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

BRIEF OF EVIDENCE OF CLARK WILLIAM KEITH HYLAND
IN RELATION TO THE CTV BUILDING

DATE OF HEARING: COMMENCING 25 JUNE 2012

BRIEF OF EVIDENCE OF CLARK WILLIAM KEITH HYLAND IN RELATION TO THE CTV BUILDING

1. My full name is Clark William Keith Hyland. I live in Manukau. I am Director of Hyland Fatigue + Earthquake Engineering, a specialist consulting engineering company.
2. I prepared the report on the CTV Building Collapse Investigation (BUI.MAD249.0189) ("the BCR") for the Department of Building and Housing jointly with Ashley Smith of StructureSmith Ltd.
3. I have read and agree to comply with the Code of Conduct for Expert Witnesses.

Evidence

4. Since the release of the BCR other witnesses have become known and a number of the witnesses previously interviewed have prepared Statements of Evidence for the Royal Commission.
5. This brief of evidence therefore has been prepared in order to review the new evidence put forward and identify any changes of my opinion to those expressed in the BCR that may have occurred due to the new evidence.
6. The witness locations and perspectives of the witnesses described in this Brief of Evidence only supersede those shown in Appendix A of the BCR for the same witnesses.

Academic Qualifications

7. PhD in Civil Engineering, University of Auckland, 2009

   BE(Civil), University of Auckland, 1985

   BCom (Management Studies), University of Auckland, 1986

   NZIW Certificate of Welding Engineering, NZ Institute of Welding, 1999

   DipCL (Cross-cultural Communication), New Covenant International Bible College, 1996

Professional Practice Qualifications

8. Registered Engineer (New Zealand), 1989

   Registered Structural Engineer (Papua New Guinea), 1992

   Chartered Professional Engineer, 2004

Professional Service

9. IPENZ CPEng Practice Area Assessor

   NZ Society for Earthquake Engineering: Management Committee Member

   Convenor of Southwest Pacific Earthquake Resilience Workshop, Wellington 2011

   NZ Structural Engineering Society: past-committee Management Committee member

   Auckland Structural Group: past-committee member

New Zealand Standards Committees

10. NZS 3404: 1997 Amendment 2 2007 Steel Structures Standard: Committee Member

    NZS 3404.1:2009 Part 1 – Materials, fabrication and construction: Committee Chair

Joint Australian /New Zealand Standards

11. BD23: Structural Steel Products: Committee member

    AS/NZS 1163:2009 Cold-formed structural steel hollow sections

    AS/NZS 3678:2011 Structural Steel Plate

    AS/NZS 3679.1:2010 Structural Steel Part 1: Hot Rolled Sections

    AS/NZS 3679.2:2010 Structural Steel Part 2: Welded I Sections

Design Guides Authored

12. SteelDoc: Steelwork Documentation Guidelines

    SteelDeck: Design for Point loads on Composite Metal Decks

    Structural Steelwork Estimating Guide

    Structural Steelwork Connections Guide

    Design Guide for Penetrations in Composite Steel Beams

    SteelEst: Estimating Software

Software developed

13. COBENZ 97: Steel Composite Beam Design Software

    Fatigue design of lighting poles

University Lecturing

14. Structural Design 3 lecturing on Steel structures and tutoring in Engineering Design 1 at the University of Auckland 2002 and 2003.

Continuing Education Seminars for Consulting Engineers

15. Preparation and presentation of technical seminars nationwide on structural steel design, construction and estimating topics typically twice-yearly between 1997 and 2009.

Papers Published

16. Cowan, H., Beattie, G., Hill, K., Evans, N., McGhie, C., Gibson, G., Lawrence, G., Hamilton, J., Allan, P., Bryant, M., Davis, M., Hyland, C., Oyarzo-Vera, C., Quintana-Gallo, P., Smith, P., "The M8.8 Chile Earthquake, 27 February 2010", Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 44, No.3, September 2011.

    Wijanto, S., Hyland, C.W.K., Andriano, T., "Lessons Learned from the 2010 Canterbury Earthquake and Aftershocks", 2nd International Conference on Earthquake Engineering and Disaster Mitigation (ICEEDM-II 2011), Surabaya, Indonesia, July 2011.

    Bothara, J., Beetham, D., Brunsdon, D., Stannard, M., Brown, R., Hyland, C., Lewis, W., Miller, S., Sanders, R., Sulistio, Y. "General Observations of Effects of the 30th September 2009 Padang Earthquake, Indonesia", Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 43, No.3, September 2010.

    Bothara, J., Beetham, D., Brunsdon, D., Stannard, M., Brown, R., Hyland, C., Lewis, W., Miller, S., Sanders, R., Sulistio, Y. "Building Safety Evaluation Following the 30 September 2009 Padang Earthquake, Indonesia", Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 43, No.3, September 2010.

    Hyland, C.W.K., Wijanto, S., "Lessons for Steel Structures from the 2009 Earthquake Damage in Padang", Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 43, No.2, June 2010.

Hyland , C.W.K., Ferguson, W.G, “Steel Fracture Behaviour in the Chilean Earthquake February 2010’, International Conference on Structural Integrity and Fracture, University of Auckland, 2010 *(presentation only)*

Hyland, C. W. K., Ferguson, W. G., and Butterworth, J. W. (2007). "Assessment of Cyclic Ductile Endurance of Structural Steel Members." International Journal of Advanced Steel Construction, Hong Kong.

Hyland, C. W. K., and Ferguson, W. G. (2006). "A Fracture Mechanics Based Approach to the Assessment of Seismic Resisting Steel Structures." Fracture of Materials: Moving Forwards 2006, Sydney, 312, pp.89-94.

Hyland, C. W. K., Ferguson, W. G., and Butterworth, J. W. "Recommendations for Improved Material Performance Criteria for Seismic Resisting Steel Structures in New Zealand." International Symposium of Steel Structures '05, Seoul.

Hyland, C. W. K., Ferguson, W. G., and Butterworth, J. W. (2005). "Structural Steel for Seismic Performance." Journal of the Structural Engineering Society New Zealand, 18(1).

Hyland, C., Ferguson, W. G., and Butterworth, J. W. "Assessment of Cyclic Ductile Endurance of Structural Steel Members." Pacific Steel Structures Conference 2007, Wairakei, New Zealand.

Hyland, C. W. K., Ferguson, W. G., and Butterworth, J. W. "Selection of Structural Steel for Seismic Performance." New Zealand Metals Industry Conference 2004, Christchurch.

Hyland, C. W. K., Ferguson, W. G., and Butterworth, J. W. "Effects of Pre-strain and Aging on the Fracture Toughness of Australasian Constructional Mild Steel." Structural Integrity and Fracture 2004, Brisbane.

Hyland, C. W. K., Ferguson, W. G., and Butterworth, J. W. "The Effect of Monotonic Tensile Pre-strain on the Charpy V-Notch Properties of AS/NZS 3679.1 G300 Structural Steel Sections." 2003 Joint Conference of SCENZ / FEANZ / EMG, Institute of Technology and Engineering, Massey University, Wellington, p.59-64.

Hyland, C. W. K., and Ferguson, W. G. "Cyclic Fracture Limit States in Seismic Resisting Steelwork Structures." Proceedings of the Australasian Structural Engineering Conference, 2001, Gold Coast.

Hyland, C.W.K., Clifton, G.C.C., Butterworth, J.W., Stickland, S., “Composite Down-Stand Steel Beam Behaviour with a Profiled Deep-Deck Slab”, Australasian Structural Engineering Conference, Gold Coast, 2001.

Summary of Professional Practice

17. I have 27 years of civil and structural engineering experience. This includes 11 years in general consulting engineering, 10 years as Manager of the Steel Structures Analysis Service at the New Zealand Heavy Engineering Research Association, 3 years as Secretary and Manager of Steel Construction New Zealand, followed by specialist consulting engineering focussing on structural fatigue, earthquake engineering and collapse investigation.

Professional Practice Experience Relevant to the CTV Building Collapse Investigation

18. Collapse and Earthquake Damage Assessment and Reconnaissance

PGC Building Site Examination and Materials Testing Report for the Department of Building and Housing.

Forsyth Barr Stair Collapse Site Examination and Materials Testing Report for the Department of Building and Housing.

Assessment of reinforcing steel damage in the February Aftershock for Pacific Steel Group.

Stadium Southland Roof Collapse Investigation report with StructureSmith, and Laboratory Examination and Testing report for the Department of Building and Housing.

Building safety evaluation data management system development and application support to the Christchurch City Council in the aftermath of the September 2010 Earthquake on behalf of the Department of Building and Housing.

Revision of Building Safety Rapid Assessment forms, guidelines and data management software with David Brunsdon drawing on lessons from Padang evaluations, for the Department of Building and Housing, 2010.

Earthquake damage reconnaissance with NZSEE Chile 2010

Building safety evaluation and repair concept development with NZAID/NZSEE team member to Padang, Indonesia, 2009.

19. Analysis and Strengthening of the Stanford Graduate School of Business after the Loma Prieta Earthquake in 1989, on secondment to Rutherford and Chekene Engineers, San Francisco.

Analysis, evaluation and design for major structural upgrading to compliance with the demands of the USA 1988 Uniform Building Code. This work was initiated after damage to the 5-level building occurred during the October 1989 Loma Prieta earthquake.

The existing concrete shear wall building designed in the early 1960s was analysed using ERSA and strengthened by thickening selected existing shear walls and adding new ones to bring greater regularity and structural symmetry. This then reduced demands on the existing structure to acceptable levels. Upgraded wall thicknesses varied from 450 to 560mm with heavy reinforcement and were constructed using shotcrete.

Cracking in existing walls caused by the earthquake was epoxy grouted prior to the strengthening works. This project was featured in the American Concrete Institute magazine ‘Concrete International’ May 1992.

20. Experience using the Loadings standard NZS 4203:1984 and the Code of Practice for the Design of Concrete Structures NZS 3101:1982 design standards used in the design of the CTV Building.

Ten years practice designing some or all of the reinforced concrete aspects of the following projects from 1985 to 1995 in New Zealand and Papua New Guinea. City Life Apartments; Quay West Apartments; Hobson Centre; BHP Glenbrook: Cogeneration Plant Turbine Hall and Pipe Bridge; 19 Storey Hotel in Federal St; Skycity: Best Dressed; Skycity Development; Barrys Point Rd Shopping Centre; Teaching Block, St Kentigern College; Balfour Rd Apartments, Parnell; People-Mover:Whakarewarewa concept, Rotorua; Serra Wharf, Vanimo, PNG; Wewak Main Wharf Rehabilitation; Lamana

Commercial Development, PNG; Webb Street Apartments; Harbourview Apartments; Nambawan Finance Haus ; Government Haus; Daru Provincial Government Building; Wewak Main Wharf Rehabilitation; Nambawan Finance building; Jackson Airport Redevelopment; 20 storey, Parktower, Port Moresby; 27 Storey PTC Downtown, Port Moresby. Watties Frozen Foods, Gisborne: Addition of corn-cob Conveyor Mezzanines to No. 2 and No. 3 Blast Freezer Tunnels; Pakuranga Shopping Centre Redevelopment; NZ Parliament Buildings Seismic Strengthening Proposals; Princes Wharf Redevelopment proposal; Auckland High Court.

21. Experience using the Specification for Concrete Construction NZS 3109:1980 used in the construction of the CTV Building.

I was involved in the observation and inspection of reinforced concrete construction specified to comply with NZS 3109:1980 for many of the projects described above. In addition during that time I prepared the specification and undertook engineering observation and inspections of 200 metres of Whenuapai Airforce Base runway reconstruction. I also undertook engineering observation and inspections during the construction of the Waiwera River Bridge replacement, and a multi-level teaching block at Carrington Polytechnic.

22. Experience using Elastic Response Spectra Analysis (ERSA) in the design of structures.

I have used ERSA since 1989 on numerous reinforced concrete and steel structures. This includes its use for over 120 preliminary design schemes prepared for consulting engineers around New Zealand including Pacific Tower in Christchurch.

23. Practical work experience relevant to the CTV Building collapse investigation

I worked as a reinforcing steel placer during the construction of reinforced concrete penstock inlet structures for Ohau C and a weir on the Upper Waitaki hydro-electric scheme at Twizel from November 1980 to February 1981.

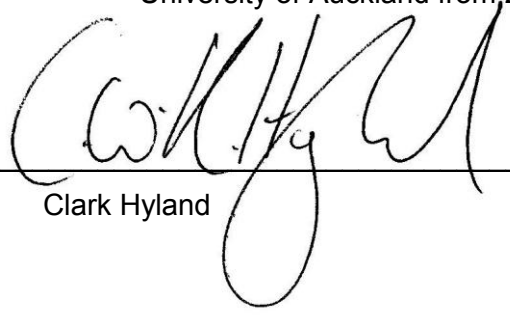
24. Research projects relevant to the CTV Building collapse investigation.

While working at the New Zealand Heavy Engineering Research Association I undertook a number of applied research projects involving the development of a laboratory testing programme, testing, analysis of the results, computer modelling and development of design guidance.

Two of these projects have some relevance to the CTV Building collapse investigation.

Push-off testing of long shear studs with deep composite steel and concrete decking, at the University of Auckland in 2000.

Tall building response to serviceability wind loads project including wind tunnel testing with Opus Central Laboratories, in conjunction with a sponsored undergraduate and Master's research project at the University of Auckland from 2001.

Signed  Date: 24 June 2012

Clark Hyland

Contents

TABLE OF FIGURES

LIST OF EYEWITNESSES

The following is a list of Royal Commission references to Statements of Evidence from and interviews with eyewitnesses shown in the Figures.

