Department of Building and Housing

Diagnosis of Buildings for weathertightness

Guidelines for building surveyors

Draft report at
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Introduction

❖ Purpose

The Department of Building and Housing ("the Department") has prepared this document in order to provide guidelines for suitably trained and experienced persons undertaking the diagnosis of currently or potentially leaky buildings (referred to throughout this document as "surveyors").

The process of diagnosis involves both investigation of the building and reporting on the findings of that investigation – and the document is written in a format that can be used as a report template.

❖ Audience for this document

The guidelines are also intended to be useful to other building professionals involved in diagnosis investigations (including architects and engineers with appropriate training). While experienced Building Surveyors are expected to be familiar with most of the contents, the document should still prove useful as a reference source and template for undertaking diagnosis and associated report writing.

❖ Scope of the Document

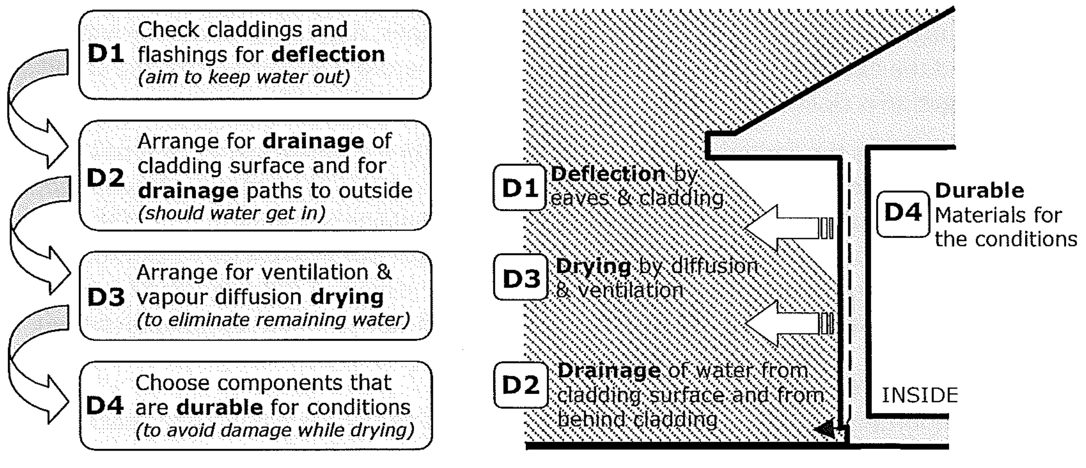
The guidelines specifically cover the diagnosis phase of the investigation process. The document does not cover the follow-up remediation work – which includes developing remediation priorities and strategies, detailed design and associated construction observation. Additional training and supervision are required for these phases, which are beyond the scope of this document. However, it is important that surveyors understand at least the broad principles of remediation, as part of the diagnosis process involves establishing a broad scope of work for the remediation (such as complete cladding replacement or targeted repairs etc.)

The diagnosis guidelines are designed to cover buildings that generally fall within the scope of NZS 3604. However, with suitable expertise and experience, the principles can also be applied to multi-storey apartment buildings.

Appreciation of the 4D's

An appreciation of the 4D's is fundamental to the diagnosis process. The person undertaking the diagnosis investigations should be thinking about the 4D's at all stages. Inevitably it will be the failure of one or more of the 4D's that will be leading to the leaky building conditions. The 4D's are relatively simple in principle and are shown in ***Figure 1***.

Figure 1: The 4D's approach to weathertightness



- **Deflection**
  The external claddings (including walls, windows, roofs, flashings etc) provide the initial barrier to water penetration by deflecting rain away from the structure. Features such as drip edges also contribute in deflecting water away from the building.

- **Drainage**
  In the event that water does penetrate the outer layers of the cladding, provision is made to drain the water out of the structure before it can cause any damage. One of the major reasons for damage to existing buildings is the lack of such drainage provision. A common reaction to a leak is often to apply silicon to seal any gaps – and this can result in moisture being trapped in the structure with consequent damage.

- **Drying**
  After water has drained from the structure, sufficient air flow is required to dry those parts of the structure which have become wet. If a structure is sealed up, there will be a difficulty with drying in the event of water entering the structure.

- **Durability**
  Of all the D's, durability is often considered to be the most important. Usually if 2 or more of the other D's are not present, the critical factor will be the durability of the structure. An obvious example is the comparison between treated and untreated timber. Treated timber, being much more durable, will typically last 2 to 5 years in a leaky building situation before needing to be replaced – while untreated timber is likely to last only 3 to 12 months. As it is likely to be at least a year before investigations begin, untreated timber exposed to water in a typical leaky building situation will usually need replacing while treated timber may be undamaged.

Another important factor is the Building Code requirements (under Clause B2 Durability) – in which the structural framing must last at least 50 years and the cladding 15 years. This means the surveyor must thoroughly investigate the condition of the framing, and take this into account when recommending remedial work.

The nature of diagnosis

❖ The required level

The guidelines are designed to ensure the diagnosis process (including investigations and report writing) are of a sufficient standard to sustain cross examination in the High Court.

In some situations a less comprehensive process may be appropriate – for instance, where the brief requires the surveyor to determine only whether there is moisture penetration and/or timber damage. In such limited or preliminary investigations, determining how the water entered and the extent of damage is not required. It is therefore important that the scope of the investigation is clearly understood and (if necessary) stated in the associated report.

Another example is the limited assessment associated with the Department's Determinations for Code Compliance. In this case the full scope of this diagnosis document is not required, as the surveyor is required to determine only whether the building is leaking or not. If the building is found to be leaking, then the building will not comply with clause E2 External Moisture and a Certificate of Code Compliance cannot be issued. A full diagnosis investigation would usually subsequently be needed – as part of providing a detailed remediation design.

❖ The iterative nature

It is most important that the surveyor keeps an open mind and does not jump to conclusions - instead continually testing theories on how water entered and travelled through the structure to the point where elevated moisture levels and/or damage are evident. Often a hypothesis will be wrong and an iterative process is needed before conclusions on actual mechanisms can be reached and substantiated. In many cases, the reasons for moisture penetration and/or damage are not simple – and involve a failure of one or more of the 4D's.

Specialist expertise required

There are two main areas where additional specialist expertise may be required – both involving health and safety considerations.

❖ Timber decay, mould analysis and air sampling

Within these guidelines, advice is provided on when and how to take samples for laboratory analysis from timber and other building materials. The identification of the type and extent of timber decay is considered beyond surveyors' expertise – and samples should be sent to recognised specialists for laboratory examination.

Surveyors also often discover moulds which may be toxic. Because of the health and safety implications, it is important to send samples to a specialist laboratory for identification and/or arrange for air sampling by a specialist organisation.

❖ Imminent structural failure

Where there is any likelihood of imminent structural failure, a structural engineer must be consulted. Concerns in regard to imminent structural failure arise in situations where the consequences of failure are serious (such as where cantilevered deck joints have significant decay, support framing is severely decayed or similar situations).

❖ Health and safety considerations

There are various health and safety considerations in undertaking diagnosis – including;

- *necessary care when undertaking investigations e.g. using ladders, working from scaffolding or in confined spaces, using power tools, etc*
- *imminent structural failure*
- *toxic mould danger to the surveyor and/or the building occupants.*

Related documents

It is important that this document be used in conjunction with:

- E2/AS1 3rd edition
- Other Department of Building and Housing publications
  - *A Guide to weathertightness remediation*
  - *An introduction to weathertightness design principles*
  - *A Guide to using the risk matrix*
  - *Constructing cavities for wall claddings*
- BRANZ Good Practice Guides and other publications

A full list of resources is provided in ***Addendum 5*** (page 46).

Format of this document

The guidelines have been written so that the format is consistent with a reporting template (however, it is appreciated that different reporting templates are also valid). The format also aims to be consistent with the actual diagnosis investigation process.

Additional detailed information is provided in addenda at the back of the document – which include information on high risk building details, a system for undertaking onsite investigation, a methodology for making cut-outs and taking timber samples for laboratory analysis, and information on timber rots and moulds. This allows the reporting template in the body of the document to remain clear, with the additional information easily referred to as necessary.

Background

1 Description of Property/Development

The following information should be researched and included in this section of a report:

❖ Address of property

❖ Site factors

- **Wind**
  - *Wind zone – according to NZS 3604 (will range from Low to Very High and Specific Design) – usually obtained from TA.*
  - *Prevailing wind – how does it impact on building – which walls are sheltered, which are exposed?*
- **Site topography**
  - *Is building at top of hill, near the edge of a cliff etc?*
  - *Is site sloping, etc?*
- **House orientation to prevailing winds and sun**
  - *It is important to understand the implications (for moisture ingress, drying etc.) of elevations exposed to sun and wind*
  - *Is the house close to the sea?*
- **Protection from trees, buildings etc**
  - *A building may have similar cladding features on all walls, but be leaking on one elevation with no apparent leaks on another. The reason is often the sheltering effect against windblown rain provided by other site features.*

❖ Construction Details

- *Number of storeys*
- *Foundation type(s)*
- *Floor construction type(s)*
- *Framing type (e.g. timber, steel, etc) - if timber, degree of timber treatment if any*
- *Cladding type – face-sealed, direct fixed monolithic claddings are well identified with leaky buildings*
- *Joinery type – windows and doors – note any unusual joinery design or type*
- *Roof type – claddings, slope, levels etc.*

Early in the surveyor's report establish the system to be used for identifying each elevation – which should be consistent with the Building Consent documentation (e.g. east elevation on Building Consent drawings continues to be referenced as the east elevation in the report and may also be the street elevation).

2 Building documentation and construction history

This section is about sourcing documents relevant to the history of the building being investigated, identifying the key dates and noting details in the surveyor's report. Relevant information should include;

- *Period of construction/alteration*
- *Date Building Consent applied for*
- *Date Building Consent issued*
- *Date of final inspection by Territorial Authority (TA) or Building Certifier*
- *Date Code Compliance Certificate (CCC) applied for (if applicable)*
- *Date CCC issued (if applicable)*

- *Date building first occupied (when substantially completed)*
- *Any other relevant documentation held by owner or TA (such as inspection records, producer statements, warranties etc.)*

❖ Other relevant documentation

Information relevant at time of construction from;

- The consent drawings and specifications (including any amendments)
- Manufacturers' publications
  - *Manufacturer's installation and maintenance specifications relevant at date of construction*
- Standards
  - *NZS 3604 – relevant version*
  - *NZS 3602 etc*
- BRANZ
  - *BRANZ Library*
  - *Good Practice Guides*
  - *Bulletins*
  - *Appraisal Certificates*
  - *Guidelines*
  - *Study reports*
  - *Technical recommendations*
  - *Home bulletin series*
- NIWA (National Institute of Water and Atmospheric Research)
- Text books
- Seminar series
- Consultants who may or may not have been involved in previous repairs

Copies of relevant sections of the above information should be included as an Appendix to the surveyor's report.

3 People and organisations associated with the construction

This should record general information on those involved with the building work – and may be obtained from TA records and/or the building owner (it is **not** a list of those held to be responsible for the building leaking). It depends on the brief for the report as to whether the surveyor is expected to provide an opinion as to the responsibility for the moisture problems.

A useful way of documenting this information is shown in ***Table 1***.

Table 1: Associated parties

Construction phase/component	*Name of Service Provider or product*	*Details of role/association*	*Source*	
			TA/Certifier	*Other*[1]
Project Initiator(s)				
Land purchase				
RMA Consent				
Project Team: Pre-construction				
Developer				
Designer/architect				
Engineer				

Other				
Building Consent Processors				
Building Certifier				
Territorial Authority				
Project Team: Construction phase				
Project Manager				
Head contractor				
Specialist Contractors / Product suppliers				
Builder				
Plasterer				
Roofer				
etc				
Window supplier				
Flashing installer				
etc etc				
(1) For instance, Developer, Contractor, Project Manager				

4 Identifying weathertightness design risk factors

It is useful to begin the identification of the weathertightness risk factors by using the E2/AS1 matrix. This gives a good appreciation of the degree of risk associated with the building. The following table based on E2/AS1 can be used;

Table 2: Weathertightness risk factors

Risk factor	Description	Comment on:	Score (from E2/AS1 Table 2)
A	Wind zone	Orientation and exposure to prevailing wind, sunshine	
B	Number of storeys	Any changes for different elevations	
C	Roof/wall intersection design	Flashings, unusual features	
D	Eaves width	Level of shelter provided to cladding	
E	Envelope complexity	Building shapes, junctions between claddings, special features etc	
F	Deck design	Deck and balustrade types	

A high risk score does not necessarily mean the building will leak. Much depends on how well the building has been constructed and how different the actual construction type is from the requirements of Table 2 of E2/AS1. The following list sets out features often associated with leaky buildings;

- **Monolithic face sealed cladding**
  EIFS, Stucco and fibre cement without a cavity are closely associated with leaky buildings
- **No cladding water management features**
  No drained cavities
- **Lack of eaves protection**
  Eaves protect windows, doors and the cladding

- **Balconies and decks**
  Enclosed balconies and decks in particular have been a major source of leaks. The attachment of open decks through the cladding and the penetration of cantilevered deck joists through the cladding at first floor level have also been significant problems
- **Deck/wall intersections**
  It is important to follow manufacturer's specifications and to properly flash these intersections
- **Balustrades, parapets and handrails**
  The same comments to the above 2 points apply
- **Windows and doors**
  Many problems have been associated with the inadequate flashing and sealing of windows and doors. The situation is made more challenging with sloping windows and raked or curved window heads
- **Ground clearances**
  After completion of the building it is not uncommon for owners and contractors to build up gardens and/or driveways so that ground clearances between the bottom of the cladding and the ground are reduced to unacceptable levels. Sometimes the bottom of the cladding sheet will be buried. This can lead to moisture wicking up behind the cladding into the framing – with subsequent damage to the framing
- **Penetrations**
  Penetrations from cables, service pipes or other fixings are often not adequately sealed or flashed
- **Window flashings**
  Windows are often not properly flashed. This includes sill and jamb flashings as well as head flashings. Head flashings may not project sufficiently past the line of the window jamb, or be installed in accordance with manufacturer's specifications
- **Complex roofs**
  Particular care has to be taken with flashings at the intersections of complex roofs
- **Roof/wall junctions**
  A very common water entry point is at the bottom of a roof wall apron flashing where an inadequate kick out flashing is installed – and gaps may be apparent.
- **Complex building junctions**
  Roofs and walls – as discussed above

Addendum 1 Common Areas of Risk (page 21) illustrates and describes common high risk design features for a hypothetical 2 storey dwelling. The associated ***Table 9: Common weathertightness defects*** lists the incidence of the defects from DBH determinations for each weathertightness design feature.

