



**Canterbury Earthquakes Royal Commission**  
**Te Komihana Rūwhenua a te Karauna**

**UNDER THE COMMISSIONS OF INQUIRY ACT 1908**

**IN THE MATTER OF CANTERBURY EARTHQUAKES ROYAL COMMISSION**

Before: The Honourable Justice M Cooper  
Judge of the High Court of New Zealand  
Sir Ron Carter  
Commissioner  
Associate Professor Richard Fenwick  
Commissioner

Appearances: S Mills QC and M Elliott as Counsel Assisting  
D Laing and N Daines for Christchurch City Council  
G Gallaway and Ms Adams for BECA  
John Hannan for Holmes Consulting Group

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**TRANSCRIPT OF HEARINGS IN RESPECT OF  
THE FORSYTH BARR BUILDING**

**COMMENCING ON 23 FEBRUARY 2012 AT CHRISTCHURCH**

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**JUSTICE COOPER:**

The subject of this part of our enquiry is the collapse of the stairs in the Forsyth Barr building. Mr Mills you appear with Mr Elliott?

5 **MR MILLS:**

Thank you Sir I appear for, as counsel assisting with Mr Elliott.

**JUSTICE COOPER:**

Thank you. Mr Laing and Ms Daines for the City Council.

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**MR GALLAWAY:**

Yes Sir I appear for BECA and with me Ms Adams.

**JUSTICE COOPER:**15 

Good morning. Anyone else? Thank you. Yes Mr Mills.

**MR MILLS:**

Thank you Sir. Just before I start on the opening submissions just one addition to the witness list which I just ask you to note. The decision has been made to call a Mr Ewan Carr who will also be a witness of fact about the condition of the building and the stairs post-September and he will be called after Mr Cameron. So he will be the second witness this morning and Mr Elliott will call him.

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Now I think the Commissioners have already got a copy of the opening and if things have worked correctly you've also got a bundle of documents which are the documents that are referred to in the opening so while they'll be brought up on the screen that ought to enable you to see them without having to constantly duck and dart around the bigger bundle.

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30 **JUSTICE COOPER:**

Thank you Mr Mills.

**MR MILLS:**

Turning then to the opening submissions. The Forsyth Barr building is on the south-east corner of Colombo Street and Armagh Streets in Central Christchurch a short distance away from Cathedral Square. It is an 18-storey building and of course it's still there. The permit was issued in 1988. The building relies for its lateral strength on concrete beams and columns. The stairs which of course is the focus of this hearing were pre-cast. They were scissor stairs, fixed at the top end of each flight but designed to slide at the bottom during an earthquake with that movement being accommodated in what's referred to as a seismic gap and I'm going to take the Commissioners to the structural drawings just to have a look at this because this seismic gap features prominently in the issues we'll be looking at and so those details, I think if you could bring those up. And it's under tab 1 of course in the bundle you've been given.

Now that's the first of the several pages that you've got in those documents in front of you. It's taken from the structural drawings, Holmes Consulting Group, and shows them but the one that I particularly want you to look at, at this point, if we could go three pages on to page 87 and then I want to take you to page 88. Now, yes, it will be impossible to read on that screen. It's almost impossible to read on the page that you've got but if you look at the drawing in the upper right-hand corner on that page that's in front of you, you will see the words "seismic gap" written on the drawings shows a distance of 30 millimetres and you can see, and the BECA witnesses will deal with this in much more detail so this is just an introduction to all of this. You'll see the toe of the stairs in that darkened part on the right of the seismic gap. It's the landing and, again, we'll come to this in a bit more detail and BECAs will do it in more detail still but you'll see underneath that there is a, a metal runner in effect, metal seating that the landing is sitting on and a seismic gap in front of it and then of course in front of that again on the left-hand side is the wall and a beam. And so that seismic gap of 30 millimetres is designed, there it is, we can see it much better there, is designed to allow it to slide in, in lateral movement of the building. Now if we can then go to the next drawing, just so

you can see what was shown in the structural drawings. This is, I can hardly read it, I think it's page 88, .88.

## **JUSTICE COOPER ADDRESSES MR MILLS – PRINTER**

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### **MR MILLS:**

Again if I could just take the Commissioners down, when it re-appears, take you down to the bottom row there in the drawings and it's the third design drawing from the left and, again, you will see the seismic gap is noted on that  
10 drawing. There it is there. So that's the, that's what was shown in the structural drawings. Then just for completion if we could then go to the specifications which are the next document in that bundle that the Commissioners have and this is BUI.COL764.004A, 4OA rather, .7 and that's simply the excerpt from the specifications dealing with the pre-cast stairs.  
15 Now as you'll see there are others provisions which cross-reference into this but as far as I'm aware there's no dispute that this is what was in the specifications dealing specifically with the stairs.

### **JUSTICE COOPER:**

20 What, I see, yes, it's in the tab.

### **MR MILLS:**

Yes it's in the same tab and I just draw your attention in particular to the inspection provisions under 6.2.4 because inspection of the stairs is an issue  
25 that gets some attention in this hearing. Right I'll just then come back to the, I'll just pause a minute so people can see that if they want to. Then I'll come back to the opening at paragraph 3. The building, as the Commissioners will be aware, the building itself performed well in both the September and  
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30 Boxing Day earthquakes but in February the stairs sustained an almost complete collapse and it is the fact that this occurred a point well before the building itself sustained any significant damage that has now emerged as an

issue of particular concern. Egress stairs, as I put it here, need to be the last man standing and the contrary has occurred here. In effect the stairs were first down and the building stayed up with predictable results that, of course, no-one could get out.

5 Now by great good fortune no-one was on the stairs at the time they collapsed but if there had been there, undoubtedly, would have been deaths in this building and, similarly by great good luck, no-one died trying to descend the stairs in the dark. Now Mr Cameron, who is the first witness will describe this more graphically but the tenants were trapped in the building for a number of  
10 hours while aftershocks continued and some of them had to escape by abseiling down the side of the building, others were lifted out by crane. Tenants had no immediate way of getting out. There was clearly a fear of fire and, as will be very clear from Mr Cameron's evidence, for many of them it was a truly frightening experience. I just then want to touch on an account  
15 which I have read and summarised here which was on Stuff.co.nz which, for those who want to read it, is a particularly chilling account of how close this came to a tragedy for some people and I am simply going to refer to this person, whoever it was, who put this account on stuff as 'Jane'. Jane was on Level 17 of the building when the February earthquake hit. She describes  
20 how during a lull in the rocking, rolling, shaking and crashing that she refers to, that seemed to last forever, she decided she was getting out of there. She took off for the exit stairs only to find when she opened the stairwell door that there was no emergency lighting in the stairwell and, as she puts it 'it was dark'. Not just night-time dark but pitch black dark. She could see nothing.  
25 Nonetheless she decided she had to get out of the building. She describes how she began to feel her way down the steps in the dark. She was scared. She became even more scared when she felt loose things underfoot on the stairs. She reached the Level 16 landing before deciding she could not continue on in that way. She went looking for someone she knew on Level 16  
30 and then joined by five others from that floor they all continued on down the stairs, propping open the door on Level 16 and also the door to the toilet unit to try to get some light. They reached Level 15 and propped open that door

as well. She and her group were about to continue when someone told them that below Level 15 there were no stairs, they had collapsed. It is clear that if she and her partner, and her little party, had gone any further they would have plunged into what was then a dark void. So this has been a very lucky result  
5 that no-one died.

I turn then, briefly, to the Commission's terms of reference as they apply to this particular hearing. Because of the high level of concern engendered by the collapse of the stairs in a relatively new high-rise building where the building standards that applied in 1984 are not significantly different to those  
10 that are in place today, the Royal Commission has been required to enquire into the issues that I have set out below. They have been re-worded a little to apply more specifically to what is involved here but the questions that the Commission is required to look at involve the design of the stairs, whether, as originally designed and constructed, they complied with any earthquake risk or  
15 other legal or best practice requirements that were current when it was designed and constructed and then, on or before the 4<sup>th</sup> of September 2010. Then why the stairs failed when those in other buildings did not. Next whether there were any particular features of the building that contributed to the failure of the stairs. Then the nature of the land that was involved and whether that  
20 was a contributing factor. And, finally, the nature and the effectiveness of the assessments of the stairs that were carried out between the 4 September earthquake and the 22 February event that brought the stairs down.

I do observe, and this will be dealt with by Professor Bull, who is the last witness at this hearing, that the stairs in the Forsyth Barr building were not the  
25 only ones that collapsed in the February earthquake. While we are focusing on this particularly in this hearing it is not a single event nor a single worry. According to Professor Bull stairs collapsed in at least four other multi-storey buildings and in many other cases they sustained serious damage and I have referenced there – and there's no need to bring it up – but I've referenced  
30 there the report that Professor Bull did for the Royal Commission. He was commissioned, as you know, by the Royal Commission to provide this report and the issue with the stairs included an issue with Grand Chancellor building

which, of course, has been dealt with in an earlier hearing. Whereas I understand it the stairs collapsed in the upper two-thirds of that building. The Bull report, just to briefly encapsulate one of its findings or one of its conclusions, was that the horizontal displacement of floors relative to each other that occurs during an earthquake – this concept of ‘inter-storey drift’ that is the terminology the engineers use – had been under-estimated, both in the current standards and also in the previous loading standards. That level of lateral movement that the building might sustain that might impact on the stairs had been under-estimated.

10 In that paper by Professor Bull, in addition to the collapse event that occurred in the Forsyth Barr building, he also identified two other ways in which an under-estimation of the inter-storey drift can implicate the stairs in the way the building performs, and I have noted them both there. The first is, effectively, as I understand it, a jamming that can occur when the stairs compress which can increase the stiffness of the building and can cause the building itself to react in a different way to that which was anticipated in the design of the building and, as I’ve said, there rather more precisely as a result of stairs transferring forces between floors the building may deform in unanticipated ways significantly reducing seismic performance. The other way that is mentioned by Professor Bull is the stairs can damage the landings and that also can lead to collapse.

Just turning then briefly to the history of the building. The permit for it was issued by the Christchurch City Council on 9 May 1988. It was for a building that was described as a retail and office development. The developer was Paynter Developments Ltd and the building was sold to Robert Jones Canterbury Ltd on completion and was originally called Robert Jones House. The architectural design was done by Warren & Mahoney. The final structural drawings were done by Holmes Consulting Group. The contractor was Fletcher Construction Ltd and the current owner of the building is a company called 764 Colombo Street Ltd and the site manager for Fletchers will be called as a witness to give some description of the building and the way the seismic gap was understood and treated during construction. The design

certificate for the building was signed off on behalf of Holmes Consulting Group by Mr R A Poole and I've referenced that there. The design certificate is in the bundle I've given the Commissioners – I don't think we need to bring it up. I've set out there the parts of it which I thought were most relevant to the hearing. It will be familiar to the engineers, at any rate, on the Commission in the way in which it is done. It is a certification that the building's been designed in accordance with sound and widely accepted engineering principles and that it is the belief of the person signing off that

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10 that certificate that the stresses in the various materials of construction and force resisting elements are such that they will ensure the safety and the stability of the structure if the building, and that would include stairs, are constructed in accordance with the drawings and specifications.

Now just briefly on the foundations and the effect, if any, on the events that we are dealing with of liquefaction I have said at paragraph 16 the building was founded on a reinforced raft slab at a depth of around two and a half metres below the ground and both the BECA report and the report of the expert panel have concluded that there is no evidence that liquefaction or foundation failure played any role in the collapse of the stairs.

20 I turn now then to the reports that were commissioned by the Department of Building and Housing on the collapse of the stairs, of course by BECA Carter who did the report itself and then the expert panel reviewed that, which is a process that by now is well familiar to anyone who has been following the Commission hearings. Both the report by BECA and also the expert panel have reached a clear conclusion on the cause of both the stair collapse and the design changes that are required to minimise the risk of recurrence. Its conclusions, or their conclusions really, are relevant to the design to be used when the stairs for the Forsyth Barr building are replaced and I did note when I was watching TV3 this morning there was a brief item on this hearing which referred to the building being on the demolition list. That is not my understanding. My understanding is that the building will be able to be re-occupied. What will have to be replaced is the stairs, and only the stairs.



There will be some other issues of damage that will have to be dealt with but the building appears to have come through, other than the stairs, very well and is not slated for demolition. So this issue that the BECA report has identified about the stairs and what's needed to deal with the problem will be directly relevant to the remedial steps, the retro-fit steps, required for the stairs in the Forsyth Barr building and, significantly, they are also relevant not only to other buildings in Christchurch but buildings elsewhere in New Zealand where urgent investigations are now required to ensure the stairs can survive these very occasional but extremely powerful shakes that were experienced here in February, and I see a photograph of the building has just come up.

As I mentioned, the expert panel has confirmed or agreed with the conclusion that BECA has reached on the cause of the collapse and the problems with the type of stair design that was used in the Forsyth Barr building and Mr William Holmes, the distinguished American structural engineer who has been retained by the Commission to peer review the work of the Department of Building and Housing, has also agreed with the conclusions that have been reached and as a result Mr Holmes will not be required to give evidence at this hearing.

**20 JUSTICE COOPER:**

Q. Just going back to your paragraph 17 Mr Mills where you talk about urgent investigations are now required. That's been understood I think since last September –

A. Yes it has –

25 Q. – when the Department of Building and Housing issued its practice note and a second practice note –

A. Yes, and the Commission issued its own report.

Q. And then we our interim report on the 11<sup>th</sup> of October so it's not something that needs to take place from today –

30 A. – No, indeed.

Q. – It's a process that presumably is underway?

A. Yes and I have referred later in the opening to both of those matters but it is one of the issues I had asked Professor Bull to speak to when he gives evidence about what is going on and he said to me when I spoke to him on the phone that structural engineers have got a grip of this, it's  
5 underway, and he will tell us what is being done when he gives his evidence as I understand it.

**MR MILLS:**

Now, turning then to paragraph 19, and I have tried to just briefly summarise what it is that the various parties have agreed on as the cause of the collapse  
10 and the remedial steps required. As I have said before this will be dealt with in much more detail by BECA when Mr Jury and Dr Sharpe give their evidence but, in brief, the conclusion is that in the face of the strong lateral shaking the building experienced in February that seismic gap that we saw on the structural drawings was insufficient or gave insufficient space for the pre-  
15 cast scissor stairs to respond. The result of that was that the stairs compressed or, as I would put it in more lay terms, "crushed" when they reached the limits of the space available in that seismic gap. The effect of it was that the length of the stairs was actually permanently reduced and the stairs slumped and then when the lateral movement of the building swung  
20 back the other way the stairs literally fell off the seating that they were on and I think it would probably be useful to just bring up that document and that will be tab 3 in the Commissioners' bundle and you will see there this is taken from the BECA report of course. You'll see there the sequence that is thought to have occurred. It starts out with the 30mm gap, the building moves one  
25 way and the gap closes up and continues to move and you'll see there the drift distances at which that is thought to begin to happen. As I understand this diagram – at 34mm which is the third sketch down, the bottom steel begins to yield, the stair unit begins to deflect down and then once that drift reaches 65mm you've got the consequences that are shown on that fourth  
30 flight of steps, the gap closes, the stair unit continues to deflect down and it shortens by 31mm. Then you see what happens next when the shaking then

moves in the opposite direction and that stair then moves the other way and there's that seating which is shown in the fifth sketch down and the stair because it has been permanently shortened then is not long enough to stay on that seating and literally slides off it and the conclusion in the various reports is that probably then what happened starting at a fairly high level in the building, bearing in mind that the stairs are still there above level 15 and 14, one stair then struck another and it cascaded the whole lot down the building. Just to complete that...

10 **JUSTICE COOPER:**

Q. So, just in my layman's terms at the top of the stair the landing and the stair and the wall are effectively joined together and operating as one fixed point.

A. They are fixed at the top.

15 Q. The building sways in the earthquake and that effectively pushes the bottom of the stair –

A. Yes –

Q. – across the seismic gap to the point where it can't go any further?

A. Yes, yes that's my understanding. It's fixed at the top flight so the stairs for pre-cast is a double flight as you can see here which is a single unit, fixed at the top, landing in the middle and designed to move only at the bottom and some of the stairs as BECAs will no doubt describe in their evidence continue, well I think some at any rate, continue to hang from their top end – might be one I think.

25 Q. Yes I read that.

A. But it's the bottom moves, isn't enough space for it so it gets squeezed, it compresses and at a certain point in that movement it permanently compresses. As I understand it, it regains a little bit of its length as the pressure comes off but ultimately it's compressed to a point where it's too short to stay on that seating, that steel seating as it moves back the other way.

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**MR MILLS:**

Now just to complete the relevant documents that you've got in front of you, if we could then go to what in your bundle is tab 4, and it's BUI.COL764.0003.15, that'll just show us the position of the stairs in the building, there it is. Now those red lines in the upper diagram are the, as it says on it, the steel channels that support the stairs. They also supported the prefabricated toilet system in the building, so they're running out not just to support the stairs, but also a prefabricated toilet unit as I understand it which would have been swung into place and sat on those steel runners as well, and then if we could have the one down below. This will be familiar I know to the engineers on the Commission, probably to Your Honour as well, but for others who are here it we could just see the scissor stairs which are just below that. So there's the system, and so that top end is fixed, the bottom end slides. And one of the concerns that has been stressed about this in the reports is that scissor stairs themselves are a concern because they are very vulnerable because when one comes down the other one generally will come down as well and so the only means of egress from the building in an event like this is gone and so there are some real concerns expressed in the panel report in particular about scissor stairs. That's something I expect that Professor Priestley will touch on when he gives his evidence.

Then at paragraph 21 of the opening and I'll just take you in more – I think we might have already had a close enough look at this but just in case we haven't I'll take you to the next document that's referred to there which is tab 5 in your bundle. Can we just enlarge that a little bit for people who are only seeing it from the screen? Yes if we can just do the top one first perhaps. This will show in more detail Your Honour the question you were just asking me. So there's the top support detail and you'll see how that's fastened, the stairs go down from that and then if we could just go down to the bottom stair detail, this'll show the seismic gap. If you would just enlarge that as well that'll be good. Yes, so that'll show it in more detail than we've seen it before I think. So you'll see that the capacity for movement is a combination of the seismic gap of 30 millimetres and the seating that steel runner that it's sitting on, is 72

millimetres, and so one way it can go 30 millimetres before it starts to compress, yet when it comes back the other way it's got that 30 millimetres plus the 72 millimetres to move back again. If it goes more than that it's in trouble as it was here.

5 Now at paragraph 21 of the opening I just observe again that Mr Rob Jury and Dr Richard Sharpe will explain this in much more detail and that is the design feature that's critical to this collapse scenario.

Now at paragraph 22 I have probably already touched on most of the points that are made there about the design allowing it to slide, the risk of  
10 compression and the consequences of that and the fact that this collapsed in that way.

Now in its investigation as I say at paragraph 23 BECA identified several factors that affected the actual width of the seismic gap and the first of them is that the pre-casting of the stair units may have removed the option of  
15 adjusting the stair length when it was installed if there was found to be a problem, and it does appear, particularly from some site reports that we received from Holmes Consulting Group yesterday that there were some difficulties with stair length, whether it was the stair length or the tolerances of the building, I don't know, but there clearly were some issues about having to  
20 try and adjust for the length to maintain the seismic gap, and secondly and again this will be shown later on in some of the photographs, some of the collapsed stair units appear to have had the lower end ground back or cut back with a concrete saw but the problem that was identified with this when BECA looked at the stairs, is that that there's a steel cap at the bottom of the  
25 toe at that bottom stair, and that had not been cut back so the concrete was cut back but the steel cap was not and as a result that attempt to shorten the stairs would have been ineffectual.

The third issue which has a bearing on the inspection or the assessment process is that it appears the seismic gap at least in some cases had been  
30 filled either in part or entirely with things such as construction debris and mortar and also a polystyrene strip and again BECA will no doubt describe this in more detail but it appears that what had happened was that in order to

get a straight edge on the seismic gap when the concrete was being finished on the landing, that a polystyrene strip was put in the gap so to give an edge to work up against and in a number of cases, not clear how many, the polystyrene strip was left in there and even though of course it would  
5 compress it wouldn't compress infinitely so that was taking up some of the 30 millimetre gap.

**JUSTICE COOPER:**

This is just by accident I take it?

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**MR MILLS:**

One assumes, yes. Although having said that, I think Mr Tonkin touches on this, the site manager from Fletchers. It's possible that because there was carpeting or vinyl subsequently put over the gap, and the gap was intended I  
15 think to be filled with some kind of flexible material like silicone so that the cover could go over it, that there's some suggestion that the polystyrene strip might have been a fairly convenient base on which to put the silicone but that's conjecture really, but that is a possibility that it was used when it shouldn't have been to stop the silicone dropping down into the gap and  
20 cutting back is the suggestion, cutting back the top of the polystyrene strip but then using that in part to give support for the flexible filler that went in.

**JUSTICE COOPER:**

Well then what would remain of the polystyrene, would it still impair...

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**MR MILLS:**

Potentially in the gap.

**JUSTICE COOPER:**

30 ... the utility of the gap?

**MR MILLS:**

It would, yes. I was just responding to whether it was accidental, and –

**JUSTICE COOPER:**

Do we know the answer, or ...

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**MR MILLS:**

No we don't know the answer, no. I don't know whether BECAs will be able to cast any more light on that but certainly I'm not able to go further than that.

Now then just touching on the urgent remedial action that's already been  
10 recommended which Your Honour referred to, and I won't go through it in detail, I've set out there the recommendations the Royal Commission made in its interim report back in October. I've also given the reference to the Department of Building and Housing Practice Advisory that they issued for anyone who wants to look at that. That's at tab 6 in the Commissioners'  
15 bundle, and I do just note that that Practice Advisory expresses a particular concern about stairs designed to what they describe as the 'gap and ledge detail' and that is the design that has been used with the Forsyth Barr stairs.

I've set out there the recommendation that is in that advisory note and it is that the clearances and seatings for stairs should be sufficient to accommodate at  
20 least twice the ultimate limit state inter-storey drift. They've urged structural engineers who are undertaking building assessments for clients to strongly recommend to them that this include checking stairs and carrying out any necessary retrofits, and the advisory also urges that the seismic gap be checked for obstructions. There's a very similar recommendation, at least as I  
25 1010

understand it from the expert panel, the Department of Building and Housing expert panel. It too has urged that there be a provision for at least twice the ultimate limit state inter-storey displacements but adding, of course, after allowing for construction tolerances.

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**JUSTICE COOPER TO MR MILLS:**

Q. Now Mr Mills have you formed a view on which of these recommendations is the more strict?

5 A. Well as I, I would have thought that the Department of Building and Housing was slightly because of its recommendation that this be included in the Building Code and I don't think that's in the Practice Advisory.

Q. Yes but in terms of what the Commission, compared to what the Commission was recommending in its interim report.

A. Well I think they're all –

10 Q. I've no doubt Commissioner Fenwick knows the answer to the question.

A. Well Commissioner Fenwick will know the answer because I discussed it with him (inaudible 10:11:04).

Q. My question was about your – can you help with that or should we just move on?

15 A. Yes I think, not as much as Professor Fenwick will be able to, but the Commission's recommendation is as I understand it potentially requiring a larger capacity for inter-storey drift than either the advisory note or the expert panel are recommending and I see I'm getting an affirmative nod so I was listening when the Commissioner told me that.

20 Q. All right. Well you've passed that test Mr Mills. You can move on now.

### **MR MILLS:**

Turning then to the way that the stairs had been treated in the previous standards and the current standards and I just briefly touch on this. The performance of the Forsyth Barr stairs appears at least in part to be a consequence of the way in which the stairs are treated in both the present and the current standards. Stairs in buildings are both required to meet what is referred to as the ultimate limit state and that in turn implies a high level of confidence that there will be no collapse in a 500-year return period earthquake. What this has not sufficiently factored in as I understand it is the way in which stairs respond to lateral shaking is different to the way in which the building structure itself responds and as I say in paragraph 29, and the

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Commissioners will all be well aware of this, a modern ductile building is designed to be able to sustain a number of sustained cycles of ground shaking without collapsing. On the other hand, and one can see this looking at the design drawings we looked at a moment ago about the way this stair  
5 fitted onto the seating – the way in which stairs perform can be the consequence of just a single cycle. So they don't have this ability to withstand repeated cycles backwards and forwards the way modern, ductile buildings do. A single big movement can finish the stairs and that does not appear to have been adequately factored into the way in which the standards were  
10 written and that now seems to be recognised, as I understand it, as a problem that was shown up in the Canterbury earthquakes and is now well understood and appreciated I think.

