

Under **THE COMMISSIONS OF INQUIRY ACT 1908**  
In the matter of the **CANTERBURY EARTHQUAKES ROYAL COMMISSION  
OF INQUIRY INTO THE COLLAPSE OF THE CTV  
BUILDING**

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**THIRD STATEMENT OF EVIDENCE OF ALAN MICHAEL REAY –  
EVIDENCE IN REPLY**

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**THIRD STATEMENT OF EVIDENCE OF ALAN MICHAEL REAY – EVIDENCE IN REPLY**

1. My full name is Alan Michael Reay. I reside in Christchurch. I am a Chartered Professional Engineer and a Company Director.
2. I refer to my first statement of evidence dated 7 June 2012 for details of my qualifications and experience. I again confirm that I have read the Code of Conduct for expert witnesses and that my evidence complies with the Code's requirements.
3. The purpose of this third statement of evidence is to respond to matters raised in the evidence of a number of other witnesses that have provided statements of evidence to the Royal Commission.

**John Henry**

4. There are aspects of Mr Henry's evidence that I do not agree with or wish to comment on. I respond with reference to his paragraph numbers.
5. At paragraph 24 Mr Henry refers to buildings at 58, 64 and 329 Durham Street. At least two of these buildings are significantly different to the CTV Building. The building at 329 Durham Street contains a long shear wall on the opposite side to the core which, while it has some coupling beams, the stiffness of the wall is such that these would not contribute significantly to the seismic response of the structure. The building at 64 Kilmore Street has what are described as shear columns on the wall opposite the shear core and, as such, would expect to have energy absorption at the base of those columns only. This is in contrast to the CTV Building which has a coupled shear wall structure opposite the shear core which is able to absorb energy through the yielding of the coupling beams over five levels.
6. At paragraph 31 Mr Henry refers to his work on the Westpac Centre. Mr Henry states that this building was a shear core building and was symmetric. It was therefore significantly different to the CTV Building. The symmetry of this building would have normally indicated that it would have performed well. I note that the shear core has not protected the columns. I have observed that the columns in the building suffered significant damage and that the building is currently being demolished. I also understand that the building suffered damage in the 4 September earthquake.

7. At paragraph 41 Mr Henry refers to his work on an eccentric 14 storey building called the AA Centre. I note that this building has an eccentric shear core, but it also has a perimeter frame that provided torsional resistance and is therefore significantly different to the CTV Building.
8. Relevant to paragraph 42, based on Mr Henry's experience as he has noted, he had not designed buildings similar to Landsborough House prior to joining ARCE.
9. At paragraph 43 of his evidence, Mr Henry suggests that I had only designed tilt-slab buildings at the time he joined ARCE. However, I was also at that time a leading engineer in the field of Cold Formed Steel and its use in buildings, plus many other structures. By way of further example, I designed the (then) world's largest span fibreglass trickling filter cover at the Christchurch City Council's Bromley sewerage plant. The span was 54 metres. Mr Henry worked on the initial stages of that project with me and is therefore well aware of my experience in this respect. Neither Mr Henry nor I had, at that time, experience of fibreglass structures of that scale. But this project illustrates that competent, Registered and experienced Engineers do and are expected to work on structures that extend their basic knowledge.
10. In relation to paragraph 44 of Mr Henry's statement, I do not agree that experience and a high level of expertise was required for the design of reinforced concrete shear wall structures. A level of expertise and experience could be said to be required for all multi level building structures and such experience is the basis of Engineering Registration. The critical knowledge was that the engineer knew when he or she was beyond his or her capability and at that stage the engineer should seek assistance from appropriate senior engineers, just as John Henry did in consulting with Professor Paulay.
11. At paragraph 45 of his evidence, Mr Henry refers to the Ibis House Building which I had designed prior to his arrival to ARCE (incidentally, not ARCL as he has incorrectly referred to in this and other paragraphs). Ibis House, an eight storey building designed in 1974, was partly blockwork, as were the three 1970's Holmes Building referred to by Mr Henry, but the primary load resisting elements in the east - west direction were reinforced concrete movement beams connecting into walls and columns. The beams were designed for ductile action in an earthquake. The building was asymmetric



and account was taken for this in the design. A computer analysis was not used in the design of Ibis House.

