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STUDY REPORT

No. SR 114 (2002)

Survey of Nail Plate Corrosion In the Roof Space of Houses Near the Coast

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Preface

This report presents the condition of nail plates in the roof space of seven concrete tile roofed houses near the coast of New Zealand. The report is intended for building researchers, corrosion specialists, fastener and fixing manufacturers, contributors to building codes, maintenance persons and homeowners.

Acknowledgements

The author would like to thank Housing New Zealand for their assistance in searching for suitable houses for the survey. The assistance of Mike O'Malley and Bill Irvine with the site inspections is gratefully acknowledged.

SURVEY OF NAIL PLATE CORROSION IN THE ROOF SPACE OF HOUSES NEAR THE COAST

BRANZ Study Report 114 (2002) **L. R. Jordan**

REFERENCE

Jordan, L. R. 2002. Survey of Nail Plate Corrosion in the Roof Space of Houses Near the Coast. Building Research Association of New Zealand (BRANZ). Study Report SR 114 (2002), Judgeford, New Zealand.

KEYWORDS

Chloride, durability, fastener, nail plate, roof space, salt.

ABSTRACT

The objective of this project was to determine the condition of the nail plates in the roof space of houses with concrete tile roofs. Of primary concern is the extent of corrosion of nail plates in the roof spaces of houses that are built near the coast and have concrete tile roofing with no building paper underlay.

Houses in the sea spray corrosion zone having a concrete tile roof with no building paper underlay were found to be not widespread. Two houses in Auckland in the sea spray zone without building paper underlay in the roof space were inspected and the nail plates were in almost 'as new', condition having less that 1% white rust on their surface.

Several houses in the sea spray zone that had building paper underlay were also investigated. One of these houses showed considerable white rust on the surface of the nail plates. However, the nail plates in this roof space would still be expected to last the life of the building. It is suggested that the cause of this surface white rust could be salt deposition before the roof space was enclosed.

This survey gives confidence that in general the nail plates in the roof space of houses near the sea will easily meet the 50 year durability requirements of the New Zealand Building Code. However for houses built near the coast where the level of salt deposition is particularly high (eg a surf beach) this survey does not provide a sufficient level of confidence due to the inability to locate suitable houses in such severe locations for the survey.

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1. INTRODUCTION

The durability requirement of nail plates in the roof space of houses under the New Zealand Building Code (NZBC) [1] is for a minimum durability of 50 years. The corrosion protection required for nail plates in the roof spaces of houses covered under NZS 3604 [2] is continuously coated galvanized steel with a coating weight of Z275 [2], being approximately 137 g/m^2 on each side. This requirement is the same for all corrosion zones and all roof cladding types.

There is a particular concern with roofs made with concrete or terracotta tiles as these roofs are not required to have building paper underlay, unless specifically required to under NZS 4206 [3]. The concern is that without building paper underlay, these roof types may have a high ingress of corrosive salt laden air into the roof space, leading to the corrosion of metal fixings, such as galvanized nail plates, compromising the structural integrity of the building and the 50 year durability requirement.

Houses with concrete or terracotta tiles are required to have building paper underlay in situations with the following conditions [3]: (a) the roof pitch is 17° or less (b) the roof is a skillion roof, (c) where the wind zone as determined by NZS 3604 [2] is designated VH (Very High wind speed) or requiring specific design. Outside these specific situations there is no requirement for building paper under a concrete or terracotta tile roof.

The selection of houses was limited to those constructed post 1960's as nail plates were not used in New Zealand prior to the late 1960's.

1.1 The Environment

The environmental corrosivity classifications in New Zealand are defined in NZS 3604 [2] where the most corrosive 'Sea spray zone' is located within 500 metres of the sea including harbours, or 100 m from tidal estuaries and sheltered inlets, off shore islands including Waiheke, Great Barrier, Stewart Island and the Chatham Islands, and the other zones as shown on the corrosion zone map in NZS 3604 [2]. For comparison with the ISO 9223 classifications [4] as described in AS/NZS 2728 [5], the sea spray zone in New Zealand would fit into ISO Category 3 (Marine), ISO Category 4 (Severe Marine) and ISO Category 5 (Very Severe Marine). ISO Category 3 extends from the coastline to about half a kilometre from the beach in sheltered areas. For much of the New Zealand coast it can begin from several hundred meters to a kilometre inland and extend inland for 10 to 30 km. ISO Category 4 is found in areas of continual breaking surf and near the coast from about 100-400 m from the beach up to 1 km inland. ISO Category 5 conditions are found off shore and up to 100-400 m from the water line of areas of breaking surf.

2. METHOD

2.1 Survey Form

A survey of existing houses was devised to assess the condition of nail plates and to record other roof space conditions that may cause corrosion of the nail plates. A copy of the survey form can be found in Appendix A. A photographic record of the house location, the roof space, and the condition of the nail plates was included in the survey.

2.2 House Survey Selection

When selecting houses for the survey the following criteria were used:

- Location as near to the coast as possible – preferably in the sea spray zone.
- Houses of approximately post 1960's construction.
- Roofs clad with concrete or terracotta tile.
- Roof constructed using trusses with nail plates.
- No building paper under the tiles.

Note: It could not be determined whether or not the roof space contained trusses with nail plates or had building paper underlay until an inspection was made.

2.3 Locating Houses

Houses that were selected for survey but on inspection found to have a construction type that did not use nail plates were not surveyed. It was preferred that the houses surveyed did not have building paper underlay although houses in the sea spray zone that had building paper underlay were surveyed when houses without building paper underlay could not be found.

