

## CHRISTCHURCH POST-EARTHQUAKE RECOVERY

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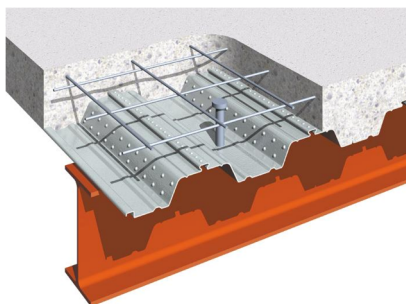
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The 2010-2011 Canterbury Earthquakes caused significant damage especially in the city of Christchurch. As a result, much of the infrastructure – vertical and horizontal - is being replaced. This presentation describes the process of the Christchurch recovery.

The Christchurch recovery only occurred the way it did because of the infrastructure, laws, culture, relationships, and relative costs before, as well as immediately after, the earthquakes. Christchurch had a mix of old and new structures of different sizes and heights. Most multi-storey structures were of reinforced concrete. However, the last two constructed before the earthquakes were of structural steel. Factors influencing the rebuild were the “performance-based” building standard, the wide uptake of insurance, the relatively low cost of structural steel, and the availability of new structural systems, (including low-damage systems, and lightweight economical long-span cold-formed floors (Figure 1-a).

The most significant shaking event affecting the city of Christchurch occurred on February 10, 2011. The shaking intensity was greater than twice the design level explicitly considered in current standards. There were soil issues, including slides, slips and extensive liquefaction. Some older buildings collapsed, as did a couple of poor newer structures. The majority of older buildings and many newer buildings remained standing but were damaged and were pulled down. There was a perception that even well-designed concrete structures performed badly, as repair was difficult. On the other hand, the few damaged steel buildings within the city were repaired rapidly.

Immediately after the earthquake, decisions were made affecting the later recovery. These included changes to design shaking levels in Christchurch, stair overlaps, ratchetting, and inelastic torsion, as well as others related specifically to reinforced concrete structures.



(a) Cold formed decking (Comflor)



(b) Rocking Frame

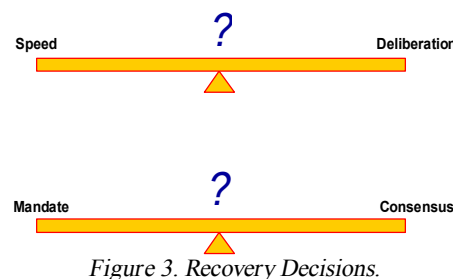
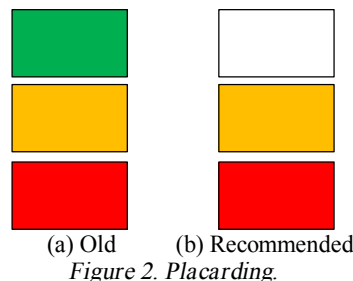


(c) BRB Frame

Figure 1. Rebuild Construction Examples

Building structures constructed after the earthquakes were of a large variety of structural form, including eccentrically braced frame systems with and without replaceable links, concentrically braced frames including buckling restrained brace frames, base-isolated buildings, friction frame structures, rocking frames, and those with supplemental damping (e.g. Figure 1-b and 1-c). Some interesting buildings are described as were the drivers for the different forms used in the rebuild. About 90% of the multi-storey floor area is supported by structural steel construction with cold formed composite floors.

The remainder of the presentation deals with societal aspects. The roles of different organizations shaping the recovery are described. These include Christchurch City Council (CCC), which had a full workload before the earthquakes. It had developed procedures consenting new structures, to meet the pre-quake requirements of the city. However, as time was necessary to perform all checks and a fast recovery was desired, some regarded the CCC procedures as being too slow. The Earthquake Commission (EQC) provides \$100,000 residential property insurance for all homes with a bank mortgage, and many others voluntarily. EQC received more than 500,000 claims for more than 13 separate shaking events (EQC, 2018). While EQC contributed significantly to the recovery of Christchurch, there were some who took advantage of EQC, and others felt that EQC was unfair or harsh in its appraisals. Repair work was contracted to a large construction company employing many new staff, often from overseas. Some of the work was conducted poorly. Insurance companies provided additional insurance to that from EQC for the majority of commercial and other structures in NZ which financed the rebuild. During the aftershock sequence insurance was sometimes unavailable, slowing the recovery as NZ banks require earthquake insurance for loans on buildings. Residential Advisory Service provided independent mediation of insurance disputes. Canterbury Earthquake Recovery Authority (CERA) was responsible directly to the government and permitted large scale demolition of buildings, a cordon throughout the city, and it produced the Christchurch Central Recovery Plan. However, it was criticised for implementation of the Plan. Stronger Christchurch Infrastructure Rebuild Team (SCIRT)'s \$2.2 billion programme was supported by the government to replaced damaged horizontal infrastructure. This work was successfully undertaken with the five major contractors working together using “competitive collaboration” contracting. Canterbury Earthquake Royal Commission investigated what caused some buildings to fail severely, so that it would not happen again. The local indigenous Maori tribe/iwi was involved with recovery of the city at many levels. This was a world first for people. It promoted, and was involved in, meeting the needs in responsive and culturally responsible manner, and its work was highly regarded. Other groups were also limited in the recovery. Ministry of Business, Innovation and Employment (MBIE) – established an Engineering Advisory Group (EAG) to provide support across a range of issues arising from the Canterbury earthquakes, and promoted communication and the development of guidelines. One recommendation was that building placards should be white (inspected), orange and red, rather than green, orange and red, as per Figure 2.



People themselves were also affected. Some left the city, others came. The number with mental illness increased significantly. A few people reported actions about the recovery that they believed were good and others that could have been done better. While some views represent various political perspectives, they help understand the recovery. Some said it was too fast, and people should have been more involved to make better decisions, while others thought that the recovery was far too slow. However, while there was disagreement about the ways of conducting the recovery (see Figure 3), all agreed that it is for the people, and that this should not be forgotten.

## ACKNOWLEDGMENTS

The work presented draws heavily on previous studies, with the paper using much of MacRae (2019).

## REFERENCES

MacRae G.A., “Recovery after the Canterbury Earthquakes”, *12<sup>th</sup> Canadian Conference on Earthquake Engineering*, Quebec, 17-20 June 2019, Paper 192-kH8h-43.