The "Alternative Solution"
For Untreated Douglas-fir (New Zealand Oregon)
in Building Construction

1. Executive Summary

This document aims to provide adequate documentation to satisfy the requirements of Territorial Authorities in approving an "Alternative Solution" for Douglas-fir (New Zealand Oregon) in building construction under the verification method B2/VM1.

This documentation will be progressively upgraded to strengthen the case for New Zealand Oregon (NZO) for building construction as further research results and endorsements are obtained.

2. Background

The Building Industry Authority's (BIA) analysis of inspection reports for 'leaky buildings', prepared for the Weathertighntness Resolution Service, concluded that;

- High incidences of leaks are associated with junctions in, and penetrations of, the building envelope, especially where monolithic and thin sheet cladding systems have been used.
- Serious structural problems, resulting from leaks, are mostly associated with cladding systems that have limited capacity to dry out if a leak does occur.

The dominant reaction of the BIA to these conclusions has been to stimulate changes in the New Zealand standard governing durability of timber and wood-based products in building construction. The resultant changes to NZS 3602 have restricted the use of NZO timber in building construction in New Zealand. In particular the use of NZO has been restricted as an external wall framing.

Clause B2.3.1 of the Building Code defines performance requirements for building elements based on their specified intended life such that; building elements that provide structural stability and/or are difficult to access or replace and/or failure would go undetected during normal maintenance to have a minimum durability of 50 years. NZO external wall framing comes under this performance classification.

NZS 3602:2003 Table 1 specifies that to achieve this performance (minimum 50 year service life), requires all NZO external wall framing to be treated to H1.2 standard. The exception to this is for external walls in single storey houses with a masonry (brick) veneer, which can be constructed with untreated D. fir. Internal wall framing and roof trusses can be untreated D. fir and also require a 50 year performance requirement.

The time frame for the implementation (of the changes introduced in NZS 3602) is such that it is not possible to campaign for the new standard to be rewritten with a more rational, reasonable and realistic approach. Consequently it has become necessary to present an "Alternative Solution" that fulfils the requirements of the various Territorial Authorities, in issuing building permits and compliance certificates, where NZO is the most suitable and preferred choice, while campaigning, in the longer term for the standard to be rewritten.

3. The "Alternative Solution"

The alternative solution as presented in this documentation seeks to address the concerns about the durability of framing timbers where limitations in design, material performance and/or workmanship have created a risk of moisture penetration and retention leading to decay by classifying both buildings and cladding systems into high risk and low risk categories and then relating these categories to the suitability of untreated NZO to adequately meet the requirements of clause B2.3.1 of the Building Code.

3.1 High & Low Risk Buildings

3.1.1 Low risk buildings

Buildings shall be categorised as low risk if they:

- Are single storey, and have eaves of 450 mm or more, or
- Are two storey, and have eaves of 600 mm or more, and
- Have a roof pitch of at least 10 degrees, and
- Are in a low wind zone

3.1.2 High risk buildings

Buildings shall be categorised as high risk if they:

- Are two stories or more, and/or
- Are in a very high wind zone, and/or
- Have eaves less than 450 mm, and/or
- Have roof/wall junctions, and/or
- Have wall cladding/wall cladding junctions, and/or
- Have solid parapets or balustrades, and/or
- Have cantilevered balconies, and/or
- Have roofs with a pitch of less than 10 degrees and/or
- Have decks above living spaces

3.2 High and low risk cladding systems

3.2.1 Low risk cladding systems

Cladding systems shall be categorised as low risk if they comprise:

- Concrete and clay brick veneer over a drained ventilated cavity (Untreated NZO used in external wall framing with brick veneer cladding fulfils the requirements of the BIA documentB2/AS1 and as such it qualifies as an Acceptable Solution)
- Timber weatherboards fixed over a drained ventilated cavity
- Fibre cement weatherboards fixed over a drained ventilated cavity
- Stucco fixed over a drained ventilated cavity
- Horizontal corrugated steel sheet fixed over a drained ventilated cavity
- Vertical corrugated steel sheet directly fixed to framing
- Painted plywood sheet claddings fixed over a drained ventilated cavity
- Fibre cement sheet claddings fixed over a drained ventilated cavity
- EIFS fixed over a drained ventilated cavity

3.2.2 High risk cladding systems*

Cladding systems shall be categorised as high risk if they comprise

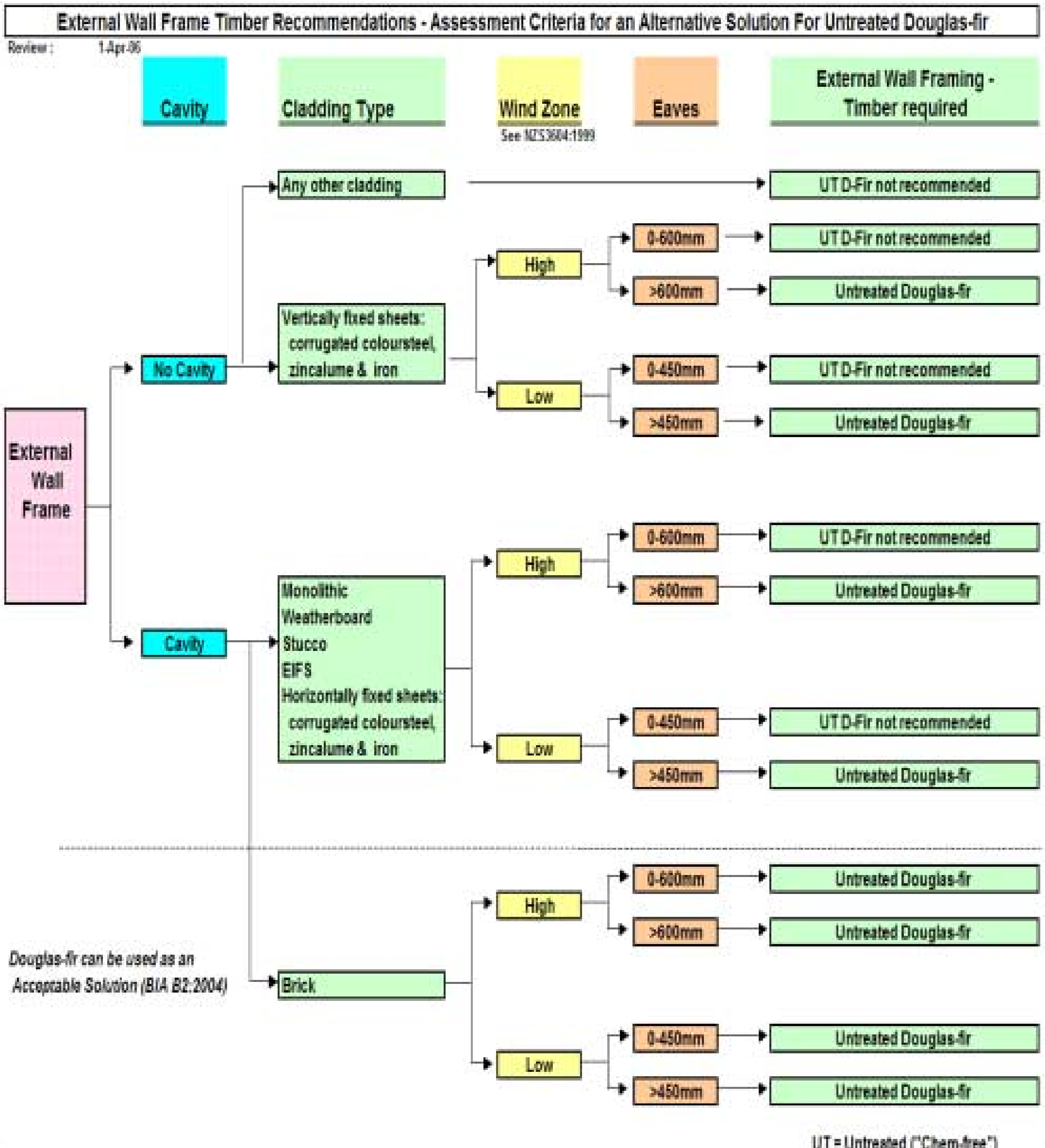
- Fibre cement weatherboards directly fixed to framing
- Timber weatherboards directly fixed to framing
- Plywood sheet claddings directly fixed to framing
- Fibre cement sheet claddings directly fixed to framing
- EIFS directly fixed to framing

* Risk of moisture penetration is increased on sites with very high wind.

3.3 Assessment Criteria for Suitability of untreated NZO

The suitability of untreated NZO for external framing can be derived from the decision tree below:

Assessment Criteria



The recommendation above for External Wall Timber Frames assume the following Low risk building design features:

Cavity	Drained and Ventilated
Number of storeys	1 or 2 storeys, with > or = 450mm eaves on single storey or 600mm eave on second storey.
Roof type	Simple gable/hip roof with a pitch of 10 degrees or more, with eaves
	BIA E2 defines flat roofs, skillion roofs or complex roof shapes, internal gutters as high risk, therefore untreated D-fir is not recommended
Deck / Balcony	BIA E2 defines an extended or cantilevered balcony or a deck above a living area as high risk, therefore Untreated D-fir is not recommended.
Bottom Plates	Bottom plates fixed on concrete foundations should be treated to H1.2 or better

3.4 Verification using B2/VM1

To achieve an "Alternative Solution" Territorial Authorities must utilize verification method B2/VM1 which requires verification of durability by;

- In-service history and/or
- Laboratory testing and /or
- Comparable performance of similar building elements.

3.4.1 In-service history (Full endorsements appended) .

3.4.1.1 Endorsement by Mr. Len Cadzow.

Mr. Len Cadzow (F.N.I.O.B., A.I.O.B., A.C.I.Arb., A.N.Z.I.Arb., A.A.I.A.) has been involved in the building construction industry for 63 years. To quote;

"In summary the writer's considered opinion is that N.Z.O. is a suitable structural timber for all wall, ceiling and roof framing (i.e. all framing above sub-floor), where professional construction techniques, metal flashings and ventilation and drainage cavities prevent the ingress of water into the framework. Under such conditions the writer believes that N.Z.O. can last for more than 50 years in situ without any degradation or failure. If considered desirable a treated (H3) sole plate can be utilized, for added protection, under the normal external wall framing."

3.4.1.2 Endorsement by MAF Policy 2003. Submission on BIA consultation document Building Code Clauses B2 Durability. Proposed Changes to Acceptable Solution B2/AS1

In summary "The BIA's proposals should address the causes of timber decay in residential buildings (design and construction related), rather than addressing a symptom of the problem (decay of untreated timber exposed to moisture uptake). The ministry believes that the BIA should work with industry and research representatives to develop a regime that recognizes the wood properties of the principal tree species used for house framing timber. The regime should also limit the requirement for treated framing timber to predetermined risk situations, and the types of structures and cladding systems that have been at the centre of the weathertightness problem".

3.4.1.3 Endorsement Mr. Richard Carver (Registered Member NZIA)

In summary "I have read the proposal put forward by the Douglas-fir Industry, outlining certain conditions under which Douglas-fir could be considered. I personally consider this to be very appropriate. …

It allows a client the option to use untreated Douglas-fir as an alternative to treated pine."

3.4.1.4 Endorsement Mr. Don Frame (NZIBS, MINZIOB, MBOINZ – Building Inspector)

In Summary "I consider that Douglas-fir has not been given a fair hearing and has been blamed for our 'leaky buildings'. That is not true, it not the timber that has failed, but the cladding that the BIA and BRANZ have previously approved."

…"Unless the Authority provides a full ventilated (free air flow) cavity, buildings will continue to decay whether or not Douglas-fir has been used. If the proposed Standard is allowed to dominate the Industry, buildings constructed today will again leak within the next 25 years. History repeating it's self."

…"Douglas-fir is permitted in brick cavity construction where full cavity ventilation remains, why not allow Douglas-fir in other external cavity construction? Reason is possibly that Radiata requires treatment and Douglas-fir none

3.4.1.5 Endorsement Mr. Tim Barton (Nelson/Marlborough Institute of Architects)

I hold degrees in Architecture and Building Science from Victoria University of Wellington. I have been involved with the building industry for some 35 years and have practiced architecture for 25 years. My knowledge of the performance of cladding and the durability of timber has been informed by academic study, by the design and evaluation of a large number of buildings, and (not least) by the examination of older buildings during their dismantling prior to alteration. I specified Douglas-fir wall framing for the house in which I live.

I support the greater use of Douglas-fir in the NZ building industry. While changes to codes and standards are required to control and restrict the use of some cladding systems, and to prevent a further fall in the craft of building, recent changes to NZS 3602 and NZBC B2/AS1 are premature and do not take the natural advantages of Douglas-fir sufficiently into account.