5 Comments from the Owner (Claimant)

It is important to gather as much information as possible from building occupants – who may be the owner (and client) or the tenants. Occupants can provide useful information on issues such as where leaks are showing up, the effects on leaks of varying wind directions, and any other signs of moisture apparent inside the building.

Frequently, past attempts will have been made to fix leaking by applying sealant. Occupants may be able to tell a surveyor whether any changes in leak patterns were apparent following previous repair attempts. This experience can be very useful following a prolonged dry period – when timber framing may have dried to such an extent that moisture cannot be detected using a moisture meter.

The following standard questions should be asked:

- *Can you show me any indication of water damage and other weathertightness concerns you have about the house?*
- *Has any repair work been done?*
- *Do you have any builder's, supplier's and/or manufacturer's warranties?*
- *Who do you know was involved in constructing, altering or repairing the building?*
- *Is there any other relevant information they may have?*

Include any relevant documentation supplied as an Appendix to the surveyor's report.

Site Investigation Methodology and Observations

The following sections of the surveyor's report are intended to provide a comprehensive record of all observations and measurements. Investigations must be sufficient to provide a robust assessment and to justify the conclusions made.

Any observations (and evidence) as to whether the leak/damage is a weathertightness issue should be included. If investigation reveals that the cause is not a weathertightness, but rather is a plumbing or maintenance issue, this needs to be made clear in the report.

6 Investigation Process

The investigation process described below covers sections 9 to 12 of the "Report template". Section 6 of the surveyor's report will usually be a brief summary of the investigation process covering the 5 stages set out in the summary below. More detail is given in ***Addendum 2 Investigation Process*** (page 24), which provides more detail on the stages of the diagnosis process.

- **Stage 1**
  Undertake visual investigation using;
  - *Obvious signs of moisture entry from detailed on site inspection*
  - *Observing standard of workmanship*
  - *Information gathered from off site*
  - *Information supplied by owner*
  - *Knowledge of weathertightness risk factors*
- **Stage 2**
  Undertake non invasive investigation;
  - *Using moisture meter in capacitance mode*
  - *Focus on information obtained from Stage 1*
- **Stage 3**
  Undertake invasive investigation (Drilling)
  - *Drill into framing*
  - *Take moisture readings using long probes*
  - *Focus on information obtained from Stages 1 and 2*
- **Stage 4**
  Undertake invasive Investigation (Destructive)
  - *Cut holes to confirm (or otherwise) drilling results*
  - *Take further confirmatory moisture readings*
  - *Determine "as built" construction details at both current damage locations and likely future damage locations*
  - *Take samples of timber and other materials and send for laboratory analysis.*
- **Stage 5**
  - *Identify causes of moisture ingress and extent of damage*
  - *Report on conclusions of investigations*

9.1 Visual Assessment (Stage 1)

Describe how the visual inspection of the building was carried out and what was found. Concentrate on:

- *Obvious signs of the building leaking*
- *Following up comments from the occupants*
- *Checking all weathertightness risk features that are present*
- *Observing standards of workmanship – issues such as head flashings not being taken sufficiently far past the line of the window jamb, the base of the cladding not having the required gap to allow drainage, the incorrect installation of apron flashings (without kickouts) for roof to wall intersections etc are all indications of both the quality of workmanship and the understanding of weathertightness principles by those responsible for and/or constructing the building.*

9.2 Moisture readings (Stages 2 and 3)

9.2.1 Stage 2: Moisture readings – non invasive (Capacitance meters)

Limitations of capacitance meters are described in ***Addendum 2 Investigation Process*** (page 24). Focus readings on areas identified during the visual examination. With capacitance meters, look for variations against a defined control point. The control point is a reference point that is known not to be affected by moisture ingress (e.g. sheltered beneath eaves). It is also important that no reliance is placed on capacitance meter readings – as these should be treated as being indicative only.

9.2.2 Stage 3: Moisture readings – invasive (Resistance meters)

Take invasive readings by drilling pairs of small holes (in accordance with the meter manufacturer's specifications). Again, focus on the areas identified during the visual examination and the capacitance readings and always establish a control point for each elevation (as discussed above). It will often be necessary to drill holes in locations which appear suspect or have been identified as high risk (despite the lack of abnormal capacitance readings).

❖ Timber drillings

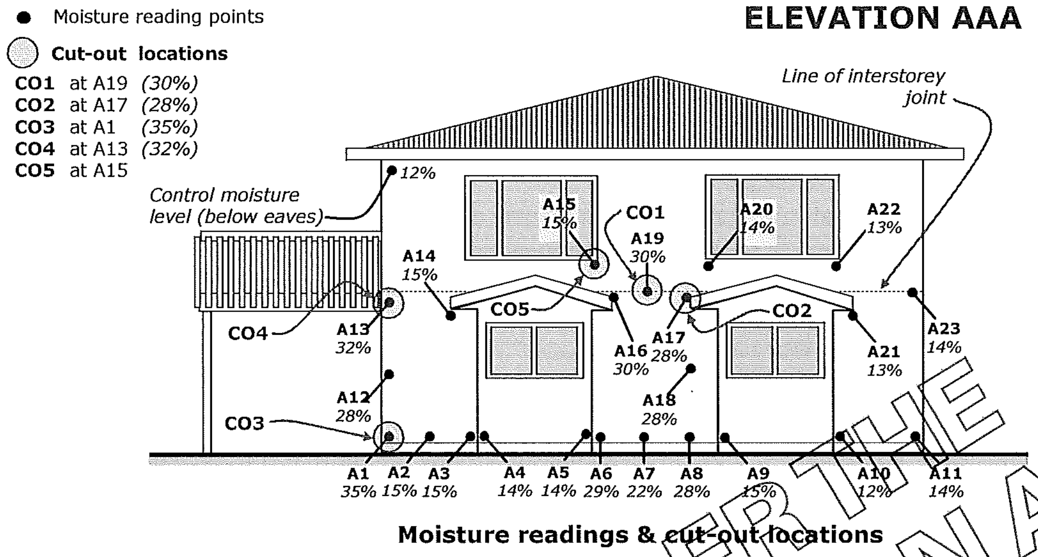
An experienced surveyor can gain useful information about the state of the timber during the drilling process. Sometimes, the drill may appear to have missed the stud or bottom plate altogether – but a careful examination of the drill bit shows that the drill position is correct. In such a situation, the timber is so decayed that it has practically no resistance to the drill bit – leading to the impression that the drill has missed the framing altogether. The nature of the timber drillings can often give a good lead as to the moisture content and degree of decay (particularly in comparison with the control). However, this must always be checked by taking sufficient samples for laboratory testing.

❖ Recording the findings

For future reference and inclusion in the surveyor's report, it is important to photograph investigations (including all cut-outs) – in order to provide the report reader with a clear pictorial representation of the investigation and findings.

Positions of moisture readings and cut-outs should preferably be shown in a photo of the elevation. If photographs are not suitable, an elevation may be used as shown in ***Figure 2***.

Figure 2: Recording moisture readings



Moisture meter readings should also be presented as shown in ***Table 4***.

Table 4: Table of moisture readings

Probe location	*Description of probe location*	*Moisture reading*	*Photo no.*
	Elevation AAA		
A1	Bottom plate LH corner	35%	P2
A2…etc	Bottom plate 1.2m from LH corner etc	15%	P6
A13…etc	Corner stud just below first floor joists	32%	P8
A16	Stud below kickout flashing	30%	P11

Express readings as a percentage. It is not usually necessary to correct moisture readings for timber type, temperature etc. (although some types of treatment affect readings more than others). What is important is the comparison against the control point known to be "dry".

A guide to what the recorded moisture contents mean should be provided in the surveyor's report. The following range is taken from NZS 3602, and provides some guidance.

Very low	*0 – 10%*
Low	*11 – 18%*
Medium	*19 – 24%*
High	*25 – 35%*
Very high	*36%+*

Photos showing more detail of damage, construction details etc should be included in an appendix and referenced in the moisture readings table (as shown above).

9.3 Further investigation of current damage – cut-outs (Stage 4)

Remove small sections of cladding ("cut-outs") to:

- *confirm the results of drilling*
- *check construction details*
- *confirm leak pattern*
- *establish the extent of damage*
- *take samples of timber and other materials and send for laboratory analysis..*

Most owners will want holes to be as small as possible – and it is sometimes sufficient to use an approx 100mm diameter keyhole saw (which also allows a neat patch repair). However, larger holes (at least the size of an A4 sheet of paper) are usually necessary. Often the hole size will need to be extended for a number of reasons including following the leak path, determining the extent of damage, checking an as-built detail etc.

❖ Maintain overall perspective

A surveyor should always maintain a macro view of the project while testing at an individual detail level. An example of this is a situation where it is likely that complete recladding is required, so little further detailed investigation could be required - when:

- *the timber is untreated,*
- *the leaking is widespread,*
- *there is already some decay*
- *the cladding system would not currently comply with E2/AS1 (re building's risk)*

In this case, it is expected that detailed checking of any timber that is to be left in the structure would be undertaken during the subsequent repair work (after the cladding has been removed). A discussion of that stage is beyond the scope of this document – but laboratory analysis of timber samples is likely to be needed during the construction work.

At the other extreme, if there is only one leak (e.g. due to the lack of a proper kickout in a wall to roof apron flashing) then it is important to do sufficient testing to ensure that targeted repairs will result in durable weathertightness. This should include taking timber samples for laboratory analysis.

❖ Taking samples

More information on sample taking is given in ***Addendum 3 Building Examples*** (page 31), and information on timber rots and moulds is given in ***Addendum 4 Timber rots and moulds*** (page 41).

Timber and/or mould samples are usually taken once a cut-out has been made. Considerable forensic information can be obtained from an experienced practitioner undertaking microscopic investigations of samples in the laboratory – including the type of mould and associated decay, the degree of treatment of the timber (if any), the length of time that the building has been leaking, and possible remediation strategies.

For the report it is useful to have a cut-out table to record observations and reference photos:

Table 5: Record of cut-outs

Cut out location	*Photo reference (if any)*	*Observations*
CO1	P22	Severely decayed timber at bottom plate
CO2	P23	Inter-storey joint detail

The position of cut-outs should also be shown on the elevation photo or diagram showing moisture contents. This allows the reader to gain an appreciation pictorially of both the high moisture content areas and where cut-outs have been made (refer also to ***Figure 2: Recording moisture readings*** on page 15).

9.4 Further investigation – likely future damage (Stage 4)

Diagnosis investigations may be required to give assessments of likely future (potential) damage. Clearly if complete recladding is required the potential damage issue becomes redundant – except for estimating the percentage of framing needing replacement.

For targeted repairs the situation is not as straightforward. Future likely damage can be divided into 2 categories;

- **High risk features – failed on one elevation (or part) but not elsewhere**
  In this case it is usually only a matter of time before a high risk type of feature that has failed (say on an elevation exposed to the sun and wind) fails on a more sheltered face. An example from experience is a flat-topped balustrade (with or without a top fixed hand rail) which has not been built in accordance with the manufacturer's specifications. These will progressively fail around a building – with the most exposed failing first.

- **High risk features – not yet failed**
  This situation is more complex and requires judgment and experience. Again the degree of variation from the requirements of the acceptable solution E2/AS1 is one of the factors to be taken into account in deciding how much investigation should be undertaken before deciding that a detail risks future damage. An example could be whether a window sill flashing can effectively drain out any moisture entering at the jambs. In such cases some sample destructive testing will be necessary to confirm or otherwise that the detail will continue to perform to Building Code requirements.

10 (to 12) Repeat above for other elevations

This is included to accommodate the template chosen for reporting.

13 Compliance relating to weathertightness

This section of the surveyor's report sets out where the building does not comply with the relevant clauses of the NZ Building Code (NZBC), Acceptable Solutions prepared by the Department, NZ Standards prepared by Standards NZ, manufacturers' specifications, Good Practice Guides, other trade supplied documentation and any other information relevant to the construction of the building and good trade practice at the time of the building's construction or alteration.

