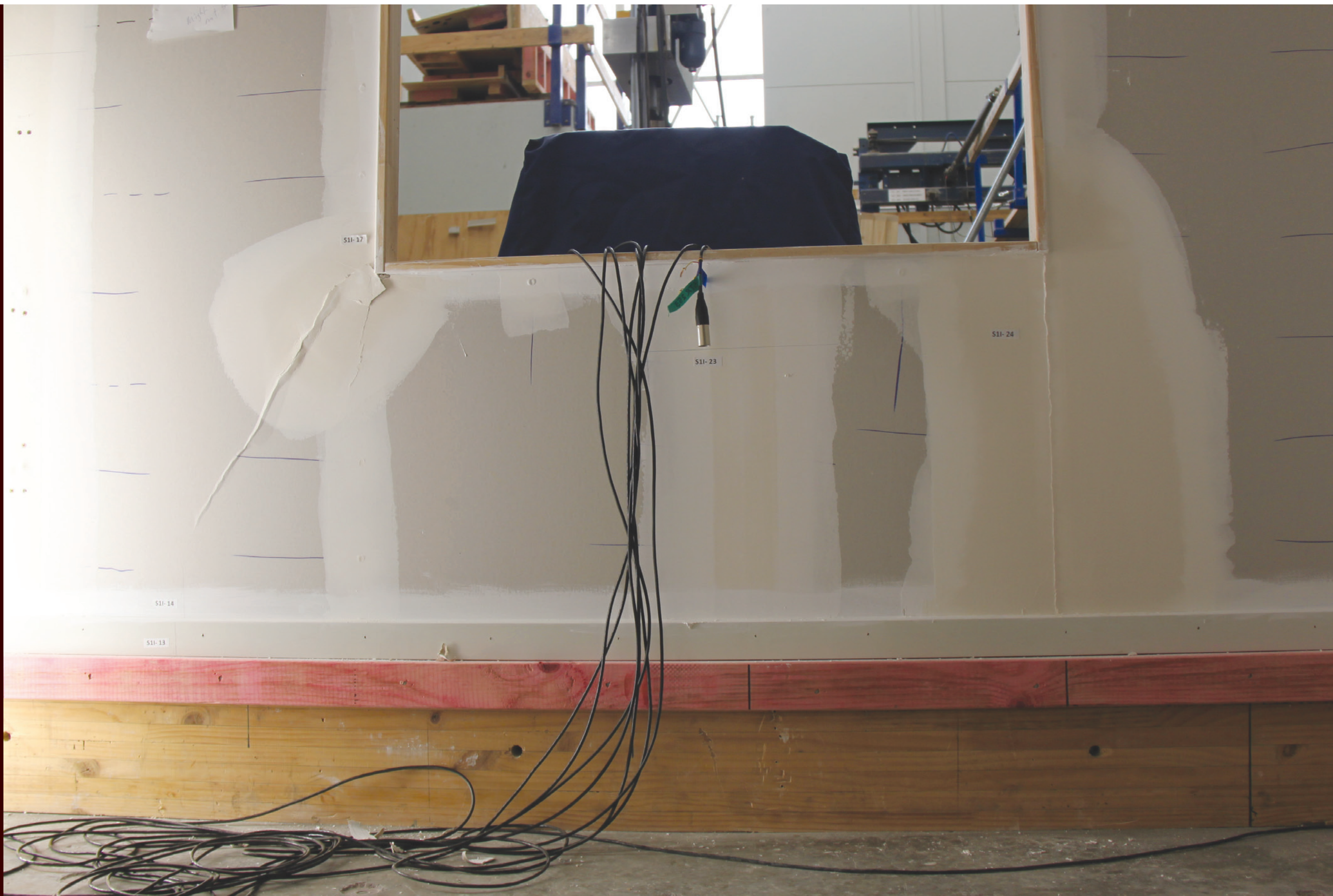
BRANZ

ISSUE548 BULLETIN



REPAIRING PLASTERBOARD AFTER AN EARTHQUAKE

June 2012

- After the Canterbury earthquakes, some homeowners reported that their houses were noisier than before.
- This bulletin provides guidelines for repairing plasterboard-lined walls to assist reinstating strength and stiffness and to help modify this effect.
- It is recommended that a building bracing assessment is carried out before committing to repairs if the plasterboard bracing system has been damaged to the extent that it must be replaced.

