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**

COMPOSITE STATEMENT OF EVIDENCE OF ALAN MICHAEL REAY – DESIGN ISSUES

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COMPOSITE STATEMENT OF EVIDENCE OF ALAN MICHAEL REAY – DESIGN ISSUES

FIRST STATEMENT OF EVIDENCE

1. My full name is Alan Michael Reay. I reside in Christchurch. I am a Chartered Professional Engineer and a Company Director.

Introduction

9. Most of the events that are relevant to my evidence occurred around 26 years ago. I set out below the events as I remember them, to the best of my recollection. The passage of time means that it is not possible to be precise about many of the events. While, for some reason, some details stand out, others do not.

10. ARCL does not have full files relating to the CTV Building. ARCL's record keeping and record destruction protocols related solely to statutory requirements under income tax legislation. The records that ARCL does still hold for the CTV Building have, over the years since the building was constructed, been subject to decisions on retention or destruction, made at the discretion of individual managers when the files ceased to have currency or thereafter. ARCL shifted premises in 2000 and a major cull of historical records was carried out at that time. The actual practice followed by individual principals and staff shows an emphasis on retaining drawings, calculations and geotechnical reports for significant projects. This is consistent with the records held by ARCL in respect of the CTV Building.

ARCE and ARCL – background and practice

11. As noted above, I established ARCE in 1971 and began practice on my own account. Initially it was just myself and a couple of drafters and tracers. Generally in these early days, ARCE had no other Registered Engineer. The business grew steadily and, by 1986, employed around 13 professional and support staff.

12. During the early 1970s structural engineering practice was generally stable with no price competition. The fees were set based on a recommended scale and generally each significant architectural practice utilised the services of its preferred engineer and rarely used others unless clients insisted.

13. The work available was from young architects setting up, architectural designers and contractors. This was the market I pursued in establishing a consulting engineering practice.

14. During the late 1970s and early 1980s the design build market became more prevalent, where the contractor employed the architects and engineers, and I undertook work for various contactors.

15. During that time I developed construction systems for the design of precast concrete onsite cast structures and also for the use of cold form steel in the light industrial and farming sector of the building industry throughout New Zealand and parts of the South Pacific.

16. Prior to the early 1980s I had been responsible for the design of an eight storey office building in Hereford Street, a seven storey apartment block in Carlton Mill Road and a six storey concrete frame building in Liverpool Street (with Hardie & Anderson).

17. In the late 1984 I employed John Henry to undertake primarily medium height multi-storey buildings, a number of which I had started to take on at this time. Amongst other works he designed the Landsborough House Building **[BUI.DUR287.0003E]**.

18. Following John Henry's departure to set up his own consulting practice around the end of 1985, I had been advised by a common acquaintance that David Harding, who had worked with me previously, was considering changing jobs. Mr Harding had worked with ARCE for a period around the late 1970s before leaving to pursue other interests. In late 1985 or early 1986 Mr Harding accepted a job with ARCE which was to include the design of medium height multi-storey buildings. I considered that he had the experience, was a Registered Engineer and was competent to undertake the work.

19. ARCL was incorporated on 18 August 1988 and took over the assets of ARCE.

20. David Harding left the practice around October 1988 and set up his own consulting practice, which I understand still operates today. Geoff Banks joined the practice at that time. Mr Banks had previously worked for Holmes and he had left to set up his own firm called Cambridge Consulting Engineers Limited. He shut down his business after he came to work for ARCL. Mr Banks later became a shareholder and director of ARCL.

21. Geoff Bank's role initially, as had been Mr Henry's and Mr Harding's, was to be responsible for the design and construction observation of the multi storey structures that were being designed at that time.

22. For many of the projects that were undertaken by ARCE, I had the role of Principal Consultant. Under this role, ARCL employed the architect services together with the required electrical and mechanical engineering consultancy and the quantity surveying services for the projects. I note that Landsborough House was undertaken and delivered by this methodology. This contrasted to the CTV building which was designed after the Landsborough House building and was a project in which ARCE was involved solely with the structural design and not as Principal Consultant.

Responsibility for design of the CTV Building

23. I am unable to recall how the CTV Building job came to ARCE. It was a design build project by Williams Construction (Canterbury) Limited ("**Williams**") for Prime West Corporation Limited ("**Prime West**"). At the time I was fully engaged on other projects and would not have had the time to take on this job. Mr Harding took responsibility for it.

24. I have read Mr Harding's letters to the Royal Commission **[BUI.MAD249.0041.RED.1, BUI.MAD249.0235.RED.1, BUI.MAD249.0231A.RED.2, BUI.MAD249.0286A.RED.2, BUI.MAD249.0413.RED.1]**. I disagree with many of Mr Harding's statements as to my involvement in the project. I set out below the extent of my involvement in the project.

25. Despite what Mr Harding says, I was not involved in the design of the project. As with all significant projects my role was to check the quality of the client, in this case Williams and, given that it was a design build contract, ensure that the contractor had the knowledge and experience to undertake the work proposed. At the time, Williams had a strong reputation for building quality buildings. I also verified that the engineer, in this case David Harding, considered himself capable and prepared to commit to undertaking the work. I would also have ensured that an appropriate draughtsman was allocated together with any other staff required to assist in the work the engineer was undertaking.

