

Submission of ADAM WILLIAM THORNTON

to the

**CANTERBURY EARTHQUAKES
ROYAL COMMISION**

**EARTHQUAKE PRONE BUILDINGS &
STRENGTHENING OF EXISTING BUILDINGS**

[Unreinforced Masonry Buildings Hearing – week beginning 7th Nov]

16 Oct 2011

INTRODUCTION

- 1.1** My full name is Adam William Thornton. I am a civil/structural Chartered Professional Engineer. I graduated with a Bachelor of Engineering (Honours) degree in Civil/Structural Engineering from Canterbury University in 1974. I am a Fellow of the Institute of Professional Engineers and I am a Past President of the Association of Consulting Engineers of New Zealand. I am also a past member of the executive board of FIDIC, the International Federation of Consulting Engineers and a past member of the IPENZ Practice Board.
- 1.2** I am or have been a member of the following:
- (a) NZSEE Study Group on Earthquake Prone Buildings
 - (b) NZ Govt Department of Building and Housing – Advisory Board Member
 - (c) NZ Govt Department of Building and Housing – Sector Reference Group Member for 2011 Building Bill Amendment
 - (d) Canterbury/Auckland Universities Seismic Retrofit Research Programme - Review Board
 - (e) Member of DBH Expert Panel for Christchurch Earthquake Investigations
- 1.3** After graduating from Canterbury University, I was employed for several years as a design engineer before becoming a director and shareholder of Dunning Thornton Consultants Limited (**DTC**) in 1986.
- 1.4** DTC is a Wellington-based consultancy engineering company offering primarily structural design services to clients, architects, contractors and suppliers in the construction industry.
- 1.5** I have over 35 years' experience in the construction industry including:
- (a) structural design and monitoring of many and varied new buildings and structures for private, institutional, local and central government clients;

- (b) structural design and monitoring of the strengthening (seismic retrofit) of over 50 buildings including unreinforced masonry buildings (URMs) and many heritage/listed buildings.

1.6 The seismic strengthening/assessment projects I/DTC have been involved in include (note that these are predominately in the Wellington area):

- (a) The St James Theatre;
- (b) The Embassy Theatre;
- (c) The Futuna Chapel;
- (d) The Dominion Museum (Massey University);
- (e) State Insurance (Te Puni Kokiri);
- (f) The Hope Gibbons Buildings ;
- (g) Turnbull House ;
- (h) Wellington City Council Social Housing (tower blocks) project ;
- (i) Numerous buildings in the Courtenay Place/Allen/Blair Streets precinct;
- (j) Dockside;
- (k) Shed 5;
- (l) Shed 21 – Waterloo Apartments;
- (m) Odlins Building (NZX Centre);
- (n) Shed 22 – now Mac's Brewery;
- (o) Steamship Wharf Development
- (p) Queen's Wharf – Outer Tee;
- (q) The Free Ambulance Building;
- (r) The John Chambers Building
- (s) The Huddart Parker Building
- (t) The Waihi Cornish Pumphouse (Waihi)
- (u) The Rob Roy Hotel (Auckland)

2. SCOPE OF SUBMISSION

2.1 My submission is on the following topics relating to the assessment and seismic strengthening of existing buildings in New Zealand. It is set out under the following headings:

- (a) Description and observations relating to existing legislation for earthquake prone buildings;
- (b) Observations relating to existing earthquake prone building policies (as prepared by Territorial Authorities);
- (c) Existing assessment and strengthening practice;
- (d) Observations relating to risks from existing buildings;
- (e) Recommendations for legislation;
- (f) Recommendations for Local Authority policies;
- (g) Recommendations for training and practice;
- (h) Recommendations for heritage structures;

3. Description and Observations Relating to legislation for existing and earthquake prone buildings

3.1 The definition of an Earthquake Prone Building (EPB) is stated in section 122 of the Building Act. Design practitioners and Building Consent Authorities (BCAs) generally agree that it is ambiguous in a number of respects.

3.2 In subsection (a) and relevant regulations a structure is required to achieve an ultimate capacity in excess of 33%NBS. However there is no stated requirement for ductility or robustness beyond 34%NBS. A brittle structure ($\mu=1$) that just achieves 34%NBS may have an unacceptably high likelihood of collapse if ground motions exceed 'moderate' levels. For a Return Period Factor (R_u) for 0.35 the return period for exceedance is 50 years. A structure with some ductility will have a greater chance survival when it's ultimate capacity is exceeded.

