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TOPICS IN THIS EDITION | EARTHQUAKE | ENGINEERING | MITIGATION

THE BENEFITS OF STRENGTHENING BUILDINGS AGAINST EARTHQUAKES

ABOUT THIS PROJECT

This *Hazard Note* presents research conducted by the University of Adelaide and Geoscience Australia for the Bushfire and Natural Hazards CRC's *Cost-effective mitigation strategy development for building related earthquake risk* project. Researchers identified forms of Australian construction that are vulnerable to earthquakes and developed an evidence-based risk and economic models to help justify strengthening of existing buildings.

AUTHORS

Prof Michael Griffith, University of Adelaide;
Mr Mark Edwards, Geoscience Australia;
Dr Jerry Vaculik, University of Adelaide.
Contact michael.griffith@adelaide.edu.au.

SUMMARY

Although the international reinsurance industry recognises that a moderate earthquake in Sydney is in their top-10 financial risks, there is a perception in the Australian construction industry that design for earthquakes is a poor use of money due to the low likelihood of a strong earthquake in Australia. As the September 2021 earthquake in Victoria showed, cities like Melbourne are not immune to earthquake damage. This research developed risk and economic-loss models for earthquakes, which allow authorities to conduct cost-benefit analyses for economically justifiable seismic-strengthening requirements for existing buildings.

BACKGROUND

Earthquakes have only been recognised as a hazard in the design of Australian buildings since 1995. This lack of recognition resulted in many buildings representing a high risk to property, life and economic activity across the country. These older buildings contribute to most of



▲ Above: THIS RESEARCH HELPS JUSTIFY THE COST OF STRENGTHENING EXISTING BUILDINGS TO WITHSTAND EARTHQUAKE DAMAGE. PHOTO: CHRISTCHURCH, SEPTEMBER 2010, MICHAEL GRIFFITH.

This project has identified the two most seismically vulnerable forms of construction in Australia - unreinforced masonry buildings and low-ductility reinforced concrete buildings - and cost-effective techniques to mitigate damage. This evidence base enables building owners and government to make cost-effective decisions about strengthening buildings against earthquake damage. Researchers not only examined the impacts of building damage, but importantly also accounted for fatalities/injuries, business interruption and heritage structure impacts. These findings are also relevant to the impact of earthquakes on other infrastructure

the post-disaster emergency management logistics and community recovery needs following major earthquakes. With an overall building replacement rate of 2% nationally, the legacy of vulnerable buildings persists in all cities and predominates in most business districts of lower-growth regional centres.

around the country, when constructed of concrete and/or unreinforced masonry.

The evidence-based recommendations that this project developed for unreinforced masonry buildings were implemented by the York Shire Council in Western Australia. York has many heritage masonry buildings on the WA and national heritage registers that are vulnerable to earthquake, with the heritage value of the area significantly contributing to the local economy. A historic museum in York is now being used as a demonstration of effective examples of strengthening against earthquakes, to develop skills in the local construction and building industries.

The two most vulnerable building types that contribute disproportionately to community risk are a) unreinforced masonry buildings and b) limited ductility reinforced concrete structures. The damage to these building types in the event of a strong earthquake will not only lead to direct repair costs, but also to injury (including

fatalities) and significant disruption to economic activity and business.

Prior to this research, retrofit strategies existed but the resistance of existing Australian buildings was poorly understood and the economic benefits of strengthening versus costs were completely unknown. Existing practice used cost-benefit assessment on a building-by-building basis, which significantly underestimated the benefits to any region where multiple buildings are impacted by a single seismic event.

BUSHFIRE AND NATURAL HAZARDS CRC RESEARCH

The aim of this project was to provide an evidence base to inform decision making on the mitigation of seismic risk posed by the most vulnerable Australia buildings. Between January 2014 and December 2020, researchers:

1. investigated the seismic vulnerabilities of two types of existing buildings - unreinforced masonry and limited ductile reinforced concrete - and analysed the methods to address these vulnerabilities using seismic retrofitting techniques
2. conducted a risk assessment of the buildings through an economic loss model with trial evaluations for a regional town (York, Western Australia; in collaboration with the Department of Fire and Emergency Services, York Shire Council and local residents) and a metropolitan area (Melbourne, Victoria)
3. developed risk and economic loss models, as well as recommendations for seismic

retrofit guidelines and policy, based on the evidence base developed by this project.

RESEARCH FINDINGS

This project determined that seismic strengthening of the most vulnerable parts of unreinforced masonry buildings is justifiable from a cost-benefit perspective, which considers reduction of casualties, business interruption costs and loss of heritage value.

The most vulnerable components of unreinforced masonry buildings are parapets, chimneys and upper-storey walls, which pose a significant public safety hazard in most urban areas because older unreinforced masonry buildings remain in common commercial use.

HOW IS THE RESEARCH BEING USED?

This research provides the necessary information for government and building authorities to examine the introduction of minimum seismic strengthening requirements for existing buildings.

The evidence and recommendations were implemented by the York Shire Council, where an unreinforced masonry building is now being used as a demonstration of how to effectively strengthen existing structures against earthquakes. This demonstration is being used to develop skills in the local construction and building industries.

The project has also resulted in a follow-up project through the National Disaster Resilience Program in Western Australia

FURTHER READING

Griffith M (2021) Cost effective mitigation strategy development for building related earthquake risk - final report, Bushfire and Natural Hazards CRC, available at www.bnhcrc.com.au/publications/biblio/bnh-7952.

Ryu H, Wehner M, Vaculik J, Juskevics V, Edwards M, Griffith M, Mohanty I, Butt S, Corby N, Allen T, Hewison R (2021) Cost effective mitigation strategy development for building related earthquake risk - Melbourne case study, report, Bushfire and Natural Hazards CRC, available at www.bnhcrc.com.au/publications/biblio/bnh-8215.

Wehner M, Ryu H, Griffith M, Edwards M, Corby N, Mohanty I, Vaculik J, Allen T (2020) Earthquake mitigation of WA regional towns: York case study, final report, Bushfire and Natural Hazards CRC, available at www.bnhcrc.com.au/publications/biblio/bnh-7186.

to expand the building typologies beyond the six considered in this project, to include three more building types that are common throughout the rest of the state. These retrofit strategies for all typologies will be made publicly available online in mid-2022.

FUTURE DIRECTIONS

This research could be expanded to include other building types common across the rest of Australia. Demonstration projects in states and territories other than Western Australia will enable more reliable cost estimates of seismic retrofit options, which would greatly improve confidence in cost-benefit studies for urban and rural communities. This will allow local government planners and building regulators (for example, the Australian Building Codes Board) to set economically justified requirements for seismic retrofit requirements for existing buildings across the whole country.

END-USER STATEMENT

The research from Geoscience Australia and the University of Adelaide in this Bushfire and Natural Hazards CRC earthquake mitigation study on six York building types is of immense benefit to the town. The results will not only be useful for York, they will enable the refinement and adaptation of the retrofit information for wider application to similar buildings elsewhere in the state and nation. It is a great example of what is possible when organisations work together for shared goals; to preserve life in natural disasters and preserve Australia's built heritage and the economies that depend on it.

Denese Smythe, Shire President, Shire of York, Western Australia

The Bushfire and Natural Hazards CRC has been incorporated into Natural Hazards Research Australia, the new national centre for natural hazard resilience and disaster risk reduction. The new Centre is funded by the Australian Government.

Hazard Notes are prepared from available research at the time of publication to encourage discussion and debate. The contents of *Hazard Notes* do not necessarily represent the views, policies, practises or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire and Natural Hazards CRC.

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