

# Creating a More Resilient Built Environment for New Zealand

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**ABSTRACT:** The Canterbury Earthquakes highlighted vulnerabilities in the way we build and the land we build on, the fragility of our infrastructure and, above all, the importance of resilience for our cities. To effect change and achieve a more resilient built environment for New Zealand MBIE, EQC and BRANZ hosted a Built Environment Leaders Forum in September 2015 in Wellington. This forum reflected on lessons from Canterbury for New Zealand as a whole, across the full spectrum of natural hazards. The aim was to identify priority actions to improve the management of natural hazard risk for New Zealand's buildings and infrastructure.

The forum covered five key resilience themes - strategic directions, economics of resilience, smarter land use, better building performance and resilient infrastructure. A facilitated workshop approach was used to obtain feedback from forum participants and a multi-agency work programme with clear pathways to implementation was developed.

This paper outlines the main outputs from the forum including:

- A framework explaining the key principles to achieve a resilient built environment
- Priority areas for action identified by forum participants to improve the resilience of New Zealand's built environment.

**Key words:** Built environment, Resilience, Leadership, Action, Hazards.

## 1 INTRODUCTION

New Zealand has a high and ongoing exposure to natural hazards. The 2010-2011 Canterbury Earthquake Sequence represented New Zealand's biggest disaster in recent history, costing the nation around \$40 billion or 20% of our GDP.

The most significant event, the magnitude 6.3 aftershock on 22 February 2011, was a very shallow quake with one of the highest ever recorded vertical ground accelerations. This shaking was greater than typically assumed for the design of buildings in Canterbury and resulted in two major central city buildings collapsing, with the deaths of 133 people in those buildings. Around 1200 central city buildings needed to be demolished and 170,000 homes needed to be repaired or rebuilt. A further 8000 properties were 'red-zoned' due to damage from lateral spread and liquefaction or unacceptable risk from rockfall or cliff collapse.

The performance of buildings in the Canterbury earthquakes provided lessons on where to focus attention to ensure our building stock is more resilient for future generations. The social impacts of the earthquake sequence were significant and six years on some homeowners still do not have their homes repaired or rebuilt.

The New Zealand government organised the Built Environment Leaders Forum to respond to the lessons from Canterbury; to improve the treatment of risk in built environment policy, investment and design; and to create a plan for improving the performance of our built environment. The forum brought together 200 public and private sector built environment leaders and decision makers to influence and effect change.

The organisation of the forum and analysing and synthesising the forum findings was facilitated by a cross-agency Built Environment Leadership Steering Committee comprising senior advisors from central and local government. A background document outlining the built environment lessons learned from the Canterbury earthquakes was produced by MBIE to stimulate debate at the forum (see <http://www.mbie.govt.nz/info-services/building-construction/safety-quality/documents-and-images-library/built-environment-leaders-forum/built-environment-lessons-report-final.pdf>).



**Building damage, Christchurch**

Credit: NOAA/NGDC Steve Taylor



**Built Environment Leaders Forum**

The Hon. Dr Nick Smith Minister for Building and Construction and Minister for the Environment opened the forum. International context and developments were provided by addresses from four acclaimed international resilience experts:

- Professor Tom O'Rourke, Thomas R Briggs Professor of Engineering, Cornell University
- Dr Lucile Jones, Science Advisor for Risk Reduction, US Geological Survey
- Dr Laurie Johnson, Principal, Laurie Johnson Consulting
- Michael Nolan, Global Leader Climate Adaptation and Resilience, AECOM.

## **2 RESILIENCE ACTIONS IDENTIFIED THROUGH THE FORUM**

A framework documenting the outputs of the Built Environment Leaders Forum provides a vehicle to drive change for built environment resilience. Achieving built environment resilience will require public and private sector collaboration, and engagement with local communities.

The key principles, identified through the forum, for achieving a resilient built environment were:

- national level governance and a framework for managing risks to the built environment
- appropriate decision-making frameworks
- incentives and tools to support appropriate levels of private and public sector investment in urban resilience
- better public understanding of the risks from natural hazards, and educating communities on the benefits of resilience investment as it relates to levels of service
- information and evidence to communicate resilience and support the development of prudent risk mitigation measures.

Forum participants identified areas for action according to these key principles:



**Figure 1. Key principles for built environment resilience**

### **3 GOVERNANCE AND LEADERSHIP**

The need for strong leadership and national level governance was identified as a key principle for managing risks to the built environment. Forum participants highlighted the need to:

- develop stronger collaboration between private and public sector agencies to improve built environment performance
- improve the resilience of New Zealand’s critical infrastructure components
- revisit the importance of Lifelines Utilities and Lifelines Groups in achieving resilient infrastructure networks.