1.0 INTRODUCTION

1.0.1 After the Canterbury earthquakes of 2010–2011, some homeowners reported that their houses were noisier than before when doors were slammed, people climbed stairs, heavy vehicles drove by and during strong winds and aftershocks.

1.0.2 Often, these houses have had only minor apparent earthquake damage. It is possible that there is unseen damage, such as loose framing connections or weakened wall lining fixings along sheet joints or behind timber trims (such as skirting boards), that has resulted in more flexibility.

1.0.3 BRANZ conducted laboratory experiments to determine how much more flexible houses become following earthquake shaking and the effectiveness of different repairs. A small test house was built, and it was exposed to various levels of lateral displacement. The damage and house stiffness were recorded at each stage of testing. Several repair methods were used, and the amount of restiffening that occurred was measured. The repair methods included:

- simple cosmetic repair
- simple cosmetic repair plus the addition of extra plasterboard fixing screws
- adding an overlay of new plasterboard over the damaged plasterboard and adding wall hold-down anchors
- removing all wall lining and replacing with new lining in affected areas.

1.0.4 The tests also examined the effect on house stiffness when the adhesive bond between plasterboard and framing fails. It is thought that this sometimes happened in Christchurch because linings have been reported as feeling loose and 'drummy' when tapped.

1.0.5 Gypsum plasterboard linings are designed to provide most of the bracing in New Zealand houses constructed since 1978 (the date of the first issue of NZS 3604 *Timber-framed buildings*), although fibrous plaster continued to be used in the 1980s and 1990s and is still used in very small quantities today. In older houses, diagonal timber braces were often used, although wall linings still carried most of the forces because of their greater stiffness. This bulletin only applies to houses where the primary bracing is from paper-faced gypsum plasterboard.

1.0.6 Earthquake damage to bracing elements can reduce lateral strength and stiffness, depending on the size of the earthquake. Bracing must be reinstated for the building to regain the resistance it possessed before the earthquake.

1.0.7 Future earthquake events may recrack plasterboard joints and reduce stiffness, particularly in houses where the bracing resistance is not reinstated or does not meet the requirements of current standards.

1.0.8 Even if the repair work is carried out with good workmanship, the quality of the finished surfaces may be less than before the earthquake damage occurred.

2.0 TEST HOUSE DESCRIPTION

2.0.1 BRANZ constructed and tested a single-room single-storey building (Figure 1). The building was nominally 2.4 m high and incorporated windows and doors and two short internal walls (one in each direction) (Figure 2). It had plasterboard-lined light timber-framed walls and a timber-framed plasterboard-lined ceiling with a 20 mm thick particleboard flooring on top. This flooring served to ensure that the

