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Finding Faults in Residential Buildings

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ABSTRACT

Buildsure is a private company which has provided house inspection services since 2004. Some 700 inspections have been completed, the majority for a pre-sale house condition assessment. This results in a detailed report and a "House Warrant of Fitness".

The inspection takes approximately 4 hours and involves a detailed inspection of the building and site, including assessing the condition of habitable rooms, plumbing services, heating and cooking utilities, electrical, internal stairs and doors, moisture readings at selected openings, roof space, foundations & subfloor, exterior of property including windows, doors and stairs, storm-water and other external services, roofing, decks or balconies, garage and any other external out buildings.

A simple random sample of 70 reports was taken and each abstracted into a spreadsheet for detailed analysis. The large majority of houses had timber framing with different claddings. 46% of the houses had only suspended floors, 30% only slab-on-grade and the rest both floor types.

Just one fifth (21%) of the houses could be considered to be in excellent condition. Given that when a house is being sold, the seller wishes to present it in the most positive light, this would suggest there is a very large, currently un-met, need for house maintenance work. Three common issues have been identified: asbestos, moisture levels and sub-floor ventilation

36% of the inspected houses had indications of asbestos cladding. It is most likely that the house occupants had little or no idea of the potentially hazardous cladding, and would be likely if undertaking their own maintenance to expose themselves to an unnecessary hazard.

65% of the inspected houses had mean timber moisture levels of 13% or below. A moisture reading of 14% is considered the point at which "borderline" risk presents itself. The mean disguises a wide spread of moisture levels. In 88% of the houses the level was so high (>13%) in one or more locations as to give concern. 56% of the houses had no locations with a moisture level above 18% but in 3% of the houses there were 7 or more locations with moisture levels above 18%. The majority of these cases are a direct result of poor maintenance by the owner or the owner's agents. There was no obvious relationship between house age and higher levels of moisture – high levels could be found in very new or very old houses.

New Zealand does not have tradition of basements – houses are built over the ground, raised on piles or foundation walls. 53% of the sub-floor pile moisture measurements were in the 16% to over 22% range. Even given that the timber piles are treated with a suitable preservative to withstand long term ground contact, this is a high, and ultimately unacceptable, level of moisture.

The identification of problems is a first step to their resolution. Future analysis of this database, along with other research exploring the condition of New Zealand houses, will help to led not only to improved durability of the houses but also create an improved environment for living.

KEYWORDS: houses, moisture, maintenance, asbestos, sub-floor ventilation, New Zealand

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1 INTRODUCTION

Buildsure is a private company that has been undertaking detailed house inspection services since 2004. The service meet a need created by the change to a performance based, national building code in 1992. Coupled with changes in training over the following decade, this meant that house purchasers could no longer rely on simple, visual pre-purchase inspections.

Since 2004 approximately 700 inspections have been completed, the majority for a house condition assessment (Figure 1). This results in a detailed report and a "House Warrant of Fitness". The warrant is subject to the general requirement that any necessary maintenance being properly undertaken by the property owner during that five year period. In addition specific exclusions may be applied that are relative to that particular house and conditions (e.g. develop and implement a maintenance plan). Figure 2 provides an example of a completed 'House Warrant of Fitness' (WOF).

The inspection takes approximately 4 hours and involves a detailed inspection of the building and site, including assessing the condition of habitable rooms, plumbing services, heating and cooking utilities, electrical, internal stairs and doors, moisture readings at selected openings, roof space, foundations & subfloor, exterior of property including windows, doors and stairs, storm-water and other external services, roofing, decks or balconies, garage and any other external out buildings. The reports are from 40 to 50 pages long and include numerous photographs to document any issues of concern. The client is provided with an electronic (PDF) copy of the report. The warrant and supporting documentation provide independent advice to vendors, purchasers, real estate agents and lenders as to any likely major building costs to be incurred during the next five years [Buildsure Ltd. 2014].

