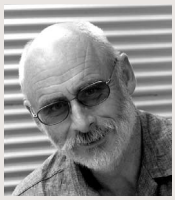

STRENGTHENING PILED FOUNDATIONS

The recent earthquake in Canterbury was a wake-up call for the rest of the country. Owners of pre-1978 houses with piled foundations should be asking themselves if their foundations need checking and upgrading.

By Trevor Pringle, BRANZ Principal Writer

While houses on slabs in Christchurch suffered badly from liquefaction and attracted much attention, piled foundations were also not immune (see Figure 1). As in previous earthquakes, piled foundations and their connections were vulnerable to shaking damage.

Previous earthquake damage

An EQC report *Inspecting earthquake damage to New Zealand houses* published in 2000 stated that 'historically, weaknesses in house foundations have been responsible for foundation and subfloor failures and consequent building damage. Weaknesses in connections between foundations and building superstructure can result in buildings moving off their foundations and collapsing.

'Foundation damage can take many forms but is generally due to sideways movement. Such damage may result in breaks in the plumbing and services connected to the house. Severe and prolonged ground shaking may result in the superstructure sliding or being thrown off its foundation support and the building collapsing. Secondary damage of piles punching up through the floor lining can result.

'House foundation systems that are irregular in layout and/or lateral stiffness typically twist when shaken. This can result in more damage to the foundations and in the house. The combination of strong anchor points such as concrete chimney bases or entrance steps and more flexible piles are examples of irregular foundation layouts.'

1987 EDGECUMBE EARTHQUAKE

A 2003 BRANZ report found that damage from the moderate 1987 Edgecumbe earthquake revealed weak points in conventional residential construction – foundation bracing and connections between framing. Many of these houses were built before the introduction of formal construction standards and had little or no foundation bracing.

Dwellings with no foundation bracing commonly collapsed, usually seriously damaging the superstructure, trapping occupants and severing any service connections to the dwelling, including sewer lines, water supply, electricity and reticulated gas.

Current housing stock at risk

A 2007 study *The adequacy of existing house foundations for resisting earthquakes: Effect on service reticulation and ignitions* commissioned by the New Zealand Fire Service and carried out by Victoria University of Wellington assessed the adequacy of a sample of 80 dwellings' foundations in Wellington against the current standard NZS 3604:1999 *Timber framed buildings*.

The study reported that:

- 39% of the sample had inadequate subfloor bracing
- 16% of the sample relied solely on the strength of ordinary piles
- 11% relied entirely on large concrete anchors
- 76% of dwellings had some form of fixing deficiency, ranging from degradation to incorrect or non-existent fixings.

In terms of foundation performance, the report stated that 'in the Inangahua earthquake, piles overturned and jack studding collapsed due to the lack of bracing. This vulnerability of dwellings with irregular plans was also illustrated by the torsional racking at the extremities of dwellings in the Edgecumbe earthquake. The connection of R6 (6 mm diameter) steel reinforcing bars between slab-on-ground and foundation wall was also seen as inadequate, as it failed to prevent the slab moving relative to the foundations.'

RECENT WELLINGTON STUDY

Just released research by Victoria University master's student Jamie Irvine, sponsored by the Earthquake Commission (EQC), showed that 'more than half of domestic dwellings randomly sampled in Wellington did not meet current Building Code requirements and their ability to resist a major earthquake is highly questionable. Houses moved on their foundations during the Edgecumbe and recent Darfield earthquake, but the potential consequences are far more severe for houses on sloping sites, such as many in Wellington.

'Houses found to be especially at risk were those with fully piled foundations built before 1978 and those with damp, poorly ventilated subfloors.'

THE CANTERBURY EXPERIENCE

Since the Darfield earthquake, BRANZ has been actively surveying damaged buildings in Canterbury. Subfloor house inspections confirm the Wellington studies' findings about connections. The presence of a continuous →

Figure 1: Piled foundations that moved during the Darfield earthquake.

Figure 2: Many piles are not connected to the floor framing.

perimeter foundation probably saved many piled houses from much more serious damage.

Upgrade options

A straightforward upgrade option that should be considered first for existing piled foundations in houses built before 1978 is to provide adequate bearer connections to all piles. Many existing pile connections are badly corroded, and many piles are simply disconnected from the floor framing (see Figure 2).

Other upgrade options for existing piled foundations may be to:

- ensure all braced piles and anchor piles have the correct 12 kN connections to bearers or joists
- add 100 × 50 mm timber braces fixed to existing piles and foundation walls or to piles and joists/bearers (see Figure 3)
- fixing plywood sheet bracing around the perimeter, which may be attached to the piles directly (see Figure 4) or to the jack stud framing if on a sloping site – this can be quite tricky and may require the services of a consulting engineer
- consider constructing a new continuous concrete perimeter foundation wall, or at least an L-shaped corner foundation wall at each internal and external corner of the building
- construct a number of concrete walls between two existing piles, with starter bars fixed into the piles – to be effective, the length/height ratio of these walls should be greater than 1.5 (see Figure 5)
- perhaps in conjunction with a more major alteration, it may be feasible to replace at least part of the existing timber floor with a concrete slab on ground.