An important message from Dr Laurie Johnson, was ‘To really achieve resilience we have to get governance right’. Having the right governance structures in place prior to a natural hazard event was a key lesson from Canterbury where a new government agency (the Canterbury Earthquake Recovery Authority) and associated powers had to be put in place to deal with earthquake recovery.

The Chief Executive of the Department of Prime Minister and Cabinet set four key leadership challenges – the need to understand all risks and think through what to do about them; to get better at making the case for action including having ‘courageous conversations’; to get better at working together; and to keep learning from Canterbury, from international experience, and from each other.

Some relevant leadership initiatives are underway including:

- the establishment of Chief Resilience Officers and the development of Resilience Strategies for Christchurch and Wellington Cities through the 100 Resilient Cities programmes
- the establishment of a Local Government Risk Agency to assist the local level in understanding natural hazard risk management
- Ministry of Civil Defence and Emergency Management work programme around the National Disaster Resilience Strategy
- the Canterbury Learning and Legacy Programme which brought together key lessons from the Canterbury earthquakes across all sectors
- EQC, LGNZ, the Insurance Council of New Zealand and a private sector group ‘Resilient New Zealand’ provision of think pieces on national resilience lessons from Canterbury.

Stronger collaboration is needed in New Zealand between central and local government and the private sector to achieve resilience. New Zealand is a small country that relies on people and their

relationships, particularly in times of disaster. Brunsdon (2015) notes that *‘in order to put disaster risk management into practice New Zealand has focused on using people, relationships and institutional arrangements as a substitute for financial resources’*. These relationships need to be developed and maintained in ‘peacetime’.

Professor Tom O’Rourke outlined the importance of undertaking a national assessment of our critical infrastructure components so that resilience efforts are prioritised on those components. He provided examples of critical infrastructure failures - in Fukushima where emergency generators were flooded so power was lost to cool nuclear reactors which had global consequences, closing down nuclear power plants in many countries due to safety concerns; and in New York where Hurricane Sandy closed hospitals because basement generators and water supply systems were flooded. The lesson was to install generators and water supply systems higher up in buildings and not in basements. For our critical infrastructure we need to build pipes back better, with next generation technology, when repairing and when building new. Installing flexible pipe-liners for critical water supply pipelines where they cross fault systems was also recommended.

The forum identified the need to acknowledge and further support the valuable role Lifelines Groups play in co-ordinating infrastructure information, particularly around levels of service for lifeline utility providers.

#### **4 DECISION MAKING FRAMEWORKS**

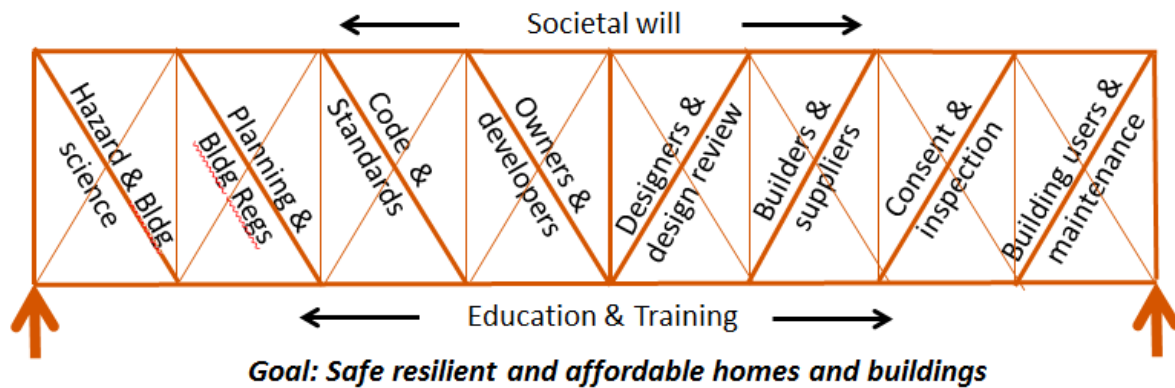
Decision making frameworks for the built environment, especially legislation and policy, need to be nationally consistent and be able to take account of local priorities. Forum participants identified the need to –

- clarify decision making frameworks for built environment resilience
- improve consistency in built environment regulation and practice
- support central and local government capability to make good decisions.

A more integrated approach is needed to consider the interconnections between buildings, infrastructure and the land on which those structures are built. Treasury’s Living Standards Framework can offer a strong basis for policy advice on resilience going forward as it includes dimensions of economic growth, sustainability, equity, social cohesion and resilience.

Dr Laurie Johnson outlined how we need to be smarter in our land use decision making - to keep future development out of known hazard areas, to keep hazards from affecting existing development, and to strengthen existing developments to resist hazards. Trade-offs will be required as risk mitigation directly affects property rights. Planners also need to better understand land conditions and work more closely with geotechnical engineers in land development decision making (Johnston 2016).

