10 STEPS TO ACHIEVE THESE SOLUTIONS

10.1 Possible changes to Building Code, NZ Standards

The previous chapters confirmed that damage-resistant technical solutions are available and more importantly have been implemented in real buildings. These successful applications to real case studies are mainly due to the strong interaction between practitioners and researchers through the help of associations like CCANZ (Cement Concrete Association), HERA (Heavy Engineering Research Association), and the New Zealand Timber Design Society.

Figure 10.1gives an overview of building regulation in New Zealand as it relates to the New Zealand Building Code System (From the DBH report on the building regulatory framework to the Royal Commission, May 2011).

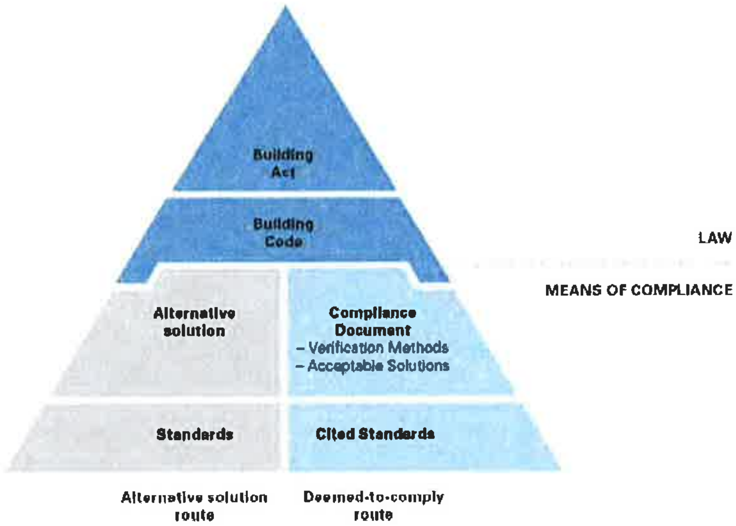

Figure 10.1 Overview of building regulation in New Zealand.http://canterbury.royalcommission.govt.nz/vwluResources/DBH2/$file/SystemofBuildingControls2.pdf)

The Building Act provides the legislative framework for administration of building controls in New Zealand. The New Zealand Building Code (a schedule to the Building Regulations) provides performance statements for all aspects of building design. The Building Code needs a review in the area of damage-resistant seismic design.

Figure 10.1 shows three different pathways for building owners and their structural designers to comply with the New Zealand Building Code. Compliance can be demonstrated using either an **Acceptable Solution** or a **Verification Method** in the "Deemed-to-comply" route, or by using an **Alternative Solution** in the "Alternative Solution route".

Most new buildings are designed in accordance with approved Verification Methods, those generally being the loadings standard (AS/NZS 1170 and NZS 1170.5), together with the material design standards (NZS 3101 Concrete Structures, NZS 3404 Steel Structures, and NZS 3603 Timber Structures). Many new or innovative damage-resistant building systems are not called up with specific design methods in these Verification Methods, in which case a full or partial "Alternative Solution" must be offered. The same applies to base-isolated buildings.

Some practitioners feel less confident to design through an "alternative" route, rather than conventional design using an accepted Verification Method. In order to have a stronger impact on practitioners a proper regulatory process needs to be introduced for the design of buildings protected by base isolation and/or damage-resistant design procedures. This will require some changes to NZS 1170.5 and new technical solutions in the cited material standards (NZS 3101 Concrete Structures, NZS 3404 Steel Structures, and NZS 3603 Timber Structures). Only NZS 3101 currently has an appendix (Appendix B) which gives a design procedure for PRESSS-technology in reinforced concrete structures.

Researchers actively involved in the development of damage-resistant systems have already disseminated design procedures through workshops and seminars. For example, last year a PRESSS design handbook, prepared by University of Canterbury, was disseminated through CCANZ to structural engineering practitioners. For timber structures, design seminars are frequently run and within the next year, specific design guidelines will be issued through STIC (the Structural Timber Innovation Company Ltd). Steel industry seminars are also held on a regular basis.

It is clear that design procedures and technologies are already viable options. In order to have damage-resistant systems becoming "ordinary structural systems" a dedicated section for damage-resistant design needs to be incorporated into each material design standard. New educational support for structural designers, building inspectors and review engineers is covered in the next section.

Modern performance-based design concepts have to be properly specified and documented in NZS 1170 Part 5. This may need an introductory document as a preliminary step. More importantly, promotion of these damage-resistant systems should be accompanied by new innovative design philosophies which are more strongly "displacement oriented", in order to reduce structural and non-structural damage in future earthquakes. Both alternatives, the newer **Displacement-Based** design methods and more traditional **Force-Based** design methods, should be properly detailed in the standards and an "open choice" should be left to the practitioners, provided that seismic performance and building displacements are adequately addressed.