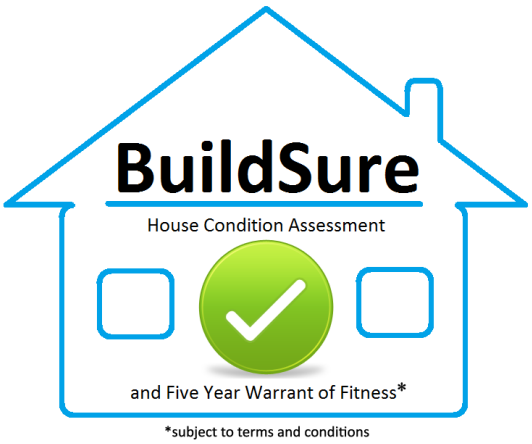
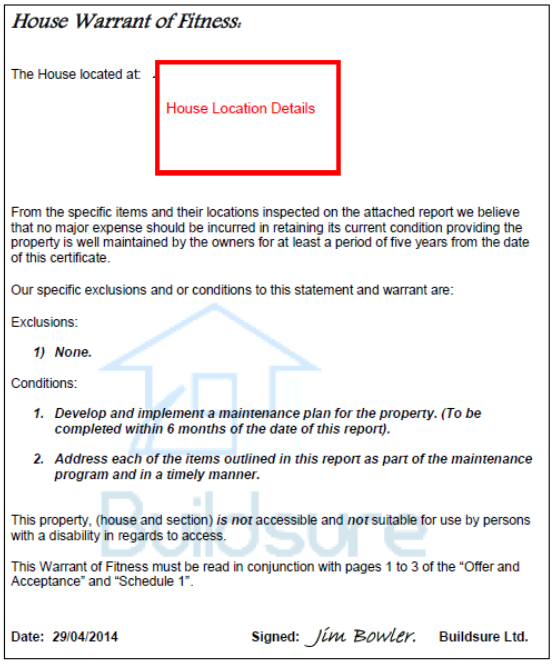


Figure 1: House Condition Assessment logo


House Warrant of Fitness.

The House located at: House Location Details

From the specific items and their locations inspected on the attached report we believe that no major expense should be incurred in retaining its current condition providing the property is well maintained by the owners for at least a period of five years from the date of this certificate.

Our specific exclusions and or conditions to this statement and warrant are:

Exclusions:

1) *None.*

Conditions:

1. *Develop and implement a maintenance plan for the property. (To be completed within 6 months of the date of this report).*
2. *Address each of the items outlined in this report as part of the maintenance program and in a timely manner.*

This property, (house and section) *is not* accessible and *not* suitable for use by persons with a disability in regards to access.

This Warrant of Fitness must be read in conjunction with pages 1 to 3 of the "Offer and Acceptance" and "Schedule 1".

Date: 29/04/2014 Signed: Jim Bowler. Buildsure Ltd.

Figure 2: Example of Building WOF

2 DATABASE DESCRIPTION

A simple random sample was taken from the approximately 700 reports by placing them in chronological order and selecting every 10th reports. The reports were then abstracted into a spreadsheet for detailed analysis. It should be noted that this is not a random sample of all New Zealand houses, as the database only includes houses for which reports have been commissioned,

generally for the purposes of sale. The first inspection in the sample was under taken in December 2011 and the last in October 2014.

All the sample houses were located in the greater Wellington region. The date of construction ranged from 1875 to 2010.

The large majority of houses had timber framing with different claddings. Weatherboard cladding (timber, cement or plastic weatherboards) was found in a majority of the inspected houses (57%), a further quarter had fibre cement (asbestos or treated cellulose) boards (23%), 7% had EIFS (Exterior Insulation and Finish Systems) and 4% were brick veneer. The remainder were of reinforced concrete or concrete block.

Just under half (46%) of the houses had only suspended floors, about one third (30%) had only slab-on-grade and the rest (24%) had a mixture of the two floor types.