Eyewitness	BCR Id	Statement	Interview	Review on page…
Margaret Aydon	3	WIT.AYDON.0001	BUI.MAD249.0051 and .0051A	18
Marie-Claire Brehaut		WIT.BREHAUT.0001	BUI.MAD249.0052	41
Liz Cammock	1	WIT.CAMMOCK.0001	BUI.MAD249.;0044 and .0044A	20
Leonard Fortune	16	WIT.FORTUNE.0001	BUI.MAD249.0047 and .0047A	21
Stephen Gill	9	WIT.GILL.0001	BUUI.MAD249.0058 and .0058A	23
Ron Godkin		WIT.GODKIN.0001	BUI.MAD249.0285	24
Alex Goscomb	5		BUI.MAD249.0043 and .0043A	
Stephen Grenfell	10	WIT.GRENFELL.0001	BUI.MAD249.0059 and .0059A	26
Euan Gutteridge			BUI.MAD249.0048	27
Tom Hawker	15	WIT.HAWKER.0001	BUI.MAD249.0060 and .0060A	28
David Horsley			BUI.MAD249.0436	
Maryanne Jackson	2	WIT.JACKSON.0001	BUI.MAD249.0053	29
Nilgun Kulpe	4	WIT.KULPE.0001	BUI.MAD249.0049 and .0049A	30
Phillippa Lee		WIT.LEE.0001		
Dennis May			BUI.MAD249.0045 and .0045A	

Eyewitness	BCR Id	Statement	Interview	Review on page…
Kendyll Mitchell		WIT.MITCHELL.0001	BUI.MAD249.0047 and .0047A	33
Phil Royal	12		BUI.MAD249.0057 and .0057A	
Christie Seator	13		BUI.MAD249.0057 and .0057A	
Penelope Spencer	8	WIT.SPENCER.0001	BUI.MAD249.0056 and .0056a	36
Mike Williams	7	WIT.WILLIAMS.0001	BUI.MAD249.0055 and .0055A	37

Summary of Reviews

Column Cracking Prior to February Aftershock

Column cracking appears to have been limited to three Level 6 columns and one Level 4 column. The Level 6 columns were C18 attached to the North Core, Column 1/A-B on the south face and one at 3B. David Coatsworth mentioned C18 and 1/A-B. David Bainbridge mentioned Column 3B. The only other column reported to have been damaged was column F4 at Level 4 north east corner as reported by David Coatsworth. Graeme Smith inspected all those columns reported by David Coatsworth for the purpose of preparing remedial works estimates and concurred with the observations of David Coatsworth in terms of their condition.

Level 6 columns would be expected to have behaved differently to the lower columns as they were cantilevered off the Level 6 floor compared to the lower columns which were fixed each end. As cantilevers they would also be expected to respond as parts attached to the primary structure and not to have participated in the primary structure response.

Column C18 was different in that it was connected into the North Core walls and so participated as a member of the North Core. The head of the column attachment to the North Core shows cracking occurred at the attachment in photo by Leonard Pagan and also Peter Higgins. The column was found to have broken away from the North Core in the February Aftershock at that location (BCR Fig 116). The connection also appeared to not have the specified amount of reinforcing steel.

David Bainbridge observed concrete blowouts on this column indicating some level of compressive damage had occurred. The six evenly spaced cracks along the column observed by Peter Higgins indicate tensile flexural damage. Those inspecting the C18 column in the absence of structural drawings or reference back to the original design engineer assumed it connected into a lintel beam. David Bainbridge observed water damage through this area.

The cracking seen in the photos by Peter Higgins and Leonard Pagan in conjunction with the brownish coloured water damage to the attached ceiling indicates that severe damage had occurred to the connection of the column into the North Core. I was not previously aware of this damage.

This damage may have contributed to increased flexibility in the building after the September Earthquake as the column was part of the North Core wall system and therefore contributed to the performance of the North Core. However the Core had significant redundancy of strength and did not collapse in the February Aftershock. If the connection of the C18 column head to the North Core had been stronger and the column had been detailed to match the ductility of the North Core it is possible that column C18 and the floor area tributary to it may not have collapsed but it would not have prevented the collapse of the building as a whole.

The Level 4 column indicates that there may have been Spandrel Panel contact in the south direction that may have been a precursor to damage initiating in columns on this level in the February Aftershock. This is because no other columns along Line F were reported to have been cracked, though the same level of north-south drift would have occurred and the east-west drift at Line 4 would have been less than that at Lines1, 2 and 3 along Line F.

Leonard Pagan noted partitioning and non-structural damage was greatest on Level 2 and 4 in general. However it is not known if this was due to some of the tenancies being vacant on some floors. Level 3 was unoccupied.

Response of Building to Aftershocks

The building was reported to have swayed east –west in aftershocks. The glazing damage reported along the south and east faces was consistent with the torsional response of the building being affected by contact of the masonry infill with the frame on Line A west face as per BCR Fig 53.

Building Groans and Shudders

The Drag bar anchors were specified to be inserted in 2 mm oversized holes in the Drag Bars. This gap would allow slippage to occur without structural consequence. The friction between the Drag Bar and the galvanised metal deck may have caused the groaning sound, which may have been echoed through the lift well, after the connections were loosened by the September Earthquake.

This sort of noise can occur in buildings with slipping steel connections or abutting surfaces. For example Butler mention this on their website with respect to buildings that aren't adequately braced: http://www.bluescopesteel.com.cn/butler/products/difference.asp. A sound track can be heard at Audiosparx of an old metal building creaking in the wind: http://www.audiosparx.com/sa/archive/Foley/Creaky-sounds/Creaking-Metal-Building/357573

Hump in Level 4 Floor and Unevenness

The hump in the Level 4 floor caused concern to a number of occupants. The location appears to have been most likely along the Line 3 beams that ran east-west.

The flooring was vinyl stuck directly to the concrete in the lobby of the Level 4 lifts and reception. No cracks were observed in the vinyl indicating no cracking had occurred on the concrete below. The hump may have been due to thermal expansion of the vinyl on an uneven floor that increased as summer temperatures rose from September 2010 to February 2011.

The floor had been specified to be poured propped with an upward camber and then cast to specified thickness. Bill Jones recalled that this had been done in his interview with me (BUI.MAD249.0042). Such floors are never level or flat unless a levelling compound is poured prior to floor coverings being laid. The flattest area would have been along the beams on Lines 2 and 3. In between the floor would have varied in surface profile. This also could explain the pens rolling off the desks. The floor was also reported to be uneven on Level 5 in the north east corner offices.

North Core Cracks at Lift Area

Horizontal cracks in the construction joints were observed at most levels after the September Earthquake. These appear to have become more obvious after the December Aftershock on Level 5 and 6 according to Liz Cammock. There were also fine diagonal cracks reported in the lower parts of the North Core after the September Earthquake.

The inside of the North Core elevator shaft was inspected on 11th February 2011 by Graeme Smith and an Otis Contractor, as organised by John Drew. Hairline vertical and horizontal cracks were observed. The Drag Bars were not observed and no photos were taken. The horizontal cracks aligned with floor construction joints and the stair landing construction joints. Vertical cracks were observed 1 m and 1.5 m from the western end of the lift shaft and ran all the way up.

Effects of Demolition

The proximity of the demolition and the dropping of wrecking balls from 6 metres caused movement in the CTV Building and heightened concerns about the state of the building.

Building Liveliness

The building was known to be lively before the September Earthquake according to Ron Godkin. It is well documented that building occupants are more sensitive to footfall induced floor vibration when they are in a stressed state (ATC-1 Floor Vibration Design Guide).

However the damage to the connection of column C18 at the North Core, possible slippage of the Drag Bars attaching the Level 4, 5 and 6 slabs to the North Core and damage to non structural partitioning may have contributed to increased building liveliness.

West Wall Masonry Infill

The condition of the wall appears to be as described in the BCR. The two men working on the outside wall testified that they saw no obvious gaps between the masonry and the columns. Intermittent gaps to the underside of the horizontal beams were reported by Leonard Fortune. Reports by tenants inside the building of light coming through cracks were consistent with the gaps having being filled by mortar tailings or a bead of mortar during construction. Only small cracks or holes are necessary for light to penetrate. The mortar filling the gaps was still in place after the September Earthquake but appears to have fallen away when the panels fell outwards during the collapse in the February Aftershock.

The damage of glazing along the east and south faces after the September and December Aftershocks also indicates that the masonry infill wall was affecting the torsional response of the building in a manner similar to that shown in BCR Fig 53.

Collapse Sequence

North-south swaying in combination with east-west twisting appears to be consistent amongst witnesses. The final movement appearing to have been a lurch to the east and north as it collapsed. The upper portion tilting to the east was observed by two witnesses. Two witnesses who were together on the south face, and another observing the south and east faces all recalled the glazing bursting off on all floors. On the east face the panels were also observed to burst out. The two witnesses on south face both recalled seeing Level 5 collapse initially. A tree may have partially obscured their view.

On the east face the level at which collapsed initiated was not as clear with one witness saying it initiated 2 or 3 floors up, which could mean Levels 3 or 4. Another witness just described the top floors being intact as they fell.

Another witness saw Level 1 or 2 in the southeast corner collapsing, but he was in a car with restricted view of the south east corner and could only see the lower two levels at that point. He noticed that the northern end of the building of which he had better view was more intact. A number of witnesses reported strong vertical jolts before the building came down. The South Wall stayed upright briefly after the collapse of the floors had finished before it fell northwards onto the debris with beams on each side still attached to it.

In summary it seems based on the eyewitness accounts that the building collapse initiated on the east face from Level 3 or above near the southeast corner and rapidly progressed along what appeared to be Level 4 or 5 on the south face as the upper floors tilted eastwards as the internal columns or their beam column joints failed. The collapse then spread northwards rapidly also and pulled the slabs away from the North Core as the columns and beams along Lines 2 and 3 collapsed.

Scenario 1 presented in the BCR therefore still appears to be the most consistent with these collective observations. Vertical acceleration effects also appear to have coincided with the collapse. Scenario 2 of collapse initiated by an initial internal column is also possible based on these observations but less so than Scenario 1 due to its dependence on lower than specified concrete strength and vertical acceleration coinciding on a critical column..

Time to Collapse

It seems that the collapse started within 7 to 12 seconds of the shaking beginning and collapse was completed within 30 seconds.

Liquefaction Locations

Liquefaction occurred west of the CTV Building site close to the Les Mills building but not immediately adjacent to the CTV Building. No sinking of the building due to liquefaction occurred.

EYEWITNESS STATEMENT REVIEWS

In this Section

Review of Statement of Evidence WIT.Aydon.0001 (BCR Witness 3 BUI.MAD249.0051 and .0051A)

WIT Ref	Issue	Comments
C2	Operational Manager joined October 2010	Was not employed by Kings Education at the time of the September Earthquake
C4	Sketch A	Similar to that drawn by her in interview with me 28 April 2011 with reception desk mid way between grid line 2 and 3.
C5	Vertical crack between pillar and partition wall between AV room and Staff Room approximately 1 cm wide	Near column 3C? Marie Claire Brehaut recalled what seems to be the same crack as 1 mm wide. Leonard Pagan recalls a significant crack on Level 3 or 4 which may be this one.
C6	Rolling pen on reception desk. Floor not level	Ron Godkin thought this was due to hump in vinyl flooring. May be natural as-built slope of floor also. The floor was specified to be constructed with precamber and poured to thickness so would likely not have been flat with low spots at the beam lines 1, 2, 3 and 4 (ARCL Drawing S15).
C8	Cracks down corners in rooms next to lift	Presumably office on Line 4. No obvious significance of this.
C12	Reception desk slop increased	Difficult to identify a cause for this except possible vinyl expansion in heat of summer.
C16	Metal ties between adjacent wall on west boundary. Light coming through holes in the masonry infill in carpark.	Leonard Fortune said there was no evidence of any fixings in the past to the wall in his interview with me and Ashley Smith on 5 May 2011 (p.14). It is also not something that is consistent with construction practice. The building with the brick walls was built before the CTV Building. It therefore would not have had external ties to the bricks. The blockwork of the CTV Building would not have been required to have been constructed with ties to the brick. Simon Thomas recalled a 4 inch gap between the walls and did not think anything connected them. It is hard to reconcile Margaret's recollection of metal ties connecting the two walls. However it is also not critical from a structural point of view as the building and its performance in the February Aftershock as it was designed to have no connection to the adjacent building. See also Fig 29 of wall just before it was demolished. The light coming through holes in the masonry infill wall in the dark carpark after the neighbouring wall was demolished is consistent with mortar on outer face having intermittent holes and cracks in the mortar and is consistent with the small pinholes as seen by Tom Hawker on Level 2 archives area and David Coatsworth as considered in BCR p.240. From the outside these small holes may not have been visible to those working on it but in the darkness the light would have made them

WIT Ref	Issue	Comments
		visible. Fig 151 shows the wall to be in reasonable condition from the inside.
C17	The CTV Building moved a lot more after the removal of the wall	It is not possible to explain why this would occur. Others did not appear to notice such a change. Maybe a heightened sensitivity.
C18	Floor vibration in accounts room	Open plan offices with this span and depth of floor slab have been shown to be susceptible to footfall vibration. It is not a structural strength issue but is annoying for occupants. Others in the building reported this phenomenon.
C20	Demolition crew not the same as those recladding the west wall	Refer Leonard Fortune and Bruce Campbell. They started 21 February.
C21	Rosendo Ramos with her at the time of the collapse.	
C22	A jolt then thrown to east wall then back westwards, then falling	Consistent with west then eastwards lurch of building just prior to collapse as per Ron Godkin interview 9/4/12.
C27	Located 1 metre from North face on Line 4	

Review of Statement of Evidence WIT.Cammock.0001 (BCR Witness 1 BUI.MAD249.0044 and .0044A)

WIT Ref	Issue	Comments
C6	Two cracks appeared on either side of the elevators after September Earthquake on Level 6 (5th Floor)	Refer BCR para 6 p.50. The Drag Bars on Level 6 remained attached after the February Aftershock and collapse. The slab in front to the elevators was held up by them even after the column C18 supporting the slab had collapsed as seen in BCR Fig 31, 36, 37 and 163. Therefore it is clear that the cracks observed by Liz Cammock were not due to failure of the Drag Bars in the September Earthquake. It would appear to be best explained by slippage of the cast in anchors in the holes of the Drag Bars to the slab. The holes were specified to be 2 mm oversized compared to the diameter of the threaded anchor rods as noted in Fig 168. A 1 to 2 mm slippage of the anchors would have resulted in a very noticeable vertical crack in the locations described by Liz Cammock. The slipped Drag Bar anchors may also explain the shuddering and groaning of the building as they moved under load. This is an observation in buildings with slipping bolted connections.
C13	Felt like the adjacent brick wall was attached to the CTV Building when it came down.	She thought it had to be attached to make that sort of impact but never saw whether it was connected or not. Margaret Aydon thought she saw it attached. However as noted there it does not seem consistent with construction practice to have done so. Leonard Fortune saw no trace of attachments when working on the wall. Simon Thomas didn't think there were any attachments.
C17	Cracks up the stairwell in North Core Level 5 and Level6	Horizontal cracks were seen by the David Coatsworth perhaps at construction joints. This was also confirmed by Graeme Smith. Greater northward displacements were noted in the lean north after the collapse above Level 3 as seen on SEMT fig 57. Perhaps evidence of west wall bracing effect below Level 4.
C19	Vertical cracks in front of elevator more pronounced after December Aftershock	Consistent with slippage of Drag Bars.