3.4.1.6 Endorsement Mr. Bill Andrew (Consulting Engineer)

We endorse your proposed alternative solution for the use of untreated Douglas-fir for external framing in low risk situations where there is a drained cavity between framing and exterior cladding. Our opinion is based on the superior durability of Douglas-fir compared to untreated Pinus Radiata.

3.4.1.7 Endorsement Mr Roy A. Farris, FNZICW, AIArbA, MNZIBS, JP.

Roy has been involved in the construction industry for the last 45 years from a trade background MOW Building Overseer, Clerk of Works Dunedin City Council and since 1973 own consultancy practice as Building Surveyor, Clerk of Works, Project Manager and construction failure investigator.

For the last 30 years he has been directly involved within the construction industry assisting with failure investigation, construction dispute resolution and as the BRANZ (Building Research Association of New Zealand)

Advisor for the Central Otago area. *"During the last 30 years especially, I have undertaken many investigations, surveys, arbitration's, and litigation, as an expert witness in building failures, both product, systems and workmanship.*
In all that time I have found New Zealand Oregon to be a perfectly satisfactory framing timber for all framing above sub floor level, providing the common sense rules of drainage, drying and deflection are adequately dealt with in the constructions system".

3.4.1.8 Endorsement Mr Gary Littler, B.E. (Hons), M.IPENZ, ACENZ (Consulting Civil & Structural Engineer)

In Mr Littler's professional opinion, the proposed Alternative Solution addresses the many types of construction available as well as considering the different climatic conditions present in the country in a logical way.
This solution will eliminate the risk of Douglas-fir being used in inappropriate situations, and will allow the end user, the client, to maintain the choice of using chemical free timber.

3.4.1.8 Endorsement NZ Timber Industries Federation (W Coffey)

The NZTIF is New Zealand's largest and oldest timber association. TIF's collective experience spans over 100 years of building practise in New Zealand.

TIF endorses the identified risk levels where untreated Douglas-fir timber can be used with confidence.

3.4.2 Laboratory (and in-field) testing.

3.4.2.1 Report by Dr M. Hedley, G. Durbin, L. Hansen, L. Knowles, 2004. "Comparative Moisture Uptake of NZ Grown Douglas-fir and Radiata Pine Structural Timber When Exposed To Rain-Wetting", Forest Research, Rotorua, NZ. Douglas –fir Co-operative Report No. 36.

This report concluded that Douglas-fir timber shows significant positive differences from radiata pine in terms of susceptibility to moisture uptake. In the winter trials radiata pine reached a moisture content which would sustain decay (approximately 27% mc) after 7 days exposure, and remained well above that moisture content for the remaining 48 days of the trial. The maximum moisture content attained by Douglas-fir throughout the trial was only 21.8%. See full report attached.

3.4.2.2 Report by A. J. McGuire "Durability and Treatment of Douglas-fir" presented as a paper at FRI Symposium No 15, 1978 A Review of Douglas-fir.

The author outlines that Douglas-fir timber is suitable for use as a building timber without preservative treatment where protected from the weather. This having been standard practice for many years and has not been known to cause any problems. An explanation of the cell structure changes that occur during drying (and in heartwood formation) explain the reason for the extremely low permeability of the timber to water and preservative penetration. See full report attached.

3.4.3 Comment on the Pacific North West Experience

3.4.3.1 Comparative Analysis of Residential Construction in Seattle, WA and Vancouver, BC

In Vancouver and the lower Mainland of British Columbia, Canada and in Seattle Washington, the response to a similar leaky homes crisis was to introduce a rain-shield based on a four pronged approach: Deflection, Drainage, Drying and then Durability (the 4D's). The focus has been on keeping external moisture out of the wall cavity through better design and construction. The natural durability of Douglas-fir framing, which resists taking up moisture, was judged sufficient to allow its continued use, untreated.

3.4.3.2 Durability and Performance of Building envelops, by Michael A Lacassa, Institute for Research in Construction, National Research Council Canada.

This article reviews the important issues for assessing long-term performance of wall assemblies. Moisture is identified as the primary agent of deterioration. See full report attached.

3.4.3.3 Recent Studies on the control of rain penetration in exterior wood – frame walls, by Michael A Lacassa, from the Institute for Research in Construction, National Research Council Canada.

A key design element for exterior walls is the control of rain penetration. Lack of attention to design principles or failure to implement them in the detailing of wall components may lead to premature deterioration of wall elements as has been evident across Canada in past years. See full report attached.

3.4.3.4 Report on "The Envelop Drying Rate Analysis Study – conducted as part of the program of the British Columbia Building Envelop Research Consortium (BERC)

This paper confirmed that builders and designers should follow the 4-D Principles (Deflection, Drainage, Drying and Durability) with particular emphasis on deflection and drainage. It also demonstrates the use of rain screen cavities improves the deflection and drainage contributes to drying. See full report attached.

3.4.3.5 Report on British Columbia Moisture Management Experience by D.R. Rickets, P. Eng.

Dave Ricketts, P. Eng., is one of the British Columbia building industry's most influential experts on building envelope problems and solutions. He was retained by the Barrett Commission of inquiry in British Columbia to help develop the technical recommendations for the Barrett Report, and has recently been appointed to the Provincial Advisory Council for the New Homeowner Protection Office. He is also the prime author of the Building Envelope Rehabilitation Guide which identifies the current best practice in design and construction and addresses the differences between new and rehabilitation construction.

Mr. Ricketts is also the author of numerous authoritative industry reports and guides on building envelope practices in the coastal climate of British Columbia, and is the President of the British Columbia Building Envelope Council.

Supporting Documents

In Service Histories

Professional Endorsements

Len Cadzow
25 March 2003

Southern Douglas-fir Producers Association.
C/- Mr. Paul Adams.

This writer is asked to offer comment on the decision to modify the building standard NZS 3602 to require that all structural timber used in house construction in New Zealand be chemically treated, which in effect would prevent the use of Douglas-fir (N.Z. Oregon) because of its inability to be pressure treated.

The above requirement arises from the investigation into the leaky home syndrome carried out in 2002/03, the results of which appear to this writer to be far more politically driven and directed, than would have been the case had the real reasons for the problem, historical background, and common sense, been given the opportunity to be seriously heard and considered.

I am Leonard William Cadzow of Mosgiel with a carpentry apprenticeship commencing in 1941 and being an ex Building Contractor for 30 years standing, Master Builders Association Secretary to twelve years, a New Zealand Master Builders Federation Management Councillor for twelve years, a Building and Construction Industry Training Officer for three years, a Life Member of the New Zealand Master Builders Federation and the Otago Master Builders Association, a Fellow of the New Zealand Institute of Building (FNIOB), Retired Associate member of the A.I.O.B. (Australian Institute of Building), A.C.I.Arb (Associated Chartered Institute of Arbitrators U.K.), A.N.Z.Irb (Associate of the New Zealand Institute of Arbitrators, A.A.I.A. (Associate Australian Institute of Arbitrators).

The principal argument I bring to the durability issue of N.Z. Oregon (N.Z.O) is my experience with NZO and OB or sap Rimu. In my apprenticeship days Pinus, in the main Pinus insignus was not permitted on site, even for concrete formwork. My earliest experience of Radiata Pine was its use in interior panelling where it became recognised by its marketing name of Knotty pine. However with the introduction of Pinus Radiata as sawn construction timber we soon learnt the limitations this timber had when faced with competition from rimu.

With the price of rimu slowly increasing, boron treated radiata started to gain certain popularity as did the small quantities of N.Z.O which were beginning to become available. Rimu, because of price started to be replaced by Radiata and N.Z.O, builders started to assess the pros and cons of these two timbers, and those who had previously had any experience of Canadian Oregon (both select and merchantable) immediately accepted N.Z.O in favour of radiata, and while heart rimu was still used for sub-floor framing N.Z.O became the timber used for wall, ceiling and roof framing. Eventually rimu framing timber, the principal timber used for hundreds of thousands of New Zealand houses for over one hundred years came to an end, and in that time there does not appear to be any recorded evidence of problems associated with rot or decay. Whatever timber would replace rimu would for some time be compared to rimu, and its variety of uses.

In this regard Radiata could not match rimu for strength and its durability was questioned, but by treating radiata, its durability was enhanced to match rimu but not its strength. On the other hand N.Z.O matched sap or OB rimu for strength and for some of us, the earliest use we made of N.Z.O, almost fifty years ago, suggests its durability to be at least equal to rimu.

This writers earliest experienced was the fabrication and erection of N.Z.O roof trusses on a shearing shed at Waikoikoi west of Tapanui in March 1957 for the late Mr Henry Gow. The shed stands today with the truss timber as sound as at the time we used it. In the years that followed from that time my work comprised medium commercial work and high class housing. In my particular case all framing timber used above sub-floor level was either rimu or N.Z.O, but in later years was always N.Z.O. Below floor level, heart rimu or tanalized radiata was used. It is this writer's belief that N.Z.O is equal to or superior than sap rimu anywhere that rimu would have been used in the past. The comparison between rimu and N.Z.O is purposely used in this submission as a comparison between two untreated timbers. N.Z.O in this writer's opinion gives builders a wider range of on site uses than radiata. From the last house lot of N.Z.O 100 x 50P.G. that this writer ordered for a house I built for my wife and I, the large number of 7.2 M knot free lengths delivered, I was able to acquire quality exposed rafters and joinery timber for a light well. Whilst I am aware of N.Z.O being used for horizontal weatherboards and vertical board and batten in Queenstown and other Central Otago areas, my belief is that N.Z.O is primarily a quality structural timber. Like Rimu its durability to moisture was never a concern, our construction techniques, with the use of metal flashings and ventilation and drainage cavities prevented the ingress of water into the framework. The current modification to NZS 3602 is not due to the failure of timber to natural deterioration, but rather to overcome results of the incompetence of so call tradespersons, why then should a quality timber be penalised because the Government does not want to eliminate the incompetent as a means of keeping the cost of housing to a minimum. With the experience I bring to this issue the suggested banning of N.Z.O is in my opinion nothing more than political interference, trying to convince a New Zealand public that the Government of the day will ensure them safer housing. Such political nonsense was highlighted when the Government in its first reaction to the problem, had the C.E.O of the Building Industry Authority in Wellington removed from office, because some incompetent clowns in Auckland had built rot-prone houses in Auckland, before Dr Bill Porteous had even been given the C.E.O's position. A fair comparison to this kind of political nonsense would surely demand that Mr Trevor Mallard as Minister of Education be sacked the next time a teenage schoolgirl becomes pregnant.

While the evidence being accumulated in respect of using treated or non treated timber in house construction appears to be weighted in favour of treated timber, the evidence is being gathered in accelerated laboratory conditions. As the need for information is urgent, this situation is understandable, but houses do not exist under accelerated climatic conditions.

Do the authorities therefore have any evidence from real, in the field examples, of where N.Z.O has failed when used correctly. We certainly have not after a use period of not less than forty seven years, sporadically over the first ten years, but with the reduced availability of rimu, constantly for the last thirty to thirty five years. Unless N.Z.O has been shown to fail under normal conditions of use in the field, there surely has to be a case to answer from the Building Industry Authority. After two thousand years we do know how to build weathertight homes. That there are people who chose through ignorance and incompetence not to do so, should not be a reason to prevent the use of a timber found by experience to be perfectly suitable for the purpose for which it was grown - Construction Framing.

In all the houses this writer has built using a concrete floor slab, we always fixed a 100 x 50 tanalized sole plate over a malthoid damp proof course on top of which we erected the wall frames. This was done as an added protection to the bottom plate of the wall framing to keep it completely clear of the concrete.

With the introduction of new materials, new problems arise. One of the first of these was the mandatory insulation of houses, and the subsequent fungi and mould problems that developed within the basement areas.

The peeking and popping issue associated with the introduction of tapered edged Gibraltar Board wall lining. The current trapping of moisture within new houses due to the speed modern construction techniques permit, allows the escaping moisture of the concrete to affect the kiln dried timber used.

There is a history to the New Zealand Building Industries problems, much too long to background here, but while this writer was a member of the New Zealand Master Builders Federation's Management Committee in the late 1980's the Auckland members of that committee sought the support of the N.Z.M.B.F to seek a change to NZS 3602 permitting the use of untreated radiata pine in house framing. While the South Island members were aghast at the idea, the Auckland builders were supported by the rest of the North Island members and as usual won the day. Coupled with the incompetence generated by labour only contracting it is very easy to see why the leaky home scenario became a National issue, and whilst we will never know, this writer will continue to believe, until shown otherwise, that none of the rotted timber was N.Z.O.