3 COMMON BUILDING PROBLEMS

For each of the houses an estimate level of maintenance was allocated. This was based on the general descriptions as well as the specific detailed recorded for each component. Table 1 provides a brief description of the levels, from level 1 where the house has excellent maintenance through to level 5 where the houses of more than two major problems e.g. moisture problems and asbestos very likely to be present. Figure 3 plots the data, showing that the large majority (87%) of the inspected houses had between level 1 and level 2. Only 12% of the houses had major maintenance problems to be dealt with.

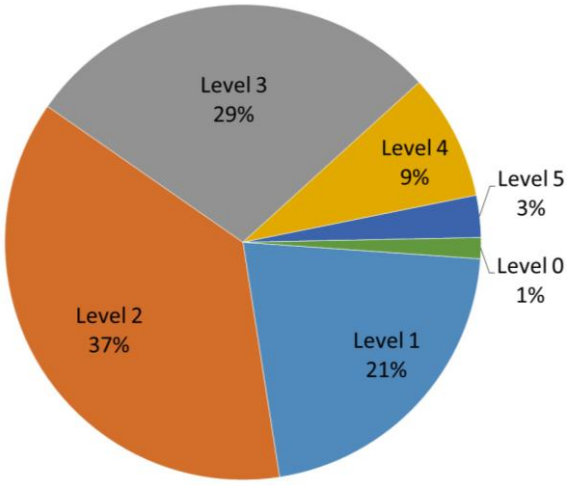


Figure 3: Estimated Maintenance Level

Table 1: Maintenance Level Descriptions

Maintenance Level	Percent
1. Excellent	21%
2. Minor, General Wear & Tear	37%
3. Wear & Tear plus 1 noticeable issue	29%
4. Poor condition plus 1 or 2 major problems	9%
5. Major problems (more than 2)	3%
0. Missing/Insufficient data	1%
TOTAL	100%

While in one way this is a reassuring result, suggesting the majority of householders maintain their homes in reasonable condition, on the other hand only one fifth (21%) had houses in an excellent state of maintenance suggesting there is considerable room for improvement.

A number of building issues have been identified from the analysis and will be explored in the following sections.

2.1 Asbestos

Asbestos sheet was first advertised in New Zealand in 1907 and take up was sufficient that it appeared in the 1921 Census where 466 dwellings reported asbestos wall cladding (out of 260,229

dwellings in total), with the big increase in use occurring post-WWII with 21,163 dwellings in 1951 (494,012 total dwellings) using asbestos sheet alone or in combination with other materials. The numbers grew steadily to 72,319 dwellings in 1976, but the material was dropped in the 1981 Census, apparently replaced by the term "Board". It is possible the census numbers underestimate the use of asbestos, as a householder not knowledgeable about the wall construction material, could easily report it as being a proprietary wallboard [Census and Statistics Office 1931].

Table 2: Indication of the Presence of Asbestos

Asbestos Present	Count	%
Roof & Wall	1	1%
Roof only	-	0%
Cladding only	25	36%
Neither or no data	43	62%
TOTAL	69	100%

Table 2 tabulates the presence of asbestos as found by a House Inspection Assessment inspection. Asbestos was not found in just under two thirds (62%) of the houses, with the remaining (36%) of the inspected houses having asbestos in the wall cladding. Only one house was found with the potential for asbestos in both the wall and roof materials. Where the material is only suspected as being asbestos, generally in houses built around the 1980s, then a laboratory report is suggested.

2.2 Wall Moisture

Normal moisture levels for wood framing and cladding range from 8% to 14%. It is widely recognized that significant decomposition by wood-rotting fungi will occur above the fibre saturation point at 28 to 30% moisture content. Depending on the type fungi present, pre-conditioning and limited decomposition may occur at moisture levels as low as 20% to 25%. Several fungi, including certain species of Aspergillus and Penicillium, grow at water activities as low as 0.70-0.80, which correspond to wood moisture contents of approximately 16%.