Housing New Zealand assisted in locating houses for the survey by searching their data bases of houses in Wellington and Auckland. Unfortunately no suitable houses were located in Wellington. In Auckland several houses were located but on inspection were found to be not suitable, having building paper underlay or being in a sheltered area, such as near the inner Waitamata Harbour. With Housing New Zealand houses not being suitable, a number of private homeowners were approached on Auckland's North Shore and in Wellington (Kapiti Coast, Paremata, Titahi Bay, and Petone).

2.4 Tests and measurements

2.4.1 Zinc thickness

Zinc thickness on the nail plates was measured using a calibrated 'PosiTector' eddy current based electronic thickness gauge. In some cases suitable readings could not be conducted due to a suitably sized flat area not being obtainable, or the build-up of zinc corrosion product on the nail plates leading to spurious results.

2.4.2 Timber moisture measurement

Timber moisture measurements were conducted using a 'Protimeter' digital mini meter, based on conductivity measurement between two prongs embedded in the timber.

3. RESULTS

3.1 House Locations

The number of houses that were located that met the survey criteria was very low, with a common difficulty being that houses in the age bracket of interest were often constructed using traditional frame roof techniques or that building paper underlay was used under the tiles. In total seven houses were surveyed. The location of these houses is shown in Table 1.

3.1.1 Auckland

On Auckland's North Shore three houses were surveyed. House 002 in Murrays Bay and 004 in Browns Bay met all the survey criteria and are the best examples in the survey. However these houses were not in a worst case corrosion location as Auckland's North Shore beaches are at most times of the year relatively calm. These houses are good examples of houses in the sea spray zone on Auckland's east coast and similar marine environments. These locations would be classified as ISO category 3.

3.1.2 Wellington

Finding suitable houses in the Wellington region was also difficult. Four houses were surveyed in the Wellington region but none fully met the survey criteria due to building paper underlay being present or the house being outside the sea spray zone. It appeared that the Kapiti Coast District Council and Porirua City Council recommend the use of building paper underlay with concrete and terracotta tile roofs and hence no tile roofs without building paper underlay could be located in these regions. In Petone and Eastborne the houses selected were found to be of traditional framed construction and were not surveyed. One house in Camborne without building paper underlay was surveyed, although this house was not in the sea spray zone.

3.2 House Inspections

3.2.1 House 001, Concrete tiles, no building paper underlay

This house at Camborne, Wellington, was 28 years old and is approximately 500 metres from the coast (west coast). The coast near the house is predominantly sandy and the swell is from nil to approximately 1 metre. The house is sheltered from the predominant on shore wind from the westerly direction by a hill. The outlook from the house, (Figure 1), is in a west direction. Overall this house could be considered to be an extreme case of a house in a Zone 1 corrosion zone or ISO Category 3.

The house has a concrete tile roof, (Figure 2), and no building paper underlay. The condition of the nail plates (Figures 3 and 4) was extremely good, having a zinc thickness of approximately 26 μm. The nail plates appear shiny with little dulling due to surface corrosion of the zinc and no white rust evident.

3.2.2 House 002, Concrete tiles, no building paper underlay

This house at Murrays Bay on Auckland's North Shore was approximately 24 years old and approximately 200 metres from Murrays Bay beach. The coast near the house as shown in Figure 5 is predominantly sandy and the swell is from nil to approximately 1 metre. The house is very exposed to the NE wind. This house is in the sea spray zone or ISO Category 3. The coast near the house is not a rough breaking surf beach with a prevailing on shore wind, subsequently the house is not in the most severe corrosion conditions found in New Zealand.

The house has a concrete tile roof and no building paper underlay. The nail plates in this house were in extremely good condition having a zinc thickness of approximately 24 μm with <1% white rust on the surface. Photographs of the nail plates in Figure 6 show the nail plates to appear shiny with little dulling due to surface corrosion of the zinc and very little white rust evident. The galvanized wire tie shown in Figure 7 is in a more exposed environment in the roof space and shows some white rust on its surface.

3.2.3 House 003, Concrete tiles with building paper underlay

This house in Murrays Bay is approximately 25-30 years old and is in a similar location to House 002 but is closer to the coast at a distance of approximately 100 metres. The outlook from the house is shown in Figure 8.

The house has a concrete tile roof with building paper under the concrete tiles. The nail plates in this house were in extremely good condition having 26 µm of zinc and appearing shiny with little surface dulling as seen in Figure 9. It is not possible to say whether they would be in worse condition had there been no building paper underlay

3.2.4 House 004, Concrete tiles, no building paper underlay

This house in Browns Bay is approximately 30-35 years old and is in a similar location to House 002 and 003. It is approximately 150 metres from the top of a steep cliff as shown in Figure 10.

The house had concrete tiles with no building paper underlay. The nail plates in this house were the oldest seen in the survey. The nail plates in this house were in extremely good condition having 20 µm of zinc and very little surface dulling as can be seen in Figures 11 and 12. A wire tie is shown in Figure 13.

3.2.5 House 005, Concrete tiles with building paper underlay

This house in Paraparaumu, Wellington, was approximately 10 years old and about 50 metres from Paraparaumu beach. The coast in front of the house is shown in Figure 14. The coast nearest the house is predominantly sandy and the swell is from nil to approximately 1 metre. The predominant wind from the westerly direction is on shore and the house is very exposed. This house is in the sea spray corrosion zone or ISO Category 4.

The house has a concrete tile roof with building paper underlay. However there was considerable air leakage and sand deposition into the roof space due to the roof space opening into the garage.

The nail plates, as seen in Figure 15 and 16, had about 19 µm of zinc coating and white rust over approximately 10% of the surface. It is not possible to say whether they would be in worse condition had there been no building paper underlay.