It would appear from the amendment to NZS 3602 that all those hundreds of thousands of rimu and other untreated timber framed houses built in the first one hundred and more years of New Zealand settlement, would today have had to have treated timber, yet many have doubled the durability period of fifty years demanded by the code and most of them will. The evidence is there to be seen, yet authority demands that incompetence be upheld and protected by an inferior treated timber, while a timber for which I have never heard an anti quality comment, nor have I witnessed it in a self deteriorating state, would be subjected to rejection, without a fight. While the use of an alternative solution may overcome a legal imposition, it is this writer's belief the southern Douglas-fir producers need to seriously organise and mount a concerted campaign to overturn a decision based on scientific rather than real facts. North Island organisations would certainly put up a fight.

In summary the writer's considered opinion is that N.Z.O. is a suitable structural timber for all wall, ceiling and roof framing (i.e. all framing above sub-floor), where professional construction techniques, metal flashings and ventilation and drainage cavities prevent the ingress of water into the framework. Under such conditions the writer believes that N.Z.O. can last for more than 50 years in situ without any degradation or failure. If considered desirable a treated (H3) sole plate can be utilized, for added protection, under the normal external wall framing.

Len Cadzow

Ministry of Agriculture and Forestry
Te Manatu Ahuwhenua, Ngaherehere

6 August 2003

SUBMISSION TO: Building Industry Authority
P O Box 11-846
Wellington

SUBMISSION ON: BIA CONSULTATION DOCUMENT

Building Code Clauses B2 Durability

Proposed Changes to Acceptable Solution B2/AS1

For Public Comment

SUBMISSION FROM: MAF Policy
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The Ministry's Position

1. The Ministry believes that the BIA's proposals should be amended to target the Proposed Changes to Acceptable Solution B2/AS1 according to the wood properties of principal tree species, the type of structure, and the nature of the cladding system.

Rationale for the Ministry's Position

2. The Ministry concurs with most of the Consultation Document. However, the Ministry considers that the information presented does not adequately justify the conclusion and proposal that all house framing timber be treated to the H1.2 level.

3. The Ministry notes that:

   a) The principal factors associated with the systemic failure of the building control system (as identified in the Hunn Report and the Government Administration Committee's Report) do not include the use of untreated framing timber. (See Consultation Document, Appendix One, 1.0 Background).

   b) The Government Administration Committee inquiry concluded that the weathertightness problems appear to be mainly associated with multi-unit, speculative housing, and very complex, high cost, single story family homes, with a focus on the Auckland area. (See page 12 of the Committee's Report).

   c) Most leaking houses have "monolithic" claddings. (See Consultation Document, Appendix One, 2.0 Nature and Magnitude of the Problem and the Need for Action).

4. The Ministry therefore considers that the use of untreated and untreated, kiln-dried framing timber should not be regarded as a cause of the weathertightness problem. However, it exacerbates the resulting decay once weathertightness failure occurs.

5. The extent of the weathertightness problem is difficult to determine, but clearly relates to a small fraction of the houses that have been built in the last ten years. The Building Industry Federation has described the problem as affecting less than 1 percent of new houses.

6. The Ministry also notes that the BIA's proposals must be considered alongside the proposals for better regulation of the building industry, as announced by the Minister of Commerce in May 2003.

7. Accordingly, the Ministry considers that if:
   - the timber framing is not the cause of the problem;
   - the problem is largely limited to certain types of structures and cladding systems that comprise a small percentage of the new houses built; and
   - the building industry will be better regulated;

   then requiring all house framing timber to be treated is unjustified.

The Douglas-fir Sector

8. The Douglas-fir sector of the New Zealand forest industry would be particularly affected by the proposals. Industry spokespeople have estimated the sustainable market value of sawn timber from the current Douglas-fir estate at $320 million per year, and the value of the estate itself at about $1 billion.

9. Douglas-fir contains a much greater proportion of heartwood than radiata pine. Most of the sawn timber produced is heartwood (although the proportion is lower in younger thinnings) and is immune to insect borer attack. Sapwood is seldom attacked by the common house borer. Neither the sapwood nor the heartwood can be properly pressure treated with copper-chrome-arsenic (CCA) for higher hazard risk situations, but the sapwood can be treated by the boron diffusion method to a level proposed by the new H1.2 standard to give some resistance to fungal attack.

10. Because Douglas-fir contains a high proportion of heartwood that cannot be treated with preservatives, the BIA's proposals essentially exclude the use of Douglas-fir for structural purposes such as framing, joists, trusses and purlins, and eliminate the principal New Zealand market. Yet Douglas-fir has an excellent reputation as a structural timber (generally untreated) on both the domestic and international markets. The sawn timber is more stable than radiata pine, and is described in FRI Bulletin No.124 (14 Douglas-fir) as suitable for use in buildings without preservative treatment. As it dries with little distortion it can be sold to the end user straight off the saw.

11. In theory, use of Douglas-fir could be approved under the "Alternative Solution" mechanism, but that operates on a case by case basis, adds cost, and does not provide the necessary end-use "certainty" for the forest growers or processors to invest in the industry.

12. Under the BIA's proposals, the growing of Douglas-fir in New Zealand would need to be almost totally re-focused on to the export market. This has been largely untested by New Zealand growers and processors of Douglas-fir, with only small volumes of sawn timber and logs exported to date. It is understood that overseas sawmills generally seek larger diameter logs than are currently produced in New Zealand under a 45 to 50 year rotation. Longer rotation lengths would therefore be necessary to meet export requirements.

13. The ability to re-focus on the export market is therefore uncertain. It is also contrary to the Government's objectives (as expressed under the Wood Processing Strategy) of maximising on-shore processing of wood products and so reducing reliance on unprocessed log exports.

14. The domestic and international use and reputations of Douglas-fir as a structural timber suggest that its coverage by the BIA's proposals for all house framing timber to be treated, is unjustified.

Treatment of House Framing Timber

15. The BIA's proposals should address the causes of timber decay in residential buildings (design and construction related), rather than addressing a symptom of the problem (decay of untreated timber exposed to moisture uptake).

16. The Ministry believes that the BIA should work with industry and research representatives to develop a regime that recognises the wood properties of the principal tree species used for house framing timber. The regime should also limit the requirement for treated framing timber to predetermined risk situations, and the types of structures and cladding systems that have been at the centre of the weathertightness problem.

Mike Jebson
Director, Sustainable Resource Use Policy

Carver Architects Ltd
Ref 04.99
11 March 2004

Mr Scott Gibbons
General Manager
Waimea Sawmillers Ltd
PO Box 7004
Nelson

Attention: Scott Gibbons

Dear Scott,
Re Endorsement for Douglas-fir

As an NZIA registered architect involved in the building industry for over 20 years, I was quite surprised to read that Douglas-fir was to be disallowed in construction of buildings in New Zealand. If the current changes are put through, then our liability insurers, (ie: those used by a majority of NZ Registered Architects), will not allow us to specify Douglas-fir.

I have used it for framing and linings in many successful projects over the years. I see no reason why Douglas-fir cannot be used behind certain claddings in conjunction with a drained and ventilated cavity and in certain other situations. Other factors, such as local wind exposure, eave overhangs, and the like need to be carefully considered as well.

I have read the proposal put forward by the Douglas-fir Industry, outlining certain conditions under which Douglas-fir could be considered. I personally consider this to be very appropriate. Just as with other facets of design, covering bracing, etc where site conditions such as wind exposure and earthquake zone are considered and vary the extent of bracing required, this tabulated approach seems appropriate and workable.

It also allows a client the option to use untreated Douglas-fir as an alternative to treated pine. This is becoming more and more relevant to clients, especially with regard to play centres and the like.

We hope that this proposal is accepted allowing our clients to select the Douglas-fir option.

Yours faithfully

Richard Carver
Principal Architect
Carver Architects Ltd
Nelson

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Don Frame RMNZIBS RMNZIOB RMBOINZ

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11 March 2004 **File 2067**

To whom it may concern

Alternative Solution - Douglas-fir:

Special Note

My response relating to the use of Douglas-fir Timber in the structural framing of buildings, is my opinion only, and not that of the various Institutes that I am a Registered Member of.

Background:

The first time I worked with Douglas-fir was making around 1000 (three glass pane) sashes for single light windows for the State Hydro single men's huts at Roxburgh. These were made from Douglas-fir trees grown at Conical Hills near Tapanui. Some of these sashes are still serviceable and have provided 53 years of durability.

I have been involved in the Building Industry for over 50 years, both hands-on, inspection, and administration. For around 40 years of construction, mainly in Otago, Southland, and more recent Nelson I recommended the use of Douglas-fir providing it was reasonably 'clean', this timber will remain stable and borer resistant. Like any other wood fibre timber it must be kept dry, if not will decay.

I recall around 30 years ago while attending a Conference in Napier, Forestry Service introduced us to Kiln Dried Radiata that was to be borer free. I remember asking about New Zealand Oregon (Douglas-fir) and was told that as the majority of the forests were in the North Island were Pine, they were not concerned about Douglas-fir because it did not require treatment and was borer resistance.

During the early 1970's I was involved in some research relating to the proposed Insulation Bylaw Requirements that involved in moisture testing of various framing timber, Radiata, Douglas-fir, and Sap Rimu. This was to identify at what moisture levels the various species began to decay. Up until that period all external framing was allowed to 'breath' by have holes bored in the bottom, top plates including the dwangs (nogging). The air circulated through these voids and was dispersed through the roof space natural air flow. We always vented the soffits with 'peg-board' at each corner and where gables existed, placed in a bird-proof timber louvre vent. This allowed the building to 'breath', evaporate any moisture penetration through air drying within the wall cavity.

With the advent of the insulation during mid 70's, this air flow was cut off. No external wall ventilation was allowed. The soffit line was blocked off with building paper to prevent any moisture entry into the roof space. I recall many arguments that within 25 years many dwellings would be rotting. This is now happening. The use of Douglas-fir to external wall framing in my view is irrelevant, as any timber that remains wet will decay. More so with treated timber, if it gets wet will decay the linings and allow various toxins and fungi *(Stachybotrys atra*) to escape causing a health risk. Attachment (*Workplace Health Bulletin)*

Recommendation:

1. Douglas-fir has proven over the past 50 years it meets the Durability requirements of the Building Code. It not the timber that has failed, but the Administration of both BRANZ and the Building Industry Authority by inadequate research and direction on preventing a building to 'breath'.

2. Providing Douglas-fir is kept dry (free from external cladding leakage) it will remain durable for more than 50 years plus.

3 The BIA, BRANZ and Standards have **now** suggested that we go back to providing a ventilated external cavity to our buildings, and intend to exclude Douglas-fir. It is my view that this new requirement has been dominated by a group with interests in the Pine Industry.

4 This new requirement will also fail due to no external wall ventilation through natural air flow back into the roof space. My research in the 70's showed that cavity moisture became stagnant around 1.5m up the wall and penetrated the plaster board causing black mould, fungi and dampness on the wall paper. Once the cavity was ventilated the plaster board dried out and the fungi disappeared. What is proposed will create the same issues that I investigated 25 years ago.

5 I consider that Douglas-fir has not been given a fair hearing and has been blamed for our 'leaky buildings'. That is not true, it not the timber that has failed, but the cladding that the BIA and BRANZ have previously approved.

6 Unless the Authority provides a full ventilated (free air flow) cavity, buildings will continue to decay whether or not Douglas-fir has been used. If the proposed Standard is allowed to dominate the Industry, buildings constructed today will again leak within the next 25 years. History repeating it's self.

7 Douglas-fir is permitted in brick cavity construction where full cavity ventilation remains, why not allow Douglas-fir in other external cavity construction? Reason is possibly that Radiata requires treatment and Douglas-fir none.

Qualifications and Membership:

- > Registered Member New Zealand Institute of Building Surveyors No 0027
- > Registered Member New Zealand Institute of Building No 607
- > Registered Member Building Official's Institute of New Zealand No 552
- > Trade Certification Carpentry and Joinery No 1220
- > Affiliate member Arbitrators' and Mediators' of New Zealand Inc.
- > Retired BRANZ Accredited Advisor
- > NZIBS Weathertightness Course 2002
- > Retired Registered Master Builder No 2667

Comments made in this review are my own personal views and not that of the various Institutes mentioned above that I am a member of.

Reviewer's Experience:

I have had more than 50 years involvement within the Building Industry, both ‘hand-on’, construction, administration and supervision. I commenced my Apprenticeship in 1951 and the holder of a Trades Certificate in Carpentry, Joinery and Machining. Over these years I have been accepted into various Institutes as a past Registered Master Builder, a Retired Building Research Accredited Advisor, and at present a Registered member of the New Zealand Institute of Building Surveyors, New Zealand Institute of Building, Building Official’s Institute of New Zealand, a member of the Arbitrator’s and Mediator’s Institute of New Zealand Inc., and have acted as an advisor to several Territorial Authorities. For the past 35 years I have been involved with more than ten thousand investigations that include disputes, leaky homes, inspection assessments, property evaluations and other related building failures. I believe I am able to make such comment, assessment and form an opinion based on the vast knowledge and experience I have gained over these years.

