Christchurch City Council

UNDER	**THE COMMISSIONS OF INQUIRY ACT 1908**
IN THE MATTER OF	**ROYAL COMMISSION OF INQUIRY INTO BUILDING FAILURE CAUSED BY CANTERBURY EARTHQUAKES** **KOMIHANA A TE KARAUNA HEI TIROTIRO I NGĀ WHARE I HORO I NGĀ RŪWHENUA O WAITAHA**

STATEMENT OF EVIDENCE OF JOHN STUART O'LOUGHLIN IN RELATION TO THE CTV BUILDING

HEARING BEGINNING: 25 JUNE 2012

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INTRODUCTION

1. My full name is John Stuart O'Loughlin. I am a Structural Engineer living in Christchurch.

2. I graduated with a Bachelor of Science from Canterbury University in 1968. I then commenced my degree in engineering and graduated with a Bachelor of Engineering (Honours) in 1970, also from Canterbury University. I then worked for the predecessors of what is now known as Holmes Consulting Group. I commenced my own practice in 1974, which was known as O'Loughlin Taylor Spence Limited. Since 1974 I have been engaged on a significant range of commercial and industrial buildings throughout Christchurch and the South Island. I have 42 years experience in the profession. Along with my business partner, we sold the business of O'Loughlin Taylor Spence Limited to Babbage Consultants Limited in January 2012, and the name changed to OTS Limited. I am currently employed by OTS Limited as a consultant.

3. I was a Chartered Professional Engineer and an International Professional Engineer until December 2010. I am currently a Member of the Institution of Professional Engineers of New Zealand (MIPENZ).

4. Throughout my career I have dealt closely with Council reviewing engineers on a regular basis in Christchurch and in other locations in New Zealand. I am also regularly required to review the work of other engineers within OTS Limited and my current role involves a large element of supervision and oversight. I am currently being frequently asked to peer review the work of other consultants from outside our office.

5. I have been asked by the Christchurch City Council to provide the following evidence concerning the CTV building:

(a) The expectations of the engineering community in Christchurch in the 1980's as to the nature of the structural review undertaken by Christchurch City Council reviewing engineers in the context of considering applications for building permits.

(b) In relation to the non compliances identified in the Hyland Smith *CTV Building Collapse Investigation* report (**the "Hyland report"**), how difficult it would have been for a competent Council Engineer carrying out a review of the documents submitted with the building permit application, to have identified these alleged non-compliances.

(c) Any other relevant matters arising out of a review of the Christchurch City Council file for the CTV building permit, and in particular the Council's approach to the processing of the 1986 building permit application.

6. I have read the Code of Conduct for Expert Witnesses and agree to comply with it. I confirm that all of the matters to be addressed in my evidence are within my areas of expertise.

REVIEW OF RELEVANT MATERIAL

7. I have reviewed the original calculations for the structural design of the CTV building undertaken by Alan Reay, Consulting Engineer. These calculations are pages numbered G1 to G79, S1 to S57, and F1 to F52. (The last page is presumably F52 although unnumbered) (**BUI.MAD249.0008**).

8. The relevant New Zealand concrete and loading standards current at the time of the design of the CTV building were NZS 3101 Part 1:1982, Code of Practice for the Design of Concrete Structures (**NZS 3101**), and NZS 4203:1984, Code of Practice for General Structural Design and Design Loadings for Buildings (**NZS 4203**). I understand that these two documents were the standards that applied to the design of reinforced concrete buildings under the Christchurch City Council's Bylaw 105 (1985), at the time of the issue of the building permit for the CTV building (1986). I have reviewed these documents, as well as NZS 3109:1980 and NZS 3101 Part 2:1982 Commentary as they relate to the CTV building design.

9. In addition, I have read the following documents for the purpose of preparing this Statement of Evidence:

(a) The Hyland report. (**BUI.MAD249.0189**)

(b) CTV Building Site Examination and Materials Tests, for Department of Building and Housing, January 2012, Hyland. (**BUI.MAD249.0126**)

(c) Structural Performance of Christchurch CBD Buildings in the 22 February 2011 Aftershock, February 2012, Expert Panel Report **(BUI.VAR.0056).**

(d) William T. Holmes Peer Review of the Hyland Smith report dated April 30 2012 (**BUI.MAD249.0372**).

(e) The structural drawings for the CTV building as stamped and dated 30 September 1986 by the Christchurch City Council. These drawings are on Alan M. Reay Consulting Engineer drawing sheets and are identified as File 2503, numbers S1 to S39 inclusive. There are no amendment identifiers on the drawings.

