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"... there comes a point when all of a sudden it snaps. That's called fatigue failure. It occurs when the specimen is subjected to first of all compression and then tension, compression/tension, so it's not that the stress is fluctuating, it's actually reversing.

Again, it needs to be highlighted that for the 3 metre thick slab ... I'm just under 2 metres tall, so put another half of me on top, that's 3 metres. It's a huge, enormous slab. To experience that sort of load reversal, that huge, thick slab has to bend upwards against its own self-weight, and that simply will never happen."

Now, you've seen how Prof McQuillan describes this concept about cyclic tension test.

A. Yes.

Q. I am suggesting to you that on the basis of what Prof McQuillan has said, this test is irrelevant in the context of the structure that we are talking about here?

A. I'm not worried about cyclic test either.

Q. You are not worried about that?

A. I'm not worried about that. I'm only worried about the permanent elongation test.

Q. Okay. Can I then now move on to the question of shear links.

A. Okay.

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Q. You would accept that the opening-up and the inspections did show the presence of shear links?

A. Whose? You mean Leighton's or the MTRC's?

Q. MTR's and Leighton's. Both showed the presence of shear links in the opening-up exercise?

A. Anyway, 16 of the 40 openings showed no shear links.

Q. 16?

A. 16, in MTR's investigation, they have carried out altogether 40 openings, and of the 40 openings, 16 of them show no shear links; okay?

Q. Yes. The others do?

A. The others do. But some of them the space is too wide, some of them the diameter is too small, some of them -- but I'm not worried about the anchorage thing either. I agree with Mr Southward there will be strength in the shear link.

Q. Now, we have seen a number of drawings and photos over the course of Friday and today.

A. Yes.

Q. Before we look at those drawings, can I just put to you a basic proposition, and that is opening up merely an L shape as opposed to a 1 metre by 1 metre square shape is necessarily exposing less; correct? If you open up 1 metre times 1 metre, obviously you reveal more than merely an L shape; okay? You accept that?

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A. Yes.
Q. But what you are saying is that opening it in an L shape of the dimensions that you have described would be enough to expose shear links if they were there?
A. Okay.
Q. That's what you say; right?
A. That's what I say. But of course -- let me put this way -- it will be better if it is 1 metre by 1 metre, but this is something done. There's nothing we can do about that. But even based on 1 metre by 1 metre L shape, if the shear links were there, we can still see it.
Q. Mm-hmm. Following on your answer, if the shear links were there, you would see it?
A. We would see it.
Q. But that is at the mercy of the precision of where the shear links were placed, because you cut the L shape in a particular way, it's based on a particular assumption as to where the shear links were actually located; correct?
A. But the shear link --
Q. If there's a tolerance, an imprecision in locating the shear links, there would be a risk of missing them. As a big-picture observation, do you accept that?
A. Yes and no, because the spacing of the shear link is

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150 millimetres. We are bound to see some.
Q. I was told it is 300.
A. Well, it depends. 75, 150 to 300. There were three types. So, if it is 150, we are bound to see some of them. If it is 75, we are also bound to see some of them. But if 300, I think we should still be able to see some of them. But don't forget that on the honeycombed underside, on the honeycombed area, there's a big area we did not see any shear links, as far as the photograph is concerned. So there's a concern that there's no shear link in the right position.
Q. Can I take you to your slide number 33.
A. Yes.
Q. The red shape is what was shown in Mr Southward's slides or report.
A. This opening is the Leighton opening. This is not the MTR opening; right? First of all. Leighton only do one opening and that's the only one. Mr Southward tried to show, using the red line, that it's possible to miss the shear links, and I tried my best to show that if there are shear links there, you can see them. That's all.
Q. So this is an example where shear links were there and where you were able to see the shear links; yes?
A. Yes.
Q. Okay. But can I then ask you to look at your report,

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your own report, appendix JL1-E at page 4. This is a photograph of an MTR --
A. Yes.
Q. -- opening-up --
A. Yes.
Q. -- in an L shape, and this was an attempt to demonstrate -- or this is relied upon as showing that there was no shear links on this opening-up?
A. Yes.
Q. But, you see, the focus of this photograph was on the rebars on what I would call the top layer.
A. Okay. Yes.
Q. If, as a matter of fact, the shear links were not hooked onto the rebars of the top layer but on the bottom layer, then this method of opening-up would have missed it, or there's a possibility or likelihood that this form of limited opening-up would have missed the shear links on the layer below; do you accept that?
A. It's impossible to open up because -- it's nothing to do with the size. It's the depth you were talking about; am I right? You want -- you are not -- are you concerned about the size or the depth?
Q. The size.
A. As far as size is concerned, I think this is good enough. If you are worried about the depth, maybe I can

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understand, because I think Mr Southward said the depth is not deep enough to expose the shear links; am I right?
Q. Well, let's leave the depth to one side, because the depth would show you what's there at the next layer down. But the width of the vertical column, if you make it wider, you could be able to see what, for example, is to the right of the second vertical bar on the photograph.
Do you follow what I'm saying?
A. I follow what you are talking about. This is --
Q. There are two vertical bars facing us, but to the right of the bar on the right-hand side or to the left of the bar on the left-hand side, there could very well be shear links attached to the rebars in the layer below.
A. If it was hooked onto the main bar, we should see it; right?
Q. The main bar meaning the top two bars?
A. Yes, because they are supposed to be hooked onto the main bar.
Q. You are assuming, as a matter of fact, that if shear links are attached at all, they would be attached to the top, what you call the main bar?
A. It's supposed to be, anyway.
Q. We will deal with it, but if the hooks are in fact