3.2.6 House 006, Concrete tiles with building paper underlay

This house in Titahi Bay, Wellington, was 18 years old and is at the top of a cliff and approximately 300 metres from the coast. The outlook from the house is shown in Figure 17. The coast nearest the house is predominantly rocky and the swell is from nil to approximately 1 metre. The predominant wind from the westerly direction is on shore and the house is very exposed. This house is in the sea spray corrosion zone or ISO Category 3.

The house has a concrete tile roof with building paper underlay. The nail plates, as seen in Figures 18 and 19. had considerable white rust on the surface.

It is difficult to say whether the cause of corrosion in this case is due to salt deposition on the nail plates before the roof was closed in or due to salt deposition afterwards. However due to the presence of building paper, salt deposition before enclosure is a strong possibility.

3.2.7 House 007, Concrete tiles with building paper underlay

This house in Titahi Bay, Wellington, was 19 years old and is approximately 500 metres from the coast. The outlook from the house is shown in Figure 20. The coast nearest the house is predominantly rocky and the swell is from nil to approximately 1 metre. The predominant wind from the westerly direction is on shore and the house is very exposed. This house is in a Zone 1 or ISO Category 3 corrosion zone.

The house has a concrete tile roof and has building paper underlay. Photographs of the nail plates in Figures 21 and 22 show the nail plates to appear shiny with little dulling due to surface corrosion of the zinc and no white rust evident. It is not possible to say whether they would be in worse condition had there been no building paper underlay.

3.3 Discussion: Corrosion rates and mechanism

Based on this survey, the corrosion rates of nail plates in the roof space of houses with concrete tile roofs without building paper appears to be low. If the same nail plates were exposed directly to the outside environment in a sea spray zone, the expected corrosion rate would be in the order of 10-20 g/m^2/year [6]. At this rate, on a nail plate coated with Z275 (137 g/m^2 on each side) galvanizing there would be no galvanising left after 15-30 years.

The condition of the nail plates seen in House 001, 002 and 004 indicate that that the nail plates in the roof space of houses with concrete tile roofing and no building paper under the tiles that comply with NZS3604 are most likely to meet the NZBC requirement of a minimum durability of 50 years in the sea spray zone and less severe corrosion zones.

The incidence of white rust on one house in the sea spray zone that had building paper underlay raises the question of whether corrosion of nail plates may occur through deposition of salt before the roof space is enclosed. A suggested method to overcome this issue, if found to be a problem, is a peel off coating protecting the nail plates during construction.

The low corrosion rates seen in the roof space of houses could be due to two factors:

(1) Low salt deposition rates, due to the low air flux in the roof space compared with outside the building, or due to rapid fallout of aerosols in going from a high pressure zone outside the roof to a low pressure zone behind the tiles in the roof space.

(2) Low time-of-wetness of the nail plates, due to a large area of the nail plates being in contact with the timber framing, and possibly due to low relative humidity in the roof space as indicated by the moisture content measurements of the roof trusses (Table 1).

4. CONCLUSION

Of the houses surveyed there was no significant corrosion of nail plates observed in the roof space under concrete tile roofs.

The houses surveyed give a high level of confidence of the condition of nail plates in the roof spaces of houses near the sea in a Zone 1 corrosion zone and in the sea spray zone near non surf beaches such as Auckland's east coast. The corrosion of nail plates in the roof space of houses in particularly corrosive environments, such as near breaking surf beaches, ISO Category 4 or 5, is uncertain. It should be pointed out that in some locations houses may require building paper underlay by default due to the wind zone classification rather than for corrosion protection.

5. REFERENCES

[1] New Zealand Building Code Handbook and Approved Documents, Building Industry Authority, 1992.

[2] NZS 3604:1999 Timber Framed Buildings.

[3] NZS 4206:1992 Concrete Interlocking Roofing Tiles.

[4] ISO 9223:1992 Corrosion of Metals and Alloys; Corrosivity of Atmospheres; Classification.

[5] AS/NZS 2728:1997 Prefinished/prepainted sheet metal products for interior/exterior building applications – Performance requirements.

[6] C. Kane, BRANZ Study Report 145, Atmospheric Corrosion Survey of New Zealand – Six Year Exposure Results, 1997.

Table 1: House and location description.

House designation	Date of survey	Location of house	Distance from coast, m	Age, years	Exposure to wind	Weather at time of survey	Roof	Trusses / moisture content	Insulation	Area of white corrosion	Zinc thickness
001	30.01.01	Camborne, Wellington	500	28	Sheltered from predominant westerly wind by hill	Fine, light breeze	Atlas concrete tile. 20° pitch	Douglas Fir. 9 % m.c.	Pink Batts	0 %	26 µm
002	30.08.01	Murrays Bay, Auckland	200	24	Very exposed to NE wind. Predominant wind westerly.	Showers, windy	Monier Elabana concrete tile 25° pitch	Boric treated pine. 14 % m.c.	Pink Batts	<1 %	24 µm
003	30.08.01	Murrays Bay, Auckland	100	25-30	Very exposed to NE wind. Predominant wind westerly.	Showers, windy	Concrete tile 25° pitch	Boric treated pine. 12 % m.c.	Rockwool	<1 %	26 µm
004	30.08.01	Browns Bay, Auckland	150	30-35	Very exposed to NE wind. Predominant wind westerly.	Showers, windy	Monier Elabana concrete tile. Double pitch 15° then 25°	Douglas Fir. 11 % m.c.	Pink Batts	<1 %	20 µm
005	25.10.01	Paraparaumu, Wellington	50	10	Very exposed to predominant westerly wind	Dry, windy	Monier Centurion concrete tile 25° pitch	Douglas Fir. 10.5% m.c.	Pink Batts	10%	19 µm
006	20.11.01	Titahi Bay, Wellington	300	18	Very exposed to predominant westerly wind	Showers, windy	Monier Centurion concrete tile 20° pitch	Douglas Fir. 12.4% m.c.	Ragfelt macerated paper	90%	Not measurable due to corrosion product
007	20.11.01	Titahi Bay, Wellington	500	17	Very exposed to predominant westerly wind	Showers, windy	Monier Centurion concrete tile 25° pitch	Radiata pine. 12.4% m.c.	Ragfelt macerated paper	<1 %	Not measured due to limited flat area on nail plate

Figure 1: House 001 Outlook from house.

