BRANZ FACTS

VALUING SUSTAINABILITY #1

Cost-effectiveness of adding resilience features in New Zealand houses

Installing resilience features that go beyond the minimum legal requirements may reduce repair costs after floods, severe winds or earthquakes.

THIS FACT SHEET covers the costs and benefits of installing features to enhance building resilience in the face of high winds, floods and earthquakes. The findings come from a larger BRANZ study on valuing sustainability and resilience features in New Zealand housing.

The overall project aims to provide an evidence base to help builders, designers and specifiers make better-informed decisions about investing in these features. (For more details and findings from the wider study, see the study reports listed in *More information*.)

Resilience features to protect human life are well covered by the New Zealand Building Code, standards and other building rules and regulations. Current design loadings allow for severe wind and earthquake actions, so safety is adequately addressed in new housing. New homes are permitted on flood-prone areas if they meet the specific minimum floor level requirements.

However, additional resilience features may be cost-effective in reducing repair expenses, and it is this aspect that BRANZ explores for new and existing houses.

BRANZ analysis indicates the following:

- Where flooding occurs at 10-year or less intervals, raising a house that sits on a flood-prone area is often the best financial option. For longer return periods, replacement of linings and insulation after flooding is generally more cost-effective. Use of resilient materials for replacement has similar lifetime costs to like-for-like replacements, and their quick reinstatement has socio-economic benefits.
- Owners of older houses should consider strengthening roof fixings against the risk of wind damage. The simplest measure is to replace leadhead roof fixings with screw fixings in wind-prone areas. If there is evidence of roof assembly movement in storms, owners need to get expert advice. This advice may be on retrofitting truss connectors to the top plate and installing additional fixings between purlins and rafters. Modern houses built today should be adequate in all situations.
- There may be a financial case for above-minimum bracing to reduce damage to new

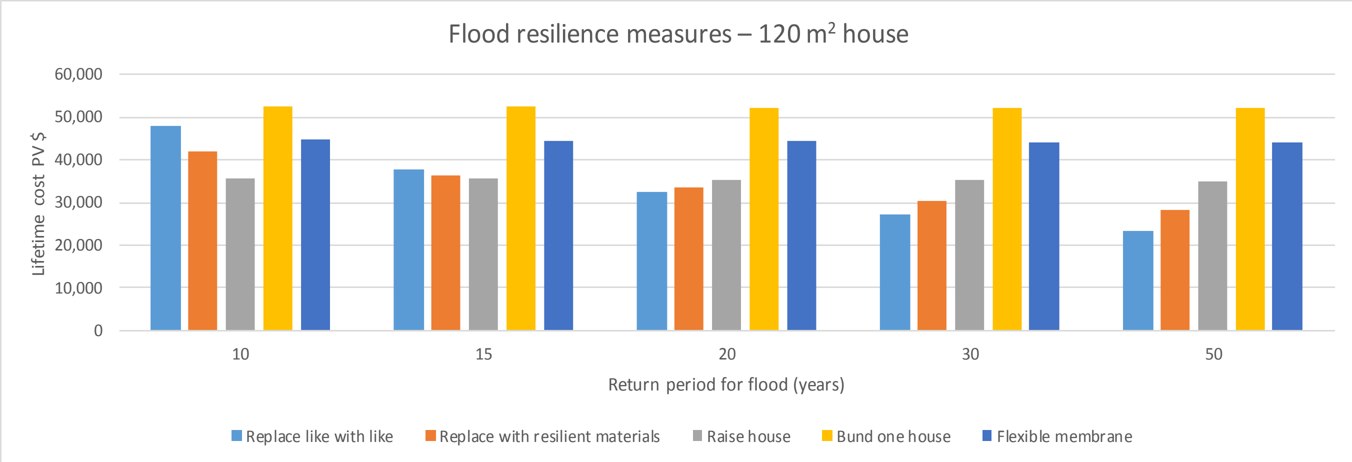

Figure 1. Flood restoration lifetime costs and return period – 120 m² house. (Costs as at final quarter 2015.)

houses during frequent but non-life-threatening earthquakes. New houses with lightweight claddings generally have scope for increased bracing using more of the traditional bracing materials such as bracing-grade plasterboard or sheet plywood. If damage in a 20-year return period earthquake can be reduced by about $3,000, increased bracing appears to be cost-effective. However, further study on a range of these scenarios needs to be done to determine the net benefits.