Review of Statement of Evidence WIT.Fortune.0001 (BCR Witness 16 BUI.MAD249.0047 and .0047A)

WIT Ref	Issue	Comments
C7	Started Monday 21 February with Bruce Campbell and James Askew	Tom Hawker advised that CTV filmed the wall on the Monday in DBH interview. James Askew has not been interviewed.
C8	Foundations being cleared from site. Dropped wrecking ball 6 m causing shudder and groans in the building. Groans inside.	Groans may have been slippage of Drag bars against steel decking. May have loosened during September Earthquake. A groaning sound is known to occur in some buildings with bolted connections that slip occasionally. Refer para 6 p.50 BCR. There are a number of mentions of creaking and groaning of steel buildings. Here is one on the Butler website: http://www.bluescopesteel.com.cn/butler/products/difference.asp. Also a sound track at Audiosparx: http://www.audiosparx.com/sa/archive/Foley/Creaky-sounds/Creaking-Metal-Building/357573. If connections are fully tensioned this should not occur. However if the connections had been loosened by the September Earthquake creaking and groaning may have resulted at the Drag Bar connections when movement caused by aftershocks and perhaps the demolition next door occurred. The lift shaft may have amplified the noise and also transmitted it through the building.
C8	Wrecking ball was being dropped 6m by demolition crews	Would have caused shaking of the CTV Building. This was what appears to have been the cause of complaint by CTV Chair Nick Smith to Leonard Fortune (Refer WIT.Jackson.0001).
C9	Mortar between blocks and columns and horizontal beams	Refer BCR Fig 149 and 150 and last para p.239 BCR
C10	Top row of blocks in each section hollow	Refer BCR Fig 149
C11	Other blocks hollow in places	Refer BCR Para 1 p.240 BCR. 140 mm masonry is known to be difficult to grout fill due to small cores.
C12	Concrete beams connected to columns	As per BCR Fig 149 to 150
C13	Had to scrape off excess mortar to smooth wall. Mortar had spilled through because building on the boundary when built	BCR Fig 149 shows them using a spade or similar.
C14	CTV staff member spoke with them because bricks were being knocked to the ground floor in Level 1	Probably Nick Smith the CTV Chair, according to Maryanne Jackson. She recalled him asking them to stop because of the shaking of the building. But probably due to the demolition contractor dropping wrecking ball from 6 meters in C.8. Perhaps the smoker's wall north of Line A that was demolished? Facing of blocks?

WIT Ref	Issue	Comments
C17	Working at about 3 m above south western corner	
C18	Strong vertical jolt and scissor lift jumped	Similar to Stephen Gill's observation, early in event possibly due to P-wave.
C19	1.5 m drift. Masonry spitting into cladding at upper level	Difficult to judge relative movements. Level 3 to 4 top row?
C21	Saw southwest corner column between L3 and 4 crack in middle. Like the two bits held together by the steel had kicked outward sand the whole column was buckling	BUI Mad 249.0222.2 shows the Level 3 to 4 column in one piece lying kicked out southwards from the corner. It does not have a mid-height fracture. An explanation may be that the beam pulled out of the beam-column joint at Level 3 causing the column to kick outwards and tear away from the lower portion of the column. Consistent with Stephen Gill's observation that it appeared to have been kicked out, but up a couple of levels. Also consistent with collapse having progressed from east to west and fragility of beam column joints.
C22	Saw piece of concrete falling towards him after he jumped out of scissor lift.	In DBH interview it was a column. Could have been L3 to4 column seen in BUI Mad249.0222.2
C24	A few seconds later piece of concrete landed on scissor lift bringing it down to ground	BUIMad249.0222.2 shows 2 panels of masonry on scissor lift. Level 3 to 4 masonry panel first as scissor lift was up at least 3m at the time.
C25	It looked like the building had fallen into a hole	

Review of Statement of Evidence WIT.Gill.0001 (BCR Witness 9 BUI.MAD249.0058 and .0058A)

WIT Ref	Issue	Comments
C14	Bounced up and down and sideways on Les Mills Roof	Vertical acceleration early in event consistent with p –waves. On roof perhaps more lively compared to other locations in Les Mills.
C15	Number of aftershocks	
C16	Southwest corner lifted and looked like it had been kicked out	Southwest corner columns Level 1 to Level 3 still standing after collapse as seen in BCR Fig 153. So would indicate he saw Level 3 to Level 4 column kicking out. Refer also to the Leonard Fortune interview.
C17	South wall fire escape remained standing for 5 seconds	Eventually toppled north on top of the debris.
C18	All happened within 30 seconds	
C19	Floors still attached to North Core on an angle	
C21	There was liquefaction everywhere	BCR Figs 71, 72, 73,74, 77,78 show no liquefaction adjacent to the CTV Building so must have been close to the entrance of Les Mills.
C23	There was nothing attached to the North Core above third Floor (L3)	Level 3 at top of floor debris in BCR Fig 73.
C24	Cars in CTV carp ark undamaged. The building looked like it had come straight down.	Refer BCR Fig 73 and 74.

Review of Statement of Evidence WIT.Godkin.0001 (Level 4 Lifts Interviewed 9/4/12 BUI.MAD249.0285)

WIT Ref	Issue	Comments
C6 & 10	Hump in vinyl covered floor in front of reception	The location shown on the drawing appears close to midway between Line 3 and 4. However drawing does not agree with Margaret Aydon and Marie-Claire Brehaut or his sketch during interview with me on 9/4/12 in which he described the hump in some detail and located it along Line 3. The hump was then described as in the vinyl that had been stuck to the concrete floor. Appeared to be on both sides of the beam and caused the reception desk to have a southeast slope. It was pointed out to David Coatsworth during post-Sep inspections and was not considered unusual or significant by him. The floor was specified to be constructed with precamber and poured to thickness so would likely not have been flat with low spots at the beam lines 1, 2, 3 and 4 (ARCL Drawing S15) No cracking of slab through vinyl was observed in front of lifts.
C16	Demolition of neighbouring building began about mid-October	After the September Earthquake
C17	Glazing cracked after September Earthquake	Glass damage on south face and east face after September Earthquake in sketch of 9/4/12 and more detailed discussion of glazing damage. This perhaps indicates enhanced torsional response as noted in BCR Fig 53 due to engagement of masonry infill on Line A.
C21	Concrete blocks described falling	The concrete slabs he described falling on him are difficult to reconcile with the actual structure and David Horsley's testimony (BUI.MAD249.0436). May be other objects. The slab at Level 5 rotated downwards onto where he had been standing in BCR Fig 31. May have also been disoriented in terms of timing of debris falling.
C22	Description of the waving floor and the stapler and falling over	This out of sequence compared to interview on 9/4/12 which had the elevator wall coming towards him on lean, then him falling to floor, then seeing person lift arms in air as south floor fell below them , and stapler flying westward into tutors room. He seemed confident of the sequence in the 9/4/12 interview and it seems more consistent. Stapler flying just before collapse is consistent with Margaret Aydon being thrown west on the same Level just before collapse.
C23	Large lump of concrete	Can't reconcile what this could be. May be timing of this is out.
C24	Person dropping with arms stretched out above head at south end and south wall dropping before him	Similar to 9/4/12 interview.
C25	Sky above him after collapse	Level 6 and 5 appears to have pulled southwards and downwards over him as the collapse progressed with loss of support on

WIT Ref	Issue	Comments
		Line 2 and 3 see BCR fig 20.
C27	Other survivors on Level 4	Margaret Aydon and Rosendo Ramos.
A	Sketch out of scale	Sketch does not match Margaret Aydon, Marie-Claire Brehaut or his sketch on 9/4/12 in terms of relative positions of features and offices. However this is not to scale and should be interpreted in light of these other sketches.

Review of Statement of Evidence WIT.Grenfell.0001 (BCR Witness 10 BUI.MAD249.00598 and .0059A)

WIT Ref	Issue	Comments
C7	The building was twisting towards the east and in a slightly north direction. It was rocking back and forth and appeared to be trembling	Consistent with Euan Gutteridge's observation of twisting and Tom Hawker's observation of north-south movement. Both appear to have been occurring at the same time. Refer BCR fig 64 and p.146
C8	He then got into his car for protection and had his view restricted by sitting in the driver's seat (facing north). Could see the bottom two levels clearly	
C9	The building twisted towards the east before he saw the southeast corner of the building collapse. It looked like it collapsed on Levels 1 or 2	His field of view was probably restricted to the lower two levels at the southeast so was not able to see what may have occurred prior to this at the higher levels as reported by Tom Hawker and Euan Gutteridge and Penelope Spencer. Southeast corner failure consistent with Euan Gutteridge and progression of the collapse from Line F initiation further up (refer BCR Fig 19 steps 2 and 3). This would all have happened in milliseconds once collapse started. The final eastward twist is consistent with reports of Ron Godkin of stapler at level 4 flying westward and Margaret Aydon being thrown westward just before the collapse. Also consistent with compression spalling damage on South Wall east end and differential northwards lean on North Core SEMT Report Fig 57.
C10	North east end of the building appeared more intact as it came down	Consistent with collapse initiating at south end and slab still being connected to North Core as proposed in Scenario 1 and 2. Scenario 4 is not consistent with this observation.
B1	Photo across Madras Street	Same photo he gave us during interview as seen in BCR Fig 79
B5	Photo across Madras Street	Same photo he gave us as seen in BCR Fig 85.

Review of Statement of Evidence WIT.Gutteridge.0001 (BCR Witness 14 BUI.MAD249.0048)

WIT Ref	Issue	Comments
C6	Could see the building twisting and shaking considerably in both north-south and east-west direction. Twisting about north west corner	Consistent with west wall infill masonry engagement with frame as per Fortune and Campbell and BCR Fig 53.
C7	About 10 seconds from onset of earthquake to collapse.	Similar to Tom Hawker who estimated 12 seconds.
C8	Almost in unison the entire glass exterior shattered; all the cladding fell off and the building disintegrated	Penelope Spencer also recalled all the glazing shattering at every level on the south face. Euan identifies this happening on both the south and east face at the same time. Spandrel Panels falling off indicating engagement with columns.
C9	Collapse appeared to begin on the southeast corner and about 2 to 3 floors up, and rapidly worked its way back from there	Levels 3 to 5. Not as definite on level it initiated on as Penelope Spencer and Tom Hawker on the South face. Consistent with BCR Fig 17.
C10	Saw some pillars from within the southeast corner two or three floors up falling outwards as the building collapsed on itself	Possibly beam column joint failure or mid-height fracture at splice terminations following column head and base hinging and splaying above and below fracture point. Fortune and Gill speak of a column kicking out also but on south west corner.