In terms of our building stock we need to consider how all actors in the building regulatory system interact. MBIE’s Chief Engineer uses a structural metaphor to illustrate the building system – if all elements are in place with good connections then the system is strong, if one chord is broken the truss has redundancy - it may sag but will not break (Stannard 2016).



**Figure 2. Integrated construction system**

Understanding and incorporating consistent approaches to assessing risk in decision making frameworks for the built environment was highlighted as an area for action by forum participants. Local Government New Zealand is taking action, around the establishment of a risk agency to build decision-making in local government. The Prime Minister’s Chief Science Advisor has released a report to help raise the profile of risk and risk management at a national level (Gluckman 2016).

## 5 INCENTIVES AND TOOLS

The session on economics of resilience identified themes around the need for clarity around the economics of risk management as it relates to resilience; and the ability to incentivise asset owners and communities to integrate resilience into investment decision making. Forum participants identified the need to –

- assess if we have the right financial and non-financial instruments in place to increase built environment resilience
- give communities a framework to make decisions on the resilience of their buildings.

Funding infrastructure has major challenges – high costs, aging assets, population growth, an aging population and outdated funding models. New approaches for funding infrastructure, national versus local apportionment, are being considered by the Local Government Risk Agency Establishment Board.

Incentives and tools to support appropriate levels of private and public sector investment in urban resilience are needed. Professor O’Rourke provided American examples of infrastructure bonds used for private sector funding of infrastructure which are now also being used in New Zealand. Other mechanisms such as developing distributed infrastructure systems, for power and water, as opposed to reliance on centralised systems were also recommended.

Existing land-use planning tools already developed overseas can be applied in New Zealand for areas subject to natural hazards eg hazard-specific set-backs, property acquisition, transfer of development rights and flood protection systems. Resilience ‘scorecards’, as used by the 100 Resilient Cities programme, can be developed to show where our cities are weak or strong in terms of resilience.

## 6 PUBLIC ENGAGEMENT

A strong theme that came through at the forum was the need for better public understanding of the risks from natural hazards, and the need to educate communities on the benefits of investing in resilience. Forum participants identified the need to –

- provide building owners and occupants with a better understanding of hazards and resilience
- improve community involvement in built environment hazard and risk management

- engage the public on levels of service expectations for infrastructure

Dr Lucy Jones highlighted the need to better communicate natural hazard risks. She told the forum that *‘The fact that all of you were surprised at the Christchurch earthquake when no statistical seismologist was, says we aren’t communicating our information very well’*. Her recommendation for communicating building performance science to the public and building owners was through scenarios or scientifically defensible ‘stories’ like Los Angeles’ shake-out scenario. She stressed the need to help decision makers identify what they can change prior to a natural hazard event to avoid catastrophic impact after. She also noted that buildings are part of a community, that one person’s decision affects others, for example the impact of one building going down affects neighbouring buildings and the use of a street.

Greater efforts are required to involve communities in natural hazard risk management. Communities need to understand the levels of service they can expect from their infrastructure services following a disaster event, eg how many days would they be likely to be without water. If communities can become more self-reliant there will be less dependence on lifeline utility services following disaster events. The small actions that individual households can take will make a big difference should a disaster event happen. This includes simple things such as storing more water than you think you will need, having a fire extinguisher, securing foundations and chimneys, securing internal furniture and appliances, having back-up food and emergency supplies, and knowing your neighbours.

## 7 INFORMATION, DATA AND EVIDENCE

Underpinning all of the other key principles to achieving resilience is the need for information and evidence to support the development of prudent risk reduction and risk mitigation measures. Forum participants identified the need to:

- develop evidence to improve built environment resilience across all of the priority areas for action
- identify built environment strengthening measures that deliver the best cost-benefit resilience gains
- examine systems approaches to better understand inter-dependencies within and among infrastructure systems to improve understanding of costs.

To better understand and manage the risks from natural hazards we need to develop accessible data sets and maps showing the risks we are exposed to. The New Zealand government has recently invested \$19.6 million in the National Science Challenge around resilience to nature’s challenges which will provide robust data to inform decision making on where investments should be made to achieve resilience.

Understanding the costs and benefits associated with achieving built environment resilience requires further work. We heard from Michael Nolan that the private sector needs to know the value of resilience before they will invest in it. Although increasing resilience comes at a cost there can also be a ‘resilience dividend’ for increasing the resilience of some built environment components eg better specified pipes.

