HEARING RESUMES ON THURSDAY 12 JULY AT 9.32 AM

MICHAEL JOHN NIGEL PRIESTLEY (RE-AFFIRMED)

EXAMINATION CONTINUES: MR MILLS

Q. Just a couple of just a couple of more matters Dr Priestley that I wanted to tidy up with you this morning. The first question relates to a question I asked you towards the end of the day yesterday about your opinion on the performance of the building in February if the column and beam column and joints had been designed for full ductility. Do you remember I asked you that question?

A. Yes I do.

Q. And you referred to some calculations you had done but at the time you didn't have those calculations in front of you?

A. Correct.

Q. And I take it you now do and you've been able to refresh your memory about what you said there?

A. Yes I have.

Q. All right, well I wonder then if you could, I'll ask you the question I asked you yesterday and we'll take it from there.

A. Can we – actually my copy of some calculations has not been given back to me but I think you have it on the screen.

Q. We do and I can also give you a hard copy so that you have it to hand.

A. Thanks, great thank you.

Q. It has been handed out to other counsel.

A. I hadn't initially run a series of calculations for predicting the displacement capacity of the columns as designed and then subsequent to a meeting in I believe it was August there was – that's a meeting of the expert panel in August, there was discussion as to whether in fact the columns would have survived if they had had been designed for ductility. I was informed that the probable reinforcement for the column would have then been R10 spirits or R10 spirals rather than R6 spirals, at 35 millimetre spacing. That would be what would satisfy the code so I

ran some more analyses for these which you can see on these on the screen here.

Q. Just to get it clear that you haven't, you are not expressing a view yourself, about what constitutes compliance with code. You have been told what would be and you've done your analysis on that basis?

A. Yes, that's on that basis so I can't be certain that that's the case. Maybe we could first blow it up a little bit so that we can see the diagrams a little better.

Q. Want that larger still?

A. Well I was hoping that we could get the figure in the middle of it, to zoom in on that a little bit because it's rather hard to see at the moment. That's great. Okay in this here it's a plot of the moment curvature response predicted for the critical sections at the top and the bottom of a typical column with an axial load of about 1750 kilonewtons and the first of these curves is the predicted response for the columns as designed and built. You can see it has rather low curvature capacity and once you get to the peak it drops off very rapidly. This curve here is what would be – what I'd predict anyway from my calculations to be the moment curvature response given that it was reinforced with R10 spirals at 35 millimetre spacing which I understand was determined by others to be the code requirement or would satisfy the code requirement. First you can see that it's much more stable. The strength drops here as a consequence of spalling of the cover concrete as it does here, but then it picks up again due to confinement of the core and ends up with a rather large curvature, this location here. I also did two other one. These ones are not particularly important. This one here is the same thing but with less cover concrete so only 30 millimetres instead of 50 millimetres of cover and you'll recall that I thought that the cover was excessive particularly for the diameter of the column itself and you can see that with that degree of reduced cover that there is very little degradation in strength and there is a significant enhancement in the overall capacity in terms of moment and also in terms of curvature as a consequence. The fourth curve down here is one that I just did as an

example to see what would be the case if it still didn't satisfy the code but we had the R10 spirals at 80 millimetres spacing which is approximately, a little less than half of the code requirement as I understand it from others, and you can see that there is still a significant drop off but the ultimate curvature is rather large. Now can you scroll down to the bottom of that page.

What I've done at the bottom here is to look at, well to show the results of some calculations to determine what the fixed end ultimate drift capacity of the columns would be based on those moment curvature results and as designed then for an ultimate strain, ultimate compression strain of .004 then the fixed end curvature, there's a fixed end drift rather would be .007, that's .7 percent and that's very similar to what has been obtained by others in the analyses of this. I also looked at what would be the case at a higher strain, extreme fibre compression strain of .007 and that increased it only marginally up to 1.1 percent. To these would need to be added the additional drift resulting from flexibility of the beams and flexibility of the joint but they're rather less than 50 percent of this value. This is the value then that I understand complies with the code, that's the R10 at 35 millimetre spacing, and this gives us an ultimate drift of 6.7 percent so that's essentially 10 times the drift capacity of that. This corresponds to a displacement, an inter-storey displacement of 217 millimetres and I compare that with the maximum values that were obtained for the three records that were carried out in time history analyses where the maximum inter-storey displacement was 90 millimetres, 110 millimetres and 115 millimetres so you can see that this value significantly increases this and the value corresponding to an 80 millimetre spacing of R10 with a cover of 50 millimetres would give a drift of 3.2 percent corresponding to a displacement of 104 millimetres which is very similar to these. Now in observing then that we would predict that the displacement capacity would exceed the displacements predicted by the time history analysis it’s important to emphasise that the reinforcement in the columns as designed there

would also have to be in the joints so if you had just reinforced the columns without reinforcing the joints they would not survive but my belief is that if the joint had also been reinforced with additional spiral reinforcement then the, I can't say that the structure would have survived but I can say that the displacement capacities would have exceeded that predicted in the time history analyses and therefore the time history analyses would not have predicted failure.

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Q. Thank you Dr Priestley, that's very helpful. Just one final question for you. Dr Mander, in the evidence that he's expected to give later today, has described the building as innovative and I wonder whether that's the term you would use to describe this building?

A. No I would not. There are certainly have been other buildings designed in such a fashion with an external shear core but primarily in non-seismic regions. It's quite clear that from a seismic point of view this is an undesirable building configuration and very difficult to make it perform well. So it's one of the, to get a perhaps a comparison there's one of the worst things that we know about in earthquake engineering is what's called a soft storey mechanism where the columns in the lowest level are so weak that they provide all of the inelastic displacement and it's like saying that a building that was designed in such a way would be innovative. It might be innovative but in a very undesirable sort of fashion. So I cannot accept that this is an innovative structure in a desirable form for seismic resistance.

Q. Thank you Dr Priestley. I'll just ask you to stay there and answer any questions from anyone.

A. Thank you.

COMMISSIONER FENWICK:

Q. Just a quick question on your load perfection diagrams. Normally we look at the limit of deformation when you get to 80% of the moment capacity or the load lateral force drops to 80%, but there is some capacity beyond that just for resisting axial load with a loss of moment,

of course very widely spaced spiral in this case. What I was wondering if there is any capacity that you would see for that column after the moment has dropped away and you're just relying on it to act purely as a prop?

A. I think in this particular case as I've mentioned the cover was very, very large and once you start to get to the ultimate compression strain which typically we start to see signs of spalling at about .004, maybe a little bit higher, and once that starts to happen the cover concrete becomes inoperable and the effective section size of the column for resisting compression reduces dramatically as well, and because of the size of the cover and the comparative size of the core of the concrete to the maximum diameter then if it spalled back just to the core dimensions the columns would not have the axial load capacity in the lower levels to resist the axial force on them and of course normally we would expect that in such a situation where we were getting spalling of the cover concrete that the core would be, that's the core being the region inside the reinforcing cage, would have sufficient integrity to be able to stop the spalling going any further and with a spiral reinforcement spacing of 250 millimetres this just wouldn't occur, so the spalling would continue to go on inside and eventually you would get an explosive failure. This may well have happened in the lower floors. We really can't tell because the information isn't available after the collapse of the structure. I think that what we see in the column remnants are more associated with the higher levels and also perhaps the peripheral columns which were not so heavily confined, not so heavily loaded, sorry.

Q. Thank you.

CROSS-EXAMINATION: MR ALLAN – NIL

CROSS-EXAMINATION: MR REID

Q. Professor Priestley, I'm counsel for the Christchurch City Council.

A. Yes.

Q. And I have a number of questions. Firstly just in relation to the document that you've produced this morning, that's the one dealing with the code requirements as you were told they potentially were. Can you just confirm who it was that calculated the code requirements please?

A. I can't be certain. It was at one of the expert panel meetings but I understand it. My recollection is that it was Rob Jury that had done that calculations.

Q. Yes.

A. Although it may equally have been Clark Hyland or Ashley Smith.

Q. Yes, thank you. Now yesterday when you were responding orally to the questions that had been put forward to all of the experts appearing before the Commission -

A. Yes.

Q. – by the Commission, you made a reference to some of the evidence that Dr O'Leary has put forward?

A. Yes.

Q. And I think you had a discussion with Dr O'Leary afterwards. Did that discussion affect your view of the interpretation of his evidence that you had conveyed to the Commission?

A. Yes, I think so. He was, what we discussed was in relation to the what appeared from his evidence to say that there were two different mechanisms available for resisting the torsion, two different sets of elements. One was the north and south walls, that's on line 1 and line 5, and the other were the walls CD, D and DE in the north south direction and I've viewed that as saying that he'd viewed these as independent elements itself. When we discussed this it became apparent that in fact he was not intending that and we agreed that what his implication was that the north core had torsional resistance of its own which would provide the response, some torsional resistance to the structure as a whole.

Q. Do you regard that as being correct?

A. Somewhat, though it's a little difficult to say that because it's an open section. If the box section had an additional wall on line 4 then certainly I

would accept that it has significant torsional resistance but given that the structure itself if it was at maximum response then that, the capacity of the, of the core itself would be utilised for flexure and would not also be available for additional resistance due to shear. It's a rather, and torsional shear in this case. It's a difficult element to understand completely and to describe in an easy sort of fashion but my view would be that the structure did not really have additional torsional resistance unless that north core was not responding inelastically.

Q. Yes, thank you. Now I don't know whether you've had a chance to read Dr O'Leary's second brief of evidence?

A. Yes I have.

Q. Yes, so I think he makes it clear part of his second brief of evidence responds to your material?

A. Yep.

Q. I think he makes it clear in that brief that he largely agrees with you –

A. Yes.

Q. – on the vast majority I think of your material but there are some aspects in which he makes comments and a few aspects in which he disagrees?

A. Yes.

Q. So I'd just like to put areas where he disagrees with you to you?

A. Yes.

Q. And allow you to comment?

A. Okay.

Q. So I'm not sure whether this is a disagreement but in relation to your evidence at paragraph 77 –

A. Yes.

Q. – this is where you're talking about best practice in design?

A. Yes.

Q. Just to summarise his evidence, as I understand it, he's saying that from a compliance perspective which is the perspective that the council would be looking at it from –

A. Yes.

Q. – best practice is not something that's able to be dealt with by the council as, would you agree with that?

A. Yes, I completely agree with that.

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Q. Yes. Now at paragraph 17 of Dr O'Leary's second brief of evidence, he makes a comment that he will no doubt explain in some detail but this is an area where he, where you and him might disagree but I will allow you just to, I will read it to you so that you can comment. He says, "I do not consider that there were high levels of axial compression in the columns. The columns complied in that respect with the standards and in my view reflected normal practice within the profession at the time."

A. Yes I disagree with that in that the calculations – I think they are presented in the Hyland report and the CTV report – indicate that for the specified concrete strength of the columns it would not have been possible to have any further load on them. In other words the factored gravity loads got the columns up to the maximum possible level permitted by code, so that to me seems to be a very high level of compression force. Anything further would not have complied with the code so, and there is a lot of evidence that columns should really, this is again not a code of compliance issue but columns in a seismic situation should be designed for reduced seismic load because of the sensitivity of their performance in terms of lateral drift when the loads are high.

Q. So just in that answer you are making reference to the code requirements and is that based on your understanding of the code requirements as explained to you in the context of the consultant's investigation?

A. Yeah, the consultant's investigation looked at gravity load design of the columns. The requirement at the time was that the calculated dead load, that is the weight of the structure, multiplied by a load factor of 1.4, plus the calculated tributary live load calculated and multiplied by a factor of 1.7 which were the factors applying at the time I understand provided an axial load which was at the absolute upper limit of what was permitted. So they were heavily loaded columns there is no doubt about that.

Q. So just so that we are clear though, your understanding of the code requirement in terms of axial load and so on, that is material you haven't independently calculated?

A. No I haven't calculated, no.

CROSS-EXAMINATION: MR RENNIE

Q. Morning Professor Priestley. I think you are probably aware that I appear for Dr Reay and for Alan Reay Consultants Limited?

A. Yes.

Q. In your brief of evidence at paragraph 8, there were some words which appear in the brief but which I didn't understand you to read yesterday and they appear five lines down where you say that, "The panel's report was more of a consensus document," and the words were, "...which was required by the panel's terms of reference to endorse the consultant's report." Do you see that?

A. Yes.

Q. Is that in fact evidence that you give and the view that you have?

A. Yes.

Q. And did that situation, namely a requirement for the panel to endorse the consultant's report, create the tension which has led to your giving independent evidence today?

A. Yes.

Q. In the sense of the requirement you reference that to the terms of the panel's report?

A. Yeah.

Q. I am sorry to the terms of reference of the panel?

A. Yes.

Q. Was there any other instruction or direction to the panel to proceed in that way?

A. Not that I am aware of.

Q. No but certainly on your understanding that was a requirement that the panel align itself with what was found in the consultant's report?

A. Yes it was rather difficult to determine exactly how this should be viewed given that there was disagreement on a number of issues and the way in which this was resolved was to mention in the report that there was some disagreement on some aspects.

Q. Yes, now you were the vice chair of this panel as I understand it?

A. Correct.

Q. And it met on five occasions, the last of which was on 20 October 2011?

A. Yep.

Q. I can have the minutes for that meeting put up if you wish?

A. No.

Q. They record that you were not there at that time?

A. That is correct.

Q. Had you by that stage reached this point of independent difference as to what should be in the report or did that arise later?

A. No there was – there, the draft was still in a very draft form at that stage and there was still quite a lot of work done after that until the report was finalised I think in February so there was still a great deal of to-ing and fro-ing of correspondence between the various members of the committee and Dr Hyland and Mr Smith and also Dr Hopkins who did much of the drafting of the final document.

Q. In that regard, Dr Hyland filed a reply brief in relation to your evidence?

A. Yes.

Q. Is that something you have had the opportunity to consider?

A. I have.

Q. And given the points that he raises in that, have you taken those into account in the evidence that you have given?

A. I have.

Q. And are you conscious of having modified or changed your view on any matter in the light of those?

A. Not in any significant fashion.

Q. Now the expert panel of which you were the vice chair was actually responsible for the reports on 4 separate buildings, wasn't it?

A. Correct.

Q. And did the difficulty that you describe in relation to this building arise in respect of any of the other three?

A. Not to anything like the same extent. I think that the final status of the reports on the other three buildings were ones that were essentially in full agreement with the members of the panel.

Q. The panel had some 11 members and some of those would have been better qualified in a formal sense than others?

A. Yes.

Q. To reach views on the key issues of concern to you?

A. Yes.

Q. Did the panel in fact operate in a way which acknowledged that expertise when matters were dealt with?

A. I am not sure quite what you mean by that?

Q. Well I will put it more bluntly, for example did the lawyer decide the engineering issues?

A. I think that the advice that was given from all of the members in the committee were appropriate to their expertise.

Q. Yes but when the final issue of consensus came, was consensus a failure in this case simply amongst the seismic experts on the panel or was it wider than that?

A. Which are you talking about now, are you back to talking about the CTV building?

Q. Back to the CTV, yeah sorry?

A. On the CTV the disagreement was largely I think between the people involved, well the structural engineers.

Q. Now if we turn over to paragraph –

A. Well could I just clarify –

Q. I am sorry yes please do?

A. I would just point out to people that when I say that the disagreement was between the structural engineers it may not be apparent to everyone that the consultants who performed the work, that is Dr Hyland and Mr Smith, were structural engineers on the panel meeting so when I

say the disagreements it doesn't mean that were disagreements between panel members excluding those two but including those two.

Q. Yes. Disagreement being the opposite of consensus?

A. Yes I suppose.

Q. Because what we are talking about is a genuine professional dispute on these issues in respect of the matters you have addressed, isn't it?

A. I think that is putting it a little strongly because in many cases it is a matter of interpretation of the relative importance of various aspects. I would not call that dispute to the same extent.

Q. It is my understanding form the evidence-in-chief that you gave that you are not really addressing the concrete strength issues in any way at all?

A. I have taken them as – no I have not really considered those. There is evidence presented in the expert, in the CTV report materials and examination report indicating that concrete strengths may have been low, and this may have had an influence on the response, but this is not viewed as a major factor.

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Q. Yes and we have more recent evidence which we're going to come to later in the enquiry about the outcome of further testing on that, but that's not an area you're addressing in your evidence?

A. No.

Q. And in relation to code compliance is it my understanding is that although later in your brief you discuss what would have been in your view best practice in 1986, you're not making an assessment of code compliance in 1986?

A. That's correct.

Q. Now if we come to paragraph 35 of your brief and this is where we are talking about the – you just prior to this being talking about ERSA and the proper use of ERSA and then you were coming on to talk about the input of the results from the various seismic measuring centres, and at paragraph 41 you talk about using an average of the spectrum from particular sites, you see that?

A. Yes.

Q. In there you refer to the use of spectra from four sites, although it seems that the consultants discarded one site, the REHS site when arriving at their calculations. Is it your view that the REHS site should have been used?

A. No.

Q. Sorry.

A. No.

Q. No, and your reason for that?

A. Because the geotechnical engineers Tonkin and Taylor who were giving advice on the ground conditions indicated that in their view the ground conditions at the REH site were significantly different from those at the CTV site and therefore should not be used.

Q. Have you had the opportunity to consider the evidence to be given by Dr Brendon Bradley in this hearing?

A. No I haven't.

Q. No. Briefly Dr Bradley details evidence in respect of post 22 February 2011 tests on the CTV site itself and the comparison of that to data from four sites including the REHS site and his opinion which he'll be presenting is that all four sites should have been considered and in addition some calibration obtained from testing on the CTV site. You have any view as to that approach?

A. I take it that you're referring to information which is also provided in Dr Mander's –

Q. Yes, doctor, the attachment of Dr Mander's evidence is Dr Bradley's evidence.

A. Yes. From what I've been able to see of that and I have read that information in Dr Mander's, is that you're referring to the recordings that were taken after February 22nd in a number of aftershocks and the results that are shown for these. I would point out I don't have any particular strong view about these apart from the fact that the intensity of measured ground shaking was extremely low in comparison with that in the Christchurch earthquake and we know that spectral characteristics changed dramatically with intensity and this is quite apparent looking at

the graphs of those four elements, so I think that the – at the period of response to the building at 1.0 seconds, the maximum response in these aftershocks was about two and a half percent of what was recorded in the Christchurch earthquake and that makes extrapolation rather unreliable to that level.

Q. And to be clear in terms of the extrapolation which you referred to, are you referring to extrapolation of each site's data for comparative purposes?

A. Yeah, all of those ones.

Q. Yes.

A. If you look at the shape first of the four records that are taken, they are very different from the shape that occurs in the February 22nd earthquake and the amplitude is very low in comparison so I would be reluctant to read too much into them.

Q. Yes, the interpretation more particularly relates to an assessment of whether the REHS site is appropriately included given its comparability of the other three sites. Do you have a view on that?

A. Well again I think that I've already answered that. I just don't think that you can read too much into the comparisons. There's not a uniform relationship between the REHS site and the other ones in terms of being more intense or less intense than the other ones. It depends on the individual record. But to me the most important thing is that the intensity of shaking that is recorded in these three aftershocks is not high enough to be able to draw any valid conclusions in my view about the relevance and the applicability of the REHS site to the CTV site.

Q. And lastly on that point would you ascribe value to the data obtained by testing on the CTV site itself after 22 February?

A. Again I'm not sure of how this was obtained, whether the core of the – north core of the building was still there at the time when that happened. If it was then that would make the CTV recording rather suspect because it would be probably contaminated to some degree by the structural response of the building itself.

Q. The date we have for the removal of the north core is 12 May 2011.

A. Yeah, okay, I'm taking (inaudible 10:06:48). Are you asking me a question or -

Q. I was about to do that.

A. – informing me?

Q. I was about to add to that, give you the date and say tests after that would not be affected by the factor you mentioned?

A. Correct.

Q. Now at 62 where you refer to the Hi-Bond trays and then more particularly at 79 –

A. Which one should I be looking at?

Q. Well I'm taking you to 62 and then to 79.

A. Yes.

Q. Sixty-two you discuss the issue of delamination of the slab from the Hi-Bond.

A. Yes.

Q. And then in 79 you discuss the fact that even if there had been delamination in September 2010, the Hi-Bond trays and the east-west supporting beams would have continued to support the floor, you discuss that.

A. Yes.

Q. And you go onto say it's conceivable that separation did occur but was not picked up in the post earthquake inspections. Now is that essentially because the Hi-Bond remains sufficiently in place that you cannot ascertain the state of the slab above it from underneath?

A. That's partly the case, yes.

Q. Yes, so in terms of the skill and the knowledge that was available to people carrying out post 4 September inspections, can you accept that there's a possibility that they may have missed damage?

A. Yes.

Q. That had in fact occurred by reason of this factor.

A. That fact and other facts as well.

Q. Is this a situation which is something that has been learned from the Christchurch earthquakes as to the extent that which damage may be concealed from visibility?

A. I think so. I think that, not just in the CTV building but in many buildings I think that the – on not advice but the rules under which people did the investigations perhaps did not result in things being looked at as strongly as they could've, but it's important to recognise that the, you know in the immediate aftershock, aftereffects of an earthquake the important thing is to get in and to see what is obviously an unsafe situation.

Q. Yes.

A. And to identify that (inaudible 10:09:38) and then generally there is the second stage and maybe even a third stage of investigation being done. One of the things that has surprised, not surprised me but I feel that in the later stages it's very important to have some idea of what the building plans are for the building, because that enables you to look more clearly into see what the actual response is likely to be and where to look for damage.

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Q. The building's –

A. You can't do that in the initial stages.

Q. And the building plans being preferably the "as built" or "post construction" plan.

A. Absolutely, yeah. With any modifications that might have been done.

Q. I was going to come onto that and then the whole consenting process is intended to catch the post-construction modifications so that a full current picture of the building is presented.

A. Yes, yes.

Q. You carried on in 79 to suggest that the, it may be that the increased flexibility of the building noted by many of the occupants has an explanation in the possible slab damage and the de-lamination after the 4th of September.

A. That's correct. I put that as a possibility.

Q. Yes and we've had evidence from witnesses of such matters as, one witness talked of, in the 4 September quake, filing cabinets flying about. Another talked at a later stage after the Boxing Day earthquake of feeling seasick because of the extent of motion in the building and so on. Are those the kind of occupant experiences that you're referring to?