Review of Statement of Evidence WIT.Hawker.0001 (BCR Witness 15 BUI.MAD249.0060 and .0060A)

WIT Ref	Issue	Comments
C10	Pinhole cracks in west wall with daylight coming through on Level 2 in archives room	As noted BCR para 3. p.240.
C11	Floor less stable after Boxing Day Aftershock	May have had heightened awareness after the December Aftershock. Mentioned trucks moving past the building being noticeable and floor vibration. Similar to others.
C16	CTV filmed the work on the west wall on 21 Feb for the news	As per Leonard Fortune testimony.
C18	Located adjacent to west wall.	Need to move his position shown in BCR Fig 57, 58 and 69.
C19	Saw Level 5 cracking and this level collapsed and pancaked down the rest of the floors. Level 6 remained intact	As per BCR p.151. BCR Fig 17 shows Level 4 initiating collapse. Other testimonies along the East face indicate the collapse may have started L3 to L5 along the east face. Perhaps collapse initiating on Level 4 on east face became apparent as Level 5 collapse along the south face as it progressed. Leonard Fortune and Stephen Gill saw column Level 3 to 4 kick out at the southwest corner. His view may have been hindered by the tree.
C20	Collapsed in about 12 seconds	
C21	Thought it might fall on them but it fell straight down	Refer Euan Gutteridge who saw twisting and north south and east west motion. Also Stephen Grenfell reported north south movement and twisting.
C24	Photo of North Core shows Level 5 slab at lift well had dropped away by 4 to 6 pm that evening	

Review of Statement of Evidence WIT.Jackson.0001 (BCR Witness 2 BUI.MAD249.0053)

WIT Ref	Issue	Comments
C6	Internal staircase next to her would shake badly and move in and out in an aftershock	
C8	You could feel the floor moving on Level 2 when people walked down the corridor	Footfall vibration sensitive floor. Not a structural strength issue.
C10	2 windows broke on Level 2 east face and one on South face after the December Aftershock	Evidence of torsional response of building as per BCR Fig 53 enhanced by west wall masonry infill.
C13	Nick Smith chair of CTV went to tell people drilling on west wall to stop on 21st February because of the way the building was shaking.	This seems to be the person reported by Leonard Fortune. Leonard Fortune recalled the demolition contractor was also dropping wrecking balls from 6m on the site so this is likely to have caused the shaking that was felt.
C14	Windows and stairs moving at start of Feb Aftershock	
C15	Left after 7 to 8 seconds of shaking	Shaking was well developed before collapse started. Compare to 12 seconds overall for collapse estimated by Tom Hawker and similar by Stephen Gill. Indicates near peak response of record at time of collapse initiating.
C17	An aftershock then caused collapse of the Church on opposite corner	

Review of Statement of Evidence WIT.Kulpe.0001 (BCR Witness 4 BUI.MAD249.0049 and .0049A)

WIT Ref	Issue	Comments
C4	CTV Building would vibrate when aerobics classes were happening at Les Mills prior to the September Earthquake	The building was lively prior to the September Earthquake as identified by others such as Ron Godkin and Peter Brown.
C5	Didn't notice any movement when the Les Mills Building one over from the CTV Building was being demolished before the September Earthquake	
C10	The building next door to the CTV Building was demolished after the September Earthquake. The CTV Building moved a lot when this building was demolished	Proximity would be a factor. Perhaps also some Drag Bar slippage, effect of damaged internal partitioning, and damage to the connection of the head of Column C18 to the North Core at Level 6.
C11and C12	She believed the two buildings were attached by the adjoining walls which alarmed her. Felt like the CTV Building was being pulled when they pulled the adjoining wall down	Refer to comments on Margaret Aydon's thoughts about the adjoining wall and Leonard Fortune's observation that there was no sign of anything having been attached in his interview of 5 May 2011. Simon Thomas recalled a 4 inch gap between the walls and did not think anything connected them. There wasn't any obvious construction reason for the two walls to be connected.
C15	Noticed column C18 was cracked after the December Aftershock	
C17	Drilling of holes caused vibrations through the building	Hammer drills would have been used and do cause vibrations.
C20	Comments about the CTV Building being the safest building in Christchurch and being base isolated	May have originated in misinterpreted comments from David Coatsworth to Peter Brown and from him to CTV staff.

WIT Ref	Issue	Comments
C28	Vertical jolt upwards at start of February Aftershock	Almost propelled off seat upwards.
C29	Another vertical jolt that lifted the floor then sideways movements	The large vertical jolts and horizontal lurches seem to be separate experiences rather than happening together.
C31	It didn't feel as long as September Earthquake, just sharper and more violent	Consistent with records of both events and comparative response being 2.2 times September (BCR p.259). Effect of vertical acceleration on columns possible, but perhaps not synchronised with peak lateral accelerations (Ref BCR Fig 137). So effect of reduced drift capacity under extra axial load from vertical acceleration as can be seen by changing the axial load in BCR Fig 161 may not have resulted in failure initiating if isolated jolts unless concrete strength was low as comparison of same loads in BCR Fig 160 shows.
C33	It happened in stages, collapse, collapse ,collapse…	Consistent with the upper floor(s) pancaking progressively done onto the floors below.
C36	Believed the building collapsed in the Southeast corner due to feeling of the floor tilting that way	Consistent with progressive collapse from east to west along Line 2 after initiation on east face like in Steps 3 and 4 of BCR Fig 19. Also consistent with Dennis May's (BUI.MAD249.0045 and .0045A) report of a slight tilt of the top of the building to the east before it came down (BCR eyewitness 6 p.139)

Review of Statement of Evidence WIT.Lee.0001

WIT Ref	Issue	Comments
C4	Was on Level 5 at the northeast end in the Clinic	In similar location in plan to Margaret Aydon who was a floor below on Level 4.
C7	An engineering inspection was undertaken for the Pegasus Trust Ltd before it moved in.	Were engineering drawings sighted and who did the inspection?
C8	No obvious cracking in the exterior concrete at Level 5	
C9	Internal partition damage	As reportedly occurred all through the building.
C10	Did not notice any movement when people walked past. Desk used to wobble due to uneven floor	Floor was specified with precamber and cast to thickness so floor was likely not flat. Refer to comments on Marie-Claire Brehaut of pen rolling. Partitioning may have damped floor response in her office.
C14	The shaking was violent and then a pause in shaking. She had time to stand up and started to walk towards Dian	The pause is consistent with Mike Williams who also got out from under a desk then saw the CTV Building collapse (BCR witness 7)
C15	A loud crack then falling to the south	Consistent with collapse starting at south end of building.

Review of Statement of Evidence WIT.Mitchell.0001

WIT Ref	Issue	Comments
C2	Was on the Level 6 on Line 4 west of the North Core	Would have been located just off the slab remnant left at Level 6 shown in BCR Fig 166
C8	Seated with back to the north wall facing south. An internal wall was about 4 metres in front of her.	
C4	After about 10 seconds of shaking the building collapsed very quickly. Most vivid recollection was seeing the internal wall in front of her crumble and disintegrate, separating from the ceiling. She could see light through a gap between the ceiling of Level 6 and the internal wall	The gap at the ceiling line is similar to what David Horsley recalled on Level 4 immediately before the collapse. These indicate collapse starting from the south of the building from the floors below.
C6	Sucked downwards because the floor was going down fast	

Review of Statement of Evidence WIT.Ross.0001

WIT Ref	Issue	Comments
C2	Was in his van stopped at the Cashel St and Madras St intersection looking Northwest towards the CTV Building	
C5	Was initially more concerned about the Church on the corner so turned the car into the middle of the street	
C6	After about 10 seconds turned to see the CTV Building	
C7	Could see the east face and part of the south face. Noticed that the top was bending over towards Madras Street and knew it was going to fall down.	Consistent with Dennis May's (BCR Witness 6 BUI.MAD249.0045 and .0045A) observation of a tilt of the upper to the east before it came down. Also Tom Hawker and Penelope Spencer of the top floor initiating collapse. Euan Gutteridge reported it starting a few floors up near south east end. Consistent with east face initiation at upper levels Scenario 1 BCR Fig 17 to 19.
C8	A really firm jolt and it was then it started to collapse	Refer also Kulpe, Aydon and Lee.
C9	Thought it would collapse over Madras Street but it went straight down.	
C10	Could see the top floors were intact as they disappeared into the dust	Levels 5 and 6 perhaps intact on east face compared to Level 6 on south near west end according to Tom Hawker and Penelope Spencer.
C11	Did not see any columns breaking	Compared to Euan Gutteridge who did. Perhaps because of dust and proximity affecting view.
C12	Earthquake finished 15 to 20 seconds later	Timing not consistent with Mike Williams and Maryanne Jackson and who felt the earthquake had ended before the collapse started. So perhaps the rumbling and movement associated with the collapse is what Matthew Ross felt as part of the

WIT Ref	Issue	Comments
		earthquake similar to observation of Stephen Gill.

Review of Statement of Evidence WIT.Spencer.0001 (BCR Witness 8 BUI.MAD249.0056 and .0056A)

WIT Ref	Issue	Comments
C7	Significant crack around column on Level 2	Line 3C? Difficult to explain what caused this. No other reports of this cracking.
C9	No cracking on the outside of the building	No apparent external damage to structure to casual observer.
C12	Located on south west corner and could see whole south side and south end of the west side of the building	Need to correct BCR Fig 62 and Fig 58 for her location with Tom Hawker.
C13	North south swaying noticeable; Glass on every floor on south side shattered; concrete pillars on Level 5 then exploded and collapsed at the same time. Focussed on south side and did not see what happened down the west side	Similar to interview summary BCR p.142 though did not mention pillars exploding in that interview. A person standing at the southwest corner would see north-south movement along that line as part of the twisting reported by Euan Gutteridge. Other testimonies along the East face indicate the collapse may have started L3 to L5 along the east face. Perhaps collapse initiating on Level 4 on east face became apparent as Level 5 collapse along the south face as it progressed. Leonard Fortune and Stephen Gill saw column Level 3 to 4 kick out at the southwest corner. Her view may have been obstructed to some extent by a tree .
C14	Level 5 collapse and hit next floor then it all pancaked down after a short pause	

Review of Statement of Evidence WIT.Williams.0001 (BCR Witness 7 BUI.MAD249.0055 and .0055A)

WIT Ref	Issue	Comments
C10	Saw it collapse after he had got out from under the table after the earthquake had finished. Had full view of the South face.	Closer to window than shown in Fig 61
C11	It didn't come down immediately.	Consistent with Stephen Gill that South wall held up for 5 seconds after collapse internally. Initiation on east face followed by progression along internal Line 2 and around south face perhaps explains this slight delay to collapse along South face. Phillipa Lee who was on Level 5 reported a pause after violent shaking then the building collapsing. Margaret Aydon also reported enough time to call out to people to take shelter after the first shocks. Not sure that this pause in the ground motion records used for the NTHA.
C13	Top floated down like World Trade Centre	Consistent with Tom Hawker, Penelope Spencer and Euan Gutteridge.
C14	Looked like it came straight down	Didn't fall south into carpark.

BUILDING OCCUPANT STATEMENT REVIEWS

In this Section

Review of Statement of Evidence WIT.Bainbridge.0001

WIT Ref	Issue	Comments
C2	Ex-builder with 14 years experience and carpentry qualifications	
C6	Noticed concerning damage on Level 6	
C7	Column C18 cracks noticed	As seen in BCR Fig 22. Refer also Leonard Pagan and Graeme Smith.
C8	Three large cracks 5 mm wide and other hairline cracks 2 to 3 mm wide at 200 mm centres. Flakes of concrete at the base the size of 50 cent coins. Blow out marks visible on the concrete.	The crack widths appear to visual including the paint that had flaked off, so hard to tell what the actual crack widths in the concrete were. The blowouts on the base indicate that the column may have reached compression yield of the concrete in combined compression and flexure. Other Level 6 columns acted as cantilevers supporting the roof and had little axial compression on them compared to the columns in the floors below. They would have sustained greater demands in terms of drifts than those below because of their cantilever behaviour and being attached portions to the Level 6 slab rather than part of the primary seismic resisting system.
C9	He thought the column had performed to its maximum capacity and would fail in future events	Not sure of what basis was used for his structural assessment. However the damage to the connection into the North Core as seen in photo 037 WIT.PAGAN.0001.45 seems to be a precursor to its pull out in the February Aftershock.
C11	Cracks also in a column at 3B	This column would not have been affected by Spandrel Panel interaction indicating cantilever effects. Not mentioned by David Coatsworth, Leonard Pagan or Graeme Smith. Column 1B cracks not mentioned but may not have seen that column.
C12 & 13	Water damage in ceiling around connection of column C18 to North Core overhead wind wall on Line D/E.	The water damage may indicate that water was coming through the cracked concrete of the connection of the column to the North Core. This appears to be what was also seen in wit.pagan 0001.45 photo 037. The damage indicates distress to the connection of the column to the North Core that may have led to increased flexibility of the building.

WIT Ref	Issue	Comments
C15	Spandrel Panel on Line 4 E-F uneven and chipped and damaged at the end. It appeared to have experience significant movement and at some stage been compressed against the North Core	David Coatsworth reported the damage to the end of the Spandrel Panel as due to corrosion and specifically noted that it was not caused by the earthquake.

Review of Statement of Evidence WIT.Brehaut.0001 (BUI.MAD249.0052)

WIT Ref	Issue	Comments
C4	Vertical crack between pillar and partition wall between AV room and Staff Room approximately 1 mm wide	Perhaps near column 3C? Margaret Aydon recalled what seems to be the same crack as 1 cm wide. Leonard Pagan recalls a significant crack on Level 3 or 4 which may be this one.
C6 & 9	No cracking of external walls or other structural damage	No cracking to columns noticed on Level 4. Though David Coatsworth recorded the column in the northeast corner F4 having a crack above the Spandrel Panel and as seen in photo from CPG.
C13	Building swayed east-west direction in aftershocks	Indicative of torsional response. Seated at reception area between Line 2 and 3.
C15	Shudder and short bursts of movement, with dull thudding sounds	Perhaps Drag Bar bolt slippage. Leonard Fortune described groaning sounds.
C18	Pen rolling west to east	Vinyl hump described by Ron Godkin along Line 3 may have caused this. Maybe thermal expansion of vinyl during summer. The floor was specified to be constructed with precamber and poured to thickness so would likely not have been flat with low spots at the beam lines 1, 2, 3 and 4 (ARCL Drawing S15). This could be another cause of pen rolling off the desk.
C21	Exterior columns repainting in the week before Feb Aftershock	Would be interesting to know what the painters saw of the columns.
C28	Building paper was being stapled to timber battens on masonry infill on west face at time of collapse.	
C31	Water pouring out of the road and footpath west of CTV Building	Corroborates Stephen Gill. But liquefaction was not seen at the CTV site based on photos. Liquefaction footage given to RC time stamp 12:55 pm.