Figure 2: House 001 Roof.

Figure 3: House 001 Roof Space.

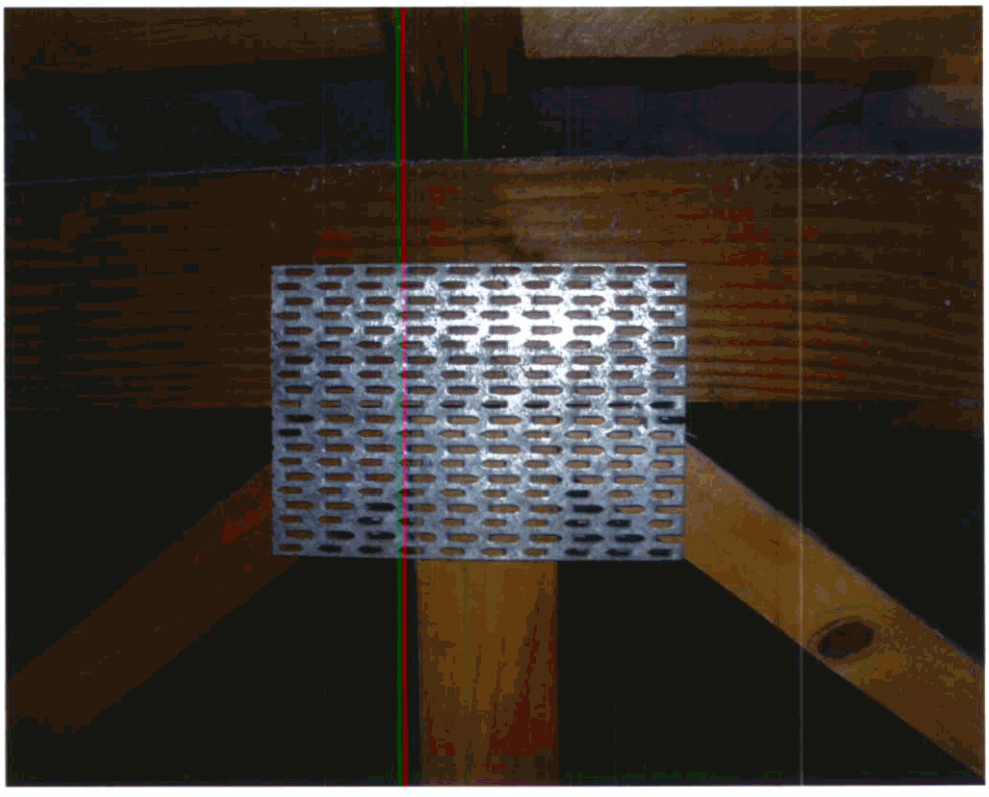

Figure 4: House 001 Nail plate.

Figure 5: House 002 Coastline near house.

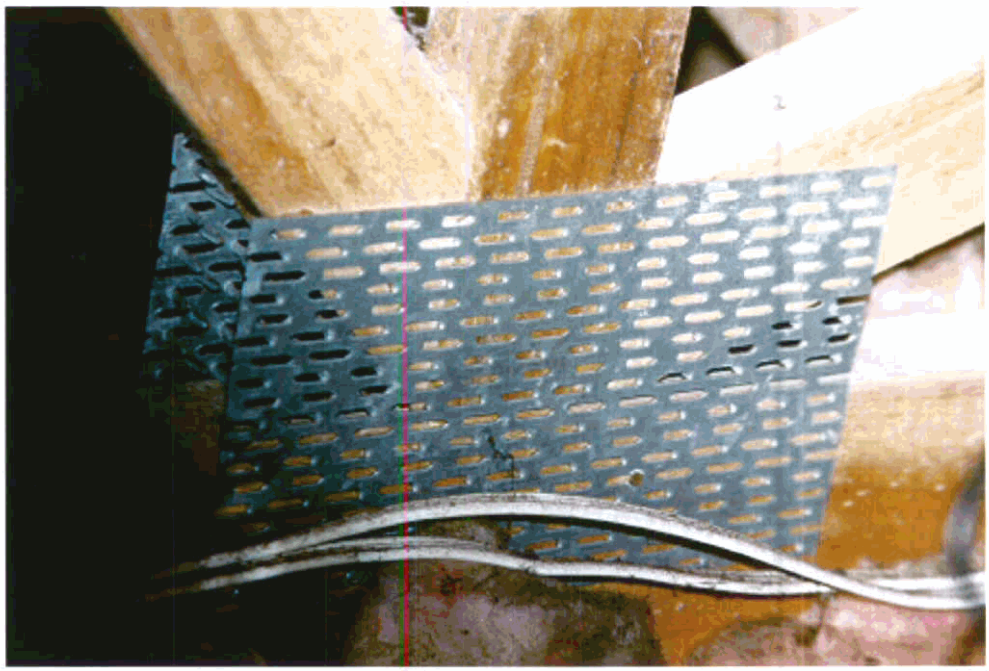

Figure 6: House 002 Nail plate.

