BRANZ

STUDY REPORT

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Report on a Short Study Tour of Houses Following the 15 July 2009 Fiordland Earthquake

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Funded by BRANZ from the Building Research Levy

EQC EARTHQUAKE COMMISSION KŌMIHANA RŪWHENUA

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Preface

This report describes the findings of a short study of the damage sustained in houses clad primarily with EIFS systems in a moderate earthquake.

Acknowledgments

This work was jointly funded by the Building Research Levy and the Earthquake Commission.

Note

This report is intended for Loss Adjusters, Earthquake Damage Assessors and Engineers interested in the effects of earthquakes on houses.

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Abstract

A visit was made by BRANZ to several houses in the Queenstown and Wanaka areas that had been surveyed by EQC Damage Assessors after the 15 July 2009 Fiordland earthquake. The aim of the visit was to determine whether houses clad with EIFS systems suffered greater internal damage than those clad with weatherboards or brick veneer.

It is suggested that the damage was no greater in the EIFS clad houses, but that the size and complexity of the houses that were visited was the main cause of the observed internal damage.

Contents

1. INTRODUCTION

On 15 July 2009 there was a significant earthquake in the Fiordland area. The earthquake was centred 100 km west of Tuatapere and had a focal depth of 12 km. Its recorded Richter intensity was 7.8 and the estimated Modified Mercalli intensity was a maximum of 10 (MM10) near the epicentre. There were many aftershocks, and at the time of writing this report these are still occurring.

Reports of damage to houses were received by the Earthquake Commission (EQC) from many parts of the lower South Island, particularly in Te Anau, Queenstown and Wanaka.

The EQC has been assessing the damage at properties reported to have experienced earthquake damage over the period since the earthquake. In this assessment process, it appeared from the feedback from the assessors that houses clad with an exterior insulation and finishing system (EIFS) had a higher level of damage in the interior linings than those with weatherboard or brick veneer clad buildings.

2. BRANZ SURVEY

Graeme Beattie visited the Queenstown and Wanaka area on 21 and 22 September 2009 and surveyed eight dwellings that had previously been assessed by EQC Damage Assessors. No reference will be made in this report to any particular property visited in order to maintain the anonymity of the property owner.

Of the visited properties, one was an autoclaved aerated concrete (AAC) block structure, one had a block veneer cladding and the remainder (six) had an EIFS exterior cladding. On all but two occasions, a survey of both the exterior and interior of the property was carried out. In the case of the two exceptions, there was no internal survey because of lack of access.

3. OBSERVED DAMAGE – EXTERIOR

The exterior of the AAC block property had many small cracks evident. The majority of these appeared not to be new, nor did they appear to have any relationship to earthquake action. Rather, they appeared to be related to everyday movement of the wall system, caused by temperature and moisture fluctuations. Shrinkage control joints were used around the structure, and at one of these joints some render and some of the block surface had spalled from the wall. While it might first be thought to be related to earthquake actions, the spalled area was at the mid-height of the wall, with no damage above or below the spalling. Such evidence is not what would be expected if the wall was being racked in-plane in an earthquake, where the top and bottom of the wall would be under stress at the joint.

The exterior of the block veneer structure had no signs of damage. This structure was single-storey over its entire plan.

The EIFS claddings showed varied patterns of damage, from nothing to wide open cracks. Fine cracking of the thin plaster coating occurred quite regularly. Many of these cracks did not align with the corners of window or door openings, as would be expected if the walls had been racked by an earthquake. Rather, they were randomly disposed. This suggests that they are the result of shrinkage of the plaster coating. An example of such cracking is given in Figure 1.

Figure 1. Cracking of the plaster on the EIFS cladding

Well-formed corners in the EIFS cladding did not appear to sustain any damage from the earthquake. However, others did not behave as well. In one instance, it appeared that in forming the corner the applicator had not built up the plaster coating to the same level as the remainder of the wall, which may have weakened the detail. The observed recess could not be accounted for on the basis that the framing behind the area had shrunk as the crease was not aligned with the thickness of the framing and the recessed area was parallel to the body of the wall. A view of the recess and the effects of the recess are shown respectively in Figure 2 and Figure 3. In this particular instance, racking action in the plane of the right side wall in Figure 3 during an earthquake could have resulted in this damage occurring, although at other corners the flaking of the plaster was higher up the wall. There was no associated damage in the interior linings to confirm that sufficient movement of the structure had occurred to damage the exterior.