Signed

D G Frame
Building Surveyor
NZIBS NZIOB BOINZ
(Registered)

Tim Barton Architect
Wednesday, March 24, 2004

The Coordinator
Southern Douglas-fir Producers
C / o PO Box 7004,
NELSON

Dear Sir

THE USE OF DOUGLAS FIR
IN DOMESTIC EXTERNAL WALL FRAMING

I support the greater use of Douglas-fir in the NZ building industry. While changes to codes and standards are required to control and restrict the use of some cladding systems, and to prevent a further fall in the craft of building, recent changes to NZS 3602 and NZBC B2 / AS1 are premature and do not take the natural advantages of Douglas-fir sufficiently into account.

The regulatory changes have been driven by failures in cladding systems. A proper evaluation of the effectiveness of cladding systems should *precede* changes to the treatment of timber behind the claddings. Only when we have an idea of the risk and frequency of water penetration through the cladding should we attempt to determine the durability requirements of the structure behind the cladding

Knowing that drained cavities will be required behind monolithic cladding systems, and assuming that drained cavities will be required behind most other cladding systems, my experience is that a properly constructed drained cavity will reduce the risk and extent of water penetration to such an extent that the inherent low-level decay-resistance of Douglas-fir is sufficient to allow its use in external domestic wall framing in most NZ situations

The widely publicised (but geographically localised) failures in house claddings have quite properly brought into question the durability of the structure behind the cladding. It is realised that no cladding system is absolutely leak-proof in all weather conditions over the 50-100 year life of the building. It is prudent to require that there is some minimum resistance to rot in external wall (and other) timber framing. The changes to treatment requirements for Pinus radiata well reflect that requirement. However in regulating for Pinus radiata, insufficient account has been taken of the natural and inherent advantages of Douglas-fir.

The comparative advantages of Douglas-fir with respect to Pinus radiata are:

- Greater resistance to absorption of moisture
  (and parallel resistance to the fungal decay induced by moisture)

- Greater stiffness
  (less deflection under load)
- Available in larger sawn lengths and cross-sections
  (by virtue of being cut from trees which naturally grow larger)
- Fewer knots
  (stronger and straighter)

Of course only the first advantage is really significant to the durability argument. However it was compelling enough to convince regulators in British Columbia, Canada, where the building industry had undergone an uncannily similar catastrophe 10 years before NZ, that Douglas-fir, where protected behind a drained cavity, was sufficiently durable for use in domestic external wall framing

I agree with the recent changes to NZS 3602 and NZBC B2/AS1 in so far as:
- drained cavities impart much higher resistance to water penetration.
- Even behind drained cavities, pine should be treated to H1.2 when used in external wall framing
- complex and leak-prone parts of buildings (such as parapets and balconies) should be framed only with H3 treated timber
- unventilated parts of buildings (such as under flat roofs) should be framed only with H3 treated timber

However I disagree with recent changes to NZS 3602 and NZBC B2/AS1 which ban the use of Douglas-fir in domestic external wall framing generally. I disagree with unnecessary use of poison into our saw-mills, building sites and houses. I am dismayed that the regulation of building practice has become politicised and irrational.

I hold degrees in Architecture and Building Science from Victoria University of Wellington. I have been involved with the building industry for some 35 years and have practiced architecture for 25 years. My knowledge of the performance of cladding and the durability of timber has been informed by academic study, by the design and evaluation of a large number of buildings, and (not least) by the examination of older buildings during their dismantling prior to alteration. I specified Douglas-fir wall framing for the house in which I live.

I support the use of Douglas-fir as an Alternative Solution to NZBC B2/AS1 by virtue of its in-service history and laboratory testing.

Yours faithfully

Tim Barton

W. R. ANDREW LTD

CONSULTING ENGINEER

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18 March 2004

Waimea Sawmillers Ltd
P O Box 7004
Nelson

Attn: - Scott Gibbons

Dear Sir

RE: **Douglas Fir - An "Alternative Solution"**

We endorse your proposed alternative solution for use of untreated Douglas Fir for external framing in low risk situations where there is a drained cavity between the framing and exterior cladding.

Our opinion is based on the superior durability of Douglas Fir compared to untreated Pinus Radiata. Douglas Fir has a natural resistance to moisture absorption, which significantly reduces the risk of the timber framing reaching a moisture content that would sustain decay when moisture or water temporarily penetrates a drained cavity.

For external wall cladding systems with a cavity it is our opinion that Douglas Fir would be at least as durable as H1 treated Pinus Radiata as the H1 treatment is only suitable "for situations which are adequately ventilated and continuously protected from the weather by roofs or external walls." (Quoted from MP3640: 1992)

The use of Douglas Fir in this situation has been common practice in the NZ building industry and North America for over 50 years and the performance of Douglas Fir is known to be satisfactory.

Yours faithfully

W. R. Andrew

(File: Letter.doc)

Roy A. Faris FNZICW, AIArbA, MNZIBS, JP
March 26, 2004

ALTERNATIVE SOLUTION
Douglas-fir (New Zealand Oregon)

3.4.1 In Service History

3.4.1.4 Endorsement by Roy A. Faris

Roy has been involved in the construction industry for the last 45 years from a trade background MOW Building Overseer, Clerk of Works Dunedin City Council and since 1973 own consultancy practice as Building Surveyor, Clerk of Works, Project Manager and construction failure investigator.

For the last 30 years he has been directly involved within the construction industry assisting with failure investigation, construction dispute resolution and as the BRANZ (Building Research Association of New Zealand) Advisor for the Central Otago area.

Roy is a Fellow and Past National President of the New Zealand Institute of the Clerk of Works and Founding President, and executive member of the New Zealand Institute of Building Surveyors.

During the last 30 years especially, I have undertaken many investigations, surveys, arbitrations, and litigation, as an expert witness in building failures, both product, systems and workmanship.

In all that time I have found New Zealand Oregon to be a perfectly satisfactory framing timber for all framing above sub floor level, providing the common sense rules of drainage, drying and deflection are adequately dealt with in the constructions system.

It is my view that New Zealand Oregon is a very good timber for all general framing as it allows only minimal water uptake and a very rapid dry out after wetting. Further, it is my opinion that New Zealand Oregon has proved itself as an above sub floor framing timber suitable and able to meet the requirements of B2 of the Building Code Handbook and the 50 year minimum durability requirement as detailed.

This endorsement assumes construction systems that provide drainage cavities and have the ability to ventilate and dry out and that exterior joinery and dissimilar material junctions are all treated with appropriate flashings and weatherings.

Alternative solution

This endorsement using the verification method B2-VM1 is based on in service history knowledge over a period of more than 40 years, providing the following criteria is met and forms part of the consent application.

New Zealand Oregon for all timber framing above sub floor level.
Alternative Solution criteria

CRITERIA

1-01 Low to medium risk construction.

- Buildings categorised for low risk if they.—
  - are of single storey,
  - and/or have a roof pitch of at least 10 degrees and/or
  - have eaves of 450mm or more and/or
  - are in a low wind zone.

- Buildings categorized as medium risk if they-
  - are of 1 ½ story and/or
  - have a roof pitch of at least 8 degrees and/or
  - have eaves of 250mm or more and/or
  - are in a low to medium wind zone

1-02 Low to medium risk cladding systems

- Cladding systems that comprise.—
  - concrete and clay brick veneer over drained and ventilated cavity
  - timber weather boards fixed over a drained and ventilated cavity
  - fibre cement weather boarding fixed over a drained and ventilated cavity
  - stucco fixed over a drained and ventilated cavity
  - horizontal corrugated steel sheet fixed over a drained and ventilated cavity
  - vertical corrugated steel sheet fixed to framing
  - painted plywood sheet claddings fixed over a drained and ventilated cavity
  - fibre cement sheet claddings fixed over a drained and ventilated cavity
  - EIFS cladding fixed over a drained and ventilated cavity

1-03 Construction systems

Low to medium risk construction systems shall include and comprise the following.—

- Full details of all exterior joinery, flashings to head jamb and sill
- Full detail to all roof and associated weathering flashings.
- Full flashing and junction detail including control joint detail, all junctions of dissimilar materials and/or sub strata.
- A complete building wrap laid horizontally and fixed prior to any cavity or cladding system.

1-04 General

That all documentation be complete for the Building Consent Application and include an attached statement regarding compliance with all of the above conditions.

Roy A Faris

G.R. Littler

Consulting Civil & Structural Engineer

44 Theodosia Street
Timaru

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Timaru

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5 April 2004

Southern Douglas Fir Producers Association.
C/- Mr. Paul Adams.

ALTERNATIVE SOLUTION FOR USE OF DOUGLAS FIR IN BUILDING:

I have been in the construction industry for 30 years, twenty two of those as a Registered Engineer. I have run my own consulting engineering business since 1986, with most of the workload involving domestic and light commercial buildings in the South Canterbury area.

I have not experienced any problems during that time with the durability of Douglas Fir when used in conventional timber framing. In light of the changes to the Building Act in regard to the level of timber treatment to be used for various components of light timber framed buildings, I would fully endorse the proposed Alternative Solution. This solution, I believe, will eliminate the risk of Douglas Fir being used in inappropriate situations, and will allow the end user, the client, to maintain the choice of using chemical free timber.

The Alternative Solution in my opinion addresses the many types of construction available as well as considering the different climatic conditions present in the country in a logical way.

Yours faithfully

Gary R Littler

G.R.Littler, B.E. (Hons), M.I.P.E.N.Z.
Member of A.C.E.N.Z.
Member

ipeNz

New Zealand TIMBER INDUSTRY FEDERATION INC

28 June 2004

Alternative Solution – New Zealand Oregon

This is to confirm our support for the document "The Alternative Solution for Untreated Douglas Fir (New Zealand Oregon) in Building Construction."

Our organisation has consistently held that so called "leaky building" issues have been caused by poor design, poor workmanship or poor cladding systems (or a combination of all three).

Regulatory changes have now forced improvements with respect to design, workmanship and cladding systems.

In general it should not therefore be necessary to treat wall frames and trusses.

However rather than require treated timber only in areas of vulnerability (where the cladding system and/or design is still deficient) the new regulations require treated timber (both pinus radiata and New Zealand Oregon) in situations where there is little risk of moisture ingress.

We note that your Document has categorised these risk levels and in so doing identified where untreated timber can be used with confidence.

The NZTIF is New Zealand's largest and oldest timber association.

Our collective experience spans over 100 years of building practise in New Zealand.

In our opinion the solution offered in your Document is well researched and well supported by the practical experience of the Members of this organisation.

We recommend its immediate implementation as a transitional step towards amendments to NZ3602.

Yours sincerely

Wayne Coffey
EXECUTIVE DIRECTOR

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E-mail: inquiries@nztif.co.nz
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<u>Supporting Documents:</u>

Laboratory testing

Comparable performance of similar building elements

<u>Attached documents:</u>

CMHC 2003. The Envelope drying rates analysis study. Technical Series 01-139. Canada Mortgage and Housing Corporation, Ottawa, Ontario, 8p. *

Hedley, M., G. Durbin, L. Hansen and L. Knowles 2004. Comparative moisture uptake of New Zealand grown Douglas-fir and Radiata pine structural timber when exposed to rain-wetting. Forest Research, Rotorua, NZ

Holger Militz, Cor Blom and Christian Hof (2004) Lap-joint trials in natural durability testing. http://www.bfafh.de/inst4/43/ppt/5lapjoin.pdf

Lacasse, M.A. 2003. Recent studies on the control of rain penetration in exterior wood-frame walls. National Research Council Canada, Institute for Research In Construction NRCC-46889 7p. * michael.lacasse@nrc-cnrc.gc.ca

Lacasse, M.A. Durability and performance of building envelopes. National Research Council Canada, Institute for Research In Construction NRCC-46888 6p. *

McQuire A.J. 1978. Durability and Treatment of Douglas-fir. A review of Douglas-fir in NZ. FRI Symposium no 15. Report no 20. *

NZ BIA E2 Guide. Introduction to External Moisture. Acceptable Solution E2/AS1 (third edition, 2004). Philosophy underpinning E2/AS1

Ricketts D. R. 2004 British Columbia Moisture Management Experience. RDH Building Engineering Limited, BC, Canada. Report commissioned by NZ Douglas-fir Forest Owners and Sawmillers

(*separately attached)

Comparative moisture uptake of New Zealand grown Douglas-fir and Radiata pine structural timber when exposed to rain-wetting

Report prepared for Douglas-fir Research Co-operative

by

Mick Hedley, Gavin Durbin, Lars Hansen and Leith Knowles
Forest Research, Rotorua, NZ

Douglas-fir Research Co-operative Report No. 36

SUMMARY

Trials were undertaken to determine the relative resistance of radiata pine and Douglas-fir to wetting when exposed to the weather.