A. Those are some of them. I would have thought that the seasickness was most unlikely because that's normally associated with very low period response not with high period, sorry low frequency response. So a very slow sort of movement causes seasickness type things whereas this, I think this effect would have been a very much higher frequency which is unlikely to be the case. However, I mean this is what I'm talking to the, the fact that there were reports of people being more sensitive. I would also mention though we have to be careful about those because we know very well that after an earthquake people become sensitised to, to movements that they were not sensitive to beforehand. So we, we should not perhaps read too much into these things.

Q. No it's a matter in the end of evaluation of the aggregate of all the reported experiences isn't it?

A. Mmm.

Q. We have had evidence, however, of a number of building occupants having a sufficient level of concern as to the state of the building, particularly after Boxing Day, that they raised the matter with either the manager of the work unit in which they were employed or with the building manager. Would you attach significance to people going that far in terms of their enquiry?

JUSTICE COOPER:

After Boxing Day Mr Rennie.

MR RENNIE:

Sorry Sir?

JUSTICE COOPER:

I think you mean to ask after Boxing Day.

MR RENNIE:

After Boxing Day.

JUSTICE COOPER:

Yes.

MR RENNIE:

Principally after Boxing Day Sir, yes.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. So for the present purposes we can concentrate on that period.

A. I think, yeah, I think that that indicates that certainly there was considerable concern. I, I'm just very reluctant to try and read too much into witness reports of sensitivity to structure.

Q. Yeah.

A. So I think that others are probably better qualified to, to make that sort of judgment than I am.

Q. Yeah I, I'm not trying to draw you into the detail of that as you can see by not citing specific witnesses. I'm looking really to the question of the adequacy of future inspections should there, unfortunately, be further quakes.

A. Yep. I think that that's, I think that perhaps we can state that, I think that the job done by the, the engineers of Christchurch and New Zealand in assessing buildings was an exceptionally good job in general but there are certainly things that could be improved and that has been quite well recognised and I'm sure that there will be improvements in, in the assessment of buildings in future earthquakes.

Q. And plainly the parties that I represent would respectfully –

A. Sorry what was that?

Q. Plainly the parties that I represent would respectfully accept your statement.

A. Mmm.

Q. Now you went onto refer to paragraph 80 of your brief to the matter of a two millimetre crack being sufficient to identify a mesh break or failure underneath it. Do you recall that?

A. Mmm, I do.

Q. And your stated basis for that was an empirical basis, the actual findings in the Clarendon Tower in Christchurch.

A. That was one of the things that I did. I did also do calculations, given a knowledge of the ultimate strain capacity of the mesh, which is only about 3%, the spacing of the, of the bars in the mesh of 150 millimetres and that, that if you, if all of the steel between the mesh actually expanded uniformly which would not happen you would get a failure displacement of six millimetres. Bond will reduce that because you have a crack just through the middle and my estimate was that it would be about one and a half to two millimetres would be sufficient in the crack widths to, to cause fracture and the fact that this agrees very well with Clarendon's, the experience in Clarendon I think confirms that.

Q. And in this we're discussing fracture in the slab floor, aren't we?

A. Yes.

Q. And so the observed width of the crack post-earthquake will be partly influenced by how that floor resettled post quake? The crack may have stayed open, may close, may partially close?

A. Yeah, it could do.

Q. So two millimetres is the observed width in Clarendon but isn't necessarily the minimum figure that need be found before mesh failure could be assumed, or suspected might be a better word?

A. It's, it's unlikely that the slab will close up sufficiently on that.

Q. Mmm.

A. But it's, it's just like any crack in a building. After an earthquake it's what the crack is now. It's not necessarily what the maximum crack was.

Q. Yes. At paragraph 83 of your brief you referred to the explosive failure, last line, of the columns and joints.

A. Mmm.

Q. Now that word "explosive" could have a variety of meanings ranging from a actual explosion which one would not associate so much with concrete as perhaps with gun powder or something of that kind, or an extensive fracturing of the whole of the joint or large parts of the joint. Just what exactly is the feature that you're describing there?

A. If you do tests on a concrete cylinder which is tested very rapidly and where there is a reduction in the area of the concrete it can behave in a manner which when you observe it, it looks like an explosion in that the concrete over a region actually flies out.

Q. Yes.

A. So it's something or other which is rather impressive to watch. It's not just a gentle crumbling which may happen if you do slow speed testing.

Q. Does it follow that in relation to the joints, this is the beam column joints that you're talking about isn't it?

A. I'm talking about the columns as well as the joints.

Q. I was coming to the columns. I was starting with the joints.

A. Well this refers to both of these.

Q. So you're seeing it as a single explosive mechanism in which the –

A. It would be more, it would tend to be more explosive in the, I would believe, in the columns than in the joints themselves because the joints have some degree of confinement laterally by the beams on the two sides of them as well.

Q. Yes and the part of the column that you are seeing as exploding in those circumstances?

A. I can't tell you that. It would depend. There are a number of regions where it could occur. My belief is that it would be more likely to occur close to the top of the column rather than anywhere else for a number of reasons. One, when you place concrete the concrete strength tends to vary from the bottom to the top. It tends to be stronger at the bottom of the column than it does at the top of the column and this is just due to

segregation and movement of the moisture up there. So when you say a particular concrete strength for a column it doesn't necessarily apply for the full column strength. So (inaudible 10:19:48) full height of the column, it's likely that the column will be weaker at the top than at the bottom. So that's a more likely region. Also it's a, it's partly influenced by the lateral drift that occurs. It's influenced by the – and the top and the bottom are the regions where the combined effects of moment and axial load will be greatest. And then also another region at the top of the lap splice is a region where there may be additional weakness associated with that, with the compression forces from the terminated vertical reinforcing bars causing local distress to the concrete immediately above it and then creating a situation where you may get failure there.

1020

Q. At a meeting in April 2011 between the consultants, Dr Hyland and Mr Smith on the one hand and five USAR engineers who had had an involvement in this building, the minutes of that meeting record that the engineers reported that in virtually every case their finding was that the beams had disengaged from the columns. Is that consistent with the explosion that you're describing?

A. No. Not particularly. It would not be an explosive failure associated with that.

Q. Now, my friend Mr Mills put to you a statement that appeared in Dr Mander's evidence. He simply said that Dr Mander said that the building was an innovative building. The reference which is 4.1 in Dr Mander's brief, the sentence reads, "The CTV building was designed and constructed in an innovative fashion." I take it that's the reference that you're thinking of?

A. I, I can't be certain. I think he might've used it more than once in the, in his evidence, but that will be certainly one.

Q. Yes. Well to the extent that one can rely on Microsoft to do word searches on documents I can tell you that that's the only instance that I could find yes.

A. Well then it must be that. Certainly it took my, it caught my eye when I read the report.

Q. The statement therefore related to both the design of the building and the construction of the building, I can read it to you again if you wish? "The CTV building was designed and constructed in an innovative fashion". Now, he then went on to say, "This structure was one of the first in a new generation of multi-storey buildings in the 1980s that used precast components". Do you accept that?

A. I know that about that time it was the, the start of using more precast concrete in New Zealand construction as an alternative to cast in place.

Q. And then Dr Mander continues, "Instead of using a ductile moment frame as had been the custom for cast in place structures of the day, the CTV building was designed with a "strong" wall system coupled with a "elastic" frame of columns and beams to support a proprietary type of floor system composed of a lightly reinforced slab cast – "

JUSTICE COOPER:

Mr Rennie this is a bit too long.

MR RENNIE:

A bit too long?

JUSTICE COOPER:

A bit too long we –

MR RENNIE:

I can have it put then Sir.

JUSTICE COOPER:

– can display it surely?

MR RENNIE:

Indeed Sir. The reference is BUI.MAD249.0446.48.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. It's 4.1.

WITNESS REFERRED TO SLIDE – DOCUMENT

A. Yes.

Q. I'll just give you a moment to read it through which I'm sure you'll find easier than listening to my voice.

A. Yes I've read it.

Q. Now firstly you'll see that Dr Mander's use of the word "innovative" related to the type of building as much as to this particular building. Do you accept that?

A. I think you can interpret it that way but I'm not sure that's particularly implied. I can say that, "Was designed in an innovative fashion," so you're saying that it's the design process rather than the structure is what we're talking about?

Q. Well what I'm saying is really that he was discussing this as being one of the first of a new generation of multi-storey buildings. Do you see that?

A. I'm not aware of there being a great number of other ones built with eccentric shear cores poorly connected to the floor system.

Q. Well if we remove from that for the moment the question of the connection of the floor system and just concentrate on buildings which had separated cores, that was a new feature of this time?

A. I don't think I'm qualified to answer that.

Q. Because the point I was coming to was that one of the design challenges in this building therefore was to understand how the shear connection to the floors would be provided, wasn't it?

A. It would be, yep. In fact given, if you, given that it perhaps was different from other structures than had been built before, I would expect there to be an increased level of design investigation as to the probable performance.

Q. Yes. Well the evidence will be that there had been in Christchurch buildings of a similar, shall we say –

JUSTICE COOPER:

Mr Rennie just help me. I'm sorry to interrupt. I'm trying to find that paragraph that's displayed in my version of –

MR PRIESTLEY:

It's in the conclusions.

JUSTICE COOPER:

– Mr Mander's?

MR RENNIE:

It's page 48 of Dr Mander's brief Sir. It's, it has a secondary reference which is WIT.MANDER.0001 –

JUSTICE COOPER:

I've got it now thank you.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. The evidence will be that there had been some buildings of a similar type in Christchurch before but –

A. I'm aware of that, the Landsborough building which was rather different in that it was smaller, the core was internal to the building footprint which makes the force transfer very much more successful, and that there was a closed form of wall, in other words as a box rather than as an open one like a cone. If we get back to, you know, to this business of being designed in an innovative fashion. My impression from reading the testimony and the evidence of David Harding that the design was not, the design process was rather straightforward and similar to what had been used before, so I'm not clear what innovative aspects of design, of the design process were used in this building, and I have not seen evidence of that.

Q. I understand Dr Mander's reference but it will be a matter for him to discuss in due course, to relate to the concept, if you like, the architectural concept of the building to be innovative?

A. So he's not talking about the structural design, you don't believe?

Q. Well I'm coming to that in stages, and the question then is the design response of the engineer to the concept of the structure, because as Mr Harding explains, it began as a concept which did not have a south shear wall and the south shear wall was introduced as part of the design process to try and work out how to achieve a building which met the architectural concept. That's the point I'm coming to. Follow that?

A. I think so.

Q. Because the point I want to put to you is that the requirements which then existed in the code really did not contemplate a building of this, I'm calling it an architectural concept, did they?

A. I think that, I don't believe that you could draw that conclusion. The, the building codes are genera. They are not built around the concept of different structural forms, and certainly if there was some doubt as to the applicability of the code to this particular building, then what I have mentioned already, that is that the building would need to be designed to best practice, and with considerable additional care in the design, and there, in my view there is not evidence that that was done.

Q. Yes well I'm going to come on and ask you about the best practice point in a moment because my understanding is that you have not yourself assessed the design in 1986 against the code in 1986. You've assessed it against best practice. Is that right?

A. I haven't, I've just looked at it in terms of the performance of the structure itself.

1030

Q. Yes.

A. I've certainly not done a code compliance check.

Q. In about 1985 or 1986 there was in fact a seminar in Christchurch at which you were a presenter on the issue of the requirements of the new generation of reinforced concrete buildings. Do you recall that?

A. No, no I don't.

Q. No. Well the evidence will be that Mr Harding had gone to that seminar, it was a one day working session with developed papers as part of his consideration of the design. Would you regard that as a prudent step for him to take?

A. Certainly but as I said I can't recall the seminar or what was presented in it. Can you tell me what the title of the seminar was?

Q. I will be able to in a moment because I'll get my junior to find it for you. We – I believe have succeeded in locating the seminar papers. If you would like a copy for your library I can probably arrange that later. The – 249.0469.1 will come up on the screen. Point 3 please, does that help bring it back?

A. I see that my involvement in this was on structures for the storage of liquids, and masonry structures.

Q. Yes the main thrust seems to have been Professors Park and Pauley who you mention in the best practice -

A. Indeed.

Q. – in your brief.

A. And I see that there is a session there on reinforced concrete beam column joints, concrete members with shear and torsion, reinforced concrete members with flexure within or without axial loads and the various aspects there I would imagine if Mr Harding had attended these he would have – I'm surprised then if he would not have, or perhaps he did consider them in his design but I'm not sure quite what the – what you're getting at at this stage.

Q. Well several points Professor, but the first is in relation to your contention that an engineer should design to best practice. I'm inviting you to think about Mr Harding, he had quite a number of years experience as an engineer in Christchurc. He had but recently joined this firm.

A. I understand he had not had the experience in multi-storey building design before that.

Q. Maybe one previous example, maybe some previous computer modelling.

JUSTICE COOPER:

Which was the previous example?

MR RENNIE:

Well I just said Sir, maybe one previous example, because it's a matter I'm meant to put to Mr Harding Sir.

JUSTICE COOPER:

Without going into detail then how many storeys?

MR RENNIE:

My junior's departed from me Sir probably to get the information. I will come back to you on that Sir.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. But the point I'm coming to is if we're thinking of this you can think of Dr Reay in this situation as well in 1986, and we've lost that list I'm sorry can we have it back please. The familiarisation with best practice for an engineer working in that situation in Christchurch, one effective way of dealing with it would be to go through a three day course of this kind?

A. Certainly.

Q. And I understood you to say that if Mr Harding attended then you would have expected him to take away, yeah, would have expected him to take away an understanding of many of the best practice matters that you've been talking about?

A. Certainly some of them, without actually seeing what was presented in the seminar again I can't be too specific about that.

Q. Well you have the headings there and it would be maybe not instantly possible to provide you with copies of the papers but the point I'm making is that Mr Harding then went away and one of the matters that –

JUSTICE COOPER:

I think the papers are available and maybe the fair thing is to let the witness just have a look at it.

MR RENNIE:

Sir we've been conducting a search for the seminar papers and I believe – apparently if we keep going through the pages we'll find the papers. Can we just go through the next three or four pages and we'll see what's there. So it's 249.0519.1.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. This is the document we located a few days ago. We turn to the first page so this page is actually a calculation sheet, sorry it's the second page, .3. That's simply a calculation or a note that Mr Harding, we understand made at the seminar so if we move on from there, .5, this is a description of the seminar, .7 is a more detailed contents page, .9 is Professor Park's paper on ductile design approach for reinforced concrete frames, just go through .10, .11. I'm happy Professor to take you through as many pages of this as is helpful but –

A. No I don't think it's particularly helpful, no.

Q. But what I'm putting to you is that this is a presentation of best practice as at July 1986, you'd accept that?

A. Yes I would believe so, at least in the topics that were covered by it.

Q. Yes, so that an engineer confronted with delivering a structural design for a building concept of the CTV type would be acting prudently in going to such a seminar?

A. Certainly.

Q. If an outcome of that is the introduction to that concept of a south shear wall that is an attempt to respond to the issues identified?

A. I'm sorry could you –

Q. In the – an engineer who's then attempting to respond to the architectural concept who introduces a south shear wall to the design.

A. Yes.

Q. Is acting prudently?

A. Yes, well his calculations showed that the drifts were too high without it and therefore if he wished to put that in, yes.

Q. An engineer who then uses the resources of the University of Canterbury to provide an ETABS analysis, E-T-A-B-S analysis of the design requirements is acting prudently?

A. It's – certainly he was required to do a modal analysis by the type of the structure that was being designed.

1040

Q. Yes.

A. Yes.

Q. So in relation to the proposition that my friend put that this was an innovative building do you accept that the steps that were taken in response to it appear to have been appropriate even if the outcome may have had issues about it?

A. I think that the, I suppose so, they would be required for any building really, whether it was innovative or not.

Q. Now my understanding is that when you come to the section in your evidence which relates to best practice which I think starts at paragraph 77, you, the test which you apply as to the design is a best practice test not a code compliance test?

A. Correct.

Q. Now the question of code compliance which the Commission in fact intends to deal with on another day was a matter which was investigated by the consultants, wasn't it?

A. Yes.

Q. You will be aware I think that there is some controversy as to whether the building as designed was or was not code compliant?

A. Yes.

Q. Now the first issue that you raise tested against best practice is the lack of ductile detailing for the columns? You say that?

A. Correct.

Q. Yes. The evidence will be that, well some evidence will be from the parties that I represent that the columns as detailed met the standard code provisions that is for members which were not designed for earthquake loading. Now your test steps aside from that to identify that these were columns which in your view in best practice would have been detailed for a ductile column, that's what you say isn't it?

A. I'm saying that the requirements were, would have been that the and in fact my understanding of the code at the time also is that the test was that the columns, if, the columns were required to respond elastically to the deformations that were predicted by the design process itself and if they did not, if that test was not met, then they had to be designed as either limited ductile or ductile columns.

Q. Well the point that I'm addressing and the expert witness for the Christchurch Council will also address is this issue about whether the code required the columns to be ductile?

A. Well –

Q. If an engineer in 1986 arrived at the view that these columns could be designed as standard columns within the code, you disagree with that?

A. My, I'm not sure quite sure what you're asking me to disagree with?

Q. Well –

A. My, my view is that they could not have been designed as non-ductile columns because of the deformations that were predicted.

Q. And –

A. And calculations that I have done would indicate that that the level of displacement that was expected from the design itself were significantly larger than the elastic limit of the columns and therefore they needed to be.

Q. So although in this case you have said in your evidence you're testing this issue against best practice –

A. Well certainly –

Q. – in –

A. – in that case I'm, I am going on the basis of what others have told me is in the code –

Q. Yes.

A. – so certainly that can be clarified by others.

Q. Yes.

A. I have read various aspects of the code. I just don't consider myself to be as experienced and informed as many of the designers who are designing on an everyday basis –

Q. Yes.

A. – with aspects of the code, but reading the aspects that I have I find it very difficult to imagine how it would be possible for these columns to be designed as non-seismic columns unless you take the evidence of Mr Harding who says that they were designed as pin-ended columns.

Q. Yes.

A. Which they were not. And that's not a matter of good practice or anything that's just a matter of fact.

Q. Yes.

A. They were not pin-ended columns.

Q. Now the second matter you referred to is the excessive splicing of the transverse reinforcement, see that?

A. Mhm. Yes.

Q. Again, there will be evidence that this complied with the code. Are you resting on best practice or on a code in that regard?

A. I am not, certainly I'm on, on code, I'm not on code requirements, I've not looked at that particularly but I don't believe that the code would have permitted for an element which is subjected to shear which these columns certainly were and quite high shear associated with the development of their strength that would have occurred at rather small displacements that a spacing of greater than half of the diameter of the

column would be acceptable. Certainly not from the point of view of resistance to shear.

Q. Now you then refer to the question of excessive cover. If we could have put up please ENG.CCANZ.0002.48? When we get it Professor you'll find that this is a chart from the New Zealand Reinforced Concrete Design Handbook in relation to NZS3101:1982. Right, we now have that?

A. Yes.

Q. Would you regard it as reasonable for an engineer in 1986 to rely on this handbook in the interpretation of this requirement?

A. Of what requirement? Of this, of the cover (inaudible 10:48:00)

Q. Of excessive cover? Well cover.

A. You'll have to explain to me what G means?

Q. G is a value which relates to various levels of column sizes and reinforcing bar sizes and the figure for the CTV G was 0.7.

A. But I am not, I am not, it's not clear to me what G means. Perhaps I should know but perhaps you can explain?

Q. The odds are Professor you're more likely to know than me but I, my understanding was as I've just put it to you. I'll put the question this way. If it is correct that the CTV value for G was 0.7, does it appear from that that the design was within the limits in that chart?

A. It's quite, I don't think you need to go to that level.

Q. Mmm.

A. (inaudible 10:49:12) in saying that it was the cover was excessive in itself. What I've said is that the excessive cover to the reinforcement. In my testimony yesterday I mentioned that it was a very large amount of cover for a very highly loaded column of small diameter because in the event that the cover concrete spalled then the core concrete would not have sufficient strength to support the level of axial loads that they were designed for. So I think that's a completely separate issue from what is shown in this -

Q. Yes but –

A. – graph here.

Q. – Professor your evidence in relation to what should have occurred is acknowledged. I am looking at an engineer in 1986 endeavouring to achieve design compliance. G I am now told is the ratio of core to gross area which is where 0.7 comes from. Would you regard it as best practice for an engineer at that time to refer to this reference work for that information?

A. It is important and it depends on how he uses it.

1050

Q. Yes.

A. If that is the case but you are saying that – I don't believe that the value of G is the relationship of, is the ratio of core concrete to.

COMMISSIONER FENWICK:

Q. Can I just intervene, Mr Rennie, G is the distance between the ratio of distance between the centre of the bars to the dimension of the column.

A. So it is the distance it is not the area ratio.

Q. Yes, it is not the area, it is the distance and –

A. Okay so that should be the square of that so it would be .49 in terms of the area and that indicates that if the cover concrete is spalled off the effective area that would be left is less than 50% of the gross area and the stress levels under the very high levels of axial load on the columns would then be extremely severe.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. Yes that is acknowledged.

JUSTICE COOPER:

Mr Rennie I don't know if you would like time to confer with your junior here or whoever it is who is advising you on this matter I will give you five minutes because I wouldn't want there to be any misapprehension about this.

MR RENNIE:

Well I am obliged to you Sir but I am able to move forward because I am not attempting to defend the calculation that was made on this. I am attempting to identify whether the process that was used involved going to best practice.

JUSTICE COOPER:

Yes I don't see how you can if there is lack of clarity about this point. That is my concern.

MR RENNIE:

Well I acknowledge that Sir and I appreciate –

JUSTICE COOPER:

I will give you five minutes.

MR RENNIE:

I think I will take the five minutes.

HEARING ADJOURNS: 10.52 AM

HEARING RESUMES: 11.04 AM

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. I did have 112 up if you could put it up again.

A. Would you mind speaking into the microphone.

Q. No, I will. Now Professor the page now in front of you is 112 of the same handbook that we were referring to before. This is the column design chart which was used in relation to the design of the columns on the CTV building. Have you had an opportunity to look at that while we had the break?

A. This has only just come up recently but I can see that it's a standard moment, a moment axial load interaction diagram and I see that the value of G that you're putting up before is something or other that is

hardly necessary to be in a chart. It would take any engineer about five seconds to calculate itself, but that is the case.

Q. Yes. So that –

A. Could I ask you a question though associated with that 'cos you've said that this was used in the design of the columns whereas Mr Harding has said that he designed these as pin-ended columns which would not have any moment on them.