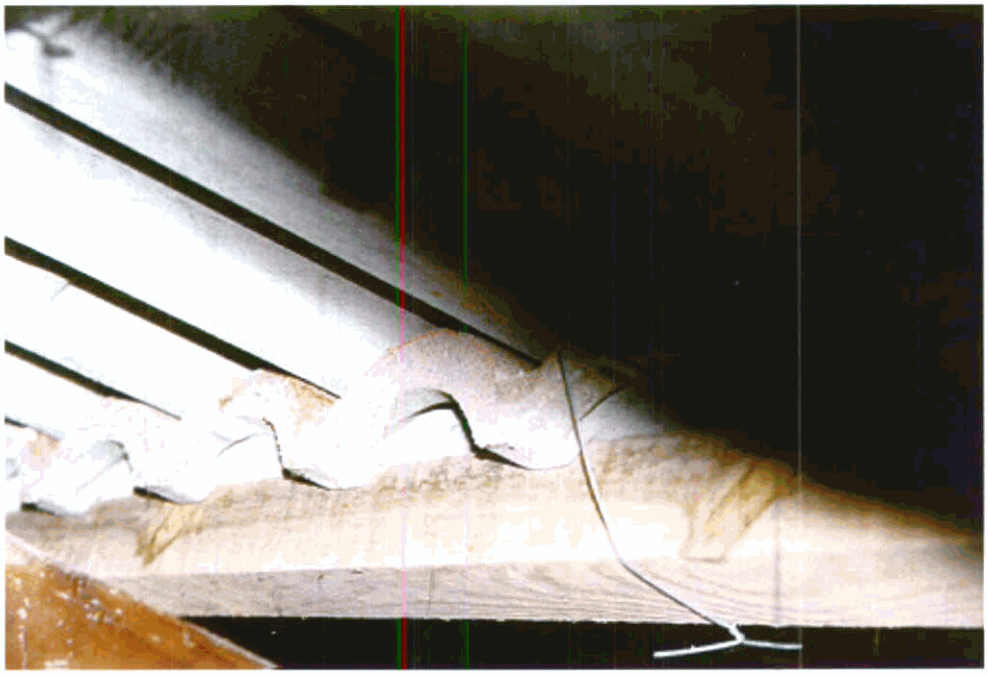

Figure 7: House 002 Roof Wire tie.

Figure 8: House 003 Outlook from house.

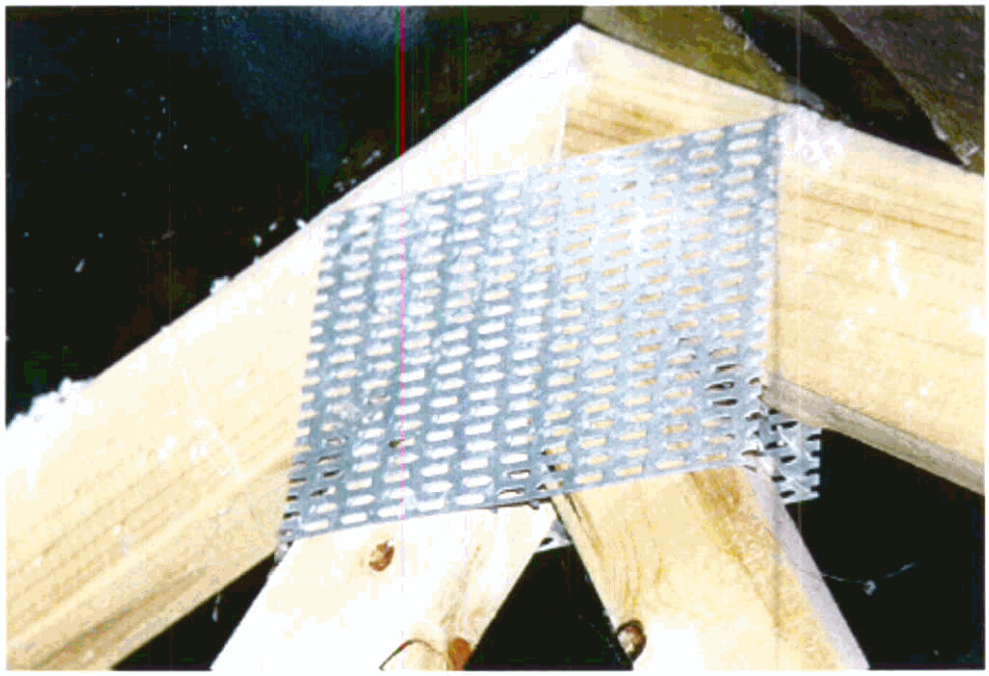

Figure 9: House 003 Nail plate.

Figure 10: House 004 Coast near house.

Figure 11: House Roof space.