The Department has stated that if a building is leaking now it does not comply with Clause E2 (External moisture) of the NZBC. If it is likely to leak during the future lifespan of the components it does not comply with Clause B2 (Durability).

Within the surveyor's report, it is usual to quote relevant E2 clauses as follows;

❖ NZBC Clause E2 External Moisture

Objective **E2.1** states;

> *The objective of this provision is to safeguard people from illness or injury, which could result from the external moisture entering the building.*

Functional statement **E2.2** states;

> *Buildings shall be constructed to provide adequate resistance to penetration by, and the accumulation of, moisture from the outside.*

Performance requirement **E2.3.2** states;

> *Roofs and external walls shall prevent the penetration of water that could cause undue dampness or damage to building elements.*

Performance requirement **E2.3.3** states;

> *Walls, floors and structural elements in contact with the ground shall not absorb or transmit moisture in quantities that could cause undue dampness or damage to building elements.*

Performance requirement **E2.3.5** states;

> *Concealed spaces and cavities in buildings shall be constructed in a way which prevents external moisture being transferred and causing condensation and the degradation of building elements.*

A leaking building is non-compliant with clauses E2.1 and E2.2 and will not comply with (as relevant) clauses E2.3.2, E2.3.3 and E2.3.5.

As-built construction details will often not comply with the manufacturers' specifications relevant at the time of construction. In such cases the relevant part(s) should be quoted, and a copy of relevant sections of the manufacturer's documentation included in the report appendix.

Sometimes there will be no documentation on the TA records as to which (if any) product specification was followed – and in such cases recognised standards or guidelines are needed.

> *An example is some types of stucco claddings – where the actual construction should be evaluated against industry accepted documents (like the BRANZ Good Practice Guide to Stucco relevant at the time of construction) or a relevant standard (like NZS 4251 1974 Code of Practice for Solid Plaster).*

14 Health and Safety Issues

This section of the surveyor's report is used to record any health and safety issues (such as toxic moulds being identified and/or cases of imminent structural failure etc). Copies of relevant reports from specialists (such as structural reports, laboratory test results etc) should be included as appendices to the report.

15 Conclusions

The above investigations process should provide sufficient information to cover Stage 5 of the diagnosis process by:

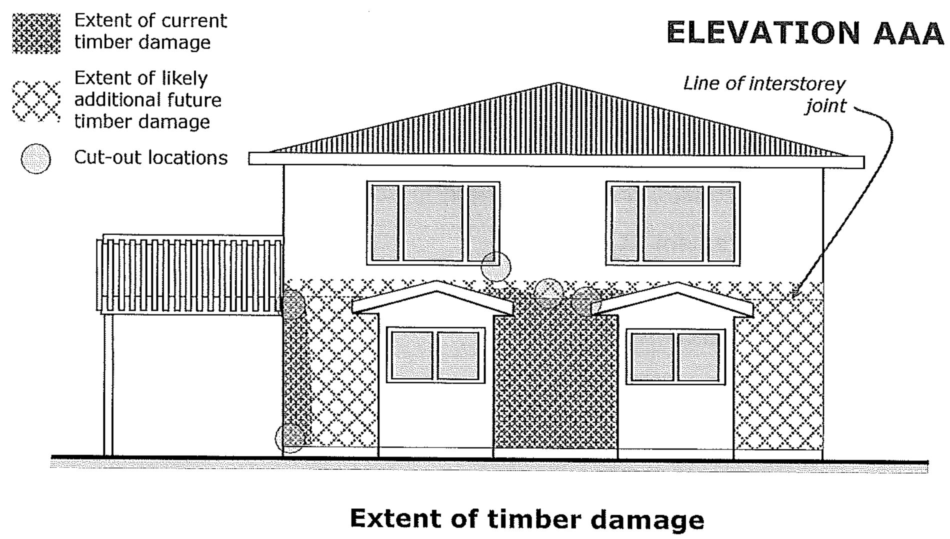
- *identifying the cause of moisture ingress and the points of water entry,*
- *determining the extent of damage and the type of decay*
- *predicting the extent of future likely damage.*

From this information, conclusions can be reached on whether complete recladding is required or whether targeted repairs are sufficient. It should provide sufficient information to be able to estimate the amount of timber framing needing replacement.

Extent of damage

The extent of damage is best shown in appropriate photographs or diagrams. An example of an appropriate diagram is shown in ***Figure 3***.

Figure 3: Extent of damage



Having undertaken the comprehensive process outlined in this document it should be relatively straightforward to provide conclusions in the form of answers to a series of questions set out in the "Report template" as:

15.1 Does the building leak?

A 'Yes' or 'No' statement is required

15.2 Where and why does it leak?

Identify moisture entry points. List these along with the observations and reasoning which lead to the conclusion that the observed moisture originated from those entry points. If the building is leaking now, it does not comply with clause E2 (External Moisture).

15.3 What damage has been caused to the building?

Describe the extent of the damage caused by summarising conclusions from:

- *Destructive testing carried out on-site*
- *Results of laboratory tests commissioned*

If testing shows no real damage this should be stated in the report.

15.4 Where and why might it leak in the future?

For answers to this question refer back to ***Section 9.4: Further investigation – likely future damage (Stage 4)*** on page 16. If the building is likely to leak during the future lifespan of the components, it does not comply with clause B2 (Durability).

15.5 What damage might be caused by a leak in the future?

Describe any future Likely damage that could result from a future leak (refer ***Figure 3: Extent of damage*** on page 18). Base the assessment of likely future damage on weathertightness experience with the building component or structure under review – in line with the two categories described in ***Section 9.4: Further investigation – likely future damage (Stage 4)*** on page 16.

15.6 What remedial work is required?

Remedial work required should be specified in sufficient detail so that the work necessary to address consequences of each actual or potential leak is identified. Consider:

- *What is needed to stop current leaks?*
- *What is needed to repair current damage?*
- *What is needed to prevent future leaks?*

The extent of the work necessary to make the remediation fully code compliant should be clearly explained, along with the reason for recommendations made. Remedial work should be scoped on the assumption that it will require a building consent to proceed and will be inspected during construction by TA Building Inspectors.

Previously published Department of Building and Housing (DBH) determination decisions, particularly those cases involving dwellings which are found to have the potential to leak in the future (i.e. are not compliant with clause B2) can be useful. These determinations can provide direction regarding remedial work considered necessary for buildings to be made compliant. Copies of determinations are available on the DBH website http://www.dbh.govt.nz/WHRS-adjudication-determinations.

15.7 How much will the remedial work cost?

Often the costs will be calculated by a Quantity Surveyor – who will prepare estimates in response to being briefed by the surveyor (preferably in writing).

16 Summary tables

Setting the information out in a tabular form offers a convenient method of dealing with the items without having to refer to several documents. It also brings the information forward so it is not 'lost' in the detail of the report.

Where the damage in one location is caused by a combination of component failures (leak sources), it may not be possible to separate the information, i.e. relate it directly to each individual component. In this situation leave that part of the table blank and explain why.

Table 6: Summary table 1 - current damage

Building component	*Damage*	*Scope of repair*	*Cost*

Table 7: Summary table 2 - likely future damage

Building component at risk	*Why location is likely to allow water ingress*	*Scope of repair*	*Cost*

❖ Report appendices

An appropriate format for summarising supporting information included as appendices to a surveyor's report is provided by ***Table 8***.

Table 8: Table of Appendices

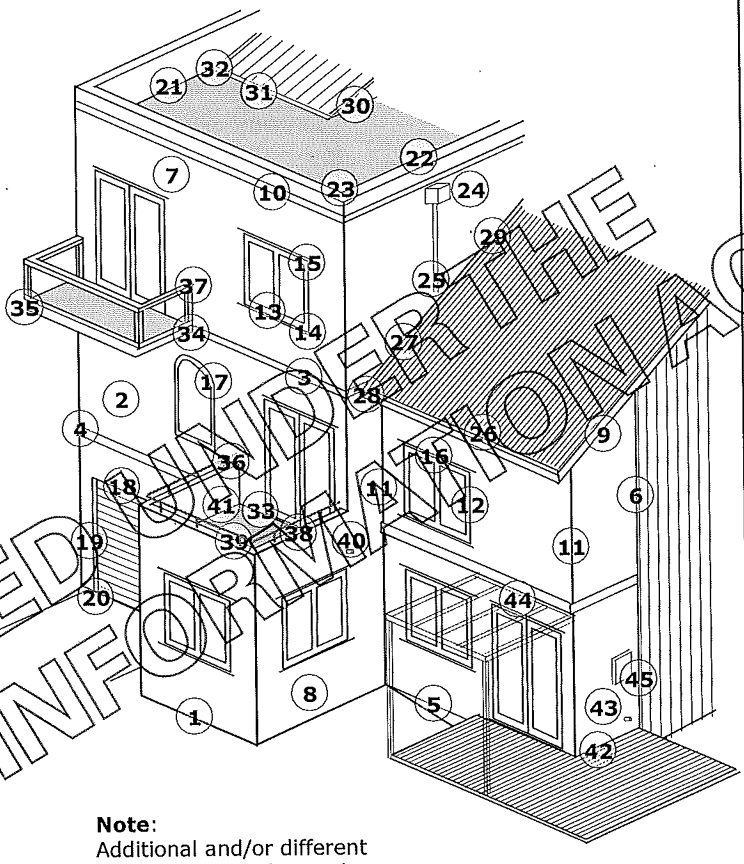
Appendix No.	
A	Surveyor qualifications
B	Information from TA
C	Information supplied by owner
D	Building Consent Drawings
E	Building Consent Specification
F	Photographs
G	Engineering and laboratory reports
H	Manufacturer's Specifications
I	Cost schedules

Addendum 1 Common Areas of Risk

Figure 1 indicates common locations of weathertightness risk.

Figure 4: Common high risk locations

1 Base clearances
2 Vertical control joints/cracks
3 Horizontal control joints
4 Horizontal joints – corners
5 Cladding base
6 Intercladding junctions
7 Sheet joints
8 Material quality
9 Cladding top
10 Decorative bands
11 Corners
12 Window jambs
13 Window sills
14 Window sill/jamb junctions
15 Window head/jamb junctions
16 Window heads
17 Raked/curved window heads
18 Garage door heads
19 Garage door jambs
20 Garage door jamb bottom
21 Parapet/roof junctions
22 Parapet tops
23 Parapet top corners
24 Rainwater outlets
25 Downpipe spreaders
26 Roof edge/gutter
27 Wall/roof junctions
28 Apron flashing bottom
29 Roof to wall clearances
30 Other roof flashings/skylights
31 Inter-roof claddings
32 Inter-roof/wall junctions
33 Deck/wall junctions
34 Deck/wall junctions
35 Deck perimeter
36 Balustrade/wall junction
37 Balustrade/wall junction
38 Balustrade top
39 Handrail fixings
40 Deck drainage/overflows
41 Balustrade/deck junction
42 Timber deck/wall junction
43 Pipe penetrations
44 Pergola fixings
45 Meterboxes/grilles



Note:
Additional and/or different areas of risk apply to other design forms or materials – such as solid masonry or masonry veneers, solid timber walls, timber subfloors etc

A 1.1 Examples of defects

Table 1 describes the type and incidence of defects found at these high risk locations.