10.2 Educational Needs

By and large, members of the structural engineering profession in New Zealand are well educated in seismic engineering compared with other earthquake-prone countries, given that most only have a four-year B.E. degree. Structural engineering education at New Zealand universities has had a significant emphasis on earthquake engineering, but the structural engineering content of the B.E. degrees at the University of Canterbury and the University of Auckland has been steadily dropping over the past few decades.

For some years there has been recognition that a four year B.E. degree is insufficient to give practising structural engineers all the education and skills they need to design sophisticated modern buildings for earthquake resistance. This is certainly the case if the structural engineering profession is to be up-skilled across New Zealand to design a new generation of damage-resistant buildings.

For some years the University of Canterbury has been recommending that a Masters degree should become the accepted entry point to the engineering profession. This would require additional study (an extra 1 to 1.5 years) beyond the current B.E. degree. In the aftermath of the 2010 and 2011 Christchurch earthquakes, this is seen as an essential change to the future education of professional structural engineers.

Another major advantage of a new Masters Degree in earthquake engineering would be the opportunity for practising structural engineers to up-skill their knowledge on a course-by-course basis, leading to a new qualification for those that complete enough courses. Flexible delivery methods could allow practising engineers to attend block courses as required at the University of Canterbury and the University of Auckland.

At a lower more urgent level, the universities need to work with IPENZ and the other learned societies to provide short-courses for new graduates and practising professional engineers. Short introductory courses in earthquake engineering should also be made available to architects, quantity surveyors, the insurance industry, building inspectors, and many others in the building industry. Such short courses could be accompanied by much wider publicity to the general public about the high level of awareness of engineering education, and the responsibility of building owners to safeguard their buildings against earthquakes.

The government needs to see an investment in earthquake engineering education and research as a long-term investment in a safer New Zealand, with much reduced loss of life and property damage in future earthquakes.

A widely discussed idea in the structural engineering community is the introduction of a "seismic star-rating" for earthquake performance of individual buildings. This could be a suitable way of raising awareness of earthquake safety among building; owners and occupiers.

10.3 Research Needs

Research and education must go hand-in-hand if new cost-effective design methods are to be introduced for a whole new generation of damage-resistant buildings.

At the research level, the resources must be provided to allow continued growth of the innovative Kiwi technology which has led to many of the design strategies described in this report. Implementation will require a modest investment in people, resources and facilities, mainly at the Universities of Canterbury and Auckland, but also at associated research hubs such as BRANZ, GNS Science, and other organisations responsible for research and testing of structural materials.

On the world stage, the structural testing facilities in New Zealand are woefully inadequate. There is no need to duplicate the huge and very expensive shaking tables in Japan, US and Europe, but a few million dollars of appropriate investment could provide world class experimental testing facilities and the associated computational analysis tools.

Testing facilities are needed, not only for academic researchers to test innovative new building structures, but also to allow practising structural engineers to create trial prototypes of their new designs. The New Zealand construction industry has a unique opportunity to lead the world in the design and construction of damage-resistant buildings, but that will only be possible if the New Zealand research community can back them up with design tools, expert advice, and testing facilities.

New testing facilities are necessary not only for the development of new techniques and materials, but also to give confidence to practising engineers, and allow them to test innovative ideas before using them in new damage-resistant buildings.

11 CONCLUSIONS

- A large number of modern buildings in Christchurch are facing demolition because of the very high costs of repairing structural damage, compared with the insurance cover.
- The high cost of damage in the Christchurch earthquakes has shown that future New Zealand buildings should be designed to be much more damage-resistant than the current building stock.
- There are three basic alternatives for designing buildings which will suffer much less damage in earthquakes. These three can be combined in many different ways. The three basic alternatives are:
    - Design for much higher levels of earthquake loading (overdesign).
    - Provide base isolation to reduce the earthquake response of critical buildings.
    - Use new damage-resistant design methods.
- Techniques for base isolation and damage-resistant design are available, from New Zealand and from around the world.
- With good design, base isolation and damage-resistance does not need to result in more expensive new buildings.
- A modest investment in education and research is necessary for rapid and effective implementation of new design methods.
- Financial incentives (such as tax incentives for research and development) will encourage innovation in modern earthquake engineering.
- There is potential for New Zealand to become a world leader in the export of earthquake engineering design services.
- Modern earthquake testing equipment is urgently required in New Zealand, for the development of new techniques and materials, and to give confidence to practising engineers.

11.1 Summary

The recent Christchurch earthquakes present a huge challenge and a huge opportunity to New Zealand's professional engineers. Now is the time to show how Kiwi structural engineers and geotechnical engineers can contribute to a sustainable cityscape for the new Christchurch, designing attractive and safe modern buildings which will not suffer the fate of today's older buildings in future earthquakes. The tools are available, with only a modest investment in building codes, education, and research necessary to make it happen.