12. The Ibis House Building survived the earthquakes but has subsequently been demolished. There was no evidence of cover concrete spalling at the underside of the first floor level, as there was at the five storey Spicer House building referred to by Henry.
13. Beginning at paragraph 46, Mr Henry discusses the Landsborough House Building. I also discussed this building in my second statement. There are further comments on this building which I wish to make in response to Mr Henry's evidence. The initial plan for Landsborough House was prepared by the architect without structural design input.
14. It is not correct to state, as Mr Henry does in paragraph 48, that I was committed to an offset configuration for Landsborough House. As Principal Consultant it was my role to ensure all options were considered.
15. I do not agree with Mr Henry's statement in paragraph 49 that an ETABS analysis was mandatory. The requirement of the Code was that for particular structures a spectral modal analysis could be used as an alternative to the equivalent static force method. Either of these methods could utilise the ETABS Software.
16. At paragraph 50 Mr Henry suggests that an ETABS analysis was the only method of accurately determining likely building response to earthquake loading. This is not correct. I refer to my comments in paragraph 15 above. The method is only reliable while the structure is elastic. The seismic coupling beams are designed to be subject to inelastic behaviour and in this mode an ETABS analysis could be unreliable. Best practise at that time (if there was such) could have been to have utilised an analysis based on research such as Dr Sharpe's PhD research on inelastic structural response analysis.
17. At paragraph 52 Mr Henry states that the ETABS analysis for the Landsborough House Building showed that the structural model worked. I emphasise his follow-on statement that the corner deflections were at or near the maximum code drift limits.
18. I note that Mr Henry discussed the Landsborough House building with Professor Paulay (paragraph 56). It appears Professor Paulay agreed with my opinion that the eccentricity was not a major issue.

19. At paragraph 63 of his evidence, Mr Henry states that I was dismissive of his concerns about the Landsborough House Building. I was not dismissive of Mr Henry's concerns. I was aware he had (appropriately) discussed his concerns with Professor Paulay and I advised him that I was satisfied with the solutions agreed.
20. At paragraph 64 Mr Henry states that he was concerned about whether the gravity load system for Landsborough House would be adequately protected by the shear walls. In response he detailed the column tie reinforcing with a reasonable provision for some ductility demand in the end regions. I question why, if Mr Henry was concerned about the gravity load system, he did not detail for full ductility or modify the column design accordingly. I suggest that what Mr Henry did was in accordance with the standards in Christchurch at that time.
21. At paragraph 68 Mr Henry refers to David Harding's calculations for the CTV Building. He also refers to a requirement that the Landsborough House and CTV Buildings be analysed using ETABS. If Mr Henry is referring to a spectral modal analysis then I disagree with the statement and consider both buildings could have been analysed by the equivalent static force method. I also note that Dr Arthur O'Leary has stated that static analysis would have been a compliant code analysis for the CTV Building.
22. In paragraph 55 of Mr Henry's statement he is saying that it was essential to complete the concept design, of which inter storey drifts were part, before proceeding to the detailed design. This is standard engineering practice.
23. In paragraphs 53 and 54 Mr Henry has gone to some lengths to explain how difficult it was to use the version of ETABS that he had utilised. It is not clear whether the version used by Mr Harding was the same as that used by Mr Henry. However, in any event, the use of ETABS and the perceived difficulties that Mr Henry had in calculating deflections is not, in my opinion, a complex issue at all. I also note that the full extent of the Mr Harding's calculations is not known. There may well be significant further calculations which have not been retained.
24. At paragraph 61 Mr Henry refers to a building with a wall on each end and otherwise little torsion resistance, which, he says, could lead to the majority of the yielding occurring on one of the walls. This example also applies to the two east-west shear walls in Landsborough House. The north wall is



designed to remain effectively elastic and the south wall ductile by use of coupling beams.