Table 9: Common weathertightness defects

Detail		*Description*	*Examples of possible defects*	*%(1)*
1	**Cladding - general**	Base clearances	*Inadequate cladding clearance* *Bottom of cladding buried* *Floor to ground separations*	*64%*
2		Body of cladding	*Cracking*	*55%*
		Vertical control joints	*No or poor control joints*	*50%*
3		Horizontal control joints	*No control joint, unflashed joint* *Poor overlaps, flashing traps moisture*	
4		Horizontal joints – corners	*Gaps, poor seals, no soakers*	
5		Cladding base	*No anti-capillary gap/poor overlap* *No plaster drip edge*	*45%*
6		Inter-cladding junctions	*No back-flashing, scribers etc*	*27%*
7		Sheet joints	*Joints pouting, nails popping* *Joints lining up with window jambs*	*20%*
8		Material quality	*Sub-standard solid plaster* *Sub-standard weatherboard profiles*	*20%*
			Paint coating/sealer defects	*14%*
9		Cladding top	*Poor barge flashings* *Inadequate overlap/no drip edge* *Unsealed under fascias*	*19%*
10		Decorative bands	*Unsealed fibre cement under bands* *Flat top/cracks*	*15%*
11		Corners	*No back-flashing, scribers etc*	*12%*
12	**Windows and doors**	Jambs	*Unsealed under jamb flanges* *No jamb flashings where needed*	*29%* *9%*
13		Sills	*No drainage gap at sill flashing* *No or inadequate flashing where app.*	*30%* *27%*
14		Sill/jamb junctions	*Poor seals/no soakers where needed* *No sill flashing turnups*	*23%*
15		Head/jamb junctions	*Inadequate/unsealed head projection* *No returns to head flashings*	*19%*
16		Heads	*No drainage above flashing slope* *Inadequate head flashing*	*18%*
17		Curved/raked heads	*Inadequate head/jamb junctions*	*30%*
18		Garage heads	*No head flashing. No drip edge*	*10%*
19		Garage jambs	*Unsealed/unflashed jamb liners*	*8%*
20		Garage jambs - bottom	*Clearance from paving*	
21	**Parapets**	Parapet/roof junctions	*Inadequate flashings*	*22%*
22		Parapet tops	*No capping. Flat top.*	*50%*
23		Parapet tops -corners	*Poor capping joints*	*38%*
24	**Roof drainage**	Rainwater outlets	*Unsealed scuppers* *No overflow provisions*	*11%*
25		Downpipe spreaders	*No or poor spreaders*	*4%*
26		Roof edge/gutter	*Inadequate overhang, gaps* *Building paper not overlapping gutters*	*4%*
27	**Roof flashings**	Wall/roof apron flashings	*Inadequate upstands/overlaps*	*9%*
28		Apron flashing - bottom	*No kickout, poor sealants,* *gaps, bare fibre cement/framing etc* *Gutters/fascias buried*	*38%* *27%* *34%*
29		Roof/wall clearance	*Inadequate clearance to apron*	*15%*
30		Other roof flashings	*Inadequate overlaps, poor sealants*	*12%*
31		Inter-roof claddings	*Inadequate overlaps, poor sealants*	*35%*

Detail		Description	Examples of possible defects	%[1]
32		Inter-roof/wall junctions	*Inadequate flashings*	*22%*
33	**Solid floor decks**	Deck/wall junctions	*Poor cladding clearance above deck* *Inadequate overlaps, capillary gaps*	*50%* *22%*
34		Deck/wall junctions	*Inadequate flashings*	*26%*
35	**Open balustrades**	Deck perimeter	*Poor membrane overlaps* *Balustrade penetrations*	*15%* *9%*
36		Balustrade/wall junction	*Unsealed fixings*	*5%*
37	**Clad balustrades**	Balustrade/wall junction	*No saddle flashings*	*52%*
38		Balustrade top	*No slope to tops* *No capping* *Poor capping/capping joints*	*51%* *47%* *13%*
39		Handrail fixings	*Handrail penetrations through tops*	*46%*
40		Drainage/overflows	*Inadequate overflow/drainage* *Poor slope*	*34%* *10%*
41		Balustrade/deck junction	*Poor cladding clearance above deck* *Inadequate overlaps, capillary gaps*	*14%*
42	**Timber slat decks**	Deck/wall junctions	*No drainage gaps* *Decking buried in coating*	*47%* *17%*
43	**Penetrations**	Pipe penetrations	*Poor seals*	*50%*
44		Pergolas etc	*No flashings, poor seals etc*	*30%*
45		Meterboxes/grilles etc	*No head flashings* *Poor sealants/gaps/cracks etc*	*23%*
Note: (1) Incidence of defects from analysis of determinations up to December 2006 ***Not all defects are included in the table – only the most commonly found defects are noted.***				

Addendum 2 Investigation Process

This addendum provides further detail on the 5 stages of the investigation process (beyond that outlined in ***Sections 9, 10*** and ***15*** of the document. The overall investigative methodology described below is designed to be a logical, methodical and iterative process – with the aim of causing minimum damage to the building, while still ensuring that causes and the extent of the damage are identified.

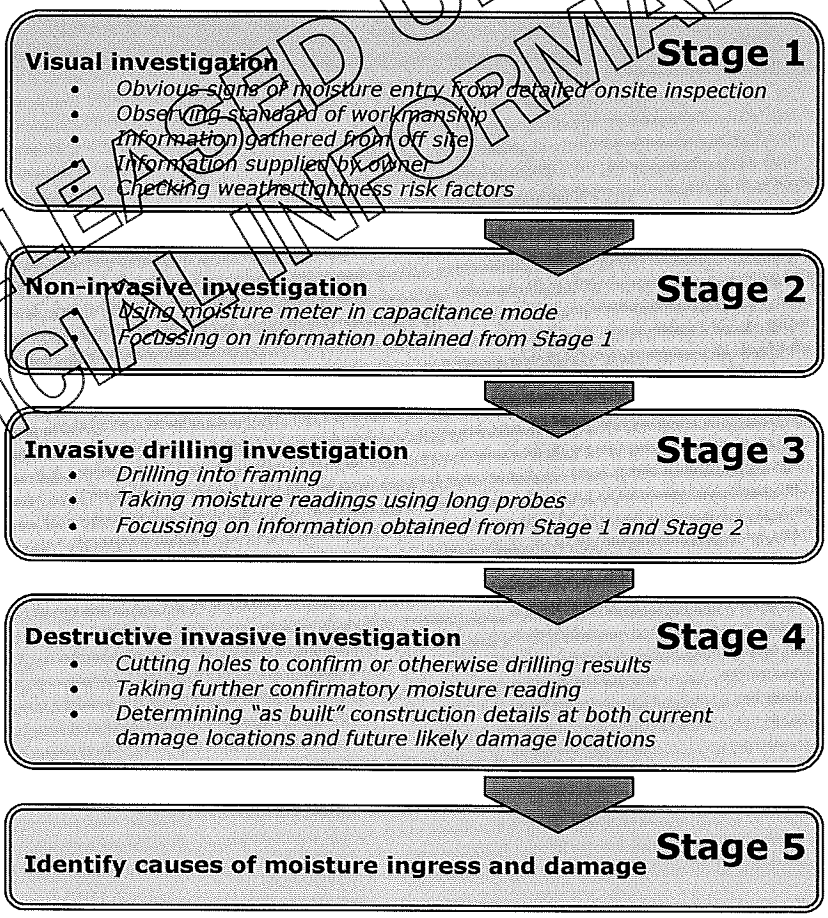
A significant issue is the extent of investigation required and associated reporting levels – to ensure that the investigation and resulting report are sufficient to withstand the required level of scrutiny in the High Court (including cross examination by legal Counsel).

For further guidance, two building examples are given in ***Addendum 3 Building Examples*** (page 31). The examples are a 2 storey residential dwelling and a multi-storey apartment building – and include advice on issues such as the required number of cut-outs and timber samples that need to be taken. Guidance on the implications of rots and moulds (to the diagnosis) is also provided in ***Addendum 4 Timber rots and moulds*** (page 41).

A 2.1 The investigation stages

There are 5 general stages in the investigation or diagnosis process – as shown in ***Figure 5***.

Figure 5: The diagnosis process



An appreciation of the 4D's is fundamental to all 5 stages (refer ***Figure 1*** on page 5). Remember that these weathertightness principles are an integral part of the strategic overview process.

At all stages of the investigation, aim to answer the questions:

- *Where is the damage?*
- *What is the extent of the damage?*
- *What path did the moisture take to cause the damage?*
- *Where did the moisture enter the structure?*
- *Why did the moisture enter the structure at the point it did?*

The point of moisture entry will inevitably be due to a failure of one of the 4D's – and further , the degree of damage will be due to a failure of one or more of the remaining 4D's.

By taking a strategic view that is based on well-accepted weathertightness principles of the 4D's, a comprehensive understanding of the reasons for moisture entry and the associated extent of damage can be developed.

A 2.2 Stage 1: Visual examination

The detailed visual examination ideally starts after the occupant has described their knowledge of:

- *Where leaks are evident at present*
- *Whether leaks vary depending on the wind direction and strength*
- *What changes there have resulted from past attempts to fix leaks*

Other important components of the visual examination are:

- **Building condition**

The condition of the building (including apparent damage due to leaking) is an important precursor to the detailed examination of the building.

- **Initial signs** (of severe moisture penetration)
  - *Stained or rotting carpet*
  - *Mould and mildew growth on surfaces*
  - *Swelling of skirtings or other trim*
  - *Rusting of carpet fixings*
  - *Water dripping from soffit long after rain has finished*
  - *Dark staining on material or finish*
  - *Musty smells*
  - *Cracks – type and location*
  - *Bubbles forming under paintwork*
  - *Deterioration of paintwork and substrate materials*
  - *Efflorescence*
  - *Sagging ceiling linings*
  - *Sagging or uneven floor surfaces*
  - *Corrosion of fixings*
  - *Lifting of vinyl floors*

- **Standard of workmanship**

The standard of workmanship and apparent appreciation of weathertight detailing by the builders can be a significant factor in the degree of leaking of the building.

- *A building is likely to perform better if it has been built in a tradesman-like manner, with vertical corners vertical, flashings neatly installed and so on.*
- *A lack of appreciation of weathertight features by the builder (represented by evidence such as flashings being inadequate and/or incorrectly installed, down pipes directed at critical points such as apron flashings etc) are a good indication that the builder had little idea of proper weathertight construction detailing - with obvious consequences for the building*

A 2.2.1 Appreciation of weathertightness risk factors

The surveyor must also have an excellent appreciation of the weathertightness risk factors (as set out in documents such as E2/AS1, related guidance documents and ***Addendum 1 Common Areas of Risk*** on page 21).

❖ Understanding mechanisms

The surveyor must understand the underlying mechanisms that transport water into a structure and cause leaks. (The Department's guidance document *An introduction to weathertightness design principles* provides more detailed descriptions of these mechanisms).

- **Wind pressure**
  - *Wind-driven rain can penetrate around window and door frames – especially where no air seal has been installed*
  - *In high wind situations, water can drive up underneath flashings and into the structure (if not adequately detailed). Wind pressure can also be very important around corners of buildings – where there can be a pressure differential depending on wind direction, slope of roof and so on.*
- **Gravity**
  - *Water flows down surfaces (either inside or outside the building) until it reaches an obstruction – where it can pond and spread out horizontally until it is able to track vertically again. Then, when water does reach the base of structure, it can be trapped to varying degrees (depending on detailing at the cladding base).*
- **Capillary action**
  - *This occurs due to hydrogen bonding of water molecules. Droplets migrate through cladding by attaching to sides of small cracks (less than 6mm width) and micro-cracks*
  - *Movement can be upward or inwards. This is particularly relevant at the base of cladding sheets that lack an adequate anti-capillary gap between the sheet and foundation. With insufficient ground clearance, water can wick up between the foundation and the back of sheet and/or building wrap – to pond on bottom plate*
- **Momentum**
  - *Water splashes off a flat surface and enters the structure (an example is where there is insufficient ground clearance between the paving slab and the base of the cladding – rainwater can splashes off the paving and up behind the bottom of the cladding sheet. Depending on the anti-capillary gap thickness, moisture can then wick up into the structure)*
- **Water vapour transmission**
  - *Water can be transmitted by vapour transmission (particularly where leaking occurs in an otherwise sealed structure). With daily temperature fluctuations, water can evaporate in one location – then be transferred to another location as vapour where it recondenses where it comes into contact with a cold surface or when there is a general drop in temperature.*
- **Internal leaks**
  - *Leaks can also be due to plumbing fittings such as leaks at wingbacks, shower trays, wastes etc.*

A 2.2.2 Appreciating monolithic cladding problems

While not all leaky buildings have monolithic claddings, the relatively high percentage that do means that it is important for the surveyor to understand the strengths and weaknesses associated with these claddings. While not exhaustive, the following lists main problems areas to watch for when investigating the three broad styles of monolithic claddings.

❖ Stucco

- Painting – solid plaster needs to be regularly painted to be waterproof

- Cracking – can be due to a variety of factors including:
    - *improper mix design*
    - *does not have required 21mm thickness in 2 or 3 coats*
    - *plaster is not applied evenly*
    - *needs clean, sharp, well graded sand*
    - *requires continuous foundation*
    - *requires framing support of 400mm centres for non-rigid backing and 600mm for rigid backing*
    - *requires rigid backing with slip layer or non rigid backing*
    - *requires control joints correctly installed at recommended spacings of 4m maximum – horizontally at inter-storey floor levels and vertically at the sides of openings)*
    - *incorrect or combining different additives*
    - *incorrect curing*
    - *reinforcing placed 6-9 mm off backing and fixed at 150mm centres to framing*
- Window leaks
    - *lack of flashings*
    - *relying on paint, plaster or incorrectly applied sealant to seal joint*
- Wicking of water behind cladding
    - *where cladding buried in ground*
    - *insufficient clearance from ground, paving, decks or roof claddings.*

(Clearly samples need to be taken for laboratory analysis to substantiate many of the above defects.)

❖ Texture coated fibre cement

- Cracked fibre cement sheets and problems at joints due to:
    - *Cladding system inappropriate for location (e.g. very high wind zone)*
    - *Framing above 18% moisture content*
    - *Sheet joints not made over solid joints*
    - *Lack of adequate control joints (typically at about 5m centres vertically and at inter-storey level horizontally)*
    - *Construction not in accordance with manufacturer's specifications*
    - *Sheet joints not made away from line of window and door jambs*
    - *Incorrect sheet joint detail*
    - *No slope on parapets or deck balustrades*
- Window leaks
    - *lack of flashings*
    - *relying on paint, texture coating or incorrectly applied sealant to seal joint*
- Wicking of water behind cladding
    - *where cladding buried in ground*
    - *insufficient clearance from ground, paving, decks or roof claddings.*
- Cladding poorly maintained
    - *Impact damage to coating or backing sheets*
    - *Inadequate paint protection*
    - *Must be regularly painted to be waterproof*

❖ EIFS

- Cracking in panels and joints due to:
    - *Paint coating failure*
    - *Construction including joints, junctions, flashings not in accordance with manufacturer's specifications*
    - *Cladding buried in ground or with insufficient clearance from ground, decks or roof claddings.*
    - *Lack of control joints (typically 20m maximum spacing)*

A 2.3 Stage 2: Non-invasive investigation

The detailed non-invasive testing (using a capacitance type meter) follows the visual inspection – and includes appreciation of all the factors listed in Stage 1.