Review of Statement of Evidence WIT.Brown.0001

WIT Ref	Issue	Comments
C6	Fitness centre on Level 5 in 2008 caused vibration through the building	Indicative of flexible floor slab system. Ron Godkin interview also said a bank tenant had apparently left eight years prior because of structural liveliness. David Millar also reported floor vibration in the Level 6 meeting room at times as did Nilgen Kulpe. Calculations showed the floor to be susceptible to footfall vibration in open plan areas.
C16	Glass cracked along east face on L2	Could indicate increased torsional response due to engagement of west infill masonry as per Fig 53.
C23	South Wall vertical crack	Apparently non-structural based on comments by David Coatsworth .
C25	Building seemed to move more easily when trucks went past after September Earthquake	Could be result of Drag Bar slippage, non-structural partition damage, and damage at the connection of the head of Column C18 to the North Core at Level 6.
C28	Was told he thinks by Coatsworth that the CTV Building was designed to move between the lift shaft and the opposite part on the South Wall, and told CTV Staff this	A number of CTV Building people mentioned hearing that the building was base isolated like Te Papa or similar. This may be the source of that.

Review of Statement of Evidence wit.Drew.0001.Red

WIT Ref	Issue	Comments
C2	Company Director of New Regent Medical Centre.	He owned the Clinic that moved into the Level 5 after the September Earthquake.
C3	He was looking to buy Lionel Hunter's 4/9 share of the building	
C9	As far as he was aware the building was Code compliant and entirely satisfactory	A lot of trust is placed on the building consent and approval process by purchasers of buildings. Apparently he was not aware of the Drag Bars having been required and that no consent had been sought.
C10	Did not see any engineering drawings with construction details.	
C13	Became Building Manager in May 2010	
C25	On 29 September 2010 met with David Coatsworth and Leonard Pagan and spent part of the day	Plans were obtained from Peter Brown. But these were apparently only architectural drawings of Level 1 and 2 according to David Coatsworth.
C30	2nd report from David Coatsworth	Probably his email of 19 October 2010 after a small aftershock.
C34	The Clinic moved into Level 5 on 10 January 2011.	
C38	Viewed Lift Shaft exterior with Hunter 17 February 2011 to acquaint him with the repair work required.	Drew had been involved with the inspection of the lift shaft with Graeme Smith of Concrete Protection and Repair Ltd and Otis on 11th February 2011 (Drew.Red.69).

WIT Ref	Issue	Comments
C42	His filing cabinet on the Level 5 office that contained all the reports in his possession about the building, about the purchase and about repairs were lost in the collapse.	
Emails p.29	Recladding of west wall discussed with loss adjuster and damage after December Aftershock	

Review of Statement of Evidence WIT.Harris.0001

WIT Ref	Issue	Comments
C2	Sat along west wall on Level 2. Noticed 15 to 20 cracks in the wall and could see daylight through some.	This was apparently a gib lined wall as seen in BCR Fig 152 and on the collapsed panels in Fig 154. Cracking in the wall linings did not necessarily reflect damage in the masonry infill. Refer Tom Hawker and David Coatsworth who also reported daylight perceptible through cracks.
C17	He thought the wall was only made of gib board	

Review of Correspondence Peter Higgins and Royal Commission (BUI.MAD249.0453)

WIT Ref	Issue	Comments
.1 para1	Two visits were made after September Earthquake at request of Building Manager	Refer also John Drew (BUI.MAD249.0001.RED)
.1 para2	The purpose was to quantify the amount of cracking and prepare cost estimates for epoxy injection	Detailed and specific inspections are required to set cost estimates so is indicative of the extent of known structural cracking as limited by his access and scope. On the second visit he had the CPG Report by David Coatsworth (BUI.MAD249.0082) so was presumably aware of the Level 6 Line 1 and the Level 4 F4 columns
.1 para3	First visit was preliminary on 8 February 2011 without reference to the CPG report	Saw typical crack damage in the stairwell in the North Core, Level 4 bathroom end wall (North Core) . This may have been gib lined for services duct? Saw the Level 6 cracked column C18 and “beam”. The connection was to the North Core not a “beam” ARCL dwg S11 Wall Line D/E and S14 .
.1 para5	Second visit on 14 February 2011 with CPG Report to determine the approximate quantity of reported crack and spall repair to provided budget estimate for remedial works	
.2 para6	Limited access, occupation and no removal of architectural linings. External assessment form ground level	Column heads internally not checked. Limited view of columns except from ground and from inside.
.2 para9	Difficult to quantify scope of a crack repair until architectural layers of paint render and surface laitance along the line of the crack is ground back.	Difficult to quantify crack widths and sizes when plaster etc is still on the surface.

WIT Ref	Issue	Comments
.2par10	Not all columns were sighted or accessible and similarly access to the North wall limited	Did not check all just what was identified by John Drew and David Coatsworth's report.
.2 para11	South wall crack outside fire escape, 1st floor beam cracks (L2) on north face, stairwell walls and construction joint cracks, cracked column on 5th floor (C18 L6) and adjoining crack on lintel	The lintel at Level 6 was in fact the North Core wall D/E (ARCL dwg S11 and S14). There did not appear to be awareness among any who inspected that this was in fact part of the North Core. The C18 column pulled away from the connection to the North Core in the February Aftershock. If structural drawings had been available this damage to the connection into the North Core may have raised greater concerns. However it is not thought to have been a collapse initiator though it may have prevented some localised collapse around the North Core as the rest of the floors collapsed to the south.
.2 para12	Advised by John Drew on 15 February 2011 to add in 80 linear meters of cracks in the lift shaft walls	This was after the inspection by Graeme Smith on 11 February 2011 (wit.gsmith.0001).
.2 para13	Stairwell cracks generally horizontal at construction joints. A thin render plaster render was over the concrete which had cracked. Cracks were noted on both sides of the stairwell as well as the north shear wall (Line 5)	Not significant structural damage from a strength point of view but may have increased building flexibility.
.3 para14	Level 6 column C18 had 6 horizontal circumferential cracks, with concrete spall or crack in the overhead connection into the North Core wall extension D/E approximately 1200 to 1500 mm out from the face of the column. Photo is shown	This cracking indicates that compression in the C18 column during the September Earthquake may have forced a shear failure of the connection into the wall D/E outstand. This connection broke away during the February Aftershock (BCR Fig 116). This may have been a cause for some loss of flexibility in the building post –September Earthquake and was serious structural damage. It appears that only three rather than 4 H20 bars had been located in the connection of the column into the D/E wall.
.3 para15	1st Floor (L2) beam over entry as shown in CPG Report photo 5	This may be infill wall 4/ D/E to F. Perhaps indicating some interaction with the structure.

WIT Ref	Issue	Comments
.3 para16	Crack in South Wall was 1 near vertical or diagonal crack approximately 2 metres long adjacent to the fire escape landing as referred to in CPG Report photo 2	This is best description of the extent of this crack which is difficult to see in the CPG photo.
.3 para17	Not aware of the Drag Bars in the North Core and did not sight them during the visits.	

Review of Statement of Evidence WIT.Thomas.0001

WIT Ref	Issue	Comments
C4	Located in south west corner on Level 2 and could see two major cracks in the wall	This was the gib board lining to the wall over battens. So does not necessarily reflect movement in the masonry infill. Refer BCR Fig 152.
C6	Damage to windows on Level 2 along east face and south east corner	Consistent with increased torsional response due to masonry infill on west face not separated as per BCR fig 53. Similar to reports on Level 4 by Ron Godkin.
C11	Heightened footfall vibration sensitivity after September Earthquake	
C13	Adjacent building wall about 4 inches from West face of CTV Building. Did not appear to be connected	Consistent with Leonard Fortune. Different to Margaret Aydon and Nilgun Kulpe who thought it may have been connected.
C14	Made a video of the wall as it was demolished and forwarded it to RC	This may help to identify if there were any ties between the two walls.

DAMAGE OBSERVERS' REVIEWS

In this Section

Review of Statement of Evidence WIT.Ayers.0001

WIT Ref	Issue	Comments
C2	Fire-fighter	Not an engineer but familiar with assessing safety of buildings for emergency access.
C4	A lot less damage in CBD in December Aftershock compared to September Earthquake	This is consistent with relative magnitude of spectra records being about half that of the September Earthquake as seen in BCR Fig 145 and comparative demands of the earthquakes on p.259.
C6	Rapid visual survey using USAR forms.	
C8	Visual survey in each direction	
C9	No obvious structural damage, and no tell tale signs on the ground eg Spalled concrete. One broken pane of glass. Engineering assessment did not appear to be required	Low level of damage. Where was the window that was broken? Tell tale signs of significant concrete damage is typically spalling of concrete cover.

Review of Statement of Evidence WIT.Campbell.0001 (With BCR Witness 16 Leonard Fortune prior to collapse)

WIT Ref	Issue	Comments
C8	Blockwork was joined to the columns using mortar. The top masonry blocks had been slid in last and they appeared to sit tight under the beam. There were no gaps between the blockwork and the columns, or between the blockwork and the beam on the western side of the wall.	Consistent with full engagement of the masonry infill with the frame and Fortune's statements and BCR p239-244.
C9	Top row of blocks not filled with concrete.	
C10	Mortar had spilled out through the joins in the masonry infill blocks and we had to scrape this off to obtain a flat surface.	

Review of Statement of Evidence WIT.Pagan.0001

WIT Ref	Issue	Comments
C2	Quantity Surveyor with Rawlinsons and heavily involved in preparing estimates for cost of earthquake repairs.	
C3 to C5	Inspection on 29 September 2010 with David Coatsworh of CPG and John Drew the Building Manager. Walk through inspection of every floor and outside of the building.	
C7	South Wall had some hairline cracks were diagonal and "from the initial structural investigation (by David Coatsworth) these are believed to be superficial only at this point."	
C10	Inspection took 3 to 4 hours.	Reasonable level of detail.
C13	In absence of structural report the damage appeared repairable and from an aesthetic perspective the damage did not look that bad. He had seen far worse in the CBD at that point.	
C14	His recollection was that the worst of the damage was on Level 2 and 4. This accords with the indicative Estimate he prepared. He recalls a significant crack in the plasterboard on Level 3 or 4	Level 4 damage may be indicative of the change in torsional response of the structure at Level 4 due to the west face infill masonry stopping at the underside of Level 4. Was the level of partitioning the same in all the levels at the time? The crack in the plasterboard may be the vertical crack next to the column described by Marie Claire Brehaut in the wall that separated the teachers room from the AV room on Level 4 recollecting it to be 1 mm wide (Bruehat.0001 C4) and Margaret

WIT Ref	Issue	Comments
		Aydon who recollected it being 1 cm wide (Aydon.0001 C5).
C15	The western side of the building was the worst in terms of damage to the plasterboard	Was this related to there being more offices on that side of the building in the tenancies or any issue like that?

Review of Statement of Evidence of Graeme Smith (wit.gsmith.0001)

WIT Ref	Issue	Comments
C2	Qualified Civil Engineer who has worked in concrete repair industry since graduating 1994	Experienced with engineering insight.
C4	Instructed to prepare estimate in relation to the inspection report of David Coatsworth	Limited scope to only repair as instructed
C6	Three visits made in early 2011	Comprehensive checking of the specified areas is indicated by the three visits.
C7	First visit he inspected the South Wall and North Core. No cracking was seen on the exterior of the walls.	Very low level of damaged indicated
C8	Second visit he met with John Drew and looked at both the outside and inside of the building.	
C9	Third visit was specifically to look at the inside of the lift shafts	This was 11 February 2011 according to Katrina Roy of Concrete Protection & Repair Ltd (BUI.MAD249.0449)
C11	The cracking observed in the CTV Building was in his experience unremarkable and did not give cause for concern. The damage was consistent with and did not appear to go beyond what was identified by David Coatsworth. Fine hairline cracks.	Indicative of elastic cracking or low levels of yielding.
C14	He did not see the diagonal cracking as the base of the South Wall.	

WIT Ref	Issue	Comments
C16	On the second visit he inspected the stairwell on each level. Cracking was consistent with David Coatsworths report. Did not remember seeing cracking in the toilets.	
C19	Horizontal and vertical cracking in the lift shaft. The horizontal cracking aligned with the construction joints at each floor. There was also cracking about half way up each floor corresponding to stair landings. Both types of horizontal cracking were present the full height of the western lift shaft wall (Line D) and the northern wall (Line 5). But not in the eastern wall (Line D/E)	Some extension of cracking from the construction joints at the stair landings indicates some tension may have occurred in the Line 5 wall to extend the cracks from the stair well landings. Not sure why none would have occurred on D/E.
C20	Two vertical cracks ran the length of the shaft 1.0 and 1.5 metres from the western side of the lift shaft. 0.2 to 0.5 mm wide	It is not obvious what may have caused that vertical cracking.
C21	No spalling at any of the cracks referred to in the North Core	
C22	Looked at the beam column joints where they were not covered by linings	No reported damage
C23	He looked at the columns referred to in the CPG Report	This would have included F4 at Level 4 northeast corner and 1/A-B at Level 6. No apparent view on them. So it appears their condition was as noted by David Coatsworth.

WIT Ref	Issue	Comments
C24	He did not look at the blockwork on the west wall as it did not require crack injection	The implication is that it had appeared to be undamaged and uncracked to David Coatsworth.
C25	Was going to return a fourth time to look at the exterior columns at the higher floors once the painters returned but was not contacted to say that had occurred..	Marie-Claire Brehaut commented on painters having commenced work prior to the February Aftershock (wit.brehaut.0001).