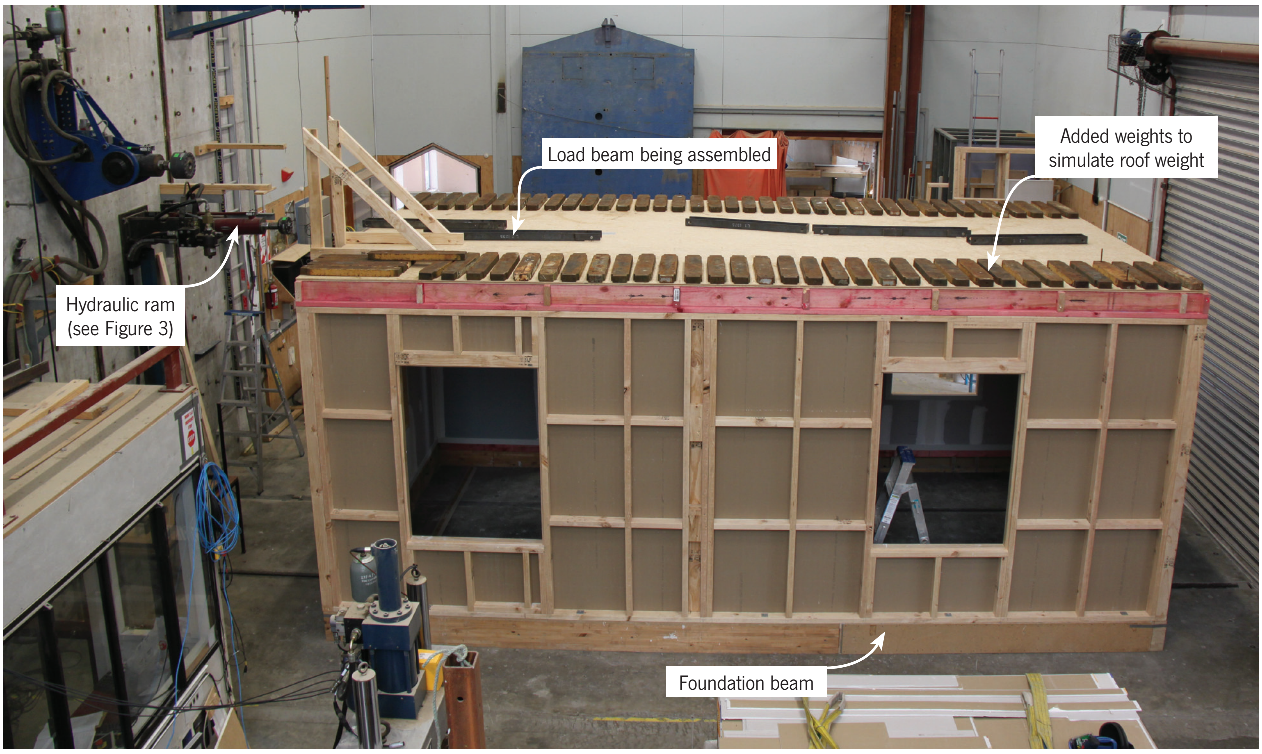


Figure 1. Test building

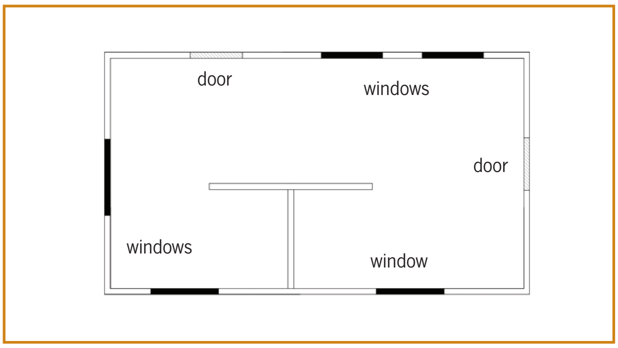


Figure 2. Plan showing location of short internal walls

displacement introduced by the single hydraulic ram at the centre of the room was transferred to the outer walls. The outside plan dimensions of the building were 6.5 x 3.7 m.

2.0.2 The near exterior wall in Figure 1 was bolted to the timber foundation beam. The remaining walls were nailed to the beam.

2.0.3 Weights totalling 43 kg/m² were added to the roof to simulate the gravity weight contribution from the roof of an 8 m wide house. This weight is typical for a concrete tile roof. NZS 3604 assumes a heavy roof weighs between 20 and 60 kg/m².

2.0.4 Force was applied with the hydraulic ram, which moved a load beam connected to the particleboard flooring at roof level (Figure 3). The load beam ran the full length of the building and was located at mid-width of the building. Thus, the building 'roof' moved horizontally, imposing racking deformations on the side walls similar to the deformations that are imposed by earthquake loading in this direction.

3.0 TEST PROGRAMME

3.1 BUILDING RACKING TESTS

3.1.1 After racking the house and inducing damage, the building was repaired by one of the listed repair strategies and the building retested. Strength and stiffness measurements were taken to compare the effectiveness of each repair strategy.

3.2 BUILDING NATURAL FREQUENCY TESTS

3.2.1 At various stages in the test programme, the building 'roof' was moved horizontally by a few millimetres and then quickly released, causing oscillation in a decaying vibration (Figure 4). The building's natural frequency and damping were able to be determined from these plots using standard formulae.

3.2.2 As the building racks further, the natural frequency reduces relative to its natural frequency before the earthquake (Figure 5) because the building becomes more flexible. The effectiveness of the repair method can be judged by the regain in natural frequency achieved.