Q. Well all I can tell you is that the advice I'm given is that this was used and you're saying, look, the two statements would be inconsistent.

A. They're in conflict.

Q. If that identifies an error in the design is it nonetheless the case that the use of this handbook by an appropriate – is the appropriate best practice approach to this design?

A. It's an approach. It's not necessarily best practice, it provides a means for determining the moment capacity, it does not give you a means for determining the displacement which is the primary area that we're all looking at.

Q. Which drives you back to the code as your other reference source?

A. Not necessarily.

Q. One of the issues in relation to the code is the extent to which it is the prescription of a minimum standard as opposed to the presentation of a safe set of instructions to any engineer as to how to design a safe building. Do you follow the difference?

A. I don't think that there is a difference.

Q. No.

A. Because –

Q. In other words, sorry –

A. – the minimum standards are the minimum standards required to build a safe structure so there is not a conflict between them. It's just the second half of the same standards.

Q. Any engineers commencing the design of a building of this scale, one of the first, even the first that that engineer has done, should be driven primarily by the standards. Do you agree?

A. Not necessarily, I think that if it's a new type of structure and the person does not have confidence that the code would cover it, he would be required to use – to go beyond the code to determine how to design it, ensuring of course that the code requirements are met but not necessarily that being the limit to what was being done.

Q. Now if you have a look at your paragraph 78 you cite a reference from Professors Park and Pauley in support of your view that, well in fact you cite them as saying that the work described there is potentially dangerous.

A. Yeah, that's – well let me see, identified yeah as a dangerous situation that are poorly designed columns with high axial load levels.

Q. If the drifts were small enough to ensure that the columns remained elastic, that would nonetheless comply with the code at the time would it not?

A. It would I believe.

Q. Yes.

A. As far as I understand.

Q. And is it not the case that Professors Pauley and Park were actually members of the code committee for NZS 3101:1982?

A. Correct.

Q. So an engineer seeking to follow best practice in the situation that you refer to there, are you saying that an engineer should follow their book or should follow the code?

A. I think they should do both.

Q. So the book becomes a gloss on the code as it were?

A. No the book – the code is an absolute minimum that can be done. It doesn't describe all of the circumstance. It doesn't necessarily reflect the state of knowledge at the time that the person who is doing the design. It reflects a consensus of the code committee. There are a number of aspects which mean at least to me that if there is an area of some conflict then you'd better look up what has been done in terms of research and in terms, particularly of text books, talking about that sort of an item and seeing if there is any concerns associated with it.

1110

Q. That involves –

A. Which I believe would certainly be the case and be apparent, I would have thought, to pretty much all practising engineers in New Zealand at the time.

Q. That involves, first, perceiving that there is a conflict.

A. Yes.

Q. In terms of the average New Zealand engineer in 1986, that's to say those that were engaged in the design and worked by day-by-day in this, are you saying that that is a conflict that should have been perceived?

A. I would say that it is impossible for a designer to just design in accordance with the code. I always use reference books in addition to that and the reference book that would almost, in my view would have certainly been used in New Zealand at that time was the very well received book, *Reinforced Concrete Structures* by Park and Pauley. Internationally recognised as one of the most important books in reinforced concrete design, particularly for seismic structures, worldwide and I think the particular problem area here is, is well discussed in, in the book and it seems to me that the, the major issue revolves around the, the point that the designer, that is, Mr Harding conceived of the columns as being pin-ended in accordance with his evidence. If he believed them to be pin-ended then there would be very little need for him to worry about the, the lateral displacement capacity because the lateral displacements would not induce any moments in the columns and therefore the chart that you had up there would be completely irrelevant. So there is a conflict there.

Q. Just to complete this aspect and going back to your paragraph 77, you also refer to very high levels, this is your little paragraph b., very high levels, just give me a moment, of axial compression.

A. Yes.

Q. Acknowledging that they nonetheless, the design in relation to those nonetheless complied with the code didn't it?

A. My, I'm relying here on the report by Hyland and Smith on the CTV and their calculation that the axial load at, in the columns was at or slightly above the maximum level that could be permitted for straight axial load.

Q. Yes.

A. So I'm not sure whether they actually complied or just slightly missed out. But that is, I think again any designer who is designing at the absolute limit to a code would suck his teeth a little bit and have a look further into it – I would hope.

Q. And to some extent is it your strong concern that design should be at best practice and not simply at code compliance level that led you to present independent evidence in this enquiry?

A. No.

Q. Now we've made some reference already to the evidence to be given by Professor Mander and I take it from your earlier answer that you've had an opportunity to consider that evidence.

A. I've had a brief read of the first evidence that he has written. I understand there's a second one which I have not seen.

Q. Yes there's a supplementary brief with some additional technical material. I'm just going to, I'm not going to go into great detail but I'm just going to put to you the key points from the first brief to provide you with an opportunity to respond to them.

A. Yep.

Q. He begins with a critique of a DBH report and you and I have already traversed your own concerns about elements of that. He then suggests or proposes that the DBH report essentially neglects the effect of the pre-22 February earthquakes on the structure of the building and his opinion is that it's evident that the structure must have sustained hidden damage in the earlier earthquakes. Your view about that?

A. My view is that it's possible but it's supposition.

Q. And, and in that sense something we will never know.

A. Indeed.

Q. Just pausing on that, given your level of involvement with the expert panel and the overview of the investigation by the consultants in that

process in relation to the CTV building, is it of concern to you that there was not more preservation of the remains of the building for further investigation?

A. No it's not been a concern of mine.

Q. One of the matters that we have identified in the evidence to the Commission is that there were, as you heard yesterday, two vertical breaks or fissures in the north tower in the lift well area.

A. Mmm.

Q. The impact on that tower of east-west motion and, and the extent to which either of those fissures or both of them may be related to that is not a matter that can now readily be assessed without the tower is it?

A. I think if there is knowledge of the crack widths and their location it can be assessed as easily now as it could have been if it was still standing.

Q. And the reference material you would use for that purpose?

A. The idea of what the crack widths are and the location of the cracks.

Q. Would you expect there to be a photographic record with the dimensional reference in it for example?

A. I'm not aware of what evidence is there.

Q. No I'm talking about best practice of post-earthquake investigation.

A. Clearly it would be desirable to have some idea as to what the crack widths would be. I imagine there must be some information associated with that. In fact if I recall correctly Dr Fenwick did mention yesterday what the crack widths were in the vicinity of up to 0.8 millimetres in diameter. Is that correct?

COMMISSIONER FENWICK:

Yes.

CROSS-EXAMINATION CONTINUES: MR RENNIE

A. So it seems that information is available to you.

Q. It's, as I understand it, eyewitness information from somebody who was able to inspect the lift well rather than direct forensic evidence of a, of a nature of measured photographs and so forth.

JUSTICE COOPER:

Commissioner Fenwick's recall of that evidence is that it was measured for repair purposes.

MR RENNIE:

Yes, yes. I'm, I'm referring to forensic level investigation with calibrated photographs.

JUSTICE COOPER:

Well he was a, a workman on the site.

MR RENNIE:

Yes I'm not demeaning evidence as far as it goes Sir.

JUSTICE COOPER:

No. All right.

MR RENNIE:

I'm pursuing a contention which we will develop in closing that the level of forensic records which appear to be available in matters of this kind are significantly less than those that are used, for example, in the work of the Transport Accident Investigation Commission.

JUSTICE COOPER:

Right.

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. Now the next point in Dr Mander's evidence is that he supports the DBH conclusion that exceptionally high vertical ground motions helped lead to the demise of the building but he feels that the two consultants essentially neglect the effect of the earlier earthquakes and he contends

that the exceptionally high vertical ground motions were a primary contributor to the CTV building failure and collapse. Your view on that?

A. The exceptionally high vertical accelerations – are you referring to the Darfield earthquake or the Christchurch earthquake because –

Q. More particularly the 22 February earthquake.

A. Yes because I believe he, he describes the accelerations in the Darfield earthquake also as being exceptionally high.

Q. Yep.

A. Which was not the case, but certainly I have the, I have the opinion that vertical accelerations were very important in the failure of the CTV building.

1120

Q. In relation to the columns of the building, he expresses the opinion that although they did not have substantial transverse reinforcing this was neither a problem nor a cause of failure, your view on that?

A. I disagree.

Q. In relation to the interaction of the perimeter columns with the spandrel panels on the building his opinion is that this may have been a contributing factor in the final demise of the structure but was neither the trigger nor the cause of the collapse?

A. I agree with that.

Q. In relation to –

A. Well I agree that that's probably the case. I still, I still believe there is some small possibility that the spandrels on line 1 not line F may have caused initial problems.

Q. Yes, in relation to the matter of the floor slabs, we've discussed that and the question of the separation. He expresses a view on that, and he expresses the opinion that the DBH report overstates the impact of the asymmetry of the shear wall layout. Your view on that?

A. I think that there are two somewhat conflicting aspects in the DBH report, and that the time history results do indicate to some eccentricity but that the ERSA results indicate much larger, and I've already given evidence that I think that the ERSA torsional response is over estimated

for good reason, we know that's the case, but there is still very high evidence in the time history results of eccentric results. If you compare the displacements on line 1, the predicted displacements on line 1 with those on line 4 you see a factor of about four difference between them, indicating very significant torsional response of the structure.

Q. And Dr Mander strongly criticises the use of ERSA and I understand you to have a similar view on it?

A. Yes I do.

Q. When you were on the expert panel you indicated that at some point the panel learned that the consultants had suspended use of the NTHA investigation and proceeded with the ERSA investigation. Do you recall referring to that?

A. I recall, that's not quite what I said, I said it was my, I was not aware of it before that time and I wasn't sure whether the panel was, but my feeling was that, well my sense is that the panel wasn't aware of it. I may be wrong. I certainly wasn't aware of it.

Q. Oh, well that may present a difficulty for my next question, but I'll ask you just to give you the opportunity because I was going to put to you. Is that change of investigative procedure something that you would've expected to have been taken to the panel and formally approved?

A. To stop the, yes I think I would've, if that had been the case.

Q. But terms of reference essentially contemplated that the expertise of the panel overlay the work of the investigators, would you agree with that?

A. We were there to give advice to them and to confirm the results. I think that it was more considered to be co-operation between the consultants and the panel itself. It wasn't the matter of the, the panel instructing the consultants how to do their job, but to give advice.

Q. But the concept of an expert panel suggests that the primary expertise lay with the panel rather than with the investigators?

A. I, I think that that's unfair because the consultants were members of the panel itself. It's rather difficult to separate the two.

Q. Now finally Dr Mander in his first brief presents an alternative collapse scenario. Have you had an opportunity to look at that?

A. He provides several alternative collapse scenarios.

Q. Yes well perhaps more accurately he presents a single hypothesis and then several scenarios?

A. Yes.

Q. And you have had an opportunity to look at that?

A. I have, yes.

Q. And do you – dealing first with the hypothesis?

A. You will have to describe the hypothesis again as I will have to –

Q. Well he contemplates clarity –

A. Give me the reference in terms of the paragraph if you can?

Q. I can and I will probably, I can probably have it put up if that is of assistance to you?

A. Yep that would be good. That will refresh my memory.

JUSTICE COOPER:

3.1 Mr Rennie, overview of alternative hypothesis –

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. Yes indeed Sir that is the reference I was about to give Sir. It seems to travel with two references perhaps WIT.MANDER.0001.79. Now I am not sure Professor whether you wanted to quickly look through that or even slowly look?

A. I would like to yes spend a few minutes just going through it again.

HEARING ADJOURNS: 11.26 AM

HEARING RESUMES: 11.44 AM

CROSS-EXAMINATION CONTINUES: MR RENNIE

Q. Professor Priestley, have you had, given the time in these hearings there's never sufficient, but have you reasonable time to familiarise yourself with that section of the brief again?

A. Not really but I'll have to rely on the notes that I made beforehand and I'll probably just read from those.

Q. I was going to invite you to do that rather than my asking you questions and you trying to fit your view around that because my question you may recall was whether you had a view on the hypothesis and then whether you had a view in relation to each of the scenarios.

A. Yes, I don't find either the hypothesis or the scenarios very convincing I'm afraid due to a number of assumptions that are made in this, suppositions which are basically stated as facts and I find this rather difficult. The notes that I've got are rather brief so I'll just read them out and see where we go from there perhaps.

In relation to section 3.1, in the second sentence on this and on page 38. The fundamental period of the building one second, the average recorded intensity was less, this is referring to the Darfield earthquake, was less than the 1984 design intensity. The statement by Mander is incorrect. The same comment on paragraph 2, the first sentence; also in the second paragraph, Mander claims that the vertical acceleration response in the Darfield record was exceptionally high and I see no evidence of that. Just when relooking at the accelerograms for the CHHC, looking at the wrong one, at the Darfield record which is the CBGS record where we have peak horizontal accelerations up to .15 g, peak vertical accelerations to .1 g which is two-thirds, which is the standard expected value itself, and if we look at the response spectrum for the vertical accelerations, the horizontal plateau is .5 g and two-thirds of that would be .33 g and that's around about what was occurring for the vertical response. So I don't accept that the Darfield earthquake had exceptionally high vertical acceleration. Certainly that was the case for the Lyttelton earthquake where they were exceptionally high and would have caused considerable problems.

In section 3.1 I don't find the trigger to be feasible. First the drifts on line two and three are a little lower than Mander assumes which he is taking

a 3 percent drift and the average I think from the three records would come out closer to 2 percent drift on lines two and three and I'm wondering if he's using the values on line one which were significantly larger than on lines two and three for that level. Second the moment capacity of the beam framing into the columns on line A is more than twice the capacity of the supporting 300 by 400 column. So in other words we would not expect that there would be column hinging, sorry we would not expect the beams to hinge first in this region before the columns got to its capacity. I did some rough calculations to support that, certainly the column capacity is such that we would not expect that there would be spalling of the beam soffit to occur before the columns start to hinge in this region. This means that spalling of the beams soffit would not occur and elastic action would develop in the column. According to Mander's statements elsewhere the columns are unable to form hinging before joint failure occurs and hence the opening out of the beam column of his trigger would not occur. And I would also comment that I do not believe that his mechanism for describing joint failure is a one that is well supported by other theories and by experimental evidence. It's very conservative and it's very unusual in my experience to see a failure of a beam column joint at something like 70 percent of the capacity of the members framing into it. Almost always the capacity of the critical elements, either the beams or the columns is reached first and then as an elastic action develops we get degradation of the columns themselves.

The column buckling scenario seems unlikely. It requires very little lateral restraint to inhibit lateral or buckling and for his mechanism to occur there has to be total separation from the floor and the beams and the columns itself, and this as it says, it seems inconceivable at least to me that lateral restraint sufficient to inhibit buckling would not remain on both lines one and, sorry line A and line B after joint damage at line A. This restraint would occur as a consequence of reinforcement connection of the beams to the columns and also due to the connection

between the slabs and the perimeter beams. So there is very little strength required to inhibit a buckling mode that goes over several storey heights.

Section 3.3.1, the trigger requires the slabs to de-bond from the Hi-Bond trays and form catenary action. The implication is that this occurred as a consequence of the Darfield earthquake. I agree that the de-bonding may have occurred and this may well have happened before Darfield due to pre-cambering of the Hi-Bond during concreting or due to cretin shrinkage in live load action. However my understanding from Mr Harding's evidence was that the mesh in the slabs was designed to be able to carry the design dead plus live load to ensure that safety under fire when the tensile capacity of the Hi-Bond could not be relied on would occur. I think there's a requirement under these things that if you're going to rely on the Hi-Bond as a tensile element of the slab then you have to protect it by providing special material to provide the fire rating and I don't believe that that was done. What Mr Harding mentions to my recollection from his analysis, sorry from his evidence is that they chose to put sufficient reinforcement in the slab for it to be able to carry its own weight in the event that the Hi-Bond was heated and lost its tensile capacity. In this case the de-bonding of the slab, concrete and Hi-Bond would not result in catenary action. Further if catenary action had developed after Darfield it would have been apparent in terms of greatly increased vertical displacement of the floor because the catenary action cannot occur without very large displacements. There maybe, have some of this that may have occurred but I don't think to any great extent. Finally the Hi-Bond would have continued to support the floor due to its own flexural strength in this case. If catenary action could develop due to de-bonding then the structure would have been unsafe and the fire loading and the pulling action on the columns would have been the same. The final two sentences of 3.3.1 do not follow from the preceding sentences. He refers to the diaphragm ie in-plane stiffness but I think he means the flexural, that is out of plane stiffness.

It should be noted that Mander has suggested a flexural stiffness of only 10 percent of the gross stiffness in the flexural stiffness of the slab. Given the low reinforcement ratio provided by the mesh it would be very substantial tension stiffening and I believe that Mander's value is too low and I find this trigger to be unconvincing.

Section 3.3.2 the southward mechanism. The trigger here, failure of the very weak connection between the floor diaphragms and the north core is more reasonable and was included in the non-linear time history analysis carried out by Compusoft. However for the displacement of the columns on lines two and three to follow this and to provide the potential for column buckling, other restraining mechanisms must fail. In other words the floor slab is essentially rigid in its plane and hence the displacements along lines A and F must also increase by the same amount for this to occur. "The general behaviour may make the columns on lines 2 and 3 more susceptible to failure but at the same time the connection forces between slab and north core at level 4 must increase leading to increased probability of connection failure and increased column drift". These are written in some haste and I've only had a look at the thing recently –

1154

Q. Yes.

A. – but my general impression of the mechanisms suggested and the conclusions drawn from them is that they're somewhat simplistic. They do not appear to be adequately supported by any calculations that I've seen anyway on this side and I believe that the mechanisms that I've presented earlier are more likely than this.

Q. Thank you Professor. One point arising from what you've just been through, you were indicating that if catenary action did occur after the Darfield earthquake you would expect to see that evidenced in the slab, in the floor I think you said?

A. Mmm.

Q. In what way would you expect to see that evidence?

A. I'd expect to see it, well first in greatly increased displacements in the region midway between perhaps lines F and, sorry, between lines 4 and 3 and between 3 and 2.

Q. And in displacement you're referring to the surface alignment of the slab?

A. Sorry?

Q. The surface alignment of the slab?

A. Well this –

Q. The slab has (inaudible 11:56:01)

A. – vertical position of the slab's midway between them so it's a vertical displacement –

Q. Yes.

A. – but to get, to get catenary action with the slab mesh very difficult to do because the capacity would not be sufficient to allow the displacements that would be necessary to form catenary action.

Q. Yes. I under –

A. So –

Q. – I understand that in the particular design that would be constrained by the mesh that you've described, I was looking for a general answer as to what the observed effect on the slab, whether it's humping or sloping or what?

A. You would expect to see, if catenary action did occur it would expect to be apparent in greatly increased displacements at the middle of the slab midway between lines 3 and 4 and midway between lines 2 and 3 and between 1 and 2.

Q. And you'd expect that to be perceptible to occupants of the building?

A. Very perceptible. It would have to be very considerable in fact.

Q. And in terms of very considerable do you mean such that their occupancy would become impossible or simply that it would become different or?

A. As I said it's difficult to imagine catenary action really occurring based on mesh capacity because its ultimate strain is so low. As a consequence any attempt to get this would result, I think, in fracture of

the reinforcement of the mesh reinforcement. I've already said that there may well have been fracture of the mesh in close to the end of the saddle bars 1.2 metres from line 4. That may have occurred. If, I understand that there is some witness, eyewitness evidence of humping of the floor which I take to be more likely to be a sagging of the floor between the supports. This could have been caused just as easily by debonding of the Hibond tray from the floor. This could create some increased displacements but I think that the formation of full catenary action is not really feasible because of the low tensile strain capacity of the mesh itself.

Q. Thank you. Now moving to a quite separate subject.

A. Yes.

Q. On level 2 of the building at the time of the television company became the occupant a hole was cut in the level 2 slab to enable the installation of a staircase between those levels. Is that a matter you were aware of?

A. Yes I've read about that, yes.

Q. And is that a matter you would attach significance to?

A. Not particularly, I believe it was looked into in some detail by the Holmes Consulting Group at some stage or –

Q. Not that I'm aware of, no.

A. Okay, well I believe there was, perhaps I should say that I was aware that a slab, that a hole had been cut and I've seen evidence somewhere that this was not considered to have a significant effect on the performance of the structure.

Q. But it's not a matter you personally assessed?

A. No. I have not.

Q. One of the witnesses the Commission has heard, a Mrs Jackson, her, she was the receptionist at the television company and sat immediately adjacent to the staircase –

A. Mhm.

Q. – which was installed in the hole which was cut as a metal structure which you walked up half distance and turned to the right to walk to the second floor. Her evidence was that after the Boxing Day earthquake

the staircase in her words, "jumped around". Would you attach significance to that?

A. The staircase jumped around?

Q. Jumped around, not, this is not talking about the earthquake, this is talking about its post-earthquake performance before 22 February?

A. I find it hard to understand how a steel staircase could do that. The only, the characteristics of the staircase itself would not change. It's possible that the fixings of the staircase to the slab at level 2 and possibly at ground floor might have become damaged but even with that it's hard to actually see what would cause the staircase to become more lively if it is just a steel staircase on that.

Q. Would you attach any significance to a staircase of that type in that location becoming more lively?

A. Not particularly I don't think. I can't think what the significance would be.

Q. Would you attach any significance to the impact of the hole cut in slab 2 as to the integrity of the level 2 slab or its connection with the south shear wall?

A. It's possible that it might have affected the in-plane action of transferring the inertia force from level 2 back into the wall itself but can you tell me, can you refresh my memory about the location in the floor plan of the staircase?

Q. The eastern edge of the south shear wall.

A. The eastern edge of the south shear wall?

Q. Was just west of the western edge of the hole cut in the slab.

A. Yeah, okay, so it's located in the, in the south east side of the –

Q. Correct, it's in the –

A. – yeah, and fairly close to the floor slab to the south wall itself. What sort of distance would it, would the south edge of the staircase be from line 1?

Q. Maybe simplest if I –

A. I don't know that it would make much difference on (inaudible 12:02:56)

Q. There is an engineering plan and there will be a witness to deal with that. I probably taken you further than I could fairly take you in assessing this matter in any event.

A. I doubt whether it would have significance to the ability of the forces, the inertial forces to get through to the south wall itself. If the building was constructed as designed and I think there has been some suggestion that perhaps some of the reinforcing steel may not have been placed between the floor slab and the south wall itself.