FIGURES

This section contains bird's eye graphics from various angles and witness perspectives referenced in various statements. Relevant page references to reviews of Statements of Evidence are provided.

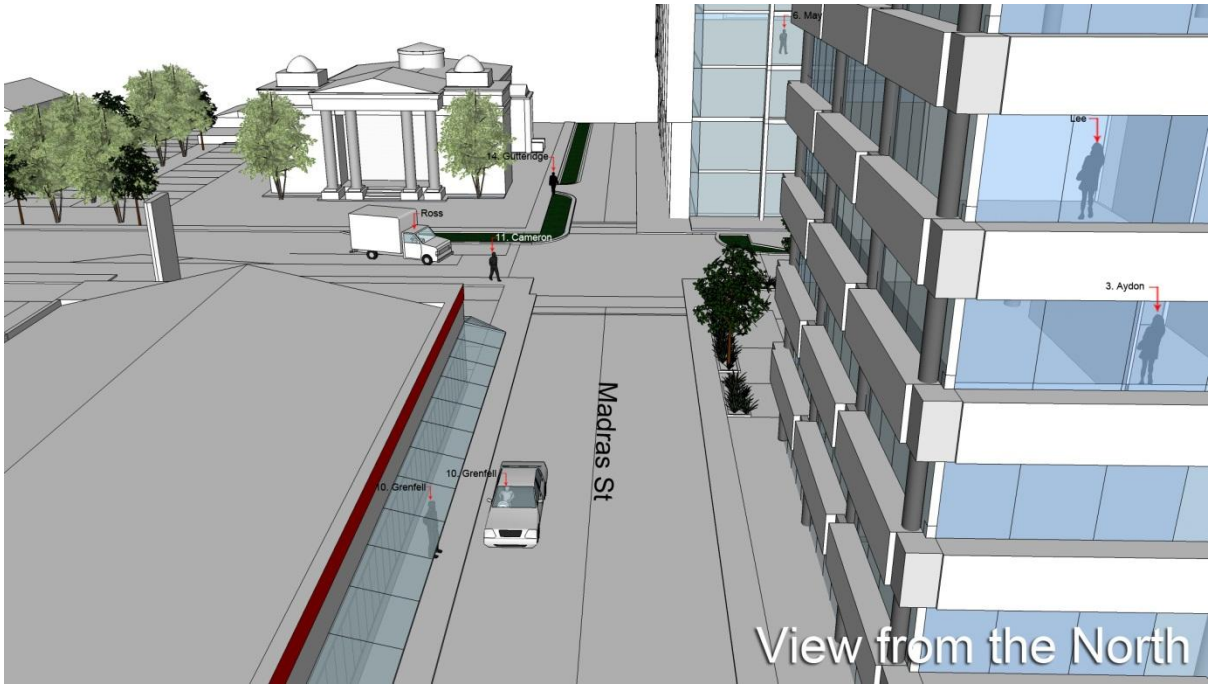


Figure 1 - Bird's eye view from the North.

Figure 2 - Bird's eye view from the Southwest.

Figure 3 - Bird's eye view from the Southeast.

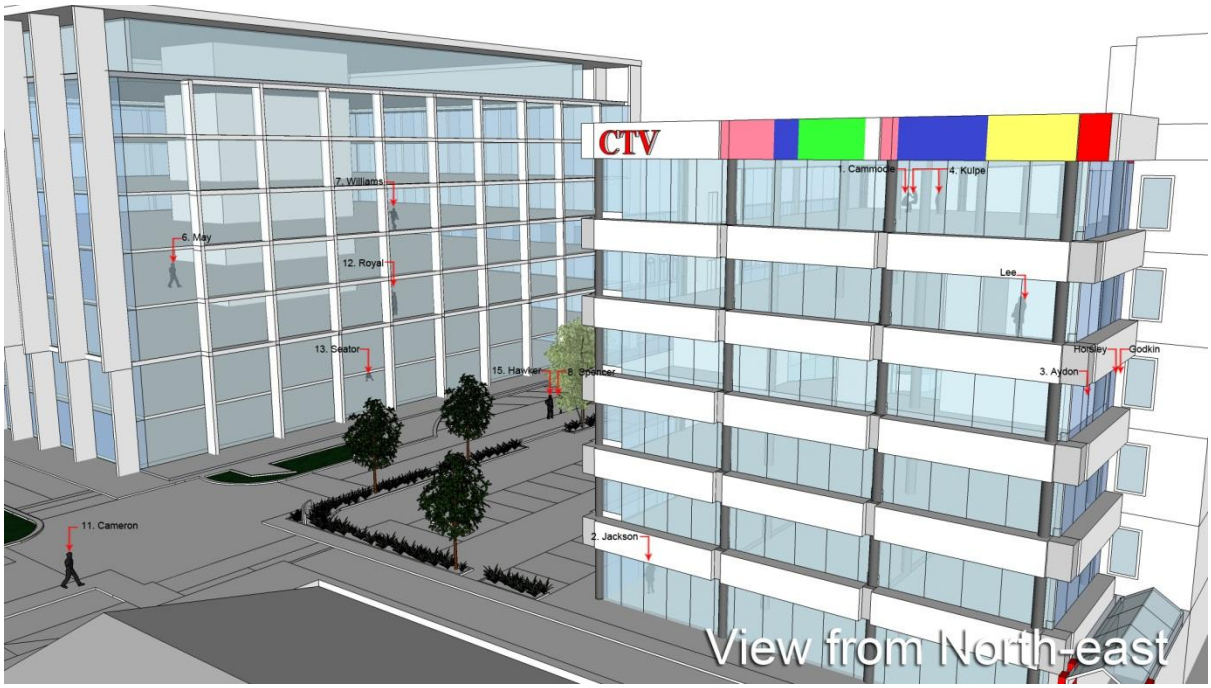


Figure 4 - Bird's eye view from the Northeast.

Figure 5 - Photo of Column F4 (249 Madras Street 068C.jpg) at the northeast corner of the CTV Building at Level 4 taken by David Coatsworth during his inspection after the September Earthquake. It is the only column that was found to be cracked below Level 6. See review of Statement of Evidence by damage observer Pagan on page 53. See also the review of the Statement of Evidence by eyewitness Smith on page 55.

Figure 6 – View on Level 4 as seen by eyewitness Aydon – see review of her Statement of Evidence on page 18

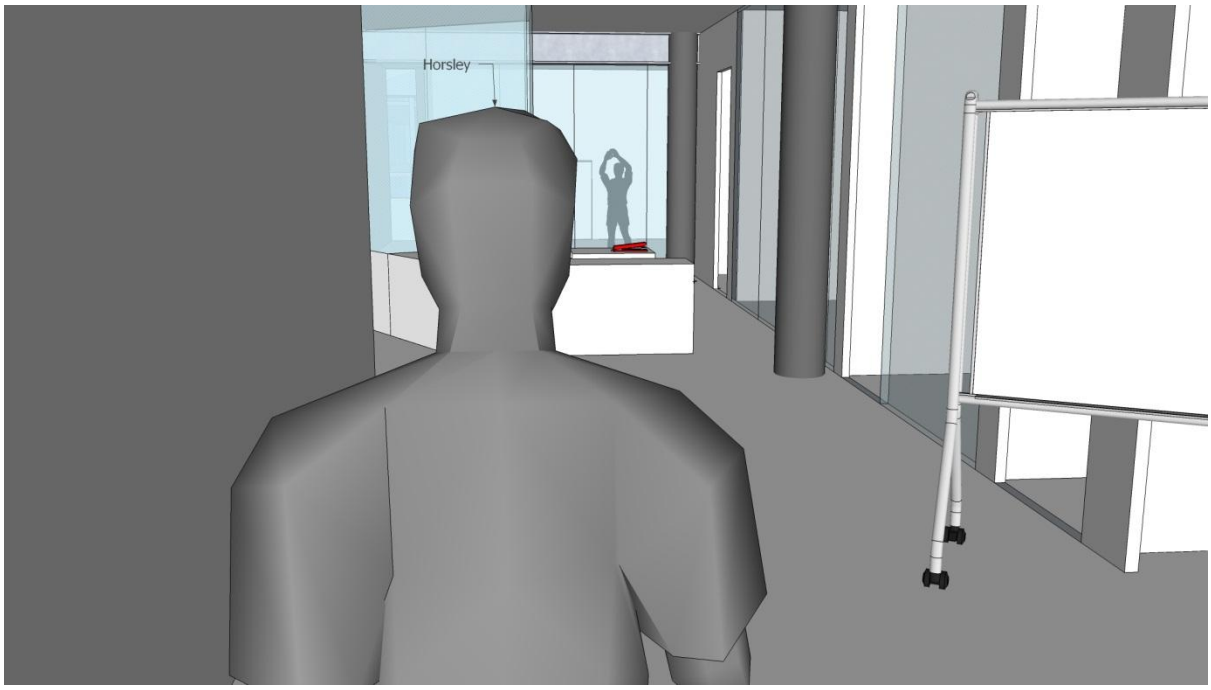


Figure 7 – View on Level 4 by eyewitness David Horsley (BUI.MAD249.0436.2) who was standing at the lifts. David recalled the notice board easel fell westward.

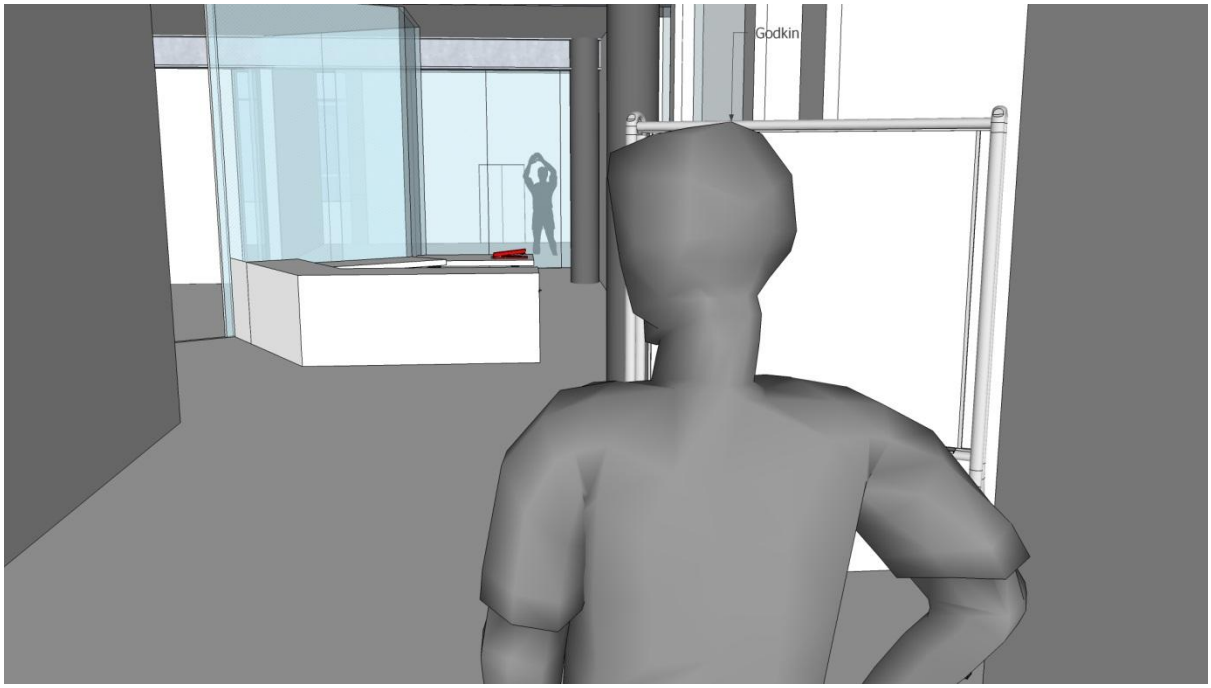


Figure 8 - View on Level 4 as Ron Godkin (BUI.NAD249.0285.3) was standing at the lifts. Ron recalled that the person in the room at the end of the corridor at the south end of the CTV Building raised their arms in the air as the floor collapsed beneath them. He then described the floor undulating, filing cabinets bouncing, and a big stapler behind the reception desk being flung westward through the tutor's window across the corridor just before the building collapsed (BUI.MAD249.0285.5). See review of Ron Godkin's Statement of Evidence on page 24.