Douglas-fir samples were obtained from one Central North Island and three South Island sources and had a heartwood/sapwood mix typical for each resource. Radiata pine sapwood and heartwood samples were obtained from a Central North Island source. Material was exposed to the weather as horizontal studs in the first trial, and as horizontal or vertical studs in the second trial. The first trial ran over later winter from 29 July to 22 September 2003; the second, and more comprehensive investigation, from 22 October to 17 December 2003.

In the first trial, after 7 days exposure, radiata pine reached a moisture content which would sustain decay (~27% mc) and remained well above that moisture content for the remaining 48 days of the trial. However, the maximum moisture content attained by Douglas-fir throughout the trial was only 21.8 % mc.

In the second trial, radiata pine sapwood again rapidly attained a moisture content conducive to decay, and Douglas-fir did not. Because of the warmer and sunnier weather, fluctuations in moisture content were more pronounced than in the winter trial. Samples exposed horizontally attained higher moisture contents than those exposed vertically, irrespective of wood species or relative heartwood/sapwood content.

It is concluded that Douglas-fir timber shows significant positive differences from radiata pine in terms of susceptibility to moisture uptake. This trial confirmed the ‘refractory’ reputation of Douglas-fir, and the ‘absorbent’ reputation of radiata pine. At a practical level, Douglas-fir heartwood and sapwood can be regarded as equally impermeable, and independent of where in New Zealand it was grown.

INTRODUCTION

Untreated Douglas-fir and untreated radiata pine are assumed, to be at similar risk of decay when used in the same structural situations (NZS 3602: 2004 "Timber and wood-based products for use in buildings" and the NZ Building Code,). Neither is approved for use in the untreated state as framing for exterior walls except in buildings at a low risk of inadvertent moisture ingress.

Previous research has shown that a minimum wood moisture content of 27% is necessary for decay to be initiated in radiata pine sapwood when it is in contact with decaying wood (Page *et al.*, 2003). For the purposes of this report and conclusions, the conservative assumption is made that the minimum moisture for decay initiation is the same (27%) for Douglas-fir sapwood and heartwood and for radiata pine heartwood. However, once initiated, the rate of decay would be less in most examples of radiata pine heartwood and even less in Douglas-fir heartwood because of their comparative and greater natural durability than sapwood.

It is well-known that Douglas-fir (sapwood and heartwood) is a refractory species and is difficult to impregnate with water, even under pressure. Radiata pine sapwood, on the other hand, is much more permeable to liquid water. Radiata pine heartwood has more variable permeability; some being as permeable as sapwood, some being almost as refractory as Douglas-fir.

It has been argued that although both timbers would differ little in susceptibility to decay if they attained the same moisture content (~ 27% MC), there would be significant differences in resistance to moisture uptake if both were exposed to the same wetting regimes, such as that represented by rainfall. Being the more permeable, radiata pine would be expected to attain a moisture content suitable for decay much more readily than Douglas-fir.

PRELIMINARY TRIAL

To test that hypothesis, ten 3.5 m lengths 90x45 mm of Douglas-fir and six 3.5 m lengths of radiata pine were selected from stock at Forest Research. Douglas-fir samples tended to be more "hearty" than radiata pine samples. A 10 mm thick section was taken approximately 1 metre from one end and initial moisture content determined by weighing the section, oven-drying and reweighing.

Residual 2.5 m lengths were weighed and lightly hosed with water. Samples were then laid out on bearers on an open asphalted area on Forest Research campus. Samples were sufficiently high off the ground to avoid additional wetting by rain splash. Samples were weighed at irregular intervals, although the frequency of weighing increased as the trial progressed. Moisture contents were calculated at each weighing from initial moisture content, initial sample weight and increase/decrease in weight from the previous weighing. The trial commenced on 29 July 2003 and was terminated 55 days later on 22 September 2003.

Daily rainfall was recorded at a weather station located approximately 1 km NE of the trial. Although neither temperatures nor sunshine hours were recorded, the weather could be regarded as typical for late winter in Rotorua.

Results (Fig 1) showed that after the first 6 days exposure - during which time 11 mm of rain fell - the moisture content of radiata pine reached the minimum required to initiate decay in that species (blue line in Fig 1). It remained above that minimum for the next 49 days after which the trial was terminated. In contrast, the moisture content of Douglas-fir samples never approached the required minimum moisture content throughout the whole period of the trial. In one 24 hour period in this test (Day 38), framing was subjected to 40 mm rainfall. During that time the moisture content of Douglas-fir rose from 20.9% to 21.8%, well below the threshold moisture content of 27% required to initiate decay in radiata pine. During that same period, the moisture content of radiata pine rose from 39.7 to 43.1%.

Conclusions from the trial were that Douglas-fir is more difficult to wet than radiata pine and, under the conditions of the test, failed to reach a moisture content where there would be a risk of decay if it was in contact with decaying wood. Conversely, radiata pine reached this moisture content after 6 days exposure to rainfall and never went below that moisture content for the remainder of the trial.

Following this preliminary trial, the Douglas-fir Research Co-operative commissioned a more detailed investigation to assess moisture absorption characteristics of Douglas-fir from South Island sources and to compare this with that of Douglas-fir from the initial trial. Emphasis was also placed on determining if there were any significant differences in moisture absorption between Douglas-fir sapwood and heartwood in relation to that of radiata pine sapwood and heartwood.

MAIN TRIAL

Forty pieces of dried 90 x 45 mm gauged radiata pine 2.4m in length were selected from central North Island sources, with 20 pieces consisting entirely of sapwood and 20 of heartwood.

Thirty pieces of 90 x 45 mm gauged Douglas-fir, 2.4m in length were sourced from each of four locations: Rotorua, Canterbury, Tapanui and Naseby. Shipments contained samples which were 100% heartwood and up to 90 % sapwood. Samples were received either green or dried. Green samples were forced-air dried in the laboratory so that moisture contents of all samples at the commencement of the trial would be as similar as possible (Table 1). It was felt inappropriate to kiln dry all Douglas-fir shipments to a constant moisture content, since kiln drying this material is not common industrial practice.

Table 1 Initial mean moisture contents

Shipment/location	Initial mean moisture content (%) (range)
Douglas-fir Rotorua	13.4 (11.8 - 16.5)
Douglas-fir Tapanui	14.8 (13.1 - 16.8)
Douglas-fir Naseby	14.9 (13.2 - 16.9)
Douglas-fir Canterbury	13.4 (12.3 - 16.6)
Radiata pine sapwood CNI	12.1 (10.9 - 13.6)
Radiata pine heartwood CNI	13.9 (9.9 16.9)

The sapwood percentage of each piece of Douglas-fir timber was estimated, and the pieces from each separate source were divided into pairs with similar sapwood content. A nail was fixed at one end of one of each pair of samples so that it could be hung vertically from wire mesh which formed the East wall of a building located on Forest Research campus. The roof of this building was sufficiently high so that it did not impede exposure to rainfall..

The other pair of each sample was exposed horizontally in the same manner as the preliminary trial.

All wood samples of Douglas-fir and radiata pine were weighed immediately before exposing the test material to the weather over a 56-day period from 22 October 2003. All samples were weighed at intervals and weight gains or losses recorded. Weight gains and losses were then converted into changes in moisture content of individual samples.

RESULTS

Changes in moisture content over the 55-day exposure period are shown in Fig 2 (horizontal exposure) and Fig 3 (vertical exposure). Included in each figure is a line drawn at 27% moisture content, which is the limiting moisture content of radiata pine for decay to be initiated if susceptible wood is in contact with decaying wood (Page *et al.*, 2003).

Statistical Analysis

The moisture content measurements were analysed as effects of the following independent variables: location (timber source), position (horizontal or vertical exposure), sapwood percentage, and species using analyses of variance (PROC GLM of SAS 8.2). The effects of the independent variables were grouped using Fisher's Least Significant Difference (95% significance-level). The effect of sapwood percentage was modelled for Douglas-fir using a linear regression.

The effects of location of the timber for Douglas-fir are presented in Table 2. The effect of position for both species is presented in Table 3. The effect of sapwood percentage on moisture content for radiata pine is presented in Table 4, while the results for Douglas-fir are presented in Figure 4. The linear regression for moisture content as a function of sapwood percentage for Douglas-fir was significant with a slope of 0.018 ($R^2 = 0.03$).

A total of 19 different pieces of radiata pine had at some measurement time higher moisture content than the critical 27%, and on average those 19 pieces were above the threshold for 10 measurement times. For Douglas-fir only one piece at one measurements time was above the threshold.

Site	Mean	Standard deviation	Group
Canterbury	17.87	2.60	A
Naseby	17.48	2.22	B
Rotorua	17.75	2.73	A
Tapanui	17.37	2.36	B

Table 2 – ANOVA summary for moisture content of Douglas-fir as an effect of location. Combined effects of location and sapwood, and location and position were not statistically significant.

Position	Mean	Standard deviation	Group
Horizontal – Douglas-fir	18.26	2.75	A
Vertical – Douglas-fir	16.85	1.88	B
Horizontal – radiata pine	25.72	9.22	C
Vertical – radiata pine	18.58	4.70	A

Table 3 – ANOVA summary for moisture content of Douglas-fir and radiata pine as an effect of position. Combined effects of location and position, and sapwood and position were not statistically significant.

Wood	Mean	Standard deviation	Group
Sapwood	24.89	9.73	A
Heartwood	19.73	5.25	B

Table 4 – ANOVA summary for moisture content of radiata pine as an effect of sapwood/heartwood percentage. A combined effect of sapwood and position was not statistically significant.

Discussion

From Table 2 it is evident that there were statistically significant differences between Douglas-fir from some of the different locations. However, the absolute differences were very small, for example the wood with the highest average moisture content was that from Canterbury, and it contained on average 0.48 percent more moisture than the driest wood from Naseby. There were no combined effects between location and position, or location and sapwood percentage. In other words, wood from different sources does not react differently to position (vertical or horizontal) nor sapwood percentage (range 0-90%). Hence, it is concluded that all NZ grown Douglas-fir timber can be similarly classified with respect to moisture uptake, regardless of its origin.

From Table 3, it is evident that it was important how the wood was positioned, with marked differences between species. Horizontally positioned radiata pine had an average moisture content 7.1% higher than if positioned vertically. The difference for Douglas-fir was only 1.4%. Douglas-fir positioned horizontally did not differ significantly from vertically positioned radiata pine.

The amount of sapwood has only a small effect on the moisture uptake for Douglas-fir (Figure 4). The modelled difference between pieces which are entirely sapwood and are entirely heartwood is only 1.8%. For radiata pine, the difference in moisture content between all-sapwood pieces and all-heartwood pieces was 5.2 percent. Furthermore, pieces of Douglas-fir sapwood on average contained less moisture than pieces of radiata pine heartwood.

We conclude that Douglas-fir timber shows significant positive differences from radiata pine in terms of susceptibility to moisture uptake. This trial confirmed the ‘refractory’ reputation of Douglas-fir, and the ‘absorbent’ reputation of radiata pine. At a practical level, Douglas-fir heartwood and sapwood can be regarded as equally impermeable, and independent of where in New Zealand it was grown.

Reference

Dave Page, Mick Hedley, Betty Patterson and Jackie van der Waals. 2003. The effect of wood moisture content and timber treatment on initiation and development of decay in radiata pine framing. Report prepared for the Weathertight Buildings Steering Group, February 2003.

