

Summary of Findings

(Slide no. 86 from presentation by Dr Clark Hyland on 5 July 2012)

(Ashley Smith variations dated 9 July 2012 shown as **tracked changes** below)

- “ The **earthquake 22 February 2011** aftershock was severe but the building appears to have collapsed at inter-storey drifts **much** less than ~~those expected by the Standards~~ the potential drift demands calculated.
- “ A number of collapse scenarios were ~~considered~~ evaluated. Variability and uncertainty in physical properties and analysis processes do not allow a particular scenario to be determined with confidence. A likely scenario, and the scenario that appears most consistent with the collapse evidence and the eye witness reports, was initiated by failure of ~~Collapse most likely initiated in~~ substandard concrete a -columns ~~along~~ the east face of the building at a mid-to-upper ~~Levels 3, 4 or~~ 5. This column failure would have been caused predominantly by north-south direction drift, but could also have been influenced by east-west drift and/or vertical seismic loads, spandrel panels and low concrete strength.
- ~~“ Columns designed in accordance with the standards would have been expected to be safe at drifts of 1.51%.~~
- “ The columns along the ~~North and~~ East faces of the CTV Building ~~at Levels 2 to 4~~ were estimated from the pushover analysis to have drift capacities between 1.15~~1.0~~ and 1.45~~1.3~~%
- “ It appears that these East face columns may have failed ~~at drifts of less than 1.0%~~ prior to diaphragm slab or Drag Bar ~~failure~~ disconnection at the North Core

Summary of Findings

(Slide no. 87 from presentation by Dr Clark Hyland on 5 July 2012)

(Ashley Smith variations 9 July 2012 shown as **tracked changes** below)

- “ Specific factors that contributed (or may have contributed) to the columns failures include:
 - . Columns did not have the minimum amount of spiral confining and shear reinforcing steel required by the design standard.
 - . There was no ~~specific~~ minimum seismic gaps specified between the Spandrel Panels and the Columns
 - . The South Wall may have begun to yield and lose stiffness at drifts as low as of 0.40% ~~due~~ contributing to the asymmetry of the seismic resisting structure ~~at asymmetry~~ and thereby increasing column drifts
 - . Vertical accelerations may have reduced column drift capacity
 - . Smooth construction joints in the South Wall may have slipped and increased inter-storey drifts.
 - . The concrete in some of the columns had test strengths less than the minimum strength specified.
 - . Seismic separation gaps between the Infill masonry on the west face and the structure appear to have been compromised and the masonry may have changed the response of the structure.

Summary of Findings

(Slide no. 88 from presentation by Dr Clark Hyland on 5 July 2012)

(Ashley Smith variations 9 July 2012 shown as **tracked changes** below)

- “ Critical connections of the floors to some of the North Core walls were omitted in the original design and were only identified during a pre-purchase structural review 3 years after construction.
 - . The Council did not have any record of the remedial works that were subsequently undertaken.
 - . The Drag Bars that were installed at levels 4 to 6 only lacked toughness and ductility and (in my opinion) could not be relied on to sustain the ultimate ~~design~~ response of the structure.
- “ The ~~building did not appear to have suffered significant~~ structural damage reported following in the 4 September 2011 Earthquake or 26 December 2010 Aftershock appeared to be relatively minor and was not indicative of a building under immediate distress or having significantly impaired resistance to earthquake shaking. Some key areas including diaphragm connections to the North Core and column bases were not inspected. The photograph recently provided by Peter Higgins [BUI.MAD249.0454] was an indication of damage to the connection between column C18 and the North Core.
- “ The presentation is based on the findings of the CTV Building Collapse Investigation Report by Hyland Fatigue + Earthquake Engineering and StructureSmith Ltd and the Site Examination and Materials Testing Report by Hyland for the Department of Building and Housing
The scope of the investigation was limited to identifying technical reasons for the collapse.