Q. Yes.

A. Okay.

Q. That is, that has been raised.

A. Yeah.

Q. Separately there is some evidence suggestive that an unknown number of holes of an unknown number of dimensions were drilled on dates not precisely known in the late 1990s in the floor and/or the beams for cabling purposes. Are you aware of that?

A. I've seen, I've heard some evidence to that extent.

Q. I understand, I recognise that we can really only discuss this issue in principle absent any better data but in principle would you attach significance to that type of activity taking place in the building?

A. These –

JUSTICE COOPER:

What type of activity Mr Rennie?

MR RENNIE:

Drilling an unknown number of holes of an unknown number of dimensions in an unknown number of locations Sir. I'm asking about the general principle issue of the significance or lack of significance of drilling holes.

1204

JUSTICE COOPER:

Right.

CROSS-EXAMINATION CONTINUES: MR RENNIE

A. Impossible to answer that.

Q. Yes. Thank you Professor.

QUESTIONS ARISING: MR ELLIOTT - NIL

RE-EXAMINATION: MR MILLS

Q. First of all just to make sure there's no loose ends around this you were asked some questions by my friend Mr Rennie about the measuring device that had been put right on the CTV site -

A. Yes.

Q. – at a certain point in the process and you asked about whether the north core was there at the time because of the significance of whether it was or it wasn't and the response you got was that the north core had been removed at a time before this measuring went on, or at least a substantial part of it, and I just wanted to be sure to say that there was nothing left un-concluded about that by asking you whether, with that fact established, that the north core wasn't there at some of the time that this testing was being done, what do you think about the relevance in later aftershock events of measurements taken on that site in trying to determine the performance of that site on 22 February and presumably in September as well.

A. I did not take it into account in my assessment of it. I assumed that the north core had been removed before any measurements were taken. So my, the answers that I gave about the difficulty in assessing or extrapolating from the results of these very low level excitations to the February earthquake were made on the assumption that the north core was not there. My question about the presence of the north core was an added element that if it had been there this would make it still even more uncertain as to the relevance of these results.

Q. Now just a couple of things I wanted to ask you about in relation to the seminar paper that you were, or seminar session that you were taken to, and I wonder if we could bring up again that first page of that document

and then I'll move you through from there. It's BUI.MAD249.0519.1 and then I want to go immediately to page 3. Now if you could just go to page 3 of that document. Now you'll see that what we've got there is somebody taking some notes and doing a sketch and it's on the letterhead of Alan M Reay Consulting Engineer and before I ask you to comment on that and whether it might have any relevance to the issues around the CTV building design I want to take you first to page 103 of that seminar document. Now, first, you agree with me that's what shown on 103 is essentially what somebody has sought to replicate on page 3.

A. Correct.

Q. Now I don't know whether you would find it useful to just look at the page in front of you right now to see the context of that before I ask you a further question, if you do tell me, but what I'm interested in as I said before is whether that sketch and the significance that somebody, probably David Harding, has taken from it in sketching it himself has any relevance to the issues we're considering around CTV building design?

A. I'm familiar with what is being suggested and shown here.

Q. Yes.

A. It's a sketch done by Professor Paulay originally. It's a figure from him indicating that what the effect of flange width is for flexural response of flanged walls. So it particularly is relative to the amount of reinforcement that might be acting in a flange that's in conjunction with a web and it does have relevance to the behaviour of the north core because it's indicating a method for determining how much of the flexural reinforcement might participate in let's say the east-west direction where we have the web would be the wall on line 5 and the flanges would be the, the walls on the four lines C, C/D, D and D/E.

Q. Yes.

A. And would be used in determining how much of the reinforcement in those flanges could be considered to participate with the web in flexural resistance.

Q. Yes.

A. And applying that test to these that would give the indication that the amount of the flanges that would participate would be 100%, in other words the entire reinforcement in the flanges would participate with the web on line 5 in the flexural resistance.

Q. Yes and you able to make any comment on whether this drawing originally from Professor Paulay which has been, I think, reproduced here by David Harding –

A. Yes.

Q. – has been carried through into the design of the north core of the building?

A. I find it difficult to, to answer that apart from the point of view that I've already mentioned that the, my calculated strength and also the calculated strength of the wall incorporating the, the flanges in the east-west direction is. My estimate was that the capacity would be about .35 g. The Compusoft analyses would indicate about .29 g and it would seem that the code would have required about .08 g. So one has to ask why is there that very large discrepancy? Why is that north wall so strong? One possible explanation, and all I can say is that it's a possibility, is that the designer chose to not rely on the composite action of the flanges and the webs in determining the flexural capacity but chose to consider them as separate elements and it's not uncommon in design for such an approach to be taken but when it is done then normally what would happen is that the flanges would be physically separated from the, from the webs itself and if that's done then it is a valid design approach. It simplifies the behaviour and performance of the walls and does provide elements of a rather clearly determined capacity in the two different directions but, of course, that was not done in this case.

Q. No. All right. Thank you for that. Now, finally, I think you've been taken to all the relevant parts in Dr Mander's brief but I just wanted to give you the opportunity if there was anything else that you wanted to comment on in his brief and the attached submission. Here's your opportunity.

A. Okay I'll just mention a few things. As you say we've gone through many of them but on page 6 there is some discussion of vertical acceleration. The vertical period has not been accurately established by anyone and that includes Mr, Dr Mander. It's quite complex involving consideration of the extent of cracking in the floor slabs, the amount and distribution of live load, the axial flexibility of the columns et cetera. Also it is unlikely that the different floor levels and the different bays of the floors at a given level would respond synchronously thus determining the effect of vertical acceleration by simply factoring up the axial loads on the columns by an assumed vertical acceleration response factor is extremely crude.

Elsewhere, and I don't know where I've got this, yeah, also relating to vertical accelerations Dr Mander on page 27 in the second to last paragraph claims that it's inevitable that maximum vertical load and maximum drift will occur simultaneously. My reading of the results from the time history analysis is that this is not the case as it assumes a steady state response. In fact examination of the Compusoft results on figure 56 shows that the peak vertical load occurred at about 3.7 seconds but the peak east-west response occurred at about 6.5 seconds, these are not simultaneous. This loose use of definitive statements is something that I regret to say that I found not infrequently in Dr Mander's report.

On page 6 the last paragraph Mander claims response would have broken the fixed end conditions of the slab and I suspect that may not be his terminology but may have been forced on him by his counsel, increasing the displacements by 500%. It is not clear to me does he mean that the reinforcement connecting the slabs to the beam had fractured, if so what evidence does he present to support this? If not, if he means that the reinforcement would have yielded and reduced the extent of end flexity then the displacement increased would be much less than 500% claimed. Hysteretic response would have further reduced response by increased damping associated with that.

1214

JUSTICE COOPER:

Just pause for a moment. Mr Rennie, you wish to comment on the observations that's just been made –

MR RENNIE:

I was just chatting with my junior Sir. Professor Mander wrote his submission without input from counsel and presented it as I will say shortly, in the nature of an academic paper which he will defend in the academic sense. Secondly, while I am willing to accept blame for many matters Sir I don't believe I rise to the level of engineering competence necessary to have such an influence even were I to try.

JUSTICE COOPER:

Q. All right, well I just thought I should clarify that partly so that Professor Priestley can proceed sure in the knowledge that everything in Dr Mander's submission, I think he calls it, he wrote himself.

A. Okay, so he did choose those words?

Q. Yes.

A. Anyway just to finish that little bit I think finally even with a perfect fracture at the end so that the structure changed from being fully fixed to simply supported at the ends the increase in displacement is I believe 400% and not 500% but again it may just be loose terminology that it increased to five times the, well it would have been an increase of only 400%.

RE-EXAMINATION CONTINUES: MR MILLS

Q. Yes.

A. I think that a lot of these are rather minor. One aspect that I am concerned about and I think that it will probably be clarified by Dr Mander is related to the concrete testing and it is, I find the interpretation by Dr Mander of the eight test results carried out by CTL to be perhaps doubtful there is no statistical justification for assigning

the lowest strengths to the upper storeys and the subdivision of the test results between the storeys is entirely arbitrary i believe and conjectural and rather dangerous with such a small sample. The conclusion of the actual strength being 1.5 times the specified strength is strongly skewed by the two highest values which according to Mander's ordering are related to levels 1 and 2 and which have values of more than two times the specified strengths. If the lowest four test results are assigned to the upper floors the average strength is 1.27 times the specified for those, but again I don't see any justification for doing it this way. It is also – there may be good reasons for this but I can't see why the results that he presented with these eight tests have not been combined with the results in the more extensive body of data reported in the CTV report so presumably he is saying that these are all of the tests results that were taken in Christchurch were unreliable. The other aspect –

Q. I might just observe I think that might be what is going to be said but we have a later session which will explore that in more detail?

A. Yes, okay, so we can do that. The 400 millimetre test results while I think it is perhaps premature to make any comment on these because the results have not been provided to us but it would be interesting to know what this would mean. I think, I had some problems with the figure on, I think it is page 25 of the column drift capacities, a number of these figures, 2.6 and 2.7. It appears to me that there may have been problems with the analysis programme used and I am sure Dr Mander will be able to clarify this. A few of the inconsistencies that appeared to me would be that in figure 2.6 level 5 results the sensitivity of the level here that is V max to the concrete strength appears to be much too large. I have repeated those analyses myself and got, instead of an 11% increase, only 6% from my analyses.

JUSTICE COOPER:

Q. Perhaps this should be displayed so we can understand it?

A. Yep sure.

Q. If we stick with the WIT.MANDER reference it is 0001.67.

A. Right that is fine, thank you.

RE-EXAMINATION CONTINUES: MR MILLS

A. So the first point to that I mentioned was related to the strength in the first case, this is at level 5. These numbers here refer to the storeys of the building or the levels on them. The two different strengths one, the value used in the Compusoft analyses and the other Dr Mander's suggested values itself and comparing the peak values here and here there is an 11% increase here. I calculate 6% it may not be very large but it's a significant value. The second thing associated with this is that we seem to have extraordinarily large ultimate drifts predicted on 23% which in my view is quite impossible for a concrete column and I note also that as you increase the concrete strength this drift, this is not a very large increase in concrete strength but the ultimate drift reduces from 23% to 7% which seems a rather unlikely aspect for me. It would have been helpful if the drifts at maximum strains of say .004 and .007 had been provided but they are not and it would have also have been helpful if the vertical loads that were assumed for these particular cases had been noted. The trends are often counterintuitive to me at least for example 4F (inaudible 12:22:15) plus 2.5 megapascals that is the ones down this line here, the drifted maximum reduces from level 4 to level 3 but increases from level 3 to levels 4 as the vertical load increases. So from levels 4 to level 3 the drifted maximum load decreases from .88% to 0.7% but then it increases again from level 3 to level 2 going up to .87%, there may be reasons for this but it's not obvious to me. Increasing the concrete strength increases the drift at maximum, at levels 1 and levels 3 but reduces the drift at maximum, at levels 2 and levels 4. So that seems rather strange.

Q. And is this again because there is more gravity load being carried lower down?

A. Well it would not be the case that is why I have mentioned that we get an increase at levels 1 and 3 but not at 2 and 4 so the trend goes up down, up down which is not what we would expect I think in that sense.

It's not clear to me that given the very large drifts that are being shown here that P-Delta effects have been considered which they certainly should be for these cases with very large drifts that are predicted. I also note that on figure 2.7 perhaps we could have that on.

JUSTICE COOPER

The suffix is 70.

1224

RE-EXAMINATION CONTINUES: MR MILLS

A. I'm sure that Professor Mander will explain all these things but I find the performance of. These are meant to have been provided by a pushover result and yet we see a situation where the pushover results in a situation where the displacement decreases as the force is decreasing as well, which is an unusual behaviour. It's possible that this may be relating from elastic unloading of other parts of the column but this would not normally be able to be picked up by a pushover analysis. So I'm uncertain about this behaviour as described here.

JUSTICE COOPER:

Q. That is most pronounced in the bottom right-hand diagram in that figure?

A. Yes it has, yeah, that's correct yeah, this one in particular, yeah.

RE-EXAMINATION CONTINUES: MR MILLS

A. I think that another aspect that perhaps I think should be commented on, Dr Mander has, claims in his evidence that the way in which the columns were modelled with just a single moment axial load inter-relationship was so coarse that the results are meaningless from the time history analysis. I don't believe that that really is the case because the displacement of the building is so dominated by the stiffness of the north core and the south coupled shear wall that the values of the stiffness and the failure envelopes for the columns would not influence

the predicted displacements at the columns by any significant amount. That makes it reasonable to do what Compusoft have done which was to take the predicted displacements of these and the calculated axial forces that determine that occurred in the analysis to do some back analysis to determine whether the capacities had actually been exceeded, so I don't believe that what is called PMM modelling would've made any significant difference to the displacement of these structures, nor to the prediction of the actual performance of the individual columns. There undoubtedly would've been some influence but I think it would be well within the inherent uncertainties of the analysis anyway. I think that's all I would discuss.

JUSTICE COOPER:

Mr Rennie I would give you an opportunity if there is anything in that that you wish to pursue?

MR RENNIE:

Thank you Sir, no I listened to that and I don't wish to.

QUESTIONS FROM COMMISSIONER FENWICK - NIL

QUESTIONS FROM COMMISSIONER CARTER - NIL

QUESTIONS FROM JUSTICE COOPER:

Q. Can I just ask, on this issue of concrete strength which you have gone into and I think you said that it is an area you don't want to go into?

A. Yes.

Q. But we are to hear evidence which will, as I understand it dispute the assumptions or the conclusions reached in the consultants' report about inadequate concrete strength?

A. Yep.

Q. If the strength of concrete is shown to have met the specification or maybe exceeded it, what does that do to the evidence or the conclusions that you have reached about why this building failed?

A. It would have no influence on it.

Q. Now, just you've been taken to a range of statements made by Professor Mander, but there was one that caught my eye that you haven't been referred to, and I wonder if we could just see document WIT.MANDER.0001.48 which is part of paragraph 1.3 of the statement that he's going to give and in the penultimate paragraph on that page after some introductory sentences he says, "The CTV building was in fact quite revolutionary at that time," that time being the 1980s, "As the details of the design are clearly contractor friendly it appears to be for these reasons that the structural designer evidently thought a simpler form of construction that avoided the use of copious quantities of transverse reinforcing steel to provide a ductility capability." Now would you care to comment on those sentences?

A. Certainly, I think that I don't believe that the final sentence there saying that the simpler form of construction had avoided the use of copious quantities of transverse reinforcing steel in the columns to provide ductility capacity has any relevance at all to the form of construction and the use of precast concrete in this because the columns were in fact cast in situ and the difficulty in providing adequate reinforcement in those and in the joints would've been negligible. For example if, normally the reinforcing cage is prefabricated and then put into position, and the difference in amount of effort in winding a six millimetre transverse reinforcement at 250 millimetre centres, or using a 10 millimetre at a much lesser spacing would be negligible. It would have no influence and I think that this sentence, in fact this whole paragraph is rather dubious. I cannot see any justification for it at all.

QUESTIONS ARISING – REMAINING COUNSEL - NIL

WITNESS EXCUSED

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JUSTICE COOPER ADDRESSES MR RENNIE – OPENING STATEMENT

JUSTICE COOPER:

No all right. One thing before you start. I think it would be of interest to the Commission that, to know the other building that you were referring to even if you wish to do so in a way that is, suits your forensic purposes. I think we would like to know what the building referred to was.

MR RENNIE:

Yes.

JUSTICE COOPER:

And, and how many storeys it was.

MR RENNIE:

The name eludes me at this moment Sir but I –

JUSTICE COOPER:

Yes.

MR RENNIE:

I will ascertain it and I will provide it, yes.

JUSTICE COOPER:

Will you find out and let us know?

MR RENNIE:

Yes.

JUSTICE COOPER:

All right. Thank you. So now if you wish to you can present your opening statement.

MR RENNIE:

Thank you Sir. I anticipate that almost exactly the time available is what I'm likely to be to do the opening. The opening is in writing and I believe it's been uploaded. It will be very soon.

JUSTICE COOPER:

You can take the time that you feel appropriate Mr Rennie of course.

MR RENNIE:

Thank you Sir.

JUSTICE COOPER:

Mr Mills in your absence we've established that you're not calling another witness before Mr Rennie addresses us.

MR MILLS:

No Sir, (inaudible 12:35:21) he wants to come back I think so I've just been getting him organised so he could do that. He wants to just sit and –

JUSTICE COOPER:

Very well thank you.

MR RENNIE:

Yes, Your Honour and Commissioners, Alan Reay Consultants Limited and Dr Alan Reay have been granted status as affected parties before the Royal Commission. Dr Reay was the founding director of ARCL in 1988. He remains on its board. He works as one of its engineers and he's behind me today Sir. Before 1988 Dr Reay maintained a professional practice as Alan M Reay Consulting Engineer. In 1986 that firm undertook the structural design for a building project which was ultimately built and became the CTV building. The staff engineer who was responsible for that work moved to other employment in 1988. In 1988 ARCL was incorporated as the successor to Dr Reay's professional practice. Dr Reay was the initial principal and in

1990 to '91, by which time the CTV building had been constructed, ARCL was asked to consider the adequacy of the design in relation to the connection of the floor slabs at the northern shear wall. This was investigated and uncertainty as to the extent of that connection as constructed led to the installation of additional connection by drag bars. ARCL and Dr Reay had no further involvement with the building. The catastrophic collapse of the CTV building and the deaths and injuries which were caused shocked and distressed Dr Reay and all who worked with him in ARCL. His feelings are insignificant compared to the impact on those who died, those who lived and their families but they are nonetheless very real and retain their impact every day. No adequate words exist to convey his feelings for their loss.

Dr Reay and ARCL have organised their representation in this hearing in order to best know the truth to what caused the collapse of the building. So do many others. Engineers do not design buildings to fall down. The code to which they are designed sets the criteria that engineers over time have established to limit and direct how individual designs are developed and it is against that code that the consenting authorities review each design. Engineers design and structure buildings which meet their clients' needs and respond to their wishes and the work of architects and others but in doing so must work within and respond to the requirements of that code. This imposes safe practice on structural design. The code is not the minimum standard but the required standard. The first and continuing response of Dr Reay and ARCL has been to investigate and so understand what happened. As will be shown in evidence their intention of doing this in co-operation with other investigators is rebuffed, in particular by the Department of Building and Housing. This rebuff is contrary to long-established professional principles and rightly or wrongly was seen as an implied accusation and with degrees of pre-judgment. The consequence has been that ARCL and Dr Reay were left to attempt their own parallel investigation with such information as they could obtain. Only at the start of December 2011 was a draft building collapse report provided with a short time period for response. They believe that despite their response they had no meaningful input into that report. From 9

February 2012 the DBH publicly released a report which included conclusions on the cause of the collapse of the CTV building. These conclusions made by the report writers were not part of their terms of reference. The expert panel held a wider range of views. It was inappropriate for the DBH to claim certainty before this Royal Commission considered the CTV building under terms of reference which are more extensive and with much greater information. Particularly, Sir, we acknowledge Professor Priestley's adherence to those principles by giving evidence independently in this matter. ARCL and Dr Reay determined to complete the research and investigation they'd undertaken for which experts had been engaged and key investigations also initiated and present it to this Royal Commission. Every effort has been made to complete that work to a high forensic standard, independently and with no predetermined outcome. A particular focus has been to put the issues in the hands of independent experts and be guided by them. Where that process leads is a matter Sir for the Royal Commission to determine in its findings. From the perspective of ARCL and Dr Reay the design work should be assessed based on the information available and the practices adopted at the time of the design and not with perfect hindsight vision.

Then Sir there's an outline history which is not actually so much a chronology as a perspective and that's why I am going to read it.

In 1986 the building was designed. It's now seen to have issues as to code compliance on some points but it was typical of its time, was consented and in respect of those issues probably not different to many others. Its intended use was as an office building and later use as television, education and health services were not contemplated.

1986 to '7 the building was constructed. It's likely to have had less reinforcing, particularly in beam to column joints than the design specified. The builder was a reputable construction firm of its time which was re-established by its management during construction.

In 1990 Holmes Consulting Group was engaged to report on the building as part of due diligence for the Canterbury Regional Council who considered occupying it. Holmes doubted that the slab floors were sufficiently tied to the north shear wall. It was never finally determined whether the specified reinforcing was in place. The regional council did not take up occupancy.

In 1991 a new owner acquired the building. They were informed by ARCL, not Holmes, of the issue of the slab to shear wall connection. Drag bars were installed on some floors. This work was designed to be code compliant at the time and probably was but in accordance with common practice at the time was not separately consented. The focus was on achieving the planned tie not on any overall review of the structure which was reasonable given that the Holmes' structural review had been done.

Between '91 and 2010 the building was left to look after itself with minimal review or maintenance. It was initially occupied by the ANZ. From 1995 to 2000 holes may have been drilled through beam reinforcing in the floors. It's now known that in 1998 or 1999 Mr Mitchell of Opus who did many peer reviews of structures on the Council's instructions did a desktop review. He concluded the building would be vulnerable to a moderate earthquake but closed the file and didn't pass on this information. In contrast Mr Tindall, perhaps four years earlier, didn't find any signs of damage. In 2000 CTV moved in and installed a staircase from level 1 to level 2 next to the south shear wall. This modified the junction of the level 2 floor slab to the south beams at that point.

In the 2000s there were two changes of use for language schools, one consented, one not and later on a medical centre. Consent was sought for the Going Places tenancy in 2001 on level 3. It doesn't seem that loadings or building structural design were appropriately considered as part of the consenting process.

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In principle, a school increases the loading requirement from 250 KPM to 300 KPM and this requires an engineer's review but none appears to have been done in either case. In the fact of the Opus review it is reasonable to predict that if it had been done, that's to say if a further one had been done, some further investigation of a structure is likely to have been triggered. No consent was sought for the Kings Education tenancy on level 4 or if required, which depends on whether the detail of its use meant it was a health facility, the medical clinic on level 5.

In 2010 a series of events begins triggered by the 4 September 2010 M7.1 Darfield earthquake. 4 September earthquake, the building survived a design level quake and was visually intact. The actual structural damage may have been greater than was visible but we will now never know. On 5 September there was a level 1 rapid inspection by a team which included a CPEng engineer. On 7 September there was a level 2 rapid inspection by three Council inspectors wrongly understood by many connected with the building to have been an inspection by three engineers. It was green stickered. The start of twin lifts green sticker means good to go and the engineers have checked the building.