This stage includes the following steps:

❖ Equilibrium moisture levels

Surveyors need to be aware of the seasonal effects on moisture testing – which can mean that no abnormal readings are detected despite advanced decay. It is therefore important that equilibrium moisture readings be obtained from a control point established for each elevation in a known 'dry point' such as below eaves (as discussed in ***Section 9.2: Moisture readings (Stages 2 and 3)*** on page 14).

These readings will vary according to the weather and season – so what is important is their relationship to the reading at the control point.

❖ Limits of capacitance testing

The surveyor must understand the limits of moisture testing in the capacitance mode:

- *Different meters vary significantly in the depth of moisture they can detect. Some meters can only detect up to 20mm depth, so are ineffective in many situations.*
- *Establish a control point as discussed above (it is important to identify variations in moisture content from control point rather than the absolute meter reading)*
- *Meters can frequently show false readings due to different types of chemical preservatives and/or the interference of metal within the wall – such as mesh in stucco, embedded electrical cables, metal bracing, pipes, mouldings etc.*
- *Capacitance meter readings should not be relied on, and the results should always be confirmed by further testing (actual readings should not be recorded in the report).*

❖ Sampling locations

Use initial evidence and also check at identified high risk locations (as described in ***Addendum A 2.2.1: Appreciation of weathertightness risk factors*** on page 26). The surveyor should be aware that there will often be hidden moisture and/or damage that the occupants are not aware of – so it is important for the investigation to cover all high risk areas.

❖ Internal and external testing

External investigation is always favoured as water often accumulates immediately behind the external cladding layer. However sometimes only internal investigations are possible (e.g. where access is not possible).

❖ Leak sources and paths - understand causes of leakage:

As always the investigation is about determining the location and extent of damage as well as the source and cause of all leaks. Realistically it is impossible and dangerous to conclude investigations at this stage.

A 2.4 Stage 3: Invasive investigation

It is not until the completion of this stage of the process that some appreciation of the extent of moisture ingress and resulting damage is achieved.

High moisture readings taken by inserting probes into the framing behind the cladding are good evidence of moisture ingress. In addition, the appearance of the drillings (both in terms of moisture and the amount of decay) can also provide guidance on the extent of moisture ingress and decay.

By the end of Stage 3 the surveyor should have developed a good understanding of the extent of damage, the locations of leak entry points and the causes of those leaks. However as always it is important to keep an open mind and to be prepared to review any assumptions that are not supported by subsequent stages of the investigations.

❖ Sampling locations

Select number and locations for sampling (refer to ***Section 9.2*** for further information)

- *Focus on suspect areas determined from visual and non-invasive investigations*
- *Also drill in areas identified as high risk (even though they may not show any signs of damage or abnormal capacitance readings)*
- *Again, use a control point to establish a benchmark moisture reading*

❖ Drill pairs of small holes

- *Use insulated long probes*
- *Guard against false readings from short circuits due to damaged insulation*

❖ Examine drillings

Gather information from drillings

- *Dampness of timber and cladding*
- *Degree of decay*
- *Softness and colour/consistency of drillings*

❖ Record findings

- *Findings are best shown on elevation photo (or diagram) – cross referenced to a Table of Moisture readings (refer **Figure 2: Recording moisture readings** and **Table 4: Table of moisture readings** on page 15)*
- *Elevation photos (or diagrams) give good idea of areas of high moisture content*

Refer to ***Section 9.2.2: Stage 3: Moisture readings – invasive (Resistance meters)*** on page 14 and ***Addendum 3 Building Examples*** (page 31) for further information on stage 3

A 2.5 Stage 4: Destructive testing (cut-outs and sampling)

It is very important that the Stage 3 results (from moisture testing and examining drillings) are confirmed by making cut-outs and extracting samples of timber or other materials. Stage 4 involves cutting out small sections of the cladding to:

- *confirm the results of drilling – if drilling shows decay and high moisture levels this can be confirmed by a visual examination after a cut-out. The cut-out also allows the direction of the water ingress to be confirmed*
- *check underlying construction details*
    - *Part of determining causes of leaks is to check actual construction details against good trade practice and/or the manufacturer's specifications at the time of construction*
    - *As-built details can also be assessed for future likely damage considerations (refer Section 9.4)*
- *confirm leak patterns*
- *establish the extent of damage*
- *confirm moisture entry points and cause(s)*
- *take further samples for laboratory analysis as necessary – for legal or forensic purposes it may be necessary to take further samples for laboratory analysis.*

Refer to **Section 9.3:** ***Further investigation of current damage – cut-outs (Stage 4)*** on page 15 and ***Addendum 3 Building Examples*** (page 31) for further information on stage 4.

❖ Destructive testing not permitted

Destructive testing is a critical part of the diagnosis process, and if clients do not permit this, then the limits imposed on the investigations must be clearly stated within the surveyor's report. This should include a statement that reliance on the results report is severely restricted by the inability to undertake destructive testing.

❖ Sampling locations

Select number and locations for sampling

- *The number and location of samples will depend on a number of factors including the brief, the client, the degree of timber treatment etc. Further guidance is given in **Addendum 3 Building Examples** (page 31)*

❖ Reasons for sampling

- *The reasons for taking samples and the amount of forensic information that is available from laboratory analysis are set out in **A 4.3: Laboratory analysis** (page 44) and **A 4.4: Using analysis results** (page 45) of **Addendum 4 Timber rots and moulds**.*

❖ Record findings

Results are best presented on a diagram

- *The extent of damage is best shown on suitable photo or elevation diagram (as shown in **Figure 3: Extent of damage** on page 18)*

A 2.6 Stage 5: Conclude on causes of moisture ingress and damage

This stage involves recording the identification of and conclusions for the causes of moisture ingress and damage. The surveyor should identify the causes and extent of damage when working through Stages 1 to 4. Sometimes assumptions on causes are not supported by evidence revealed by cut-outs. As previously discussed, investigation is often iterative (for instance, revisit Stage 1 if necessary for further visual examination before carrying out further Stage 3 drilling).

Refer to ***Section 15 Conclusions*** (page 18) for further information on an approach for setting out the conclusions in a logical format.

Part of the diagnosis process also involves identifying where and why the building does not comply with the documentation relevant at the time of construction (this can include the Building Act, Building Code, relevant Standards, compliance documents, manufacturer's specifications, good trade practice etc.). Refer to ***Section 13 Compliance relating to weathertightness*** (page 17) for further information.

Addendum 3 Building Examples

Methodology for determining numbers of cut-outs and samples for laboratory analysis

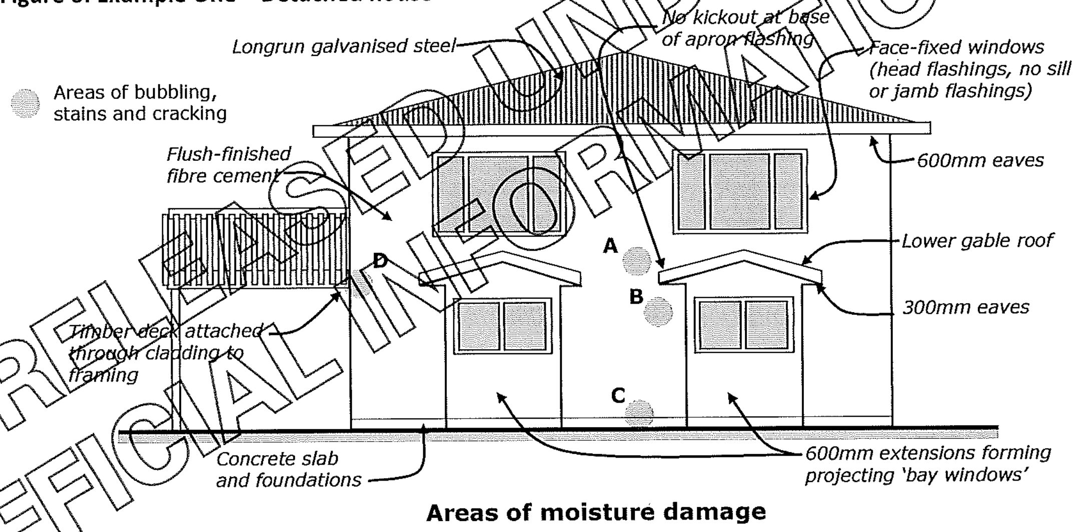
Decisions on the number of cut-outs and samples for laboratory analysis cannot be based on simple rules of thumb (such as number of samples per square meter or similar). The process is site specific and part of the overall diagnosis process involving information collection, onsite investigations and laboratory testing of samples. The aim of the process is to determine the likely extent of current and likely future damage in order that a remediation strategy (recladding, targeted repairs or a combination of both) can be developed.

The following examples set out typical investigation processes for two different types of buildings - first for a 2-storey detached house and then for an apartment building within an urban setting. For simplicity and brevity, a number of stated assumptions are made throughout the examples.

A 3.1 Example One: A detached house

This example is a detached house as shown in ***Figure 6***, which has areas of wall cladding where the textured coating is lifting and stains and cracks are apparent.

Figure 6: Example One – Detached house



A 3.1.1 Information collection and observations

❖ Offsite information

Information collected from the owner and Building Consent Authority records:

- *High wind zone*
- *Specification records timber as untreated kiln dried framing and treated first floor joists*
- *Building constructed during 2002*

❖ Visual investigations

As shown in ***Figure 6***, the following information can be collected from onsite observation:

- *2-storey house*
- *Longrun galvanised steel roof cladding*
- *Flush-finished fibre cement wall cladding (with no visible inter-storey joint)*
- *Windows are face-fixed, with metal head flashings but no sill or jamb flashings*
- *Several complex roof to wall intersections (above bay windows) – the apron flashings have no kickouts, and sealant has been used at the bottom of the apron flashings in an attempt to prevent water from entering the wall. The sealant appears to have failed close to area A.*

- *600mm eaves at upper roof level and 300mm eaves at bay window roof level*
- *Timber deck with open slats at 1st floor level, fixed through cladding to timber framing*

The cladding is showing signs of damage due to moisture ingress at locations A to D shown in ***Figure 6*** as follows:

- **A** Cracking of cladding and paint bubbling at inter storey level above bay window roof
- **B** Cracking of cladding and paint bubbling below missing kickout flashing
- **C** Nail popping and discolouration at bottom plate level directly below other defects. Cladding is installed hard up against foundation restricting drainage at bottom of sheet
- **D** Cracking of paint and bubbling of paint at inter-storey level - adjacent to where deck fixed with coachscrews through cladding into timber framing

A 3.1.2 Moisture readings – non invasive

Undertake non invasive capacitance readings over full cladding elevation – concentrating first on the "at risk" areas listed above. Readings should be taken at all high risk locations:

- *At bottom plate level for full perimeter commencing at areas where cladding shows signs of moisture ingress*
- *Immediately below positions where bay window roof to wall apron flashings lack kickouts at the bottom*
- *At the inter-storey joint level for full width of elevation*
- *At the timber deck to wall junctions*
- *Underneath all windows - particularly at corners*
- *Along jamb edges of the windows – moisture may be entering due to lack of jamb flashings and poor sealing of the window jambs against the cladding*
- *At other relevant areas of the elevation - to determine leak pattern from the source e.g. water enters cladding at the lowest point of the apron flashing, then down wall to where the moisture is trapped at bottom plate level due to lack of a drainage gap.*

❖ Limits of capacitance meters

It should be noted that due to the limitations of current capacitance type meters the results of non invasive testing are usually not conclusive and are merely indicative.

It is important to establish a control point where the framing is known to be sound and not affected by moisture. This can be used as a reference point for all other readings.

The following additional factors should be taken into account when using capacitance meters:

- Some meters can only read to a depth of 20mm – and for some cladding systems, this is insufficient to even reach the framing. This is also one of the reasons why taking readings from inside the building is likely to fail to detect moisture ingress – as moisture is often trapped between the cladding and the framing, and may not have been absorbed through the depth of the timber.
- Be aware of effects of hidden materials (such as metals and chemical preservatives) that can affect readings in both meter modes. Non-invasive testing should always be undertaken from the outside wherever possible.
- While evidence of high moisture contents may not be found when measurements are taken from the inside (due to the limitations of capacitance meters), interior readings may be useful in areas where there are signs of leakage on the inside.