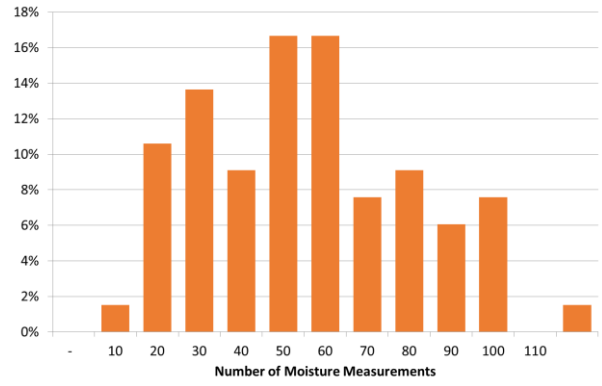


Figure 4: Distribution of number of moisture measurements made in each house

Figure 5: Surveymaster Protimeter in use on a piece of rotten timber

Detailed moisture measurement data was available for 66 houses in the sample. In each house a number of measurements were made of the moisture levels – a minimum of 8 and a maximum of 112 measurements. Figure 4 shows that in 52% of the houses more than 50 readings were made.

Moisture readings are measured using an electronic Surveymaster Protimeter[5] which provides both a digital read out and a scale of colour-coded lights. Figure 5 provides an illustration of the Protimeter in use. Moisture readings are taken on the inside wall of all external openings, heads, jambs and sills. Where any areas visually indicate moisture ingress, then readings are also taken at those points.

Figure 6 shows the proportion of houses by count by the mean moisture level. Nearly two thirds (65%) of the inspected houses had mean moisture levels below 13%. A moisture reading of 14% is considered the point at which "borderline" risk presents itself.

However, the use of the mean moisture level as a measure disguises the distribution of moisture levels – the average of 13% and 13% is the same as the average of 9% and 17%, yet in the first case there should be no moisture problem but in the second case the situation is very different. Figure 7 shows the proportion of houses by count by the maximum measured moisture level. Just 12% of the inspected houses had a maximum moisture level of below 13%. In 88% of the houses the moisture level was so high in one or more locations as to give concern.

In softwoods, the main timbers used in New Zealand houses, once the moisture content is above about 14% any further increase in the moisture content would be likely to produce: degrading of the timber strength; corrosion of fixings; expansion of the timber in the fixing cavities; mould growth; and finally degradation of finishes (paint/wallpaper etc.). At around 16% moisture content, fungal attack is likely to occur, with the possibility of danger to occupant's health [Andrews 2002, Lstiburek 2002]. These expectations are matched by the experience of house surveyors.

Figure 7 shows this is the situation in 23% of the inspected houses.