- 3.3** The word 'and' at the end of subsection (a) has been the cause of considerable debate and can provide an onerous level of assessment to prove that a building is earthquake prone.
- 3.4** In subsection (b) the term collapse is open to interpretation; does it mean the first broken window pane or total pancaking of a building.
- 3.5** Section 131 requires Territorial Authorities (TAs) to adopt policy on EPBs. It does not:
- (a) Require all buildings to be assessed
 - (b) Require all EPBs to be strengthened
 - (c) Require buildings to be strengthened within a certain timeframe
 - (d) Allow TAs to enforce a capacity in excess of 34%NBS
 - (e) Require TAs to have a policy on buildings that are not earthquake prone but which still fall well short of current requirements for new buildings.
 - (f) Require TAs to enforce rapid strengthening for structures that have extremely low capacities.
- 3.6** In Wellington, for example, the TA has been extremely proactive in attempting to identify all EPBs. However building owners have a 10-20 year timeframe to strengthen buildings, some of which have assessed strengths below 10%NBS. In the meantime people are still living and working in these buildings.
- 3.7** Section 112 requires that buildings that are altered shall comply structurally/seismically to the same extent that they did before the alteration. However additions are not specifically covered so that, for example, a building that meets 40%NBS could potentially be added to provided that the resulting capacity is still not less than 40%NBS. This potentially allows construction of additional substandard structure, increasing the overall life-safety risk.
- 3.8** Section 115 requires that existing structures that undergo a change of use comply with current Building Code requirements 'as nearly as is reasonably practicable'. While the term 'as nearly as is reasonably

practicable' is undoubtedly a sensible qualification, differing interpretations have led to consideration variation in the target %NBS.

4. Observations Relating to Existing Earthquake Prone Building Policies (as prepared by Territorial Authorities)

4.1 Each Territorial Authority has prepared an Earthquake Prone Building policy (some had already been revised prior to the Canterbury Earthquakes)

4.2 The policies vary widely in many respects including the following:

- (a) Whether initial assessment is carried out by the territorial authority or by the building owner
- (b) Whether assessment is proactive (all buildings are assessed within a certain time frame) or reactive (buildings are only assessed if the building owner applies for a Building Consent)
- (c) Strengthening time frames (varying from around 5 years to effectively indefinitely)
- (d) Whether strengthening time frames are risk related.
- (e) Strengthening level (although opinions vary as to whether TAs can require strengthening in excess of 34%NBS)
- (f) Whether alterations/refurbishment (of a non-strengthening nature) exceeding a percentage of capital value should trigger strengthening.
- (g) Provisions for heritage buildings
- (h) Provisions for staging/incremental retrofit

5. Observations on Existing Assessment and Strengthening Practice

5.1 Detailed seismic assessment can be a very difficult and time consuming process, even for practitioners who are experienced in complex seismic design. It is my opinion that detailed assessment of existing structures is more difficult and requires greater experience than for the design of new structures. For new buildings, the Building

Code and associated compliance documents (Verification Methods prescribed by codes and standards) should generally result in structures with appropriate modes of response, collapse mechanisms and levels of ductility/robustness.

- 5.2** Existing buildings, particularly (but not exclusively) those designed prior to 1976 do not inherently have these features and thus the engineer/assessor has to determine the 'weakest-link' from many possible failure mechanisms.
- 5.3** Many of the technologies both of analysis/assessment and retrofit are complex and relatively new. Accordingly practice in terms of skill/experience and outcomes is somewhat varied. When the extra variable of sensitive heritage preservation is added the available experienced design resource is quite limited.
- 5.4** The NZSEE guide "The Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" is generally well regarded and is widely used. However its interpretation can be varied and it is not a compliance document cited by the Building Act.
- 5.5** My observations of assessment and seismic retrofit practice include:
- (a) Considerable design effort to justify an assessed performance of just exceeding 34%
 - (b) Obviously brittle (no or low ductility) structures being accepted as not earthquake prone yield/ULS just exceeding 34%NBS
 - (c) Instances of extremely conservative assessments (e.g. of timber structures) and of non-conservative assessments.
 - (d) Variance of IEP assessments between different engineers of up to 200%
 - (e) Instances of very inappropriate matching between existing and retrofit structural stiffness and/or ductility.