29 September to 19 October, Mr Coatsworth reviewed the building in some detail with a quantity surveyor, recommended repair work including epoxy injection to cracks. His work proposal offered an initial structural review, but later in the office stated that his work would not be a structural review and he didn't perform a structural analysis. In consequence there was no review of the structural plans, no interpretation of seismic records and no calculations were done. His report reinforced the erroneous belief of both owner and occupants that the building had undergone structural review by engineers and passed. However at this stage Mr Coatsworth may have been right to conclude that the building was repairable for the damage it was known to have. The uncertainty is whether that damage was more severe and unseen.

In November to December demolition was undertaken on the neighbouring property to the west. The effects of the removal of the old building, including the excavation of foundations along the west wall after which the building movement became greater, and the vibrations from the wrecking ball may have been an alert to hidden weaknesses, but it's doubtful that it caused any actual damage.

From 4 September onwards many aftershocks occurred. The ground acceleration effect on the CTV building varied considerably. An aftershock on Boxing Day caused building occupants to believe that the building had sustained new and worrying damage. Certainly there were observations of visible change, "An increasingly sloping hump on level 4," (Mr Godkin), slope on desks of Mrs Aydon and Ms Brehaut. "It goes out of square," said Mr Reynish. Beams and columns are visibly damaged for example the level 6 Higgins evidence and, "The level 1 staircase starts to jump around," (Mrs Jackson). However a second green sticker was assigned by the Council on 27 December 2011.

After Boxing Day, sorry that should be 2010, after Boxing Day 2010 and going into 2011 the building manager took no action, stating to the level 6 manager Mrs Vivian that an engineer had checked the building.

Continuation of events triggered by the 4 September 2010 earthquake in 2011. In January the medical clinic on level 5 was added. The owner's position is that the building may look damaged but is safe as engineers have said so. Staff were uneasy. In January and February Mr Drew slowly got around to organising quotes for the recommended repairs but not many were started. His timeframe may have been related to the owners and insurers. Mr Coatsworth was not brought back. The visible damage was now more extensive. The motion of the building had increased. One witness speaks of seasickness from the motion and noise from the building movement was reported.

On 22 February 2011, after a fresh severe aftershock, (inaudible 12:48:34) with vertical uplift assessed at almost twice the force assumed in the code, the building collapsed over a period of about half a minute and in this sudden and disastrous collapse 115 people lost their lives.

So we will be calling a number of witnesses, the first of which is Dr Reay who has submitted three statements of evidence. In his first statement Dr Reay provides factual evidence in respect of the relation to the design of the CTV building and the 1991 retrofit works. Dr Reay's evidence will be that he was not principally involved in the design of the project. It was a project undertaken by Mr David Harding, an experienced engineer who joined the practice with an interest in undertaking such work. Mr Harding was considered capable and was prepared to undertake the work. Dr Reay would've ensured that appropriate resources were available to assist Mr Harding. Dr Reay confirms that Mr Harding, a registered engineer, was appropriately qualified and experienced for the project.

There are two points in this opening where I put a matter in footnotes. The first related to a document at the beginning, and I've just put a note here about something counsel assisting said in opening about supervision. While Mr Harding was in a legal sense an employee, he had substantial experience in his earlier positions as an engineer and could have practiced on his own account as an engineering principal. He was not junior staff recruited to be trained under detailed supervision.

Dr Reay doesn't recall having anything to do with Council permit process or the construction. Dr Reay outlines the history of the addition of drag bars to the building in 1991. This potential issue was brought to his attention by Holmes who had carried out a review for a potential purchaser of the building.

Mr Banks from ARCL handled the matter at ARCL. Dr Reay was not directly responsible for resolving it. ARCL was unable to verify whether adequate reinforcing had been added during construction. As required by its

professional cover it notified its insurers. Some time passed and ARCL then noted from the Press that the building had been sold. ARCL notified the new owners of the potential issue.

Mr Banks prepared construction drawings for the remedial works and the works were carried out by CBD Construction Ltd. Mr Banks' calculations showed that the drag bars were necessary at levels 4, 5 and 6 only. The building owners met the cost of the remedial works which was around $5000. In his first statement, Dr Reay also covers some background to the DBH reports released in February 2012 and references ARCL's comments on the draft reports.

In his second statement of evidence Dr Reay provides expert opinion on a number of issues relevant to the collapse including the design of the Landsborough House building which has been raised in evidence by other witnesses. Landsborough House was designed by Mr John Henry while he was with ARCL. Sorry ARCE which is the earlier practice. Dr Reay outlines the similarities and differences between that building and the CTV building. There is some evidence but the drawings and calculations for Landsborough House may have been given to Mr Harding at the time he started the design of the CTV building and influenced his decisions.

Secondly the DBH report. Dr Reay outlines a number of areas where he rejects matters in the DBH report. These include the computer analyses that had been conducted by the authors of the report. Dr Reay proposes other analyses that ought to have been conducted including a scale physical model on a shake table.

Concrete. Dr Reay is critical of the concrete strength utilised by the authors of the DBH report in conducting their analyses and refers to the concrete testing commissioned by ARCL.

Geotechnical report. Dr Reay notes that no advice was sought from the original geotechnical engineer who prepared the site report in 1986, Ian McCahon, particularly with respect to the likely soil stiffness properties that would have been recommended at the time of design. Dr Reay produces this advice from Ian McCahon. He also refers to another ARCL witness Dr Brendon Bradley who reports on the results from a seismic recording device placed on the CTV site by ARCL.

Dr Reay comments on the DBH's reports references to construction tolerances in relation to the installation of spandrel panels with either limited or no gap between the end of the panel and the concrete column. Dr Reay considers that it is unlikely construction was completed in this manner and produces photographs from another building constructed by Williams Construction showing good alignment of the spandrel panels.

Destruction of evidence. Dr Reay is critical of the authors of the DBH report for making no attempt to retain the sections of the remaining shear wall and floor elements that were intact after the collapse in breach of good forensic practice.

Dr Reay was asked by the Royal Commission to express an opinion on the compliance of the CTV building with the code of the day. In his statement Dr Reay notes that it is not possible to definitively state that the building complied as there is no certainty about the documentation issued to the building contractor. However, he notes that after the addition of drag bars in 1991 and based on the 1990 report by the Holmes Consulting Group it is his opinion that the building complied after the completion of those works.

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JUSTICE COOPER:

Can I just ask there? You say there is no certainty about the documentation issued to the building contractor?

MR RENNIE:

Yes Sir.

JUSTICE COOPER:

But there is no doubt about what was before the Council and what the Council submitted is there?

MR RENNIE:

In essence that is correct Sir, although whether there is a comprehensive set of all documentation I'm not sure can be confidently stated but you're quite correct there is as held by ARCL as held by the Council –

JUSTICE COOPER:

Well we have got plans up from sheets 1 to 39 which have Council stamps on them in on the 30th of September 1986.

MR RENNIE:

Yes but there's an issue, for example, about the calculations which were not initially provided, they were then called for by the Council. The matter is or will be detailed in evidence because in essence Sir and this is a point which is worth a moment when, after 22 February when the enquiries began for the documentation the ability of the Council as to what it could find and the ability of ARCL as successor to the previous practice as to what it could find in both cases there were imperfections in that.

JUSTICE COOPER:

All right.

MR RENNIE CONTINUES:

Dr Reay, I'm at the top of page 9 Sir, Dr Reay then expresses a view on scenarios that have not been adequately considered in relation to the collapse of the building. The issues he raises are reinforcing strain hardening. Dr Reay comments on this phenomenon which has been discovered in a number of

buildings around Christchurch including the IRD building. It involves the concrete reinforcing being strained to the point of being stretched beyond repair resulting in an irretrievable loss of capacity to the building.

Vertical accelerations. Dr Reay believes that the effects of very high vertical accelerations have not been adequately accounted for in the collapse analysis to date.

South wall lateral load resistance. Dr Reay comments that the lateral load resistance of the southern wall has not been adequately considered. Vertical accelerations affect the gravity restoring force provided by the gravity loading of the floor.

Building modifications. Dr Reay comments on the evidence of Mr Morris in relation to holes drilled in the building during the 1990s for the installation of cabling and ducting including through some of the reinforcing.

JUSTICE COOPER:

You must accept that it is very difficult for us to do anything with that evidence Mr Rennie?

MR RENNIE:

Yes.

JUSTICE COOPER:

In fact I wonder whether it is even evidence because evidence –

MR RENNIE:

I accept –

JUSTICE COOPER:

Evidence is defined in the Evidence Act anyway is evidence which has a tendency to prove or disprove something and that –

MR RENNIE:

Sir I accept the limitations on that evidence and that was why I put the question to Professor Priestley in the way that attracted Your Honour's attention because asked to answer the question, "Were holes drilled in the building or were there not?" I would say in a civil standard approve the answer is, "Yes they were." Asked, "How many of what dimension and where?" The answer would be, "The information is not known." And that was why I put that question in the way that I did.

JUSTICE COOPER:

So is there any evidence that tends to prove or disprove something?

MR RENNIE:

Your Honour will find that the way that this point is ultimately developed relates in our perspective although Dr Reay I have to say has the position that I have put and has to take his view against the limitations of the information. The position that I ultimately put in relation to this relates to the better control of alterations to buildings once constructed as a general point of principle and not as a causative issue and my view respectfully Sir is that that is about as far as I can take it unless somebody rings up and announces that when he drilled some holes he had some photos taken because he was so proud of them and that hasn't happened Sir.

JUSTICE COOPER:

Okay.

MR RENNIE CONTINUES:

He also comments on the installation of an internal staircase between levels 1 and 2 of the building in 2000. Dr Reay notes that both of these issues have not been adequately considered by other experts. Finally Dr Reay discusses the possibility of cumulative damage to the building as a result of ongoing aftershocks between September 2010 and February 2011 and produces a schedule listing all such major aftershocks. This evidence is also dealt with by other ARCL witnesses. Finally Dr Reay produces time records from ARCE

from the time of the CTV building project which identifies a number of hours worked by various staff members on the job. This time records are that Dr Reay recorded 3.5 hours for the job and Mr Harding 304 hours.

In his third statement of evidence Dr Reay responds to evidence given by some other witnesses. Primarily he focuses on the evidence of Mr John Henry. Dr Reay's evidence will be presented in a number of stages. This week his evidence on collapse considerations will be given. Later in the hearing Dr Reay will be heard on the topics of code compliance, design and drag bars. Now Your Honour of course my optimism about time has been completely contradicted by the clock and I'll take a break there if I may?

JUSTICE COOPER:

Yes.

MR RENNIE:

And I will just say one more thing about Dr Reay's evidence. Hopefully with a view of assisting and this has been discussed with counsel assisting Mr Mills, we have actually prepared a copy of the three briefs consolidated containing only the evidence that Dr Reay will give this week and we're proposing to make that available if the Commission considers that that is a way in which it would be helpful to proceed.

JUSTICE COOPER:

Mr Mills?

MR MILLS:

That is right, he did discuss it with me. There is one, a little addition to it which I've mentioned which will be drawn to your attention but other than that it is just as it has been described. It's drawn together with the original paragraph numbering so you can still cross-reference if you wish to. It did seem to me that it was quite convenient rather than picking pieces between three different briefs which is the way it's actually been given.

JUSTICE COOPER:

All right. Does anybody else have an opinion on this difficult issue? Well we will do it that way, thank you.

HEARING ADJOURNS: 1.02 PM

HEARING RESUMES: 2.15 PM

MR RENNIE:

Sir, just before I resume the opening just to tidy up several matters that came up in the course of the first part this morning.

JUSTICE COOPER:

Yes.

MR RENNIE:

And one matter that it was my intention in any event to raise at the end of referring to Dr Reay's evidence.

JUSTICE COOPER:

Yes.

MR RENNIE:

I was asked about the extent to which the records of the plans et cetera were or were not available.

JUSTICE COOPER:

Yes.

MR RENNIE:

There are a number of points in relation to this and I thought if it's convenient to you Sir I might just orally give you an indication of those and then offer to submit a more precise memorandum or a later statement.

JUSTICE COOPER:

Thank you.

MR RENNIE:

Council has a set of the plans which as Your Honour noted has some stamped approvals on them.

JUSTICE COOPER:

Yes.

MR RENNIE:

And ARCL has a set of the plans but in relation to some of the sheets of those plans there are differences in the detailing between those two plans and that's why I'm suggesting that a memorandum may be helpful.

JUSTICE COOPER:

Yes, I hadn't appreciated that.

MR RENNIE:

Yes. I don't want Your Honour to think that they are major or significant but the fact remains that the two are not identical and rather than leave it at that I'll arrange for a memorandum just indicating that to be provided Sir.

JUSTICE COOPER:

Yes that will be helpful. Can you tell me whether the ones in your client's possession, do they have Council stamp on them?

MR RENNIE:

I don't recall that Sir but, no, I shouldn't answer that because I don't recall that. Now next Sir –

JUSTICE COOPER:

Well that would be not terribly good would it if there were different plans both stamped approved?

MR RENNIE:

No, but it depends on the degree of significance of the difference Sir and my understanding is that the difference is not central to what the Commission is concerned about but it's part of why I was saying that there is not certainty as to precisely what went to the contractor because there is no record of the plans that went to the contractor and there is, of course, no as-built set of plans. Now in addition to that you will be aware that the Council issued a set of requisitions in respect of further information and a request for calculations and so forth. There is a set of the calculations. That set of the calculations is held by ARCL and while it can be inferred that they are likely to be the same as the calculations held by the Council at the time that can't be confirmed because, at least to this point, the Council's copy of those calculations have not been located.

JUSTICE COOPER:

Well in that case is there any reason to suppose they wouldn't be the same?

MR RENNIE:

It's, the reference BUID, BUI.MAD249.019127 does not contain stamped copies and I understand that to be the Council's copy Sir. So by definition the stamped copy must be the copy we held.

JUSTICE COOPER:

Okay.

MR RENNIE:

What I, what I'm saying about the calculations Sir, no I've got it back to front. Right I, I misunderstood what I was just told by counsel assisting Sir. It's exactly the other way round. We don't have the stamps. The set of plans that we had we provided the copy of to DBH and that's the reference that I gave to you. The point about the calculations Sir is the set that we may, that we hold may well be complete but, again, there cannot be absolute assurance that they are, neither can we say conclusively that they are what was given to the Council. So that's that element of uncertainty. Then there are some lesser points Sir. The, the building permit as it would have been in those days that was given to the builder would plainly have encompassed the plans as approved by the Council but what there may have been beyond that which is a matter which would be known to the Council and the builder doesn't presently seem to be ascertainable. And then, of course, Sir, lastly, one would have wished to have a set of as-built plans but if any such set of plans were prepared no such set has been traced. Those are the main differences.

JUSTICE COOPER:

Yes.

MR RENNIE:

But having given Your Honour that it seems to me that you would be much assisted by having a more detailed memorandum.

JUSTICE COOPER:

Yes.

MR RENNIE:

That just takes up those points.

JUSTICE COOPER:

All right. Thank you. When you can.

MR RENNIE:

Now Sir the next point. The Commission requested the building that I was referring to and I am having the name and address of that building identified and I will come back to you about that as soon as I can.

JUSTICE COOPER:

Thank you.

MR RENNIE:

Now Sir the last matter that I have to raise about Dr Reay's evidence relates to this. In his evidence Dr Reay, as I indicated in the opening this morning, gives, or will give evidence about strain hardening.

JUSTICE COOPER:

Yes.

MR RENNIE:

That is in the evidence given as a general statement. In other words it's not presented as a discussion of a particular investigation or project with which he is familiar. Underlying that evidence is some actual practical experience in respect of a particular investigation, not of course related to the CTV building but in Christchurch, which is current and incomplete and currently in relation to the parties involved, he being only an expert advisor, in contention between several parties. If the Commission or counsel wish to go beyond the general statements on strain hardening which appear in Dr Reay's evidence to discuss the underlying basis for what he expresses it would be necessary for me to seek an order to protect the confidential interests of third parties at that point Sir. I respectfully suggested it won't in fact be necessary to go that extra step but I simply wanted to signal that now so that the position is protected and if necessary I could outline to the Commission how the interests of third parties could be affected if the evidence led to the identification of that particular matter.

JUSTICE COOPER:

Yes well you, yes, you may have to do that.

MR RENNIE:

Yes. Well if -

JUSTICE COOPER:

But, but –

MR RENNIE:

If you think it's more prudent for me to do that now Sir I, I could do that either orally but I would be seeking a conference with the Commission in that regard or I could have something prepared in writing and submit it and then proceed from that basis Sir.

JUSTICE COOPER:

Yes, all right well we've got, I don't think I want you to interrupt your opening to do that.

MR RENNIE:

No Sir.

JUSTICE COOPER:

And we'll see where we get to when it comes to –

MR RENNIE:

Yes I have to emphasise Sir that what is affected in this matter is not the interests of Dr Reay or ARCL. What is affected is the third parties and the obligations that they are entitled to expect from an expert advisor.

JUSTICE COOPER:

Yes. Well, is it possible that they might waive any interests that they had –

MR RENNIE:

Not in the nature of the unresolved position between them Sir.

JUSTICE COOPER:

Yes. Have you spoken to Mr Mills about this?

MR RENNIE:

Yes Sir.

JUSTICE COOPER:

Yes, all right.

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MR MILLS:

(inaudible 14:25:03) request that I had made for the underlying documentation for the evidence that Dr Reay gives about strain hardening, that's the background for this.

JUSTICE COOPER:

So when we get to that point, when it becomes necessary for this issue to be aired and resolved we can deal with it then because that would give it –

MR RENNIE:

That is what I am suggesting Sir and it may well be possible to meet the needs of counsel assisting without the other difficulties that I am endeavouring to signal.

JUSTICE COOPER:

All right, thank you.

MR RENNIE:

Now Sir, I am back at page 10 of the opening at paragraph 23 and I am about to refer to the evidence to be given by Professor Robin Shepherd.

JUSTICE COOPER:

Yes.

MR RENNIE:

"Professor Shepherd is a consulting engineer who divides his time between Tauranga and California, USA. Professor Shepherd specialises in earthquake analyses and this is the focus of his consultancy business. Professor Shepherd has been engaged as an expert to advise on a number of issues relevant to the issues before the Commission.

Forensic engineering practice. Professor Shepherd outlines standard practice but carrying out a forensic engineering investigation into structural failures. Professor Shepherd is critical of the authors of the DBH report for failing," I would have written, "to examine properly and preserve the remains of the building for proper examination." "Evolution of seismic standards Professor Shepherd comments generally on the development of earthquake investigation practices including strong ground motion measuring instruments and the contribution to earthquake investigations. Over the years there has been an increasing recognition of the need to provide for earthquake resistant designs in design standards.

Cumulative earthquake damage. Professor Shepherd comments on the effect of successive earthquakes and aftershocks on structures. He notes that the ongoing practice of repairing cracked reinforced concrete structures by injecting epoxy resin into cracks attempts to reinstate the strength and stiffness of the building and in doing so recognises the fact of cumulative damage. Professor Shepherd expresses the view that the CTV building may well have been damaged more seriously in the September 2010 earthquake than was appreciated immediately following the event.

Seismic excitation at the CTV building site. Professor Shepherd expresses the view that a recording instrument ought to have been placed at the CTV building site promptly after the earthquake on 22 February 2011. Records obtained from the several subsequent significant aftershocks would have provided evidence regarding the unique properties of that site. In the absence of any records from the CTV building site the actual vertical acceleration experienced by the CTV building can only be a matter of conjecture but Professor Shepherd notes that it was clearly enough to apply loads significantly in excess of those typically anticipated in code requirements.

Dynamic analyses. Professor Shepherd comments on the developing use of digital computers over the last half century and their use to predict the response of structures to earthquakes. Professor Shepherd comments on the analyses conducted in the DBH report and expresses the view that the computer analyses appear to have been conducted with a view to proving a certain hypothesis rather than "investigating all collapse possibilities without prejudice". Professor Shepherd's evidence I say will be presented this week, well, will be presented in the context of collapse considerations.

Dr Brendon Bradley. Dr Bradley is a lecturer at the University of Canterbury and also has an independent seismic engineering consultancy practice. Dr Bradley will give expert evidence on two key issues: an analysis of ground motion aspect of the Canterbury earthquakes, and a statistical analysis of the concrete test data presented in the DBH report. Dr Bradley's seismic report will be presented in relation to the collapse considerations. Dr Bradley analyses the case for utilising the four strong motion stations near the CTV site (and they are listed there). Seismic analysts use readings from these and other sites to assess the likely seismicity at any given place. In the analyses carried out for the DBH the REHS site readings were disregarded. The justification for this related to the ground conditions at the REHS site. Dr Bradley disagrees and notes that the readings from the REHS site were consistently higher than the readings from the other three sites which were taken into account. Dr Bradley's opinion is that all four strong motion stations near the CTV site are appropriate for use in analyses. This conclusion feeds

into analyses being carried out by other experts and it appears to be now accepted by other experts notably Mr Sinclair. Dr Bradley also comments on the readings from the instrument deployed by ARCL at the CTV site at March 2012. Importantly Dr Bradley concludes that the general response at the CTV site is consistent with those at the other four CBD stations.

The second part of Dr Bradley's evidence will be presented later in the concrete section. Using his expertise as a statistical engineering specialist Dr Bradley has analysed the concrete column test data presented in the DBH report. Dr Bradley reviews the correlation between different types of strength tests, used statistical distribution of the results and then adopts recognised analysis methods to reach conclusions. Dr Bradley concludes that there is no credible evidence to suggest that the observed concrete strengths are lower than the specified concrete strengths in the construction contract. Dr Bradley also presents two figures which analyse the results of the strength test commissioned by ARCL. The graphs which are attachment C to Dr Bradley's statement demonstrate the higher observed distribution of concrete strengths in the tests carried out by CTL Thompson.

Professor John Mander. Professor Mander is a New Zealand citizen who is currently a professor at Texas A & M University in USA. His evidence is presented as a formal submission which he will speak to and in the academic sense defend.

JUSTICE COOPER:

Well I just have some difficulty with that classification. We spoke about this the other day. I mean it is expert evidence isn't it?

MR RENNIE:

Well it is Sir and I anticipate, assuming that this is your preferred approach, that Dr Mander will simply read it on the basis that it is equivalent to a statement of evidence.

JUSTICE COOPER:

And be cross-examined on it?