25. At paragraph 70 Mr Henry states that he was very much in the driving seat in doing the structural design for Landsborough House. It was Mr Henry's role to undertake the responsibility for the structural design and documentation of Landsborough House. He was not employed to project manage the job, or take the lead consultant role as I understood he had no experience in this role.
26. At paragraph 71 Mr Henry states that I was not closely involved in the work he was doing on Landsborough House. As lead consultant, review of the construction methodology was my responsibility.
27. In relation to paragraph 72 of Mr Henry's statement, as lead consultant I would have been responsible for the provision of the permit documentation.
28. At paragraph 75, in relation to Bradley Nuttall House Mr Henry says he had no involvement with the client and little to do with recycling the Landsborough House structural design within the office. Again, I was lead consultant on this project. The architectural façade elements were separated from the structure by the Architect to provide a deeply modelled façade. This was also the case with the Landsborough House building. My recollection is that Mr Henry did undertake significant structural design work on this project, in addition to the façade. For example, the foundations were based on shallow foundations, and Mr Henry would have designed these as they were different to the fully piled foundations of Landsborough House.
29. At paragraph 82 of his statement, Mr Henry states that when he left ARCL (again, actually ARCE) there was no designer there who had experience of using either the ETABS system, or multi-storey shear core design. I agree that I had not used the ETABS software to design a multi-storey building at the time of Mr Henry's departure from ARCE. However, he is incorrect to say that there was no one with experience in designing multi-storey shear core buildings using computer analyses. Dr Robert Donald had written software for modal analysis of building structures which I used in the latter half of 1960's.
30. At paragraph 83 Mr Henry states that he left ARCL (meaning ARCE) in early 1985. I believe he left ARCE in late 1985, not early 1985.

31. At paragraph 84 of his statement Mr Henry states that Mr Harding had worked for ARCL (actually ARCE) for a number of years before Mr Henry went to ARCL (ARCE). In fact, Mr Harding only worked for ARCE for about one year before Mr Henry joined.
32. At paragraph 86, Mr Henry states that he was concerned to hear that Mr Harding had followed his Landsborough House calculations for the CTV Building design for two reasons. First he states that it was unlikely his calculations were sufficiently detailed for a "first time" designer to be able to adequately understand the design process. Secondly, Mr Henry notes that the shear wall design for the two buildings were significantly different. In respect of Mr Henry's first point, a design engineer's calculations should include reference to decisions made based on experience. The concept of the design should have been summarised in the calculations. Further, I do not know if the Landsborough House calculations were all that were available to Mr Harding, at the relevant time. I also note that the construction drawings for Landsborough House and other projects were available to Mr Harding.
33. I also refer to the 1990 Holmes Report. The report describes the layout and design of the building as "quite simple and straightforward" **[BUI.MAD249.0130.5]**. There is no reference in the Holmes report to design difficulties as claimed by Mr Henry, indeed the Holmes report suggests the opposite.
34. Beginning at paragraph 87, Mr Henry discusses differences between the CTV Building and Landsborough House. I have also covered this issue in my second statement.
35. In paragraph 88 Mr Henry comments in on the wall configuration. While there are elastic response benefits from a tubular structure, this benefit is reduced following the inelastic behaviour of the coupled shear wall. It is this response which Professor Paulay would have been concerned with due to the increased rotation of the structure. The location of the coupled shear wall in the CTV Building, being on the south side with the main shear core on the north side, would have provided more control over the torsional response of the structure in the event of post elastic behaviour.
36. At paragraphs 91, 92 and 93 Mr Henry refers further to the shear wall arrangements for the CTV Building. These issues are simply part of the



design process just as was the case for Landsborough House and other eccentric shear core buildings.

