# Retrofitting to resist extreme wind

Strong wind causes damage to houses, particularly their roofs. A recent BRANZ study started by defining 'extreme winds' before developing retrofit solutions to ensure roofs on older houses are adequately secured.

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Extreme wind has no universal definition. The Loadings Standard, NZS 4203: *General structural design and design loadings for buildings*, requires a building to be designed to resist a certain wind level. Such a wind is expected to occur once in 500 years at the particular location. A building is not expected to collapse during such a wind but may sustain some damage. Tornadoes are a special type of extreme wind event and were not considered in the study.

## Defining 'extreme wind'

Houses designed to the latest version of NZS 3604: 1999 *Timber framed buildings*, are assigned to one of four groups (wind zones), depending on their location (geographic, on a slope), house size and the presence of shielding features in the near vicinity. NZS 4203 was used to determine the wind loads for the four wind zones defined in NZS 3604 (see Table 1).

If the combination of contributing parameters is such that a specific engineering design will be necessary and NZS 3604 cannot be used, we know that the force of the wind is greater than the Very High wind zone category in NZS 3604. It would not be possible to suggest any retrofit solutions for existing houses in this category because the level of force would be different for each house. The engineer should have taken this into account and designed for it.

Therefore, in this study, an 'extreme wind' event was defined as the maximum expected load for each of the four NZS 3604 wind zones.

**Table 1: Wind zones and corresponding wind speeds.**

| Wind zone | Wind speed |
|---|---|
| Low | 32 m/s |
| Medium | 37 m/s |
| High | 44 m/s |
| Very High | 50 m/s |

## Retrofitting solutions

New Zealand's housing stock has been built over many years, whereas the timber framed buildings standard NZS 3604 has only been in existence since 1978, with three revisions since then. The originally defined 'wind area' (determined only on geographic location) has transformed into the 'wind zone' (determined from the contributing factors mentioned above). As a result, for a particular location, the design wind loads for an NZS 3604 structure may have increased or decreased. Since the first issue of NZS 3604, there has also been a change from working stress design principles to limit state design principles.

In this study, the required connections between the elements of typical houses for the four zones were determined and compared with what was required at the time the house was constructed. For situations where the strength was less than required, retrofit solutions were devised.

By studying damage in historic events, BRANZ considered which parts of a house were affected the most by extreme winds. Generally, it was the roof that sustained the most damage, or damage to the roof initiated damage to other parts of the house. The study therefore concentrated on ensuring that the roof was adequately secured. Any retrofit approaches to the roofs of older houses needed to cause as little invasion as possible, to remain economic.

## Roof cladding retrofit simple

It was assumed that houses built since 1999 had adequately secure roofs as they would have been designed to the latest NZS 3604.

Heavy roofing materials, such as concrete and clay tiles, were considered to be little affected by extreme winds, provided they were still wired to the battens. Metal roof tiles are generally well fixed to the supporting framing and there is little opportunity to provide any better fixing than is already there.

Corrugated steel has been a popular roofing material, cladding up to 50% of roofs, particularly on older houses. The detaching of corrugated roofing in past storms, starting at the eave, has often led to the complete loss of the roof. Once the roof has gone, the wind can wreak havoc on the interior of the house.

Retrofitting is a relatively simple and inexpensive process. For houses located in High or Very High wind zones that are not already screw fixed, screw fixings may be added on crests between the existing fixings at the eaves, ridges and gable ends.

## Remember the roof framing

Equally important as the roof cladding connection is ensuring the purlins (supporting the cladding) are adequately fixed to the rafters/trusses and the rafters/trusses are properly fixed to the tops of the walls. A table of suggested retrofit trigger conditions was prepared for combinations of building age, old NZS 3604 wind area and new NZS 3604 wind zone. This test can be applied to individual houses. If the construction fits the conditions, retrofit solutions are required, and these are provided.

The retrofit solutions were devised so that they could generally be installed from within the roof space, with no disruption to the shell of the house. However, because the eave purlins are subjected to higher uplift loads than other purlins, they need to be secured first. Access to these can generally only be by removal and reinstatement of the eave lining.

Commonly available 'Z' nails are specified for improving the hold-down of the purlins to the rafters/trusses. Providing a retrofit connection between rafters/trusses and wall top plates that allowed simple installation was crucial. A bracket solution was considered to be best because it could be nail fixed to the side of the rafter/truss and then screw fixed to the top of the top plate. A special attachment is required on an electric drill to install the screws, but otherwise the installation is straightforward.

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### Retrofit costs quite low

An attempt was made to calculate a likely retrofit cost for an average house. Many broad assumptions were made in this process because multiple combinations of parameters exist, but for an average house, the expected retrofit cost was in the range of $600 to $2,200, including materials and labour.

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