MR RENNIE:

Absolutely, there is no suggestion as I said when Your Honour first raised this with me that it is anything other than a comprehensive statement which is evidence which he is to be questioned on in the usual way.

JUSTICE COOPER:

But that sentence that you or somebody else has written there doesn't –

MR RENNIE:

I wrote that Sir.

JUSTICE COOPER:

It doesn't coincide with my understanding of what, I mean, am I old-fashioned in this respect? You either have evidence or you have submission. A submission one expects from an advocate of some sort, usually a lawyer in these contexts and evidence is what people say whether it be fact evidence or evidence of expert opinion, and the latter two categories are given on oath so I do not know why that, I just, I mean I don't suppose this is a major point but I don't understand why the language is being used.

MR RENNIE:

Well Sir in a sense, with respect, neither do I, but when –

JUSTICE COOPER:

But you are responsible for it.

MR RENNIE:

I am absolutely Sir and I'm just about to submit a confession.

JUSTICE COOPER:

Yes, all right.

MR RENNIE:

Because what I am going to say is this Sir, that if I had perceived that Dr Mander's brief of evidence, and I call it a brief of evidence, had been intituled as submission, if I had noticed that I would have deleted it.

JUSTICE COOPER:

Yes, all right.

MR RENNIE:

None of this would have been taken up. As it was raised with me earlier I wrote this sentence to try to explain why I am in the situation which I am in and it can be replaced, if you like Sir, by a sentence in which it says, "Dr Mander has now been advised by counsel that his evidence must be described as evidence and not a submission."

JUSTICE COOPER:

Yes, well we need not spend time on it, I suppose I was more disconcerted by seeing it in your submission if I may put it that way?

MR RENNIE:

I am sorry that my attempt to resolve it has compounded it Sir –

JUSTICE COOPER:

Yes, that's right.

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MR RENNIE:

It is as far as we are concerned from this moment unarguably a brief of evidence. All previous references may be disregarded, and with respect Sir, it is not you that is old-fashioned, but it may be me that is anachronistic in this

respect. At 31, Professor Mander provides a critique of the DBH report. He also analyses and discusses results of new work done since the completion of the DBH report. Finally he presents an alternative hypothesis and three scenarios for the collapse. Among the points made by Professor Mander about the DBH report are the following.

The DBH report essentially neglects the effect of the earlier pre-22 February 2010 earthquakes on the structure of the CTV building. In his opinion it is evident that the structure must have sustained hidden damage in earlier earthquakes and ought to have been red stickered.

The DBH conclusion that exceptionally high vertical ground motions helped lead to the demise of the building is supported by him as correct, but he considers the authors essentially neglect the effect of earlier earthquakes. It is contended that the exceptionally high vertical ground motions were a primary contributor to triggering the CTV building's failure and subsequent collapse. Although the columns of the building did not have substantial transverse reinforcing, this was in his opinion neither a problem nor a cause of failure within the CTV building.

Dr Bradley's analyses show there is no statistical significance in the claim but the columns had a lower concrete strength than specified. The claim in the DBH report that the concrete had low strength in the critical columns is rejected as erroneous.

The interaction of the perimeter columns with the spandrel panels on the building may have been a contributing factor in the final demise of the structure but was neither the trigger nor the cause of the collapse. Separation of the floor slabs from the north core is problematic but it should be recognised that the structure survived the design level Darfield earthquake and many aftershocks without collapse. The DBH report has overstated the impact of the asymmetry of the shear wall layout.

Professor Mander then discusses supplementary investigation work conducted on the CTV building by ARCL. He reports on Dr Bradley's findings in respect of the seismic readings, and repeats that it was inappropriate to remove the REHS recording station from the analyses and that it should

remain. Professor Mander presents the results of the strong motion device at the CTV site.

Professor Mander comments on the concrete testing results and makes recommendations as to the strength to be used for future computational analyses. Professor Mander also comments on the testing of full columns carried out under his instruction at the University of Canterbury. Professor Mander is to provide further comment on the results of this testing which will be presented later in the hearing in the concrete section.

Professor Mander presents and discusses an exemplar structure used in part of the educational process at the University of Canterbury known as the red book building. This is a conceptual building designed according to current codes in all respects. Professor Mander presents analyses which show that even the red book building could have collapsed in the 22 February earthquake. Thus he reports that even modern buildings constructed to textbook standards may not necessarily have survived the Christchurch earthquake.

Finally, Professor Mander presents an alternative collapse scenario. His hypothesis takes into account the exceptionally high vertical accelerations and their effect on the load bearing elements of the building. Professor Mander puts forward three general failure modes. A four storey double bending buckling failure starting on column 1 B leading to the east-west collapse failure mode. A northerly motion induced collapse failure mode, and thirdly a southerly motion induced collapse failure mode.

What is common to all three failure modes is that they require the same class of buckled columns over the lower four storeys. The lower four storeys were able to buckle due to the relative movement of the floors with respect to the shear wall system. In his assessment the relative movement necessary to achieve this need not have been large. Professor Mander concludes that the collapse is primarily caused by the substantial increase in axial loads on the columns due to the exceptionally high vertical acceleration.

The second statement of evidence by Professor Mander further expresses his views on the effect of the 4 September 2010 earthquake and other earthquakes on the CTV building prior to the 22 February 2011 earthquake

that resulted in its collapse. This is in the light of additional information. He develops his earlier evidence on the issue of load cycle fatigue. Professor Mander concludes that prior to the 22 February earthquake and most certainly during the course of it, the CTV building was exposed to cyclic demands considerably greater than what would be expected at the time a structure was designed in the 1980s. He considers that after the 4 September earthquake and immediate aftershocks all concerned should have been suspicious about the state of the building. In his opinion such suspicions could only be allayed by the performance of a structural analysis with reference to the building plan, seismic and other information.

The majority of Professor Mander's evidence will be presented this week with the other ARCL collapse evidence. He will also appear later in the hearing in the concrete section.

Douglas Haavik. Douglas Haavik resides in California, USA. He is a consultant engineer specialising in concrete and concrete materials. As an expert he will advise on concrete issues and will appear in person in week 7 of the hearing. Mr Haavik is critical of aspects of the DBH report concrete testing. He quotes and supports sections of the report by Mr James McKechnie who has also been critical of aspects of the DBH concrete testing. Criticisms of the DBH testing include: a) poor test sample selection including small core diameter samples and horizontal sampling, b) poor recording of core strength testing, c) tenuous correlations being made between core strength tests and Schmidt Hammer strength tests, strength results, and d) no microscopic examination of core sections.

Mr Haavik engaged the services of other experts to assist with aspects of the concrete analysis and reports on the outcome of this were carried out by him with those inputs. The cores were sampled under Mr Haavik's instruction by ARCL employees in March 2012. Core samples were dispatched to the USA and a series of tests were carried out. The cores were tested by Olsen Engineering using an ultrasonic pulse velocity instrument to determine pulse velocity over the length and diameter of each core tested. The results were typical of concrete continued to be of sound condition.

At CTL Thompson, (inaudible 14:42:38) carried out compressive strength tests. The results indicate that all cores tested were above the 25 MPA specified strength requirement for columns at level 3 and above. The results were consistently higher than the DBH results.

The petrographic examination was conducted by Dr Rothstein at DRP Consulting. Petrography involves assessment of thin sections from concrete cores examined under very powerful microscopes. The eight cores examined were relatively uniform and the cement and aggregates were similar. A close analysis of the samples showed that the contractor performed the proper job of handling and placing the concrete. Minimal micro-cracking was observed. There was no evidence of fire damage in the samples tested. Mr Haavik concludes that a wider scale testing should be conducted but the results of the tests and examinations carried out show that there is no reason to believe that there was a systematic reduction in concrete strength supplied to the project.

Arthur Tyndall. The Commission's already heard the evidence of Arthur Tyndall who's a semiretired structural engineer aged 78. He is appropriately qualified and experienced and he reported in his evidence the he inspected the CTV building for earthquake damage following an Arthur's Pass earthquake of magnitude 6.7 in June 1994. He reported some cracking in the blockwork in the entry foyer, suggesting that the building had experienced some twisting in the earthquake. However he could find no other evidence that the building had twisted. Mr Tyndall noted that he looked at the western block wall and was impressed with the design engineers efforts to reduce the stiffness in that wall, and he also noticed the detailing and workmanship of the western wall was of a high quality. Overall he concluded that the building had not been damaged in such a way that materially changed its structural integrity.

Alan Edge. Mr Edge is a director of Southern Demolition & Salvage Ltd. His evidence has also been heard already. He attended the CTV building site

approximately two hours after the earthquake on 22 February 2011 with staff and equipment to assist with the recovery operation.

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The purpose of Mr Edge's evidence was to provide eyewitness evidence of the timing and location of the fire which broke out on the site, covering around one-third of the building footprint and lasting for a number of days. It was fought with water, including by monsoon bucket. The impact of fire and water may affect the quality of the concrete that was sampled from the site.

Daniel Morris. Mr Morris's evidence was presented last week. He had previously owned a concrete cutting business. In the mid to late 1990s his company was engaged to drill a number of holes in concrete beams in the CTV building for the purpose of installing cabling and air-conditioning. The holes ranged in size from 40 to 100mm and sometimes his staff would hit reinforcing but were told by the head contractor to keep drilling. He states that the drilling was extensive and the holes were all over the place on all floors and he estimated that employees of his company drilled between 100 and 200 holes. He was unable to be specific about timing or number and has no records to corroborate his recollection. Events occurred years ago and Mr Morris sold his business a short time after. He volunteered his evidence initially to DBH because he thought it might be relevant to the Commission's enquiry. Its relevance is as much to the absence of building owner intervention and prior engineering review of such work as it is to any impact on the CTV structure.

Douglas Latham. Mr Latham is a structural engineer at ARCL. Mr Latham's evidence relates to the core sampling of columns carried out at the Burwood landfill and despatching the samples to the USA. This evidence is chain of custody evidence and it is proposed it may be taken as read without Mr Latham having to appear and that has been discussed with counsel assisting. Mr Latham is also part of an expert panel reviewing the ERSA analyses carried out by the DBH. It's possible that further evidence will come out of this when that work is complete. If so, it is proposed that this will be

presented in a later stage of the hearing, probably in the Code Compliance section.

Paul Smith is a senior draftsman employed by ARCL. He first started working for ARCL in November 1987 and is now director and shareholder. There has been other evidence presented on the working environment at ARCL in the late 1980s. Mr Smith provides his experience. He states that Dr Reay was primarily involved in client contact, seeking projects and managing those relationships. Dr Reay's involvement in projects was when a particular issue arose requiring his expertise. In general the structural design for a project was assigned to a qualified structural engineer who carried out the project and supervised drafting staff assigned to it.

Chris Urmson – Mr Urmson is another structural engineer at ARCL. His evidence covers a collection of column samples from Burwood landfill and delivery to Canterbury University for testing. Mr Urmson's evidence is also chain of custody evidence and it is proposed may be taken as read.

Your Honour and Commissioners, the Commission's work is likely to result in the best possible understanding of the causes of the building's collapse and to contribute to ensuring that New Zealand is in the future safer in all its buildings. Dr Reay and ARCL are committed to this process. The evidence we will call should not be assessed on whether it is favourable to ARCL and Dr Reay. Our single aim is to put forward such matters as will, taken with the other evidence, ensure that all facts and all issues are before the Royal Commission.

JUSTICE COOPER:

Thank you.

MR RENNIE ADDRESSES THE COMMISSION:

I am just conferring Sir with Mr Palmer on what could be described as an interlocking matter. It had been my intention to call Dr Reay at this point. That may, however, create the difficulty that I have already referred to in general terms. I can call Dr Reay. We have his brief in relation to the matters he is now to deal with. That can be done. I also have available Dr Bradley who would be a brief witness and I have available Dr Shepherd. I call Dr Reay. That may or may not occupy the afternoon. It may involve the application referred to. I seek guidance from the Commission as to what would best suit the Commission's approach to this matter.

JUSTICE COOPER:

Yes, we prefer you to proceed and call Dr Reay.

MR RENNIE CALLS

ALAN REAY (SWORN)

MR RENNIE ADDRESSES THE COMMISSION:

As I indicated to Your Honour, Commissioners, we have produced an extracted set of what Dr Reay is to read today and the Commission staff have not only uploaded it but given it document page references so what you've now been given –

JUSTICE COOPER:

We had it at lunchtime. We have now been given a second copy.

MR RENNIE:

That is what I am explaining Sir. The only difference is top right are the record reference numbers for those pages. On each page, top right is –

JUSTICE COOPER:

We have got that too. WIT.READ.0004.1

MR RENNIE:

Well then Sir I apologise that you have ended up with a second set. For the rest of us the novelty is having a copy with the numbers on it. You may all discard one of the two sets, the one you've just been given.

EXAMINATION: MR RENNIE

Q. Now Dr Reay, your full name is Alan Michael Reay and you reside in Christchurch and you're a Chartered Professional Engineer and you are a Company Director?

A. Yes.

Q. Now you have in front of you the edited statement of your evidence. Can you read from the second sentence of paragraph 1 which is a statement that you wish to make and which you have asked be inserted in this summary.

A. "I have asked to be heard because I feel people deserve to know all the aspects of why the building failed."

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Q. And now keep reading.

"Primarily this statement of evidence deals with factual matters. I will file the supplementary statement of evidence dealing with issues on which an expert opinion is required. Insofar as this evidence can be considered expert evidence in accordance with the requirements of Rule 9.43 of the High Court Rules I confirm that I have read the Code of Conduct for Expert Witnesses and that my evidence complies with the Code's requirements. Matters on which I express an opinion are within my field of expertise. I am a director of Alan Reay Consultants Limited, ARCL, an affected party in the Royal Commission hearing.

Qualifications and experience – I hold a Bachelor of Engineering Degree with First Class Honours in 1965 from the University of Canterbury and a PhD in Civil Engineering 1970, University of Canterbury also. My PhD thesis was on the dynamic characteristics of civil engineering structures. I am currently a Fellow of the Institution of Professional Engineers and hold the following memberships – The New Zealand Concrete Society,

the New Zealand Society for Earthquake Engineering, The American Concrete Institute, the Heavy Engineering Research Association of New Zealand, the Association of Consulting Engineers New Zealand and the Tilt-Up Concrete Association of the USA.

After completing my qualifications I commenced work as a structural engineer with Hardie and Anderson. Around two years later I began business on my own account in 1971 as Alan M Reay Consulting Engineer, ARCE. ARCL was incorporated in 1988. I have practised under this corporate structure ever since. I have also lectured in steel structures at the University of Canterbury in the early 1970s. My full resumé is annexed to this statement.

Referring to the Department of Building and Housing, DBH reports. In early May 2011 I met with Clark Hyland and Ashley Smith following Dr Hyland's request to meet so that he could advise us of the information that he considered would be helpful to their investigation of the collapse of the CTV building. He advised that he was being employed by the DBH. He also advised that there had been an expert panel appointed to provide review and advice regarding the report he would present which he indicated was to be provided by July 2011. I received further requests from Dr Hyland for information which I responded to. Further information was sought by Dr Hyland in August and I telephoned him for clarification. Dr Hyland advised then, or in another conversation around the same time, that he could not say what was in his report but suggested that there were serious construction deficiencies. I took from this that he had not found any design deficiencies. When I provided further information to Dr Hyland in response to his requests I was surprised by his reply which was to thank me for the information as he had overlooked it.

The draft DBH report into the collapse of the CTV building was finally received by ARCL on the 8th of December 2011. ARCL as an affected party was given until the 22nd of December 2011 to make comment.

ARCL provided a detailed response on the 22nd of December 2011. ARCL requested and the DBH agreed to provide a copy of the final report to ARCL 24 hours prior to the release to the media on the 9th of February 2012. On the 3rd of February 2012 Dr Hopkins advised me by email that the materials in the testing section of the report was unchanged from the draft so that report would not be included in the early release. ARCL received the final report ahead of public release as promised with a covering letter addressed to another affected party. In the event, although the email from Dr Hopkins was dated after the date of the final materials and testing report, that report was in fact substantially changed when finally issued.

ARCL wrote to the DBH regarding the above issues and others on the 24th of February 2012 and received an apology from the DBH on the 5th of March 2012. I remain dissatisfied about many aspects of the final DBH reports. I will address my concerns in my supplementary statement."

Q. Now Dr Reay the first couple of paragraphs on page 4 essentially repeat what you've just read and so would you read from paragraph 20 please.

A. I'll refer to the non-linear time history analysis which is part of the DBH report. "The cumulative damage and fatigue effects on the structural elements should be included in the modelling and have been insufficiently accounted for in the analyses run as part of the DBH report. Related to this point is the effect of each aftershock on the deterioration of the CTV building and its progressively increasing fragility to further large earthquake events, also discussed further below. To date there have been no experimental studies to corroborate the computational results. Strictly there should be shaking table, reduced scale physical model experiments on a 6 degree of freedom shake table to investigate the overall behaviour and to recreate the structural failure. Instruments can be used to assess the effects of lateral torsional coupling, wall frame interaction and vertical motion effects. From these results it is inevitable that the underlying assumptions in the computation models will lead to some modifications in order to more

accurately capture overall effects. It is conceded that to do this facilities would either have to be developed in New Zealand or else the study would need to be done abroad in either the United States or Japan. A dual shaking table computational modelling study will no doubt highlight several key components and sub-assemblages that were instrumental in triggering the collapse. In order to gain additional confidence in the results and to remove the uncertainties in the modelling process, further full scale experimentation of these key components should be tested under simulated earthquake loads and displacements. It is likely this would include beam column joint tests, vertical floor slab dynamic behaviour, column buckling tests over several storeys and the like. Again, following the results of such an experimental testing investigation the computational models should be enhanced to properly capture observed behaviour and then the entire NLTHA re-run for all known earthquakes in the vicinity of the CTV building to gauge the effects of cumulative damage. Only in this way can the true reasons for the CTV building collapse be known. Completing these analysis will take considerably longer than the time that was available to the authors of the DBH report but in my view in the absence of these analyses the modelling to date is inadequate and the Royal Commission does not have access to the best available information to assist with understanding the causes of the collapse.

Referring to the "Concrete." The DBH report refers to concrete strengths at the time of construction being in the range of 16 MPa and 43.8 MPa. The DBH report recommended that an average 20 MPa increased from 17.5 MPa in the draft DBH report, 28 days strength, would be appropriate for utilisation and further analyses of the CTV building as compared to the 35, 30 and 25 MPa strengths for the columns specified in the original design documents. It was my opinion that the probability of concrete strengths as low as this was negligible unless the contractor deliberately set out to order substantially under-strength concrete and mishandled the concrete workmanship on site.

Alternatively, the low strength results may have been taken from columns which were affected by the fire that broke out at the site. ARCL raised this issue in its comments to the draft DBH report but this possibility remains inadequately accounted for. The ARC report for the DBH on the 22nd of December 2011 in response to the draft DBH report recommended further testing for the DBH but this was not undertaken. I now have been advised that the samples which the draft DBH report stated were kept for further testing were not in fact kept. The final DBH report did not contain the reference to the samples being retained.

Following the release of the final DBH Report which indicates that no further testing had been undertaken by the DBH, ARCL obtained approval to extract samples for further testing and the results are presented in the evidence of Douglas Haavik. The DBH testing was limited in scope and did not comply with testing codes of practice, as detailed in others' evidence. The testing undertaken by ARCL was fully compliant and demonstrated that based on the testing of samples of the columns remaining, the concrete complied with the standards of manufacture and workmanship of the time. I refer to the evidence of Douglas Haavik.

Q.

I refer to the geotechnical report. The geotechnical report utilised in the DBH report was provided by Tonkin & Taylor. There appears to have been no advice sought from the geotechnical engineer who prepared the original site report in 1986, in particular with respect to the likely soil stiffness properties that would have been recommended at the time of the design. I have sought this advice from the author of the original Soils & Foundations 1973 Limited report, Ian McCahon and it is now produced. Tonkin & Taylor has provided recommendations with regard to interpretation of results of the 22nd of February earthquake from various seismic recording devices. ARCL did not agree in general with the basis of the recommendations regarding probable seismic activity at the CTV site for the February earthquake. An expert report on seismic predictions has been provided to the Commission by Dr Brendan

Bradley. Dr Bradley's evidence includes reference to seismic recording results from the CTV site which were obtained from equipment installed on the site by ARCL. The decision by ARCL to procure and install this equipment was made based on a recommendation from Mr William Holmes, now an expert reporting to the Commission, that it was essential to record aftershocks at the specific CTV site for future analysis. I refer to Dr Bradley's evidence.

Spandrels Tolerance. The DBH Report refers to construction tolerances being utilised to enable the installation of spandrel panels with either limited or no gap between the end of the panel and the concrete column. In ARCL's report to the DBH on the draft DBH report, we stated that we did not consider that the construction would have been completed in this manner and that the specific gap would have been maintained. Our comment was not reflected in the final DBH report and this remains a concern. I produce photographs of a building at 58 Kilmore Street, constructed by Williams Construction Canterbury Limited ("Williams") where there is good alignment of spandrel panels. The photos illustrate the high standard of construction achieved by Williams on this project which includes the precast and in situ concrete. The concrete columns of the Kilmore Street building were tested by ARCL with a Schmidt hammer and the indicative concrete strengths were between 34.5 MPa and 41.4 MPa.

Destruction of Evidence. I have referred above to the destruction of the samples which were to be retained for further testing. Destruction of evidence also occurred when the remaining structures on site, following completion of the onsite investigation for the DBH Report, were demolished and taken to the Burwood site. ARCL has established the general location where this material is at the Burwood site. I have particularly noted that no attempt appears to have been made to retain the sections of the remaining shear wall and floor elements that were intact after the collapse. Those elements might have been saw cut and

transported to the Burwood site. Instead the shear wall and floor were demolished into small pieces for transportation off site and now most of the building is not specifically identifiable.

Change of Use. The CTV Building was designed as an office building with a live load of 2.5 KPa, with a seismic design live load of 0.83KPa and for a risk factor for buildings with normal occupancy of 1.0. In 2001 a change of use application was made to the Council for a school to occupy level 2 of the building. The live load requirement for a school under the relevant 1992 loading code was 3.0 KPa with a reduced seismic design load of 1.8 KPa. The seismic risk factor for the structure, based on category 2, which includes school classroom buildings, was 1.2. The change of use, together with the basic increase in the design lateral load coefficient for the building, resulted in a substantial change to the seismic and gravity loads for the building. It does not appear that there was the expected engineering review and reporting associated with the 2001 change of use. The drawings indicate a possible occupancy of over 150 on the floor level although it appears that actual occupancy of 126 was anticipated.