A 3.1.3 Moisture readings – invasive

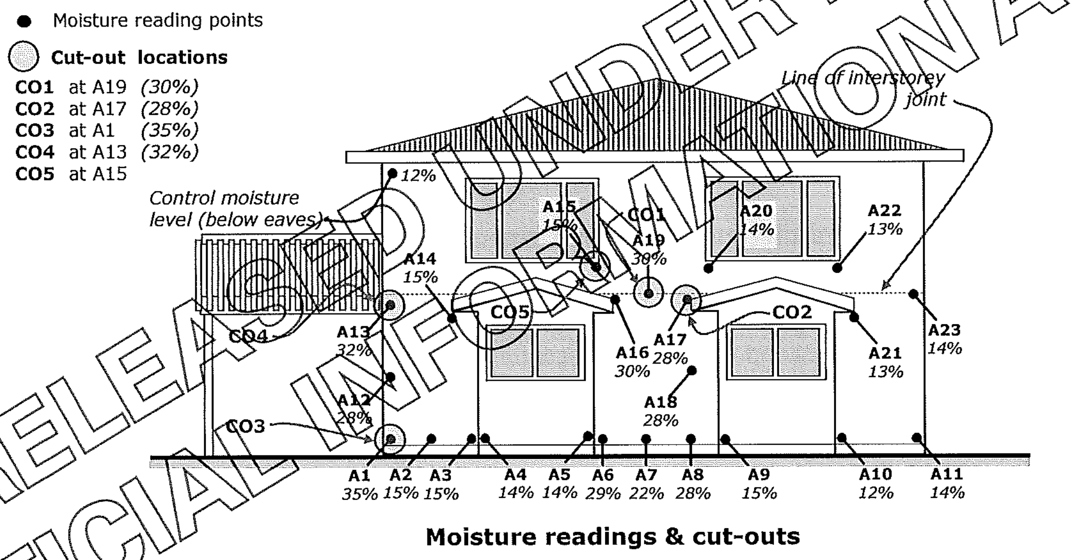
Undertake invasive moisture readings by drilling pairs of holes using the same methodology as described for non-invasive testing.

The points chosen for drilling are shown in ***Figure 7*** – with the aim of covering all obvious points of moisture damage (as shown in ***Figure 6*** above) together with all known high-risk locations.

The important point to remember is that if there is any doubt, then drilling and moisture readings must be carried out – remembering that leaking and damage will often be hidden, with occupants unaware of the moisture entering the structure.

> **Control points**
> It is important to establish a control point (if necessary for each elevation). At this point the moisture content will typically be in the range of 9 to 14%.
> There is usually no need to correct moisture content readings for timber species etc as it is the relative values compared to the control reading that is important. This assumes that all timber has the same treatment level (or lack of any), and that environmental factors are the same during testing.

Figure 7: Example One – Invasive moisture testing



❖ The drillings

In addition to the moisture readings shown in ***Figure 7***, information can be gained from the drilling process required for inserting the probes for invasive moisture readings. An experienced surveyor may be able to compare the hardness of the timber by the resistance of the drill or probes compared to the control point (refer box).

> ***Apparently dry timber***
> *It is important to appreciate that the moisture content could be within acceptable limits (i.e. less that 18%) but the timber might feel soft, with the drillings showing signs of decay.*

Observation of the moistness and nature (appearance and level of decay) of the drillings compared with the control can also provide some appreciation of the level of decay at each point that is drilled. However it is important that these results (and readings) are still treated as indicative at this stage.

Final conclusions should be avoided until cut-outs have been made, the exposed timber inspected, samples taken and the laboratory test results received.

A 3.1.4 Determining number and location of cut-outs

At this stage, the example assumes that the results of non-invasive and invasive testing have revealed high moisture contents (based on readings above 18%) and/or areas of suspected decay at 10 locations as shown in ***Figure 7***.

❖ Choosing cut-out locations

Cut-outs should be taken at locations with different construction features and high moisture readings to confirm results of invasive drilling etc. Accordingly a minimum of 5 cut-outs is recommended at:

- **CO1** *to expose the inter-storey joint detail and confirm decay*
- **CO2** *to confirm that apron flashing directs water into wall rather than away from it – because there is no kick out. (Unless there is any doubt as to the extent of decay and damage, there is usually no need to take a cut out at A16, as it is reasonable to assume that construction details are similar.)*
- **CO3** *to confirm the non-complying cladding detail at the base of the wall and resultant high moisture contents and decay. If locations and moisture readings are similar, then it should not be necessary to make additional cut-outs at similar cladding base locations.*
- **CO4** *to confirm the detail where the deck is fixed through the cladding*
- **CO5** *to confirm the underlying window sill to jamb junction. Although there is no evidence of any current problems with the windows leaking, this junction is considered to be a high enough risk to justify checking to ensure that it complies with the manufacturer's recommended installation details – to provide reasonable assurance that there will be no future leaks.*

Reasons for cut-outs
Reasons for taking cut-outs are to:
- confirm high moisture content readings and/or areas of decay
- check as-built details to compare with manufacturers' specifications and good trade practice
- determine the extent of the damage when combined with results of the drillings and other survey results
- take timber and other material samples for further laboratory analysis to support conclusions and recommendations.

A 3.1.5 Determining number and location of samples for laboratory analysis

In relation to overall costs involved in investigation and remediation work, the cost of analysing timber samples is relatively minor.

Assuming that decay and associated effects (including discolouration of timber) is evident at all locations, the objective of taking timber or other samples in this example will be to determine the:

- **Extent of decay**
  It is important to take timber samples away from the location of the obviously decayed timber. Experience shows that decay and structural degradation will often be found as a result of laboratory analysis in samples which appear sound to the non specialist eye. Also, some types of decay are impossible to detect without laboratory analysis.
- **Existence, level and type of timber treatment**
  There are quite different implications for remediation depending on whether the timber is treated or not. Also manufacturers have different required construction details in some circumstances depending on timber treatment and moisture levels.
- **Timber species**
  Some species will be more resistant to decay than others.
- **Type of mould present**
  Mould analysis can give useful forensic information as to how long the moisture has been present, the type of decay and whether mould is toxic e.g. stachybotrys atra.

In this example (assuming we have been able to confirm onsite that the timber is untreated kiln-dried radiata pine), it is suggested that 3 timber samples should be taken for wood decay, fungal and preservative analysis and one mould sample for laboratory analysis. If moulds are found, but the timber decay is not clear, it is advisable to take further mould samples.

Choose the samples so that 2 are from framing and one from the first floor timber joist. The joist is specified as treated timber (in contrast to untreated wall framing), which has probably prevented decay – but this must be confirmed by the laboratory test results. For wall framing, one sample should be taken where decay appears to have started. Another sample should be taken at what appears to be the limits of the extent of decay.

A 3.1.6 Cut-outs and samples on other elevations

While fewer should be needed, this depends on onsite investigation results. To determine the extent of damage, cut-outs are needed to confirm results of onsite observations and drillings. However it is often reasonable to assume that details are consistent on a building, so cut-outs may not be needed to confirm construction details at similar locations (e.g. at other sill to jamb junctions). Further timber or mould samples may not be needed if laboratory analysis confirms initial onsite conclusions. If analysis contradicts earlier assumptions, then more testing is needed (consistent with the iterative nature of the investigation process).

A 3.1.7 Leak sources

From the analysis described above (together with laboratory testing), a scenario of the moisture penetration and subsequent damage can be developed.

In this case, the scenario proposed is as follows:

- **Area 1** (between the bay windows)
  - *Initially water has entered the wall at the bottom of the apron flashing – where there is no kickout, the sealant has failed and water flows behind the cladding.*
  - *The resulting movement of timber and cladding has caused the defective (non-draining) detail at the horizontal inter-storey joint to fail – causing additional cracking and moisture penetration.*
  - *Water has then flowed down through the structure to the bottom plate level – where the lack of any ability to drain has trapped the moisture within the timber.*
  - *Water has then spread out along the bottom plate – causing further damage.*
- **Area 2** (the corner)
  - *Initially, water has penetrated the cladding at the deck to wall junction – where the junction is unflashed, there is no drainage gap and the fixings are unsealed.*
  - *The resulting movement of timber and cladding has caused the defective (non-draining) detail at the horizontal inter-storey joint to fail – causing further cracking and moisture penetration.*
  - *Water has then flowed down through the structure to the bottom plate level – where the lack of any ability to drain has trapped the moisture within the timber at the corner.*

A 3.1.8 Likely extent of cladding and timber replacement

The surveyor should be able to quickly conclude onsite that the panel containing A6, A7, A8, A16, A17 and A 19 will need the timber and cladding replaced. This is because the timber is untreated and decayed – and the rule-of-thumb approach is that all timber within 1m of any decayed timber should be removed and replaced.

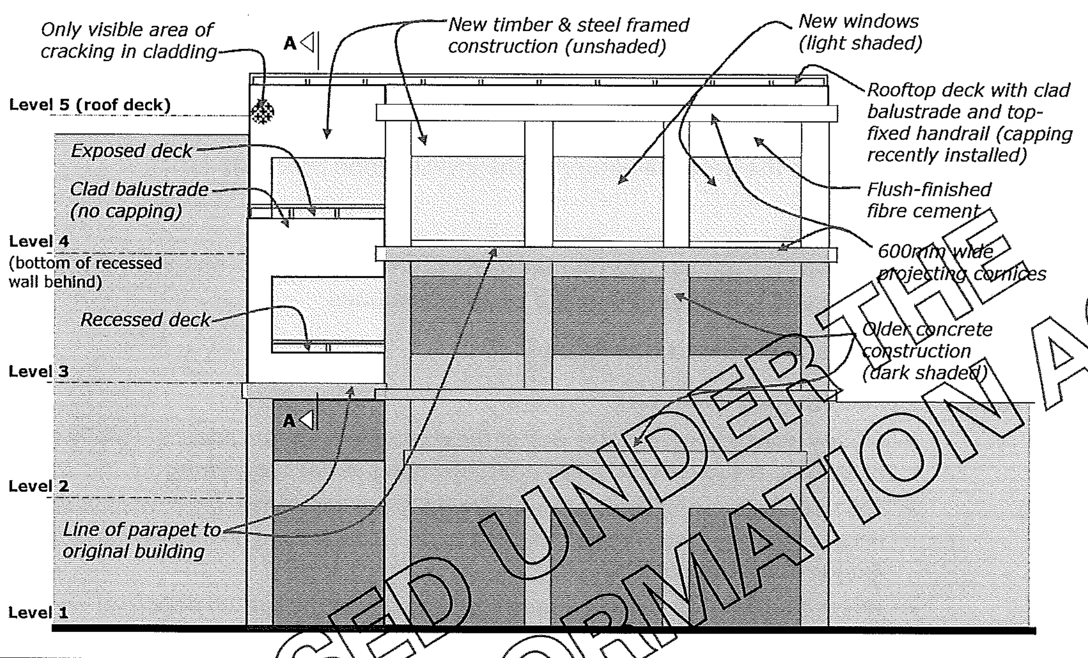
Assuming the inter-storey joint was not installed in accordance with the manufacturer's specifications and has failed, sufficient cladding will need to be removed to install a complying joint. With changes to manufacturer's specifications since the time of original construction, this may mean new cladding on a cavity is now required.

Cladding and timber replacement will also be required for the full height of the ground floor wall at A1, A12 and A13 – extending 1m along to the right (looking at ***Figure 7***) from the point of the limit of decay. Again in practical terms this panel of the wall up to the bay window will need to be replaced. The extent of the damage towards the right may be able to be determined by drilling. For legal reasons it may also be prudent to have another cut out at the foundation level at the limit of the decay.

A 3.2 Example Two: An apartment building

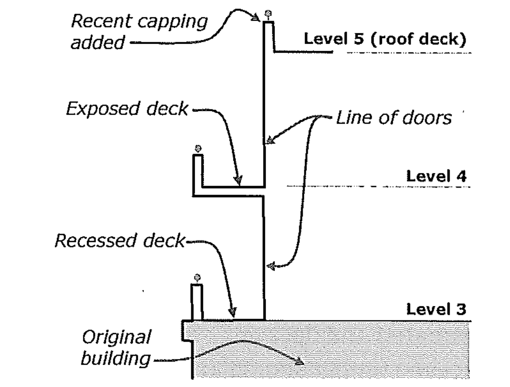
This example is an apartment building within an urban setting. The building work comprised a timber and steel framed addition to an older concrete building as shown in ***Figure 8***.

Figure 8: Example Two –multi-unit apartment



As shown in ***Figure 8***, the original concrete building (dark-shaded in the diagram) was mainly 3-storeys high, with a 2-storey section at one end.

Figure 9: Indicative section A-A



The new addition is generally one storey high, except for a 2-storey section (above the original 2-storey section) – with the resulting building becoming 4-storeys high with a roof deck.

An indicative section through the new 2-storey part is shown in ***Figure 9*** – to illustrate the relative positions of the new decks.

In this example we are assuming that the offsite information collection and onsite investigations undertaken in 2005 (including non-invasive and invasive moisture tests) have been completed.