I turn then to what I perceive to be the issues in this hearing in light of the agreement, essentially, about what happened to the stairs, what the problem  
15 is and what has to be done about it and because of that it seems to me that the issues that the Commission is now concerned with are not so much with that but with some other matters that have been thrown up by what's occurred here.

The first one is the choice of this design in the first place. There is, BECA  
20 now have described it, as has the panel, as a design with a worrying lack of resilience and the reasons for that I think are fairly apparent from looking at those drawings. There is an issue which has emerged which I've touched on in that second point on the top of the page, about whether there were other more resilient designs known at the time that the building was designed and if  
25 there were why an alternative design was not selected. It appears to be a point of some real disagreement between BECAs and Holmes Consulting Group and I'll just refer you to the document that records this just so the Commissioners can be aware of it. When the draft final report from BECA was sent out for comment it was, of course, sent to Holmes Consulting Group  
30 and if you go to tab 8 you will see the correspondence here with Dr David Hopkins of the Department and, there it is up there on the screen. If you go to the second of the two pages you've got in that bundle which is point 19 you

will see there that Holmes took objection to the statement in the draft final that there were known alternatives to the seismic gap detail and expressed concern that the use of the word known could be unfavourably interpreted as alternatives were known at the time. Accordingly we requested this bullet be

5 reworded and they set up the rewording they wanted and you'll see BECAs response there in red and they resisted that requested change and said they believed there were alternatives to this stair detail being used by other designers at the time, the use of the word "known" and the implication are correct. So there is an issue there that I think needs to be teased out in this

10 hearing about what is that alternative and why was the selected one chosen. Then we've got an issue around the seismic gap and the level of attention that was given to that at the time this building was constructed. Was there a full appreciation by the contractor about how significant this was. If there wasn't, and Mr Tonkin as I understand it is going to say that there wasn't, then is that

15 typical of a wider issue that might be there in other buildings of this era, that it wasn't sufficiently focussed on and I've, I will just take you as well to the Hyland reference. Just before I do that I should say that we've, as I mentioned earlier, that in the last 24 hours or so we've received some site reports from the Holmes Consulting Group which do reference the seismic

20 gap during the course of construction. So the question about the level of attention it got is now not entirely clear but at any rate in any event that's an issue that I think is one that we need to just take a look at in the course of this hearing because if it does reflect a lack of sufficient appreciation of how important it was then that might have some wider implications.

25 Then of course there's the question about the extent to which the design of the stairs in the Forsyth Barr building or similar buildings, or similar designs that depended upon the same kind of movement and had the same vulnerabilities have been used elsewhere in New Zealand.

Then the inspection process, we need to look at that.

30 And then the correctness of BECA's conclusion when it did its level 2 assessments that the stairs still contained sufficient capacity for normal use.

Now just before I go to that I want to take you to tab 9 in your bundle of documents. This is the extract from the Hyland report. They did a site examination and materials test, study, as part of the DBH enquiry into the Forsyth Barr building and that is, for the purposes of bringing it up, it's  
5 BUI.COL764.0008.1 and the pages I want to take you to are point 5 through point 8. Now you'll see there and I think it's possibly highlighted in the copies that the Commissioners have got, you'll see that there's a discussion of the seismic gap in the last four paragraphs on that

1020

10 page referring to the 30mm observing that the construction drawings, rather the structural drawings did not specify any particular construction tolerance – that's an issue that I think Holmes will be able to cast some light on – and referring there to the existence of the polystyrene construction packer. It was found in one of the remaining stair flights, hadn't been removed. Then, in the  
15 next paragraph referring to other ways in which the seismic gap had been compromised and Hyland says in a number of instances it had been compromised by the installation of a rigid mortar strip up to 30mm thick seated on expanded foam rods, so that would completely use up the space, and then also referring to the fact that some of the landings showed the ends of the  
20 stairs being cut off, which was the point I mentioned earlier, but as I noted to you there was a steel cap at the bottom that wasn't cut so that didn't serve much purpose and if you turn over, there's some photographs that are worth looking at just briefly at point 7 and you'll see he's also sketched in the way in which the polystyrene board packer was put into the seismic gap and that's on  
25 Level 16. Next photograph please, or next two photographs. This is point 7 in the Commissioners' bundle. There we are, if that could be enlarged a little so the people behind me can see it. So there's the polystyrene in there. And then if we could go to the next photograph, which is point 8, or series of photographs. You will see that this is on Level 15 and the Hyland Report  
30 describes this as showing debris and also the saw cut and then the sketch shows the vertical slumping that occurred as does one of those photographs.

So that's bringing your attention to that because it's a visual depiction of the issues that I've just been talking about.

**JUSTICE COOPER:**

- 5 Q. The text of the report refers to figure 3.  
 A. Which is the one on point 8.  
 Q. Which you're looking at.  
 A. With those four photographs.  
 Q. And then it says A, B, C, D.  
 10 A. Yes.  
 Q. But the photos are not labelled.  
 A. No I know they're not I'm assuming –  
 Q. So we assume it's A, B, and then C, D on the bottom line.  
 A. Yes that's what I've assumed.  
 15 Q. So B is said to depict the seismic gap with debris removed showing saw-cut end and ledge at seating angle.  
 A. Yes I think, it's not all that easy to see but I think where that arrow is in the top right-hand photograph is where the saw-cut has taken place and you'll see the ledge down there if one imagines it I think.  
 20 Q. I agree its clearer on the screen than in the reduced size.  
 A. Well it might, yes it probably is actually. And then you'll see, if you go to the left-hand bottom one with the tape measure shown down there, that's showing the slumping that has been described at the first riser. Some of that slumping will also be apparent in a photograph that I think  
 25 Mr Cameron's going to refer to.

**MR MILLS:**

- Now I have given you at Tab 10 of the Commissioners' bundle a first look at the Level 2 assessments that were done by BECA and we'll just pause on  
 30 that, not because I intend to deal with that in detail at this point but just because it will allow the Commissioners to have sort of a first familiarisation with it and it will certainly come up more later in the course of the hearing. So

that is Tab 10 in yours and for the purposes of bringing it up on the screen it's BUI.COL764, there it is. So there were three level 2 assessments. There was a level 1 assessment done initially which gave a red tag to the building and I haven't put that in there. I haven't seen it. It didn't seem important. But  
5 there were three level 2 assessments and one was on the 5<sup>th</sup> of September but then another on the 6<sup>th</sup> of September which you'll see at Tab 12 I think, no you won't you'll see it at Tab 13. No you won't. No, yes you will, sorry. I'll just put an overview on this.

10 **JUSTICE COOPER:**

Well I should alert you to the fact that in our bundle the contents of Tab 10 appears to be the same as that as Tab 13 and both are dated 6 September.

**MR MILLS:**

15 Yes, let me give an overview of this. Three level 2 assessments – 5 September, 6 September, and either the 13<sup>th</sup> or the 15<sup>th</sup> – there's two different dates given for that one. It doesn't matter in any material way but I did observe that is given different dates, different places. But what has happened here, as I understand it, and again the BECA witnesses, Mr Jury, who was  
20 involved in this assessment will be able to clarify it if I'm wrong, but the report that was done on the 5<sup>th</sup> of September was, in effect, added to on the same document when the assessment was done on the 15<sup>th</sup> of September or the 13<sup>th</sup>, whatever it was. Now, in fact, it may be, when I look at this again, that it's the 6<sup>th</sup> September one that's been added to. So you've got, in effect, if I  
25 can just take you to Tab 13 and I'll show you how this works. This is the 6 September assessment and it's been typed up and then, if you go to the second page of that, you'll see the reference to inspection on Monday the 13<sup>th</sup> of September, just below that grid, and that's been added on the same document, probably fairly sensibly to keep it all in one place, it's been added  
30 to the 6 September one, so you've really got two reports under that Tab 13. You will see the set out at the end of that Tab 13 you'll see this is taken from the BECA report, the dates of the various assessments that were done.

They've given it as the 15<sup>th</sup> but as you've just seen it's dated the 13<sup>th</sup> in that handwritten note under the grid on page 30. But I don't think it matters at all.

**JUSTICE COOPER:**

5 Well I'm pleased about that.

**MR MILLS:**

So was I. I can't see any relevance to it other than the fact that I just draw it to your attention. So those are the assessments but, as I say, I won't dwell on  
10 them in any detail at this point because we will be coming back to them but I just wanted the Commissioners to have a first look at them.

So coming back to the opening submission just following that sub-paragraph F, I see the pages

1030

15 aren't numbered so I just have to say to you the next page, five points are set out which are relevant to the consideration that will have to be given to the conclusion that BECA drew that the stairs still contained sufficient capacity for normal use because there is some concern, and Mr Cameron's evidence will express this in part, that in effect how could that conclusion have been  
20 reached in light of some other observations of damage to the stairs and if I just take you to tab 10, and again I won't spend any great time on these because Mr Cameron is going to deal with these and explain them, but again just to foreshadow some of the concerns that arise around this, if we could just go to – sorry it is tab 11, WIT.CAM0004.9 and you'll see there the  
25 photographs that Mr Cameron will deal with, and you'll see the drop in the stairs, and you can see that by reference to the white line that has emerged between the stairs and the black border to the stairs, and then the photographs that were taken with Mr Cameron present I think, of the underside of some of the stairs and the cracking that can be seen there. So  
30 that's what the Commissioners have already seen in the photographs that you've got, and you'll see it again when Mr Cameron gives his evidence.

Now I've covered already the points that are made in paragraph 34 about the number of assessments and the various changes. The only additional point that I make at this stage about the assessments and I won't go through this in detail, it's there for the Commissioners and other counsel have got a copy of this opening, is that the BECA assessment did identify the potential compromise of the seismic gap but gave a green sticker to the building without the seismic gap being checked and that is an issue that BECA will have to be asked about. It is an issue that's caused some concern in some quarters, that although the direction was given that this be done, it was not done. Now just again to give an overview of what will come in relation to why that might be, I think it's clear when BECAs were retained to do the level 2 assessments and they were retained by the property manager, that they anticipated that they would be retained to go on to do a more comprehensive investigation. In the end they were not. After doing the level 2 assessments the owner decided that Holmes Consulting Group would be brought in to do that more detailed engineering assessment, and the result of that was that BECAs stepped out of this, Holmes Consulting Group came in and there is then some confusion around what happened next which I think has finally been clarified and will be the subject of evidence, but at least initially it appears that the terms on which Holmes was contracted to do this work, would have included the stairs. That's an issue I'll have to put to Mr Hare but I think it did, but subsequently it appears that there was a discussion on site with a Mr Andrew Christian who was with Pace which was a property management group which led to a decision to defer any careful examination of the stairs until a later stage, more particularly when the vinyl on the landings was going to be lifted so that it would be possible to see the seismic gap and so on. Now again there's going to be an issue around that decision to defer. Was that an appropriate decision in light of some concerns that had been expressed about the condition of the stairs? And there's also I think an issue around what happened to the level 2 assessments that were done by BECAs. We know that it went to the Council. That's been confirmed by the Council but it seems not to have fed into the subsequent work that Holmes did and so the

concerns that BECA had expressed appeared to in effect have dropped between two stools and so that issue is one that will need to be explored in the course of the hearing.

Now that pretty well gets me down to paragraph 43 and again just so the  
5 Commissioners can have an initial look at this I'll take you to the terms of engagement on which Holmes was engaged. Firstly the fee proposal that they put in, that's at tab 14, and that's BUI.COL764.0022A.1 and the Commissioners will see that stage 1 in setting out the scope of the work, the proposed work, was to complete a preliminary structural survey of the building  
10 to identify the general form and location of earthquake damage and second to complete a review of available documentation of the building to identify potential hotspots for a more detailed investigation. Now there are other provisions set out there. Not all of the proposal is included. Those are the particular points that I draw your attention to.

15 Then following that we've got under that same tab, we've got the report that Holmes Consulting Group provided on the 29<sup>th</sup> of November and that's BUI.COL764.0003A.26. So this is the – there's no dispute as I understand it that that proposal became the basis of the contract. It was accepted on behalf of the owner and led to this report and I've dealt with this in paragraph 44 of  
20 the opening submissions and you'll see there under 1.1, the purpose of the study was to review the impact of the Darfield earthquake on the building, identify any significant life safety concerns, map typical damage around the building and identify those items requiring repairs or replacement. And then under the Scope of Work under 1.2 it includes reviewing the structural  
25 drawings to determine the building structural systems and predict likely areas of damage, and inspect sufficient of the building structure to be able to make a determination of the behaviour of the building in the earthquake and map damage to the structure. Now there's been some issue raised about whether the work that Holmes was contracted to do included the stairs. I don't know  
30 whether that will emerge in the course of Mr Hare's evidence but those are the terms and they seem to me to clearly encompass the stairs within the scope of works.



Now the other document I just draw your attention to which is under that same tab forms part of the 29 November report that Holmes did and it's headed 'Appendix A, typical building forms' and that is BUI.COL764.0003A.45 and you'll see Commissioners when

5 104000

you look at that that, as it says, it outlines the generic performance and damage expected of a variety of building forms constructed at different periods in New Zealand's construction history and the passage I want to take you to, and it's missing a page so we are going to need .46 as well. It's the

10 passage at the bottom of the page you do have which says, "Up until the late 1990s the stairs are prone to collapse" and the balance of that statement which might save a great struggle to find it is in the opening submission and what it says was, "Up until the late 1990s the stairs are prone to collapse due to the jaming between floors. Subsequently detailing of the stairs sliding at

15 one end became the accepted feature". So that's identified by Holmes in its report as being an issue in their description of typical building forms which has some bearing on the reporting issue that I'll need to ask Holmes about.

Now, in addition, and you'll see this in the last page under your tab 14, this is paragraph 47 of the opening, the Holmes report under that .5 there also

20 makes reference to the torsional behaviour that maybe caused in a building by, among other things, stairs. So the point I'm simply making is there are references to stair issues in the Holmes' report, albeit as an appendix and some issues identified there relevant to how stairs might perform.

25 **JUSTICE COOPER**

Q. Mr Mills, we've got those other pages have we but they are just not in the bundle?

A. You have the one I just mentioned is .48. It's the last one under tab 14.

Q. But there's a sentence –

30 A. – on the previous page that's missing.

Q. Well on the document with the suffix .45 – "Up until the late 1990s..." You've completed the quotation I think in your submissions.

A. I have but there's a missing page in there and in the bundle Your Honour that the Commissioners have got but I have completed what is in there in the opening.

Q. We've got the whole document I take it?

5 A. We do have it. It's just failed to find its way into this bundle and Mr Elliott has just reminded me that it's in the BECA report, it's an appendix to the BECA report. This is where this is taken from and obviously on the next one, the final page under that tab 14, I've just put in the single reference which is of interest in my submission.

10

**MR MILLS:**

Now I then, going to paragraph 49 of the opening, and I have alluded to this previously, there has been some uncertainty about why the stairs were not addressed. There are two emails that specifically record the building owner's  
15 concern about the condition of the stairs and Holmes initially, or Mr Hare initially, took the position through his lawyers that Holmes Consulting Group had been specifically told they didn't need to address the stairs. These two emails were subsequently brought to Mr Hare's attention and I'll just take you to those in a moment because again they come up later and the position that  
20 we've now arrived at is a little different and it is, as I have said before, it wasn't that they weren't to be included but rather they weren't a priority and I'll just take you to tab 15 and for the purposes of bringing it up it's BUI.COL764.0035.5 and you'll see there the email chain that emerged after that initial position was taken by Holmes or by Mr Hare and the first one is the  
25 one at the bottom, 12 October, Michael Connelly is from Colliers Property Managers. He's acting for the owner and the 12 October email is the response to the fee proposal that I took the Commissioners to a few minutes ago – "Please proceed with this report as soon as possible". And then you see he goes on to say, "Andy Christian of Pace has done a survey of the  
30 building so can advise on some areas of concern. I want to be sure the spares are okay and fixed correctly. Some cracks were covered by the plasterer. These need to be double-checked."

Then there's the response, and you will see that goes to John Hare. Then the response to that from Mr Hare to Mike Connelly reporting on the building saying, "Contrary to some of my worst expectations this building has done well..." and so on and then the following day an email back from Mr Connelly to Mr Hare, this is the 4 November email, "John, thanks for this. I have a concern about the apparent drop in the stairs. I assume your report will cover this and the best way to repair."

So that's the background to one of the issues that will have to be dealt with in the course of the evidence. That's where we get to in the emails but then subsequently there was a discussion and Mr Christian has given us a signed statement which the Commissioners have and I'm not going to call him to give evidence, I didn't think it was necessary, confirming that there was a discussion which in effect led to the advice to Holmes that the stairs would be looked at when the vinyl was lifted and Holmes would be advised when that happened and it didn't happen before the February earthquake so the stairs were never reported on by Holmes.

**JUSTICE COOPER:**

Q. Are the events that occurred now the subject of agreement?

20 A. Yes they are in terms of the exchange between Mr Christian, Mr Andy Christian and the Holmes people. Yes it's accepted although earlier on it looked as though there was a dispute.

Q. Yes I understand that but how is the agreed position going to be brought before us?

25 A. Well Mr Hare will give his evidence and that's not going to be disputed and Mr Christian's statement which I've provided will confirm the essence of that, that there was this discussion which led to a deferral of the investigation. There is a question about whether that deferral should have taken place but nonetheless the essence of the factual underpinning of that is not going to be disputed anymore. And I have referred to that at paragraph 51.

30

**MR MILLS:**

Now as I have said at paragraph 53, other than the witnesses that will be being called, this is the end of the opening. It seemed to me at any rate that in the end the relevance of this issue about what happened as between Mr  
5 Connelly and Mr Christian and Mr Hare and how it was that the BECA report identified problems that were never taken up and dealt with, from the Commission's perspective is probably principally again the kind of issue that I know the Commissioners have seen again and again which is the systems that were working here. Was there a systems failure of some kind? And the  
10 fact that relevant information in the BECA reports wasn't dealt with. It was available to the Council. The Council had it on its files. I will need to ask the Council about what they do with these level 2 assessments, how they are utilised, what knowledge they had about whether it had been carried forward on the building and so on but that seems to be, to me at any rate, to now be  
15 the issue here that something relevant to the building went somewhere but didn't go where it needed to go in retrospect.

So unless you have any questions on any of that I will just run through the witnesses that are going to be called. The first witness is Mr Grant Cameron and then, as I indicated to you before, we are going to then call, and Mr Elliott  
20 1050

will call him, Mr Ewan Carr who will, like Mr Cameron, give some evidence about the damage to the stairs that he says he saw post-September and so that's been put up first so that when BECA give their evidence they will be able to respond to it however they think is appropriate.

25 Following those two witnesses we'll be calling Mr Rob Jury and Dr Richard Sharpe to present the BECA report. There will be some questions for them around the assessments and this issue that they have with Holmes about the design and whether there were alternatives.

Then Professor Nigel Priestly will present the expert panel report on the stairs.  
30 At least on the timetable where it's expecting to work to that will be all we will do today, in part because Mr Tonkin isn't available today and we thought it was important that he give his evidence before Mr Hare gives evidence. So

he will be called first thing in the morning. He was the site manager for  
 Fletchers and, as I indicated previously, he will give evidence about the  
 significance that was attached, as far as he was concerned to the seismic gap  
 and the importance of not compromising it and the importance of it being  
 5 precisely 30mm when they were building the building and also some  
 comments on how it would be dealt with today, at least at Fletchers.

Then John Hare will be called and you're aware now of why he is being called.  
 Mr Stephen McCarthy is being called and I assume his evidence will be led by  
 Mr Laing to deal with the regulatory issues at the Council end.

10 And then, finally, Professor Bull will wrap up the hearing and he hasn't  
 provided a written brief but I've asked him to put the Forsyth Barr stair issue  
 into a wider context and to give evidence about the difficulties or not in doing  
 retrofits and what's currently going on round the country to try to deal with  
 these problems that have been identified.

15

**JUSTICE COOPER:**

Q. Yes well I'm sure that will be most interesting. Mr Mills if we got to the  
 position where we had time on our hands at the end of today would  
 there be any reason why Mr McCarthy couldn't be bumped up the order,  
 20 from your point of view.

A. Yes we could do that. I had thought that he too would probably want to  
 hear what Mr Tonkin has got to say because it raises some issues about  
 Council inspection of these issues. Now as Commissioners know from  
 previous hearings Mr McCarthy wasn't at the Council at the time so I'm  
 25 not entirely clear the extent to which he will be able to deal with that.  
 But that was the reason for the order but, yes, we probably could do that  
 without any fatal consequences. I can put to him what Mr Tonkin is  
 going to say.

Q. Yes well maybe the triumph of optimism over experience anyway but  
 30 you can perhaps confer with Mr Laing about whether –

**JUSTICE COOPER TO MR LAING:**

Q. Mr Laing if you saw an issue about that you would no doubt let me know.

A. I might just talk to my friend during the adjournment.

5

**MR MILLS CALLS****GRANT ASHLEY CAMERON (SWORN)**

Q. Your full name is Grant Ashley Cameron.

A. It is.

5 Q. You've had 31 years of experience as a solicitor.

A. I do.

Q. You're a principal in the firm of GCA Lawyers.

A. That's right.

10 Q. And in 1995 that firm took a lease of premises on the sixth floor of the Forsyth Barr building.

A. Yes.

Q. And you were in that building when the September and the February earthquakes occurred.

A. Yeah the firm occupied that site.

15 Q. All right, well you've got a statement of evidence there. I'll ask you to start reading it then please at paragraph 3.

A. "The earthquake of Saturday the 4<sup>th</sup> of September 2010 occurred early in the morning and so it was not until Monday the 6<sup>th</sup> that I became aware that Forsyth Barr House was closed, apparently because of a red  
20 sticker. At that point none of us knew what a red sticker meant but it quickly became clear that we could not access the building pending some sort of further assessment as to its safety. Enquiries of the owners revealed that some stairwell damage had apparently occurred but no other information was forthcoming. Given the considerable  
25 uncertainty then pertaining I began preliminary planning for the firm's possible relocation to another site. On about Wednesday the 8<sup>th</sup> of September we were informed by Colliers that the owners' building managers, sorry they are the building managers –"

30 Q. Can I just ask you to pause. I take it there's a deletion there to be made –

A. Yes.

Q. – to the written statement taking out the words 'days later'.

A. That's right. "– that the building could be accessed by tenants only but that it was otherwise in lock-down mode. This meant that we could enter by using our security cards but the public could not have entry. Straight after we re-entered the building I was advised by a staff member that there was considerable damage to the stairwells and that it appeared quite serious. I accompanied Sean Cottrell, one of our associates to the landing situated between the corridor from the lift-well's foyer and men's toilets on the sixth floor." Now that foyer or that, the men's toilets are on the south-east side of the building. "Although there was a lot of damage to the walls where plaster-board had cracked and general movement had taken the panelling out of shape, the most prominent damage was to the concrete stairs themselves. It was clear that they had sagged somewhat as the paint on the walls was now separated from the stair treads by about a centimetre or more for most of the length of each flight. The separation from the original position flush with the edge of the paint was clearly visible on both the stairwell leading up to the seventh floor and on the other leading down to the fifth. Close examination revealed that there had been both vertical and horizontal movement from the stairs original position. Of even greater concern was the fact of this quite distinct cracking on the underside of the stairwell immediately above us. Thus when standing on the sixth floor beside the men's toilets and at the base of the stairwell leading up to the seventh floor, the underside of the flight directly above was clearly cracked – that's the underside of the stairwell leading from the seventh floor to the eighth floor."

Q. Would it be helpful to you, Mr Cameron, if we went to the photographs you're describing?

A. Yes.

Q. They are the ones the Commissioners saw briefly in my opening.

30 **WITNESS REFERRED TO WIT.CAM0004.9 AND .10 AND .11**

Q. That's the first of them and that white line I take it is what you're describing as the drop that you had identified?



A. That's right, that's correct.

Q. And did that run all the way up the flight?

A. Yes it did. I think there was less movement towards the very top of the flight where it was affixed to the, sorry the floor plate above but it did  
5 extend most of the length.

Q. And are you, are you at mid-landing or are you at the bottom of the double length steps at this point?

A. This is standing at the bottom.

Q. The very bottom.

10 A. So these would be in the first four or five steps leading up.

**JUSTICE COOPER:**

Q. So you're on level 6.

A. That's correct.

15 Q. And that's the staircase going up to 7.

A. Leading up to 7, that's right, sir.

**EXAMINATION CONTINUES: MR MILLS**

Q. And then if we could just go to the other two photographs that you've  
20 been describing so that you can comment more visually on this.