Collapse considerations. There are at least five scenarios which have not been, in my opinion, adequately considered in relation to potential collapse scenarios for the building.

The first is reinforcing strain hardening. The effect of strain hardening on the reinforcing steel has not been considered in the DBH Report. The issue arises from the impact of the 4th of September 2010 earthquake, the 22nd of February 2011 earthquake and possibly the intervening aftershocks. This significant structural issue was first noted at a seminar at the Art Gallery on Friday the 1st of April 2011 where comment was made that this issue would probably result in damaged reinforced concrete structures being significantly affected in terms of future seismic performance. ARCL has subsequently found in several shear wall buildings in particular that the reinforcing steel has been

subject to strain hardening, with the strain hardening being limited to a very short length of the reinforcing steel frequently in the order of 1 to 2 bar diameters. This is a significant reduction in the elongation necessary for the required performance of reinforced concrete to achieve code level assumptions. The degree of strain hardening varies but loss of capacity is of the order in some instances of over 40 to 50%. I particularly refer to the impact of the strain hardening in the shear walls and floor diaphragms of the IRD building, which is the building on the other side of Cashel Street from the CTV building, where the strain hardening has resulted in the building having an assessed strength of between 30 and 40% of NBS, new building standard. This building, if undamaged, would have a design code level strength of 100% of NBS, which is the current code. I note that the IRD building complies with the strength requirements of the latest building code. It also complies with the requirements to use ductile reinforcing in the floor diaphragms. This has not prevented significant strain hardening damage to the floor diaphragm reinforcing. These issues are unlikely now to be able to be investigated for the CTV building due to the level of destruction of the original building structure. The potential significant impact of this strain hardening on the CTV building, where floor diaphragms may have been subject to reinforcing fracture and the shear walls could have been subject to a similar effect, could have potentially caused a materially different response of this structure to earthquake loading than that predicted by the analysis.

Vertical Acceleration. The vertical acceleration has been considered in the Tonkin & Taylor geotechnical report. It is probable that the vertical accelerations were very high particularly at this site, based on eye witness reports.

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The effect of the high vertical accelerations is to result in significantly increased gravity loading on structural elements such as beams supporting the floor slabs. I refer further to the evidence of John Mander and Brendan Bradley. In my view the effects of high

vertical accelerations have not been adequately accounted for in the collapse analysis to date.

The south wall lateral load resistance. The lateral load resistance of the southern wall is dependent on the gravity restoring force provided by the gravity loading of the floor. The effect of the vertical accelerations is to potentially increase or decrease this force. Should this force be substantially diminished, as could occur, at the same time as there is a significant seismic lateral load on the wall, then the wall would tend to commence overturning and allow a significant rotation to occur in the south side of the building. This issue does not appear to have been considered by other experts but, in my opinion, collapse initiated in this manner is a highly feasible scenario.

Building modifications. My concerns in this respect relate to two issues – beam damage, and an internal staircase. Evidence of drilling carried out on the concrete beams during the 1990s has been produced. It appears that extensive drilling was carried out, including through beam reinforcing. The effect of 200mm, and I wish to change that to 100mm, diameter holes near the column supports would be to cut through beam reinforcing and concrete which, together with the seismic vertical accelerations, could have resulted in beam shear failure. Holes which cut the bottom beam reinforcing in the central region of the beam could have significantly reduced the load capacities of the beam which could then have collapsed under the high vertical accelerations. I was very concerned to hear about this practice, particularly the fact that the contractors were told to drill through the reinforcing bars. In an earthquake with high vertical acceleration, such as the 22 February 2011 aftershock, the integrity of elements such as the beams becomes critical. If the main reinforcing fails, it could cause a catastrophic failure of the building such as occurred on 22nd February 2011. In my opinion the possibility that the holes drilled in the concrete beams could have contributed to the collapse of the CTV building ought to have been given considerable attention by the DBH and I am surprised that it appears to have been disregarded

without investigation. I cannot rule out the possibility that the damage caused to the beams as a result of these holes contributed to or even caused the collapse.

I have noted from evidence presented by staff members of CTV and Council files that an internal stairwell was added between levels 1 and 2 of the CTV building in 2000. A Building Consent Application for these works and an associated fit-out was made in April 2000 and a final Code Compliance Certificate was issued on the 11th of December 2000. I have reviewed the Council file in relation to this Building Consent. I note that David Falloon of Falloon and Wilson Limited was engaged as a structural engineer and Mr Falloon provided Producer Statements for the Design and for Construction Review. Mr Falloon's Design Producer Statement is dated 26th of April 2000. I note from correspondence on the Council file that this appears to predate preparation of the structural drawings. No structural drawings are referenced on the Producer Statement for Design as would usually be expected. The structural drawings dated May 2000 are on the Council file but there is no structural assessment report. In the absence of the expected seismic structural review, I am unable to assess the engineer's opinion as to the impact of the installation on the CTV building. The DBH Report makes passing reference to the installation of the internal staircase. In my view, the authors ought to have assessed this issue further. According to the drawings, the staircase was installed by cutting through floors and I would be concerned about the potential effects of these works on the overall structure.

Referring to the cumulative damage resulting from aftershocks – I have carried out numerous post-aftershock building inspections across Christchurch to assess for further damage to support occupancy or insurance assessments. I have noted on buildings such as the IRD building that the crack widths in structural elements such as shear walls have increased following ongoing aftershocks. The inspections have generally been carried out after the aftershocks of greater than 5.0

magnitude. I have observed that cracks that were originally limited in extent and crack width have over time increased gradually in length, number of cracks and crack widths. This change has occurred progressively as the aftershocks have occurred. A similar effect has been noted on the beam column joints and it has also been noted at times that debris falls from the joint following the aftershocks. I produce a schedule listing all major aftershocks (magnitude 4.9 or above) between the first earthquake at 4.35am on the 4th of September and the earthquake at 12.51 on the 22nd of February 2011. In my opinion, the ongoing sequence of aftershocks continues to cause cumulative damage to concrete reinforced buildings, each time reducing the capacity of the building to some extent. I believe that by the time of the 22nd of February earthquake the CTV building had lost part of its capacity as a result of not only the 4th of September 2010 earthquake but all of these large ongoing aftershocks.

Q. Now Dr Reay, just to put the next three paragraphs in context, can you explain who Timothy Sinclair is?

A. Timothy Sinclair is the geotechnical engineer from Tonkin & Taylor who prepared the report, geotechnical report.

Q. And in these three paragraphs that you are about to read you are responding to what he says in that technical report?

A. That's correct.

Q. Could you now read them please.

A. In his initial report Mr Sinclair recommended that the REHS site should be disregard for the purposes of analysing the CTV site response. In his latest report Mr Sinclair now accepts that the REHS site is suitable for inclusion for the assessment of the CTV building. The ground accelerations recorded and the calculated Acceleration Response Spectra at the REHS site are different to those used in the DBH report on Collapse Scenario Evaluation. The collapse assessment of the CTV building should now be reconsidered on the basis of these ground motion records.

Q. Thank you Dr Reay.

CROSS-EXAMINATION: MR ALLEN – NIL

CROSS-EXAMINATION: MR REID

Q. Dr Reay, as you probably know, I'm counsel for the Christchurch City Council. I have a couple of questions for you only and they relate to paragraphs 65 and 66 of your brief of evidence. This is where you're talking about the cut-out for the stairs.

WITNESS REFERRED TO DOCUMENT BUI.MAD249.0009.103

1525

Q. Now this is the producer statement that I understand you're referring to at paragraph 66 by Mr Falloon, is that correct?

A. Excuse me, what paragraph are you referring to?

Q. In your brief of evidence.

A. Yes.

Q. So this is paragraph 66.

A. Right. I believe that is the one.

Q. Yes, thank you and just – the concern that you're expressing in paragraph 66, just to summarise it, is that to do with the fact that the, there's no reference to the drawings, the number, the number of the drawings in the producer statement?

A. Yes there's no reference to any drawings at all.

Q. Yes so on the face of it your concern was that the producer statement doesn't appear to cover any particular drawings. Is that correct?

A. That's correct.

Q. So can I just ask you please to be shown document BUI.MAD249.0009.95. Now this is a letter from Falloon & Wilson. It's dated the 4th of May and it's to the Christchurch City Council, Attention Peter Harrow from David Falloon. Do you see that?

A. Yes.

Q. Yes and Peter Harrow, just so that we're clear, he's an engineer with the Christchurch City Council. Is that correct?

A. Yes.

Q. Yes and you can see from the letter that it makes reference to three copies of drawings that are now being provided. Is that correct?

A. Yes.

Q. And it says that, doesn't it, that the drawings that have been provided are intended to be covered by the producer statement that's previously been forwarded.

A. Yes.

Q. That's a summary of the letter isn't it?

A. That's correct.

Q. Yes and just go, just note for the Court's records, the Commission's records, the drawing reference is 2774/S1. That's in the body of the letter. Do you see that?

A. Yes.

Q. And if the witness could please be shown BUI.MAD249.0151.B2. So that's an engineering drawing by Falloon & Wilson Limited and just if you could refer to the reference at the bottom right-hand corner of the document, 2774, drawing S1, that's the reference isn't it?

A. Yes.

Q. So am I correct in summarising these documents Dr Reay that it appears that Wilson & Falloon have provided by their letter of 4 May a copy of the drawing 4774S1 and confirmed that that drawing is intended to be covered by their previous producer statement?

A. Yes that's correct.

Q. Yes, thank you.

HEARING ADJOURNS: 3.29 PM

HEARING RESUMES: 3.46 PM

CROSS-EXAMINATION: MR MILLS

Q. Dr Reay, I'd just like to ask you first for your view on the CTV building. Is it your view that it is a structurally well designed building that simply

happened to be brought down by an earthquake that was well beyond its design capacity? Is that in summary what your view is of this?

A. (inaudible 15:47:10)

JUSTICE COOPER – MICROPHONE PROBLEMS

JUSTICE COOPER TO WITNESS:

Would you like to start your answer again please?

CROSS-EXAMINATION CONTINUES: MR MILLS

A. The final comment you made was correct.

Q. Yes.

A. In terms of the building, the building was I believe a building designed typical of the time. There have been some issues raised here which I am uncertain as to whether they will eventually show to have an impact on the design or not so I'm not really at this point able to answer the, to comment on the first statement that you've made.

Q. So you're reserving judgment on whether it's a well designed building?

A. I am.

Q. Yes. And when it went out from your firm for permitting and then for construction in 1986, did you regard it as a structurally well-designed building at that point?

A. I personally didn't regard it in that manner because I never reviewed it. My understanding was that it was a building that was designed to comply with the code.

Q. So you're telling me, are you, that you never formed a view at the time that your firm put this out for permitting and for construction on whether or not it was an adequately designed building?

A. No, that's not correct. I had formed a view that it would comply based on the work being done by, done correctly by Mr Harding.

Q. And is that simply based on the fact that you had confidence in Mr Harding?

A. I certainly had confidence in Mr Harding.

Q. Was the view that you expressed though was it based solely on the fact that you had confidence in him?

A. Not solely, I was aware of the type of building it was. I was aware that the work was being undertaken, that it was being drawn by competent draughtsman, for example, who had experience in that sort of work. There was nothing that I recall that alerted me to there being any issue that would have suggested that the building was not being competently handled.

Q. And knowing what you know now at least it's come out in the course of the investigations into the building including the one we're involved in now, if you had have been aware of those issues back then would you have been concerned at the time?

A. Yes some of those issues would have concerned me, certainly.

Q. Which are the ones that would have concerned you?

A. The one particularly relating the connection of the floors to the shear walls.

Q. What about the question of code compliance? Is it your view that the building as designed and permitted complied with code?

A. I don't know what the building – I don't know what the actual building design was in as far as was put to the Council and issued by the Council because I don't, I haven't seen the records that definitively define what that is.

Q. Have you looked at the Council drawings that have the permit stamp on them?

A. Yes, I have.

Q. Have you studied those drawings?

A. Not in depth but I have looked at them, yes.

Q. Well based on your look at them is it your view that those drawings reveal a code of compliance structure?

A. I haven't reviewed them from that point of view. I've looked at them from the point of view of looking at them relative to, for example, the connection from the floor to the walls.

Q. Yes.

A. And I've looked at them from the point of view of the columns but I haven't investigated them in depth from the point of view of code compliance.

Q. I think you're aware that, and we'll come to this in more detail at a later hearing, but just in relation to the question I've put to you, I think you're aware that Mr Banks who was employed by you at the time in 1990/91 wasn't he? This is the time at which the drag bar issue emerged? He was employed by Alan Reay Consulting Engineers or is it I guess by then it was Alan Reay Consultants Limited wasn't it?

A. He was employed by ARCL.

Q. Yes, and you're aware that he has advised the Commission, and it'll be in his evidence as well, that in his view at least in 1991 the building was not code compliant in respect of the connections between the north core and the floor diaphragms?

A. I wasn't aware that he had said that but I'd accept that.

Q. Do you agree with that view?

A. I haven't actually done the analysis to either agree or disagree.

Q. I see. And you've heard the evidence that's been given by a number of witnesses about the non-compliance of various elements of the building particularly the columns and the beam joints? Have you formed a view on whether that's right or wrong?

A. I consider that the columns comply in terms of not to requiring to be detailed for full ductility. In terms of the beam column joints sorry I'm uncertain as to whether they comply or not.

Q. Do I take it from your answer, with reference to full ductility, that you accept that it required partial ductility?

A. No, I believe they could be elastic.

Q. I see. All right, now this issue's been raised before but I'd like to get your comment on it. Do you agree with Dr Mander's evidence that he will give that this was an innovative building?

A. I frankly don't know.

1556

Q. You don't have any view on that at all?

A. No.

Q. Do you think it was a cutting edge building?

A. No, I, I would tend to rely on the comment in the Holmes report that described it as a fairly standard building.

Q. Would you accept the description of it as a design build cheap developer building?

A. It's certainly a design build developer building. I wouldn't necessarily describe it as cheap.

Q. Now these five scenarios that you've referred to in your evidence, and it's in the second of your two statements, and you might, I don't know whether you need to refresh your memory on any of this. You've just read it out so presumably not, but you know you've set out five scenarios –

A. Yes.

Q. – that you think might explain what's happened here. Is it your view that before the Royal Commission is able to reach any conclusion on the causes of the collapse, that it has to closely examine each of those five scenarios?

A. My view is that the DBH should've examined them in more depth than they did. It depends on what the outcome of that examination is as to whether they, the Royal Commission needs to examine them.

Q. Well that sounds to me like a circular argument, or a circular proposition. Now just get clear, are you saying in your evidence now that until the Royal Commission has examined and run to a conclusion each of those five scenarios, that it is not in a position to reach a conclusion on the causes of collapse?

A. It is my view that those five elements should be considered further. But it's not up to me to say what the Commission should do.

Q. No, and I'm not asking you that, I'm asking you what your view is in putting forward those five scenarios in your evidence?

A. Well my view is they should be considered.

Q. But you, I take it, don't regard them as matters that have to be run to ground and run to a conclusion before the Royal Commission is properly able to reach conclusions on the causes of the collapse?

A. It depends on what weight you actually put on each of them and that weighting is not necessarily for me to determine and I just, I have simply said that I think that those matters should've received more attention from, from the DBH and yes by inference that means that the Royal Commission is entitled to have more information on them.

Q. How much weight do you put on them?

A. One of the difficulties is that they're not investigated fully at this time, and until you do you don't really know what impact they could have. They could have none or they could have a lot.

Q. And how extensive have your own investigations been into those five issues?

A. I haven't investigated them in depth in relation to the CTV building. Some of them I can't and I guess if we took the strain hardening there's no point in suggesting that that is something that the Royal Commission would consider in relation to that specific building, other than the general effects which we have noted, we have found in other buildings.

Q. Yes, so I take it, I was going to ask you about that specifically. I take it then for all practical purposes we can put a line through the strain hardening as an issue that the Royal Commission needs to consider?

A. I think that you can take from other buildings the effects that it's caused and then look at whether that would impact on the CTV building for example.

Q. But we're no longer in a position, are we, to look at the steel in the CTV building after it's gone through 22 February in particular, that would give any meaningful comparisons at all?

A. It certainly can't be absolute but one could say that perhaps the shear walls in the CTV building were affected by strain hardening in the steel. It is a possibility.

Q. So do I take it really that what is being put forward here in these five scenarios is just a series of possibilities that have occurred to you as no more than that, possibilities?

A. Based on my experience.

Q. Yes. And am I right that they all have in common the fact that none of them attribute any responsibility to you or your firm for the collapse of the building?

A. I have not considered that.

Q. It's a fact though isn't it?

A. Because I haven't considered it I cannot answer it.

Q. Now on this issue of needing to run these scenarios to ground, and you may have pulled back from where I thought you were from the statements in your evidence, Dr Mander, presumably you know what's in his statements of evidence do you?

A. I haven't read it, no.

Q. You haven't read either of them?

A. I haven't read them no.

Q. Are you aware of the alternative collapse scenarios he's put up?

A. I've heard them described today.

Q. You think that the Royal Commission would be likely to get a better understanding of the issues involved in the building collapse by pursuing issues that did lend themselves to a more real understanding than issues such as strain hardening?

A. I consider strain hardening an important issue.

Q. But one which I think you agree it's impossible now to get any hard evidence about strain hardening in the CTV building because of the February events, if not because of other reasons?

A. It is certainly impossible to get physical evidence.

Q. Would you agree with me that conclusions can be reached by the Royal Commission, I'm going to give you five points to which this will apply, the conclusions can properly be reached on each of these issues without the need for any of your five scenarios to be run to ground, just to describe them that way, and I'm going to give them to you and ask

you yes or no in relation to each of them. The first one is whether the CTV building as designed complied with best practice standards of the day? Can that be decided without the need to run to ground any of those five scenarios?

A. I don't know what the definition of best practice is.

Q. Is it possible to determine issues of code compliance without running to ground any of those five scenarios?

A. It depends on when we're defining the time in relation to code compliance.

1606

Q. At the time at which it was permitted.

A. Some of those five items include when there's a hole cut in the floor in 2000 which was after it was permitted.

Q. Yes I'm asking you at the time of permitting, is it possible to determine issues of code compliance without running to ground any of those five scenarios?

A. I don't believe it is because there isn't the defined documentation to make that assessment.

Q. I see. So that would lead you to say would it that it's never possible to determine any issues of code compliance because of uncertainty over documentation. Is that your position?

A. It's certainly my position when the documentation appears to be incomplete.

Q. I see. All right. Well we'll see where we get to on the memorandum that we're going to receive on the divergence in that. How about the sufficiency of the experience of David Harding to design this building. Can that be determined without running to ground any of those five scenarios?

A. I'll have to refer back to the scenarios.

Q. Please do. Please do.

A. So, just so I'm clear you're referring to the collapse considerations?

Q. Yes, the five scenarios that you have under that.

A. Reinforcing strain hardening wouldn't apply –

Q. No.

A. – to the consent, the permit I'm sorry. The vertical acceleration doesn't apply and thus the south wall load, lateral load resistance wouldn't apply in that circumstance and nor would the building modifications.

Q. Yes. So we're agreed that issue can be determined without the need to run to ground any of those five scenarios?

A. Certainly.

Q. And that, excuse me I'm blaming your senior counsel, he says he feels better, I feel worse. The, and similarly the adequacy of any supervision that your firm should have given to Mr Harding. That doesn't depend upon any of those five scenarios.

A. No.

Q. And it'll also be true won't it that whether the collapse was triggered by vertical accelerations or by extreme lateral forces that won't change any of these issues of best practice, code compliance, designer experience or supervision. It won't have any bearing on any of those issues will it? If it's brought down by high vertical accelerations or by very high lateral forces. They don't have any relevance to answering the questions I've been putting to you.

A. So going through –

Q. Yes.

A. – them individually.

Q. Yes.

A. Could you do that please?

Q. All right. So the question is whether vertical accelerations and/or extreme lateral forces have any bearing on these issues. First of all, best practice of the day, best practice standard.

A. No bearing on that.

Q. Code compliance.

A. No bearing on that.

Q. The sufficiency of the designer's experience.

A. No bearing on that.

Q. The adequacy of supervision.

A. What are you referring to?

Q. I'm referring to an issue that will need to be explored later around whether David Harding had an adequate level of supervision by your firm of the work he was doing.

A. No, no it won't affect that.

Q. Now just going back to your five scenarios that you've just been going through. Have you set those out in any order of priority in your own, in terms of what you think the order of priority is or are they just random?

A. There's no order of priority.

Q. All right. Okay. When did you first come up with this list of these five possibilities that might have led to the collapse of the building?

A. I didn't do it at one time.

Q. Yes.

A. It was a progressive piece of work.

Q. Yes.

A. I couldn't say exactly when it was.

Q. Do you recall whether it was soon after the February collapse?

A. No, certainly not because, for example, the strain hardening issue is, really only came to the fore perhaps last November/December.

Q. Yes.

A. In terms, in terms of actual work being done to investigate buildings.

Q. Yes.

A. So it would have been, that would have been, it would have been after that.

Q. And when did you first raise these five points, if you did, with the Department of Building and Housing?

A. I haven't raised, the vertical acceleration was raised with them in our December report to them.

Q. So raised for the first time after they had sent you the draft report. Is that right?

A. None of these matters were raised with them until we got the draft report.

Q. I see.

A. So that would be the earliest that it would be raised with them.

Q. And when did you first know that the Department was investigating the collapse of the building?

A. I wouldn't, I couldn't be specific. I only know when Clark Hyland made arrangements to come and see me but I can't remember exactly when that was.

Q. And you would have, you would have been aware before he approached you that the Department was making an investigation.

A. I can't recall.

Q. Did you anticipate that after the building collapsed on the 22nd of February that there would be an investigation into the building and why it collapsed as it did?

A. I can't remember I'm sorry, at that time.

Q. What was your reaction when you learned what had happened on the 22nd of February?

A. I learnt it I think later on that day and I was already fairly shocked having been in the city and walked back and I guess it just added to the sort of shattered feeling that I had.

Q. Now there's some criticism being made, including by one of the witnesses for your firm, Professor Shepherd, I think it's Professor, about the lack of attention to forensic examination of the site. I take it you didn't make any effort personally to go down to the site to see if, with your knowledge of the building, you could provide any assistance with what was going on down there?