Fig 1 Moisture content of 90 x 45 x 2500 mm radiata pine and Douglas fir exposed to natural rain wetting after initial artificial wetting on Day 0

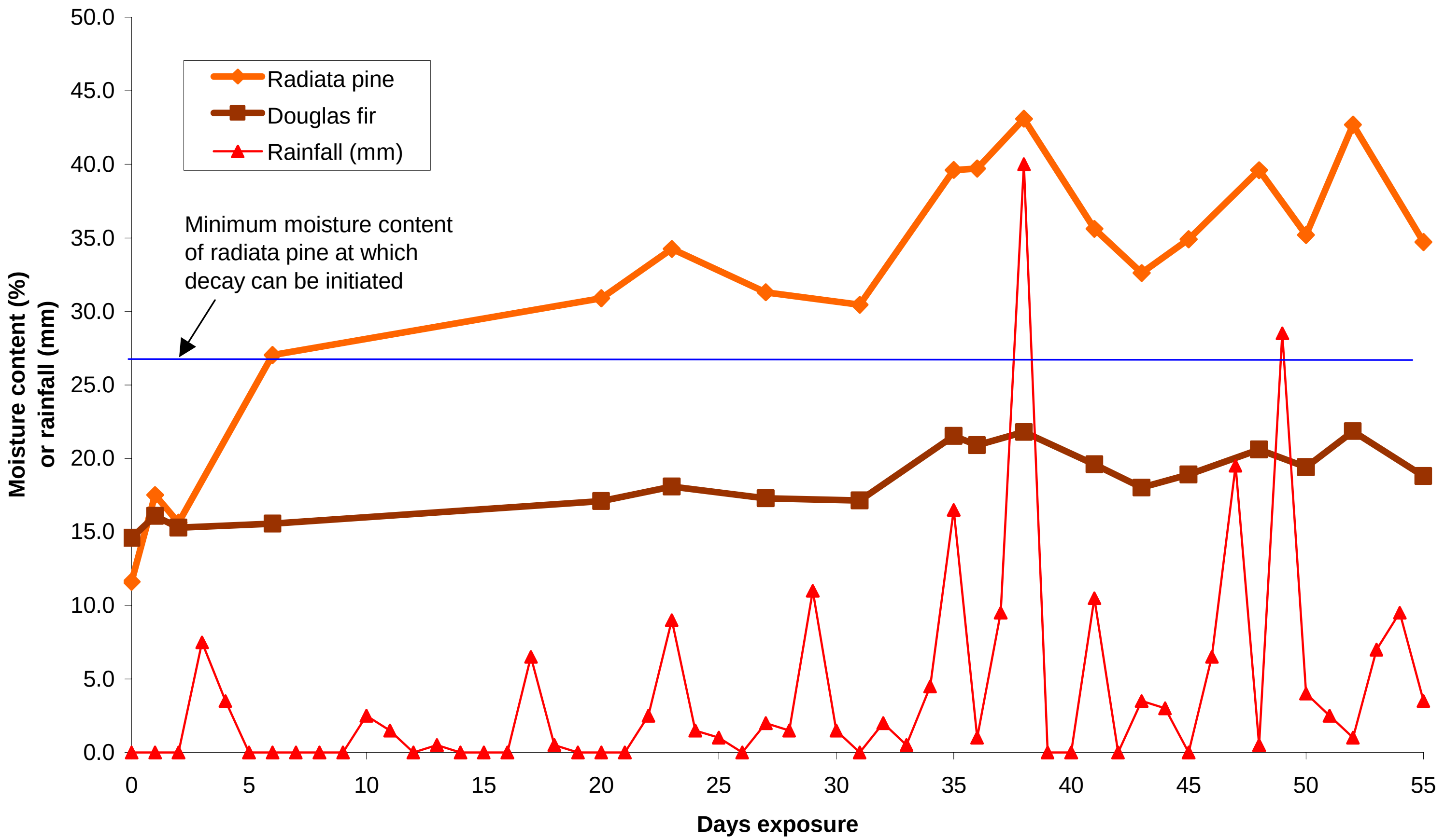


Fig 2 Main trial horizontal samples

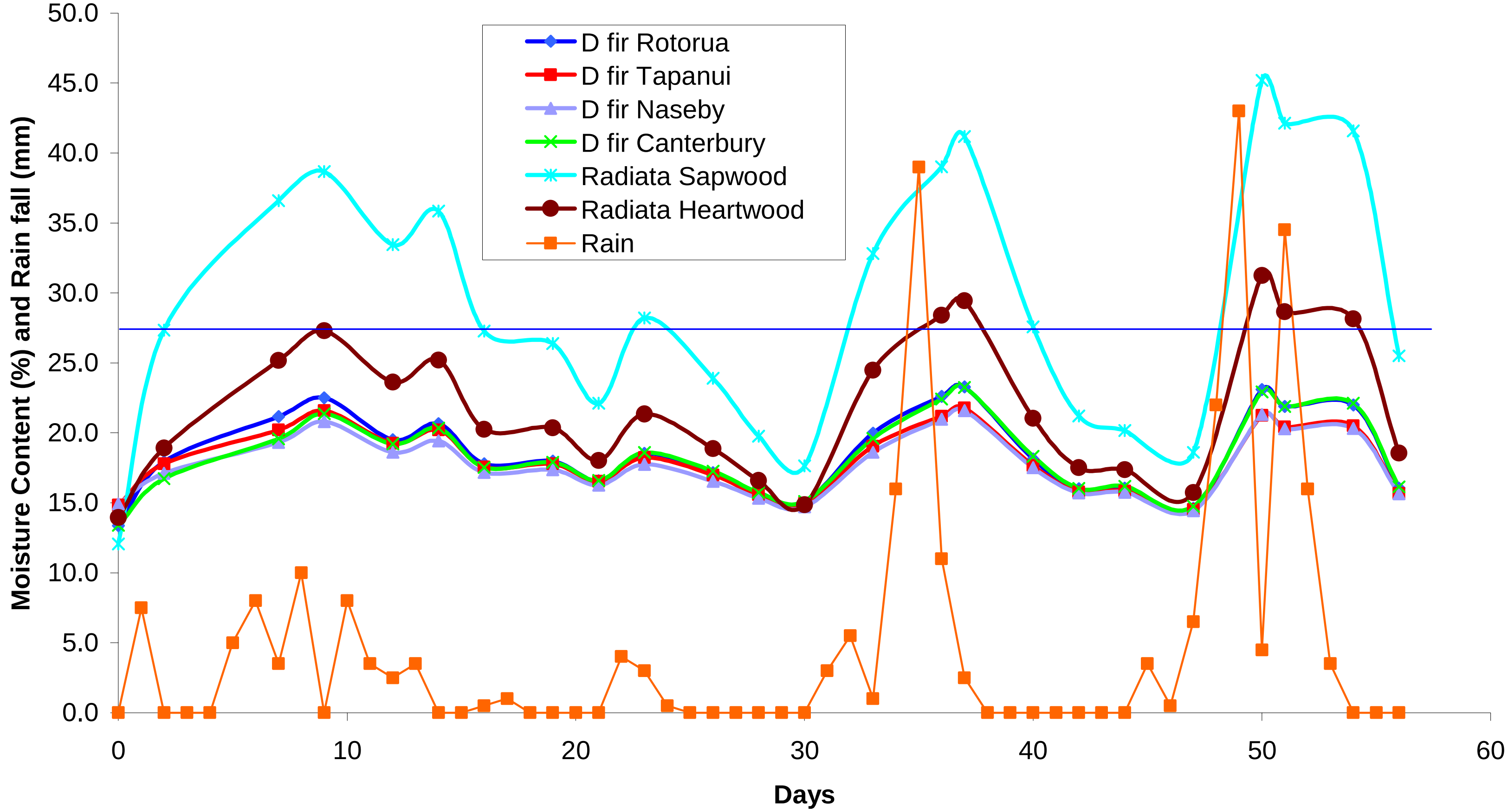
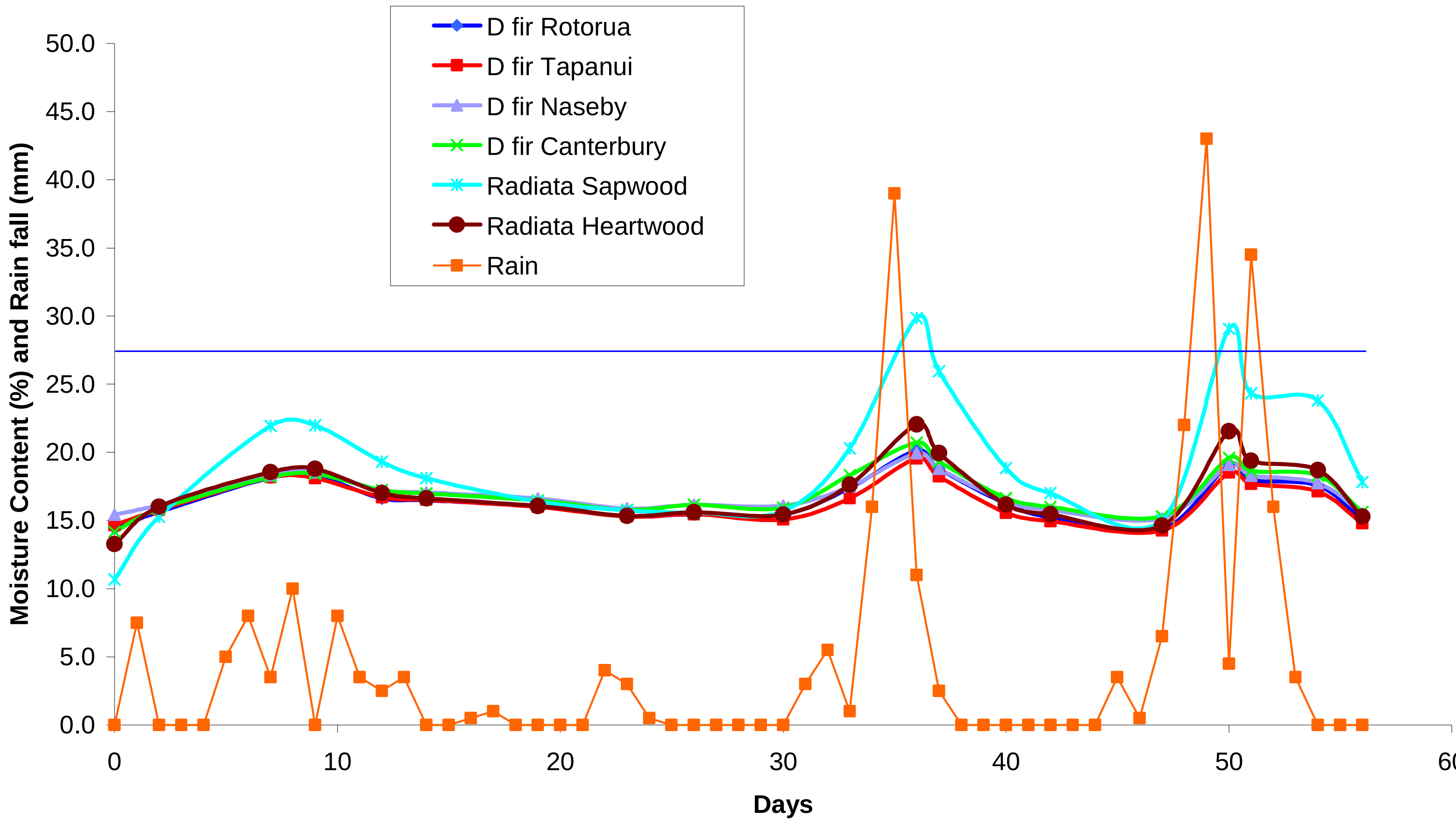


Fig 3 Main trial vertical samples



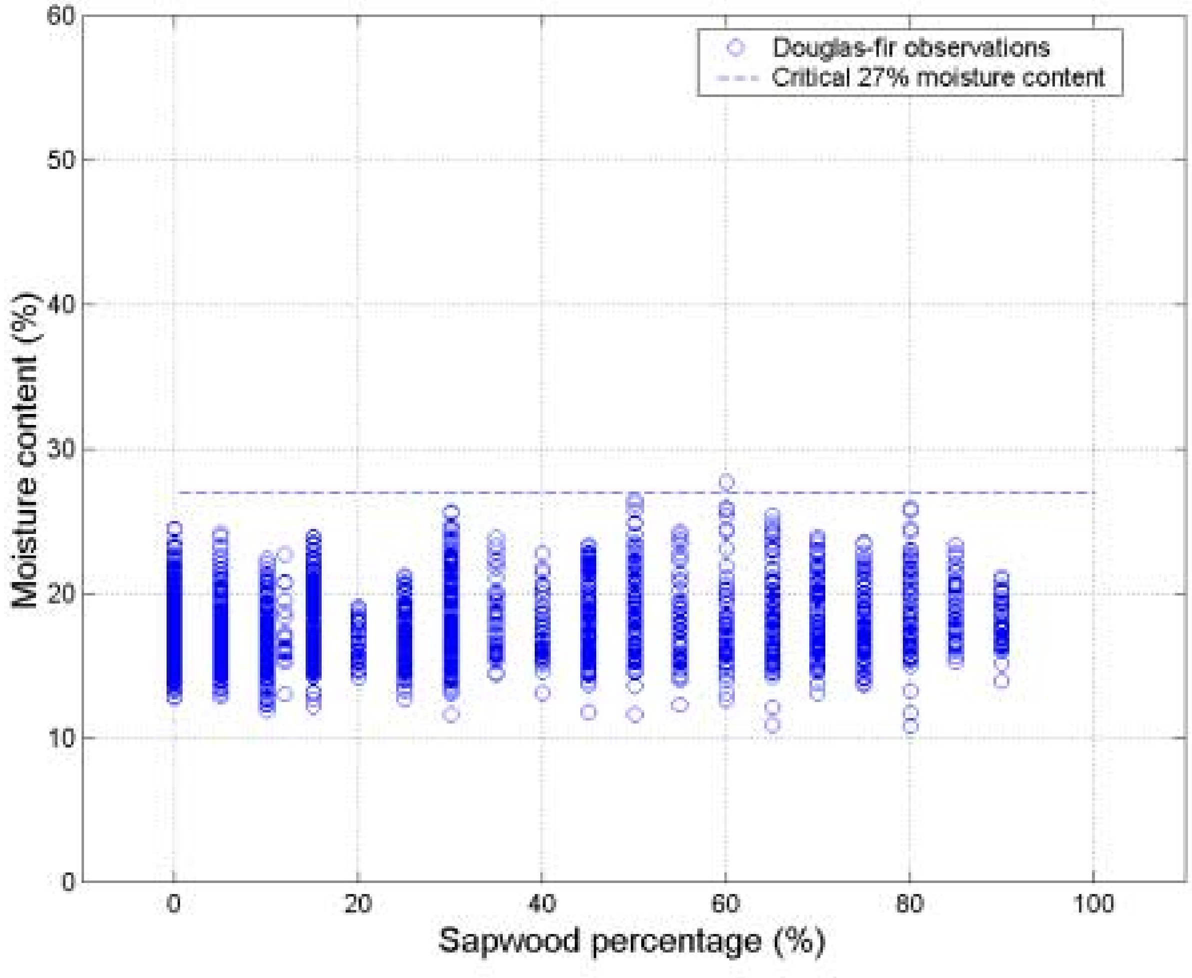


Figure 4 – Observations of moisture content versus sapwood percentage for Douglas-fir and the critical 27% moisture content threshold