A. So this is a shot taken from a few steps up on the level 6 to level 7 stairwell and it's looking up at the underside of the level 7 stair and where that flight comes down and joins the level 7 floor plate you've got this flat area, in other words the area that we're looking at here  
25 displaying the cracking is in a horizontal plane on that flight.

Q. So this is the mid-flight landing is it?

A. No.

Q. Or this is the top of the –

A. No, this would be the bottom of the flight leading between 7 and 8.

30 Q. So, in effect, the seismic gap that we've talked about is up at the top of the picture, is that right (inaudible 11:00:06) bottom.

1100

A. No I think it's actually –

5 Q. It's at the bottom?

A. - yeah, I think you can see the metal framing.

Q. Yes.

A. Support to the bottom of that flight, so coming down from eight to seven we're looking at the bottom of that flight so this is level seven.

10 Q. I see so that's the, that's the steel seating?

A. Yes.

Q. That the end of the stair sits on with the seismic gap beyond it?

A. Yes.

Q. And the other photograph that you took?

15 A. The next photograph I think is of the same situation. It's just a detailed shot looking to the right if you like of the former photograph. There were about 15 photographs taken but –

Q. Counsel has weeded them out?

A. Yes.

20 Q. Yes.

A. Appropriately.

Q. Do I take it that you were only looking at the stairs on the, really the floor that you were concerned with?

25 A. That's right. We utilised the moment simply because my daughter who was a graduate in Fine Arts photography happened to be present when this arose and we grabbed her and her camera and went out took these photographs.

Q. You didn't do a general exploration of the building?

A. No.

30 Q. And are you able to say how wide those cracks were?

A. I didn't attempt to measure them. This last photograph that we're looking at I would guess it would be seven to eight millimetres on the extreme

right where it's abutting the wall but the cracks as you will see from the former photograph varied in width across the flight.

**JUSTICE COOPER:**

- 5 Q. You've used a zoom lens I take it?  
 A. No I don't think so, I think this is the standard -  
 Q. Fifty millimetre?  
 A. Yeah.

**EXAMINATION CONTINUES: MR MILLS**

- 10 Q. And are the photographs that showed a crack, they're under the same flight that you showed initially with the drop, are they?  
 A. No, these ones here with the cracks are on the floor above between seven and eight, so standing on the landing at six, the first photograph was on the first flight leading up from six to seven.

15

**JUSTICE COOPER:**

- Q. I was finding your paragraph 6 Mr Cameron a bit difficult to follow but you've explained it now thank you.  
 A. That's fine.

20 **EXAMINATION CONTINUES: MR MILLS**

- Q. You were at paragraph 7 I think.

**WITNESS CONTINUES READING BRIEF OF EVIDENCE**

- A. "At about 3.30 pm that day I sent an email to Mike Connelly of Colliers expressing my concerns."

25 **EXAMINATION CONTINUES: MR MILLS**

- Q. Now there's a document reference for that and we'll just bring that document up so you can identify it, it's WIT.CAM.0004.8.

**WITNESS REFERRED TO DOCUMENT**

- A. Would you like me to read that?

Q. Well if there's anything in particular that you would like to draw attention to. I don't think it's necessary to read it as a whole.

5 A. I think the first couple of paragraphs are the important ones where I said to Mike Connelly, "We're at a point where we need a definitive statement on the status of the building. We appreciate that with continuing and major aftershocks there will have to be ongoing structural reassessments and a clear cut decision may be difficult. We also note with concern the stairs' subsidence particularly between six and seven," and I have a note that we hadn't looked further up. "And 10 the serious cracking in the underside of the stair seven to eight (as seen from outside the men's toilets on six). To the lay person that looks structural if not in a 'hold the building up' sense, then at least in terms of 'enabling quick tenant exit in an emergency sense'."

Q. Thank you, I think that's the relevant part. Now you are at paragraph 8.

15 **WITNESS CONTINUES READING BRIEF OF EVIDENCE**

A. "Later that day we received telephone confirmation from somebody called Janine at Colliers that the premises are safe for tenants, but she confirmed the lock-down mode status of the building. No car parks were available and the lifts would not be operating. At 4.35 pm I forwarded a 20 further email to Mike Connelly seeking the full position in writing and at 5.23 pm I received an email reply from Terry Foote. He's a member of Colliers. That in turn attached a copy of an email sent to Mike Connelly a short time before by Gary Bottema, a senior Collier manager. Bottema's email simply confirmed what we'd already been advised. No 25 further written communications were received from the building owners or their managers. About seven days later we were advised by telephone that the building had 'gone green' and that the lifts were again operating and that the public could have access. It was on Monday the 13<sup>th</sup> of September that I arranged for my daughter to visit our offices and 30 together we took a series of photographs and we've been through those."

**EXAMINATION CONTINUES: MR MILLS**

Q. So those photographs as is obvious from what you've said were taken after the building had gone green?

A. Yes.

5

**JUSTICE COOPER:**

Q. So the photos we've earlier discussed were taken on the 13<sup>th</sup> of September?

A. That's right.

10 **MR MILLS TO THE COMMISSION**

And just in terms of getting the chronology here Commissioner, you may recall that the last of the BECA level 2 assessments was on either the 13<sup>th</sup> or the 15<sup>th</sup> of September?

15 **JUSTICE COOPER:**

Yes.

**WITNESS CONTINUES READING BRIEF OF EVIDENCE**

20 A. There was a significant earthquake on Boxing Day that year but I have no information as to how that may have affected the building. The firm was closed for the Christmas break and I don't recall any further damage being brought to my attention when we returned to work.

25 At the time of the earthquake on the 22nd of February 2011, I was sitting in my office talking with Shaun Cottrell. He's one of our associates. It was immediately a lot more violent than anything we had previously experienced and I crouched forward in my chair pondering whether to jump under my desk. As I leaned forward I noticed a very large book case beginning to fall from the wall behind Shaun and although I thought it was going to hit him, I didn't have a chance to yell a  
30 warning because we were consumed by a tremendous noise and all the violence of the earthquake. Fortunately the bookcase missed Shaun

but all of my other furniture and belongings crashed to the ground and we could hear furniture falling all around the office, women screaming and there was general chaos. Although my office was positioned on the Armagh Street frontage immediately adjacent to our Board Room which

5 in turn is situated right on the corner of Colombo and Armagh Streets, the interior wall of my office was glass and so I could see clearly into the interior of the firm. My wife Ilze is the office manager and from the outset I could see her standing by her desk with her eyes and mouth wide open in obvious astonishment but strangely with thick clouds of

10 dust swirling around her. Later we discovered that these clouds were formed by concrete dust from the collapsing stairs being blasted back into our suite through the air conditioning ducts. Shaun and I clambered over furniture, files and other debris and rushed out into the main body of the office. I began calling for the staff to all come down to the Board

15 Room where we could start a head count and get ourselves sorted out. Naturally there was a lot of concern and people were quite upset.” I should add there that I also sent a staff member next door, the adjacent tenancy was the Ombudsman and we got all of their staff into our Board Room as well. “As we returned to our Board Room David Maclaurin,

20 one of our solicitors, came into the reception area from the direction of the lift wells. I noticed half of his shirt was hanging out of his trousers and he exclaimed that he had been in the toilets when the quake struck. He looked utterly shocked and then blurted out, “You won't believe it but the bloody stairs have collapsed.” It took me a moment to register what

25 he was saying but he was quite insistent that the stairs had completely disappeared. He also commented that ‘half the bloody landing has gone as well’ and then described having to carefully clutch to the walls around the sixth floor landing in the dark in order to get from the toilet back into our offices. Suddenly we realised that we could be trapped.

30 Two or three of us then ran round to the corridor on the south-west side of the lift wells to see if the stairs leading away from the landing beside the ladies’ toilets were in place. However the internal door between the

corridor and the stairwell landing was jammed shut with a lot of rubble behind it. It took quite a few shoulder shoves to slowly push it open and even then we probably only got it open 12 to 15 inches. There was about 18 inches of concrete rubble jammed up behind it. As I put my head through the now partly opened door I could see that all the stairs had disappeared as had the dividing wall between the stairwells. There was just a gaping hole stretching down through the middle of the building with blackness both above and below. There were other people standing on other levels both above and below who had also opened the same doors on their respective landings and so there was a little bit of light shining in from behind these various doors and just enough for us to all take in the damage. It was now plain that everybody was trapped on their respective floors. This reinforced my view that the big risk factor was fire. With all the stairs gone there had to be a real risk that electrical fittings would have been damaged or destroyed and at the same time there was a good chance that the fire hydrants might not operate because the plumbing to those may also have been damaged. We returned to the Board Room and had a very quick talk about the options. I suggested to everyone that we probably had enough electrical extension cords in the office to provide ourselves with a form 1110

A. of rope whereby perhaps we could lower people to the carpark on the eastern side of the building. On that eastern elevation the carpark extended up for three floors from ground level and jutted out from the main tower block. Our office overlooked that carpark and as the distance from our floor to that carpark was about 30 feet I was reasonably sure that we would have enough extension cords to come up with a solution. If we could lower staff to that level they could either then run down the carpark ramps to the street or if they were damaged they could escape over rooftops on the eastern side of the building. The staff quickly began retrieving extension cords from around the office and I set about tying reef knots to link them up. The first cord formed from

two such extension leads would probably have been of the right length but other such ropes would likely require at least a couple of joins. As I was busy with this exercise one of the secretaries from the Ombudsman's Office grabbed my sleeve and told me there was a Civil Defence cabinet situated at the back of their office. I asked her what was in it but she didn't know and so a few of us rushed around to find a large steel cabinet with double doors situated in the back corner of their office. Upon opening it we found there were several coils of rope, quite a few sets of gloves and, to my great surprise, a sledge hammer. We grabbed these materials and shot back around to our boardroom. I then explained to all our staff that we had a simple choice. We could stay where we were and await for some form of rescue or we could attempt to escape down the side of the building. To await rescue necessarily meant some sort of crane being found and we had no way of knowing if and when such a crane might be available. After all it was plain to all that this earthquake had been very serious and emergency services would have many other priorities right at that time. I should add there that from our offices we could see the PGC building flat on the ground and we could also see the smoke coming from what later proved to be CTV. Also as we were experiencing some nasty aftershocks and given that the stairs had collapsed we couldn't be sure how secure the building might be. Although there didn't appear to be any column damage we had no way of knowing if the building had been seriously weakened. I explained if there was a fire we may have very limited time to react and described how we intended to use the ropes we'd just found and the unanimous view was that we should attempt to leave the building. We then jammed a desk into an office doorway near the window through which we intended leaving. Once that had been positioned and all furniture was cleared away from our departure point the relevant window was quickly removed with a sledge hammer and we organised two or three males on each rope and having been a mountaineer John Haines from the Ombudsman's Office took



responsibility for tying the two ropes, or tying two ropes around each person. I called for volunteers, Jai Moss one of our associates stepped forward. I asked him to remain in the carpark level so that he could help others following untie the ropes. He was happy with that. He was  
5 safely lowered to the carpark. I called for further volunteers but when nobody moved my wife stepped forward. She too was lowered without incident and at this point the others began to realise that this was quite a safe exit methodology. So this is a photograph showing the exercise. The photograph depicts David Maclaurin on the right-hand side, my wife  
10 about to go out the window, my head's just behind, about to push her out and you can see the – but you can see the vehicle situated on the carpark below.”

**MR MILLS:**

15 Q. Who's in the lower window?

A. That was another office. I can't remember exactly who was in that particular one.

Q. That's a different operation from yours?

A. Different operation and when the cranes arrived were able to assist  
20 them and their was the Japanese ambassador may have been, I think, on the third one. You can see another window missing there as well.

**WITNESS CONTINUES READING BRIEF OF EVIDENCE**

A. “Over the next 90 minutes or so we were able to lower about 15 people.  
25 Ultimately only three of us remained when two cranes arrived on the scene. One was positioned at the eastern end of the building, that's in Armagh Street, and the operator advised he could soon uplift us in a cage. So we used the short interval while he was setting up to lower as many computers and other equipment that we could and shortly after  
30 4.00 pm the remaining three of us were lowered to Armagh Street in that crane.”

**MR MILLS:**

Thank you Mr Cameron. Now I'll just put in where the reference is. I'll give you the reference Commissioners. WIT.CAM.0004.12. Just for completion.

**CROSS-EXAMINATION: MESSRS LAING AND GALLAWAY – NIL****5 QUESTIONS FROM COMMISSIONER FENWICK - NIL****QUESTIONS FROM COMMISSIONER CARTER:**

Q. In addition to what we've learned through reading so much of this event, the concern about no emergency lighting being available in the stairwell. Do you know if there was such a provision in the design of the building?

10 A. I don't know about the design. Certainly there was no lighting very shortly after the quake struck. I think David Maclaurin was remarkably lucky because as he opened the door from the toilet to the landing there was light on at that stage and he could see that half the landing had gone but it went out as he stood there so he had to then escape in the  
15 dark.

**JUSTICE COOPER TO MR MILLS:**

Q. Mr Mills this might be a matter which is worthy of record for us. That the lack of lighting in these circumstances made a very serious situation a  
20 heck of a lot more dangerous than it might otherwise have been.

A. Yes I agree with that. It's possible that BECAs might -

Q. You might draw attention to that.

A. It's possible that BECAs might be able to cast, have some more information about this or Holmes who were involved in the original  
25 structural design. I suppose the architects would be the ones wouldn't they who would normally deal with that sort of issue but, yes, one would have expected there would have been emergency back-up, battery power of some kind.

Q. You might be able to enquire from the architects if that was a provision  
30 in the building or not or the building managers.

- A. Yes, we'll follow that up. In fact we've got the architectural drawings so we'll also take a look at those and see if that might have anything in it.

**QUESTIONS FROM JUSTICE COOPER:**

- Q. Mr Cameron was power on in the office?
- 5 A. Only for a very short period after the earthquake. I'd be guessing but perhaps no more than a minute or two.
- Q. And that was the period when your colleague emerged from the toilet and –
- A. Well he actually emerged after the power had gone off.
- 10 Q. I see.
- A. He had to go around the landing area feeling his way in the dark.

**MR MILLS:**

- Q. I thought you'd indicated he had a brief period of light?
- 15 A. He did. When he was standing in the toilets, in the bathroom if I put it that way, he opened the door, this is after the stairs had descended literally four inches through the wall beside him and he, the light was on behind him so in that light he could see that half the stairwell had gone on the landing area and then the lights went out. So he was left in pitch
- 20 dark and then felt his way around the wall to avoid that gap and had to sort of swing on the door to get actually physically into our premises.
- Q. And do I understand that the light that he was getting even at that point was from the bathroom rather than from the stairs?
- A. Absolutely. There was nothing in the stairs whatsoever. That was just a
- 25 void. It was from the bathroom and I imagine his light went out as ours went out.

**QUESTIONS FROM JUSTICE COOPER:**

- Q. Mr Cameron we're most grateful to you for that very interesting and at times entertaining account but I'm sure at the time it must have been an
- 30 extremely frightening set of circumstances in which so it would appear you were very helpful to everyone there. So well done.

A. Thank you very much Sir.

**WITNESS EXCUSED**

**COMMISSION ADJOURNS: 11.17 AM**

**COMMISSION RESUMES: 11.37 AM**

**MR ELLIOTT CALLS****EWAN ROBERT CARR (SWORN)**

Q. Your full name is Ewan Robert Carr?

5 A. Correct.

**WITNESS READS BRIEF OF EVIDENCE COMMENCING AT  
PARAGRAPH 2**

10 A. "I was a tenant on level 4 of the Forsyth Barr building from June 2010. After the 4 September 2010 earthquake I relocated over a period of weeks to level 10. I am not a structural engineer but I have been involved in a considerable amount of construction, general engineering both in steel and concrete, including building bridges, dairy sheds, houses and multi-storey buildings. I have also been involved in steel sub-framing for earthquake strengthening of stone building restoration.

15 Observation of Stairs after September earthquake:

There were two flights of stairs in the Forsyth Barr building. There was a separate entrance to each flight from the ground floor. One could be entered from the door on the left which is the north-eastern side as you walked into the foyer and one from the door on the right which is the south-western side.

20 Q. Just pause there please and we'll bring a document up to illustrate that. BUI.COL764.0003.15. (The system apparently is down Your Honour). That's part of the BECA report, page 10 in the bottom right-hand corner and 3.15 in the top right-hand corner. Also tab 4 of the bundle of documents Mr Mills referred to earlier on. Mr Carr there's a document there in front of you. You see firstly there's a plan of the building up at the top of the page?

A. Yes.

30 Q. And am I right in saying that the entrance to the Forsyth Barr building was there at the corner of Colombo and Armagh Streets?

A. Correct.

Q. And then one would walk through the foyer towards the south-east of the building where the lifts and the stairwells were?

A. That's correct.

5 Q. And you're referring to there being two entrances to two separate flights?

A. Yes.

Q. And one of those entrances you say was in the north-eastern side. That's the upper right section of the stairs and there was another door at the south-western section?

10 A. That's my recollection.

**WITNESS CONTINUES READING BRIEF OF EVIDENCE AT  
PARAGRAPH 5.**

15 A. "After the 4 September 2010 earthquake I saw cracking in some parts of the flights of stairs which could be entered from the door on the left from the ground floor to the 10<sup>th</sup> floor. Over a period of about two to three weeks after the 4 September earthquake I went up and down the stairs between the ground floor and level 10. I did this about three times to move boxes and furniture up to level 10, and I should refer there as being *from* level 4 to level 10.

20 Q. In paragraph 7 you're referring to the second diagram on that page which is 4.3, the diagram of the scissor stairs and you're about to make some observations about what you saw in various parts of those stairs. So could you indicate in paragraph 8 you're talking about covering. Where were you standing by reference to this diagram when you make  
25 the observations which you are about to explain?

A. Probably the easiest reference point is the red triangle that has the point coming down and just effectively onto the landing, so the observations when were on the top site or on the landings we were able to see the cracking in the lino and so we were looking at the base of the first flight  
30 generally in that area. So we were standing with our back to the wall and then looking up the flight of stairs and it's right at the base.

**WITNESS CONTINUES READING BRIEF AT PARAGRAPH 8**

A. "In some cases the covering on the floor on the landing was cracked. It was possible to pull the covering back and to look down and see cracks.

Q. You have a diagram up in front of you now and there should be a mouse in front of you. Can you indicate with the mouse where the covering which was cracked was?

5

A. Generally along this line here just below or just at the first rise and it was variable. It wasn't always along the bottom of the rise. It sometimes came out and fingered out. On some of the floors you could see where the lino had moved and we would pull it back and just look and see the cracks.

10

Q. On that diagram you are indicating the bottom right area with the set of stairs in the foreground and you've indicated just the very base of the first step?

A. Yes, and then once you've moved up the flight then you come to this corner here again. So again here we were able to observe the same on a number of floors and the reason we would stop and I would probably need to put some context around that. When we were moving the desk which I had which was a "cheepie" in terms of it was a large piece of plywood 2.4 x 1.2 Marine Ply 25mls and it was wet. It was a brand new piece of timber. It was very heavy and my friend was assisting me, we're not as young as we used to be and carrying it up 10 flights, well it was four flights of stairs, six flights of stairs from four to 10, it was pretty hard work because we had to lift over the banisters so we would stop and rest and we took a bit of time and we were just observing that on the way up.

15

20

25

**JUSTICE COOPER:**

Q. I think you said there were cracks extending out into the landing area?

A. My recollection is that some of the cracks could be described as sort of finger cracking.

30

Q. Right, so they were going back towards the wall?

A. Not towards the wall, they were parallel, well semi-parallel with the wall but came off. I think it's probably easiest to explain if you look at the underside cracks that Mr Cameron had presented in evidence.

Q. So what you observed was consistent with those photographs?

5 A. Consistent but as I think I say further in my brief, the cracks on the top sides were of lesser opening than the ones on the bottom sides.

**WITNESS CONTINUES READING BRIEF OF EVIDENCE AT  
PARAGRAPH 9**

1147

10 A. "I also saw that the stairs had dropped as can be seen in the photograph I believe which was attached to Mr Cameron's evidence."

**MR ELLIOTT:**

Would Your Honour like that produced, well, in fact, there it is.

15

**JUSTICE COOPER:**

Yes. Thank you.

**EXAMINATION CONTINUES: MR ELLIOTT**

Q. So you saw the same thing?

20 A. Yes I did.

**WITNESS CONTINUES READING BRIEF OF EVIDENCE FROM  
PARAGRAPH 10**

A. "It was also possible to look up and see cracks on the underside of the same unit. This was typical of what I observed on numerous floors.

25 This type of cracking can be seen in the photographs. That particular reference which again I believe are in Mr Cameron's photographs."

**JUSTICE COOPER:**

Yes.

30 **EXAMINATION CONTINUES: MR ELLIOTT**

Q. That's in front of you – 0004.10.



A. Yes.

Q. And 0004.11.

A. That's correct.

5 **JUSTICE COOPER:**

Just, I should have asked Mr Cameron this but that, in the left-hand photograph, the one with the suffix 10, what's the wooden, looks like wooden framing that you can see there under the landing?

10 **MR MILLS:**

I can tell you what that is Sir if it helps. It will come up with BECAs but it's the, it's level 7 as I understand it and it's referred to in the, BECAs assessment, they opened up the wall so that they could see. So it's the framing of the wall that you see.

15

**JUSTICE COOPER:**

Yes. Right. Thank you.

**MR CARR:**

20 Just in terms of my observations the walls weren't opened at the time that we were doing this.

**MR ELLIOTT:**

Paragraph 12 please.

25

**WITNESS CONTINUES READING BRIEF OF EVIDENCE**

A. "The observed fractures ranged from barely separated to openings that would have been three to four millimetres and perhaps a little more in some cases and it was everything in between. The cracking of three to  
30 four millimetres or more in some cases was more common on the underside of the units. The cracking which was visible from the top was smaller. However, in some places I pulled back the lino and the

fractures were sufficiently open that you could shine a headlamp into the crevice. Given the position of the cracks on the top and the underside of the units it appeared to me that the cracks ran right through the concrete. From my recollection this type of cracking was observed in at least seven of the 10 floors between the ground and level 10. I approached Ilze Cameron on two occasions expressing my concern and asked her to relay it to the building manager which I understood she did. I subsequently saw cracks being gibbed and I expressed some concern to the gib stopper that some more substantial repairs were not being done.”

**EXAMINATION CONTINUES: MR ELLIOTT**

Q. Mr Carr your statement of evidence has been passed onto BECA and to Mr Jury for comment and I'm just going to ask you to comment upon what Mr Jury said about your statement and as you know he's giving evidence as well shortly. So he said that he did not see any cracks on the soffit of the stair units that were as large as those observed by you. The maximum would have been about three millimetres. Do you have any comment on that?

A. I think, and I take a reasonably keen interest in construction, and Stephen O'Malley who was with me also has a lot of experience. We've done a lot of concrete work over the years and I think my observations are reasonably accurate. It's a while ago but certainly the cracking that is in Mr, this particular photograph of Mr Cameron's, there was a number like that.

Q. Did you actually carry out any measuring of the cracks?

A. No we didn't. It was merely just observation and making commentary and what we would do to have fixed it, just in passing.

Q. Mr Jury also says that he did not see any evidence that the cracks on the soffit propagated through to the upper surface of the lower portion of the stair. What do you say about that?

A. I would have to say that my observations were that it was speculative on my part that the cracks would have gone right through but it seems to me and from my experience with concrete that it was highly likely, I would have thought, that the cracks were right through the concrete.

5 Q. What made you think that?

A. Just experience and working with concrete products and types and general engineering work with concrete over the years that when you get a breakage of that type it would seem consistent with what I've experienced, that the cracks would be right through that concrete or sufficiently fractious that it would have compromised the integrity of it.

10

Q. Mr Jury also says that he didn't observe any cracking on the upper surface of the stair that could be described as a crevice. The seismic gap may have looked like a crevice.

A. We didn't observe the seismic gap. I wasn't, Stephen and I both had no knowledge of the absolute construction of those stairs at the time. Our observation was purely at the point of the bottom of the first rise and then putting two and two together effectively saying, well that crack is consistent with what we see on the bottom side so therefore we thought it must have gone right through and as I say in the evidence the cracks on the top side were not as large but certainly they would seem to be in the same places as on the underside.