We also need greater knowledge around the interdependencies between infrastructure systems, to identify which systems are critical, and what the trade-offs might have to be. Dr Lucy Jones noted that in the Los Angeles’ shakeout scenario they found that transportation, water, buildings and the internet were the ‘necessary’ infrastructure systems to keep the city functioning. Connecting fire-fighting and water services to ensure adequate water supply for fire-fighting after an earthquake was identified by overseas experts as a critical interdependency for New Zealand cities.

## 8 IMPLEMENTING THE FORUM FINDINGS

The findings of the forum are being integrated into a range of current resilience initiatives. At an international level the forum output has contributed to New Zealand's response to the Sendai Framework. At a national level the forum findings have helped inform MCDem's National Disaster Resilience Strategy and connect to the National Infrastructure Unit's 30-year Infrastructure Plan. At a local level findings have informed the resilience strategies for Christchurch and Wellington. The forum findings may also be socialised with other councils and infrastructure agencies to contribute to their resilience planning.

The Canterbury Earthquakes Royal Commission of Inquiry set out 189 recommendations for changes to building system practices. These recommendations, mainly directed at MBIE as the building regulator, provided direction to a significant programme of work to increase built environment resilience. MBIE has just released a report responding to recommendations, refer <http://www.mbie.govt.nz/info-services/building-construction/legislative-other-reviews/past-work-and-older-topics/response-to-the-canterbury-earthquakes-royal-commission/document-library/responses-cerc-recommendations.pdf>.

This work programme, originally known as the Building System Improvement Programme, includes projects such as:

- making buildings safer through new earthquake-prone building legislation and regulations
- the formation of a New Zealand Geotechnical Database
- national geotechnical engineering guidance on: geotechnical investigation for earthquake engineering, liquefaction assessment, foundation and retaining wall design, ground improvement methods and specifications, slope stability, and rockfall protection structures
- structural engineering projects around: structural design standards, non-structural building elements, the assessment and improvement of seismic performance of buildings, low damage building technologies, and the refinement of a national seismic hazard model
- planning and building guidance for areas subject to liquefaction
- guidance on better management of buildings in an emergency
- international collaboration on the performance and resilience of buildings including – residual capacity of buildings, performance of concrete walls, geotechnical research, and economic research into the costs and benefits of increasing structural performance.

Associated agencies are progressing built environment resilience work, eg the Ministry for the Environment is undertaking work to provide greater national direction and guidance on the management of natural hazards. The Earthquake Commission, GNS Science and the Building Research Association of New Zealand also have significant programmes of work to better manage the risks of natural hazards for the built environment.

## 9 CONCLUSIONS

Natural hazard shocks and stresses will remain an ongoing challenge for New Zealand's built environment leaders to respond to. We know that New Zealand has a high exposure to natural hazards generally and that climate-related natural hazard events worldwide are increasing. Our population and associated built environment are concentrated in vulnerable coastal locations.

By introducing resilience into our built environment investment and operational decision making, through actions identified through this forum, opportunities exist for achieving a more resilient built environment to cope with natural hazard shocks and stresses.



A high level of momentum currently exists in New Zealand, across a range of agencies, to increase built environment resilience. Significant programmes of work are underway. There is genuine commitment in New Zealand to effect change in response to both the Canterbury earthquakes and to the 2016 Hurunui/Kaikoura earthquakes. These events have challenged our understanding of how buildings perform in earthquakes and have highlighted the need for further research to inform building practice.

Future built environment resilience challenges will include – how we adapt our buildings and infrastructure to climate change and sea level rise; how we adapt to technological change; how we communicate the concept of resilience to our communities; how we might prepare our built environment for 'tail of probability' events, and how systems thinking can be applied across buildings, land and infrastructure. We will need to think of our buildings within urban precincts and understand and manage the interconnection of component parts, particularly our built structures with their site conditions.



**Milford Beach, Auckland**

Credit: Auckland King Tides Group



**Floating villages, the Netherlands**

## **10 REFERENCES**

- Brunsdon, D. (2015). *Collaborating to Achieve More Disaster-Resilient Development and Construction*. Background Paper for the September 2015 Asia Development Bank Regional Workshop in Manila – Reducing Disaster Risk in Urban Areas.
- Gluckman, P. (2016). *Making Decisions in the Face of Uncertainty: Understanding Risk*. Office of the Prime Minister's Chief Science Advisor.
- Johnston, P. et al. (2016). *Reducing Disaster Risk by Managing Urban Land Use – Guidance Notes for Planners*. Asian Development Bank -<http://www.adb.org/publications/reducing-disaster-risk-urban-land-use-guidance-notes>.
- Stannard, M. (2016). *Current Direction for Improving Structural Engineering and Resilience in New Zealand*. Paper for the 16th US-Japan-New Zealand Workshop on the Improvement of Structural Engineering and Resiliency