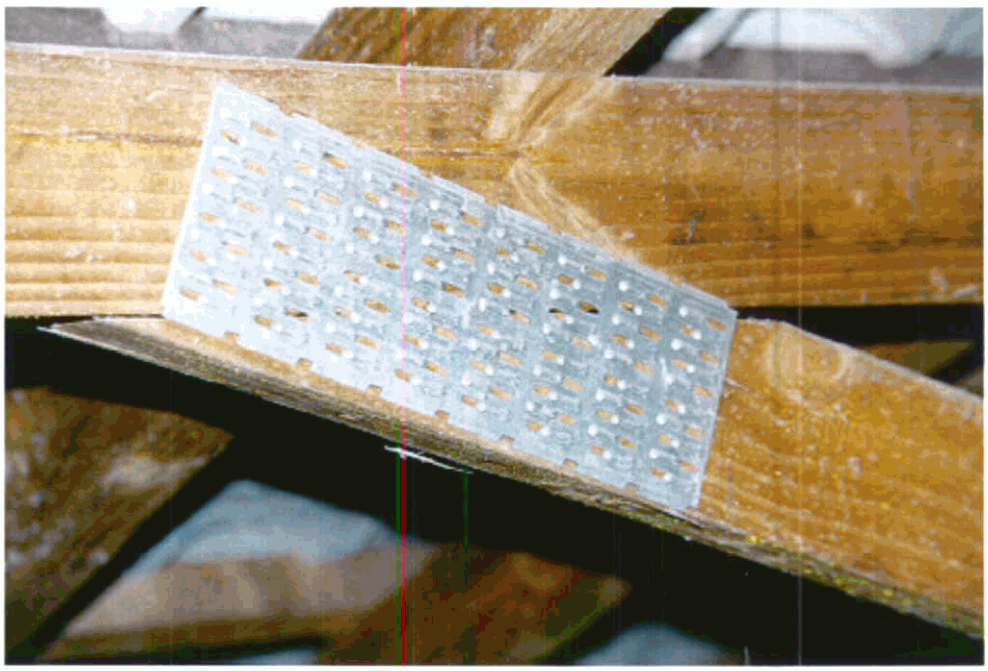

Figure 12: House 004 Nail plate.

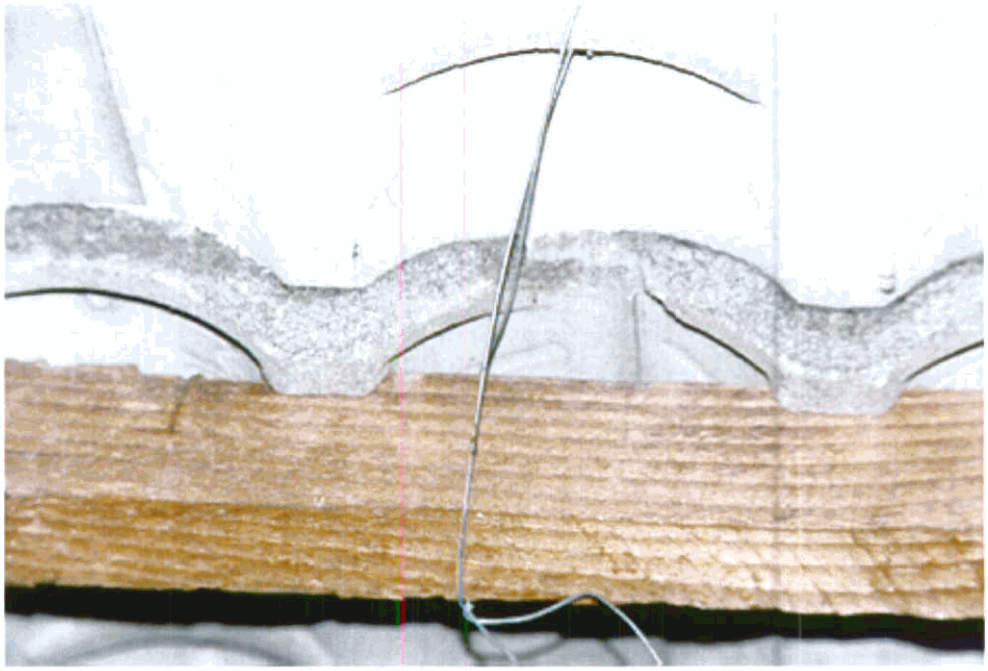

Figure 13: House 004 Wire tie.

Figure 14: House 005 Coast near house.

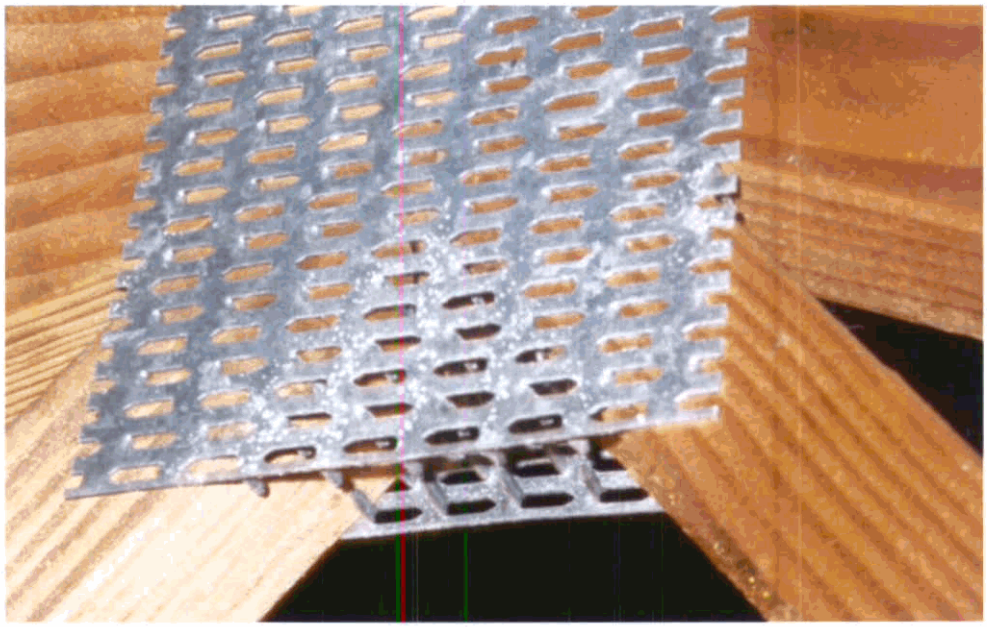

Figure 15: House 005 Nail plate.