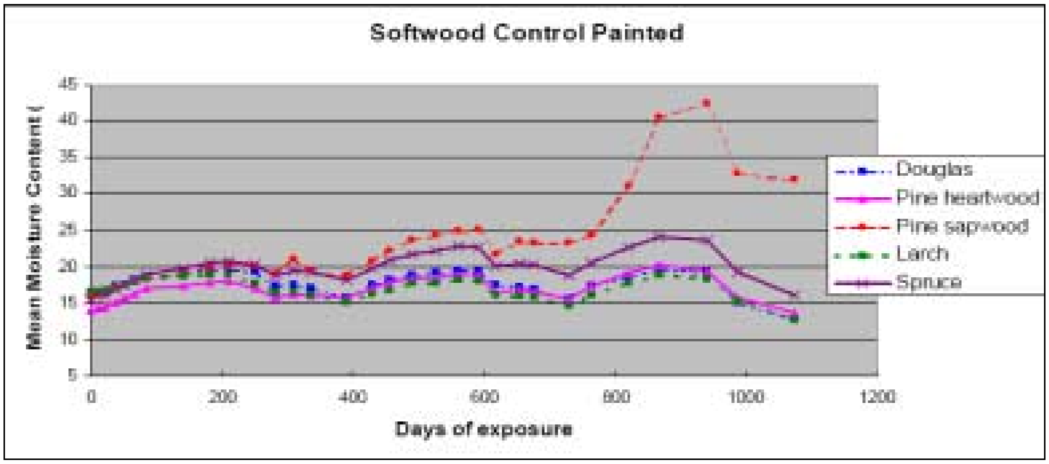
Lap-joint trials in natural durability testing.

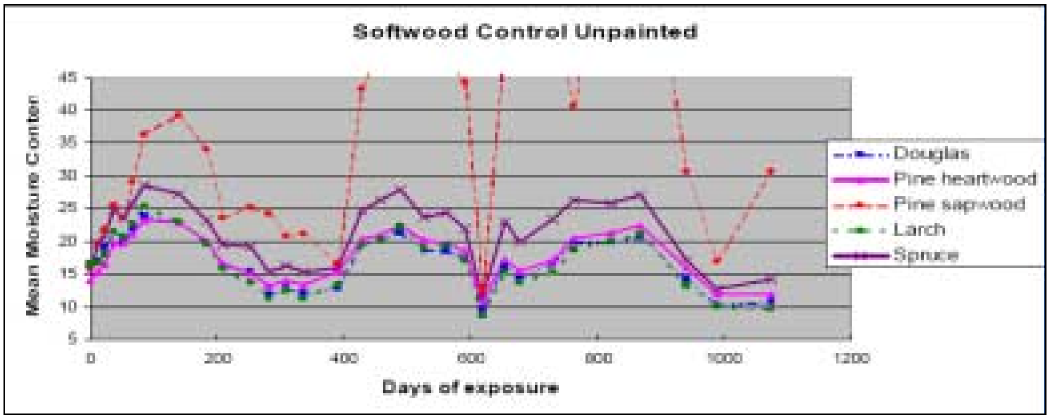
Holger Militz[1], Cor Blom[1] and Christian Hof [2] (2004).

1. Forestry Section, Wood Science Group, Wageningen University, Netherlands
2. Institute of Wood Biology and Wood Technology, University Göttingen, Germany

Sawn timber milled from plantation grown Douglas-fir failed to reach moisture levels at which decay would initiate, over 3 years of exposure. The Douglas-fir significantly out-performed pine sapwood.

Editor's Comment: This European study of plantation grown Douglas –fir and Pine is similar to the NZ moisture uptake trails of New Zealand grown Douglas-fir and Radiata pine structural timber when exposed to rain-wetting, but importantly spans a longer time period





Source:
http://www.bfafh.de/inst4/43/ppt/5lapjoin.pdf

Introduction to External Moisture

Acceptable Solution E2/AS1 (third edition, 2004)

Philosophy underpinning E2/AS1

A significant portion of E2/AS1 is new material, including a section on the assessment of risk. This approach has been developed by the BIA from work done by two Canadians, Don Hazledon and Paul Morris, who developed a simple concept called 'the 4Ds' to describe the basic principles of water management in buildings.

Don Hazledon and Paul Morris based their concept on observations of the causes of building leaks and subsequent decay problems in Vancouver. There are many similarities between the problems seen in Vancouver and those in New Zealand and the 4Ds concept is just as applicable here.

The 4Ds are ranked **in order of importance**. They are:

• Deflection
• Drainage
• Drying
• Decay resistance.

Deflection is basically keeping water away from sensitive areas where it might enter a building. The most obvious example is eaves on a roof. Except under extremely windy situations or where buildings are tall, eaves reduce the amount of rain hitting a wall and flowing over windows and penetrations. Other examples are cap flashings and head flashings. Deflection should keep the vast majority of water from getting past the outer cladding.

Drainage is the provision of paths for any water that does get past the outer cladding to be removed quickly before it can cause damage to the wall components. A drained cavity, as is used with masonry veneer, is a good example. The provision of a sill tray flashing to remove water that leaks through joinery is another.

Drying removes any water that does not drain directly from behind the cladding. Drying is predominantly by ventilation but, where ventilation rates are very low, diffusion of water vapour will also contribute.

Decay resistance was the fourth D proposed by the Canadians, but '**durability'** is the more commonly used term in New Zealand as it covers fixings and insulation as well as timber. This D states that materials used to construct the wall should have the appropriate durability for the anticipated environment within the wall.

Ideally a building should have a balanced design that incorporates all four Ds. A classic example is the simple single-storey house with a hipped roof and brick veneer cladding. As fashions and designs change, the amount of protection afforded by each of the individual Ds will change. A basic principle is that when you reduce the protection provided by any one of the 4Ds, it must be compensated for by increasing the protection provided by one or more of the other Ds.

It is crucial to note that the 4Ds are ranked in order of importance. It is more effective to keep water out than to drain and dry it when it gets in, or to try and make the wall components last in a wet environment.

Editor's Comment: The BIA's E2 document provides appropriate controls to ensure that external moisture does not accumulate in the wall cavity. It underpins, and strengthens the risk control strategy proposed in this document. Its correctly focuses on keeping external moisture outside the building envelope.

E2 should be used in conjunction with this document.

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TO **New Zealand Douglas-fir**
Forest Owners and Sawmillers
c/o Ernslaw One Ltd.
8 Settlers Crescent
Christchurch, New Zealand

PROJECT **2083.00**
British Columbia
Moisture Management Experience

17 May 2004

FAX 3 384 7850

REGARDING British Columbia Moisture Management Experience

As agreed, I am writing to you to provide you with background information related to our experience in British Columbia (BC) with the moisture management performance of wood frame housing as a result of changes to design and construction practices. Specifically, I am providing you with information regarding the success of technology changes that were introduced to wood frame buildings in the 1996 to 1998 time frame.

Writer's Background

BC faced a significant challenge in the mid 1990's when it became apparent that moisture problems in multi-unit wood-frame housing were severe and wide spread. I have been directly involved in much of the research and guideline document creation aimed at identifying the causes of these moisture problems and in establishing design and construction practices so that these problems do not reoccur. In addition, RDH Building Engineering Ltd. (RDH) is the largest consulting firm providing project specific design advice to both new and rehabilitation of multi-unit residential buildings. Since the introduction of the mandatory warranty program in BC in 1999, RDH has also been involved in program development and risk assessment work for several of the warranty providers. You are also referred to the attached resume for the writer as further documentation of my experience and background. This information is provided to establish credibility for the contents of this letter with respect to moisture problems in BC.

Cause of Moisture Problems

To summarize much of the research, BC's moisture problems resulted from a significant imbalance of wetting and drying mechanisms. The damaged elements (walls typically) were exposed to moisture sources (rain being the most prevalent source). The moisture typically entered the wall assemblies at poorly designed and/or constructed details such as window to wall interfaces and balcony to wall interfaces. The types of wall assemblies used were also very sensitive to moisture once it entered the wall. The walls were not able to drain or dry this moisture back to the exterior so that it remained in the wall assemblies for long periods of time and contributed to consequential damage such as fungal growth, wood decay and damage to finishes. Several documents noted in the writer's resume discuss the causes of moisture failure in greater depth. In particular, the *Survey of Building Envelope Failures in the Coastal Climate of British Columbia* (The Survey), published by Canada Mortgage and Housing Corporation (CMHC) specifically addresses moisture problems in wood frame buildings.

General Approach to Addressing Moisture Problems

While The Survey established and documented the causes of the BC moisture problems, it was another document, titled *Best Practice Guide – Wood Frame Envelopes in the Coastal Climate of British Columbia* (BPG), and also written by RDH and published by CMHC, that presents the approach that has been adopted by the industry as a whole for wood frame construction. The BPG has become the benchmark for wood frame envelope construction.

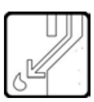
The BPG presents a general strategy of exterior moisture (rain) control that begins with an assessment of exposure conditions, proceeds through considerations of moisture control mechanisms that limit how wet materials get, and finally to requirements for utilizing durable materials in locations where wetting is unavoidable. The focus is clear; manage moisture sources and paths rather than accepting that elements of the building will always be wet. The strategy also is to use conventional materials in a slightly different manner to provide cost effective construction and achieve the fundamental goal of effective and durable moisture management performance.

These exterior moisture management priorities have been characterized and referred to as the 4D's:

Deflection: Use components and features of the building to limit exposure of assemblies to rain. These include:

- overhangs which protect an assembly from direct exposure to rain
- flashing with drip edges which divert water running down surfaces and direct it off the face

Deflection is the primary moisture control principle since it eliminates the potential for water to impact on, or enter, an envelope assembly.

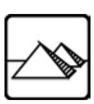


Drainage: Design assemblies to redirect any liquid water that enters the wall back to the outside.

Drainage is the next most important principle. If a small amount of water enters the assembly, it is redirected out.

Drying: Design features that speed the drying of wet materials.

Any moisture that doesn't drain quickly must be able to dry. Since the drying mechanism is slower than deflection and drainage it should not be relied upon to the same extent.



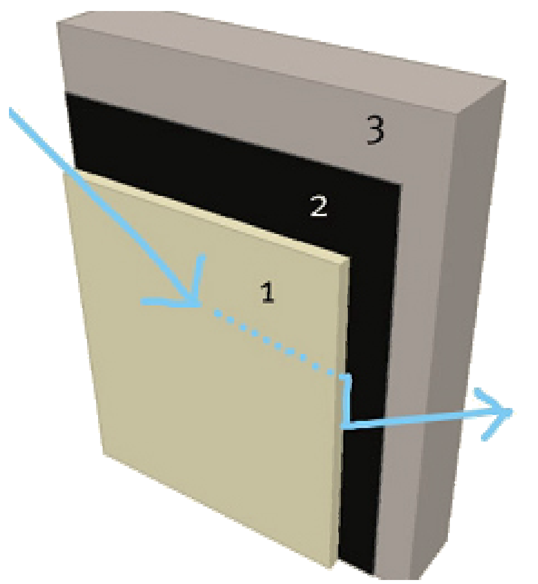
Durability: Use assemblies and materials that are tolerant of moisture.

Any material that is exposed to moisture on a regular basis must be durable enough to accommodate the moisture until it drains or dries.