(f) Sections of the Specification issued as part of the permit documentation (**BUI.MAD249.0199**). These are the sections relating to:

(i) Excavation and Hardfill;
(ii) Concrete and Reinforcing Steelwork;
(iii) Precast Concrete; and
(iv) Structural Steelwork.

(g) The "CTV Building Geotechnical Advice" report prepared for StructureSmith by Tonkin & Taylor (**BUI.MAD249.0083**).

(h) The evidence of Dr Arthur O'Leary (**WIT.OLEARY.0001**), Nigel Priestley (**WIT.PRIESTLEY.0001**), Peter Nichols (**WIT.NICHOLS.0001** and **0001A),** Stephen McCarthy (**WIT.MCCARTHY.0001**) and the third statement of Ashley Smith (**WIT.SMITH.0003**).

BACKGROUND TO ENGINEERING PRACTISE IN THE 1980'S.

10. The early 1980's was the dawn of the computer era in engineering practise in New Zealand. Personal computers were available but with very limited storage capacity or capability. Larger mainframe computers were available on a time

use basis, but most calculations for small and medium sized projects were completed manually using scientific calculators. I am not surprised to see the extent of hand calculations for the CTV building. The only reference I can find to computerised computations is at S11 to S23 (**BUI.MAD249.0272.11-23**), which appears to be the ETABs output.

11. Software for structural analysis programmes was available, but programmes for performing more sophisticated analysis came later. For example, the push over analysis, which was the result of research at Canterbury University during the early to mid 1990's, and published about 1997.

12. In my experience, at the time the cost of a building permit for the construction of a building of a similar size to the CTV building, would be approximately $2,500. This fee would cover the cost of checking all building permit issues, including planning, carparking and traffic, fire, architectural and structural details. In my opinion the structural checking would have been likely to take approximately 1 full day in total, taking into account the total fee and the other items that needed to be considered. By comparison, a full peer review for a building like the CTV building, in today's terms, would take 5 to 6 days by an experienced engineer and cost around $7,000.

13. It was my experience however that at the time the CTV permit application was processed, cost did not control the effort or time put in by processing officers to check a permit application, their overriding requirement was to be satisfied that the building complied with the relevant Bylaws. Difficult or complex projects were seldom put out for peer review to other consultants at the time the CTV building permit was processed.

THE COUNCIL REVIEW PROCESS

14. It is important to understand the role that the Council reviewing engineers had when considering plans submitted for building permit applications. I would draw a clear distinction between the design role of an engineer and a review role. Designers are tasked with ensuring that the building complies with the Standards of the day and with coming up with a design that works within the instructions given by the client. It was not the reviewing engineer's task to debate these matters. Rather, the role involved checking at a general level that

the designer had considered and dealt with compliance issues appropriately.

15. I have read the letter of 17 August 1986 to Alan Reay Consulting Limited from Graeme Tapper (**BUI.MAD249.0141.14-15**) on behalf of the Christchurch City Council. It was not uncommon to receive similar letters from Council staff after plans had been submitted on a building permit application. I regularly received these and often dealt directly with Council engineers over the types of matters raised in the letter. In my view, the purpose of such letters was to check that a design engineer had appropriately dealt with any queried issues.

16. I have read the two briefs of evidence filed with the Royal Commission by Peter Nichols (**WIT.NICHOLS.001** and **0001A**). His recollection of the role played by a Council reviewing engineer broadly accords with mine. I note that Mr Nichols refers to a number of basic mathematical checks that he would typically carry out on a set of plans. If it was typical for Council reviewing engineers to carry out these kinds of checks, I do not recall any reviewing engineer at that time referring me to his calculations when querying aspects of any plans I submitted. I therefore suspect that Mr Nichols' practice may have gone further than the practice of other reviewing engineers at other Councils. Alternatively, the checks Mr Nichols is referring to would most likely have been at a very general level.

17. With the building consent process now in operation under the Building Act 2004, it is much more common for projects to be issued to a large or specialised consulting firm for peer review. Under the Building Consent process, the applicant pays for all such costs.

18. From the 1970's up to the mid 1980's when the CTV permit was processed, I dealt with building permit applications and associated issues with the Dunedin City Council, Christchurch City Council and Wellington City Council on mid-size to large projects, as well as most smaller City and Borough Councils throughout the South Island. On a regular basis during my practice in Christchurch, I dealt with both Bryan Bluck and Graeme Tapper at the Christchurch City Council, during the years they were employed by the Council.