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hooked onto the layer of bars below?
A. "Below" means the next layer?
Q. Next layer, yes -- then this form of opening-up stands a risk of not revealing them; do you accept that?
A. Well, possibility, but unlikely, because the whole purpose of the investigation is to find the shear links. That's the purpose of this. Of course, I was not involved, but this is done by the MTR. They try their best to locate the shear links, and if you look at the comments, the third column says, "Is shear links found", they said "No", and I have to accept the investigation by MTR. I don't think I can doubt their investigation.
Q. The reason why the shear links could not be hooked onto what you call the main bar is because there is a cover zone on top of that which had to be filled with concrete, a cover zone.
A. I don't understand. Why?
Q. The shear links cannot be hooked onto the main bar on top, because there is a requirement of a cover zone on top of the main bar?
A. No, no, no. In all construction work, the shear link must be hooked onto the main bar.
Q. Not in a slab, I was told.
A. This is another reason why I have a bit of concern. If the shear link was tied onto the main bar, we should be

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able to see the shear link. It was not -- so I don't understand why the shear link disappeared.
Q. Can we look at your slide 33.
A. Okay. This investigation was done -- if you look at this, this is done by Leighton; right?
Q. Yes, but those shear links were hooked onto the layer below, not on the top layer.
A. I can accept that. In fact, they should be hooked onto the top layer, but even if it is not hooked on the top layer, I can still accept it. I will not condemn it. It's not good, but still I will not condemn it.
But the thing is, this is not a good practice. First of all, the hook should be hooked onto the main bar. That means it should be turned 90 degrees, but in this case it is not. In many situations, when I look at the shear links, the reason why they can move around is they were not tied by steel wires onto the bar. You can look at it. There's no steel wires.
Q. You have raised two distinct issues. One is whether they are tied or not tied. Let's leave that to one side for the time being; right?
A. Okay.
Q. But you said that on the basis of what you see in your slide 33, as you can see, as a matter of fact, shear links were indeed hooked not onto the main bar on top

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but onto the bar in the next layer, as you can see.
A. Yes, this is true.
Q. Never mind whether or not it is correct practice or good practice or condemnable practice, or you say you would not condemn it, as a matter of fact you accept that this phenomenon of shear links being attached not on the top main bar but on the bar --
A. Okay.
Q. -- on the underneath layer did exist; do you accept that?
A. Yes, I accept that.
MR CHEUK: I stand to be corrected, but according to Dr Lau's report, if we look at what we call exhibit JL1-E3 -- yes -- we see actually the opening, according to my understanding, the title line says "Opening at the slab soffit", which means we are looking towards above rather than below, and that's why all the confusion arises.
A. I think you now understand, because you are looking up on the soffit.
COMMISSIONER HANSFORD: Thank you. I had understood that. Thanks. That's helpful.
MR SHIEH: It may change the language a bit because we are no longer talking about whether it's top or whatever, but my point --

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COMMISSIONER HANSFORD: All we are saying is: is it tied on the outer bar or the next one in?
MR SHIEH: Correct. Is it tied to the first bar you see or the bar in the level after that first layer?
COMMISSIONER HANSFORD: Yes, and I recognise that in all these, we are looking upwards from the soffit.
MR SHIEH: So when I say below, it's actually above.
COMMISSIONER HANSFORD: Understood.
A. I understand. Don't worry.
MR SHIEH: But leaving aside whether or not it is called correct or good practice to hook the shear links onto the very first main bar or the next layer, as a matter of fact we could see that it happened that these shear links were actually not hooked onto the first layer but the next layer?
A. I agree.
Q. You agree that? Therefore, given this phenomenon, to shape the opening in the L shape that we have seen stands the risk of missing out on shear links that were hooked on the next layer; do you accept that?
A. That's a possibility, yes.
Q. Thank you.
A. That's a possibility. But the conclusion from MTR is not based on one or two photographs. They are based on 40 openings, and quite a lot of the openings are in the

honeycomb area, and they are much bigger than 1 metre by 1 metre, and they are much deeper. Some of them are 358, more than 300 millimetre deep into the concrete. They did not find any shear links.

So it is prudent to assume that they are not there in the assessment, and this is the conclusion by MTR; it's not the conclusion by me, it's the conclusion by MTR.

MR SHIEH: There are one or two small points that I may wish to pick up, but given the time, perhaps it would be an appropriate time to take the break.

CHAIRMAN: Do you have the one or two small points ready or would you like to think about them?

MR SHIEH: I need to think about them and maybe I don't need to ask them and maybe to ask them now would be counter-productive.

CHAIRMAN: Very good.

Doctor, we are sorry we are going to have to ask you to come back tomorrow morning but we will have to do that.

WITNESS: No problem. I'm happy to help, if I can.

CHAIRMAN: So we will adjourn until tomorrow morning at 10 am. Thank you.

(5.05 pm)

(The hearing adjourned until 10.00 am the following day)

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