26. On the basis of my enquiries, I would not have foreseen any significant issues relation to undertaking the job and would have been happy for Mr

Harding to undertake the work. Therefore with my approval as manager and following an agreement being reached with Williams in terms of a professional services contract, Mr Harding took on the responsibility for this project for ARCE.

27. It is standard practice to look at drawings, calculations and other records of other buildings for background information when starting a new job and I expect Mr Harding would have done this.

28. The drawings would have been prepared by draughtspersons and tracers at the direction of Mr Harding.

29. Mr Harding would have carried the project through, including dealing with Council, any site visits and any other necessary attendances. I would not have been involved in any of these stages in more than a minor way.

30. Mr Harding prepared structural drawings, calculations **[BUI.MAD249.0008**, **BUI.MAD249.0272** and **BUI.MAD249.0273]** and a structural specification **[BUI.MAD249.0199]**.

31. I cannot be certain that these calculations or drawings represent the full set of calculations for the CTV Building. It is possible that Mr Harding did other calculations or drawings which are no longer on ARCE's or the Council's files.

32. There was no review procedure in place at that time. Mr Harding was a qualified, experienced and capable engineer and would have taken responsibility for the project. He was employed in a role where he wanted to, and was expected to, take on projects such as the CTV Building without supervision. He was also expected to be building up his own client base. Mr Harding, and any other qualified engineer employed by me, was expected to seek advice if he needed it. I do not recall reviewing the drawings, calculations or specification and I would not have expected to have done so. At the time, Mr Harding was more familiar with the Concrete Code (NZS 3101:1982) than I was.

33. A geotechnical report was obtained from a specialist soils engineer, Soils and Foundations (1973) Limited **[BUI.MAD249.0203.1]**. This report would have been used to design the foundations of the building. I cannot say specifically how the report might have influenced Mr Harding's design.

34. In the mid-1980s, the economy was strong and the construction industry was performing well and experiencing good growth. It was not a particularly competitive environment for engineers and there was not a lot of pressure on fees. I believe that Mr Harding would have been involved in setting the fee, which was probably set as a percentage of the total build cost, probably a percentage of the structural value. I do not believe there would have been any great pressure on Mr Harding to meet any financial constraint.

35. This environment can be contrasted with that of the late 1980s / early 1990s, when the economy took a significant dive and the construction industry suffered as a consequence. The cost environment was considerably more competitive during this time.

Computer modelling

36. I am unable to recall whether any computer modelling was carried out during the design process. I was not involved in any modelling for this building.

37. I found on ARCL's historic files an invoice from the University of Canterbury for computer charges that may have related to the CTV Building **[BUI.MAD249.0233.1]**. It refers to the ARCE job number for the CTV Building (2503). The invoice also refers to another job number (2548), so I cannot be certain that the invoice relates to the CTV Building job. Based on the quantum of the account, it appears to be for computer time only, which (if it does relate to the CTV Building) would suggest that the inputs were prepared by Mr Harding and run through the computer. If a University staff member worked on the analysis, I would expect this to be noted on the account and the account to be higher. The computer analysis was probably an earlier version of the ETABS program.

Construction

50. I do not recall being involved in construction of the building, or having any direct dealings with Williams.

51. As a design-build contract, the engineer's role was potentially diminished. Any site visits would have been carried out by Mr Harding or under his direction. I do not know to what extent he would have visited the site. At most, Mr Harding's role would have been one of observation, not supervision. He may have visited the site before major concrete pours.

52. I note that a Council engineer visited the site from time to time, as I would have expected **[BUI.MAD249.0117B.1]**.

53. As noted above, Williams had a strong history and a reputation as a high quality contractor, specialising in concrete construction. Its pre-cast concrete work, in particular, was of a high standard.

54. I do not recall becoming aware about the ownership issues of Williams on site at the time of construction of the CTV Building, which resulted in the building being finished by Union Construction Limited.

As built drawings

55. ARCL has no record of any as-built drawings for the CTV Building and it is unlikely that there would have been any. They were not normally prepared at that time and the Council would not normally have required them.

56. However, I note that there are differences between the set that ARCL has in its records compared to the Council's records. The set of drawings annexed to the DBH report **[BUI.MAD249.0191]** appears to be the set that I provided to Dr Hyland and which is held on ARCL's file. However, some of these drawings appear to differ from the Council's set. A slightly different set of drawings appears on the Council files **[BUI.MAD249.0284]**.

57. For example on the ARCL S25 there are at least 3 additional details and in the bottom right corner it is noted that S25 was amended on 29 April 1987 **[BUI.MAD249.0191.26]**. This compares to the Council's signed plans dated 30 September 1986 **[BUIMAD249.0284.26]**. There are also differences on S26 **[BUI.MAD249.0191.27 and BUI.MAD249.0284.27]**. There is no notation as to date of amendment on the ARCL S26. Neither set are as-built drawings.