19. I always found the Christchurch City Council staff to be astute and competent in handling the permit processing. The Christchurch City Council employed competent engineers who were respected and were active as members of the

local engineering community. The structural checking section did not have the staffing resources that some consulting engineering companies possessed, but they compared favourably with Dunedin and Wellington cities and more than favourably with the smaller Councils and Boroughs, many of which did not employ engineers at all, but relied on building inspectors to process building permits.

20. As intimated earlier, computers and software analysis programs were in their infancy in 1986, and I don't believe the Christchurch City Council made much use of these tools for structural checking of that time. I don't recall seeing computers in their offices and most checking was by visual study of the permit documents and manual checking of calculations with calculators. The same was true of Dunedin and Wellington City Councils.

THE HYLAND SMITH REPORT – DESIGN, CONSTRUCTION AND STANDARDS ISSUES

21. I have read the Hyland Report, and the comments by Dr O'Leary on this report, as to whether the CTV building complied with the applicable standards and Bylaws of the time. I now deal with each issue raised at pages 27 – 30 of the executive summary in the Hyland report in turn, with respect to building permit processing. My comments take into account the expected time a reviewing engineer would have to process his or her section of a building permit, which would be approximately 1 day in total. I have also borne in mind that the period when the building permit was processed was about the height of the property boom, prior to the 1987 share market collapse, and the Council would have been processing more than the average number of building permit applications.

22. From an initial inspection of the structural drawings, it is clear that the lateral loads of the building were intended to be taken in the east west direction by the east west shear walls on lines 1 and 5, and in the north south direction by the shear walls on lines C, C/D, D and D/E.

23. The detailing of the frames on lines 2 and 3 was consistent with gravity frames only, and the block wall on line A levels 1 – 3 was separated from the columns and beams, and so was intended to act as a boundary fire wall only.

Building Inter-storey Drift Limits and Drift Capacity of Columns (and Column Confinement)

24. The application of the loading standard (NZS 4203) and the concrete standard (NZS 3101), to the design of concrete columns is a difficult area where there is room for varying approaches. I have read the evidence of Dr Arthur O'Leary (**WIT.OLEARY.0001**), William Holmes (**BUI.MAD249.0372**) and Ashley Smith's third statement (**WIT.SMITH.0003**). The varying views of these experts illustrates this point.

25. At a practical level, Council reviewing engineers did not in my experience enter into the detail of these alternative options. The standards provided for a variety of approaches and it was up to the design engineer to provide a workable solution, given the demands of the client. A Council reviewing engineer would not normally debate the design option chosen by the designer.

26. When it is obvious that the columns do not form part of the lateral load resisting system of a building, the approach would have been that the columns did not need to be designed for ductility. Columns for these types of buildings were simply treated as props. In my view, it would have been completely impracticable for a reviewing engineer to carry out the kind of review necessary in order to make fine judgements about the application of NZS 4203 and NZS 3101 to the design of concrete columns.

27. I note Dr O'Leary's view that the frame on line F did not comply with NZS 3101, in particular clause 3.5.14.3. I do not disagree with his view. However, when I reviewed the stamped and permitted plans for the CTV building, it occurred to me that the beam column joints set out on S19 could have been interpreted as being pin joints. I also note that this was apparently the intention of the designer, Mr Harding (**WIT.HARDING.0001.12**, paragraph 35.2). The reason I make this observation is that the beam bottom steel shown on detail 7 of S19 is not continuous, rather it is truncated at a bend. Certainly from the perspective of a Council reviewing engineer, this may well have been how the plans were interpreted.

28. In my view, the precise determination of whether the columns were required to be detailed for seismic purposes in terms of the standard required complex

analysis. A number of the present day expert commentators giving evidence in these proceedings, have used computer based mathematical modelling that would simply not have been readily available to the Council reviewing engineers at the time the CTV building was permitted.

Minimum Shear Reinforcing of Columns

29. The requirements for the reinforcing of the columns in the CTV building are dependant on whether the columns needed to be designed as seismic elements or not, as explained by Dr O'Leary at paragraphs 56 – 58 of his first statement (**WIT.OLEARY.0001.15**). Dr O'Leary's view that the columns on grid F were required to be reinforced for shear relates back to his interpretation of NZS 3101 clause 3.5.14.3. As I have said at paragraphs 25, 26 and 28 above, in my view a Council reviewing engineer would not normally enter into a debate about the design options chosen for the building on these fine matters of interpretation. I therefore consider that the reviewing engineer could well have assessed the reinforcing of the columns on the basis that none of them needed to be designed to meet the additional seismic requirements of NZS 3101, and could have assumed that Clause 6.4.7 of NZS 3101 applied. Indeed, the designer's calculations show the spiral reinforcing to be calculated as clause 6.4.7, which is without shear in the member (**BUI.MAD249.0273.44**).