20

Q. Were you in the building at 12.51?

A. No I had left the building 20 minutes before the shake for lunch.

#### **CROSS-EXAMINATION: MESSRS LAING AND GALLAWAY – NIL**

#### **25 QUESTIONS FROM COMMISSIONERS FENWICK AND CARTER – NIL**

#### **QUESTIONS FROM JUSTICE COOPER:**

Q. Mr Carr, you didn't tell us what your occupation is or was?

A. Probably best described as farmer.

Q. A farmer?

A. A farmer Sir and also I have had two construction companies, one involved in earth, stabilised earth construction and another one in straw bale construction where we did quite a lot of seismic testing for straw bale performance, structural straw bale performance in New Zealand.

5 Q. What's that used for?

A. Construction of domestic and commercial buildings. It's one of those situations where if the big bad wolf is the earthquake then the story of the Three Little Pigs needs to be rewritten.

10 Q. I think that would be outside our terms of reference Mr Carr but back in September 2010 you had an office in this building did you?

A. Correct. I was, my instructing solicitors in an arbitration case were GCA. So I was preparing for an arbitration to take place in November so I was there on a daily basis.

**WITNESS EXCUSED**

15

**MR MILLS CALLS****RICHARD SHARPE (AFFIRMED)****ROB JURY (SWORN)**

5

**MR MILLS:**

Well you have both given evidence before and your curriculum vitae are now in the Commission's records so I won't go through that again. I'll just ask now 1157

10 Mr Jury just to confirm that you're a director of BECA Carter?

**MR JURY:**

A technical director, yes.

15 **MR MILLS:**

And you were engaged by the Department of Building and Housing to prepare the report on the stair collapse in the Forsyth Barr building?

**MR JURY:**

20 That's correct.

**MR MILLS:**

And Dr Sharpe, you too are a director of BECA Carter?

25 **DR SHARPE:**

A technical director, yes.

**MR MILLS:**30 

And you assisted in the enquiry into the collapse of the stairs in the Forsyth Barr building?

**DR SHARPE:**

I did.

**MR MILLS:**

Now I understand you've got a power point and so as on previous occasions I  
5 will sit down. You can take us through your power point and at the end of that  
there will be no doubt questions on various issues.

**MR JURY:**

This presentation is intended to cover the investigations that we carried out on  
10 behalf of the Department of Building and Housing. We will discuss what we  
were able to observe or find out in terms of the history of the building and a lot  
of that has already been mentioned. We will discuss the construction and  
configuration of the building and the stairs. We will present our findings in  
terms of what happened in each of three earthquakes, the one on the 4<sup>th</sup> of  
15 September, the Boxing Day event and also the 22<sup>nd</sup> of February. We will look  
at some of the design and construction issues as we have been able to find  
out from our investigations, and we will present some of the results from the  
investigations that we've carried out. Those results are from the computer  
analyses simulations of the building performance and stair performance. We  
20 will outline the reasons that we believe that these stairs collapsed and pretty  
much just more detail on what Mr Mills has already presented this morning.  
We will present our conclusions from that and also some recommendations  
that we have made based on our investigations. Most if not all of them have  
now appeared in the panel report. Next slide.

25 Our investigations began in April 2011 and all documents were made  
available for us from the Christchurch City Council files, the owner's structural  
engineers' files. We had original drawings for the construction of the structure  
and including the stairs. We had a lot of photographs too taken by USAR and  
that's quite an important aspect, particularly for in relation to the 22<sup>nd</sup> of  
30 February, because we were not able to get access to the building to view what  
was left of the stairs until towards the end of last year, so a lot of our  
investigations were carried out without the benefit of actually having seen the

building and the stairs in situ, the remaining stairs in the building. We also carried out a number of interviews of witnesses, people who had been in the building during the earthquake in February and some observations before that. We had the earthquake records that had been obtained from around the city and I think those have been presented on a number of occasions to this Commission but we will just go through those again later in this presentation, and we had the results of our computer simulations of the way the building responded in those earthquakes, and finally we did have the site visit at the end of last year.

10 In terms of what we were able to glean from the available information the chronology of this building is set out in this table. The building was designed and constructed in around about 1988. The only other relevant thing in terms of its chronology is that in the, after the 4<sup>th</sup> of September earthquake a level 1 rapid assessment was carried out on we believe the 5<sup>th</sup> of September 2010 and at that point that was carried out by Civil Defence/Council led teams and that placed the building as red. On the 5<sup>th</sup> of September BECA carried out a level 2 rapid assessment which is the next stage in the assessment (rapid assessment process), and the building as a result of that inspection on the 5<sup>th</sup> of September was reclassified as yellow. That classification was done under a recommendation from BECA to Council who did the actual posting, prepared the placard and was fixed to the building. As part of that level 2 rapid assessment we had identified some issues and on the 6<sup>th</sup> of September with those issues addressed the building was reclassified as green, once again with the same process, recommendation given to the City Council who responded by reclassifying it and putting a green placard. On the 13<sup>th</sup> and also around about the 15<sup>th</sup>, we put it in as the 15<sup>th</sup> September, further inspections were carried out by BECA, responding to building occupants' concern for several other areas but they did not relate to stairs and as has already been pointed out the results of those inspections on around about the middle of September, they were recorded on the level 2 rapid assessment form. Between October 2010 and February 2011 repairs were going on in the

building to structure and also we understand to floor coverings within the stairwell, including perhaps some covering of cracks in a cosmetic fashion.

Just dealing with the configuration of the building and the stairs, next slide please.

This has already been pointed out by Mr Mills, the Forsyth Barr building is an 18 storey building, it has a podium up to level 3 which contains the carpark which extends out beyond the general footprint of the building. It's primarily a frame building but it does have some unusual characteristics, if I could have the next slide. In plan it is square but the lateral load resisting elements are ranged both on the perimeter and across the diagonal of the building and the structural form means that the structure is really two structures, the two triangular pieces, one at the bottom left and the other at the top right interconnected by a floor slab system which has a beam that runs around the top right-hand corner, but is very little structure across the bottom left-hand corner. The stairs as has already been pointed out run north-east to south-west at the bottom left-hand corner in a one stairwell and the scissor arrangement, which I'll describe in a minute, with a dividing wall between so the complete access to the building is provided through one stair shaft and split in two by a partition, and if we go to the next slide please.

The stairs are referred to as a scissor stair and that means that you in order to get access or egress from the building you wind your way down the stairwell going from

1207

one side to the other, overlapping with the other flight so you have two stair flights occupying the same space but separated from one another and spaced out by one floor, different from one another and so you can gain access to both stair flights from each floor – one from one side of the stairwell and the other flight from the other side of the stairwell. We have built a model of the stair which might be helpful. There is some modelling licence in terms of some of the dimensions but generally this stair is to scale so it's a very long pre-cast unit, typically spanning from one floor to the next. It is rigidly fixed into the slab at the top. It had reinforcing bars sticking out of the landing at the top into the slab at the top and when the topping was poured on the slab



that effectively locked it in. It was still sitting on the channel, the steel channel that we have heard about which was bolted to the side of the beam and also cantilevered out to pick up the toilet block on the outer edge right at the bottom left-hand corner of the plan. It is continuous through to the bottom support. The drawings did indicate that it was intended to be an in situ splice between two pre-cast units on the original drawings but finally we understand and we saw in the remnants of the stairs that that stair had been cast in one piece so that in situ stitch in the centre had been deleted and the whole lot was pre-cast. At the bottom end it was sitting on a ledge with a gap and a lot of store has been about the gap this morning but we consider the ledge to be more important than the gap and I'll explain that in a minute.

**JUSTICE COOPER:**

Q. For my edification, once you arrived at the landing in the middle could you then walk across to the other stair?

A. No, no. There was a timber partition between the two stair flights so you come into the landing on one landing, come down the stairs and then go across the landing and down the next flight and then up above there's another stair flight coming down to this level to allow you to enter from the other side of the stairwell and continue down. It's a very efficient way of providing egress in terms of practicality. It is very reliant on maintaining the structural integrity of the units. And I think because the way the egress occurs in a scissor-stair arrangement if one unit is lost it effectively takes out the whole stair, both flights, because your other flight is running immediately underneath so you've straight away lost this one. You've also lost the next one below so you've taken out the whole egress path so it does lack some redundancy.

Can I have the next slide please. These have been shown before this morning. The top detail is the one I was referring to that has the starter bar running back into the structure. It's been cast in there when the top of the beam and the slab topping has been cast so it is effectively fixed but you can imagine, and it is perhaps relevant, that once you lose the

bottom support even though it's fixed into the top, there's an awful lot of structure to try and hold and of course the structure will not be up to it. It will break the top connection.

Q. But it didn't in all cases?

5 A. No, and I'll come to that. The bottom detail is the one you've also seen which is the connection that has been left to allow the stair to slide at the bottom and therefore to avoid getting the compression force that runs between one floor and the other as this top floor moves relative to the bottom floor and the intention is that there is sufficient gap so that  
10 whatever relative displacement between those two levels occurs there is theoretically no interaction or no generation of the compression built into the stair. In this particular case there was a 30mm seismic gap and there was a, resulting to be specified in the design, a 72mm ledge. So twice the ledge or just over twice the ledge from the gap.

15 Can I have the next slide please. From our investigations we believe that the building appears to have been designed in accordance with the standards at the time, so that was the standards prevailing in 1988 so the level of gap did represent, 30mm did represent what the inter-storey drift calculation or approximately it what it would have represented  
20 based on calculations that were carried out in accordance with the 1988 Code. We found, however, that there were a number of construction issues relating to particularly the gap that did not conform with what we believed to be the designer's intent or what was shown on the drawings.

25 Can I have the next slide please. The first has been discussed this morning. This was what was observed in the remnants of the stairs that were placed outside the building by the USAR teams that took all the stairs out of the stairwell and it was immediately obvious on a number of stair flights, particularly at the lower landing at the lower support level that the concrete had been cut back. There was evidence of grinding  
30 and the circular nature of being able to get a grinder down into the gap if you like or down on the end of the unit. The fact it didn't go right the whole cut didn't go right through to the end would suggest it was done in

place so not done before the unit went up but that that cut only went down to the top of the steel angle as shown in the photograph and in this particular example that cut extended back 10mm into the bottom of the stair unit. We can surmise why that was done but the effect of it

5 may have been that when the stair was installed and the gap was formed that it looked as though the gap at the top was 30mm but in fact it was only 20 and there are some cases where the cut is more than 10mm.

Can I have the next slide please. Now admittedly this picture was taken

10 during our inspection at the end of last year so it's of the stairs that still remain but my records show that similar sorts of fillings were all the way up the stairwell in a general manner. So this slide shows the seismic gap. It shows the rod, this rod which is put in by the tradesman who is following along behind to seal up the stairs, seal up the gap so he can

15 put the vinyl on top, but what's important to notice here is the amount of broken up rubble that's also in the gap. In this particular example it could have occurred from the mortar that we've heard may have been placed above this tube although this particular one doesn't show any signs of wet mortar having been placed on top of it and therefore it's

20 crushed up and just fallen into the gap, more likely construction rubble.

**JUSTICE COOPER:**

Q. Is the tube that you have with you from the building is it?

A. It's from the building, yes.

25 Q. And is the placement of such a tube not inimical to the proper function of the gap in an earthquake?

1217

A. That, that's a very moot point. I think that the, the feeling probably at the time in the eighties was that such tubes would be crushed if stairs

30 tried to move and I guess that's a reasonable expectation but they still have a residual width and so these things in gaps don't necessarily provide the gap or the gap that was intended.

Q. Is that a practice that has since been abandoned?

A. I think not. Probably not.

Q. So should it be?

5 A. I think it has to be treated with a lot of care and allowance for that compressing has to allowed for in providing the seismic gap.

Q. What would be lost if it was simply made contrary to the Code to insert such tubes?

10 A. In construction such gaps are quite difficult to deal with from a practical sense and I guess the ramification would be that you would probably find that these would not be good enough. I mean the current requirement for gaps is bigger than 30 millimetres. So that would already be large. To allow another 10 millimetres, to allow for crushing, would mean 50 mms. That's getting to be quite a large gap in this sort of situation for the standard way that they were dealt with in the past.

15 Q. Well to my no doubt untutored way of thinking the purpose of a gap is that it be empty space isn't it?

A. I couldn't agree more.

20 Q. So my question to you was why shouldn't the Code say that the seismic gap shall be exactly that, an empty space, to which I think you replied so far, "It would be difficult to deal with."

A. I was making that comment in precursor to saying I, I agree with you totally.

Q. I see.

25 A. It's just that it does provide some practical difficulties (inaudible 12:19:25) overcome.

Q. Well can they be overcome?

30 A. I think so. In addition to this detail that's shown in the picture we also found evidence in those flights that are still existing of a polystyrene packer being placed within the gap and this comes from the building. So this, this is a polystyrene gap that we pulled from, a polystyrene filler that we pulled from the gap. We have read in the evidence provided by the builder that the method of construction as he recalls it was to put the

stairs in position, to put such a filler on the end of the stair unit at the bottom where the gap was to be placed and then pour the concrete against it and our guess is that it was, it would have been intended if it had been realised to actually take that out once the concrete had been cast.

5

Q. So it's purpose was to confine the concrete?

A. It was to create the, it was a boxing for the concrete that was being poured.

Q. A frame?

10

A. That's right.

Q. So it should have been removed?

A. Should have been removed, yep.

Q. Could it have been easily removed –

A. Yes.

15

Q. – having regard to what it's made of?

A. Yeah, no, the, the standard way of removing this is just to pour petrol on it and it will dissolve to nothing very quickly. In practical terms that really fills the gap. This one here may only partially fill the gap. So this is much worse than that in terms of the way it might perform.

20

Q. Much worse than a tube?

A. That's right which is over a much smaller length. But even the sealant in such a joint does reduce the available gap. The next slide please.

Just looking through the, the three earthquakes – can I have the next slide please. We do have the benefit of a large number of sites that

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were placed between September or, or existing prior to September but also a number of others that were added between September and when

the February earthquake occurred. The four sites that are shown on this plan and the Forsyth Barr building is the dot in the centre with the bottom yellow line, arrow going to it, the four closest recording sites are

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those shown with the red dots. These sites were all in location, in position before September so we have a direct comparison of the

earthquakes in September, or earthquake in September, the Boxing Day and February earthquake. Could I have the next slide please.

I think, I believe these plots have been shown before but I'm showing, there's lots of ways of representing the shaking but I'm showing these as a, as a means of getting some rough comparison between the three earthquakes, particularly as they relate to the Forsyth Barr building which is, its drift and its distortions are important to get to grips with in order to understand the performance of the stair. I don't think you have to worry about the finer points of this diagram but suffice to say the zone of interest for us with Forsyth Barr, in other words the response characteristics of the building as a whole, are in the zone that I've shown there with the, with the arrowed arc and the other plots there are the response that we might expect to get from the 4<sup>th</sup> of September earthquakes from the various sites that were around Forsyth Barr. So I think you can see from here that the major excitation for the 4<sup>th</sup> of September event was for structures that were beyond the zone of interest for Forsyth Barr but there were at least some records which showed responses that were beyond what the Code value, and that was the existing code at the time of September, is shown in the black diagram on there. But generally in that zone of interest the response was relatively small. And if we look at the damage that occurred to the structure in that earthquake it was relatively minor. We have listed it in our report at the, the damage that we obtained from the Holmes report that they carried out after the middle of September. They listed the damage that they had observed and we have listed that in our report. But we would describe that as being minor to moderate in terms of what was observed.

However, to the stairs – can I have the next slide please – and we have seen some of these already this morning, we would agree that on many of the soffits of the lower landing there was this sort of damage presented. And could I have the next slide please.

And also at least on some of the levels the stairs had been caused to bow down and move back so that if they separated from the, the skirting material, and you could see the differential, we ascertained that the partition on which the skirting material is attached didn't appear to have moved at all so it was the stair that had moved.

5

We'll go back to our model. I think in terms of understanding what is happening here the model is of interest and this has been confirmed by our computer analyses but when the, when the floor up here sways relative to the floor below the stair is put in compression and then because the stair has a number of kinks in it, it bends, rather than taking the load and pure compression. If it was a straight strut between there and there it would take the load as a strut and then finally when the load got big enough it would just buckle but with a stair or an element like this being subjected to compression it, it experiences bending and if we displace this in bending what happens is the whole stair bends down and we show a number of diagrams in our, in our report. But what is important is because the bottom horizontal piece of the unit is so much thinner than the rest, its capacity is

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1227

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reached before any part of the stairs and you get flexural cracks in the soffit underneath, flexural cracks underneath the – on the soffit running across the soffit of the unit. The net effect of that movement and sagging and the cracks on the bottom is that the top surface is now in compression. Bottom surfaces intention as you've loaded it, the bottom is now – the top is now in compression. We know that when we inspected the stairs in September and no doubt this will come up later that we removed the bulkhead which was over here, half way across the landing and that's the timber framing you saw in the photos this morning.

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**JUSTICE COOPER TO MR JURY:**

Q. This is the bottom landing?

A. The bottom landing.

Q. Yes, I'm just thinking of the record Mr Jury, when we don't have you and your assistant holding up a model then how we're going to know what you said, but –

5 A. Of the bottom landing, we removed the vinyl off the top of one and I'll come to that in a minute, but – and we also looked at the bulkhead at the bottom. We did notice some cracking on the top but it was not significant and it was arguable whether it was recent. The cracking we observed on the bottom was in the order of two to three mms. We were  
10 very interested in that at the time and it formed, really formed a critical part of us understanding what had gone on with the stair, for that rapid assessment in September.

**MR JURY CONTINUES:**

15 Can I have the next slide please? In Boxing Day earthquake in December, this is a similar plot, a slightly different scale on the axes to even show anything so although it was a reasonable shake, it was nothing compared with September and in the particular zone of interest, if you'd think of that quadrant radiating out from the bottom left-hand corner, there is almost no response in  
20 that area so we would have been surprised if there had been any further damage in that Boxing Day event and in fact, none has been reported. Could I have the next slide please?

That similar plot plotted again for the 22<sup>nd</sup> of February shows a vastly different picture from Boxing Day and even September. In the zone of interest we  
25 have a significant amount of displacement. If you're trying to relate it to the previous graphs that black line which represents the code type of earthquake if you like, is now well away from the peaks and the response, particularly in the zone of interest. Could I have the next slide please?

And we know that that excitation resulted in a complete collapse of the stairs.  
30 This is a shot taken from down in the lobby at the bottom. Could I have the next slide please?



This could be called the stair graveyard and we can only thank God that nobody was in the stairwell at the time. Most of these stairs have – it's a bit hard to know whether they have broken up on the way down or whether they have been broken up to remove them from the stairwell but there's no doubt in some of them the bottom landings were still intact and that's the one we can see in the foreground, and if we could continue on the slides?

We can see from the landings where the stairs have gone, that some bars have fractured in the top, so in that joint at the top of the stair, we're at top landing, where it goes into the slab those bars have broken — could we continue on?

But we also see in some other remnants from the stair that in many cases these bars have pulled out. Just continue please.

And in some cases, this photograph wasn't taken by me but by the USAR people, in some cases some of the stairs were left hanging from the top.

15

**JUSTICE COOPER TO MR JURY:**

Q. Is that a stair or is it a –

A. That's a stair, look that's a stair leaning down into the lift shaft looking from above, from the landing above. So somebody is standing on the landing here looking down the stairwell into the end of the pre-cast unit at the top, so these are – the reinforcing bars shown there are the bars that are going from the unit back into the structure.

20

Q. What was the depth of the stair, I mean the width across, the –

A. About 1200.

Q. And in the other direction?

25

A. You mean in the thickness?

Q. Yes.

A. The thickness is about 200 at that point. So those bars are about 100 from the top surface.

Q. The distance, what I'm trying to get at is the stairs, the width of the stair that you're stepping on from front to back rather than across?

30

A. That's about a metre to 1200 as well.

Q. Is it?

A. Yeah, in most of the flights it does vary in some specific cases but most of the flights that is the –

Q. That's the –

5 A. – part of the unit.

Q. That's the actual structure, but would you see that visually?

A. Without the collapse of the stair unit?

Q. Yes.

10 A. Yes you would. I heard this morning in the evidence that somebody said that they were standing at the back with their back against the wall looking at the cracks. If you were – this stairwell is made up of the stair landing which is part of the unit and also landing which is part of the structure, so if you were standing with your back against the wall you would be looking directly down at the seismic gap which is the junction  
15 between the end of the stair unit and the fixed landing.

**DR SHARPE:**

Back of the wall there isn't it, well ...

20 **MR JURY TO JUSTICE COOPER:**

A. Probably better even, well, yes, the wall – this part here is, you could say would be the part of the landing that's on the unit.

Q. Yes.

25 A. And then there's a large part of the structure which is also part of the landing and the wall is back here.

Q. Well I wonder if Dr Sharpe you could reach – hold that – just indicate what we're looking at in this photograph could you?

A. What we're looking at in the photograph is that this stair has now gone down the shaft, it's now hanging like that.

30 Q. Yes.

A. This part of the landing is now horizontal and you're looking down into the end of that part of the unit.

Q. So you're looking at part of the landing?

A. You're looking at that.

Q. That's what I thought.

A. Yes.

5 Q. I thought and I'm sure this will be fault, but I thought you were saying we were looking at part of a stair or a step, but we're looking at part of a landing.

A. That's right. The first step is where it goes into darkness there.

10 Q. Yes. And the measurements that you were giving us were in relation to that part of the structure?

A. That part of it yes.

**MR JURY CONTINUES:**

15 So I mean these bars have undergone over some slip or some distortion by quite a large margin to still hold, to see a flight in place. That's quite amazing in itself. Could I have the next slide please?

20 And this is just a photograph of the seismic gap so that's what I was talking about, the wall is on the bottom left-hand side of that photograph. There is part of the landing which is part of the structure and then the remaining part of the landing which is part of the stair unit and the seismic gap is crossing that point, and the slightly reddy coloured thing across the gap position there is the armouring on the bottom of the joint of the stair units.

**JUSTICE COOPER TO MR JURY:**

25 Q. It's the what?

A. Is the steel armouring on the bottom corner of the stair unit.

1237

**COMMISSIONER CARTER:**

30 Q. So just to clarify that – just hold that picture there. No the photograph on the screen, yes, this one on the screen. On the left, on the centre and upper part of the picture is the landing of the stair going down,

going up sorry. That is the sliding joint and on the right-hand side is the other stairway going down.

A. That's true.

Q. Which is the fixed joint.

5 A. Which is the one we were looking at before, yeah.

**JUSTICE COOPER:**

So what's the number on that, that image Mr Mills?

10 **MR MILLS:**

I'm being told we haven't got it logged.

**MR JURY:**

It's part of the, of the photographs that we sent you.

15 **QUESTIONS FROM COMMISSIONER CARTER:**

Q. Is it in here?

A. No it's not in there. It's part of the photographs we sent you, of all the photographs we've taken and had been taken. I think this one might actually be taken by the USAR people.

20 Q. Well it looks like at the top, "NZ15208781-FBpresent."

A. That's, that's our reference number for our presentation.

Q. These aren't loaded in our system though are they?

**MR MILLS:**

25 It's been suggested to me that for the purposes of the record it could be described for the moment at any rate as the 26<sup>th</sup> slide recorded in the computer. That will I think give us sufficient identification for the moment.

**THE COURT:**

30 For the moment. These haven't been received in time to be loaded with our normal numbers. Is that right?

**MR MILLS:**

Well I'm not sure what the explanation is but I've been told it has not been logged in.

**EXAMINATION CONTINUES: MR MILLS**

- 5 A. The next slide please. This is a photograph taken looking down on the seismic gap and this was taken late last year. The arrows and the measurements that are down on the bottom right-hand corner were by others and you can see there that they were taken from the 4<sup>th</sup> of March right the way through and that sort of documentation that we were able
- 10 to see when we went there indicated that the gaps had not changed much since the February earthquake but the other thing of note was that the, the gap there is full of rubble as well but it is hard to say whether that was there before the earthquake or just has accumulated after.