Flooding resilience

BRANZ investigated the costs for five flood damage mitigation options for a typical house with a 120 m² floor area (Figure 1). The options are applied before a flood event, and the life cycle costs are calculated from installation.

The costs are in present value (PV) and the options are:

- replace like with like
- replace damaged materials (linings, insulation, doors) with more resilient materials so future restoration is cheaper than like with like
- raise the house above future flood levels
- install an earth bund around the land boundary
- install a flexible membrane within a concrete perimeter pit, for extension when there is a flood risk.

The costs assume the flood height is 0.7 m maximum above floor level and the repair cost does not change up to 0.7 m. It assumes no damage to foundations, floor or appliances. A 5% discount rate is used.

With different flood frequencies, the preferred mitigation options change. With frequent floods (less than 15 years), like-for-like replacements are more expensive, while raising the house is the least expensive option. At longer return periods, like-for-like replacements are least expensive in present dollar values.

The lifetime costs of raising the house, installing bunds or installing a flexible membrane are mainly unchanged with increased return periods because, apart from accommodation, all the costs are at year zero.

Homeowners with flood damage insurance may not be directly concerned with the financial aspects of potential mitigation. However, for areas subject to frequent flooding, insurance companies may cease offering insurance or may require mitigation measures before offering cover.

The simple model in this study gives an indication of likely costs for small groups of houses or single houses subject to fairly frequent flooding and where relocation or area-wide stopbanks are unlikely to be affordable. It assumes similar amounts of damage and repair costs for flooding above floor level up to 0.7 m in height.

The lower sections of the linings are assumed to be replaced with new material, and resilient linings are cleaned and replaced after the wall cavities and insulation have been cleaned and dried.

The flooring is assumed to not need replacing but may need polyurethane recoating. Flooding higher than 0.7 m above floor level is likely to incur more damage repair costs than shown in Figure 1.

Study Report SR346 *The value of sustainability – costs and benefits of sustainability and resilience features in houses* (available free on the BRANZ website) has the calculation for flood repairs using like-for-like replacements and for installing more resilient materials. It indicates that spending an extra $78/m² floor area enables resilient materials to be used for the linings, insulation, trim and doors. This investment reduces repair cost in each future flood by $49/m².

BRANZ has also done work with NIWA on protecting houses using these and other measures , including bunds protecting small groups of houses and moving houses to higher ground (*Evaluating costs/benefits for housing flood damage mitigation* by I Page).

That model allowed for variation in damage according to flood height, including total write-off. It is a complex model to be used where detailed catchment data is available and was intended to be used for comparison with an area-wide catchment scheme.

Wind loading on roofs

As for floods, an upgrade to deal with potential wind damage is mainly applicable to older existing houses where roof and windows fixings are below current new house requirements.

Very occasionally, coastal parts of New Zealand are subject to localised windstorms or tornadoes, and roofs are damaged in these events.

BRANZ Study Report SR187 *Retrofitting of houses to resist extreme wind events* estimated roof strengthening costs up to $2,200 per house for houses built before 1999 and in high or very high wind zones. This includes additional connections between truss and purlins and, in some cases, fixing rafters to the top plate using an L bracket.

Profiled metal roof claddings are usually fixed to purlins with leadhead nails in older houses. These nails corrode with time and lose the leadhead. This can lead to a loss of strength and increased risk of water entry, and should be replaced. This is quite quickly and cheaply done using galvanised screw fixings with flexible washers and is recommended on all older houses where roof cladding is nailed.