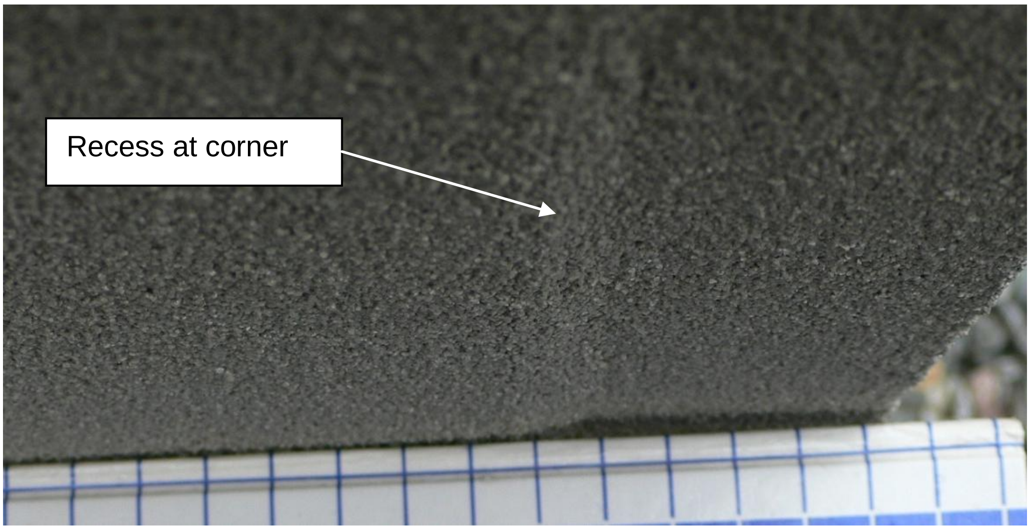


Figure 2. Recess at the corner of an EIFS wall

Figure 3. Damage at the base of the recess in the wall

On other occasions, the cracking damage at a change of direction of a wall was not earthquake related. It is likely that there was no proprietary former section available for the obtuse angle of wall intersection, so no reinforcement was provided for the joint and it has cracked under temperature fluctuations (Figure 4).

Figure 4. Cracking at the joint between two walls not intersecting at right angles (note that temporary taping over the joint has been removed to reveal the crack)

4. OBSERVED DAMAGE – INTERIOR

Unfortunately, due to lack of access to other identified properties, there was only one property available to be the "control" sample and this was the brick veneer house.

4.1 Interior damage – brick veneer house

This house was a single-storey property with a basic configuration, expected to be uniformly braced over its floor plan and expected to behave well in an earthquake. Fine cracks were observed in the ceiling and the walls of the house.

The wall locations were typical of what is often observed in houses with plasterboard interior linings, regardless of whether they have been subjected to an earthquake or not. It is BRANZ's experience that these cracks are due to normal seasonal movements and occur generally on joints between plasterboard sheets, particularly if reinforcing tape has not been included in the joint when it was stopped. They normally have a similar width over their full length, but this is not always the case if the framing behind can restrain one end of the crack from opening. If the plasterboard has not been cut around openings, the crack will often form in line with the edge of the window frame. The age of this property would mean that the joints have likely been stopped with a paper tape insert, which strengthens the joint.

Typically observed cracks in the ceiling joints are presented in Figure 5. This crack has extended into the plaster cornice at the wall.