3.3 TEST FINDINGS

3.3.1 Full details of the tests and test results are given in the upcoming BRANZ Study Report SR265.

3.3.2 A typical test comparison between performance before and after a repair is shown in Figure 6. Here, the applied force versus building racking displacement at serviceability is compared for the building in its initial condition and after it had been racked to 31 mm (the approximate ultimate limit

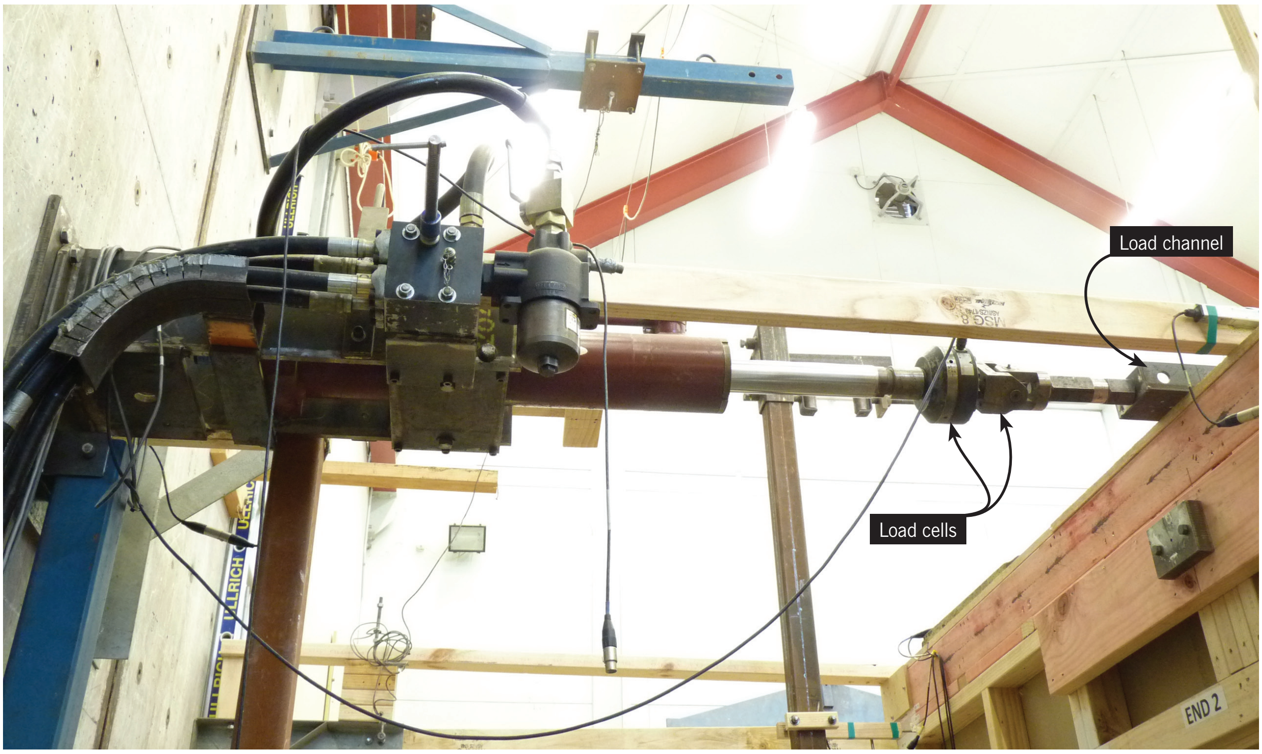


Figure 3. Hydraulic ram loading the test building via load cells

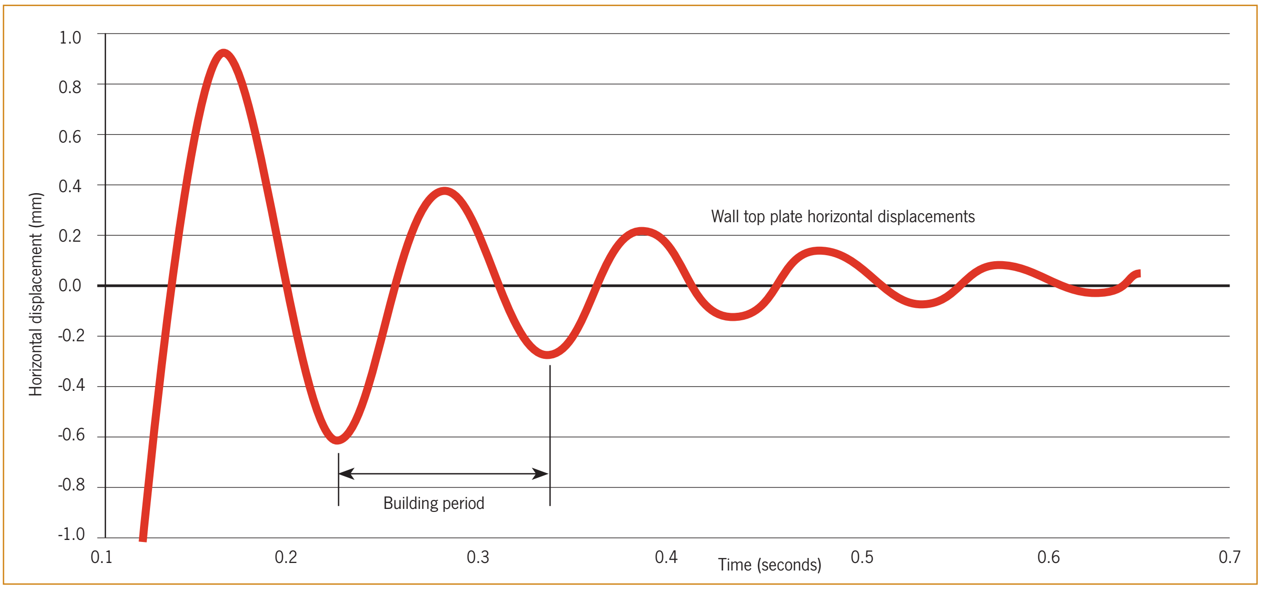


Figure 4. Top plate displacements measured in a building natural frequency test