**QUESTIONS FROM COMMISSIONER CARTER:**

- 15 Q. What level is this on?
- A. It would around about, I mean the soffit's still there so it be above level 15. We could provide a more precise description.
- Q. Well you can't exclude that the rubble went there as a consequence of the 22<sup>nd</sup> of February earthquake, got in the gap?
- 20 A. No, after, after the 22<sup>nd</sup> of February?
- Q. Yeah.
- A. No we cannot. Can I have the next slide please. In terms of the structural analyses we carried out to inform us for the purposes of this investigation we wanted to know what the inter-storey drift, so that
- 25 distortion between one level and another was in this building during each of the earthquakes. We discounted pretty quickly the 26<sup>th</sup> of December earthquake so the results that I'm presenting here are just for September and February earthquakes. We did this using time history techniques. We did keep the structure elastic and I know that might be
- 30 subject to comment later and we felt, at the time we did these analyses we felt that we didn't know precisely what the damage was in the

building and we also felt that the elastic analysis in this particular instance, to look at this, probably wouldn't be too dissimilar to a structure that had been relatively minorly damaged. This, and especially for September where there was very little damage – this plot shows the variation with time as you go through the earthquake of the inter-storey drift taken at the height of the building where this was greatest, or found to be greatest in our analyses and what it shows is that in September these analyses predict an inter-storey drift of about 34 millimetres. So plus 34, minus 34 millimetres. Now if you recall the gap was 30 millimetres and the ledge 72 millimetres we would have been surprised if the gap had been completely empty that the stair would have been damaged at all in September but in fact we know it was in several flights. So we, we predict that that is due to the accidental filling of the gap or some other process going on that compromises the gap. Friction on the bottom toe would be one, one source or perhaps even that our analyses don't predict exactly what happened on the 4<sup>th</sup> of September which could be quite possible.

Q. What was the floor that this represents?

A. This was around level 10. The analyses, they did vary between the earthquakes about which was the most critical but typically the most, the largest inter-storey drift occurred around about level 10, level 12. Around about that area. Over to the next slide please.

A similar plot for the February earthquake shows that we had inter-storey drifts at the same, at the same level, so this is all taken at the same level and I think it's very similar to the height that the previous one was taken at but it may have varied by one or two floors – showed that the inter-storey drift could have been as high as 65 millimetres in one direction and 45 millimetres in the other direction with, with a number of cycles in between achieving that. Can I have the next slide.

We also carried out a number of structural analyses of the stairs themselves, so that's the stair units, and we subjected them to both elastic, which means no yielding of the steel and also non-linear, so

some yielding of the steel particularly in that bottom hinge position where the, where we know the cracking was occurring and we also subjected them to, subjected the model to the vertical excitation to see if the vertical accelerations which we know were, have been recorded as

5 being quite large in this earthquake could have affected this very long slender element. So what we found from those analyses particularly the non-linear analyses and we incrementally pushed the supports relative to one another, we found that it took approximately four millimetres of

10 relative drift between the top and the bottom to actually start the reinforcing yielding at the bottom of the stair, at this point here, at the junction of the bottom knee. But from then on it's very sensitive, the vertical movement, sag of the stair and it's lateral displacement is very sensitive to any additional load that you put on or any additional deflection that you put on, continue to add to that stair in its locked in

15 position. So 10 millimetres additional locked in displacement, we predicted 25 millimetres vertical displacement and 15 millimetres horizontal displacement at that bottom knee joint. So that was consistent with the distortions that we saw in those photographs and we have seen from the other witnesses this morning. Our dynamic

20 analyses of the stair unit on its own did not indicate that the vertical accelerations caused huge loads in the stair that were beyond its capability to take it. On at least one of the stair flights that's still in position the landing has sheared across from one corner to the other. So running from here to here. We looked at the compressions that

25 could be generated in the stair due to this relative

1247

movement and we looked at the shear that could develop across a crack like this and that crack and that shear displacement is across the diagonal crack, is not inconsistent with really stressing the stair unit

30 under compression, especially when it's affected by the flexure, the bending across that point as well. Could I have the next slide?

So based on all of our analyses and investigations what has been our inferred collapse sequence for these stairs and that was shown this morning, but just to run through it again, we believe that up until the point that the seismic gap is taken up and that could be reduced by fillers in the gap, the stair remains effectively unstressed from the earthquake distortions of the one floor relative to the other. If we take the gap as being 30 millimetres as designed then once the building has drifted across a floor 30 millimetres then the gap is totally taken up. From then on in the stair is being stressed in compression, so as you add more displacement it is now being stressed, so I said before 4 millimetres additional inter-storey drift causes the bottom steel to yield and that's shown in the bottom diagram. So we would start to see the cracks perhaps before then, but would start see them develop at that point. The stress at that point, the top of the landing is in compression. Could I have the next slide?

If we continue to push the stair out to the level of drift we predicted in our analyses of the building, so we push it out 65 millimetres, then we have crushed the stair. As the steel yields in the bottom knee joint any additional displacement is being permanently placed in the stair, so as said this morning, the stair will shorten with that additional displacement. So it shortens by the relative – by the difference between 65 and 34, so 30 millimetres to close the gap, 4 millimetres to cause the steel to yield and then another 31 millimetres continual displacement as the earthquake forced it, so 31 millimetres roughly speaking put in as permanent displacement in the unit. So the stair has shortened in the horizontal sense by 31 millimetres. So now the earthquake reverses. It's gone 65 millimetres in one direction so now it's got to go back 65 to get to the balance point, to the point at which it started, so it goes back 65 millimetres, it's shortened by 31 millimetres. It's taken up the gap, so now you have a 61 millimetre gap which is the difference between 30 plus 72 minus the 31, so you've now got a 61 millimetre gap and now it's at the original starting point. It's now got to go 45 millimetres as



5 predicted in the other direction from that point so now you can see that  
the gap, or the ledge required to continue going the stair, is now 106  
millimetres and in fact it was 102, that was what was provided, so if our  
predictions are correct, then at that point the stair lost its seating and  
came down. I did make comment before that putting rubble, or having  
10 rubble, or having any obstruction in the gap just makes it worse, it  
makes the stair have to sustain a lot more yielding behaviour as the  
building forces it to distort and shorten, but it also increases the level of  
that shortening 'cos you've still got to take up the 65 millimetre drift. So  
it's much shorter when it comes back the other way, it falls off earlier  
from the ledge. I mentioned earlier too that we felt that the – a lot of  
store has been made about the gap but in reality it's the ledge that is  
critical. We believe that it could have been before this unit fell off its  
ledge that it was still capable of carrying vertical load. However, once it  
15 reached the end of the ledge of course it could not hold up and so it fell.  
Could I have the next slide please.

And as is has already been stated once one unit fell, and there may  
have been a number that went through this, but once one fell then all  
the units below were in jeopardy of failing because these units weigh  
20 quite a bit and just swinging from the top support would be enough to  
break the stairs on the impact. The only thing we can be certain of is  
that the stairs at the top immediately below where the flights are still in  
position, they must have fallen out on their own accord so either they –  
the landings failed in shear or they ran out of ledge and I think based on  
25 our investigations we'd say that it's more likely that it was that the step  
ran out of ledge then necessarily sheared, but we can't rule out that.  
Could I have the next slide?

So as we've pointed out in our report, the primary reason we believe for  
the stair collapse is that the shaking on the 22<sup>nd</sup> of February led to those  
30 inter-storey drifts, the between floor displacements that were larger than  
those for which the stairs were designed and one or more stairs fell from  
their lower setting at around about the fifteenth floor level and that just

caused a domino effect below pulling down of course the partition between the stairs. We don't know either whether one flight falling from one side caught another one from the other side coming down as well, but I mean that's also a possibility.

5

**JUSTICE COOPER TO MR JURY:**

Q. Just by travelling through the wall wouldn't have hindered it, the dividing wall?

10 A. No, no, the dividing wall was – is timber frame with gib board or fire line and so much lighter than the stair unit. It would have created very little barrier I think. I think – one of the things that is of interest is that it wouldn't have taken much more ledge to be present to have stopped this stair from falling based on our predictions. Notwithstanding the very intense shaking in February, it might have only taken another  
15 30 millimetres of ledge. Even if the gap had been fully filled and fully ineffective, to have – presuming that the stair unit had remained intact, hadn't sheared or failed in some other way, to prevent the stair from falling.

20 **MR JURY CONTINUES:**

Could I have the next slide please? Towards the end of our investigation and quite late last year, we were made aware of some previous investigations carried out at the University of Canterbury in the late 90s and we have read that report. I don't think we've provided comment from it have we, to the  
25 Commission?

**DR SHARPE:**

Not to the Commission but to the Department of Building and Housing.

30 **MR JURY CONTINUES:**

This report was brought about by a member of staff for one of the consultants going back to do a Masters degree and being advised by that member of the

consultants, a consultancy which was in fact one of the designers of Forsyth Barr that it wouldn't be a bad thing to go and look at the performance of stairs like that in the Forsyth Barr arrangement, scissor stairs of a very long nature, kinked in profile and in particular how would they perform when you put them  
5 into compression. That report was published in 2000 and it concluded that the seismic gaps were critical for the performance of such a stair, that the reliability of the stair unit once you forced quite large amounts of compression in it, and recognising that around about 2000, some thought was being given to the level of drift that should be designed for, as opposed to that was  
10 necessary in the code in 1988, but once again they didn't comment on the significance of the ledge support length. Now I raise this in this presentation just to the point that the performance of these stairs was not unknown as we entered into the 2000s, the potential performance of these stairs, and so  
1257

15 some warning signs were probably there. Could I have the next slide please? Just in terms of our overall conclusions. The inter-storey drifts in the 22<sup>nd</sup> of February earthquake were predicted to exceed the original code for which the stairs were designed by about 80 percent and from some pluses and minus the current code requirements by about 60 percent. We believe that the  
20 specified stair seismic gap met the code requirements of the day but would not have met the current code requirements, but not by much. There was evidence of filling of the seismic gap which would have increased the likelihood of support loss as I've discussed but we were still predicting that the  
22<sup>nd</sup> of February earthquake was likely to have led to loss of support, even if  
25 the gaps were clear, and although the stairs may have survived if the drifts required by the current code had been allowed for, collapse was still possible if the gaps had been compromised. Could I have the next slide please?

And once one stair was lost in the stairwell there was potential for progressive failure of all the units below. Next slide?

30 So just in terms of our recommendations, we made the comment that known alternatives to this gap and ledge detail were – are known and should be used on all future buildings. Could I have the next slide please?

One simple way of getting away from having to deal at all with a seismic gap, so not even have to worry about filling it, is to have an arrangement like this that has the upper flight coming down onto the landing, so incorporating all of the landing in the structure rather than splitting it between the stair and the structure as in the case in Forsyth Barr. Landing that stair unit on top of the slab and thereby being able to provide a lot of ledge very easily and having no gap that can fill, and that way provides a very easy way of achieving what everybody's trying to achieve which is the separation of the stair from the – or avoiding that strut occurring, without all the fallacies, all the problems of filling.

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**JUSTICE COOPER TO DR SHARPE:**

Q. I'm just not sure how it works. Are the stairs themselves when they arrive at the landing, are they fixed in in some way or how do they – what's that junction.

15 A. The Forsyth Barr stairs was like that it was just supported on a ledge.

Q. Yes.

A. What we're suggesting is that instead of having that, you bring that down onto there and dispense with that.

Q. Yes.

20 A. And then you're moving, when you're having that relative displacement you've got all that – you've got that very much increased ledge, (in inverted commas) available before the stairs – before it would be jeopardised.

Q. So what's holding it in place, it's just its weight?

25 A. Its weight and it would be holding at the top in the same – (overtalking 13:01:07).

Q. (inaudible 13:01:07) and is friction not an issue in that eventuality?

A. Well the stair would have to be sufficient to move under the friction of force, yes but that would not be difficult and it would be no worse than what was proposed or intended for Forsyth Barr, it's just the support is much closer to the flight than out here on the end of this extended landing. The reason why this detail is – you might think that it would be

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adopted immediately but the reason why it did not gain a lot of favour is that by sticking the slab out the back it makes it more difficult to get the clearances in the stairwell, because that knee joint right at that point there is generally the critical part of the planing the head height in the stairwell and if you extend the slab back it creates the issue that you must either push – increase the floor height or have the distance between the flights increased in a horizontal sense, so move this one further that way and that's the reason why that sort of detail on Forsyth Barr has been adopted, but I think the benefits of such a detail are so great when you consider what happened in this case, that we should not see any new buildings built with this sort of detail that was in Forsyth Barr even if the gap can be provided and the ledge can be provided.

**MR JURY CONTINUES:**

Next slide? So our recommendations were that no known gaps, no alternatives to the gap details should be used on the buildings. The DBH should issue an advisory note warning of potential issues with these current stairs of the Forsyth Barr configuration and there are quite a number around New Zealand and that has been done, they have done that. We also recommend to improve resilience and to recognise the performance of egress stairs should better building performance. Consideration should be given to requiring seating lengths and we recommended at least twice the ultimate limit state inter-storey drift and that recommendation has been issued as part of the DBH advisory which is covered in the bullet point above. We also recommended that seismic gaps that it should be promoted quite widely that seismic gaps are exactly that, they're gaps and should not be compromised under any circumstances and so building tolerance, filling, sealing should not be such as to compromise the seismic gap and the seismic gap should be clearly noted on the drawing, the tolerance should be specified and if it's a gap it should be minus 0 plus whatever as a tolerance. I think there might be one more or it might be the end. No, okay. That's the end of our presentation. We're available for questions.

**JUSTICE COOPER:**

Thank you, now Mr Gallaway, we've said we'll sit on because I understand you wish to be somewhere else at 2 o'clock?

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**DISCUSSION RE TIMING OF HEARING**

1307

**EXAMINATION CONTINUES: MR MILLS**

10 Q. I just pick up a few points that were raised in the course of that presentation and just tidy those up before I go to some questions I wanted to ask you. First the question that His Honour put to you about the photograph you showed of the rubble in the gap post February and His Honour asked you, well could you be sure whether that was in there before or after and your answer was no you couldn't be sure. Just so  
15 there's no confusion about this I just want you to confirm, which I understand is the case, that you also found rubble in the gaps in September?

A. That is correct.

20 Q. Then on this question of whether it is the seismic gap or the ledge that is more significant to the vulnerability of this design and also to what happened here. Isn't it the case that really they are equally significant because it's only because the stair is shortened by the absence of a sufficient seismic gap to avoid compression but going back the other way it comes off the ledge. So really you could say either way that  
25 equal significance couldn't you?

A. Yes I would agree with that. I would also add that falling off the ledge is a very brittle failure mechanism. The taking up of the gap, shortening the stair is far less brittle, so in terms of resilience question, I would suggest that the ledge is more important than the gap, perhaps.

30 Q. The site reports that have come in in the last 36 hours, 24 hours from Holmes who were of course as you know the structural engineers for the

building make a couple of references which I'd just like your comment on. The first is that a direction was given that on levels 2 and 3 the seismic gap could be reduced to 25mm and I wondered if you were aware of that? That's the first question.

5 A. No we weren't aware of that.

Q. And the second question is, would that cause you any concern that on the lower levels, which I think we agree are not the ones where the maximum drift is occurring, that it was reduced in that way?

10 A. I would need to consult my calculations for that but I don't think it would be a problem.

Q. Now the other thing that emerged from the site reports that we've now seen is that there was, and I'm not sure what you engineers would call it, I suppose a direction given that instead of widening the seismic gap by trying to reduce the length of the pre-cast stair unit that the space be  
15 accommodated by cutting into the beam at the end of the seismic gap on the other side. I wonder if you have any comment on that as a procedure for widening the gap?

A. Yes I think that would be a solution.

20 Q. And did you see any evidence of that? I suppose you weren't looking for it but did you see any indication that had been done when you were doing your investigations?

A. No we didn't see anything that would make that action immediately obvious to us.

25 Q. And would you have seen it from the investigations you were doing if it had been done?

A. For the investigations we did on the 5<sup>th</sup> of September, no. It's likely that that would have been covered by vinyl on most of the floors. The ones that we saw at the end of last year when we saw the remaining flights, maybe because some of the vinyl had been removed on those floors.  
30 Some hadn't but some had. It's quite possible we would have missed it.

Q. Now the other thing I just should give you the opportunity to comment on further if you think that you need to is what was said by Mr Cameron

about the width of the gaps that he thought he was observing which were shown in the photographs that you saw as well and also the evidence that Mr Carr gave about the size of the gaps and the extent to which they might have gone right through the landing. Is there any more you want to say on that. I'm just really giving you the opportunity. I take it you don't agree with either of the sizes that were being identified?

A. My recollection of the cracks in the soffit and recognised that the ones Mr Cameron showed were the worst in the building because those were the ones we decided to open up and have a look at the supports and that's the reason why the linings had been removed from the timber framing. They were in the order of 2–3mm max. That was one of those cracks you saw there. The other cracks were much less than that. So I could add that in September we were looking at the stair and its ability to be able to carry vertical load, continue to carry vertical load, and I and my colleague felt that the distortion that we saw in the stair and the lack of differential displacement across the cracks and the lack of propagation of the cracks all the way through because we did remove the vinyl off that particular flight. That the stair was, even though the steel had probably yielded, it was still capable of carrying the vertical load. Dr Sharpe has just reminded me that that report that was done by the University of Canterbury pre the earthquake but was published in 2000 also came to the similar conclusion for the units that they tested at the University.

Q. And do I take it that in a way Mr Carr acknowledged he didn't, that you saw cracks that were both underneath and above and satisfied yourself that they weren't connecting up and going right through?

A. That's correct.

Q. All right, the only other thing perhaps before I go into other questions that I should invite you to comment on if you wish, is as you know Professor Priestley is going to be giving evidence for the panel after you, but we sent through to you last night the Power Point that he is



going to be referring to and at the end of that Power Point was this page headed "Issues Requiring Discussion" which were additional issues that weren't in the panel report as I understand it and I am just inviting you whether there is anything in there that you want to comment on at this stage?

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A. I would not disagree with Dr Priestley in terms of they would be useful additions to the whole story. However, I would be interested to hear his reaction to whether they would make any difference to the findings that we have made and conclusions that we have reached in our report. We have obviously in terms of any investigation you have to make a judgement call at some stage of how far you go in a lot of these things and we concluded at the time we did the analysis for example that we didn't know how badly the structure had been damaged in February because nobody had gained access to the building, that it was not unreasonable to do the elastic analysis which I think is one of the comments he's made and to rely on equal displacement type theories to say that it wasn't going to be too dissimilar to the level of damage that might be there to what would be there if more damage had occurred.

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Q. Yes, yes, well he'll no doubt having heard that comment on that, now just for the record the document is ENG.PRI.0002.8 but that's simply to keep the record straight. That's what's being referred to there. I'll just come back to some of the topics that I wanted to take up with you and the first of them is this issue which seems to lie between yourselves and Holmes Consulting Group on the design that was used at the time, the design we've been looking at and whether there were known alternatives to it at the time which would have been more resilient. I think that's the issue isn't it? So I'm inviting you to tell the Commission what those alternatives are and why you have so firmly disagreed with Holmes on this?

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A. The detail that we've put forward as being a possible alternative has – that detail has been around for many, many years.

Q. Can you put a date on that when you say many, many years?

A. I think since it was recognised that interaction between floors with stairs might be an issue, that detail has been around so probably the 1970s, late 60s.

5 Q. Is that the detail you're referring to when you resisted Holmes asking for a change to the draft final BECA report, to not say it was known at the time?

A. That's correct.

Q. And this is the one that you've just been showing to the Commission?

10 A. That's correct.

Q. Are there any other known designs at that time that you have in mind or is it just that one?

A. Well there are a number of solutions which involve ledges and gaps but which also have a final restraint so they have a tie that stops the – if the unit does – if the ledge is potentially going to be jeopardised, then it just holds the unit on to the last bit, far less common I think than the one that we've presented.

15 Q. You said when you were describing the detail that you've just referred to as the known alternative to the disadvantage with that which as I understand it is it creates a lower head height, that then needs to be accommodated in some way. Would there be any reason for not having that blocking system that you've just described?

A. No, not – well it's just trying to physically get it into place and practically come up with a detail that's practical and buildable. You can see that contractors like to just load these units in so they like to lower them with a crane, put them immediately in position, feeding bolts in afterwards and what have you is problematical for them typically.

25 Q. Yes.

A. But I think that in order to prevent the sort of issues that we've seen in Forsyth Barr eminently – (inaudible 13:19:59) eminently suitable solution.

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- Q. Does the – let me put this differently. Is it your understanding despite the resilience concerns that you've now raised about the Forsyth Barr method of putting stairs in, that that was at the time that the Forsyth Barr building was built the most common way of putting stairs into multi-storey buildings?
- 5
- A. I think I'd answer the question this way, that many of the multi-storey buildings in New Zealand were – have been designed by one or two consultancy practices so the details that they come up with tend to be quite common throughout the building stock. I know from my experience since I started practising in the late 70s that my mentors in our firm were always very clearly of the view that this sort of detail was not an appropriate one simply for the lack of resilience. However it did meet the code, it was practical for construction and so it persisted.
- 10
- Q. Well I was going to ask you if BECAs ever used it, but you're telling me during your time that it wasn't.
- 15
- A. I can make an interesting response to that, but I hadn't seen it before but a couple of instances have been brought to my attention.
- Q. I see.
- A. Typically they are ex-staff members of the other consultancy.
- 20
- Q. I see – is it cause and effect that they are ex.
- A. So we're not immune from it, we have some that are similar.
- Q. Yes, and the reasons that BECA didn't use it, as I think you've already made clear, was because it lacked resilience, was too risky?
- A. Well the trouble with earthquakes is it's only the earthquake that knows how it's going to punish a building and we can only predict and some of our tools even now are only really approximations of what's going to happen, so you need to be mindful that resilience is important.
- 25
- Q. Yes.
- A. Particularly when the failure mechanism is a brittle one, and also codes set out minimum standards as well so – and with the difficulty of dealing with a gap detail, in this situation means that the tendency is always to go for the minimum.
- 30

- Q. Yes, and I take it from your report that the – one of the other concerns you've got about it is that that gap is so easily compromised which is what we've seen here.
- 5 A. That's correct. I think the report in 2000, one of its recommendations was that there should be – every owner should be required to have a maintenance regime to ensure the gaps were clear. That's something that just hasn't got through to the practitioners I guess.
- 10 Q. And am I correct that there has at some stage, and if I'm right I'll ask you to try and identify when, that there has been a general move away from the kind of stair detailing that we've seen in the Forsyth Barr building?
- 15 A. Yes I think most engineers who I talk to are now very aware of this issue and I don't think we'll see another stair detailed in quite the same way as the likes of Forsyth Barr. Our interest of course is going to be how to deal with all the ones that currently exist.
- 20 Q. Well I take it your first response was really, we won't see any more of these since what we've seen in Christchurch, but was there an era earlier than that where in your understanding there began to be a move away from this type of stair detailing?
- 25 A. It may well be, but I'm not aware of a particular point in time. It may have been from the knowledge of that 2000 report perhaps for those that were actually using the detail.
- 30 Q. Now a related question about scissor stairs, and you'll be aware that the panel, the expert panel expressed some serious concerns, I think that's fair to put it that way, about scissor stairs independently of the issue about the seismic gap detailing and so on and I take it that's because of the issue that you identified as well. You lose one, you're likely to lose the other and all stair egress goes. Similar questions to you on that. Has BECA during your period held that view as well or is this a late realisation?
- A. I think the profession's always known it. I think the way we have done scissor stairs. The way we have typically dealt with it is to try and

provide the resilience and not necessarily rely on the code minima and there's situations that I've been involved with that's typically been the case and we argued quite strongly for the sort of details that I've outlined as being what we would recommend. Yes I think there's

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Q. Yes, thank you. That's what I wanted to know. Now on this question of retrofitting and Professor Bull's going to be asked about this as well, but given that you're here and may have views on this, how difficult is it to now deal with the retrofitting that seems to be being called for in light of the conclusions that have been reached in your report?

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A. We have been – our firm has been involved with several retrofits over the last few months of such stairs. There is always a solution to a problem even if it's total replacement of the stairs I guess, but the reasons why the detail like the Forsyth Barr stair came about and the head height clearances that I mentioned, they are the things that make it quite difficult to retrofit because if you're going to try and create a bigger

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ledge by extending out the structure to support the stair then very quickly in many cases you're cutting into the head height clearance that's available and so that's one issue. The other issue is that quite often the knee joint occurs in a position where it's not easy to extend the ledge out to pick it up so those are two practical difficulties we've come across. The other ones are in constructing the retrofit but invariably you have to cut back structure so we have on some jobs cut back structure to create gaps. You have to be very mindful of the structure you're cutting back, making sure you're not jeopardising other things by doing that but that's just normal engineering and also you need to be able to support the flights while you're going through the exercise and so there's a safety issue. We've come across cases and have been able to stop them in time of contractors propping all the flights in sequence so gradually loading the props lower down ever increasingly and have been

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able to prevent that but that would be something that you would need to watch out for.