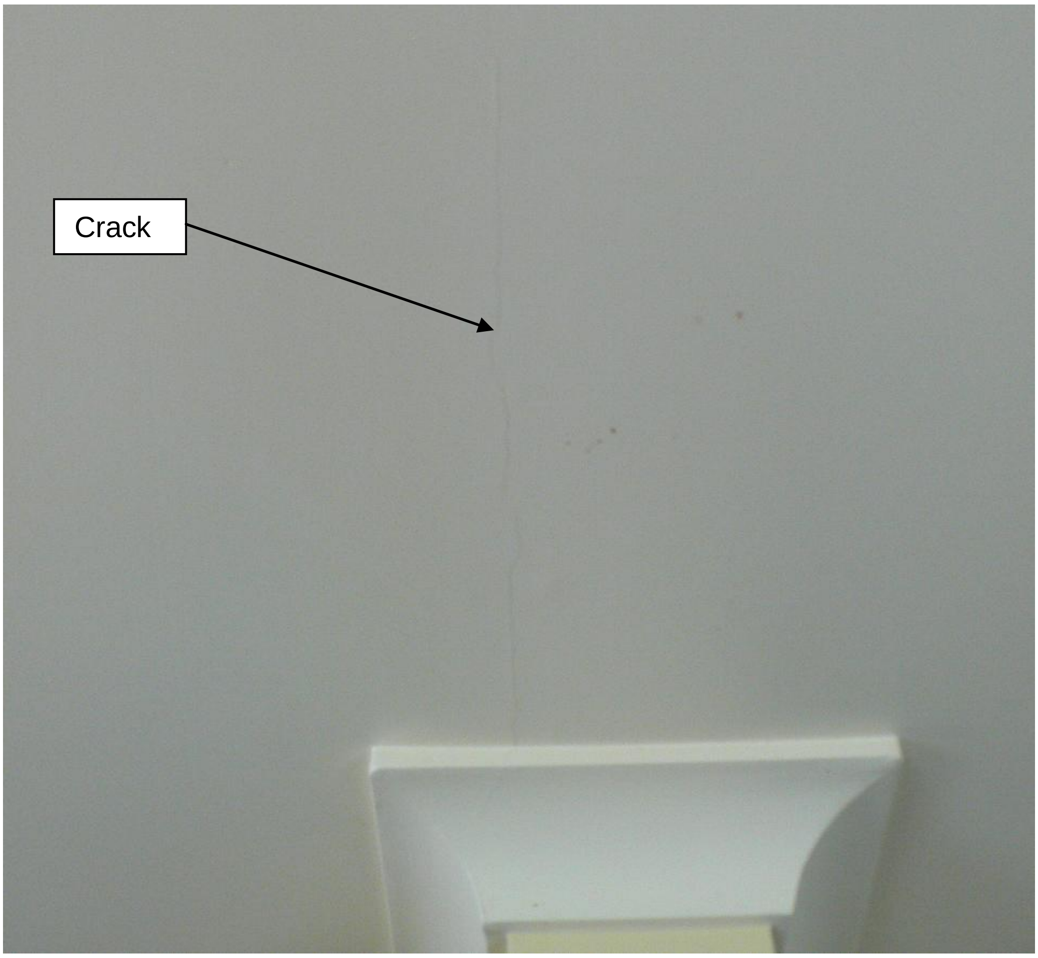


Figure 5. Fine ceiling crack extending across the ceiling from the end of an internal wall

4.2 Interior damage – EIFS clad houses

Of the six EIFS clad houses that were visited during the survey, five were substantial residences with four of these having two-storey elements. Of these five, access to the interior of one was not possible.

Considering first the single-storey property, there was a small amount of cracking in the plasterboard interior linings that was quite similar to that observed in the brick veneer house. The garage area was similar in size to the veneer house (approximately 6 x 6 m) and had similar cracking at joints between the lining sheets. Three fine cracks were observed in the wall, one at a corner and the other two remote from a corner. One of these commenced at the top corner of a doorway and the other above an opening in an exterior wall. The cracks were fine (0.1 to 0.2 mm) and of even width over their length (Figure 6).

Figure 6. Crack in the wall above a door head

The interior cracking damage was more pronounced in the larger properties. Two of these houses had wings that formed an approximate boomerang shape while the others had walls that were in two orthogonal directions. Despite this simplification, the properties did not have regular rectangular plans, but instead they had wings and protrusions from a basic rectangular shape.

It is well known that houses with irregular shapes are usually more heavily damaged under earthquake action than regular rectangular structures with many walls. Because of this, there are provisions in NZS 3604 (SNZ 1999) to ensure that bracing is well distributed throughout the building. In the sample of houses inspected, the room sizes did not generally exceed the dimensional limitations imposed by NZS 3604.

As well as the usual cracks similar to those observed in the regular single storey structure, other crack patterns were apparent in the more complicated houses. Several examples are given in Figure 7 to Figure 10.