37. At paragraph 95 Mr Henry states what might have happened if there was no South Coupled Shear Wall. Of course, there clearly was so this discussion seems irrelevant.
38. In paragraphs 97 to 99, Mr Henry refers to issues for the design associated with the South Coupled Shear Wall and the connection of the Shear Core to the Floor Diaphragms. The analysis of the building by the equivalent static force method will provide the resolution of the issues Mr Henry discusses.
39. In paragraphs 100 and 101 Mr Henry refers to the location of gravity beams in Landsborough House and the CTV Building. The code has no requirement regarding gravity beam alignment. Because the buildings are approximately square this potential benefit is not significant. One benefit of the floor beams located as they were on the line of the north-south shear walls, is that they could also act as drag bars in the north-south direction.
40. At paragraph 105 Mr Henry states that there were no floor beams to restrain the columns in Landsborough House. That is not correct. There were beams and they restrained the columns in the north-south direction. Also, the beam/floor system had torsional strength which could induce actions in the columns in the east-west direction.
41. In paragraphs 107 to 147 Mr Henry refers to the CTV Building calculations. I do not propose to comment specifically on these matters. I refer instead to my comments in paragraph 42 below.
42. I note that Mr Henry's comments are predicated on the use of a spectral modal analysis using ETABS Software. The use of ETABS was not a mandatory requirement for this building under the code. Therefore I do not comment on this aspect of Mr Henry's evidence as it is based on an analysis which is not a requirement in terms of the building code. I also note that Mr Henry's comments are based on the calculations available. I consider it more appropriate to consider the as designed building and review that in relation to the Code and standards of the day in Christchurch.
43. At paragraph 151 of his statement, Mr Henry makes comment on the Council's view of myself and ARCL. I do not agree with Mr Henry's comments. In particular I do not agree with the comments regarding Mr



- Tapper or his statement that ARCL did not like the scrutiny of Mr Tapper. I do not agree that I went to Bryan Bluck to override Mr Tapper.
44. I also note that Mr Henry was involved in reviewing much of the ARCL work at the time he was at the Council and appeared to take a lead role in this compared to Mr Tapper or Mr Bluck. ARCL did not ask Mr Bluck to overrule Mr Henry. We always responded in writing to Mr Henry's queries on behalf of the Council, as we did with queries from any other Council engineer. At the time Mr Henry was at the Council many of the Council queries were dealt with by other people in ARCL.
45. I do not agree that Mr Bluck was a 'lesser' engineer than Mr Tapper or that Tapper was confrontational.
46. I also do not agree with paragraph 157 of Mr Henry's evidence where he states that Mr Bluck tended to let consulting engineers have the last say. That was not my experience with Mr Bluck. I recall that at times a peer review would be an option to resolve any issues.
47. I note that Mr Henry's experience at the Council was some six years after the CTV Building was submitted for a Building Permit.
48. I recall that there were reviews of the ARCL work by Mr Henry, or his assistant Mr Enright, who was also an engineer. These reviews appeared to suggest that while the ARCL details complied with the code, they were not of a type favoured by Mr Henry. This became, I recall, a significant issue in relation to Building Consent approval for the three storey apartment buildings at 75 and 77 Gloucester Street, where the Building Consent approval was delayed for some months as a result of issues raised by Mr Henry.
49. Finally, I note that Mr Henry has not notified ARCL that he was reviewing ARCE's work as he was required to do under Rule 53 of the Chartered Professional Engineers of NZ Rules.

### **David Harding**

50. I do not propose to respond in detail to Mr Harding's statement of evidence. As noted in my first statement of evidence, I do not agree with large parts of Mr Harding's evidence and my recollection of events is set out in my first statement. I comment only on a small number of specific issues.