30. I confirm that the spiral hoop reinforcement complies with clause 6.4.7 of NZS 3101, which covers limits for transverse reinforcement on columns and piers.

Spandrel Panel Separation

31. This issue was raised in the Hyland report at pages 110 – 111. The report concludes that there was insufficient separation between the specified spandrel panels and the columns on line 1 and grids A and F. I note Dr O'Leary's view, at paragraphs 59 – 62 of his first statement (**WIT.OLEARY.0001.15-16**), that the plans specified a sufficient (10mm) clearance between each panel and the columns on either side.

32. Looking at the plans, the gap between grids 2 and 3 on Plan S15 is specified as 7.5m. Each column is 400mm, leaving a clear distance between columns of 7.1m. The spandrel panels are specified as 7.08m long on Plan S25. Therefore I agree that the plans specified a 10mm gap at the end of each

spandrel panel.

33. I believe that a Council reviewing engineer, without calculating the likely deflection, could have reasonably considered that this was an adequate clearance.

Beam-Column Joints

34. Whether the beam column joints were required to be detailed for seismic purposes is dependant on issues of interpretation and application of NZS 3101. Dr O'Leary deals with these issues at paragraphs 63 to 69 of his first statement of evidence (**WIT.OLEARY.0001.16-18**).

35. For the reasons I set out at paragraphs 25, 26 and 28 above, in my discussion concerning the columns, in my view it would have been impracticable for a Council reviewing engineer to carry out the kind of review necessary in order to make fine judgements about the application of NZS 4203 and NZS 3101 to the design of the column beam joints.

Plan Asymmetry and Vertical Irregularity

36. In my view, a Council reviewing engineer could reasonably have formed the view that the building was not particularly asymmetric. The building as specified had shear walls on both the north and south sides, and I believe that overall a reviewing engineer could have considered the building to be reasonably symmetrical about the centre of gravity.

37. The only qualification to this view relates to the block wall on line A, which extends over the bottom three levels. This wall is on the west side of the building and is not mirrored by a similar wall on the east side. If the wall was intended to operate as a stiff design element, this would have introduced a degree of asymmetry into the design. However, the plans show the wall as being separated from the columns, so it is clear that it was not intended to operate as a shear wall.

38. The Hyland report indicates on page 112 that there may have been an issue with the vertical irregularity of the building. This issue seems to be related to construction issues with the wall on Line A. As discussed, it is clear that the

wall was intended by the designer to be separated from the rest of the structure. In my view, a Council reviewing engineer could have reasonably concluded that vertical irregularity was not an issue.

Wall on Line A

39. As stated this was shown to be separated. If indeed it was not, then that would be a construction issue that occurred after the building permit processing.

Diaphragm Connection

40. This matter is raised at page 113 of the Hyland Smith report. Dr O'Leary discusses the issue at paragraphs 77 to 82 of his first statement of evidence (**WIT.OLEARY.0001.19-20**). Both Hyland Smith and Dr O'Leary conclude that the diaphragm connections to the northern shear core wall were insufficient. Before dealing with how the Council reviewing engineer could have approached this issue, I would like to make some general observations about how diaphragm connections were understood during the 1980s.

41. In my view, the question of adequate connection between the floor diaphragms and the lateral load resisting system was not a significant check item during the early 1980's, probably because at this time shear walls were generally designed to be of adequate total length in relation to total floor area. By check item, I mean an item that would traditionally have attracted the attention of a reviewing engineer.

42. During the 1980s, designers increasingly wished to provide open, airy and sunlit offices. Long boundary shear walls were often inconsistent with this requirement. The trend was to reduce the overall length of shear walls in relation to floor plan areas. Consequently, the need to have an adequate connection between the smaller shear walls and the floor diaphragms was gaining more recognition than previously.

43. In addition, earthquake engineers became increasingly focussed on this issue following the October 1989 San Francisco earthquake. There were a number of well recognised instances where floor plates had separated from shear walls in buildings subjected to the earthquake. Reconnaissance teams from New Zealand visited San Francisco and came back with reports of what had

occurred.