In practical terms application of these strategies has meant a focus on overhangs for many low-rise (1 to 4 storeys) buildings so wetting is limited and attention to types of assemblies and quality detailing is less critical. On buildings where overhangs are not practical, or provide limited benefit due to the building height, there has been a greater focus on rainscreen wall construction and good detailing. The fundamental benefit of rainscreen construction of wall and window assemblies, and of good detailing is the incorporation of two lines of defence against water infiltration. Much of the content of the BPG is focused on the concept of rainscreen wall construction and examples of good detailing practices.

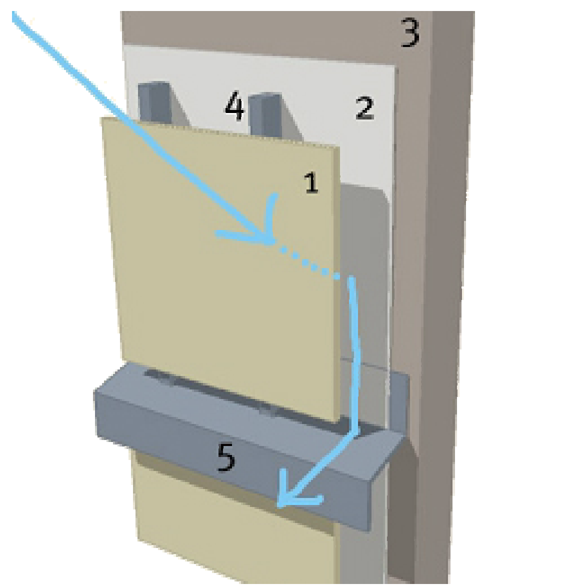
In simplified terms the difference between the face seal technology used on many of the problem buildings, and rainscreen construction that has been used in many medium and high exposure residential buildings for the last 5 to 10 years can be explained as follows.

Face sealed walls are intended to deal with exterior moisture in the form of rain by sealing the exterior of the wall and preventing any water from penetrating past the outer seal (Figure 1). Water must be stopped at the outer face of the cladding. If water does penetrate past the cladding it cannot readily drain out of the wall, and remains within the assembly where it can damage moisture sensitive materials and components. It is therefore essential to ensure that no water penetrates the outer cladding. This water management strategy can work in certain conditions where the wall is in a protected location, and receives little exposure to wetting. However in most situations face-sealed walls do not perform well. This is primarily because it is extremely difficult to fully seal the exterior cladding and ensure that no water will enter.



1. Exterior cladding
2. Sheathing paper
3. Moisture sensitive materials

Figure 1: Face Seal Wall Assembly



1. Exterior cladding
2. Water resistive barrier
3. Moisture sensitive materials
4. Strapping (batons) to create cavity
5. Cross-cavity flashing

Figure 2: Rainscreen Wall Assembly

In contrast, rainscreen walls manage water in a different way (Figure 2). The exterior cladding is still intended to deflect most of the water that contacts the wall. However, a cavity is provided behind the cladding. If water does penetrate the cladding it reaches the cavity and cannot move further into the wall assembly. Instead, water in the cavity will drain down on the inside face of the cladding or on the water resistive barrier at the other side of the cavity and will be deflected out of the wall assembly at a cross-cavity flashing. With a rainscreen wall it is not essential that the outer cladding be completely sealed, some imperfection is acceptable.

In addition to this fundamental shift in wall assembly types for more exposed wall and window assemblies, there has been much greater attention to detail design as part of the construction document package, and an increased emphasis on field review and testing during construction.

The incorporation of overhangs, better wall and window assemblies, and better detailing has lessened the need to emphasize durability of some of the wood products used. In general, the approach taken for wood products is consistent with the following statement from the BPG:

> *All inaccessible wood and structural elements located outside the moisture barrier (water resistive barrier) of the main environmental separator should be treated.*

In practical terms this has meant:

- Exposed structural wood elements such as balconies, stairs and posts have been treated
- Trim boards around windows (readily accessible and replaceable) have not been treated
- Concealed wood framing in elements such as balcony dividing walls and balcony upstand walls (outside the heated perimeter and therefore reduced driving forces for drying) has been treated
- Vertical strapping (batons) used to create the drainage cavity in rainscreen walls has been treated
- Wood framing in direct contact with concrete foundation elements has been treated
- All other wood framing and sheathing in the main walls, floors and roofs of the building has not been treated

These technology changes are a key part of what I believe to have been a successful response to the moisture problems experienced in BC. The other change that has occurred is the introduction of a mandatory third party warranty program. The legislation mandating warranty is administered through a provincial government organization, The Homeowner Protection Office (HPO). The warranty program has essentially established a financial responsibility trail that has the impact of creating an environment that encourages the use of this more appropriate technology. The purpose of this paper is not to provide details of the warranty legislation.

Performance of New Technology

Following the introduction of these technology changes to wood frame residential construction in BC there was some scepticism regarding its adequacy in addressing the moisture problems. The perception was that the technology was new and untested. In fact this was not true; the technology had been used for many years and had a proven track record of success. The only thing new was the application of this technology to wood-frame residential construction in BC. Largely because of the scepticism however, CMHC and the HPO retained us to monitor the performance of rainscreen walls in five buildings. The program was very comprehensive with continuous monitoring (every 15 minutes for more than a year) of temperature, humidity, moisture content at various locations within the wall assemblies, at five locations on each building. In addition, basic weather data for each specific site was collected to facilitate co-relational analysis with the monitoring data (Figure 3).

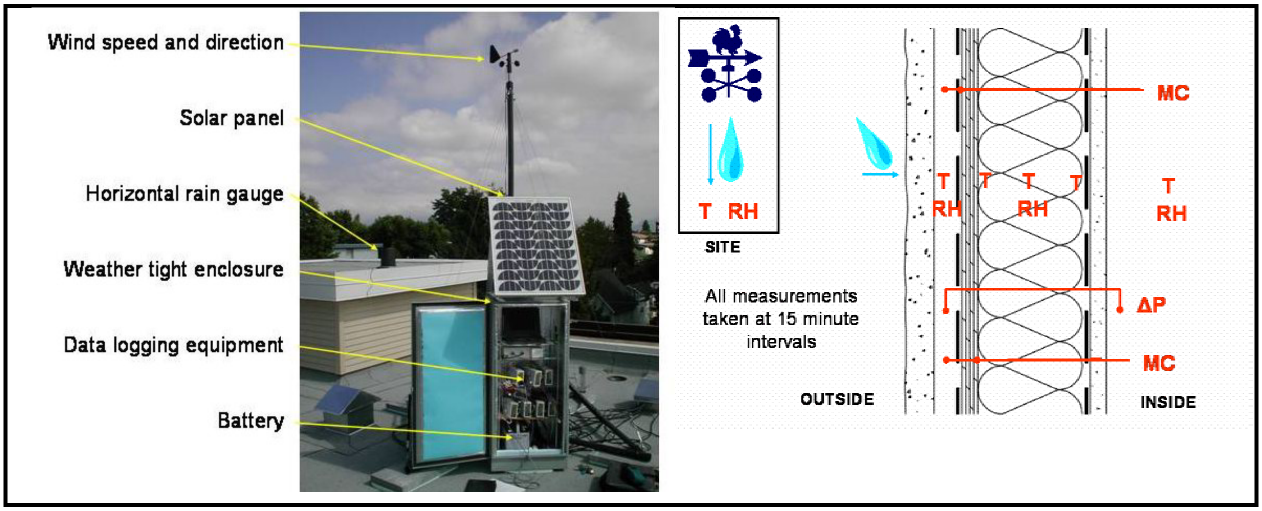


Figure 3: Monitoring Equipment and Sensor Locations

We are just now in the process of analyzing this data and it will be some time before a full report is released. However, the general conclusion is that these rainscreen wall assemblies are performing very well, with no expectation that we will experience any systemic moisture problems in the future. In addition, the monitoring program has provided useful data, to support the effectiveness of overhangs in reducing wetting, rates of wetting and drying in wood strapping behind various cladding materials, and a variety of other information related to seasonal trends in heat, air and moisture movement in exterior wall assemblies.

These technology changes have been in general use in residential construction in BC for approximately 7 years, and the warranty program has been in place for almost 5 years. We also perform risk review work for the warranty providers on a large percentage of the residential construction in BC and therefore we are generally aware of issues that the warranty providers are facing in their programs. Anecdotally, because no documentation of these facts has been assembled to date, we are aware that there have been very, very few warranty call backs related to moisture issues in walls.

Summary

In summary, I believe that the moisture crisis in BC residential construction has now been addressed and I have no expectation of future systemic problems related to moisture ingress. Changes to technology that are occurring at present are related to fine tuning of the approach outlined above.

Yours truly,

Dave Ricketts, P. Eng
Senior Building Science Specialist
drr@rdhbe.com

David R. Ricketts, M.Sc. P.Eng.

Senior Building Science Specialist

Experience

Mr. Ricketts is recognized as a leader in the building envelope field across Canada and the United States. He combines a thorough understanding of building envelope theory and materials behaviour with practical knowledge of construction practices and sequencing.

As one of the key contributors to the evolution of building envelope technology over the last twenty years, Dave has led some landmark policy, guideline and research related initiatives:

- Study of Cladding on Public Buildings, Public Works Canada. This study developed into an advisory document for the design and construction of the building envelope for public buildings.
- Survey of Building Envelope Failures in 3 & 4 Storey Wood Frame Buildings in the Coastal Climate of BC, CMHC.
- Best Practice Guide for Building Envelope Wood Frame Construction in the BC Lower Mainland, CMHC.
- Durability of Building Materials, Public Works Canada. Provided the first comprehensive Canadian based review of the factors influencing the durability of common building materials. This study was one of the primary building blocks for the formation of the CSA Standard S478, Durability of Buildings.
- Building Envelope Design and Construction Standards, British Columbia Housing Management Commission. Provides requirements for all aspects of the design and construction of building envelopes for BCHMC residential projects.
- Building Envelope Rehabilitation Guides; one for consultants, and one for property managers and owners, CMHC.
- Study of High-Rise Envelope Performance, CMHC, HPO, City of Vancouver. Examines the performance of building envelope assemblies and details in the high-rise building stock in the BC coastal climate.

Dave's building envelope expertise has been applied to the design of a wide variety of new buildings, as well as the restoration of historic buildings and the investigation and design of remedial work for buildings that have experienced premature envelope failures.

Dave regularly provides expert testimony regarding construction and design related performance problems and has presented at numerous conferences, seminars and clinics.

Education

- B.Sc., Civil Engineering, Queen's University at Kingston
- M.Sc., Civil Engineering, University of Alberta

Current Projects

Dave continues to be actively involved as the envelope consultant for numerous new construction projects and the investigation and restoration of existing buildings, in addition to his policy and guideline document work.

Current noteworthy projects include:

- Building envelope consultant for 2 new residential towers, Polygon
- Building envelope consultant for $4.5 million wood frame condominium rehabilitation project in Vancouver.
- Leading a project to assess the condition of the building envelopes of British Columbia Housing and Management Commission's entire portfolio of buildings in the Lower Mainland and Vancouver Island, a group of more than 200 buildings.
- Leading a national study of water penetration performance of windows. This project includes the preparation of recommendations for changes in codes and standards as well as the preparation of window installation guidelines. CMHC, HPO

Memberships

- Winner of the 2001 Association of Professional Engineers and Geoscientists Professional Service Award.
- Homeowner Protection Office's Provincial Advisory Council
- Past President - British Columbia Building Envelope Council
- Building Envelope Committee, The Association of Professional Engineers and Geoscientists of the Province of British Columbia
- AIBC Building Envelope Education Program Committee
- Chair of Joint - AIBC/APEGBC Building Envelope Practices Task Force
- AIBC/APEGBC Building Envelope Professional Committee
- Part 5 (Building Envelope) British Columbia Building Code Committee

Publications

"Leaky Condos: Why the Technology Didn't Work", Journal of the Association of Professional Engineers and Geoscientists of British Columbia, March 1999

"Water Leakage in Buildings, The Problem Continues", Canadian Property Management, Oct/Nov 1995

"Protocol for Assessment of Building Systems", IRC/NRC Publication, 1995

"Building Enclosure Performance: Enveloping More than Engineering", Innovation Journal, APEGBC, November 1996

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Assessment Criteria prepared by:

Ernslaw One Ltd

Weyerhaeuser NZ Ltd

City Forests Ltd

Rayonier NZ Ltd

Wenita Forest Products Ltd

Blakeley Pacific Ltd

Selwyn Plantation Board Ltd

Timberlands West Coast Ltd

Central Otago Lumber Ltd

Findlater Sawmilling Ltd

Waimea Sawmillers Ltd

Taylor Timber Ltd

Gibson Timber Ltd

Moutere Timber Ltd

Sutherland timber Ltd

Stoneyhurst Timber Ltd

Hewvan Enterprises Ltd

Naseby Lumber Ltd

Blue Mountain Lumber Ltd

Pankhurst Sawmilling Ltd