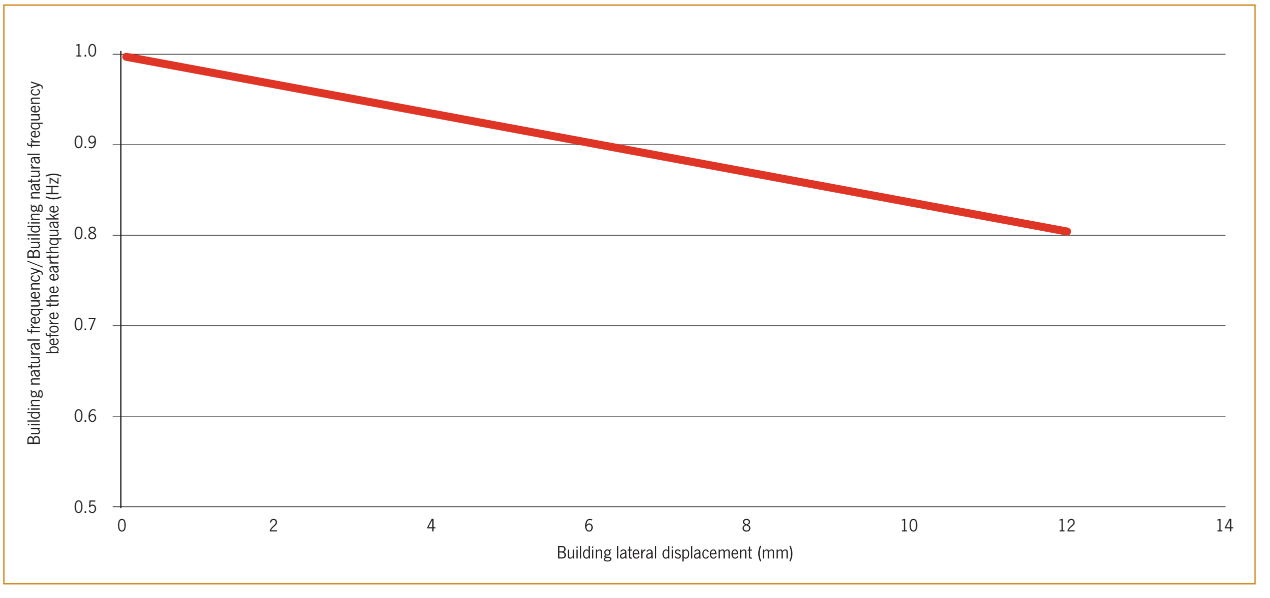


Figure 5. Building natural frequency relative to its natural frequency before the earthquake, as it is racked to greater displacements

state displacement) and then repaired using the sheet overlay technique. The plot shows that this particular repair effectively reinstated the building to its initial (undamaged) properties. While the initial cycling continued up to 31 mm, only the displacement cycles up to 8 mm are shown for clarity of the comparison. Similar plots after other repair methods showed some reduction in building stiffness.