Q. I'm about to open up the topic of the level 2 assessments that were done.

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**JUSTICE COOPER ADDRESSES MR MILLS:**

Q. You might be some time on that do you think?

A. That will be a little time yes – again it depends entirely on how much agreement we reach and how rapidly but there are several factual  
10 issues that need to be examined.

**COMMISSION ADJOURNS: 1.29 PM**

**COMMISSION RESUMES: 2.03 PM**

**EXAMINATION CONTINUES: MR MILLS:**

15 Q. There is just one issue that I feel I'm bound to raise with you before I  
start asking you about the level 2 assessments because it's an issue  
that has been raised publicly and by others including Holmes Consulting  
Group and that is I think fairly obvious conflict that you had in both doing  
the assessments and then doing the DBH report which required you to  
20 comment on the efficacy of those assessments and as I say, I feel  
bound to raise that and just give you the opportunity to comment on two  
things I think, the extent to which you were aware of that, conscious of  
it, perhaps more accurately when you were doing the DBH report, and  
secondly whether you feel that you had been able to successfully  
25 separate yourself from the pressure that that conflict created when you  
were doing your DBH report?

A. No, you are correct that it is – it is an issue that's referring. I would call  
it a potential conflict rather than an actual conflict. We made the  
department aware of our previous involvement in this building prior,  
30 when we submitted our proposal to them and then having been  
accepted we raised it in the – with the panel and it's recorded in the

proceedings of the panel, in the potential conflict register. The panel certainly considered the issue and decided that our previous involvement would not constitute a conflict that would prevent us from carrying out the investigation, so that was one aspect. The other aspect you asked me was about my own feelings in terms of carrying out the investigation. We were not required to comment on the validity or otherwise of any assessments made. The department was very clear that it wanted to keep away from culpability et cetera issues, but I – you will ask me other questions no doubt but I still feel very comfortable about what I did in September, what BECA did in September and I don't think it has conflicted us in terms of determining what we believe is the best answer to what happened in the February earthquake and the collapse. To some extent it may even had helped because we actually saw it in September, so that may be the case.

15 Q. Then I want to take –

A. Sorry, one other aspect is that by that stage another consultant was involved in the building and had been for some time so.

Q. Do you mean Holmes?

A. Holmes, yes.

20 Q. Yes, the question I think has been raised more in relation to your ability to stand back from and appraise looking back whether the decisions that were made around the level 2 assessments were the best ones I suppose, and I'm going to ask you about that so I thought I had to put that on the record given the fact that it's had attention from others and I didn't want it to go away and so it was something being tucked under the carpet.

A. I understand.

30 Q. Let me then turn to this question of the assessments and the effect potentially of the September earthquake on the stairs which is really the issue that you were looking at in the assessments that you did, those level 2 assessments, and I would like you to start by taking you to part of your report which is at BUI.COL764.0003.45.

**WITNESS REFERRED TO REPORT**

Q. You're looking at your actual report. It's page 40 of your report. It's where you discuss the effect of the inter-storey drifts, but I'll just wait until that comes up. Now really the points I want to just take you back through are included in those bullet points at the top there and they're issues that you touched on earlier today when you were giving evidence and talking about the effect of the compression, how much movement was required to initiate the compression and I take it from what you've said this morning and what you've said here, that if we assume that the seismic gap was 30 millimetres then some level of compression is initiated at anything beyond that. Is that right?

A. That is correct, yeah.

Q. And as you took us through this morning in relation to that set of drawings you've got showing the collapse scenario or the assumed collapse scenario, and as you say here a further drift of approximately 4 millimetres beyond the 30 millimetres if I'm understanding this correctly is sufficient to yield the reinforcing steel, and then as you say in your next bullet point, beyond that it begins to lock in that yielding of the reinforcing steel. So am I right then that anything beyond 30 millimetres we begin to get compression; anything beyond 34 millimetres we begin to get the yielding of the steel; anything beyond that that yielding begins to be permanent. Is that correct understanding of that?

A. That's in summary correct, yeah.

Q. Now I think that your agreeing that it's almost certain, and perhaps it even is certain that for some of the stairs at least the seismic gap had been compromised, even if built initially to the 30 millimetres, so it was less than 30 millimetres. Would you agree with that?

A. I think that's fair comment, yeah.

Q. And it is at least compromised in some cases by the presence of that polystyrene strip, agree with that? In some cases it's compromised by the presence of that polystyrene strip?

A. That's correct, yeah.



Q. Did BECAs ever do any assessment of what the compressed width of that polystyrene strip might be?

**JUSTICE COOPER ADDRESSES MR MILLS:**

5 Q. Are you talking about the tube?

A. No, the strip.

**EXAMINATION CONTINUES: MR MILLS**

Q. This one here.

A. Are you alluding to back in September considering that, or –

10 Q. Well at any stage, I'd be interested to know whether you have ever done an assessment of what that would compress down to under the pressure of the inter-storey drifts we're talking about?

A. We did consider doing a test on it but in the end have not done so. It's of interest to note that that has thickness of about 20 millimetres.

15 Q. Yes.

A. So if it was 30 millimetres and it had been put in the gap to create the gap, then it might have compressed by 10 millimetres, but it doesn't look like it from just from a simple observation of it.

20 Q. Yes, well that was there of course, the issue that I'm interested in because if we take that and its presence in any particular flight of stairs, then we're immediately prior to the compression of that down to 10 millimetres if we did start with 30 millimetres aren't we?

A. Yep, yeah.

25 Q. And we're not sure how much it comes down under compression but certainly not to zero?

A. Not to zero, yeah.

Q. Now then –

**JUSTICE COOPER:**

30 Q. Well I suppose between zero and something, it may be above – it may be not quite zero but nevertheless negligible. Is that a fair comment?

A. Polystyrene in sheet form does have quite a stiff – it's quite a stiff product so that it does take quite a bit to compress it. I mean early times perhaps back in the 70s, even the 80s, perhaps even today people think of polystyrene as being quite compressible but it's actually quite stiff, in sheet form.

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1413

Q. Of course the question that flows from that is given that you have agreed that compression starts at 30 millimetres it's almost inevitable isn't it that in the September earthquake that there was compression in the stairs?

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A. I think the distortion in the stairs and at least some of the flights would suggest there was some compression in the stairs in September. Yes.

Q. And would you agree that the photographs that among others, well particularly Grant Cameron, showed, but you also had some, that that cracking is the result of some compression or I suppose you would say compression on the top, tension on the bottom.

15

A. I think that's the best explanation for it.

Q. Yes but whichever it is, top or bottom, that's a result of the seismic gap being fully utilised and the lateral movement continuing?

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A. That, that's correct. The stair is locking up and has been forced into, to sag by the compression.

Q. Yes. Now the other bit of evidence we've got that suggests some quite significant reduction in 30 millimetres, again assuming that's what we've got to start with, is the photograph that among others you took us to which showed the attempt to cut back the concrete but left the steel cap at the bottom. It would be I think a fair assumption wouldn't it that the reason for trying to cut it back was to get the 30 millimetres.

25

A. We've certainly thought about that and think that's probably the best explanation but you can never be certain.

30

Q. No I accept that but it's the one that immediately springs to mind isn't it and if that was correct then that cap as I recall it was 10 millimetres, I think that was the figure that you –

A. The cut?

Q. The, the cap itself, well we cut back 10 millimetres but the cap was still at whatever it was before. The steel cap at the bottom.

A. The steel cap was in the same position.

5 Q. Yes.

A. But more, yeah, more than likely it was the unit had been made longer or required to be longer. That's the reason it was being cut back, yeah.

Q. Yes. So again that would be very likely to indicate a stair length which did not leave a 30 millimetres gap?

10 A. That's correct.

Q. Now in your level 2 assessment and I think it's the one to the 15<sup>th</sup> of September and I'll just get that brought up, it's BUI.COL764.0003A.18. Now correct me if I'm wrong but as I understand it this is in part the 5 September assessment but in part the 15 September assessment written over it. Is that a correct understanding of this?

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A. I think it's the 6<sup>th</sup> of September probably. If it's got, it's certainly got those additional inspections that we referred to this morning on it, which are more the 15<sup>th</sup> of September.

Q. It says 5 September on it doesn't it?

20 A. 5 September was the initial level 2 rapid.

Q. Yes.

A. And the 6<sup>th</sup>, around, well it was on the 6<sup>th</sup> that it was changed to G2. So that's reflected, so 5<sup>th</sup> of September was a Y, Y2.

Q. I see.

25 A. And then it was changed to G2 on the 6<sup>th</sup>.

Q. Yes actually I can see that because just for the Commission, if you look along the top it's got the 5 September date and that does as Mr Jury has just said have under that box, "Final posting restricted use Y2," and then under that, "Now G2, refer attached." So that will be right even though it still says 5 September that this one here is now reflecting both 6 September and 15 September. Is that correct? Because we've got the notation at the top that says, "Re-inspected 15 September."

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- A. I'm not seeing that on my copy.
- Q. If you look at the top of the page that is point 18 in our document number do you see written above the black band, "Christchurch Rapid Assessment Form" –
- 5 A. I'm not seeing that I don't think. Yeah I suspect –
- Q. Now you can see it.
- A. Now I can see it.
- Q. Yes.
- A. No that, that looks as though that's the same handwriting as the last  
10 note on the last page of the assessment.
- Q. Yes.
- A. So that would have been post 13<sup>th</sup> of September so more than likely it's the 15<sup>th</sup> of September.
- Q. Yes, yes. So we've really got three inspections wrapped up in this  
15 single document (inaudible 14:18:53)?
- A. Even four, even four because one on the 13<sup>th</sup> of September as well. So 5<sup>th</sup>, 6<sup>th</sup>, 13<sup>th</sup> and 15<sup>th</sup>.
- Q. Now I had not appreciated that there ones both on the 13<sup>th</sup> and the 15<sup>th</sup>. I thought it had just been an uncertain, uncertainty about the date of the  
20 single assessment which was one day or another.
- A. I'm looking at the note above the level 7 note on the last page which says, "Inspection on Monday the 13<sup>th</sup> of September of internal stairs, had been previously removed and infilled. Tenants noted slight sagging of the floor." That, that's a separate, I believe, I wasn't responsible for  
25 those so I'm only surmising that's the case.
- Q. Yes well it's just been pointed out to me which I was aware of that on page 20 of these documents there is a reference to inspection on Monday the 13<sup>th</sup>. So in fact there's four level 2 assessments done by BECAs. Is that what we're –
- 30 A. That's right. I think the latter two have come from probably tenant enquiries over things that they had noted and BECA had been back to the building to have a look at those.

- Q. Now what I wanted to draw attention to is first of all that reference above the black band that we just saw about, "Re-inspected on 15 September to investigate floor sag," I think that's what it's saying isn't it?
- A. Mmm.
- 5 Q. And then over on the next page point 19, this is the level 7 assessment where you seem to have focussed, "Floor has sagged." Is that give or take 10 millimetres. Is that what I should take from that?
- A. Yes, no that's the same handwriting as the last note. Yes.
- 10 Q. And then over on point 20 the Monday the 13<sup>th</sup> inspection there's a reference to the internal stairs between levels 6 and 7. "Tenants noticed slight sag in the floor by door level 7. Could not inspect without removing carpet. Recommend further inspection with carpet removed and through suspended ceiling on level 6."
- A. Yes there was, there was apparently an inter-tenancy stair previously
- 15 between level 6 and level 7 in this location.
- Q. Yes.
- A. That had been removed and what they were commenting on was the infill concrete work in that stair penetration so.
- Q. Not a sag of the floor as such?
- 20 A. A sag of the floor they were investigating.
- Q. Yes.
- A. Nothing to do with the stair.
- Q. I see, all right. Were you at any stage aware when you were doing the assessments that there, and did you conclude, that there had been
- 25 compression and that there had been some bending of the stair flights?
- A. Yes I mean that, that was our assumption right from the beginning when we first saw the stair and saw that it had deflected and that it had cracked.
- Q. How many of the levels did you go onto to do a stair inspection?
- 30 A. We walked both stairs for the full height of the building.
- Q. So you looked at all of them. Now one of the issues in your assessment which has I think caused some concern is that you did identify the

presence of obstruction of the seismic gap and that's referred to in the page, point 16, where you say the loose debris should be cleared from the seismic separation gap at the end of each stair flight to allow movement as originally started, see that?

5 1423

A. Yes I'm aware I've had it before but I'm aware of it yes.

**JUSTICE COOPER:**

Now is that started or intended? It's got our number at the top that ends

10 3A.16.

**EXAMINATION CONTINUES: MR MILLS**

Q. I thought it said started but is that your writing?

A. That's all my writing yes.

Q. Well then you're the best one to interpret it, aren't you?

15

**JUSTICE COOPER:**

I thought it looked like intended with a rather poor attempt with a pen.

**EXAMINATION CONTINUES: MR MILLS**

A. Intended.

20 Q. Yes exactly that would make more sense of it wouldn't it? Now I'm right aren't that at least while Beca was involved in the assessment work that that clearance or checking of the seismic gap and the clearance of them was never done?

A. We understand it was never done yes.

25 Q. And the reason that you had identified that in here was because you had found compromised seismic gaps in the building and were concerned about that?

A. We believed we had certainly found compromised gaps.

30 Q. Yes and in light of the points we discussed a moment ago about the point at which compression would start and from there where the

bending and then a lock in would occur, this would be a significant concern for you wouldn't it?

A. It would be of concern yes, yes.

5 Q. Now the question is or two questions, who was this directed to when you say should be cleared out or cleaned out?

A. I think it was directed to the building manager who we were commissioned by to look at the building.

Q. Now you went ahead and gave it a green sticker even though this point had been identified but had not yet been carried out.

10 A. Yes.

Q. In retrospect was that a good idea?

A. I think this is the hub of the question on the relevance of the placarding and what is trying to be achieved by that process. I believe and still believe that the adequacy or otherwise of the gap was not a  
15 (inaudible 14:26:06), the stair flight was imminently dangerous but it wasn't an aspect that would necessary reflect on whether the building was to be placarded yellow or green.

Q. Well let me just tease that out a little bit. We've got agreement that we had compression in September and we're agreed because it's your own  
20 data that anything beyond 30 millimetres commences that compression and anything beyond 34 millimetres begins to bend steel, anything beyond that begins to lock it in. Now do you agree with me that potentially the effect of – leaving the polystyrene to one side – the effect of the mortar and other builder's rubble in the seismic gap could be that  
25 there would be essentially no seismic gap at all?

A. That's quite possible but what we did in terms of or changing the placard from yellow to green was that we were particularly interested to know whether the support of the stair had been jeopardised and whether there was any indication that it had been, if it's the overlap with the ledge had  
30 been significantly reduced and that's why we had the bulkheads removed and that's why we had a look at the seating. Up to that point we didn't have any drawings so we didn't know what it was so we were

particularly keen to see that the sag wasn't due to a failure of the support. Those inspections or that inspection that we did on the most critical of those floors or the one with the most movement indicated that (a) the support was still intact and (b) that there was very little sign of any movement of the unit on the seating so on that basis we said the seating was not significantly worse than prior to the earthquake in that state and notwithstanding that the gap maybe filled that it was acceptable to post it green.

5

Q. You're not taking the position are you that it would be corruption of the seismic gap had always been there that the building's no worse than it was before and therefore it's safe to occupy?

10

A. Well it comes down to an issue of whether the building is dangerous and at that stage the fact that the gaps might be filled did not make it dangerous in the terms of the Building Act so in that respect it was green.

15

Q. But as I understood it from your evidence on today your view is that the seismic gap is critical to the performance of stairs in an earthquake. There were –

20 **JUSTICE COOPER:**

I think the answer is yes, judging by the way you were nodding.

**EXAMINATION CONTINUES: MR MILLS**

A. I think the, perhaps I can clarify in that clearing the rubble, looking at whether the stair or how the stair had actually performed was a task for a later exercise not part of the level two rapid.

25

Q. I will just come at this one other way. I don't want to extend this unduly, but is it your view that within the proper role of the level two assessments it would not have been appropriate to have said we've identified a compromise of the seismic gaps. Once that's cleaned out then we'll give it a green sticker.

30

A. We could have done that but I don't think it was necessary.



Q. And not necessary because?

A. Because I don't think it was part of necessarily the process that had to go on in order to make the building reoccupyable in the immediate sense.

5 Q. But doesn't it follow from what you've said previously about the seismic gap that it could have put the stairs very much at risk?

A. Only in an earthquake that had been bigger than the one we've just sustained potentially and quite a lot bigger because it hadn't shown any obvious signs of loss of support that flights, the flights we looked at.

10 Q. All right. Well I think we know what your position is on that so I don't think I need to pursue that further other than taking you to one final reference in your material and this is at BUI.COL764.0003A and it's at page 96 and this is appendix A2.6 to your report. It's a site visit that you managed to make on the 14<sup>th</sup> of September, 2011. And the passage I  
15 just want to draw your attention to and have any additional comment on it you want to make is under that heading down in the last word "In our opinion" and you'll see that the first point in there is the seismic gaps in stairs could have been as little as 11 millimetres prior to the 4 September 2010 earthquake. You see that?

20 A. Yes.

Q. Now was that based on the opportunity you've got to observe the seismic gap on that inspection trip?

A. That's correct, so primarily it is affected by the flights that are still in place.

25 Q. And was that because it was built that way or was it for some other reason, such as mortar and so on in the gaps?

1433

**MR MILLS TO DR SHARPE:**

Q. Is that for Dr Sharpe?

30 A. I think I wrote these words here. I recall that's because we had observed cutting back of one of the still in place lower landings to the extent of nearly 20mm.

Q. So I take it that it would follow from this that if anyone had done a full inspection of the seismic gaps after September they would have expected to find some very small seismic gaps in the building?

A. Certainly.

5 Q. Now in fairness to you I take it that when you were doing these level 2 assessments and when you were making recommendations about what should be done that at that stage you had expected that you would be retained by the building owner to go on and do the type of report which Holmes was subsequently engaged to do. Is that correct?

10 A. We were under that impression yes.

Q. Just a couple of final questions about this assessment process you've said in your evidence that the level 2 assessments were passed on to the Christchurch City Council?

A. Yes that's correct.

15 Q. We've confirmed that with Christchurch that they had them. What was your expectation about what the Christchurch City Council would do with those assessments that were passed through to them if you did have any expectation?

20 A. Well in fact in September we couldn't placard the buildings ourselves so we had to put our reports to the City Council and then they signed based on our recommendation or whatever they wished to do. I think in September they were placed in a position where they relied on assessments coming from certain people. They were prepared to rely on ours I think.

25 Q. And have you had any experience that would enable you to tell me whether another engineer would be able to go to the Council and ask if there had been any level 2 assessments done on a particular building?

30 A. That's a difficult question. I think they could certainly go and ask but I think it took quite a long time for them to find these particular assessments so whether they could have found them before February you'd have to assume that they could have but I think they were in a bit of disarray really.

Q. I'll need to ask Mr Hare about this but I understand that he will say that Holmes and Mr Hare personally were aware that BECAs had had some role and had done something on the stairs. Were you ever approached by anyone at Holmes to ask you what you had done in relation to the stairs?

5

A. No, no, we were not. When we started this investigation I have to say I was surprised when we learnt that not much had happened with the stairs in that intervening period because to me, and we walked the whole building, that was probably the main issue in that building was the stairs, other than the isolated failures in the carpark.

10

**MR LAING**

Q. Mr Jury, I think it's you. I just want to follow up on some questions that were previously asked to you about the level 2 process. Now clearly you had to submit that form to the Council to get any form of placard change and that was beyond your powers?

15

A. That is correct.

Q. And that in fact occurred, didn't it?

A. Yes.

20

Q. And then subsequently the Council, I presume, placed a green placard on the building?

A. I think the process was that they signed it off and we placed it.

Q. You placed it. Do you recall that occurring or don't recall at this stage?

A. You did that Richard.

25

**DR SHARPE:**

A. I certainly recall the yellow placard being posted because I took a number of placards I think on the Sunday evening, a number of assessments to the Council to the Civil Defence Centre on the Sunday evening and sought approval and in fact I think my name was on, I actually was told, well okay, yes, go ahead and you sign off the yellow form and take it back. On the previous ones I think we actually got John

30

5 Buchan to sign at the bottom but I have a feeling that I might have signed them so you have to appreciate that on the 4<sup>th</sup> of September very few of us in New Zealand knew about this assessment process and we were very proud of the fact that we did know what was likely to happen and we understood and second-guessed the way it was going to work and so we quickly cottoned on to the fact that we could not sign them off as we had not been through the previous day's process of authorisation for signing so I was familiar with that process.

10 **MR LAING:**

Q. And one or both of you is quite sure that a green placard was put on the building?

**MR JURY:**

15 A. Yes I'm pretty certain that a green placard was put on and I would say more than likely that we placed it after having it signed or getting it from Council.

Q. And at stage did you have any expectation of further Council involvement or were you simply anticipating getting on and advising on some remedial work?  
20

A. I think the latter was probably a fair situation, a fair reflection of where we thought it was at.

**DR SHARPE:**

25 A. I could add to that by saying that this is one or two days after the earthquake when we were dealing with very many buildings. We had already understood that for our clients a level 2 assessment was quite a good way of indicating to them the state of the building, to the client as well as to the Council. The Council was just coming to grips with the concept of a level 2 assessment and whether it was even necessary or  
30 not – quite a different situation to the February the 22<sup>nd</sup> where Civil Defence took control much more rigidly of getting level 2 assessments.

**MR LAING:**

- Q. And this is to either or both of you. Your expectation, however, once the green placard had gone up is that you would be proceeding advising the owner as to remedial work and there wouldn't necessarily be any further involvement with the Council?

**DR SHARPE:**

- A. Until consent was required I think that would be correct.

**10 CROSS-EXAMINATION: MR GALLOWAY – NIL****COMMISSIONER FENWICK TO MR JURY:**

- Q. I agree with the general findings but there are one or two points which I just wonder whether you could clarify for me. First of all the choice of using the REHS record which admittedly was closest to the site but seemed to have unusual characteristics and I understand that because of the sub soil conditions in that particular part. So can you explain to me why you actually chose that record which happens to be rather severe in the February earthquake though much more average, slightly less than average possibly, in the September earthquake.
- A. We chose it because it was the closest that we had. We carried out modal analysis using all of the records, all of those ones that are effectively around the building, the four that were around, but we felt that we needed a good reason not to use it and we didn't have that good reason at that stage at the time we did our investigation. I agree that using the other records might have come up with slightly less drift perhaps. We did carry out geotechnical investigations at the REHS site to establish the ground conditions that were there and even following that we didn't have good reason to discount that record as a possibility.
- 30 1443
- Q. The site conditions were similar to Forsyth Barr were they?

A. They're – nothing's exact Commissioner Fenwick but close enough, but it wouldn't discount it.

5 Q. You used an elastic time history analysis. Now we know from a very large number of analyses that when you use a elastic time history analysis and you compare it with an inelastic time history analysis the deflected trait changes. In fact that's true whether you – any elastic based analysis whether it's time history, equivalent static or modal you find the picture shape changes and that's allowed for in our current standard, NZS1170.5 by the drift modification factor which for this building had a ductility of four of five of your 1.5, had a less – it's probably about 1.3 something like this. If that had been applied you would have got quite a sizable larger inter-storey drifts wouldn't you. If you made allowance for that change in deflected profile, do you get?

10 A. In terms of assessing the drifts against current code, we did allow for the modification factors, say when we assessed the drift and compared – and under the current code we did allow for that (overtalking 14:44:48).

15 Q. Yes, but I'm referring not to the comparison of the current code, but comparison with your elastic analysis which does not include this change in deflected profile you get due to in-elastic effects, partly because plastic hinging forms the base and partly because the top of the structure is too strong because it's controlled by gravity load and wind load effects, and it's stronger than you need for earthquake actions so it tends to push the inelastic deformation down.