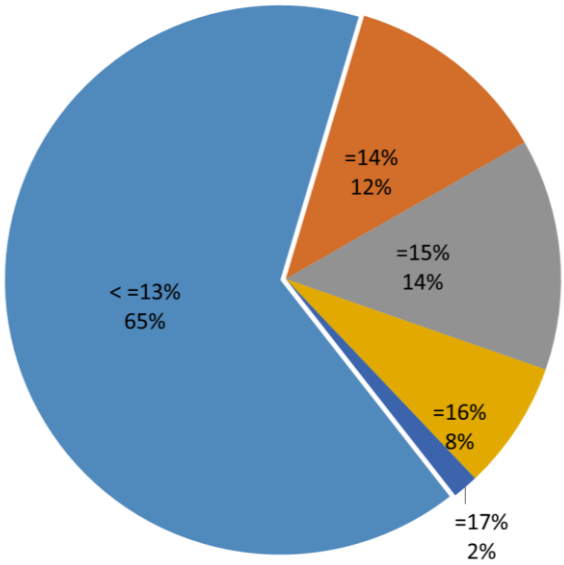


Figure 6: Proportion of Houses With given Mean Interior Wall Moisture Level

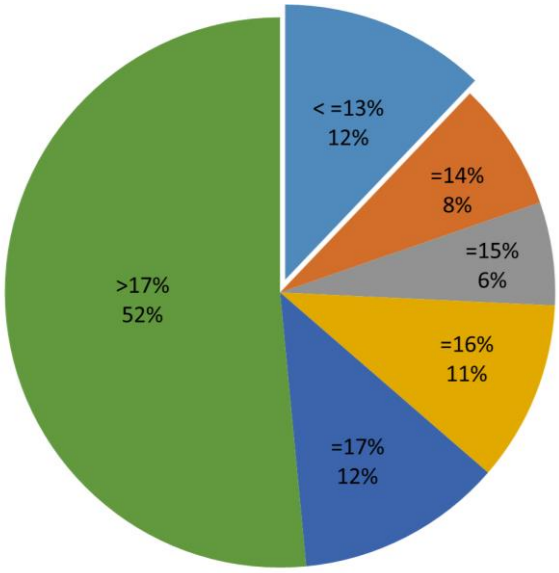


Figure 7: Proportion of Houses with given Maximum Interior Wall Moisture Level

Figure 8 shows the proportion of houses with the given number of moisture readings over 18%. While just over half of the houses (56%) had no locations with a moisture level above 18%, in 3% of the houses there were 7 or more locations with moisture levels above 18%. The majority of cases where the moisture level is above 18% are a direct result of poor maintenance by the owner or the owner's agents. There was no obvious relationship between house age and the finding of higher levels of moisture – high levels could be found in very new or very old houses. The only difference is that

[5] http://www.ge-mcs.com/en/moisture-and-humidity/moisture-meters/surveymaster.html

houses built prior to about 1960 are likely to use native timbers which have a higher level of resistance to high levels of moisture, than the softwood pinus radiata widely used since then.

2.3 Sub-floor Ventilation

New Zealand does not have a tradition of basements – houses are built directly over the ground, raised on piles or foundation walls. Ground moisture will evaporate from the earth over time, and unless removed will build up to unacceptable levels that can lead to decay of timber and corrosion of fittings. This can be a particular problem when ground water is high or external surface water can enter the sub-floor space. Methods for controlling sub-floor moisture include the use of ventilators to ensure adequate external air can ventilate and remove the moisture, or damp proof membranes (DPM) to stop the moisture entering the sub-floor space. Evidence of unacceptably high sub-floor moisture, and hence failure of either ventilation or DPM, can be detected through high levels of moisture in timber bearers or sub-floor framing.