A 2012 revision of New Zealand Building Code Acceptable Solution E2/AS1 specified fixings for window reveals to the building frame. This arose because of the introduction of the extra high wind zone and updated wind suction pressure calculations indicated a higher risk of suction in certain conditions.

Occurrence of these roof and window events is rare, and data on damage is so sparse that it is difficult to do a cost-benefit analysis with any certainty.

At this time, retrofit strengthening is not recommended as a matter of course on these houses (except roof cladding, which should be screw fixed as set out in BRANZ Study Report SR187.

However, if a house is in a very high or extra high wind zone and is particularly exposed to storms, it may be wise to consult a building surveyor with a view to installing additional purlin and top plate fixings.

As climate change proceeds, storms are expected to become more frequent in New Zealand. Assuming damage occurs more frequently, the advantages of retrofit strengthening may become more apparent.

Earthquake resilience

In the Canterbury earthquakes, some house foundations, claddings and linings suffered extensive damage.

The main change to housing design coming out of this experience was a requirement to use ductile mesh in all slab floors of new houses. It was apparent the existing style of floors was not performing structurally when no mesh, or brittle mesh, was used. The design of other components was not changed.

Is there a case for going further and reducing material damage for other components beyond that needed for health and safety? For example, if houses had more evenly distributed bracing, some or most of the earthquake (and wind) damage to linings and claddings could be avoided or reduced.

Modern houses have many openings in external walls, and already these walls are designed as bracing components for a large percentage of their area. However, additional bracing could be cost-effective in reducing subsequent repairs to linings.

Houses designed to NZS 3604:2011 *Timber-framed buildings* performed well in the Christchurch earthquakes in that life safety was maintained. If designers considered adding additional bracing, say up to 50% more, this would be expected to reduce lateral earthquake deflections and therefore damage.

It is often possible to achieve this by using bracing-grade plasterboard, plywood sheet or similar. Adding 50% more bracing in a sample new house in Wellington (a single storey of light cladding construction) has an additional cost of about $1,800 (see Study Report SR346).

It is possible that additional bracing could be cost-effective in small earthquakes with short return periods. This is analysed in Study Report SR346, which shows that to justify 50% more bracing in a new house, the design would need to save $3,100 in repair costs expected over a 25-year return period earthquake.

This appears to be a possible scenario, but further work is needed on the likely damage for a variety of new house designs and their repair costs for various return period earthquakes.

More information

BRANZ

Study Report SR187 *Retrofitting of houses to resist extreme wind events*.
Study Report SR327 S*tructural performance of houses in the Canterbury earthquake series*
Study Report SR333 *Valuing sustainability and resilience features in housing*
Study Report SR346 *The value of sustainability – costs and benefits of sustainability and resilience features in houses.*

Bulletin 455 *Restoring a house after flood damage*
www.seismicresilience.org.nz – BRANZ online resource that aims to raise the seismic performance of New Zealand's building stock.
www.level.org.nz – BRANZ website about sustainable housing.

Other

Page, I. (2012). *Evaluating costs/benefits for housing flood damage mitigation*. Climate Change and Urban Impacts Toolbox Workshop. July 2012. NIWA. Available online at: *https://www.niwa.co.nz/sites/niwa.co.nz/files/session_11_-_stage_3_cbe_for_housing_adaptation_ip.pdf*

Royal Society of New Zealand. (2016). *Climate change implications for New Zealand.* Available online at: *http://www.royalsociety.org.nz/expert-advice/papers/yr2016/climate-change-implications-for-new-zealand/*

Royal Society of New Zealand. (2016). *Transition to a low-carbon economy for New Zealand*. Available online at: *http://www.royalsociety.org.nz/expert-advice/papers/yr2016/mitigation-options-for-new-zealand/*

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