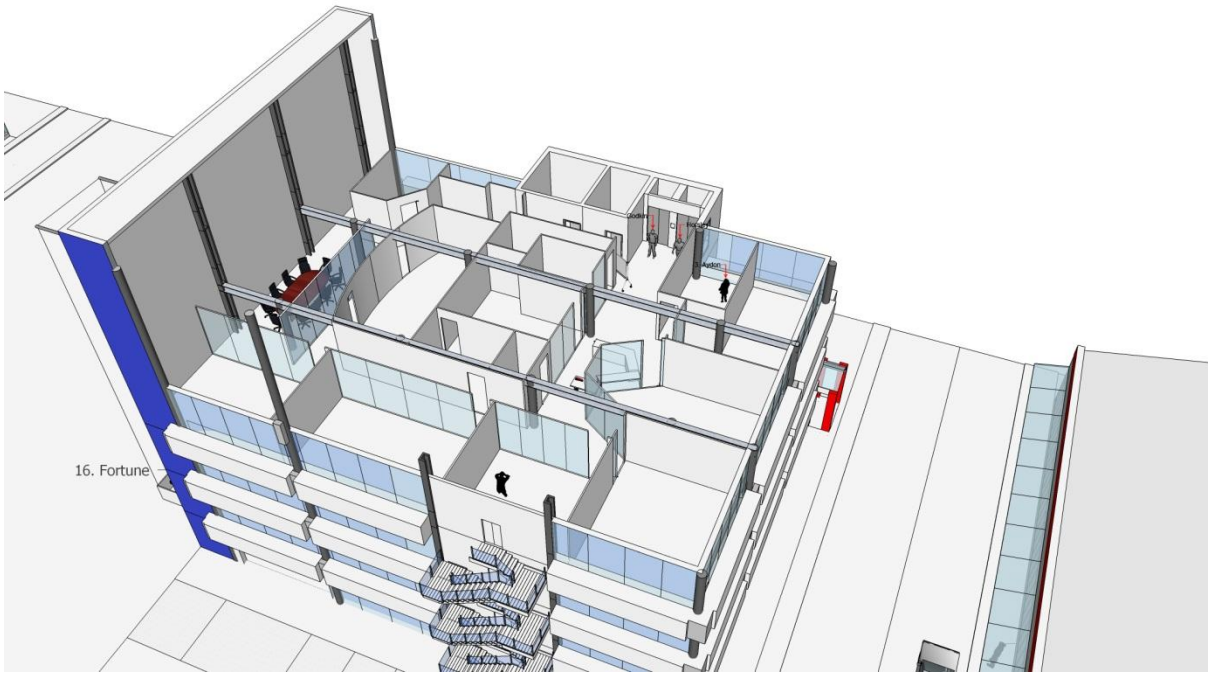


Figure 9 - Level 4 showing position of eyewitnesses Godkin, Horsely and Aydon.

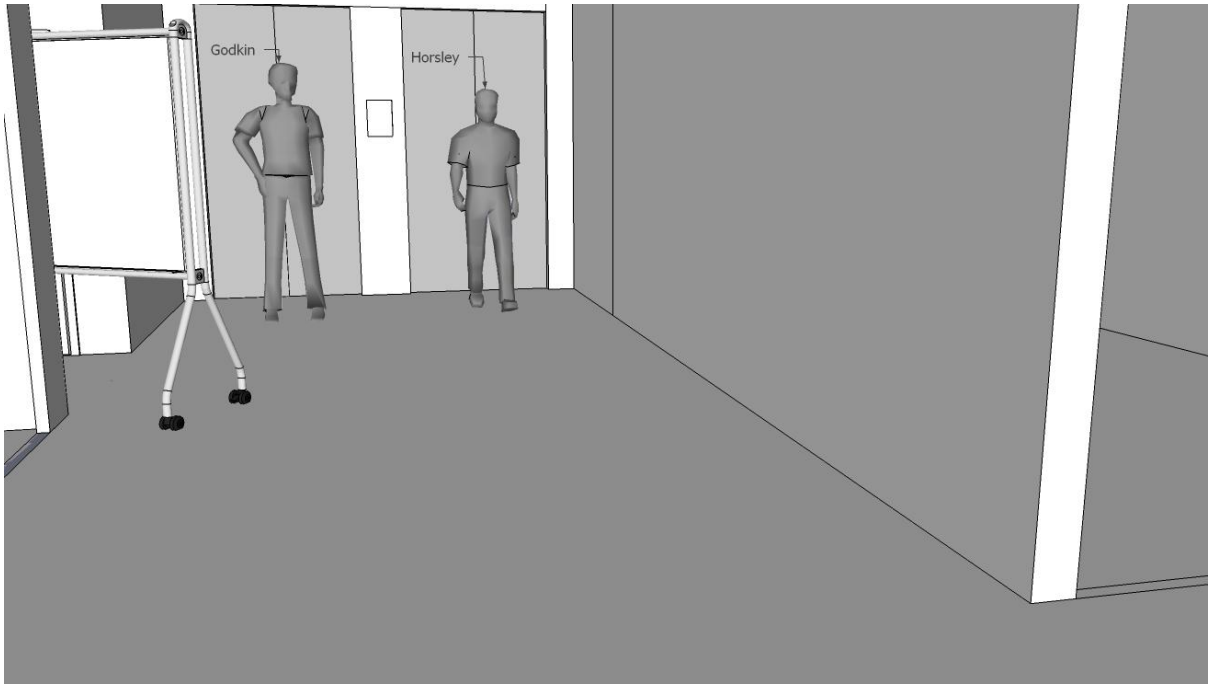


Figure 10 - Another view of Godkin and Horsley in front of the lift doors on Level 4.

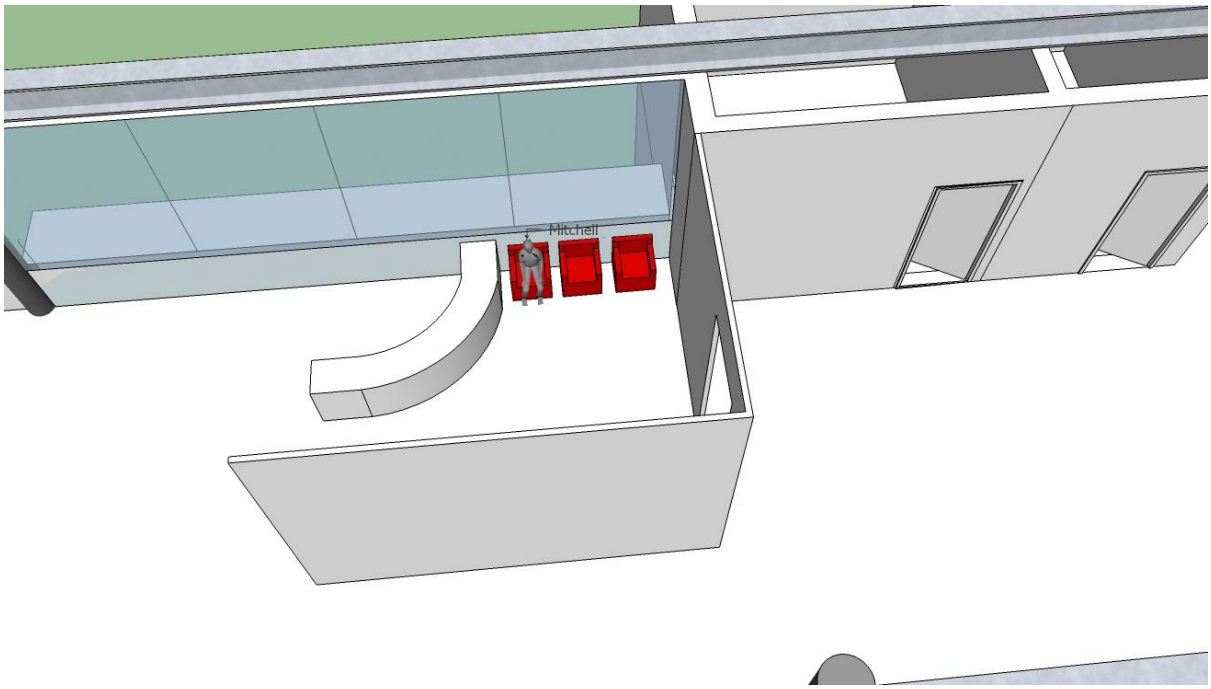


Figure 11 - Position of eyewitness Kendyll Mitchell on Level 6. She was seated at the north end of the building west of the North Core. A partition is located 4 metres in front of her based on her Statement of Evidence which is reviewed on page 33.

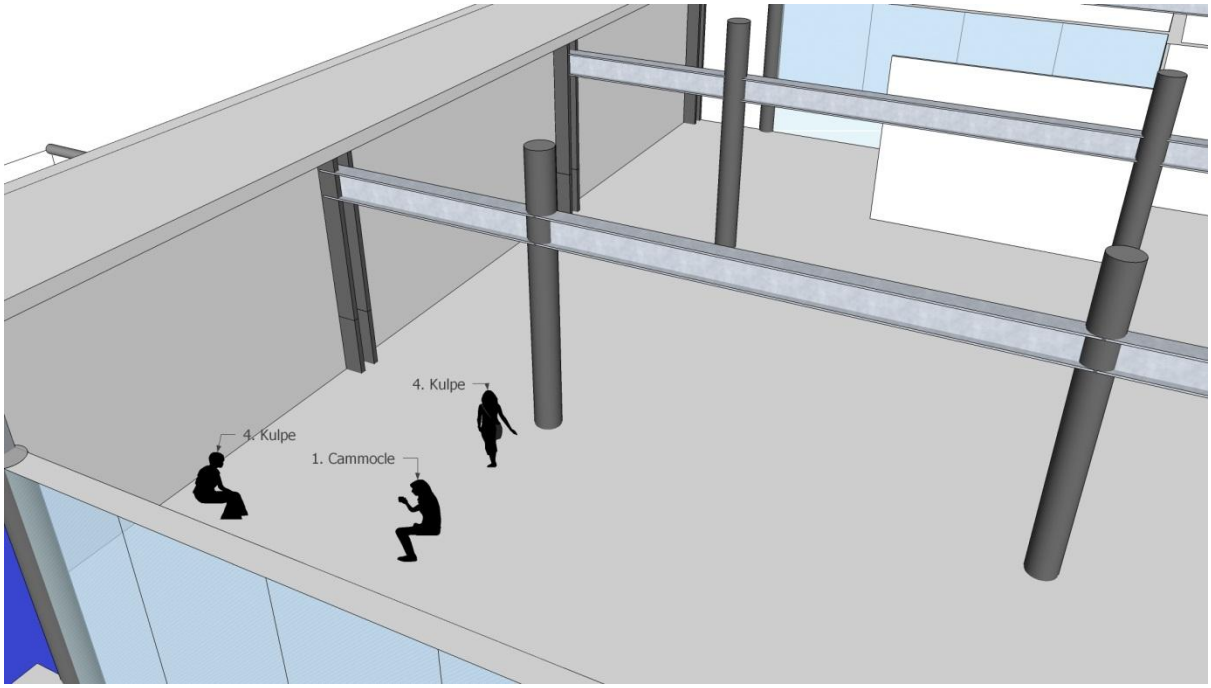


Figure 12 - Position of Kulpe and Cammock. Kulpe got up and stood under the door frame once the aftershock began. See review of Nilgun Kulpe's Statement of Evidence on page 30 and the review of Liz Cammock's Statement of Evidence on page 20.

Figure 13 - Position of Williams. See the review of his Statement of Evidence on page 37.

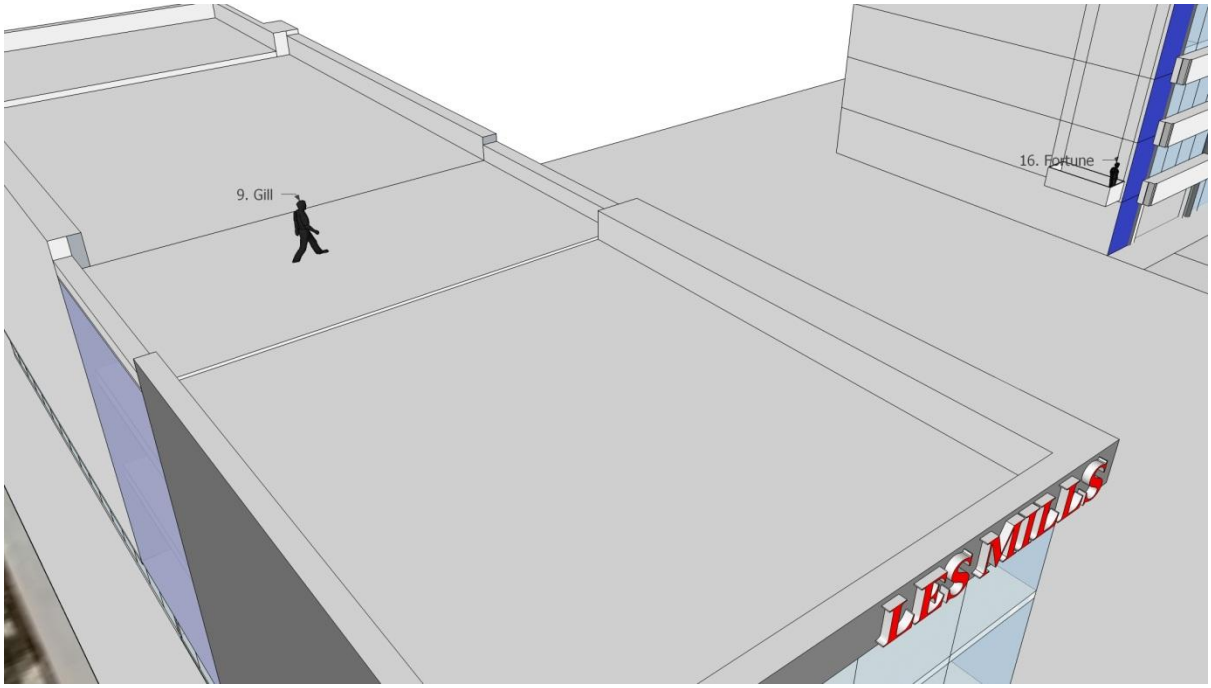


Figure 14 – Position of Stephen Gill on top of the Les Mills Building. See the review of his Statement of Evidence on page 23.

