The Canterbury Earthquakes Royal Commission (the Commission) sought the advice of Associate Professor Jason Ingham from Auckland University and Professor Michael Griffith from Adelaide University on the Performance of Unreinforced Masonry Buildings in the 2010/2011 Canterbury Earthquake Swarm.

Ingham and Griffith's report is entitled **The Performance of Unreinforced Masonry Buildings (URM) in the 2010/2011 Canterbury Earthquake Swarm**, dated August 2011.

The report includes:

- Details of the characteristics and value of the New Zealand URM building stock and of the assessed seismic vulnerability of this building stock;
- Details of the performance of URM buildings with the Christchurch Central Business District (CBD) in the 2010/2011 Canterbury earthquake swarm;
- Information on technologies (including costs) available for the seismic improvement of URM buildings, and on the hierarchy of improvements that may be applied in order to improve the seismic performance of URM buildings;
- Discussion of URM buildings that are or were representative of their class of building and whose observed earthquake performance was representative of how that class of building would behave during earthquake actions throughout the rest of New Zealand;
- Comments on the adequacy of current practices and methodologies that may be adopted in response to the events in Christchurch; and
- Descriptions of the performance of some buildings that were retrofitted to provide additional earthquake strength.

Section 7 of this report includes the authors' recommendations. They include:

> **Recommendation 3**
>
> *There are several logical stages of building performance improvement that should be considered. The number of stages involved for seismic retrofitting of a building will depend upon how well the building owner and/or officials and occupants want the building to behave.*
>
> > *• 1st stage: ensure public safety by eliminating falling hazards. This is done by securing/strengthening URM building elements that are located at height (eg, chimneys, parapets, ornaments, gable ends).*
> >
> > *• 2nd stage: strengthen masonry walls to prevent out-of-plane failures. This can be done by inserting connections between the walls and the roof and floor systems at every level of the building. In some situations, it may be necessary to stiffen the roof and floor diaphragms and flexurally strengthen the masonry walls.*
> >
> > *• 3rd stage: ensure adequate connection between all walls, floors and roof so that the building responds as a cohesive unit rather than individual, isolated building components.*
> >
> > *• 4th stage: if further capacity is required to survive earthquake loading, then the in-plane shear strength of masonry walls can be increased or high-level interventions can be introduced, such as the insertion of steel and/or reinforced*

concrete frames to supplement or take over the seismic resisting role from the original unreinforced masonry structure.

Recommendation 4

The authors propose that all URM buildings should go through the first two stages of building improvement so that the targeted structural elements have their strength elevated to match that required for equivalent structural elements in a new building located at the same site. For 3rd and 4th stage improvements, building strengthening should aim for 100% of the requirement for new buildings but as a minimum, 67% might be acceptable.

A full copy of the report is available on the Commission's website at http://canterbury.royalcommission.govt.nz/

It contains an Executive Summary which gives an overview of the content.

The Commission will publish peer reviews of the report on its website when they are available.