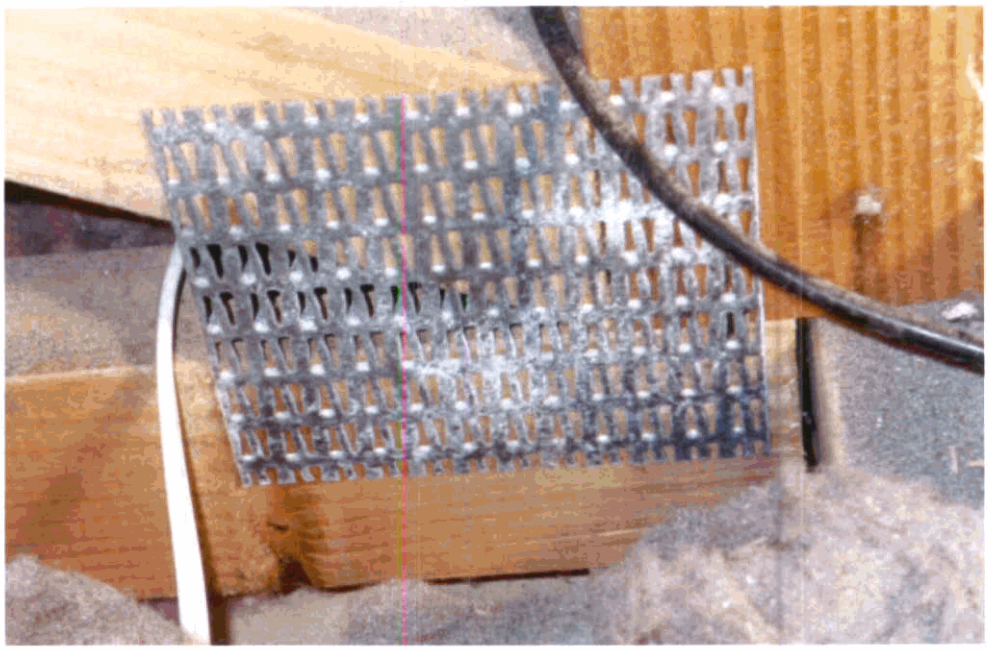

Figure 16: House 005 Nail plate.

Figure 17: House 006 Outlook from house.

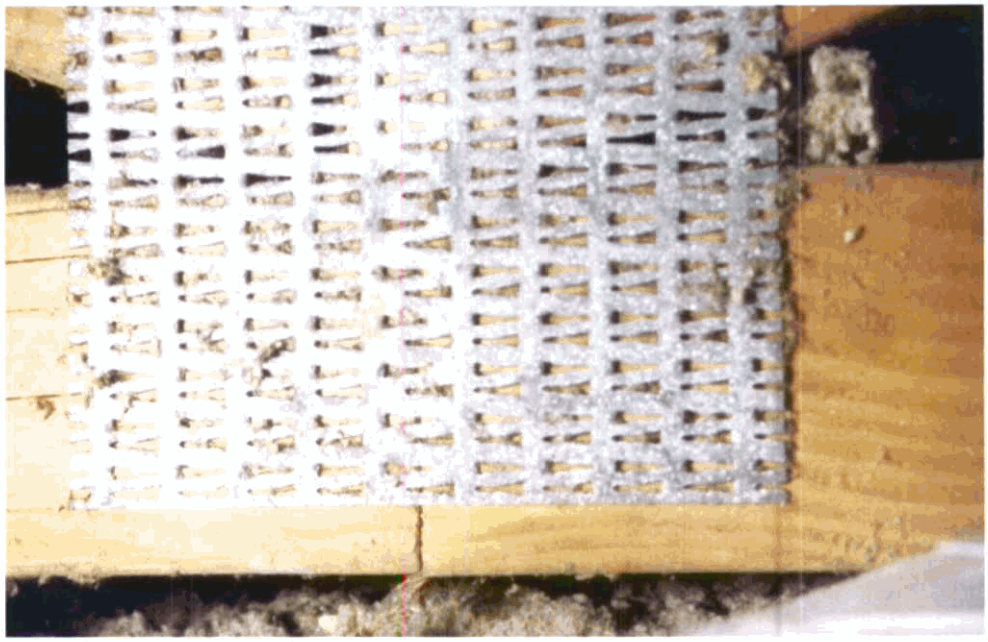

Figure 18: House 006 Nail plate.