A 3.2.1 Information collection and observations

❖ Offsite information

Information collected from the owner and Building Consent Authority records:

- *High wind zone*
- *Specification records timber framing as treated H1.2*
- *Building constructed during 2002*

❖ Visual investigations

The following information was collected from onsite observation:

- *The building is relatively new (less than 3 years old at the time of the investigations) – meaning that much of the deterioration is not yet evident from visual observations.*
- *The only evidence of cracking is at top left hand corner of level 5 deck as shown in* ***Figure 8.***

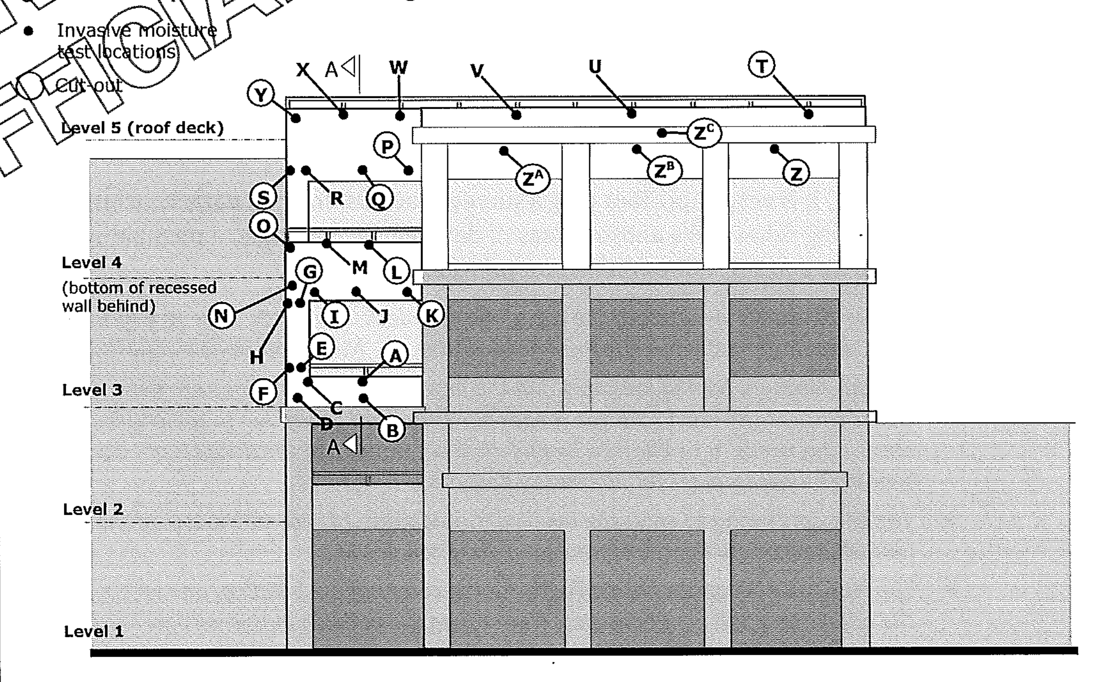
- *The wall cladding is face-sealed direct fixed 7.5mm thick flush-finished fibre cement – with no cavity. A number of features (noted below) do not comply with typical manufacturer's specifications or good trade practice at the time of construction.*
- *All panels are sealed – with no provision for ventilation (drying), or for any water that penetrates the face sealed system to drain back out of the structure.*
- *The 600mm wide projecting 'cornices' act as eaves - protecting the level 4 wall cladding and windows below as shown in **Figure 8.***
- *There are no joint details to allow for differential movement at the intersection of the varying shaped panels.*
- *The building has been constructed hard up against the adjoining building on the left – with no adequate flashing detail apparent at this corner.*
- *There is no special detail where the new structure and cladding meets the original concrete structure.*

- **Decks**
  - *Level 4 and 5 decks (and balustrades) are unprotected as shown in **Figure 9**.*
  - *Level 3 deck is recessed beneath Level 4 floor above as shown in **Figure 9**.*
  - *The soffit above the deck at level 3 has no drip edge.*
  - *There are no head flashings above the doors to decks at levels 3 and 4.*
- **Balustrades**
  - *Hand rails to all balustrades are top-fixed.*
  - *Balustrades at levels 3 and 4 have no cap flashing, and no top slope to aid draining of water.*
  - *Repairs in the form of a new capping along the complete length of the level 5 deck balustrade (building parapet) have been made (confirmed by the owner).*
  - *The cladding panels comprising the roof top deck balustrade, the panel above the exposed deck at level 4 and the panels above, below and on the left hand side of the level 3 opening are all unprotected.*

A 3.2.2 Invasive testing – initial results

The results of invasive moisture readings are as shown in ***Figure 10***.

Figure 10: Example 2 - Moisture testing



(Note: Refer to ***Figure 9*** for an indicative cross-section through the decks)

As shown in ***Figure 10***, high moisture readings (and/or areas needing further investigation) have been found in the following locations:

- **A,C** *level 3 – in top plate of balustrade framing (directly beneath connections of top fixed handrail to uncapped flat top)*
- **B,D** *level 3 – in bottom plate, where new construction meets original concrete structure*
- **E** *level 3 – in trimmer stud just above level of top of balustrade in narrow front wall*
- **F** *level 3 – in corner stud close to adjoining building in narrow front wall. No suitable flashing detail can be seen – further investigation required*
- **G,H** *level 3 – in trimmer studs just below deck soffit level at top of narrow front wall. G is close to the right face of the narrow wall and H is on the left hand side of the wall close to the adjoining building*
- **I,J,K** *level 3 – in horizontal plates at the bottom of the soffit above deck. The soffit is unventilated but showing no signs of cracking*
- **L,M** *level 4 – in top plate of balustrade framing (directly beneath connection of top fixed handrail to uncapped flat top) close to adjoining building*
- **N** *level 4 – just above deck floor level, near corner of the narrow wall*
- **O** *level 4 – in top plate of balustrade framing (directly beneath connections of top fixed handrail to uncapped flat top)*
- **P,Q,R,S** *level 4 – in horizontal plates of wall beneath clad balustrade (recently repaired with addition of a capping). Also S is located in narrow wall adjacent to adjoining building*
- **Y** *level 5 roof deck – in top plate of balustrade framing (in corner beneath connections of top fixed handrail to new capping). There is cracking that could be due to an inadequate corner flashing, or water could be entering at the point of connection of the top fixed handrail (or a combination of both reasons).*

There is no evidence of moisture ingress or timber decay at locations Z, Z^A, Z^B and Z^C – and it appears that these areas have been protected by the projecting cornice. Also, the construction detailing of the Level 5 roof deck balustrade above appears to have lead to any moisture entering the framing being trapped within the balustrade.

T, U, V, W and X are locations where the drillings indicate that the timber is suspect but the moisture content is below 18%. It is also evident that repairs have been made in the form of a parapet capping being installed at the top of the building.

A3.2.3 Possible moisture paths

As discussed earlier, it is very important that a surveyor avoids drawing early conclusions that could result in missing other leaks and/or areas of damage. Accordingly, a possible scenario for the causes of leaking and subsequent moisture paths is as follows;

- *Water has earlier penetrated the top of the roof deck balustrade - due to a lack of cap flashings and/or defective top fixed handrail details. New cappings are now installed.*
- *Current moisture testing indicates that the new balustrade cappings are now preventing water entry at this level - but the timber has suspected decay due to the previous moisture entry. This needs to be checked by making a cut-out and (if the decay is not obvious) by sending timber samples for laboratory analysis.*
- *Water is continuing to enter the building through the cracking at the top left hand corner immediately below the retrofitted balustrade cap flashing*
- *The lack of an adequate flashing detail at the corner of the building, and where it meets the adjoining building, means water is entering the building at this vertical line and tracking down the wall.*
- *Water is further entering the building at the points of the handrail connections at levels 3 and 4 (where there are no cappings on the flat-topped balustrades), and tracks down to*

the level of the soffit of the deck below. It also tracks down the narrow wall on the left hand side

- *The current limited cracking in the cladding is probably due to the building being less than 3 years old – as the extensive water penetration (combined with the high-risk construction style) means it is only a matter of time before further signs of damage become obvious.*

A 3.2.4 Number and location of cut-outs

Based on the information gathered during the investigation and the assumptions outlined above, the following initial cut-out locations are suggested (as shown in ***Figure 10***):

- **A** *to determine construction detail and extent of decay at the top of the balustrade framing and underneath top-fixed handrail connection*
- **B** *to confirm whether moisture is being trapped at bottom plate level – and to confirm construction detail where new addition meets original structure*
- **E** *to investigate whether moisture is travelling down the narrow section of wall and whether moisture is also entering the balustrade and wall at this location*
- **F** *to check flashing detail at building left hand corner*
- **G** *to determine construction detail at intersection of soffit and wall – and to determine whether water is travelling down the wall at this point*
- **I** *to determine bottom of soffit detail*
- **K** *to determine construction detail at the junction of the new construction with the original concrete structure*
- **L** *to determine construction detail beneath top-fixed handrail connection at Level 4. If drilling results indicate decay, then it is likely that the cut-out will show evidence of obvious decay (however, the extent can only be estimated after the results of the timber sample analysis have been received from the laboratory – refer also note below)*
- **N** *to determine construction detail at base of set back narrow wall. (N is at base of wall)*
- **O** *to determine construction detail at corner of balustrade underneath handrail fixing*
- **P,Q** *to determine construction detail at the bottom of the balustrade wall*
- **S** *to determine construction detail at corner of building – and whether water is passing down the wall under gravity from location Y above*
- **T** *to confirm that timber is at an acceptable moisture content (less than 18%) – and to check drilling results indicating timber decay*
- **Y** *to explore construction details in the only area that is currently exhibiting cracking*
- **ZC** *to understand the construction detail at this location of the intersection of the previously leaking panel above, the eave and the panel below – which appears to be undamaged.*

In a real situation
It must be emphasized that this scenario with the follow-up cut-out sequence is based on a theoretical example.
In practice some assumptions of the above scenario will prove to be incorrect, so further investigations including cut-outs will be required. This is part of the usual iterative investigative process.

Note: At all cut-out locations, initial moisture content readings will be rechecked and any obvious decay noted. Further cut-outs will be needed as part of determining leak patterns and the extent of decay.

This is not straightforward, as samples must be chosen to include what is considered to be the limits of decay. The extent of decay can then only be estimated after sufficient timber samples have been analysed and the results received from the testing laboratory.

A 3.2.5 Number and location of timber samples

It is not possible to give simple rules-of-thumb for the number and location of timber samples, but the following guidance should be useful.

❖ Amount of decay revealed

The number and location of timber samples depends on decay revealed at cut-outs:

- **No apparent decay**
  If no decay is detected from on site inspections of the high moisture content areas and other suspect areas:
  - *it is recommended that sufficient samples be taken from high risk areas and sent to the laboratory for analysis.*
  - *in the case of Example 2, a minimum of 6 samples is suggested. This works out at 2 samples per level. These should be taken from what the surveyor considers to be areas with the highest risk of decay.*
  - *if laboratory results show that there is decay, further samples will be required to determine the extent of the decay.*
- **Some apparent decay**
  If there are some signs of decay:
  - *more samples will be required - as the same minimum number of samples should be taken as for the case where no decay is suspected.*
  - *in addition to the minimum (for each area of obvious decay), at least 2 further samples should be taken at what is estimated to be the limits of the extent of decay.*
- **Obvious and widespread decay**
  If there is obvious and widespread decay from the onsite investigations
  - *relatively few samples will be required.*
  - *if decay is obviously widespread then both cladding and framing would need replacing and there would be no need to have laboratory analysis of obviously decayed timber.*

In the case of the building considered in Example 2, widespread decay is unlikely as:

- *the building is less than 3 years old,*
- *the framing is treated*
- *there is only one area of decay showing the effects of the damage.*

However as always it is important to keep an open mind and not jump to conclusions – so sufficient laboratory sample testing would be undertaken to confirm or otherwise the initial diagnosis.

Addendum 4 Timber rots and moulds

Issues related to timber decay and the related mould identification are probably the least understood and most complex of the entire remediation process. There is relatively little information available for surveyors on where to take timber samples, how many samples to take, the size of samples and the ongoing need for sampling throughout the repair process.

The most critical aspect of timber decay is to determine the extent of the decay. Timber that is clearly decayed is easy to identify. The difficult part is to detect decay where the timber can appear quite normal even to a specialist.

It is only when a sample is examined under the microscope by a suitably trained and experienced specialist that the type and extent of decay can be determined and the appropriate action taken. It is therefore very important to work closely with an experienced laboratory specialist who can give advice based on microscopic analysis.

It is also important that samples continue to be sent for specialist analysis throughout the repair stage as the building is opened up.

The process of assessing decay may be seen as 4 phases:

1. Before inspection
2. During inspection
3. Laboratory analysis
4. Using the results

Types of rot

While identification should be made in the laboratory, as a general guide:

- **Brown rots** (at advanced stages) usually cause wood to lighten in colour prior to becoming dark brown, and to crack along and across the grain (although only once dry). When dry, very decayed timber will crumble to dust.
- **White rots** (at well-advanced stages) cause the timber to become lighter in colour and fibrous in texture without cross checking
- **Dry rot** is the common term for one brown rot *Serpula lacrymans*, and is relatively rare in New Zealand. However it is also difficult to distinguish from other brown rots so field observations must be backed up with laboratory testing.
- **Wet rot** refers collectively to all other brown rots and white rots
- Timber affected by ***soft rot*** often shows little outward sign of decay (i.e. classical softening is absent). Sometimes the timber may become a dirty grey to brown colour. When a sample at least the size of a matchstick is broken off, the fracture surface can sometimes look like a broken carrot (although juvenile wood without decay behaves similarly).
- The main concern with ***dry rot*** is that decay is very rapid once suitable conditions prevail – and can move moisture considerable distances to dry wood and cause decay of timber that would have otherwise remained dry and resistant to other types of decay. Although rare in NZ, it is a serious issue when found.