20 A. Yes, I agree entirely. But the reason why we didn't go to inelastic was because at the time we had been told that the damage to the building structure was still relatively minor and – but the full inspections hadn't been able to be done because access was a problem so we took the view that rather than go ahead and do a full inelastic time history analysis that time we would do an elastic analysis and hold off until we knew more, but unfortunately we never got to that point before –

25

30

- Q. In hindsight when you found out there were 5 millimetre cracks around the levels four, five, six you might have actually gone about it a different way?
- A. We certainly might have.
- 5 Q. So you'd agree you might have underestimated the inter-storey drifts?
- A. We might have, we might have done. I guess our analyses showed us or confirmed to us what might have been a scenario and I suspect that making the structure inelastic as you had said would have just made it worse.
- 10 Q. Yes, compensated for by using perhaps the REHS record which is rather high?
- A. Yes, definitely, definitely.
- Q. So you've probably come to the right conclusion.
- A. We might have taken a slightly different tact in both as you suggest,
- 15 yeah.
- Q. Now you compared the requirements in a passing phase between the 84, I think you called it 88 code and I've got the 84 version, and the 2006. Now I did the same calculations and came to the conclusion which is slightly different from yours and I was wondering how you could
- 20 – if you could tell me what process you used to compare. I'm assuming you compared it for this building which I assume has a period of around about two seconds?
- A. Yes, it has.
- Q. Which I think I got from (overtalking 14:47:18).
- 25 A. First mode period, yeah.
- Q. First mode, and most of the displacement comes first mode, inter-storey drift's a wee bit different, but first mode. So just on that basis I'm wondering how you managed to come to the conclusion that the current requirements give you a 20 percent higher drift allowance for stairs,
- 30 which will be the inter-storey drift than the 1984 standard. If you could perhaps outline that so I can compare it with what I've done?

- 5 A. I'm not sure I can go into the detail on that just off the record, but I can tell you. We applied the loads as I believe it was probably with the modal analysis and we loaded the structure and determined the displacements in accordance with the code based on that. So we would have used – we did use the code spectra and the prescribed stiffnesses and in the current code to determine what the drifts in the building were under that code and we had already done the same thing but based on the 1984 code with what we understood were reasonable values of stiffness and what have you for that time.
- 10 Q. Well perhaps you can just comment then on what I've done, I've looked at it and said, right well the base shear coefficient, the elastic responding structure in 1984 which incidentally was for 150 year return period, not a 500, but we took that value, it works out to be .3, so you remember they had that minimum value which was set fairly high at the time. If you work that then gives you an indication of what the displacement was according to that standard and according to me it comes out first mode value centre of height 300 millimetres. Now if one then does the same thing for the current standard we've now changed the stiffness values so the period goes from two seconds to about
- 15 20 1.6 seconds, okay.
- A. Going from the 1984 code through to the 19 – to 1170?
- Q. You are using the 1984 when the columns it said take the stiffness on the gross section, the beams divide it by two, a half. You've taken columns as an average .55, I assume you've used .55, it's quoted in
- 25 your report.
- A. Yes.
- Q. And you've used .4 on the beams?
- A. Yep.
- Q. If you work out that, that's a ratio of about .67, taking the square root takes comes to about .8, so it moves down to 1.6. You then look at the
- 30 current standard, you find that the corresponding base share for the



elastic response instead of being .3, it's .16, it's almost half of what it was in 1984.

A. Yeah.

5 Q. Which would give you half the displacement. You'd then have to modify that to allow for P delta actions which were not required in 84, (inaudible 14:50:40).

A. Yeah.

10 Q. You've then got a drift modification factor which you've not allowed for which is 1.5, that takes you up almost to 300 millimetres, so I'm just wondering how it is you get the current standard being more generous than the – in terms of the drift requirements, than we have the previous value?

15 A. Oh I think what we said was that the ledge and gap requirements were larger in the 1170 code than they were provided in this particular design, and the same for the original code.

Q. Well let me get this correct, the ledge requirements are not specified in the standard, the inter-storey drift is and you have to design for the inter-storey drift.

A. In the 1988 code it is specified, the ledge requirement is specified.

20 Q. It's specified as twice the calculated inter-storey drift?

A. That's correct.

25 Q. That is not – that's the design value, that's not the peak value. I'm quoting of course I've allowed that two factor in my calculations because when you calculate your inter-storey drift it's based on this 2.2 over SM, structural performance factor and material factor, but your ductility displacement is based on four over SM. So if one assumes the equal displacement concept applies the peak will be four, the inter-storey drift explanation which was fairly clear when one looks back was taken at somewhere close to half that value. So in 1984 they recognise that  
30 problem and they said, right you double it, so we're now covering the peak inter-storey drift. Am I correct?

A. Yes, you're correct but the period shift between 1980s and the current code is such that it compensates quite a bit, so you get a reduced load which reduces the displacements against an increased stiffness which increases them, so –

5 Q. Thank you. I've allowed for that factor.

1453

A. Well that's, that's what we also did. I, the process you've outlined is similar to the process that we followed.

Q. And you've allowed for P delta actions in your calculations?

10 A. I believe so, yes.

Q. Because I think it's, I think when you look at these differences you've got to be very careful not to make a blanket statement. That's what I'm concerned about. In some cases the '84 Code was more generous than is currently the case. In other others it was considerably less generous, depending on the period range and the type of the structure.

15

A. I, I would agree entirely.

Q. So I'm just –

A. Our comment was solely on this building. So solely on what we found with this building. It wouldn't apply across the whole portfolio of buildings.

20

Q. The finer issue there is the recommendation that one should design for twice the inter-storey drift which of course is not twice the peak value, it's just twice the design value which is only 70, if one believes the equal displacement concept, is only 70% of the peak value because of the SP factor. So if we take that, the recommendation is you're designing for 1.4 times the calculated inter-storey drift with that recommendation. Now the question I've got. Do you think that's a sufficient margin given that there's no allowance made in that recommendation for elongation of plastic hinges which if you've got something like a metre deep will give you a 70 millimetre or so further extension.

25

30

A. We, in coming up with our recommendation of two we had in mind that it should be twice whatever you calculate for the ultimate limit state. So if

the codes require you to allow for beam elongation then that would be included before you doubled it. So I, our suggestion of a factor of two I suppose is in somewhat response to the suggestion that maybe we should design for a, an MCE, whatever that is when in fact we want these buildings to survive even more than what we've always thought to be the MCE. So we want a, we want to have confidence that we've got a conservative number. I think you're suggesting that even two might not be conservative enough. Myself I feel, and I mentioned this before, it wouldn't have required much extra ledge I think to have avoided the Forsyth Barr failure and probably some of the other failures that have occurred to stairs in a similar fashion. It all comes down to a factor of degree and what you have to provide to prevent these failures, not necessarily cover a design case perhaps but what, what level of resilience you have to provide in order to have a reasonable chance of avoiding these failures. I think there were far too many stair failures in Christchurch to suggest it was an isolated occurrence.

Q. Just following up on that then. Are you aware if any of our current standards require you to allow for elongation?

A. No I'm, I'm not currently aware of that but I'm not necessarily in the design field, in the nitty-gritty any more but I'm not aware whether they do or not.

Q. So there is a difference, there is a difference we've come up to. You and the expert panel have said double the design displacement. The Royal Commission –

A. Whatever they may be and however they (inaudible 14:57:00).

Q. On the basis of reports we've had, they say, no, you design for the maximum credible earthquake and you allow for elongation. I think you're supporting that?

A. Well I'm supporting it but I, I'm concerned and I have always been concerned about introducing an MCE limit state into design when we're even concerned about whether the two limit states we've got now have been correctly applied and a nebulous limit state like MCE causes all

sorts of issues, other issues to arise. So therefore to me the best, the best solution out of that is to take the ultimate limit state that we currently have reasonably well defined and, and be conservative and double it.

5 Q. Perhaps that sounds a bit complicated saying MCE. If you take the ultimate limit state at peak value and multiply by 1.5 and add on your allowance for elongation.

A. Yes I don't know. This peak value also has me concerned because I, that's not what we design to. We design to the, the displacement with  
10 S-P included because we believe that provides us with protection. On a theoretical basis it doesn't but in practicality I think it does, as the experience of Christchurch will show – that allowances of somewhere between 1 and 2 are reasonable.

15 Q. Can I comment? If you go back to the commentary to NZS1170.5 you'll find four reasons are given for the S-P factor. Only one of those implies that it's going to reduce a displacement. The other three indicate that a peak displacement is higher or is the same. So I think that needs to be revision – it needs to be looked at very carefully.

A. I am aware of those provisions because I think I wrote them but I think  
20 that the important thing is to, is that we are designing to two limit states but we're expecting our buildings to perform in a certain way over an almost infinite range of earthquake excitation. The higher earthquake obviously the more tolerant we are at, at poorer performance but we're expecting them to perform over the whole range not just two limit states,  
25 or not even just three limit states and so we need to come up with provisions that make it possible for designers to design buildings that are, that are going to perform as expected across the whole range of excitation we might expect and introducing another limit state is not the way to do that. Making provisions simpler so that everybody follows  
30 them correctly is in my view a much better way of achieving that end.

Q. Do I take it then you think it's very onerous to take your ultimate limit state, divide it by S-P and multiple by 1.25 and add on allowance for

elongation to ensure the safety of your stairs. Do you think that's too onerous?

A. Do you know what number that comes up with?

Q. It comes up about 200 millimetres depending on what the structure is.

5 A. Yeah, no well I, I think it's probably not too onerous, yeah.

#### **JUSTICE COOPER:**

10 Q. I think the context of the suggestion that was made by the Royal Commission was directed to the particular case of stairs, having regards to their very significant importance in a serious earthquake. Is there any reason in principle why one shouldn't take a special approach for stairs?

15 A. I, I think that's an entirely reasonable view. I think if you, if you apply a third limit state you apply it across everything when not everything has been shown to be a problem. Stairs because of the need, and now the public are expecting them to be at least as robust as the building if not better, they are a special case.

Q. Yes.

#### **QUESTIONS FROM COMMISSIONER CARTER – NIL**

#### **QUESTIONS FROM JUSTICE COOPER:**

20 Q. Just to follow that further. I gather that when you found out what the implications were for the length of the landing you weren't particularly concerned about that as a, as a matter of practicality. Your concern is how this is, what words are used to get to that result in the code. Is that right?

25 A. I'm sorry I'm not quite with you.

Q. I'm just trying to summarise my understanding of where you got to in your exchange with Commissioner Fenwick when you asked him what the result of his calculations was and he said about 200 millimetres. You seemed content with that.

30 A. No I think 200 millimetres is better for me than 100 millimetres and certainly much better than 30 millimetres.

Q. Yes.

A. I think the important thing is to show, is to send a signal that this needs to be a very robust system and not, perhaps not hide it in amongst a limit state that is nebulous for designers to apply, even researchers aren't certain how to calculate it and what it means and I think the simple factor of two on whatever number you put it on and I would put it on the number that you calculate applying everything that the codes require you to do sends that message, that you want it to be very robust.

1503

10 **JUSTICE COOPER:**

Q. But on the elongation issue, have I understood correctly that your support for the recommendation or your own report and the, how it was reacted to by the Department of Building and Housing actually assumes that provision is made for elongation and that if that were not the case you wouldn't be happy with your recommendation?

A. That's correct. I think that you certainly need to allow for these effects. It's not necessarily certain that you keep adding them together I guess but if they had to be added together that would be acceptable.

**QUESTIONS ARISING - NIL**

20

**WITNESSES EXCUSED**

**MR MILLS CALLS****NIGEL PRIESTLEY (AFFIRMED)**

5 Q. Now you're another who we've had before and your very distinguished CV has been read into the record so I won't take you through that again but I'll just ask you to confirm that you were the deputy chair of the expert panel appointed by the Department of Building and Housing to review the Forsyth Barr building?

A. I was.

10 Q. And you are now going to present both as I understand it the conclusions reached by the expert panel and also some thoughts of your own?

A. Yes.

15 Q. And I'll leave you to because I understand you've got some power points and you'll speak to that.

A. As has already been mentioned I'm going to briefly present the viewpoint of the expert panel and to make that I was the deputy chair of this panel which consisted of a number of people representing different professions including the chairman Sherwyn Williams who is a lawyer and then representatives of consulting structural engineers, architects, building officials, seismologists, geotechnical engineers and academics, and the role was to assist and review the work by the consulting engineers appointed by the Department of Building and Housing investigating the collapse or damage to four buildings – the PGC, Forsyth Barr, The Hotel Grand Chancellor and CTV and to provide a report to the Department of Building and Housing summarising the consultants' reports and placing them in a wider context. Next slide please. Thanks.

25  
30 There's very little difference in opinion between the expert panel and the Beca report. So I will be

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very brief, in fact I just have this one slide in, in outlining the conclusions and recommendations of the expert panel. There was a general endorsement of the conclusions of the BECA report. The seismic gap satisfied 1988 requirements but was inadequate for intensity of February 22<sup>nd</sup> 2011, not 2012 earthquake though we should acknowledge that there has been some doubt as to that as raised by Commissioner Fenwick a few minutes ago. The seismic gap of 30 millimetres closed during the earthquake damaging the stairs which shortened as a consequence causing unseating when the direction of shaking reversed. Additional comment that can be added to that is that beam elongation which was mentioned just briefly in the previous session would have increased the tendency for the unseating. The seismic gap provided would not have satisfied the 2001 requirements by about 20%. It's expected that a number of similar stairs in other buildings may be in risk in future earthquakes both in Christchurch and in different cities in the country. A DBH advisory note should be issued, in fact it has been now, warning about the potential problems with the detail used in the Forsyth Barr and it's noted that retrofit to improve safety would not be an expensive item. More conservative seismic gap details should be required for future building designs to ensure the safety of egress in seismic events larger than the design level. Now there's been some discussion in the last few minutes about what that number should be and I think really we're talking about rather small differences. There's a factor of two or a factor of 1.5 plus beam elongation or a factor of 1.5 divided by S-P which has been suggested by the structural engineers of New Zealand. These all come out to be moderately similar numbers and I think as long as we're all concerned and believe that the numbers chosen are conservative I think that's appropriate. So essentially that's it as far as the expert panel report is. It very much is just an endorsement of what came in the BECA Carter report. Next slide please.



And I wanted to just make a few additional personal observations on a number of issues some of which Commissioner Fenwick has already outlined. The first of these is the influence of the earthquake record. Next slide.

5 Now this is a plot of the displacement spectra which indicates the displacement at a characteristic point in the building if it responded elastically as a function of the period and the period here is the inverse of the frequency. The period, it swaying sideways like this, it's how long it takes to get from one side to the other and the frequency is the

10 inverse of that. This is the period. The period of this building was approximately two seconds. It depends on what the foundation flexibility was, whether it was a little bit less than that or a little bit more than that but the fundamental period of two seconds is not the only period of interest when you're talking about drift. Another item that's of

15 significance is the higher modes and particularly the second mode which is at about point seven of a second, about here and you can see the response here. Now these are the various records that were recorded in the CBD and you can see that at the two second period at this region this one here, which is the dark brown, which is the REHS

20 one that was chosen for the analysis, tends to be on the upper level of response but as it gets into longer periods it becomes significantly less than these values here. Now this is particularly significant if the structure had exhibited significant ductility in the September earthquake because this is the spectra for the September earthquake. So within

25 this region between two seconds and maybe two point two seconds where it probably responded in the first mode the response is rather independent of the period, of the record rather, but if it was significantly higher then the REHS record is significantly less intense than these ones here. If we take this value here you can see that the response at

30 two seconds in the analysis was about 330 millimetres and the response at point seven seconds is only about 50 millimetres, maybe 60 millimetres. Now although this is not terribly important as far as the

overall displacements of the building is concerned the response of the second mode can be quite significant to the drifts. That's the amount that one floor moves relative to the floor below and this is quite apparent in the time history response of the, that are shown in the BECA Carter, the BECA report. Next slide.

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If we now compare, and I'm sorry this is to a different scale here, the response of the earthquake, of the buildings to the different levels, the different records, the four records that are shown here and again look at the two second period and take the REHS record into account here, the other one's at this location, we can see that with the REHS the displacement of the fundamental mode at two seconds is a little bit above 400 millimetres and if you, if the period is a bit longer then it's rather less but again they're reasonably tightly bounded in this region but if we get into the longer periods, about three seconds, which would be equivalent to a ductility demand of about three or more then the REHS would be rather more conservative and this was the point that Commissioner Fenwick was making. If, however, we look at the response at round about the point seven seconds we can see that we're getting up to close to 200 millimetres. So the higher modes were very significant in this. So it may be that this is part of the reason why the response comes up with being, the displacement demand being up to 65 millimetres for the February earthquake, which this one is showing here, compared with only about 34 millimetres for the September 4<sup>th</sup> earthquake when it's considered that the displacement response apparently at two seconds is not that much different. In one case it was about 330. In the other case it's about 420. So this may be part of the reason why there's a difference. There is another thing that is perhaps worthwhile considering and that is that these response here, these levels, describe what happens to a building when it is subjected solely to a response in one particular direction, in the direction that this was recorded and there are another set of charts for what would respond in the perpendicular direction and if we take a normal building which has

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frames say in two orthogonal directions and apply these levels to one direction then it doesn't influence the response in the other direction but we have something or other which is a bit different in this case and that is that the stairs are orientated at 45 degrees to the two levels of response. That's this level, perhaps the north/south and the other level which is the east/west and they interact in the 45 degree level. So you can't take these values here as being indicative of what would happen in the 45 degree direction of the stairs. For example, if we're talking about response in the north-south direction the response may create a positive drift in the diagonal direction whereas the other direction of response may provide a negative one or a positive one. So there could be additive or subtractive at any one time. So it, I think we have to be careful about being too, well using these equivalent, simple-spectra as giving a good indication of what might have happened in the, in the actual structure itself.

Q. Is that, the point you're making now, particularly relevant to the Forsyth Barr building because of the orientation of the staircase?

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A. No, this is more in relation to some of the comments that came up from Commissioner Fenwick a few minutes ago in terms of taking values from these spectra, applying them as essentially I think Commissioner Fenwick used them as a single degree of freedom approximation which, whereas the values I take from BECA were in fact using a modal analysis which may again be a part of the reason for some of the differences but it's rather difficult to make two strong a conclusions I think from the spectra in any one of the two directions for what was happening in the diagonal direction of this structure. It's something that we don't normally bother about.

Q. Well I think we've arrived at the point I was wanting to clarify, where you talk about the diagonal directions.

A. I am talking about the diagonal direction which is the orientation of the stairs.

Q. Yes.

A. So it's just saying that with those stairs they will be impacted by what's happening in the two different directions of the structure.

5 **COMMISSIONER FENWICK:**

Q. It's a bit more complicated again isn't it?

A. Yes.

Q. Because there are frames at right angles and diagonals –

A. Exactly.

10 Q. (inaudible 15:24:13) direction, not in the other direction.

A. Yeah.

Q. So it gets very complicated.

A. Yes.

15 Q. What goes in this direction wouldn't go in that and it's orientated (inaudible 15:24:21).

A. No, the principal frames are oriented in the, parallel to the sides of the building, those certainly have the basis of the resistance to the structure, whereas the stairs are at 45 degrees to that and there are some additional columns and beams in the diagonal direction, perpendicular to the stairs but they don't have anything like the same stiffness or the strength as the other ones. What I'm saying is though, we have to be a little bit careful about just taking the spectra in one direction and trying to get an estimate of what the displacement and drift might be. Next slide please.

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**PROFESSOR PRIESTLEY CONTINUES;**

As far as the vertical acceleration is concerned, we know that these were very high in the short period range. It has been stated by BECA that there was no indication of problems when they did analyses of the stairs under vertical accelerations. I wonder however whether there were some problems with the capacity of the seating angle, the 381 millimetre by 102 millimetre angle which the beam – which the stairs foundered on at the lower level. We know that as

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the structure got damaged under compression it tilted down at the bottom of the first riser of the stair and as a consequence of that if you consider this to be the angle the seating of the stairs at that stage would be right out on the very point of it and the moment provided by that I think is though getting to be  
 5 – to induce rather high stresses in the web of that flange, of the channel section and with vertical accelerations that might have been something or other which again compounded it, the problem, but I'm not sure whether there's been that observed after the earthquake, whether there were some initial problems. If that was the case it's just vaguely a possible that vertical  
 10 acceleration may have played a part albeit of uncertain characteristics to that response.

**COMMISSIONER FENWICK:**

Q. Nigel were there no stiffeners in that channel. I'd thought there were  
 15 stiffeners in that channel to prevent the flange being –

A. If there are then that's it's irrelevant what I'm going to say. I didn't think that there were.

Q. Well you may be right but something I read here made me think, oh there were stiffeners there.

20 A. Well it could be, I'm sure that BECA can – actually they all like they're uncertain too.

Q. Sort that one out later.

A. Yes.

25 **JUSTICE COOPER ADDRESSES MR GALLAWAY:**

Q. Mr Gallaway could you seek instructions on that point?

A. Yes sir.

**PROFESSOR PRIESTLY CONTINUES:**

30 Anyway, this is not something that I'd place great importance on. It's just an observation that if the stiffeners were not there it may have been a significant aspect. Next slide please, and last slide.

Issues requiring further discussion, several of these have come up in questions placed by Commissioner Fenwick. The first of these at the conclusions of the BECA report are based on elastic time history analysis. I've calculated and done some rough estimates of what the yield drifts would be and I get something or other about 17 millimetres, as inter-storey drift for at yield, and that would indicate that bend ductility demand could have been up to about  $\mu$  equals three, certainly as high as two, two and a half and maybe higher at some cases. This does indicate significant non-linear response and the results would have been more robust if non-linear time history analysis had been used. As again Commissioner Fenwick has already mentioned the main significance to this is probably not an overall increase in the average displacement if you like of the building, but more in the shape possibly creating larger drifts in the lower storeys in particular. Only one record, the REHS, was used in the analysis. As a consequence the drift demands cannot be considered definitive and perhaps it might have been again more robust if more records had been used. The drift as calculated has not considered the possible stiffening and bracing effect of the stairs acting as diagonal struts once that seismic gap closes. Once that happens then you get a diagonal strut with some considerable stiffness until we get actual yield of the – at the end of the lower platform and that may have influenced the response. It would have made the analyses very much more complex putting in elements which would have had – it would have had to have been non-linear. It would have had to have something with an initial gap then a high stiffness and then a reduced stiffness as the elements yielded, but again that's something or other which is an approximation to the response which is incorporated in the analysis. The unloading stiffness of the damaged stairs after inelastic action following gap closure was in my view too high. Now what this means is it's been discussed that if everything was perfectly in accordance with the plans it took 30 millimetres to close the gap and then another 4 millimetres before you got to yield of the reinforcing steel at the critical section. Then if the displacements went another 20 or 30 millimetres and then the structure unloaded, the 4 millimetres which is the elastic portion of the loading after the

30 millimetres is taken up, it's assumed that that is the same unloading stiffness if you'd had – get another 4 millimetres back and that's been implicit in the numbers placed. Now normally with reinforced concrete structures when you take them into the inelastic range and you get a ductility of maybe  
5 three or something like that then the drift on unloading the elastic stiffness on unloading is lower than it is in loading. Normally by about the square root of the ductility factor. It's not a big effect but that 4 millimetres was probably more likely about seven on the unloading at the maximum displacement, so when they're taking about a gap which with a demand of 106 millimetres and  
10 a ledge of 102 millimetres, if you've got another 3 millimetres then that would take – it'd mean that you're 1 millimetre too big in the overall response. Now of course there are a number of other issues, we know that the analyses are elastic rather than inelastic. We know that beam lengthening hasn't been taken into account. We know that just one record has been taken into  
15 account. So there's a number of issues associated with that but it's something or other which might be looked at by other people when you're looking at the report. And finally if debris reduced the effectiveness of the seismic gap then damage including an increase in the size of the seismic gap should have been apparent after the September 4<sup>th</sup> earthquake and I – because it indicated that  
20 there's the 34 millimetre closure versus 45 millimetres if you took the 4 millimetre or the 7 millimetre unloading stiffness that I would – or they, or BECA was talking about then we might expect to see something like a 20 millimetre open gap somewhere associated with that response. Now it appears that that wasn't the case, though the fact that there is vertical  
25 measurement or vertical displacement of the stairs at the lower end of something like 15 to 20 millimetres in some cases, would seem to indicate that certainly there had been yield of the bottom reinforcement and that shortening should have been apparent, so maybe it was there and maybe it just wasn't picked up. Something else that perhaps could be mentioned in  
30 relation to that, there has been a little bit of difference of opinion in the  
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crack widths that were underneath the landing itself. Now I presume that they were measured by BECA and we know that they were just estimated by other people in this who have testified today but the vertical displacement of about 15mm agrees almost exactly with a crack width of 2mm so I think that there is supporting evidence to say that those cracks were about 2mm and certainly looking at the photographs that was my reaction when I was saying looks like 2mm maybe 3mm to me so I suspect that those were pretty reasonable estimates but I don't think BECA was actually asked if they were actually measured with, you know, we have engineers come round with a little gauge which has different size lines on it which you hold up against the crack and you can get a very good estimate of the crack widths to even a tenth of a millimetre but I presume that that was what their crack widths were placed on and Your Honour that's my testimony.