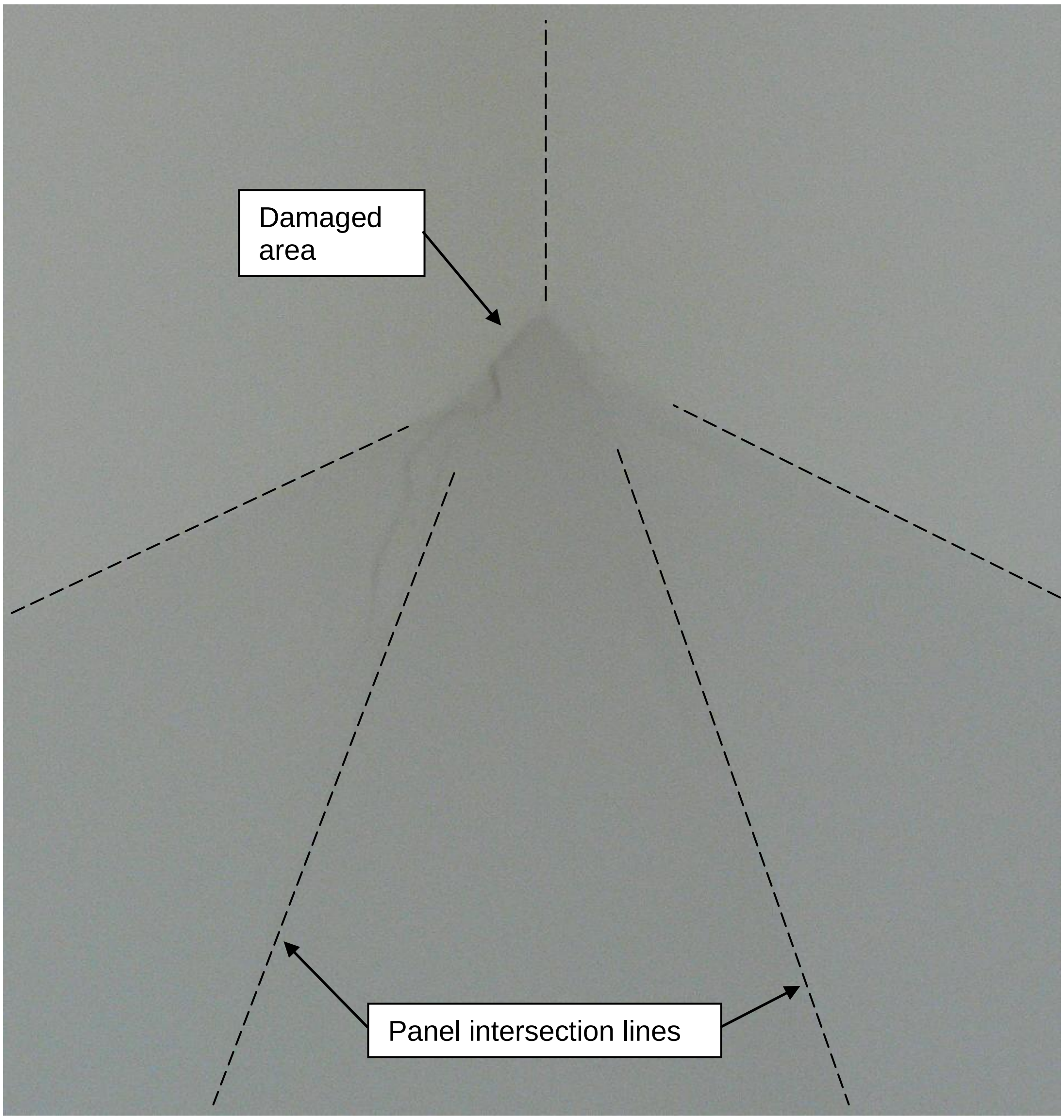


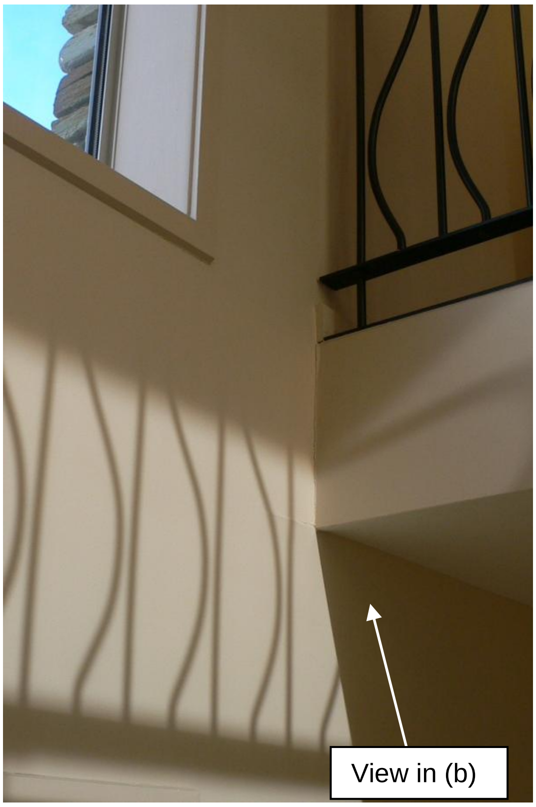
Figure 7. Cracking damage at the apex of a ceiling where the lining intersects at several angles

In all of the cases of Figure 7 to Figure 10 the damage is likely to have been caused by the earthquake.

In Figure 7 the ceiling is over a tall room with potential flexibility due to the height and light bracing. The apex of the ceiling, with the multiple faceted panels, is also a difficult area to reinforce the stopping at corners.