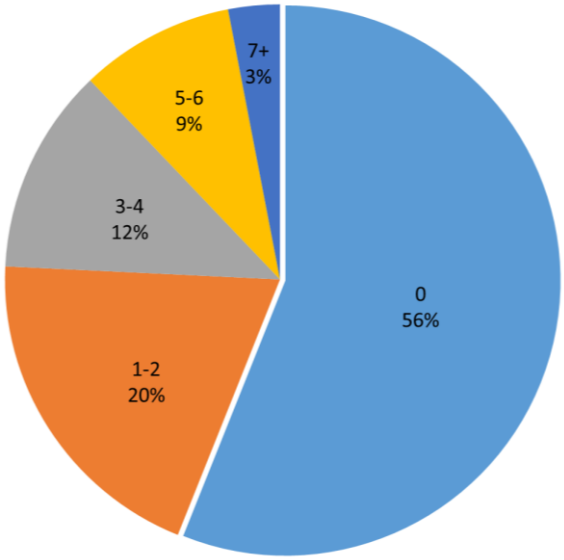


Figure 8: Proportion of Houses with Interior Wall Moisture Levels Above 18%

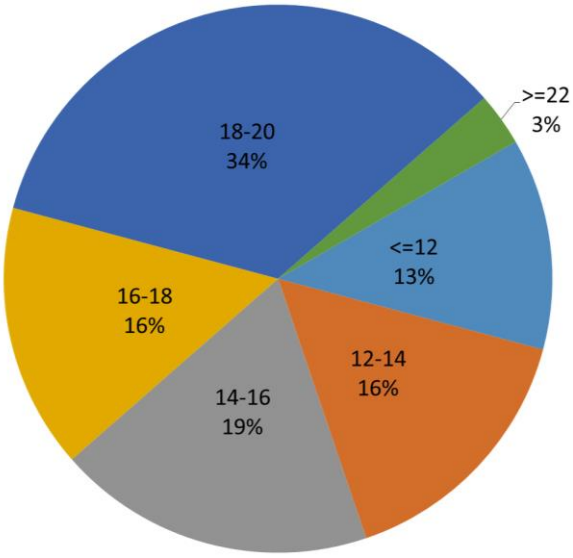


Figure 9: Proportion of Houses with Sub-floor Moisture Levels

Where there was a sub-floor, moisture measurements of the bearers are also made as part of the inspection. A total of thirty-two sub-floor moisture measurements were available for analysis, of which Figure 9 shows that over half (53%) were in the 16% to over 22% range. This is a high, and ultimately unacceptable, level of moisture.

4 CONCLUSIONS

This paper has analysed a sample of 70 house reports undertaken, in the main, as part of a pre-purchase inspection. The database of these reports offers a rich vein to be explored – this paper offers but a tiny fragment of the possible knowledge that could be extracted. Although this is not a representative sample of the New Zealand housing stock, it provides a view into a wide range of house types, construction materials, and house ages.

Just one fifth (21%) of the houses could be considered to be in excellent condition. Given that when a house is being sold, the seller wishes to present it in the most positive light, this would suggest there is a very large, currently un-met, requirement for house maintenance work. Many of the identified issues would not necessarily be visible either to the occupant, seller or potential purchaser, suggesting they could easily continue until a major, or even catastrophic, failure occurred.

Whether the market actually desires this maintenance is a very difficult question. How can a house owner lacking in building management expertise be expected to know that their house requires critical work? Paint flaking off window sills or weatherboards may be obvious, but a high level of sub-floor moisture can only be detected by a reasonably close inspection and ideally with suitable tools – and the majority of house occupants are unlikely to wish to spend time crawling beneath their houses and certainly lack the appropriate tools.

Asbestos is an ongoing problem, with many in the building industry suffering from their once unprotected handling of products incorporating this material. Over a third (36%) of the inspected houses had indications of asbestos cladding. It is most likely that the house occupants had little or no idea of the potentially hazardous cladding, and would be likely if undertaking their own maintenance to expose themselves to an unnecessary hazard.

Given the high proportion of timber framed structure systems with a cladding (weatherboard, fibre board, EIF, or brick veneer) the excessively high levels of moisture found are of great concern. The hidden consequences of high moisture and hence rot may led to expensive restoration work at some point in the future. Similar concerns must be associated with the high levels of sub-floor moisture that have been found.

The identification of problems is a first step to their resolution. Future analysis of this database, along with other research exploring the condition of New Zealand houses, will help to led not only to improved durability of the houses but also create an improved environment for living.

ACKNOWLEDGMENTS

We would like to acknowledge the many home owners and purchasers who have commissioned the WOF inspections, a selection of which are analysed in this paper.

REFERENCES

Andrews, S. 2002. “Mold: A Growing Concern.” *Professional Builder*, April, pp. 1-2

Buildsure Ltd. 2014. “Buildsure Ltd: Project Managers in Construction.” Company website. http://buildsure.co.nz/.

Census and Statistics Office. 1931. *Population Census, 1926. Vol. XIII. Number and Description of Dwellings*. Wellington, N.Z.: Government Printer.

Lstiburek, J. 2002. “Moisture Control for Buildings.” *ASHRAE Journal*, February, pp. 36-41.