15 **MR MILLS:**

Q. I only have a couple of things that I thought you might be able to help us with and one was your reference, well the panel's reference, to the known alternatives to what had been used in the Forsyth Barr building and I thought if you were able to do that it would be of interest to a lot of us to know what those known alternatives are if they are different from the one that BECA described?

A. No, that was certainly discussed with us from BECA and I don't know that any other alternatives were advanced by other consultants on the committee particularly. There were other approaches that were suggested as new alternatives but not known alternatives at the time, such as having a hanging system so that there could not be an unseating and various other types of things.

Q. Now I was interested also in your comment that the retrofitting of the kind of stair system that we have been looking at in the Forsyth Barr building is not expensive. While Mr Jury didn't put a figure on it when he described what was involved he sounded as though he was describing



something that was reasonably complicated and expensive and I just invite your comment on that?

5 A. Well my feeling was that that's certainly one of the approaches and I think he was talking about changing from the existing design to something or other which had a sliding on a horizontal surface. I would have thought that it was not too difficult to increase the gap width at the top and then to weld additional support on the underneath to take that effective 70mm of displacement, of seating, and adding another 100mm. Certainly the opening part of the retrofit would be quite easy. Perhaps the closing bit might be less easy but if we're talking about survival rather than damage perhaps the closing is not so important. That was the BECA viewpoint that the closing was less important than the opening because of the very brittle and instantaneous nature of failure once you get past the seating itself.

10 Q. And the only other question I had for you related to I think again a comment in the panel report that there were other types of problem stair details commonly used in the 1980s and 1990s and I wondered again because it will be of interest to a wider audience than this I suspect about what again the panel was referring to when it mentioned that?

15 A. I think we were taking again advice from BECA on this one and also from the other consultants, the other consultants involved with the Pyne Gould Guinness Corporation and also the Hotel Grand Chancellor. Yes we had other ones. We did not discuss them in great detail. I should preface that by saying that there were several meetings towards the end. That's when I was out of the country and unable to be present at the meetings.

#### **CROSS-EXAMINATION: MR LAING – NIL**

#### **COMMISSIONER FENWICK:**

20 Q. Just one, thanks for your response so far, very helpful. Just one thing. Just going back to your response spectra on 0002.6 where you show

the response spectra for 1976 building standard which is identical to the 1984 and 1988 standards you might like to comment on that.

A. You're talking about the 1976 one?

Q. Yes.

5 A. I'm sorry I should have picked it up but I thought in fact it was not terribly relevant to what we were talking about but this one here is completely incorrect and should be multiplied by four to get it up to the value that would be appropriate here. This is the 1976 one. It's not the value that was appropriate for the time, the 1984 case.

10 Q. The '84 spectra was identical to the '76 one?

A. Ah, sorry this is displacement, yes you are correct. It's shown correctly in the other spectra in the acceleration levels but it's not shown correctly in this one here I'm sorry so I'm glad I didn't at least refer to it in the analysis. Thank you very much. It's important that that be noted.

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**COMMISSIONER CARTER:**

Q. Professor Priestley I'd just like to have your comment on record about the importance of making sure, conservatively sure, stairs are safe because it seems that as we free them up from being part of the actual  
20 lateral forces that exist in these buildings we are also reducing the secondary support systems that are often available when things are connected more strongly. So here we have a situation where a stair is connected at one end and left free at the other and yet it's the most critical element of the structure that we're dealing with in the sense that  
25 in the event of a devastating earthquake then that's one last element you want to fail. Therefore it seems to me that there needs to be a stress on the conservatism in dealing with this because we know that the loadings and the synthesising of earthquake responses et cetera all matters which can be relied to a certain extent on findings and  
30 measurement but still there is no certainty about those elements so I think we do need a cautionary approach to say that in stairs the actual support of them has to be conservative?

A. I am in complete agreement with that. The expert panel's viewpoint was that the design should be such that the stairs and their seating should be the very last thing to fail in a building. In other words, you should be certain that if the stairs failed, the building already would have failed.

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**JUSTICE COOPER:**

Q. So it's not a case of needing to abandon stairs landing on the ledge so long as the ledge is big enough. Is that right?

A. I think it is. It's an approach which in terms of the opening is  
10 satisfactory. The problem is if it's on a ledge itself then if we have a system like in the Forsyth Barr where there is a limited amount of displacement in the compression area you have some possibility of early damage and if you have a seismic gap of let's say 100mm which  
15 might be appropriate, it's difficult to design that in such a way that it's (a) completely empty and then, on the other hand, is stiff enough on the top so that you can get movement past it if people don't put their high heels on it and go through it or anything of that sort of nature could be a problem. So there are details which you can devise which will be satisfactory with overlapping sliding plates and things of that sort of  
20 nature but they are a bit different from what is currently being used. It's a more difficult, I think in terms of the opening it's not a problem, you should be able to deal with it. In terms of the closing it is more of an issue.

25 **COMMISSIONER FENWICK:**

Q. Just one other suggestion which came up. I think it was not put in too seriously that the stairs should have a limit when they would lock up, you know, if they got to the end of their travel. I wonder if you'd like to comment and it worries me because if it locks up in tension of course  
30 you change all the closing corners to opening corners. Just wondered if you'd like to comment on that?

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A. No I don't like the sound of that because certainly you can get something or other then which you're getting bending in both directions in an area which has very little resistance. That, the bottom corner of the stairs itself is an area where flexure and shear interact and the flexure shear failure plane in this actually goes along a series of bars coming down parallel to that failure plane which means that it would propagate along that level much more rapidly and to have that going backwards and forwards you get a shear failure very, very quickly.

5 Q. You would have advocate against that?

10 A. I would advocate that against that yes. That's my view anyway.

**JUSTICE COOPER:**

Mr Gallaway did you ask Mr Jury about that point?

15 **MR GALLAWAY:**

My instructions are that the analysis did take into account the orientation of the stairs with the earthquake records having regard to them sir. If you are

**JUSTICE COOPER:**

20 I did not think that was the issue. The issue was the presence or absence of  
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**MR GALLAWAY:**

Of stiffeners in the channel?

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**JUSTICE COOPER:**

Yes.

**MR GALLAWAY:**

30 They were there but not over the entire width of the channel and no observed damage. There was no damage observed to them sir.

**JUSTICE COOPER:**

Q. Does that make sense to you?

A. It does but I'm not sure what he means by over the entire width. I would have guessed that they probably would have had three stiffeners or something of that sort of nature or possibly two and that would probably be enough.

**MR JURY:**

The drawing shows that the channel specifically had stiffeners over the (inaudible 15:45:07). It had two stiffeners in it but that was (inaudible 15:45:06).

**EXAMINATION CONTINUES: MR MILLS**

A. So there was no stiffeners?

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**MR JURY:**

(inaudible 14:45:12 – microphone not turned up)

**JUSTICE COOPER:**

20 I should not have told you to do that. You need to come forward Mr Jury if you would and you can borrow Mr Gallaway's microphone. Just repeat it please so we can get it in the record.

**MR JURY:**

25 The drawings show that the channel has stiffeners but they are over the extent of the toilet block not over the extent of the stairwell but we do know that the channels that we did, were able to view did not have a damaged top flange and we did carry out calculations not under vertical acceleration just under the general acceleration and found that we wouldn't have expected to triple the flange of the channel. That web would be the critical because it's not

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as wide as, not as thick as the flange. But the load has to get there but anyway there's distortion out of the, out of level off the top flange.

**JUSTICE COOPER:**

5 One more question whilst you're there. Did you measure the cracks?

**MR JURY:**

I can't recall whether we put the crack measuring across the ones on the soffit but I have a photograph of me putting it across the top, the one that we saw  
10 across the top. I suspect we did but I just can't say for sure.

**JUSTICE COOPER:**

Q. Dr Priestley is there anything else that occurs to you to say at this point?

A. No.

15 Q. Thank you very much for your evidence and for your help earlier in our enquiry.

**WITNESS EXCUSED**

**COMMISSION ADJOURNS: 3.48 PM**

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**COMMISSION RESUMES: 4.06 PM**

**MR LAING CALLS**

**STEPHEN JAMES McCARTHY (SWORN)**

25 Q. Your full name is Stephen James McCarthy?

A. Yes it is.

Q. You're the Environmental Policy and Approvals Manager for Christchurch City Council?

A. Yes I am.

30 Q. You have previously given evidence?

A. Yes I have.

Q. Could you start reading your brief at paragraph 6 please?

A. Certainly.

**WITNESS READS BRIEF OF EVIDENCE**

5 A. "Council records indicate that the building permit to erect a retail and office building at 764 Colombo Street was approved on 9 May 1988 and uplifted on 19 May 1988. A copy of the permit approval and conditions are attached as annexure A. A design certificate dated 7 March 1988 was provided by Russell Arthur Poole for and on behalf of Holmes Consulting Group Limited in relation to the building. A copy of the design certificate is attached as annexure B. This design certificate covered the precast stair connections and the layout including the seismic gap. As I was not employed by the Council at the time of the construction of the Forsyth Barr building my comments below concerning the Council's processes followed at the time of the construction are based on a review of material on the Council's building file, the requirements of the bylaw that was current at the time and from discussion with some building consent officers who were employed by the Council at the time. In 1988 the relevant building bylaw was Christchurch City Council Bylaw 105 (1985). Clause 2.5, 2.16, 2.19 and 8.2 of the bylaw set out various relevant obligations to the owner, the builder, the engineer and the Council in relation to the construction of the building. The relevant parts of these clauses are attached at annexure C. Whilst 2.15.2 of the bylaw states that it is the duty of the owner of the land on which the work is carried out, the employer for whom the work has been carried out and the builder or contractor who is carrying out the work to ensure that the provisions of the bylaw are fully complied with and the commencement and execution of the building works. Clause 2.16.1 states that there must be no departure from the permitted plans, drawings or specifications unless amended particulars describing any deviation are supplied to the Council and the Council engineer provides approval for the deviation. The requirements related to inspections during construction are set out in clause 2.19. Other than

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clause 2.19.3 which refers to the inspection of the foundation excavations before the placing of any site concrete or part of the foundation structure, the clause does not specify any particular mandatory inspections. It appears that this was intended to be left to the discretion of Council engineers and the building inspectors who were carrying out the inspections. The bylaw does include a number of clauses relating to supervision by the designer of specific elements of buildings during construction. Part 8 of the bylaw relates to concrete elements in buildings. Clause 8.2.6 states that the designer of any concrete element must supervise the construction of the element. The clause states that supervision means general supervision only which includes such periodic supervision and inspection as maybe necessary to ensure that the structural work is executed generally in accordance with the design, as distinct from any special supervision that may be required for a particular situation. Attached as annexure D are the Council's inspection records related to the original construction of the Forsyth Barr building. The records note that the owner's engineer was checking before all concrete pours which may have included any concrete pours associated with the installation of the precast stairs. There is no specific record on the Council files of the Council inspecting the stairs or seismic gaps in the Forsyth Barr building during or on completion of construction. However it is possible that additional inspections were carried out by the Council's building inspectors but not specifically referred to in the inspection records. Attached as annexure E is the document developed by staff in September 1989 which sets out general guidelines to Council building inspectors about the scope of inspections to be carried out for particular types of buildings. Stair construction is included as random inspection item. The guidelines note that there will often be three to four random inspections for large buildings. I understand that guideline documents such as this were developed from time to time to confirm the general processes expected of building inspectors. The Council has not however been able to locate



any earlier guidelines relating to the period when the Forsyth Barr building was constructed. The Councils and their building inspectors are not required to be clerk of works or project managers during the construction of buildings, particularly in relation to commercial buildings.”

**EXAMINATION CONTINUES: MR LAING**

Q. Just pause there, the next sentence is a new sentence isn't it?

A. Yes it is.

Q. Please continue reading.

**10 WITNESS CONTINUES READING BRIEF OF EVIDENCE**

A. “The office of the ombudsman confirmed this position in a letter to the Council dated 18 December 1986, annexure F. In the case of the Forsyth Barr building the Council would have been aware that an experienced national building contractor, Fletcher Construction Limited, had become involved with the building project at the time the building permit was issued. Council is also aware that the design engineers, Holmes Consulting Group Limited were a competent firm experienced in the design and supervision of multi-storey buildings. Counsel assisting the Royal Commission has asked the Council to provide evidence about whether debris was observed in the seismic gaps at the time of any Council inspections which took place during any office fit-outs. It is unlikely that an inspector of interior fit-outs would have had the chance to observe the seismic gaps in the stairs. The detail of the seismic gaps shows that a polyethylene tube and a flexible sealant thioflex was to be installed at this floor surface level and the floor was then covered in vinyl flooring material, detail one on sheet 217 of the original drawings. This would have precluded direct observation of the seismic gaps on the stairs when moving within the building. The Council's files do not contain any record of construction debris or mortar being observed in the seismic gaps in the stairs either during construction or upon subsequent inspections related to office fit-outs.

Response to the Department of Building and Housing recommendations. Counsel assisting the Royal Commission has asked the Council to provide evidence about the steps the Council is contemplating as a result of the recommendations of the Department of Building and Housing stage 1 expert panel report related to stairs and Practice Advisory 13 issued by the Department of Building and Housing which relates to egress stairs. Practice Advisory 13 states that its purpose is to alert practising structural engineers assessing existing multi-storey buildings throughout New Zealand to issues related to the safety of stairs. The Practice Advisory draws attention to the findings of the technical report prepared by BECA for the Department of Building and Housing, a related report prepared by Professor Des Bull for the Royal Commission, and a SESOC practice note regarding the design of conventional structural systems following the Canterbury earthquakes. In the Actions to be Taken section of the Practice Advisory the Department instructs

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territorial authorities to bring the Advisory to the attention of building owners when advising them of the need to renew their annual Building Warrant of Fitness. The Practice Advisory also instructs Building Consent Authorities to bring the Advisory to the attention of building owners when building consent applications are made for any work on a multi-storey building with sliding stair details.

The Council is accordingly sending out copies of Practice Advisory 13 with the Building Warrant of Fitness reminder letters which are sent to building owners annually. The Council will also draw the Advisory to the attention of any owners applying for building consents relating to work on multi-storey buildings with sliding stair details.

The Council is also aware that the Canterbury Earthquake Recovery Authority has commenced a process to require that owners provide a structural assessment of their buildings to allow continued occupation or re-occupation of the building. The structural assessment would include

an assessment of any stairs in the building and this information is being shared with the Council.

Events after the 4 September 2010 Earthquake:

5 The Council's records indicate that a Level 2 Rapid Assessment was undertaken by the property manager's structural engineer, Beca, on 5 September 2010 and the building was assessed as "Restricted Use – Y2". This assessment noted that the "stairs have generally settled and may be unstable". A further structural assessment was recommended and the form stated that "stair landing bulkheads need to be removed to  
10 allow investigation". The form also noted that there had been damage to a steel beam supporting the car ramp which needed to be propped.

Beca carried out a further assessment on 6 September 2010. Beca's "Level 2 Seismic Assessment" is attached as Annexure "H". The Seismic Assessment notes that temporary propping had been carried  
15 out to allow pedestrian access to the carpark and that the stairs contained sufficient capacity for normal use. Beca therefore recommended that the building be changed to category "G2 – Inspected" (Annexure "I") and it appears that the placard was accordingly changed.

20 The Council's records also include an undated Level 1 Rapid Assessment which records the building as "Inspected – Green" and noted estimated overall building damage as "none".

The Council has no record of a cordon being required for the building at any stage.

25 The Council corresponded with various parties between 4 September 2010 and 22 February 2011 regarding pending applications for office fit outs on level 7 and 13 of the building. An application for an office fit out on level 7 was received on 4 November 2010 and was later cancelled on 10 December 2010. An application for an office fit out on level 13  
30 was received on 20 January 2011 and was issued on 22 February 2011. The technical report prepared by Beca for the Department of Building and Housing refers to various other inspections and repair work

undertaken in relation to the Forsyth Barr building between 4 September 2010 and 22 February 2011. The Council holds no records of inspections or repair works other than as referred to above.”

**EXAMINATION CONTINUES: MR LAING**

5 Q. I just have one or two further questions to ask you about the proposed earthquake rapid assessment procedures. In this case the placarding went from red to yellow then to green. Is that correct?

A. Yes that's correct.

10 Q. In a case where a placard was changed to green, what was, if anything, the Council's processes from thereon in?

A. The Council had a very large body of work around red and yellow placarded buildings and we focused on those. Our expectation was that green placarded buildings the owner and the engineer would look at those buildings, assess them, and ensure that they were suitable for  
15 occupation but, to the best of our knowledge, they were, there was no observable damage which would preclude occupation.

Q. How many red and yellow placarded buildings was the Council dealing with post 4 September?

A. There were in excess of 1100 red and yellow placarded commercial  
20 buildings, a lot of them in the central area so that was very largely our focus. We were obviously engaging with the engineers to review the status of the status of those buildings as work was being done.

**CROSS-EXAMINATION: MR MILLS**

25 Q. Can I just ask you first about this term “random inspection” which is referred to in paragraph 15 of your evidence and can you just tell me what is meant by that term – “random inspection”?

A. At the time Council would do a mandatory inspection and then they would do inspections as the building evolved and the inspector would pick times when it was most appropriate to go. Clearly the focus was  
30 around plumbing and drainage inspections, around lining inspections, obviously around the foundation and the siting of the building so in

addition to those ones which are really prescribed and necessary, the rest of them were just to make sure the project was proceeding in a way anticipated in the design.

5 Q. Now I haven't seen the guidelines in whole, so all I can do is take what you've got here, oh it is in annexure, isn't it. Is that fact that stairs are on there, does that convey anything of significance along the lines that stairs were identified as something of particular importance?

10 A. Stairs are clearly important in any high rise building and as we've heard today that's been known. When the Council prioritises or undertakes its inspections it does that on the basis of the risk associated with certain elements of the building. In the case of stairs, the specifications quite clearly state that the engineer would take control of that situation and so that would not have been a particular focus for us because we knew that the engineer was engaged in supervising those and they were put in at  
15 each level of the building so the engineer would have picked that up as he went.

Q. Because we know from the facts that we've heard here that whatever inspection was done it wasn't fully effective because of the compromising of the seismic gap that we've been hearing about?

20 A. Yes I think you'll hear from Mr Hare tomorrow and certainly from Fletchers about what occasioned that but certainly from, no, look I take on board what you're saying.

Q. Now the reference in here to this random inspection. Is that still applicable today?

25 A. We pre-define inspections a lot more closely now. There were guidelines came out in 2004 and which incorporated into the forms regulations so we have a lot more pre-determined inspections now. We ask the owners to notify us at each critical point in the construction process.

30 Q. And are stairs on that list?

A. Ah, I don't think specifically they are mentioned. No they're not.

Q. Has the Council given any thought in light of what, even before this hearing was known to be a very significant concern about stairs about an increased inspection of the seismic gap and other related critical elements of stairs?

5 A. In relation to new buildings, is that what you mean?

Q. Yes.

A. Very much. The Government has, in its proposed legislation, is putting more of that responsibility onto engineers. The council is being directed

1626

10 to focus on accessibility issues. When I say that you know I'm talking about disabled access into buildings, emergency lighting, things like that, we, plumbing, drainage. Our responsibility is going to be diminished in regard to commercial buildings and much more emphasis put on the engineers in the future.

15 Q. So in relation to the methodology that the council is now following following the suggestion from the Department of Building and Housing of reminding owners when the annual warrant of fitness is processed, do I take then that there will be no follow up from the council other than simply notifying owners that they ought to do this?

20 A. The legislation, the change in the legislation is for the future. In the here and now Christchurch is probably in a slightly different situation to the rest of the country so CERA is doing our, asking for detailed engineering evaluations for each building as I think I pointed out in my –

Q. You did.

25 A. So that will, so all commercial buildings will get a review and a focus of that review is actually on the stairs by the engineers. That information is being shared with the council and obviously if there's an issue CERA and the council wouldn't anticipate people occupying buildings. We would prevent them from occupying buildings if there's problems with  
30 the stairs.

Q. Do you know whether any communication with owners about stairs for example the process that's been followed with the warrant of fitness

renewal urging attention to stairs. Do you know whether that's been shared at all with tenants?

5 A. Specifically not at this point in time. We have alerted the development community to the advisory note to our publications that we send out regularly. With regards to tenants not specifically I don't think at this stage.

10 Q. Now these level two assessments. Really the only questions I've got for you about that relate to what the council does with them, how it manages them when they come in, and that really arises as you will have heard from being here during the day from what we've seen here where we've got level two assessments identifying the need to take action but it doesn't ever get done because responsibility then passes to another firm of structural engineers and the ball drops between the two so it would seem. So what does the council do with those level two assessments? What has it been doing when it receives them?

15 A. When we receive back the level two assessments we obviously if they're yellow or red building, as I've described that's a slightly different situation. If they are a green building and there's a, and they continue to be a green building our expectation would be that the engineer and the owner would take up any remedial works. I think that was anticipated in the changes to the legislation which said if there's repairs needed that are earthquake related that they don't trigger a consent you can proceed to actually do those without alerting the council. That was very much our interpretation or my expectation following the earthquakes. Green placard, BECA was involved. They were engaged with the owner. They would undertake the work and get it done and I think that's a reasonable expectation. I think Mr Jury, his evidence was that he expected that those works would be done in concert with the owner.

25 Q. No I'm not being critical of the council.

30 A. I accept that.

Q. I'm just trying to see if there is a problem here that might be capable of remedy because clearly there does seem to have been a problem here of information not flowing to where it needed to.

5 A. If I was asked to comment on that again in the context of what you've just said, there were big gaps between the issuing of placards and if they were green placards the engineers and the owners weren't obliged to tell the council of any engineering works or repairs they were actually doing at that time. So there was a huge body of work happening out there that the council is unaware of and in retrospect it would have been 10 really good if we had known about those types of things. We could have assisted. We could have communicated with the owners and tenants and with engineers as to what was actually happening in relation to some of those buildings. There were large, we really weren't being kept informed. There would have been obvious advantage to do that, to let us know what was happening. 15

Q. And what about accessibility of those level two assessments? For example it appears that Holmes Consulting Group were aware that Beca had had some involvement. It's not clear at this point what they knew. We'll find that out tomorrow but some knowledge that Beca had 20 been involved in assessing the building. Apparently they thought it related to stairs. Supposing they had wanted to access the assessments that were held by the council, could they have done that?

A. If they were available we would have, as much as possible given, made that information available to them.

25 Q. And are you saying that at that time in September 2010, September, October let's say that it would have been readily accessible on request?

A. I believe so.

Q. Now what about when these two office applications, two office fit out applications come in. I take it that doesn't connect in any way with what 30 might have been the council's files about earthquake assessments post September or post Boxing Day for that matter?



A. No, well, what we had a situation where the building was green placarded. We had no reason to believe that it was anything other than occupyable so we would have considered the application on the face of it that this was just yet another office fit out.

5 Q. So never any thought of referencing back to the level two assessments you were holding that you've just said were readily accessible?

A. I think because our, we would have closed out those jobs in our files and wouldn't have expected that there was nothing outstanding in respect of that building.

10

#### **RE-EXAMINATION: MR LAING - NIL**

#### **COMMISSIONER CARTER**

15 Q. Mr McCarthy, I know this is not really a structural matter but can you comment on whether the Council requires emergency lighting in stairwells?

A. Yes absolutely that's a, there's a Building Code clause. I believe it might be F7. It specifically deals with such things and a building warrant of fitness regime is designed to ensure that emergency lighting, fire equipment, mechanical systems are all maintained through the life of the building. So we, so emergency lighting is very much of a part of that.

20

Q. Thank you. There are independently powered I presume?

A. Yes they would be. Absolutely once the power goes out they revert to battery power generally and I can only assume because they weren't operational in the stairwells that they'd been so badly damaged by the collapse of the stairs.

25

#### **JUSTICE COOPER: NIL**

#### **WITNESS EXCUSED**

30 **COMMISSION ADJOURNS: 4.37 PM**