Construction details and attachment of the floor framing for many of these options should follow the provisions of NZS 3604.

Limitations to upgrade options

The feasibility and extent of upgrading will be influenced by the following:

- Construction of the existing building. For example, can bolted connections be made to existing concrete piles? Is the structure itself sound?
- Height of the building above the ground. Is there enough height to allow access to install the upgrade options (or must a floor be lifted)? Space can sometimes be created by digging access trenches between rows of piles
- Ground conditions. For example, fixing a brace to an existing ordinary pile where the ground is poor or the pile is shallowly founded (only goes 100–150 mm below the ground level) may not provide enough lateral resistance.

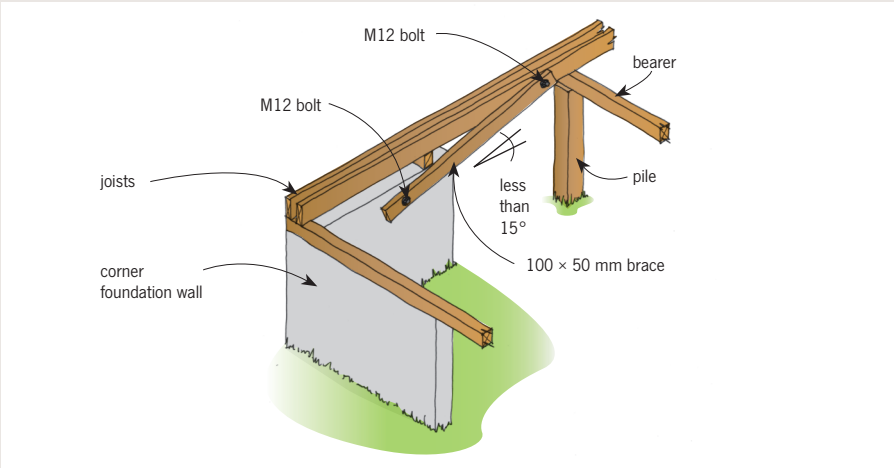

Figure 3: Corner wall foundation remedial details.

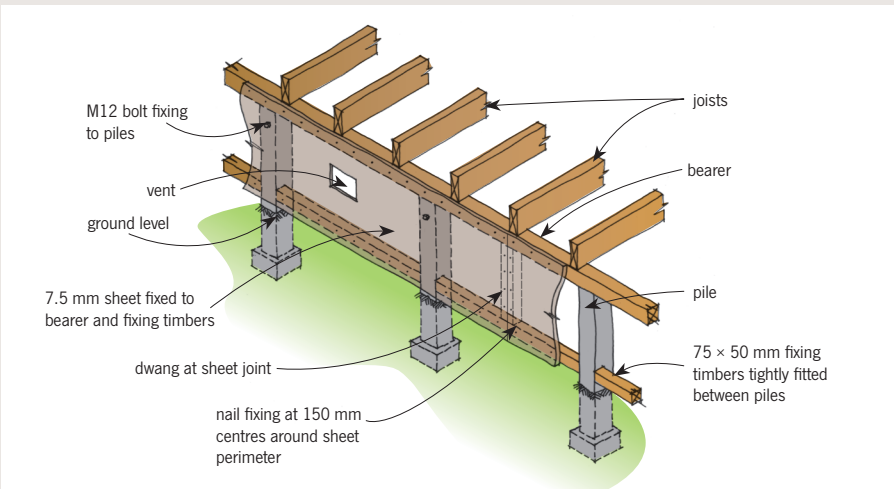

Figure 4: Bracing a piled house with sheet material. This can also be used for jack studs, probably more easily than the option below.

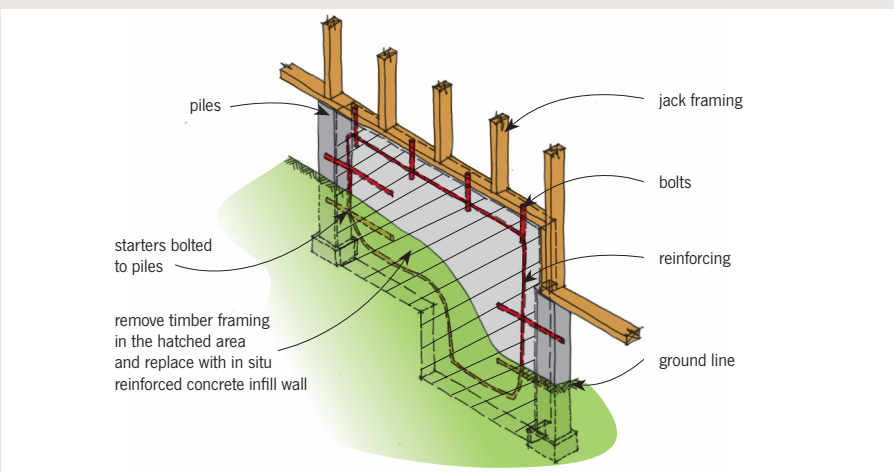

Figure 5: Jack studs on piles remedial work.

An upgrade project that becomes an 'alteration' may require a building consent from the local Building Consent Authority. Advice should be sought from the local council in this case.