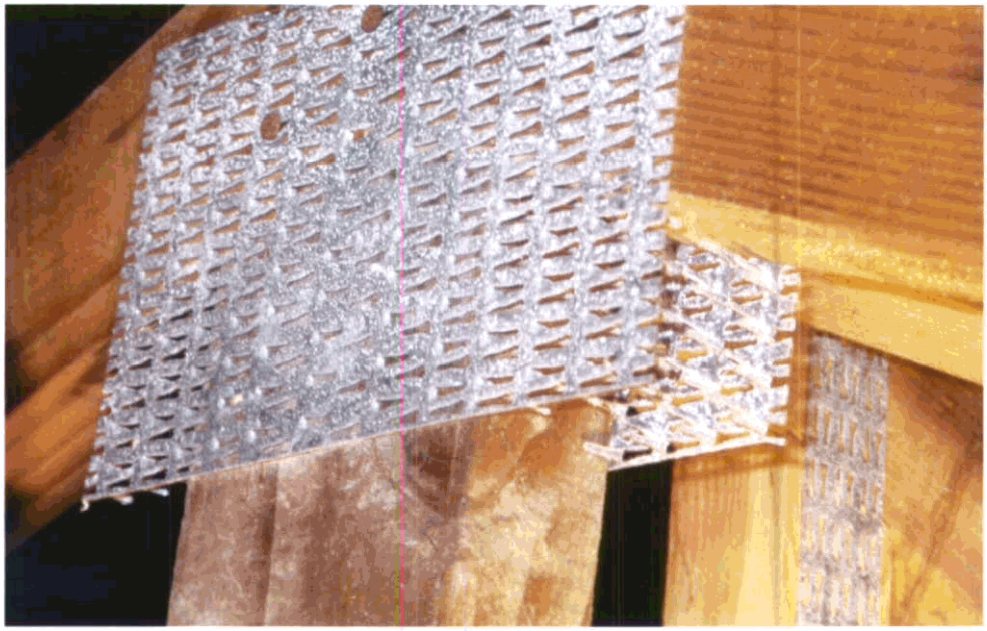

Figure 19: House 006 Nail plate.

Figure 20: House 007 Outlook from house.

Figure 21: House 007 Roof Space.

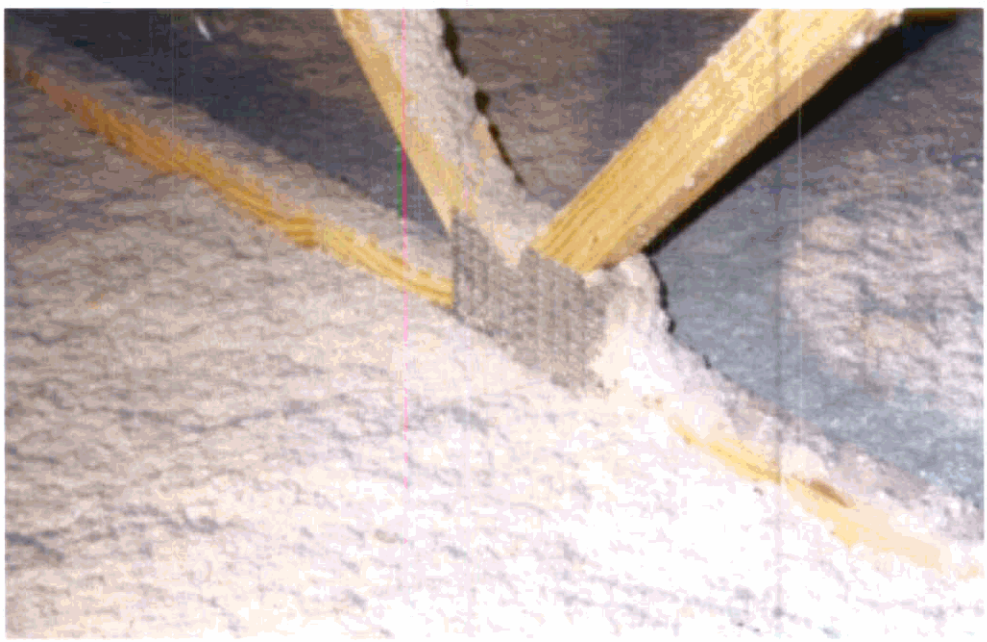

Figure 22: House 007 Nail Plate.

APPENDIX A: ROOF SPACE – NAIL PLATE CONDITION SURVEY

1. Address: .....

.....

BRANZ House
Register Number

2. Today's date: .....

3. Age of house: (years) .....

4. Weather .....

5. Roof details

5.1 Pitch.....

5.2 Construction style.....

6. Roof Cladding

6.1 Type :.....

6.2 Manufacturer .....

6.3 Colour.....

6.4 Measure gaps between tiles.....

6.5 Measure overlap length .....

6.6 Estimate of ventilation area between tiles.....

6.7 Guttering design .....

6.8 Dimensions of roof space .....

Sketch tile profile

7. Roof space

7.1 Any evidence of leaks (discolouration of timber, damage to ceiling lining).....

7.2 Sand in roof space .....

7.3 Temperature

- underside of roof ..... °C
- under purlins ..... °C
- centre of roof space ..... °C

8. Trusses

8.1 Design.....

8.2 Timber type and treatment .....

8.3 Moisture content .....%

8.4 Any extra sources of moisture.....

8.5 Evidence of moisture ingress/rot.....

8.6 Borer damage ..... _____

Sketch trusses

9. Bracing in gable ended roofs

9.1 Is bracing present .....
(either running from apex to top plate or apex to ceiling member)
If present sketch details.

Sketch details

10. Insulation

10.1 Type.....
10.2 Thickness.....

11. Wall

11.1 Type (does it enable transfer of moisture from sub floor?).....

12. Geographic details

Describe surrounding terrain particularly sheltering features such as hills .....
.....
.....
.....

Sketch roof orientation and surrounding geography

12.1 Distance to nearest coast and direction of prevailing wind .....

13. Nail Plates – surface

13.1 Manufacturer .....
13.2 Area of white corrosion product.....
13.3 Area of red rust..... %
13.4 Loss of base metal ..... %
13.5 Zn loading (posiTector measurement).....

14. Nail Plates - teeth

14.1 Area of white corrosion product..... %
14.2 Area of red rust..... %
14.3 Loss of base metal .....

15. Photographs

15.1 Nail plates
15.2 Roof (outside)
15.3 Roof space