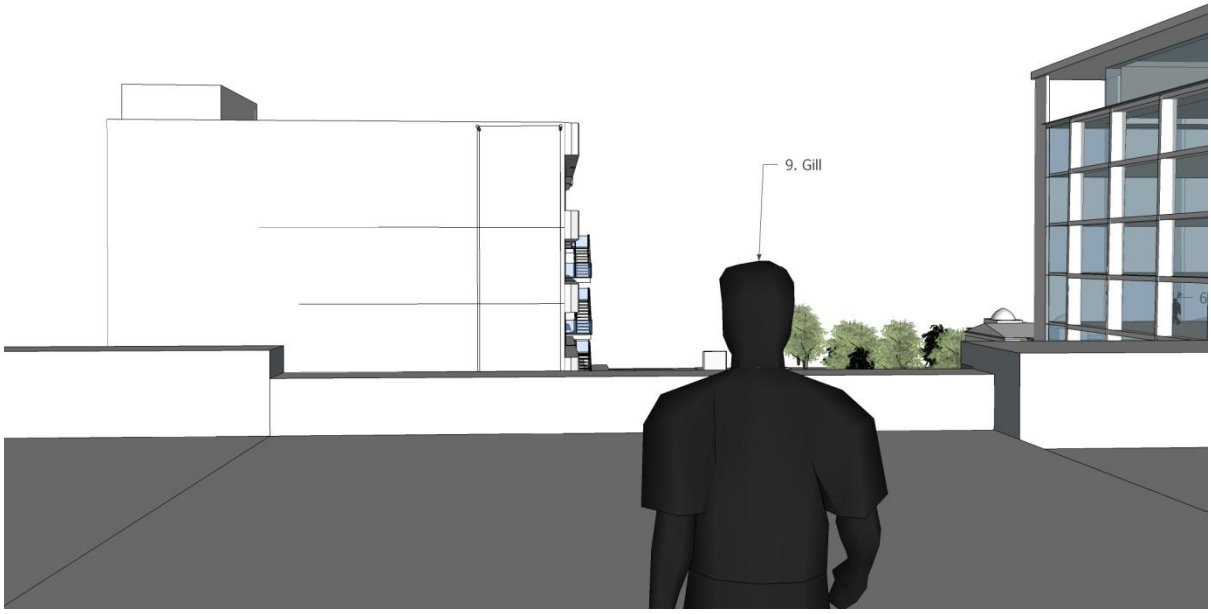


Figure 15 - View as seen by Stephen Gill from the top of the Les Mills Building. It seems to indicate that when he recalled seeing the bottom of the southwest corner column kicking out that it could have been the Level 3 to 4 column as it may have been at the bottom of his immediate field of view at that moment. See the review of his Statement of Evidence on page 23.

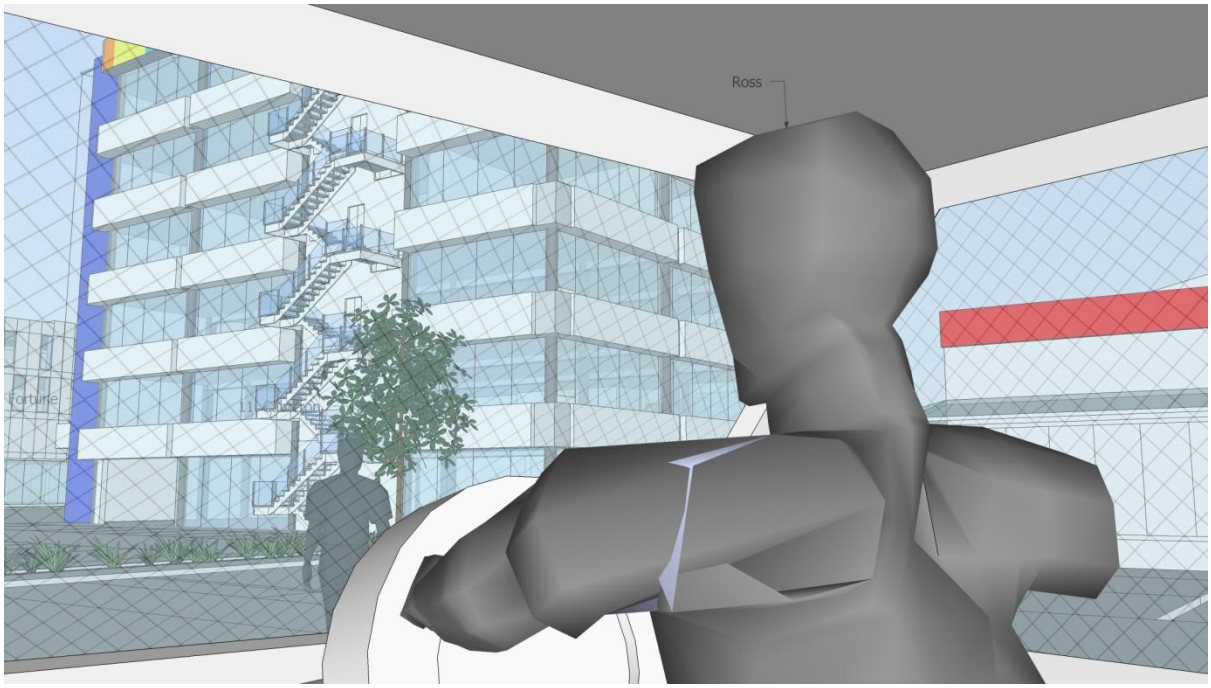


Figure 16 - View from location of Matthew Ross of the southeast corner of the CTV Building as viewed from his van at the east side of the intersection of Madras and Cashel Streets. His Statement of Evidence (wit.ross.0001) is reviewed on page 34.

Figure 17 - View showing the position of Stephen Grenfell's car as seen in the photo from Penelope Spencer's Statement of Evidence (wit.spencer.0001). The review of Penelope Spencer's Statement of Evidence is on page 36. This view also shows Stephen Grenfell's initial position standing by the car and then in the car. See the review of Stephen Grenfell's Statement of Evidence on page 26.

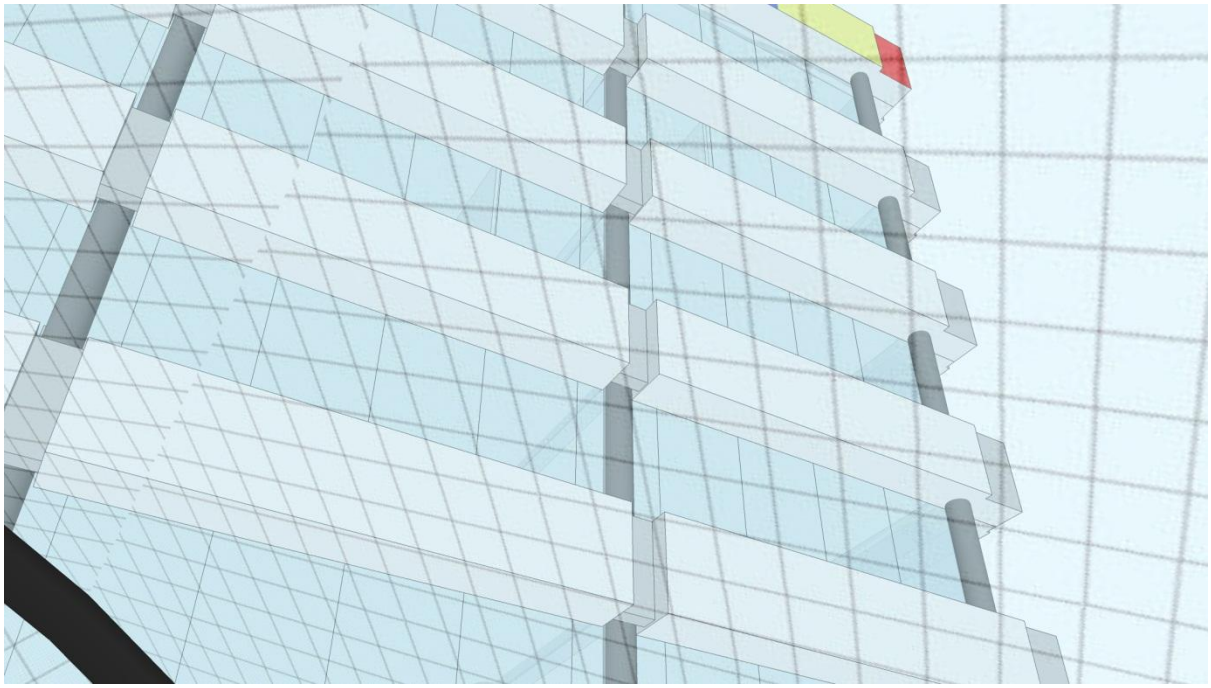


Figure 18 - View through the windscreen of Stephen Grenfell's car which shows a good view of the north eastern face of the building up most of the levels. (Initially Stephen Grenfell was standing by the car, then he is seated in the driver's seat which was on the kerb side of the car, as the car was parked heading north.) A review of Stephen Grenfell's Statement of Evidence is on page 26.

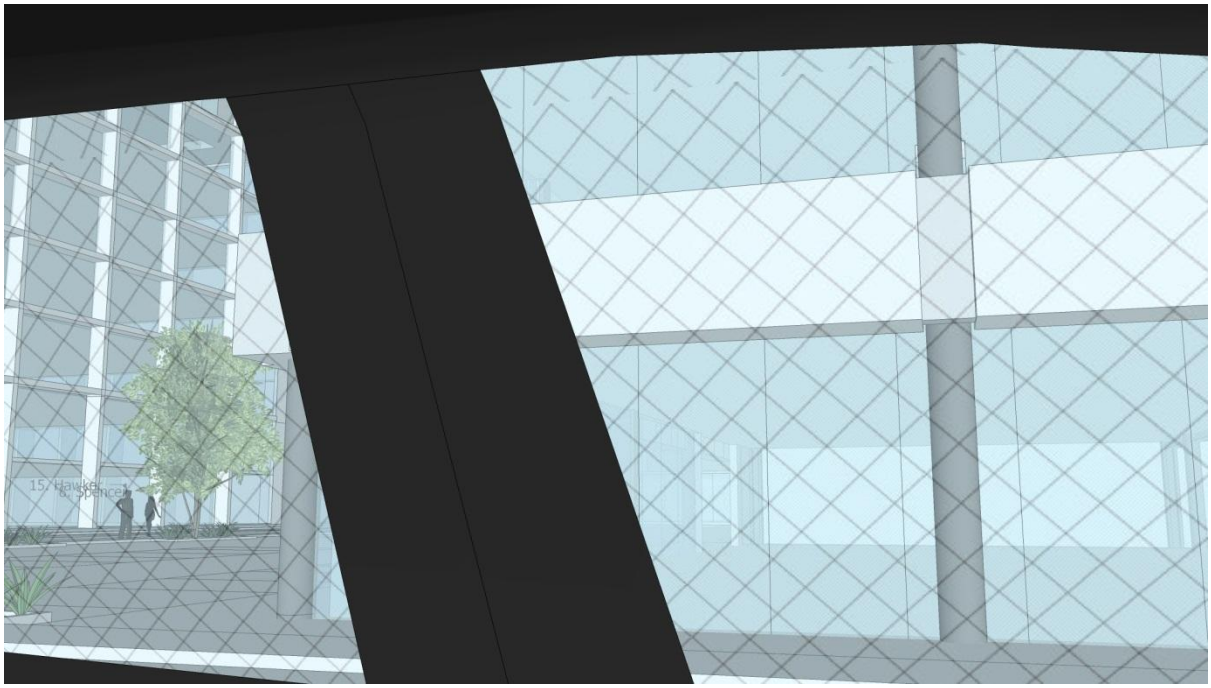


Figure 19 - View out the left rear passenger window of Stephen Grenfell's car indicates he could only see the lower two levels. A review of Stephen Grenfell's Statement of Evidence is on page 26.

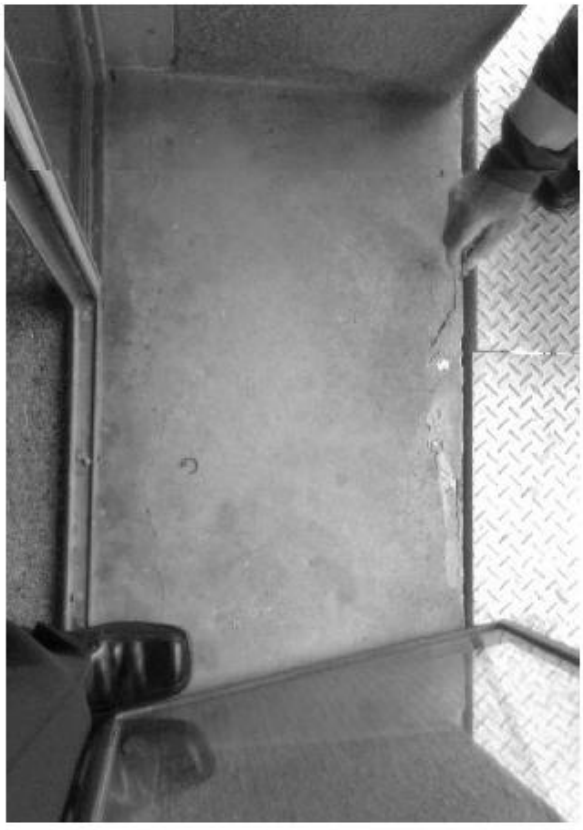
Figure 20 - View as seen by Euan Gutteridge (wit.gutteridge.0001) with south and east faces of the CTV Building clearly visible. The van of Matthew Ross (wit.ross.0001) is located at the intersection of Madras and Cashel Streets. Bruce Cameron has just come out of Blackwells Motors (BUI.MAD.0059.1). Stephen Grenfell and his car can be seen parked on the east side of Madras Street (wit.grenfell.0001). A review of Euan Gutteridge's Statement of Evidence is on page 27.

Figure 21 - Photos from Peter Higgins (BUI.MAD249.0454) showing damage to column C18 and connection to overhead North Core wing wall on Line D/E.

037

038

039



040

Figure 22 - Collection as photographed by Pagan. Photo 37 shows the damage to the connection of the Column C18 into the North Core overhead wing wall on Line D/E.