A. There's two aspects to that. Firstly, I didn't have the knowledge of the building and, secondly, I certainly wasn't in the right frame of mind to be going and helping.

1616

Q. Right and I take it that you have not at any time contacted either Mr Frost or Mr Heywood to give them any assistance with the forensic work they have been doing?

A. I have not been aware until recently that they had done that work.

Q. Right. Well just going quickly I think it can be fairly quickly in light of what you've said so far, through your various points under the collapse considerations. You are aware, I assume, that there is a further time history analysis that's been run under the auspices of the facilitation of Professor Athol Carr? You know that's going on?

A. I know that it was instructed but what's happening with it I don't know.

Q. I see. Well I can tell you that this issue of vertical acceleration at least on the advice we have had is being considered in the course of that new time history analysis so that's one of the considerations that you thought required further attention and, as I understand it, it's getting it. Then the issue that you raise about the south wall lateral load resistance, and this is paragraph 50 –

A. Could I, could I just come back to your inferred question?

Q. Yes.

A. You say that I'm satisfied with what's happening, well in regard to the –

Q. No I don't think I said that to you. I simply pointed out to you that vertical accelerations, as I understand it, are being treated as a further input or a modified input into the work that's been going on under the facilitation of Professor Athol Carr.

A. Yes but it depends on the type of input that's used with that vertical acceleration and the model that it's being input into as to how meaningful it'll be.

Q. Yes, all right, so you have reservations about that?

A. Well I have reservations because I'm unable to be involved as you're aware.

Q. Yes, all right. Now the question of the south wall lateral load resistance which is paragraph 56 if you want to refresh your memory on what you've said there. Do I take it that the point that you're raising there, and you'll forgive me if I put this in non-technical terms, refers to a simultaneous interaction of horizontal and vertical forces? Is that what we're dealing with here?

A. Or near, near simultaneous –

Q. Yes.

A. – but not absolutely necessary.

Q. No, but in broad terms we're talking about the impact of some forces coming horizontally and others coming vertically and reducing the gravity at the time that the horizontal is affecting the wall? Is that a fair summary?

A. That's a fair summary.

Q. Now am I right that the horizontal movements that the south wall is being subjected to are slow, relatively slow waves of movement that are coming through? Is that right? And perhaps I can help you by saying relative to what which might be what you might say to me, relative to the vertical movements which, as I understand it, are fast short movements?

A. The movements tend to be of a combination of what you'd call your slow movements. Superimposed on those slow movements are more rapid vibratory type movements.

Q. Yes, yes, well we're –

A. So –

Q. – in agreement then on that?

A. And that applies to the vertical as well.

Q. Yes, yes, all right, I think we're in agreement that one is slower in the horizontal direction and the short sharp movements of the vertical connection?

A. No, no, they both, each direction would have a combination of both.

Q. Would they?

A. Mmm.

Q. All right, well then I'll just leave it at that. Others will no doubt comment on that and may well disagree with that I think. Now this question of building modifications and the first of these is the activities of Mr Morris which you deal with at page 59 and following and you describe that in paragraph 63 as potentially having or potentially being able to cause a catastrophic failure. Now I assume that you either heard or have read the evidence Mr Morris gave to the Commission?

A. I certainly have read it, yes.

Q. Yes, now you've expressed concern that the Department of Building and Housing –

JUSTICE COOPER:

Q. Let us just clarify, do you mean you have read his brief or you have read the transcript of the evidence that he gave including his cross-examination?

A. I've read his brief.

CROSS-EXAMINATION CONTINUES: MR MILLS

Q. So you haven't read the evidence that he gave? The transc -

A. Not subsequently, no.

Q. All right. Well you haven't talked to your counsel about what Mr Morris said under cross-examination?

A. I'm aware –

MR RENNIE:

(inaudible 16:22:16)

MR MILLS:

All right.

JUSTICE COOPER:

Well, no, not if you object to it.

MR RENNIE:

And I emphasise even if he had Sir.

CROSS-EXAMINATION CONTINUES: MR MILLS

Q. So you're, are you telling me that –

JUSTICE COOPER:

Well he has told you that he hasn't read the evidence that was given, now for you, I think, Mr Rennie is entitled to take the point he has.

MR MILLS:

Yes, I understand that.

JUSTICE COOPER:

You might ask why he hasn't read it I suppose.

MR MILLS:

Well I'm sort of headed in that direction.

JUSTICE COOPER:

All right.

CROSS-EXAMINATION CONTINUES: MR MILLS

Q. So are you telling the Commission that your understanding of the evidence from Mr Morris goes no further than what is in his written statement of evidence?

A. Well I've read the written statement.

Q. And you know nothing more than that about the evidence that he gave here?

A. Other than the comments made by Mr Rennie in regard to an uncertain, the uncertainty surrounding that drilling.

Q. I see. So were you aware that under cross-examination from my friend, Mr Zarifeh, that he acknowledged that he had only gone to the site once and dropped a workman off there?

A. No I'm not aware of that.

Q. Were you aware of the fact that he acknowledged under cross-examination that not only might his assessment of the number of holes be inaccurate but it might be wildly inaccurate?

A. I'm not aware of that.

Q. And you weren't aware then by the end of his cross-examination, he said that the holes might have gone into the floor not the beams? Not aware of that either?

A. I've heard that comment but I can't remember where from.

Q. I see. Well I'm going to suggest to you that in light of the where his evidence stood at the end of cross-examination that the Department of Building and Housing made absolutely the right decision in not to pursue it any further?

A. I would not agree with you.

Q. All right.

A. And the reason is that around that time there were instances of contractors drilling holes through critical structural elements and we would learn of them, not necessarily in that building I'm talking about, but in general in Christchurch, we would learn of them when someone, a building owner might find out and ring us up and say, “Would you come and have a look at this?” And I can recall one in the Mair Astley building where they drilled through a critical structural shear wall element and the repair work required was massive. So it did happen. In that particular building? What would have driven someone to bore the holes in the beams is a lack of space between the suspended ceiling and the underside of the beam in that if there is no room or little room to put services through under the beam then they’ll drill holes through it and that building did have a relatively small distance from the ceiling to the beam. It would have been approximately 50mm so if you needed a 100ml hole you would actually drill it through the beam.

1626

Q. How were you aware that it had only that small space between the ceiling and the floor above?

A. Because when I learnt that he had been drilling holes, that he’d said he’d been drilling holes in the beam I had a look at the architectural drawings that we’d got from the Council to look at where the ceiling height was and had a look at the beam to see what the gap was to see if that was a likely scenario.

Q. I see. Were you aware of the fact that having been informed of the evidence that Mr Morris had given that Dr Heywood and Mr Frost went out to Burwood and looked specifically to see if they could find any holes in any beams. Did you know that had been done?

A. Yes, I've seen that piece of work, yes.

Q. And you're aware that they said they found none?

A. Yes, although in one of the photos that I saw of theirs I thought I did see a hole but not a large one.

Q. So it's fair to describe this, isn't it, as pure speculation as to whether anything of this kind happened in the CTV building?

A. From an engineering view point it remains a possibility.

Q. And the possibility is based on what you saw in other buildings?

A. Yes, and the fact of the small gap between the beam and the ceiling.

Q. Now this issue of the internal staircase. Have you seen what I think is brief of evidence number 6 from Mr Ashley Smith? He's been fairly active in the number of briefs that he's done where he refers to the fact that this issue around the internal staircase was modelled in the time history analysis that was done for the department?

A. Yes I have.

Q. And you're aware that in that brief Mr Smith says that the conclusion was that the seismic forces could still be adequately transferred despite that hole being cut in the floor. Are you aware of that?

A. Yes I'm aware he said that.

Q. Then the issue of cumulative damage –

A. Just before you move onto that there is something else I should say that on its own that hole may not be an issue but if in fact there is a reduction in the reinforcing connecting the floor to the beams or wall, as has been suggested I think by Frost or Heywood as a possibility, then it could become significant.

Q. Yes, yes, I think in the course of questioning of I think Mr Frost, and certainly by looking at the drawings, that that photograph that they took through the south-coupled shear wall on which they initially suggested that there was no steel bar where they had expected it, the drawings

show that there is a gap in the steel bars at that point through which the photograph was taken so I think it's doubtful that much can be taken from that photograph. There may be other sources of evidence on this but I invite you to look at the drawings yourself and you'll see that there is a spacing of the bars which coincides with the width of the south-coupled shear wall through which that photo was taken. In any event I'm just letting you know that.

Now this question of cumulative damage. You've given us some previous advice I think at the request of counsel assisting the Royal Commission of the buildings that you were involved in after the September earthquake and doing post-earthquake assessments. I'm not sure whether you were aware that we'd been given that but we have got a list from your law firm and there's six buildings on that list – IRD, 521 Colombo Street, 646 Colombo Street, 84 Gloucester Street, 152 Hereford Street and 137 Kilmore Street. Now is that, in your view, still a current list of the buildings that you have been involved in in doing post-earthquake assessments? Would you like me to give you –

A. I've done post-earthquake assessments but some of those I don't recollect doing.

Q. Would you like me to hand this to you so you can have a more careful look at it. It did come from your lawyers.

A. Some of these I've had an involvement with but not all.

Q. All right well then we should make that list more accurate. Can you tell us which ones we should cross off?

MR RENNIE ADDRESSES THE COMMISSION

Sir, to avoid confusion the list as supplied was the buildings ARCL had done so rather than cross them off with respect it might be better that they are marked as to whether Dr Reay was personally involved or not.

CROSS-EXAMINATION CONTINUES: MR MILLS

Q. I'm sorry that's what I meant, cross them off in terms of personal involvement. So if you could just tell us which ones to take off in terms of you not having had any personal involvement in them?

A. I would have to review my records to actually know whether, some of them I've had an involvement with post February the 22nd so I don't have a recollection of whether I was involved prior to February 22nd.

Q. In paragraph 68 of your evidence having carried out numerous post aftershock building inspections across Christchurch how many buildings are we talking about, as "numerous" buildings?

A. Well firstly most of them are post-February 22nd.

Q. And so the cumulative damage then that you would be observing was damage which would almost certainly have been principally damaged from February, not September?

A. Some of the damage may have been started in September but my involvement was post February 22nd for the most part but the company would have been involved with some of them post September.

Q. But as far as you're concerned you didn't personally have the opportunity with those buildings to look at the damage that had been caused in September?

A. No I didn't inspect any buildings in September itself. I wasn't in Christchurch when the earthquake happened.

JUSTICE COOPER:

Q. What about October?

A. I'd have to check the time records.

CROSS-EXAMINATION CONTINUES: MR MILLS

Q. So when you say in your evidence, at least this is how I read your evidence at paragraph 68, tell me if I'm wrong in taking this from it, that as a result of these numerous post aftershock building inspections you had observed that crack widths in structural elements such as shear

walls have increased following ongoing aftershocks. What's that referring to?

A. Well, for example, in the IRD building. I inspected that after February the 22nd and the cracking then, some of the cracks were around .2, .3mm. By the time we were asked last December some of them had got up to over a millimetre.

1636

Q. So is this evidence principally evidence related to the IRD building?

A. No, no there have been other buildings where once we realised that the, let's put it another way, where we'd seen cracks originally that didn't appear to be significant and then over time they'd increased and by the definitions of two years ago would still be not significant but because we'd realised that they perhaps were we took a lot more note of them and quite a few of them have ended up being tested for strain hardening.

Q. Now you're aware aren't you, and this is the issue that was raised with the Commission, that counsel assisting have asked for some information related to these issues and, at the moment at any rate, I take it there's some commercial sensitivity around providing that information.

A. Yes.

Q. Is that your understanding?

A. Yes.

Q. Because it's very difficult to assess anything about your evidence here in the way in which it's put because there isn't any hard evidence sitting underneath it. So that's an issue that needs to be pursued, particularly if the Commission wants to know more. So I'll just leave that for the moment.

A. Perhaps I could comment on that.

Q. Mmm.

A. That all the testing that we have had done has been done by Holmes Solutions.

Q. Yes.

A. There is another company that has done some testing but we don't think that this delivers the quality of information that the Holmes Solutions testing does. So all our information and probably a lot more is actually available from Holmes Solutions.

Q. Yes. Incidentally, who was it at this meeting that you referred to, I think in the Art Gallery after the February earthquake, who mentioned that strain hardening was an issue? You've referred to it as, "First noted," this is paragraph 47 of your evidence, "Was first noted at a seminar at the Art Gallery on 1 April 2011 where comment was made." What's the detail around that?

A. Professor Fenwick made the comment.

Q. Did he, then it must be right. All right, well, then as I say it must be right. Now in the buildings that you've been inspecting in respect of any that were prior to the 22nd of February did you red sticker any buildings?

A. I couldn't recall.

Q. Do you recall whether you formed a view on whether any of the buildings you were inspecting post-September had gone through a design-level earthquake?

A. The difficulty for me in answering these questions is that we as engineers have been attending seminars on a very regular basis and, in the end, you actually can't remember exactly when certain information was imparted to us.

Q. Yes. Are you aware that Dr Mander has said in the evidence that he's expected to give, on Monday now I suppose, that he thinks that any building subjected to a design-level earthquake should be red stickered and closed by fiat. Are you aware of that?

A. Yes I'm aware that that's his view, yes.

Q. Is that a view you share?

A. Well I've certainly tended to that view post the 22nd of February.

Q. You would close every building in the city would you if there'd been a design-level earthquake?

A. Well with what we know now, yes, because they all got closed on February the 22nd anyway.

Q. Of course they didn't all get closed did they?

A. Well no our building was allowed to be open, yes.

Q. Yes. Just then, perhaps a final couple of questions in relation to the evidence you've given about this question of spandrel interaction, which is paragraphs 35 and 36 of your evidence. This is your second brief I think. You, let me put that differently. You agree with me that there was no seismic gap that was specified on either the structural drawings or the specifications in relation to the space between the spandrels and the columns, no seismic gap specified?

A. What I can, I can't agree with that. What I can say is that there was a 10 millimetre gap specified.

Q. That gap is not specified though as a seismic gap that had to be retained.

A. It isn't stated as a 10 millimetre minimum gap.

Q. And do you agree with me that the concept of builders' tolerances is well understood within the design industry?

A. I wouldn't agree with that.

Q. So when a gap is specified no tolerance is permitted, even though it's not specified as seismic gap?

A. The problem with the tolerances that are theoretically in the code is that they don't, they're not necessarily applicable to certain building elements and perhaps the best example is when you have a steel frame you're bolting together. According to the tolerances they can be plus or minus 15/20mm. The steel plates are drilled to an accuracy that requires a tolerance of plus or minus 1mm or it can't be bolted together.

Q. Yes.

A. So the tolerances I think are generally an overall building tolerance of whether the building is plus or minus 20mm long rather than a specific tolerance able to be utilised by the builder for every single element.

Q. But the effect of those tolerances working in along from the first spandrel into the columns as they went along could eat up that 10 millimetre gap couldn't they?

A. Well I can't remember how those panels were fixed but if they had any bolted-type connection, for example, they wouldn't have been able to be installed because the bolts wouldn't have matched.

Q. I see. Would you agree with me that if this was a critical gap that it should have been specified as such?

A. I think it could have been specified better than it was.

Q. Yes. Now you've made a reference to the quality of work done by Williams Construction.

A. Mmm.

Q. And you've given us a photograph as an exhibit to your evidence. Are you able to tell me when that photograph was taken?

A. Four months ago, something like that.

Q. Four months ago?

A. Four to five months ago I would say.

Q. Are you able to tell me, sorry I should have put that to you differently. Are you able to tell me when the building of which that photo was taken was constructed by Williams?

A. Not exactly but I think it was the late '70s.

Q. Are you aware that the Williams' family who were, of course where the name came from, that they sold out their shareholding in Williams Construction at a later date?

A. Yes but I don't know when.

Q. And you're aware aren't you that during the course of the construction of the CTV building the contract that was initially undertaken by Williams was assigned to another company called Union?

A. Well I am now but I wasn't, it was not something I recalled from 26 years ago.

Q. Okay.

A. Until I saw it in evidence somewhere.

1646

CROSS-EXAMINATION: MR ELLIOTT

Q. Dr Reay, my role is to represent the interests of the families of the 115 people who died when the CTV building collapsed. Some of those families are here today, taking time out to come and watch you give evidence, others will be watching online either in New Zealand or in one of the other nine countries around the world from which those people came. They have many questions for you about this building. Not all of those will be asked today because you're giving evidence on more than one occasion, but I'll ask you some today.

Firstly, after the release of the Department of Building and Housing report you issued a press release in which you said, "I have huge empathy for the families waiting for answers." Do you have huge empathy for those families?

A. Yes.

Q. I'm just going to refer you to one or two pieces of evidence we've heard from some other key people in this case and then ask you a question or two about that. Firstly, Mr Drew was the building manager of this building and had also agreed to purchase an interest in the building. Were you here when he gave evidence?

A. No.

Q. He and his wife worked in the building and likely would have died if by pure chance they had not been in the building that day. He also brought The Clinic tenancy into the building weeks before it collapsed, and in paragraph 46 of his statement he said, "Since the 22nd of February I've felt a huge sense of responsibility and am forever questioning what might've been done differently." Secondly, Mr David Coatsworth, were you here when he gave evidence?

A. No.

Q. He was unfortunate enough to have been the inspecting engineer for this building and he sat and gave evidence in a quiet and sad way about the inspection he did, and in paragraph 117 of his statement he said, "It would be fair to say that I've relived the inspection that I did of the CTV building over and over in my mind, wondering whether there was anything I missed or misinterpreted. I've examined and re-examined the

120 photographs that I took and read and re-read my notes in my report. I've asked myself whether there was anything that I could or should have done differently that might have changed the outcome." So have you asked yourself what you personally could have done that might've prevented all of these deaths?

A. Yes, like the other engineers, every day, and I look back and I think that if I was, you know, and I look back and try and remember what the circumstances were at that time in my life when I was doing that, and well when I was running the firm, because I do accept that my firm is ultimately responsible for the design, should Harding have had shortcomings in his work. I probably the, the, one of the issues that perhaps hit me most was when in searching the records, historical records for the work on this building I was of course going through some very old files, having been in business for 40 years, and I came across a Press article dated the 1st of June 1991 and it was about probably the 1st of June 2011 that I found it, and it was a full page article on the effect – it had been prepared for the regional council on the risk of earthquakes in Canterbury and in it – when you read it and it's presumably still available, it read as though it could've been written today, or then, and the thing that really struck me was that in that article it was stated that there were fault lines under Christchurch and I'd obviously looked at it and put it away, but you know I felt afterwards that that was the first signal to me that the expected earthquakes may not be of the type that we had all been designing for, which was the Alpine Fault earthquake. And I feel that, looking back on my career, I could've done a lot more.

Q. Can you tell us what in particular you think you could've done in relation to the CTV building.

A. Well, not in direct relationship to it, but in fact in pushing for perhaps the code standards to be different, perhaps lending my weight to actually having different standards than what we had. Because clearly the, when I read that article the – it alerted me to the fact that there could be

worse earthquakes or different earthquakes than perhaps what we were planning or expecting.

Q. So you've given thought to what you might've done differently in relation to the CTV building from the time it was designed, and you say there is nothing that you think you could've done differently that might've prevented its collapse?

A. Well with hindsight of course one could do many things differently, and I think today in any event we do do things differently to what we did back in 1986. There is more, the codes are more stringent. There's more peer reviews. There's a different culture in the, in our professional industry, but…

Q. What exactly would you have done differently?

A. Well clearly I would've taken a greater role in the job if I was looking back now. At the time I didn't, didn't see that as necessary for that particular building, but clearly now after what's happened I would.

Q. Had you played a greater part do you think the building might've been designed differently?

A. It's difficult to say, I mean I may have done it, designed it differently, but whether it would've withstood that earthquake I still, I couldn't actually say that it would've made that fundamental difference.

Q. Can you say how you would've designed it differently though?

A. That's, that's very difficult to say because I've got to put myself back 26 years and so many things have happened in the intervening period, and particularly there's been a huge learning curve of late, it tends to modify your thinking really. The only, I mean I designed a building that was slightly higher than that in 1974, I think it was, and it remained standing.

1656

Q. Do you think if you had been more closely involved, the decision to build the building on the basis of north shear core and the south wall as being the primary seismic resisting elements, and columns being designed non-seismically might not have happened?

A. No I don't believe in principle that would necessarily have changed because I was aware that the building had that northern shear core in it, southern shear wall. The building that had been designed by another staff member previously was Landsborough House and it was probably more torsionally sensitive than actually the CTV building was and it was designed on the basis of elastic columns.

Q. I won't go any further with that topic because you are dealing with it separately in a later phase. Mr Mills asked you some questions about the period following 4th of September 2010 earthquake. Is it right that your office was quite close to the CTV building?

A. Oh, not really.

Q. Where was your office?

A. I was down near Bealey Avenue.

Q. What street was it on?

A. Madras Street.

Q. Did you take any steps after the 4th of September to go and warn those in the CTV building that it should be red, immediately red stickered as Dr Mander describes it?

A. I wasn't here on the 4th of September, immediately after the 4th of September but I was here a week or so later. It, it wasn't a building that in my, to my mind was one that I would have thought would have been a risk.

Q. It would be quite rare for you to have arranged for drag bars to be installed on a building your firm had designed wouldn't it?

A. That's the only time I'm aware it had happened.

Q. And it would be quite rare for you to have to notify your insurer of a claim in relation to a building your firm had designed, wouldn't it?

A. Fortunately, yes.

Q. But wouldn't the CTV building have stood out in your mind as one that you might consider speaking to people about after the 4 September earthquake?

A. I had every confidence in the engineer who designed those drag bars and who did the work so I had no reason to be concerned. If I had been

concerned in the way you say I would have done something a lot, long before September.

Q. But at no time between September and the February earthquake did you take any steps to alert anyone within the CTV building or the owners about any dangers you may have perceived?

A. Our company has designed thousands of buildings. You know, in my mind I thought of one or two that I thought might be an issue. For example, the one I designed in 1974 because it was a relatively eccentric building and the codes of that time weren't as good as perhaps the later, as good as the later ones were so that one was one that I wondered about but –

JUSTICE COOPER:

Q. What was that building?

A. That was Ibis House, but I think from where I was I asked one of the staff members about two or three buildings that in my mind might have suffered more so than others perhaps because of the timing when they were designed and the way the earthquake engineering had moved, designs had moved on from that time but the CTV building was not one that I you know thought of as one that I would ask a question about.

HEARING ADJOURNS: 5.00 PM

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