3.3.3 Additional outcomes included the observation that loss of glue adhesion in the body of the plasterboard sheets had little effect on house lateral stiffness and that the test house was significantly stronger than predicted from summing the strengths of individual bracing elements, as determined from standard BRANZ P21 bracing tests. This strengthening is attributed to the bracing panels being paper taped and plastered along wall-to-ceiling horizontal joints and along the vertical joints at building corners. This reserve strength has long been recognised and may help to explain the good bracing performance of post-1978 houses in the Canterbury earthquakes.

4.0 REPAIR METHODS

4.0.1 Suggested repair methods, based on the testing undertaken, are given below. The method most suitable for application in a particular situation depends on the assessment of actual earthquake-induced damage.

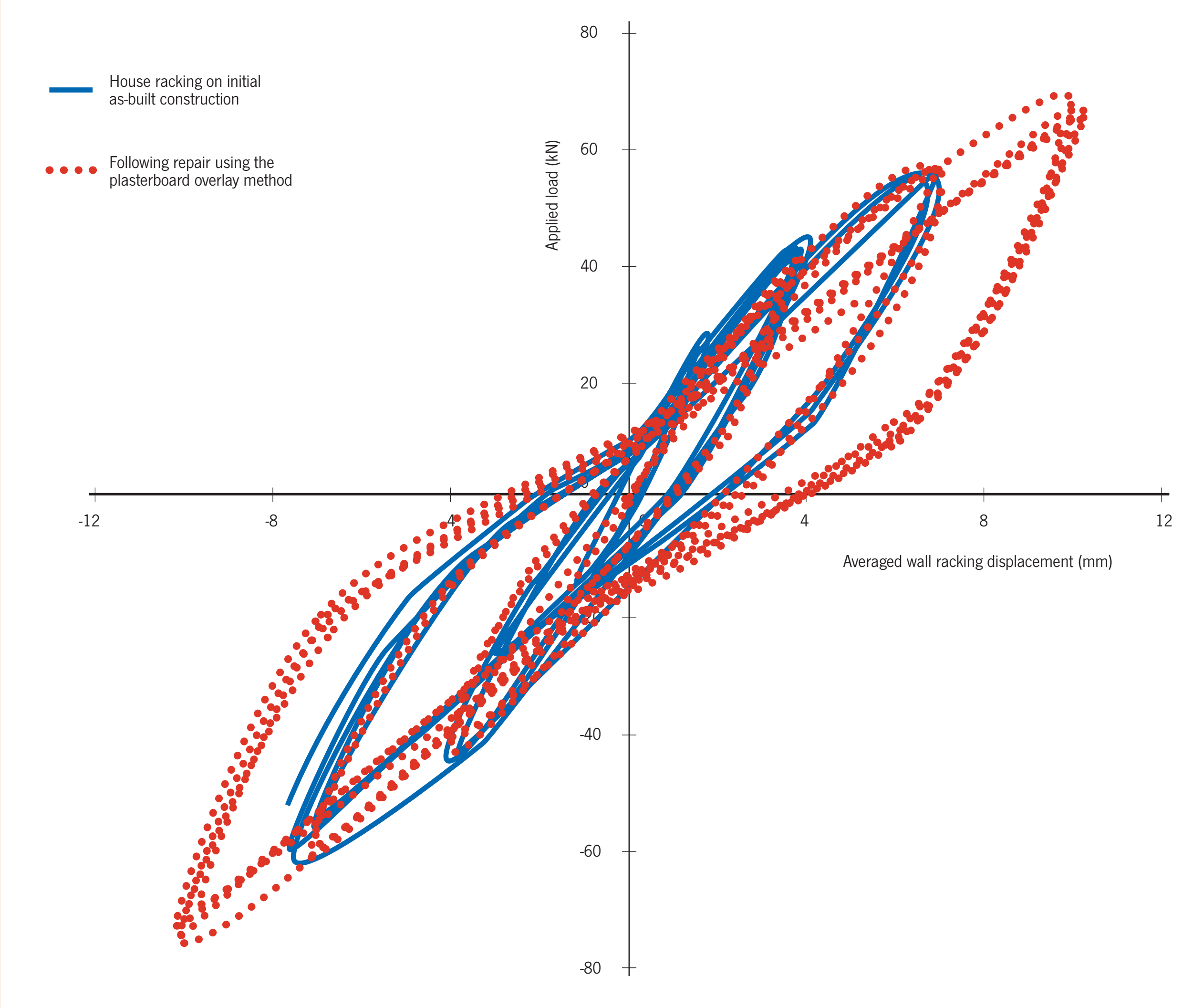


Figure 6. Comparison of applied load versus top plate displacement of the test building in its original condition and after the plasterboard overlay repair (Method 3)

1. COSMETIC REPAIR OF PLASTERBOARD DAMAGE

When to use this method

This method is applicable for houses where there is only light damage mainly consisting of thin vertical joint cracks emanating from the corners of openings. There must be no damage visible at wall-to-ceiling joints, no ceiling damage and no indications of wall uplift. Diagonal cracks from the corners of openings up to 50 mm long may be present. Some loss of adhesion or fastener 'popping' may have occurred in the centre of the sheets.

How to use this method

1. A drywall screw must be fixed adjacent to any plasterboard screws or nail fixings that have popped.
2. Any plasterboard sheet centres that are loose ('drummy') must be refastened.
3. On all walls exhibiting damage, use the cosmetic repair guidelines recommended by reputable gypsum plasterboard manufacturers.

Expected result