The investigation process

Any investigation process must:

- be carried out by an experienced professional
- use both off and on site observations and testing
- recognise that sampling and laboratory testing is needed to determine nature and extent of decay
- recognise that care needs to be taken in interpreting any on site results
- consider potential health and safety issues for surveyor and occupants where mould is an issue
- reflect current knowledge to suit current conditions.

A 4.1 Before inspection

Establish with the client the extent of inspection, including destructive testing, cladding removal and sampling that is required and obtain written approval for this work.

❖ Collect Information

Weather

Establish weather patterns over the 3 to 4 weeks before the inspection.

A prolonged dry spell combined with a type of construction that aids drying can often mean that there is little or no evidence of high moisture levels from readings taken with a standard resistance type deep probe moisture meter.

Seek information on the age and history of the building including details of any past maintenance and repairs. This should include details of the materials used in the construction i.e. timber type, degree of timber treatment (if any), date materials supplied, any details of leak history and changes as a result of previous repairs.

❖ Identify risks

This preliminary work should also include the identification of property characteristics such as wind zone, degree of shelter, slope, location etc., and building characteristics such as height, roof/wall intersection design, eaves width, envelope complexity, deck design including balustrades and parapets, type of cladding system etc. This helps to determine where cladding cut-outs should be made and timber and mould samples taken.

A 4.2 During inspection

The onsite inspection is part of the extensive and necessary diagnosis process described in ***Addendum 2: Investigation Process*** (page 24).

❖ Early indicators of decay:

Some important indicators are:

- **Internal**
  - *Occupants' knowledge of leaks, locations and length of time of moisture problems*
  - *Occupants' mentions of health problems that may be related to toxic moulds*
  - *Visible signs of dampness, mould and decay (e.g. corroding carpet fixings, swelling skirtings, cracked linings etc.)*
  - *Odours such as distinctive mushroom smell associated with decay fungi*
- **External**
  - *Cracking in cladding and/or staining and discoloration are often reliable signs of moisture ingress and subsequent timber decay*

❖ Moisture readings

In the usual manner, moisture readings should be taken first in the non-destructive or capacitance mode. This is followed by drilling holes through the cladding into the framing and taking readings in the resistance mode.

In both modes the critical factor is to identify **relative** rather than absolute values. A useful approach is to identify a location that is known to not be affected by moisture ingress. This can be used as a *control* with other moisture readings being compared with it.

- **Moisture travel**

Problems can occur remotely from leak sources, so it is important to allow for the possibility that evidence of moisture can show in unexpected positions and/or may be concealed. An example is where (due to daily temperature fluctuations) external moisture evaporates within cavities; the vapour redistributes and then condenses as moisture elsewhere

❖ Taking onsite samples

The decision as to how many and where samples should be taken for laboratory analysis is far from straightforward *(refer box)*. The number and location of samples are influenced by the following factors:

- *whether framing is known to be treated or not*
- *the estimated length of time the timber has been subject to excessive moisture*
- *the extent of decay assessed from onsite work*
- *information from drilling and other onsite testing (refer box)*
- *whether the likely repairs are tending to a complete reclad or targeted repairs*
- *whether initial judgements on decay are confirmed by laboratory analysis*

Using experience

A very experienced surveyor:

- may be confident as to what is sound timber and what is decayed from observations and testing
- may take 2-3 samples per elevation for analysis at fringes of decay
- if initial assumptions are not confirmed, then will take further samples for analysis.
- A less experienced surveyor may take more samples due to uncertainty about the extent of decay.
- However, all surveyors should remember that decay is often impossible to detect without some backup laboratory analysis.

- *the costs of taking extra samples at a repeat visit if initial assumptions prove incorrect*
- *whether laboratory analysis is required as part of a dispute resolution process.*

- **Samples of untreated timber**

The use of untreated kiln-dried timber for external wall framing was very common from 1996 to 2004. If onsite testing indicates that timber is untreated and decay is widespread, then only a few samples may be required – as the need for a reclad and major timber replacement will be obvious. In such cases, the main reasons for sampling will be to ensure the owner has sufficient evidence that a reclad is required.

Reasonable evidence of untreated timber includes observing markings on the timber and/or spot tests. Laboratory analysis can confirm that the timber is untreated and also the extent of decay.

- **Samples of treated timber**

More samples may be needed for treated timber. Untreated timber exposed to excessive moisture is likely to have severe decay after 3-12 months, but treated timber may be satisfactory for 2-5 years. If treated timber has widespread decay due to leaks over a long time, a reclad and major timber replacement will be necessary – and relatively few samples will be required (as discussed above).

> ***Cost effectiveness***
> *As timber can look sound in the early stages of decay, it may be more cost effective to take more samples initially (to be sure of decay extent) than to place greater reliance on experience that proves to be wrong (and leads to further site visits and sample collecting).*

If leaking is relatively isolated (with limited decay), then more samples may be required. This applies when targeted repairs are considered to be a possible option and the aim is to determine limits of the affects of decay (taking into account the rule-of-thumb practice that all timber within 1 meter of the outer limit of the decay must be removed).

❖ Size and nature of samples

Practices vary regarding the size and nature of timber samples.

Although analysis of very small samples is possible, send samples as large as possible to the laboratory to maximize potential forensic information (including measuring the degree of decay, how long it has been occurring, and the extent of leaching of preservative across the section of timber etc.). The largest framing sample would normally be a 100mm length of ex 100mm x 50mm framing. Samples should be included which are taken from timber that is considered to be at the least decayed end of the spectrum – to in effect set benchmarks.

The nature and size of samples also depends on the forensic information required. If the aim is to determine the length of time that the building has been leaking at a particular location, it may be important to send a sample from a clearly wet area and one from a reliably dry area.

The length of time that the building has been leaking can then be estimated by the degree of leaching of the preservative compared with the piece of timber that has not been subject to moisture. The type, location and extent of decay also enables the duration of the leak to be estimated.

> **Sellotape sampling for moulds**
> The simplest way to take a sample is to use a piece of sticky tape, which is pressed down on the mould or fungi, transferred to a grease-proof paper envelope – and then placed in a sealed plastic bag for sending to the laboratory.
> While 'Sellotape' samples are satisfactory, more useful forensic information can be obtained by sending a sample of the actual material (e.g. building paper or plaster board etc) with the mould attached to the laboratory for analysis.

> ***Records***
> *Photograph all decay samples – close up and from further back to show relative locations of samples on the building, as this helps with interpreting test results.*

When sending samples to the laboratory, it is helpful to provide photographs showing where each sample has come from. Photographs should also be provided which give an overall perspective of the type of building under investigation (showing cladding etc.) – in order to assist with the forensic analysis of the samples.

❖ Health & Safety issues

When extracting samples, it is important that precautions be taken to guard against any potential hazards to the surveyor or to the occupants of the building.

> ***Occupants' health***
> *Diagnosis of the potential for adverse health effects from mould and other microorganisms (e.g. actinomycetes and bacteria) and their by-products is often not straight forward. The amount of affected material and its location, and the type of micro-organisms can all have an effect. Experience is important, but if in doubt always obtain as much information as possible, keep people informed of potential risks and seek expert advice.*

When taking samples:

- *be careful to use suitable protective equipment including appropriate breathing masks and gloves.*
- *remove cladding from the outside of the building rather than from the inside wherever possible (to allow any potentially dangerous fungi such as stachybotrys to be released into the atmosphere rather than into a living space inside the house).*
- *disturb the mould and fungi as little as possible (for instance, stachybotrys atra is far more dangerous when it has dried out and the spores readily become airborne. When wet, the spores tend to stick together and are less likely to become airborne and breathed in by the building user).*
- *carefully seal off any voids that may have been opened up as part of the investigation process.*

A 4.3 Laboratory analysis

❖ Identifying timber treatment

Laboratory testing is important to assist the surveyor in clearly determining the type and level of timber treatment, as doing this onsite can be difficult. Site testing for boron or copper based preservatives can be successful if accepted guidelines are followed – although the most reliable boron spot test is highly toxic so generally not suitable for site testing).

Also, there can be a false positive issue for boron spot tests. These are very common if only old surfaces are tested – meaning that a potentially dangerous scenario can result where untreated wood is misdiagnosed as H1 or H1.2. Insitu treatment can also be confused as being H1 or H1.2. However, there is no reliable onsite test for H1.2 and H3.1 LOSP tin since oven-dried samples are required. H1 permethrin and H1.2 permethrin plus IPBC cannot be tested using rapid spot tests and more costly and time consuming (1 to 2 weeks) quantitative laboratory analysis is required.

> **Onsite techniques**
> (for detecting timber decay)
> Useful site techniques (which should be confirmed by laboratory testing) include:
> - observing timber hardness when drilled and the nature of the drillings – and comparing this with a control point in known sound timber (although this is not always conclusive)
> - probing timber with a sharp tool such as a chisel. If the timber breaks off into short splinters ('brashness test') when levered by the probe it is usually an indication of decay and loss of strength. Softness of the timber is also a useful indicator of decay (although juvenile heartwood may be soft irrespective of the presence of decay).
> - striking the timber with a hammer or similar. A soft and dull sound from a larger timber member, or a change in note along a length of timber might indicate decay.
>
> It is important to confirm (or otherwise) the results of onsite testing with laboratory analyses of representative samples.

❖ Moulds and fungi

The analysis of moulds and fungi found onsite can only be undertaken by very experienced specialists. The results of laboratory analysis can be used to provide information on issues such as the type of mould, its toxicity, how long it has been in place, and forensic details of the type of moisture elevation scenario.

Dormant fungi
Decay fungi can remain dormant in dry timber for several years in some situations. This should be no surprise when one takes into account how long bakers yeast (a fungus) can remain dormant in its dry form.
Laboratory testing can determine if decay was recently active or not or if it is still viable in the case of very old infected or decayed wood.

Some moulds (such as *stachybotrys atra* and *Chaetomium globossum*) also cause decay in some situations – and specialist knowledge and experience is necessary to establish their significance in any given scenario.

Specialist laboratory advice
The following advice can be available on:
Current condition
- Type and extent of decay
- Presence of wood preservative
- Retention levels and type of preservative

History
- How long decay has been present
- How long leak/fault has been present

Future
- How quickly decay will continue to develop
- If no decay, future risks of wood failure

Repair
- How much framing needs replacement
- Type of replacement framing to be used
- Speed of drying measures needed
- Appropriateness of in-situ preservative application – type recommended?

Moulds and fungi can grow on any surface. While many do not pose health risks, *stachybotrys atra* and some other types of mould are toxigenic and have been implicated in building sickness syndrome. *Stachybotrys atra* is most commonly found on gypsum paper board, fibre-cement board, building paper and other cellulose containing materials.

A 4.4 Using analysis results

The results of the laboratory tests (combined with the systematic offsite and onsite investigations) provide information that allows conclusions on:

- *the potential extent of timber damage and therefore extent of replacement timber to be estimated*
- *the time restrictions to be established for sensible remediation measures to be put in place*
- *the extent and type of required treatment to be decided.*

In this way, onsite information and laboratory testing allows an outline scope of work to be established, together with rough estimates of likely costs.

Further sampling and analysis will be required through the construction stage to confirm the integrity of timber to be retained.

- **In-situ treatment**

In some cases it may be appropriate to have targeted repairs – leaving the timber insitu and applying suitable preservatives.

In such cases it is important to follow the advice of an experienced laboratory specialist as to the insitu treatment of the timber remaining.

Insitu treatment
Framesaver concentrate, applied by brush or airless spray) is commonly used in New Zealand although an LOSP type preservative such as Metalex *is more suitable in some situations provided the wood is essentially dry.*

Addendum 5 Additional resources

Further resources are available that can provide additional detail on some of the points raised in this guide – and these should be consulted for further guidance. Some of these resources are listed below.

Department of Building and Housing Publications are available from the Department (free download from www.dbh.govt.nz), or freephone 0800 370 370.

Acceptable Solution E2/AS1

External moisture – a guide to using the risk matrix: June 2005

External moisture – An introduction to weathertightness design principles: August 2006

Constructing cavities for wall claddings

Characteristics and defects – a study of weathertightness determinations: April 2007

New Zealand Standards

NZS 3602:2003 *Timber and wood-based products for use in buildings*

NZS 3640:2003 *Chemical Preservation of round and sawn timber*

BRANZ books (latest versions)

Stucco Good Practice Guide

Timber Cladding Good Practice Guide

Profiled Metal Wall Cladding Good Practice Guide

Weathertight Solutions, Volume One Weatherboards

Weathertight Solutions, Volume Two Stucco

BRANZ Bulletins:

304: *Flashing design*

353: *Ground clearances*

428: *Weathertightness do's and don'ts*

434: *Results of Weathertightness Failure*

435: *Weathertightness evaluation*

448: *Domestic flashing installation*

449: *Keeping water out – timber-framed walls*

Canada Mortgage and Housing Corporation

Building envelope rehabilitation – Consultant's guide: 2001

Building envelope rehabilitation – Owner-property manager Guide: 2001

Occupational Health and Safety

Risks to health from mould and other fungi - Workplace Health Bulletin No.17: 2002

New Zealand Metal Roofing Manufacturers Inc.

New Zealand Metal Roof and Wall Cladding Code of Practice: 2003

Building Research Establishment

Recognising wood rot and insect damage in buildings: Third edition 2003

Robin Wakeling

Wood Decay in Leaky Buildings: proceedings of the NZIBS Annual Conference, 2005.