6. Observations Relating to Risks from Existing Buildings

- 6.1** New Zealand, as a small country, has a disproportionately high percentage of national wealth located in a small number of urban centres, the loss of any one of which can have extreme consequences for the country as a whole. While the cost to the country resulting from the Canterbury earthquakes is reportedly between 8-10% of GDP, the much larger Japanese event is apparently only costing 2-3% of their economy. Therefore the proportionate cost risk of a major natural disaster in a large city is higher in NZ than an international average. Perhaps our threshold for EBPs needs to respond to this.
- 6.2** Reduced seismic performance from existing older buildings can be justified for the risk of material loss on an infrequent basis, i.e. when a large earthquake occurs, insurance and EQC should respond to mitigate the material loss. However extreme loss of life on one structure, such as the CTV building, is perhaps an outcome that was not anticipated by many. Perhaps through this Royal Commission, New Zealand needs to re-examine its appetite for life-safety risk even for rare events and perhaps earthquake prone hazard levels should be adjusted more effectively for occupancy levels.
- 6.3** Seismic retrofit of heritage structures is a dilemma for structural engineers; balancing the call for minimal intervention from heritage lobbies with the need for life-safety and the protection of national icons. The view, sometimes espoused by heritage proponents, that “heritage structures can be rebuilt after an earthquake”, has been proven to be a fallacy both on economic and practical grounds.
- 6.4** In the past, messages from engineering lobbies to legislators and regulators relating to seismic risk from existing buildings, have perhaps been excessively tempered, at the political level, by consideration of the effects on property values that may result from more aggressive earthquake prone policies. Perhaps now is the moment for a more appropriately balanced view.

6.5 Prior to the Canterbury earthquakes, relatively few building owners have been proactive about seismic upgrading unless it can be economically justified. Apparently this is different in Japan where relatively more buildings have been strengthened to higher performance levels. Reasons for this appear to include higher levels of building ownership by central/local government and a cultural sense of obligation for high performance from prominent corporates.

7. Recommendations for Legislation

7.1 My recommendations for legislation include:

- (a) Raising of the earthquake prone threshold nationally (perhaps 50%NBS ?);
- (b) Require a reasonable level of ductility at or near the minimum level. This could be done by requiring all buildings to achieve a minimum displacement equivalent to say $R_u=0.6$ (return period of 150-200years);
- (c) For national strategic reasons, set a higher earthquake prone threshold for main centres ;
- (d) Set the strengthening target level higher than the earthquake prone level. This reduces risk nationally and also future proofs buildings, to some extent from future changes in hazard level etc. It also reflects common practice and the recommendations of NZSEE etc.
- (e) Set a higher earthquake prone threshold for high occupancy buildings
- (f) Implement a single, proactive EPB policy for all Territorial Authorities in NZ, or at least require more consistency.
- (g) Buildings subject to a change of use or addition of more than 10% of floor area should be required to achieve 90%NBS for primary seismic resisting structure.
- (h) Require effective timeframes for retrofit, bearing in mind resources, risk and effective building life.

8. Recommendations for Local Authority Policies

8.1 My recommendations for Local Authority policies include:

- (a) Allow progressive/staged strengthening;
- (b) Encourage/require adjacent owners to cooperate (particularly for pounding and party wall issues)

- (c) Require strengthening when major refurbishment is undertaken (greater than 25% of capital value). This should also be extended to cover residential dwellings that are of high risk, e.g. structural brick houses;
- (d) Work with heritage lobbies and community to prioritise heritage structures.
- (e) Guidelines for iconic heritage structures in private ownership.
- (f) Develop strengthening timeframes to coincide with urban regeneration programmes.

9. Recommendations for Training and Practice

9.1 My recommendations for training and practice include:

- (a) Develop compliance documentation (Verification Methods) for assessment and retrofit). E.g. NZS1170 should list required target levels;
- (b) Training and CPD required for seismic retrofit. This should cover new graduate engineers as well as experienced practitioners;
- (c) Encourage greater use of independent peer review;
- (d) Continued research and development of new retrofit assessment and retrofit technologies.

10. Recommendations for Heritage Structures

10.1 My recommendations for heritage structures include:

- (a) Communities to decide which structures are to be (seismically) protected in perpetuity
- (b) Those structures should be protected to minimum of 130%NBS
- (c) Accept that other heritage structures may be lost in a major event but retrofit for life safety.

Adam William Thornton
16 October 2011