Although this repair may not reinstate building stiffness to that of a new house and small cracks may reappear in future serviceability wind or earthquake events, this damage is expected to remain cosmetic only.

2 COSMETIC REPAIR OF PLASTERBOARD DAMAGE PLUS ADDITION OF EXTRA PLASTERBOARD FASTENING SCREWS

When to use this method

This method is applicable where damage is more substantial than present for Repair Method 1 and includes situations where plasterboard cracks may emanate diagonally from the corners of openings up to 50 mm long and/or where wall-to-ceiling or wall-to-wall junctions show stress by visible cracking, fastener movement, wallpaper creasing or similar. Where there is evidence of bottom plate or stud uplift, framing connections must be reinstated and Repair Method 3 or 4 must be used.

How to use this method

1. Remove all architraves and skirting in the affected areas and check for fastener stress at the bottom of the sheets, which may indicate bottom plate or stud uplift.
2. Any diagonal cracks greater than 50 mm long or where sheet edges are dislodged will require a repair in accordance with Repair Method 3 or 4.
3. Add suitable drywall screws in a bracing pattern around the perimeter of all full-height wall sections that are to be redecorated. Extra fastenings will not be required behind undamaged plastered or coved wall-to-ceiling junctions.
4. Tape and stop repaired joints and plasterboard cracks in accordance with good trade practice.

Expected result

Although this repair may not reinstate the building's stiffness to that of a new house, it is expected to be sufficiently stiff to prevent small cracks from reappearing during future serviceability wind or earthquake events.

3 OVERLAY NEW PLASTERBOARD OVER THE DAMAGED PLASTERBOARD AND ADD WALL HOLD-DOWN ANCHORS IN AFFECTED AREAS

When to use this method

This method may be used on all walls with significant diagonal cracking, in lieu of replacing damaged sheets (Repair Method 4). Ceilings that have been cracked must be treated in a similar fashion. This method is only applicable where there is no damage to the wall framing.