Compliance

58. As the design engineer, Mr Harding was responsible for ensuring that the design complied with the relevant codes. I expect that Mr Harding would have taken all reasonable care to ensure that this occurred.

59. Traditionally ARCE did not include a design review and, as a small firm, relied on the Council review process. ARCE was different in this respect from other, larger, firms where there was a core group of engineers who could review each other's work.

SECOND STATEMENT OF EVIDENCE

Landsborough House

5. This building on the corner of Gloucester and Durham Streets was designed in 1985 by John Henry when he was with ARCE. Mr Henry discusses his design work on Landsborough House in his evidence **[WIT.HENRY.0001]**. He makes observations about the design of Landsborough House and states that parts of its design were utilised in the work Mr Harding did in designing the CTV Building, including that Mr Harding adopted many of Mr Henry's calculations for Landsborough House when designing the CTV Building.

6. I have reviewed the structural drawings and calculations for the Landsborough House Building. The design was generally similar to the CTV Building. I comment on some particular features, and how they compare to the CTV Building below.

Height

7. Landsborough House was eight storeys and the CTV Building six storeys. The CTV Building had 40% larger floor plates.

Asymmetry

8. The design asymmetry of the buildings is similar, with the Landsborough House Building being slightly more asymmetric.

9. The beam column structures of both buildings are designed as secondary structural elements in terms of NZS3101:1982.

Construction

10. Both buildings used pre cast concrete beams, insitu concrete columns and shear walls for lateral earthquake loads including coupled shear walls with diagonal reinforcing.

11. The buildings differed in the location of the coupled shear walls, or wall in the case of the Landsborough House Building. The coupled shear wall was an integral part of the core shear wall system to Landsborough House, but the coupled wall was a separate wall on the south side opposite the side of the northern shear wall system for the CTV Building.

Suspended Floors

12. The suspended floors differ in that the CTV Building has a metal Bondeck floor with 664 mesh and the Landsborough House Building has a concrete rib and infill floor with the topping slab reinforced with 665 mesh. The CTV Building has 28% more mesh per square metre within the mesh reinforced floor than the Landsborough House Building.

Columns

13. The reinforcement of the columns varied. Neither was designed for additional requirements of ductile seismic detailing under NZS 3101:1982. The columns in the Landsborough House Building were generally 400mm square with ties of 10mm at 150 or 250mm centres generally. The CTV columns were 400mm circular columns with 6mm ties at 250mm centres. The vertical reinforcing laps were 900mm for the Landsborough House Building and 1200mm for the CTV Building.

Foundations

14. The foundations differed in that the Landsborough House Building was supported on piles, and the CTV Building was based on shallow footing foundations.

Landsborough House Earthquake Damage

15. I inspected Landsborough House on 16 May 2012. Damage to the structure that was evident on this date was as follows:

    (a) **Shear Walls**: There was minor cracking to the shear walls surrounding the shear core.

    (b) **Coupling Beams**: The coupling beams, particularly at the lower levels, had substantial damage and would have introduced a significant degree of flexibility on the coupling beam shear wall line of the building.

    (c) **Stairs**: There was no significant damage to the stairs or supporting system.

    (d) **Columns**: There was some limited movement between the column and the beam soffit interface at the top of the column with some limited initiation of column cover concrete spalling.

    (e) **Beam Column Joints**: There was no evidence of cracking or joint failure.

(f) **Floor Diagram**: There was no cracking to the floor diagram in the immediate area where the floor was adjacent to the shear wall system.

(g) **Foundation Levels**: I understand that the differential settlement of the foundations is approximately 100mm.

16. Based on my inspection, the Landsborough House building has performed satisfactorily with no significant damage to the columns, beam column joints or stairs.

Additional factual evidence

73. As a result of locating additional records in historic files held by ARCL, I wish to give some supplementary factual evidence.

74. I have located the ARCE time records from the time of the CTV Building project. I produce these records **[BUI.MAD249.0463.1]**. The CTV Building was job number 2503. Other job numbers, names of staff that are not involved in this hearing and totals have been redacted. The schedule **[BUI.MAD249.0463A.1]** summarises the time spent by various staff members on the project.

THIRD STATEMENT OF EVIDENCE

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.

Dated this 27th day of July 2012

A M Reay

Schedule – Summary of ARCE time records for Job 2503

	Reay	Harding	Strachan	Horn	Draftsperson	Draftsperson	Tracer	Tracer	Admin	Printing
Feb 86	2.0									
Mar 86		22.0								
Apr 86		24.0								$1.80
May 86		21.25							0.5	
Jun 86	1.5	100.5								
Jul 86		71.0		49.75		22.5		4.5	1.5	$46.04
Aug 86		28.75	0.75	82.5	89.5	97.0	22.0	87.0	6	$222.32
Sep 86		21.75	2.0	8.75	27.5	13.25	0.5	36.25	0.75	$720.56
Oct 86		7.0							1.0	$1.20
Nov 86		6.0				0.25			1.25	$30.60
Dec 86		2.5							0.5	$0.72
Total	**3.5**	**304.75**	**2.75**	**141.0**	**117.0**	**133.0**	**22.5**	**127.75**	**11.5**	**$1023.24**