

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 NGA
WHARE I HORO I NGA RUWHENUA O WAITAHA**

AND IN THE MATTER OF THE CTV BUILDING COLLAPSE

**REPORT OF PROFESSOR ATHOL CARR, FACILITATOR OF NON-LINEAR TIME
HISTORY ANALYSIS PANEL**

DATE OF HEARING: COMMENCING 25 JUNE 2012

**FIRST STATEMENT OF EVIDENCE OF ATHOL JAMES CARR
IN RELATION TO THE NON LINEAR SEISMIC ANALYSIS OF THE CTV
BUILDING**

INTRODUCTION

1. My name is Athol James Carr. I live in Christchurch. I am a Professor Emeritus in the Department of Civil and Natural Resources Engineering at the University of Canterbury.

QUALIFICATIONS AND EXPERIENCE

2. I graduated from the University of Canterbury in May, 1964 with a Bachelor of Engineering (Civil) with First Class Honours. In June 1966 I graduated from the University of California, Berkeley, with a Master of Science in Engineering. In June 1967 I graduated from the University of California, Berkeley with a Doctor of Philosophy.
3. I am a Fellow of the Institution of Professional Engineers New Zealand ('IPENZ'). I am a member of the New Zealand Structural Engineering Society ('SESOC') and I am a Life Member of the New Zealand Society for Earthquake Engineering ('NZSEE'). I am a Member of the American Society of Civil Engineers ('ASCE').
4. I am a member of the Faculty of the Rose School (Centre of Post-graduate Training and Research in Earthquake Engineering and Engineering Seismology), University of Pavia, Italy. I teach a course Structural Dynamics and Earthquake Engineering Analysis. This course focuses on non-linear time-history analyses.
5. I have an Adjunct Professorship at the Earthquake Engineering Research Centre, University of Iceland.
6. My areas of specialist professional expertise are in structural dynamics, non-linear time-history analyses of structures and finite element analyses of structures.
7. I have been actively involved in writing engineering software for structural analyses for structures subjected to dynamic excitation since 1965.
8. I have authored and co-authored over 260 journal papers, conference papers and engineering reports. I am a co-author of a book on the development and using of engineering computer software, and their user and maintenance documentation for the programs.
9. I practiced as a graduate structural engineer in 1963 and 1964 when I joined Bill Lovell-Smith, Consulting Engineer, Christchurch. I was involved in designing reinforced concrete buildings, tilt-up buildings and structural systems

such as folded truss roofs. I designed a nine storey reinforced concrete building with pre-stressed lift slab for Christchurch. I also designed the Spitfire stand near Christchurch International airport.

10. I joined the Department of Civil Engineering, University of Canterbury in January 1968 and I retired at the end of April 2010.
11. In my teaching at the University of Canterbury I have focused on structural mechanics, structural dynamics, finite element analysis and computer-based methods of analysis of engineering systems. I taught courses on Numerical Mathematics to final year undergraduates from 1968 to 1993. I taught Structural Analysis (covering multi-degree of freedom dynamics, modal analysis methods and time-history methods) to final year civil engineering undergraduates from 1980 to 2011. For most years from 1973 to 2010 I have taught post-graduate courses in both Structural Dynamics (time-history analysis) and Finite Element Methods. I have also taught courses in computer programming for engineering students.
12. One of my research interests has been in Finite Element methods of analysis. My initial interest was in dynamic analysis of thin shell structures but this evolved into modelling structural walls, floor diaphragms and box girder bridges. From 1976 to 1995 I was involved with the Wool Research Organization of New Zealand (WRONZ) in developing finite element analyses to aid in the understanding of wool yarn behaviour.
13. I have been actively involved in research using non-linear time-history analyses since 1972. My work, together with post-graduate students, into modelling of components and entire structures has led to an understanding of the validity of computational methods that can be used by the engineering profession to analyze structures subject to excitations that take the structure well beyond the elastic limit.
14. In 1980 I produced the first version of the non-linear time-history analysis program *Ruaumoko* for the analysis of buildings and bridges subjected to earthquake and other dynamic loads. A three dimensional version of the software was released in 1999. This program is now used by 130 organizations around the world. These organizations include universities (who use the software for teaching and research purposes), building research institutes, highway authorities (for bridge analyses) and consulting engineering practices.
15. During my career in civil engineering I have been consulted by many New Zealand and International engineering consulting practices, including, Holmes, Wood, Pool and Johnston, Edwards, Clendon and Partners, BECA, Aurecon, KRTA, Duffill Watts and King Ltd, Frame, Harvey and West (Papua New Guinea), Nyverk (Iceland) and the NZ Marine Department, Shell, BP and Todd

16. Projects where structural dynamic behavior and modeling was outside the experience or capabilities of the consulting practices included the projects such as the Sky-Tower and Union House and Mid-City IV buildings in Auckland, analyses bank buildings, peer review of retrofit for buildings and advice on sub-station analyses in Wellington, Lincoln College Library in Christchurch. Union House was the first base-isolated building in New Zealand that was built subject to the normal New Zealand Building Standards. I was asked to advise on the strengthening of a lift-slab school dormitory near Reykholt and the County office and library building in Selfoss in Iceland.
17. In the early 1970s I used state of the art thin shell techniques to analyze ferrocement fishing trawlers for the NZ Marine Department and for analyzing nozzle-shell interfaces in the pressure vessels subjected to earthquake excitation for the Ooanui gas treatment station (part of the Maui offshore development). This study included verifying the finite element solutions with both the British and American pressure vessel standards. I also undertook finite element analyses for the Travelodge hotel building in Queenstown which was probably the first application of finite element analysis for a building in New Zealand. I also used finite element analyses for two concrete arch dams which were being designed for the Teviot River power scheme in Central Otago. Other analyses included the spillway gate towers for the Roxborough Power Station. I was asked by SINTEF to aid in the seismic assessment of LNG tank support structures in Norway.
18. In the 1970s and early 1980s I took part in a series of dynamic bridge testing using a shaking machines to identify the natural frequencies of vibration and use these to calibrate computational models of the bridges. The bridges were the Timaru Port access bridge, highways bridges at Westport, Cobden and Stillwater on the West Coast, the Mangatiwi-iti bridge near Dannevirke, the Toe-toe bridge near Taihape and the Dominion Road Viaduct in Auckland. This work was funded by the NZ Roads Board.
19. I have taught professional courses on non-linear time history dynamic analyses for the Chilean Earthquake Engineering Society and for Icelandic engineers. I have helped teach a series of one day professional development courses on Earthquake Engineering for IPENZ.
20. 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.

21. I have prepared a report which includes a record of all communications and documents discussed by the panel. The index of this is attached and marked "A" [WIT.CARR.0001A]. The report is attached and marked "B" [WIT.CARR.0001B].

Signed: 
ATHOL CARR

Dated: 16th July 2012