44. Therefore, in my view by 1990 there would likely have been increased awareness of the significance of the connection of diaphragms to shear walls in earthquake engineering, by comparison with the start of the decade.

45. I note that Mr Tapper did indeed identify an issue with the connection between the shear wall system and the floor slabs in his letter of 27 August 1986 (**BUI.MAD249.0141.14-15**). It appears to me that the structural plans to which Mr Tapper is referring in his letter of 27 August, were different to the permitted drawings, stamped 30 September 1986. Mr Tapper identifies a number of matters to be attended to in his letter. He indicates for example that, *"S16 shear core floor slab and stair landing details are missing".* The stamped copy of S16 clearly shows these details.

46. Equally, Mr Tapper states, *"Sh15 incomplete notes. Ref line 1 – Hi-Bond mesh reinforced casing does not provide restraint to Hi-Bond for f.r.r purposes. Also floor connection to shear wall system and general connection between floor slab and walls".* Mr Tapper may have been identifying an omission in the plans he was reviewing at the time related to the floor slab diaphragm connections. It may be that the stamped copy had some additional information on it that showed that the design engineer had considered the issue which had been raised.

47. Mr Tapper also requested a copy of the calculations to support the design in his 27 August 1986 letter. The calculations I have reviewed show the mechanism to transfer loads from the slab diaphragm to the shear walls on pages S56 and S57 (**BUI.MAD249.0272.65-66**). I note that the calculations mark the load as *"ok"* at the bottom of S56. The calculations showing the mechanism to transfer shear to the shear walls are set out on page S57. The calculations indicate a reinforcing requirement of *"D12 at 400 centres slab ties at core wall".* This level of reinforcing on its own may not have seemed unusual. However, the length of wall over which the force was to be transferred was only 1.4m, which means that there would only have been room for four D12 bars. I would not have considered that reinforcing to be adequate.

48. In order for the Council reviewing engineer to have picked up this lack of connection, a critical review of the calculations would have been required. In my view, the issue should have been picked up by the reviewing engineer.

49. I also note that there is an error on S57 where the shear stress is calculated using a figure of 30,000 newtons, whereas the maximum shear to side walls shown at the top of the page, first line, is 300 kilonewtons or 300,000 newtons. The figure appears to have been mistranslated. This has the effect of significantly increasing the load to be transferred and a significant underestimate of the required reinforcing. I note that this error has not been discussed by other expert witnesses. A line by line analysis of the calculations would have been required to identify this error and in my view, it would therefore not have been readily apparent to a Council reviewing engineer.

Robustness

50. The question of robustness is dealt with in chapter 9 of the Hyland Smith report and Dr O'Leary discusses it at paragraph 83 of his first statement (**WIT.OLEARY.0001.20**). My understanding is that neither NZS 4203 nor NZS 3101 define the concept of *"robustness"*. In practice, in my view a building was robust if it complied with the standards of the day.

Documentation

51. The issues concerning documentation are raised at page 114 of the Hyland report. In my view, the plans and specifications for the building were of a reasonable standard in common with the practice of the day.

CONCLUDING COMMENTS

52. I have tried in this evidence to convey to the Commission the general scene of building design and permit processing in the mid 1980's, rather than discussing contentious technical issues such as whether gravity frames should be designed for ductility. I have left these issues to the many highly qualified experts to agree or disagree upon.

53. In my view, the scope of the Council reviewing engineer's role during the 1980s was quite limited. A detailed peer review of plans and calculations provided on

a permit application was impracticable. The approach was as described by Mr Nichols in his first and second briefs of evidence. Council reviewing engineers were checking that matters had been dealt with by the designer in general terms. They would not enter into debates about design options chosen. In relation to the drift capacity of columns and column reinforcement, in my view it would have been impracticable for a Council engineer to carry out the kind of review necessary to make fine judgements on the application of clause 3.5.14.3 of NZS 3101.

54. In terms of the issues concerning the diaphragm connection, it is not clear to me whether the matters raised by Mr Tapper had been dealt with by amended plans being provided. A review of the calculations provided to support the design would have revealed weaknesses with the design approach.

55. The other matters identified as non compliances in the Hyland Smith report which are spandrel panel separation, plan asymmetry and vertical irregularity, the wall on Line A, robustness and documentation, are not matters that I consider would have raised the attention of a Council reviewing engineer.

Dated: 18/6/12

Signed by:

Name: John Stuart O'Loughlin