51. Contrary to Mr Harding's evidence, I did not design the CTV Building. The timesheets annexed to my second statement [BUI.MAD249.0463.1] evidence the amount of time I spent on the project as compared to Mr Harding. Mr Harding never said he had a problem.
52. I recall that at the stage that Mr Harding received the Architects' drawings I asked him what the structural lateral load system was. He said it was a core structure on one side and shear wall system on the other. I would have asked to see the plan layout and recall noting that I considered the design a more stable layout than the Landsborough House design.
53. Mr Harding did not advise me of any concerns he had in relation to the project, as would have been expected of a Registered and experienced Structural Engineer if he had such problems. I particularly note that no concerns were raised following his attendance at the July 1986 Concrete Seminar.
54. I ensured that Mr Harding was conversant with the current status of concrete design. He had attended a course on Ductile Frame design in 1979 [BUI.MAD249.0466.1 to BUI.MAD249.0466.152] and a course on Concrete Design by Professor Paulay and others in July 1986 [BUI.MAD249.0469.1 to BUI.MAD249.0469.110], which was during the period he designed the CTV Building. I note that this course covered many of the design aspects relevant to the CTV Building, including the use of the 1984 version of ETABS.
55. It is relevant to record that Mr Harding held a Bachelor of Engineering (Civil) with Second Class Honours. He worked at Hardie & Anderson before gaining registration, which is also where I did my initial training. Mr Hardie and Mr Anderson, and also Peter Douglas who was there at the same time as Mr Harding, were excellent engineers. Mr Harding had over 10 years post-registration experience when he designed the CTV Building.

### **Wayne Strachan**

56. Based on the time records annexed to my second statement, [BUI.MAD249.0463.1] Mr Strachan did not lead the preparation of the drawings for the CTV Building project as claimed. In fact the records show that he did little work on this job.
57. Contrary to paragraph 16 of Mr Strachan's evidence I did not prepare the initial drawings for the Permit Application.

**Terry Horn**

58. Based on the time records annexed to my second statement **[BUI.MAD249.0463.1]**, Terry Horn led the drafting team on this project. He did this under the direction of David Harding.

**Peter Nichols**

59. I do not recall any dealings with Mr Nichols at any time while he was at the Christchurch City Council. I recall only dealing with Mr Bluck at the relevant time (1981 to 1984).
60. I recall dealing personally with Mr Nichols once when he was at Riccarton Borough Council, in which I answered his question and he subsequently approved the building permit.
61. At paragraph 26 of his evidence, Mr Nichols refers to a conversation he had with Mr Bluck in which Mr Bluck said that he had been "convinced by Alan Reay" that his reservations about the design of the building were unfounded. I do not recall any such conversation with Mr Bluck. As I have said in my first statement, I was not involved in the building permit process and would have had no reason to speak with Mr Bluck.
62. I also note that Mr Nichols refers (at paragraph 29) to Mr Bluck requiring a Design Certificate (as opposed to a verbal undertaking). I have no recollection of a Design Certificate being issued for the CTV project.
63. At paragraph 36 Mr Nichols states that I would go over the head of the "ordinary engineer" and speak to Mr Bluck. I entirely reject the evidence in this paragraph. I always appreciated the assistance and direction Mr Bluck provided and simply preferred to continue dealing with him.

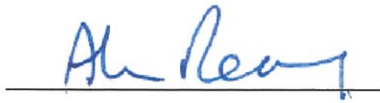
**Timothy Sinclair**

64. In his initial report **[BUI.MAD249.0083.1]**, Mr Sinclair recommended that the REHS site should be disregarded 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 **[BUI.MAD249.0470.1]**.
65. 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.



66. The collapse assessment of the CTV Building should now be reconsidered on the basis of these ground motion records.

Dated this 29<sup>th</sup> day of June 2012

A handwritten signature in blue ink, appearing to read "A M Reay", is written over a horizontal line.

A M Reay