The damage shown in Figure 8 is very likely to have been caused by the more flexible two-storey tall structure described in Figure 7 clashing with the relatively rigid first floor diaphragm, which terminates part-way along the two side walls of the room. The differential movement between the structural types is likely to have caused the observed damage to the plasterboard.

The example in Figure 9 and Figure 10 is of a change to the ceiling line from a flat ceiling over a large (but less than the unbraced area limits of NZS 3604) open plan lounge/dining/kitchen area to an alcove with a vaulted ceiling. Even though the alcove is a not large enough to be classified as a "wing" in NZS 3604, there is a potential for the alcove to "pivot" at its intersection with the main structure in earthquake motion from a certain direction. Because the ceiling step is a discontinuity in an otherwise effective "diaphragm", a stress concentration has occurred, leading to cracking of the joints in the plasterboard ceiling and the adjacent wall lining (Figure 10).



(a) Overall view **(b) Close up view from under**

Figure 8. Damage at the intersection of a mezzanine floor with a two-storey high wall

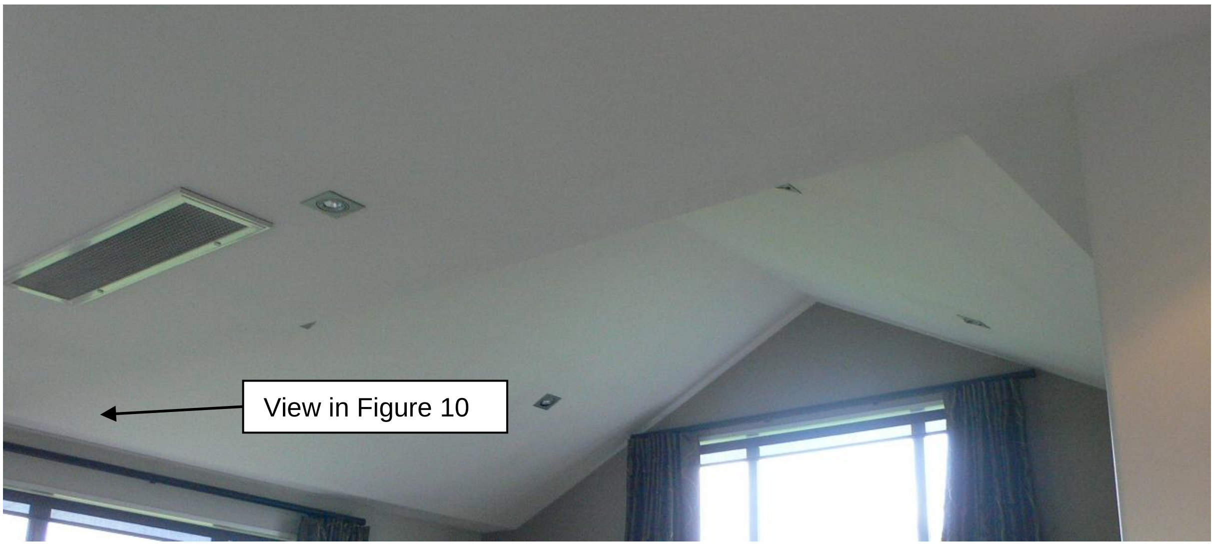


Figure 9. Cracks where the ceiling form changes from flat to vaulted

Figure 10. Close up of one of the cracks in Figure 9.

5. CONCLUSIONS

A visit was made to the Queenstown and Wanaka areas on 21 and 22 September 2009 to observe damage in houses that had been identified by EQC Damage Assessors following the 15 July 2009 Fiordland earthquake. They thought that the level of internal damage observed in the houses clad with EIFS systems appeared to be greater than that seen in houses clad with either weatherboards or brick veneer.

From the houses visited by BRANZ, it is suggested that the damage in the houses clad with EIFS systems was not worse than in an observed brick veneer house (no weatherboard property was visited). However, the size and complexity of the EIFS clad houses that were visited suggested that the damage was exacerbated more by these features than the cladding. The complexities can introduce points of high stress under earthquake action due to incompatibility of stiffnesses in the structure and the result can be cracking of the relatively brittle linings, as was seen in the visited houses. Seasonal moisture and temperature changes can also lead to cracking at complex junctions.

The quality of construction of the EIFS systems was variable in the houses that were visited. It is suggested that none of the observed damage to the EIFS cladding was a direct result of earthquake action. Rather, it is suggested that the types of cracking observed were caused by plaster material composition and climatic effects.

APPENDIX A REFERENCES

SNZ. (1999). NZS 3604. *Timber Framed Buildings*. Standards New Zealand, Wellington, New Zealand.