How to use this method

1. Remove architraves, scotias and skirting.
2. Small cut-outs are made in the corners of all plasterboard bracing elements and stud-to-plate connections are reinstated. Ensure the bottom plate is tight with the floor. This may require the installation of new plate-to-floor connections
3. Ensure the building is plumb and level.
4. All loose plasterboard is screwed tight using suitable drywall screws that penetrate the timber framing by at least 20 mm, and sheets should be scraped flat along broken joints to leave a smooth planar surface to receive the overlay board.
5. Add screws along middle studs at 300 mm centres, even if glued originally, as the glued joints may have broken.
6. Overlay (either horizontally or vertically) damaged walls and ceilings with new plasterboard which is at least the same quality as the original. Cut the sheets around openings as per Figure 7.
7. Fix the overlaid plasterboard with suitable drywall screws that penetrate the timber framing by at least 20mm. Fix at 50 mm and 150 mm from each corner of each full-height wall element and then at 150 mm centres around the perimeter of that element. These fasteners are also used at 300 mm centres in the body of the sheets if fixed vertically or to each stud if fixed horizontally.
8. Tape and stop all joints and fastener heads in accordance with good trade practice.
9. Replace architraves, scotias and skirting

Expected result.

This repair is expected to result in a similar or better strength and stiffness compared to the original construction.

4 REMOVE ALL WALL LINING AND REPLACE WITH NEW LINING IN AFFECTED AREAS

When to use this method
This method is to be used where the building structure is or can be made sound. There is expected to have been very significant damage to the wall linings (for example, extensive diagonal cracking). Ceilings that have been cracked must be treated the same way.

How to use this method

1. Remove scotias, skirting and plasterboard wall linings in the affected areas. Ensure temporary bracing is in place and ensure building is plumb and level.
2. Repair any damage to wall framing and framing connections.
3. Fix the framing and bottom plate to the foundation as if it is a bracing element.
4. Replace the damaged sheets with comparable components (that is enhanced plasterboard must be replaced with enhanced plasterboard). All new sheets should be fixed in a bracing pattern. Cut the sheets around openings as per Figure 7.
5. Plasterboard joints are to be paper taped and plastered in accordance with good trade practice.
6. Replace architraves, scotias and skirting

Expected result
This repair is expected to result in a construction that will have stiffness and strength very close to that of the house prior to the earthquakes.
If it is necessary to replace all plasterboard lining in the house, a bracing design in accordance with NZS 3604:2011 must be carried out and bracing elements installed to provide the required bracing. While the plasterboard lining is removed, a check should be made of the bottom plate fixings. Any damaged fixings should be replaced. This will result in a construction with the strength and stiffness of a new house.

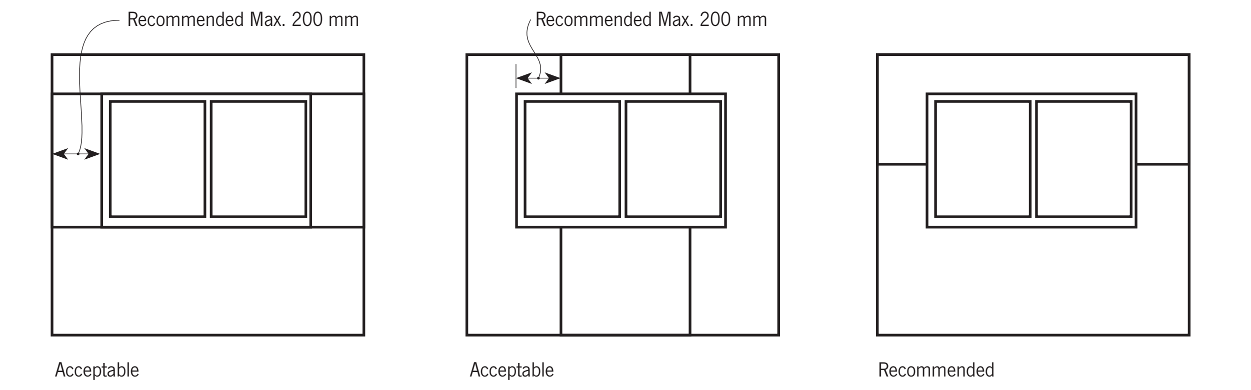


Figure 7. Sheet layout around openings

THE CORE PURPOSE OF BRANZ IS TO IMPROVE PEOPLE'S LIVES THROUGH OUR RESEARCH AND OUR DRIVE TO INFORM, EDUCATE AND MOTIVATE THOSE WHO SHAPE THE BUILT ENVIRONMENT.

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