Condition of Abodo Thermally Modified Timber Test Samples After Up to 94 Months (~7 ¾ Years) Outdoor Above-Ground Exposure.

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Note: This document has been edited and reduced in size from the original to capture key information.

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SUMMARY

Abodo thermally modified timber samples have been installed in an above ground exposure trial, to compare performance with untreated timber, naturally durable and preservative treated reference timber samples.

Samples representing different timber species and treatments were exposed in above ground situations on 45º frame racks, or as a horizontal exposure as a deck in close proximity to the ground. The trial site is located at the Abodo Wood Ltd site in Mangere, Auckland only a few kilometers from Auckland International Airport. The climatic conditions are described by NIWA as 'sub-tropical'.

The test method design was set up to have sample surfaces in contact with untreated timber and to promote decay development. This has affected the durability of the candidate treatments by increasing the decay risk for the panels or deck samples under assessment. This may have resulted in some variable results within some treatment sets. The dryness of the samples also can affect individual sample ratings at the time of assessment.

The results from this flat panel and decking trial indicate these test exposure methods at this trial location have a decay hazard that has yielded results compatible with the expected durability range of the untreated control samples.

Exposed timber faces have weathered to a grey colour. Checking number, depth and width, have increased with the longer exposure period. After 91 months exposure, the untreated Radiata pine samples are decayed. Untreated Radiata pine heartwood has a natural durability class 4[1] (perishable) and with an above ground life expectancy of less than seven years. Sapwood would be considered less durable.

After up to 94 months exposure, the Abodo thermally modified 230ºC Radiata pine samples remain in sound condition. Abodo thermally modified Radiata pine samples are performing equivalent to the preservative treated samples, and better than old growth Western red cedar and Eucalyptus grandis.

The LOSP (propiconazole, tebuconazole, permethrin) preservative treated (Hazard class H3.1[2]) Radiata pine samples remain in sound condition after 91 months exposure. Any previous detection of fungal activity/surface mycelium has not developed into decay. While the exposed surface weathers to grey, the back surface is a natural original colour.

The CCA preservative treated (hazard class H3.2[2]) Radiata pine samples show some fungal decay, which appears to have originated from contact with the back support panel. The deck boards in close proximity to the ground are in better condition than the panel samples.

Western red cedar heartwood has a natural durability class 2[1], so an above ground life expectancy of 15 to 40 years. The panel results indicate decay in some samples from the first inspection at 17 months but did not develop further subsequently. Mean ratings have been 8.7, 9.1 and 9.1 but have now dropped to 4.2 at 94 months.

Eucalyptus grandis (rose gum) heartwood also has a natural durability class 2[1], so with an above ground life expectancy of 15 to 40 years. As was observed with the Western red cedar samples, the panel results indicate decay in some samples from the first inspection at 17 months but had not developed further subsequently. Mean ratings have been 9.4, 9.4, 9.0 and are now 2.4.

[1] STANDARDS AUSTRALIA, Timber - Natural durability ratings, AS 5604
[2] STANDARDS NEW ZEALAND, Chemical Preservation of Round and Sawn Timber, NZS 3640

INTRODUCTION

Thermally modified timber treatments are relatively new for New Zealand but there is increasing interest in the technology for cladding and decking applications. The temperate climate exposure conditions represent a risk of decay in most locations in New Zealand. New treatments or technologies for wood products need to be assessed under local conditions even if already commercially available in countries overseas. Above ground, exposed to the weather end-use situations require a minimum of 15 years performance, to be able to claim the requirements of the New Zealand Building Code (NZBC) B2 Durability are being met.

Sample panels were installed at the Abodo, Mangere site from May 2017. Untreated Radiata pine, H3.2 CCA treated Radiata Pine, H3.1 azole treated Radiata pine, untreated *Eucalyptus grandis* heartwood and Western red cedar panels were included in the trial as reference material for comparative purposes.

The field trials set up followed the AWPC Protocols for Assessment of Wood Preservatives, September 2015. Where there were deviations, these are mentioned in the report.

TIMBER SAMPLES

Table 1 summarises the timber species and treatments that have been included in the exposure trials.

More details on the sample identification and numbers is in Appendix A.

Treatment details for these samples provided by the suppliers are summarised in a separate document, Abodo Trial Confidential Addendum Report.

The AWPC protocols are primarily for assessing candidate chemical treated samples where the chemical retention can be varied. With thermally modified timber this is not possible, although the process parameters can be controlled. The durability is achieved by managing the process parameters by setting a temperature and time, under specific atmospheric conditions. These are varied to optimise for the type of wood species or substrate variables.

The AWPC protocol refers to 75 x 20 mm cross-section dimensions but these dimensions were varied for some sample sets. The sample length was 200 mm for flat panels and unless otherwise stated, 300 mm for deck boards.

Table 1:
Timber and process treatment description for test samples.

Timber	Description
Radiata pine	Sapwood, untreated
Radiata pine	Sapwood, H3.1 LOSP treated (propiconazole, tebuconazole, permethrin)
Radiata pine	Commercial product (not selected for sapwood), H3.2 CCA treated
Radiata pine	Sapwood, Abodo thermally modified 230ºC open process
Radiata pine	Plywood 12mm (5 ply), Abodo thermally modified 230ºC open process
Eucalyptus grandis	Heartwood, untreated
Western red cedar	Commercial product (old growth, coastal British Columbia)

EXPOSURE AND ASSESSMENT METHODS

Refer to Appendix B for information on the test site and set up of the test frames or decks.

Ten or more samples for each species/treatment were exposed in both trials. Each set of samples should be randomly placed on the flat panel racks, but it was noted that the samples were not randomly mixed between sets over the exposure racks. For the decks, each treatment set is generally installed together.

Flat panels on rack

The flat panel samples were exposed at an approximate 45° angle on a north facing A-frame. The bottom edge of the flat panel is in contact with a wooden slot prepared from untreated Radiata pine. The top edge of the panel is in contact with a 20 x 45 mm strip of H3.2 treated Radiata pine.

Samples are beside a building so are shaded to some degree from morning sun.

The support panels on the frame at previous and latest inspection showed signs of significant decay and active fungal mycelium, and was a source of inoculum contributing to a high potential decay hazard. Decayed support frames were previously replaced in June 2020.

Flat panel racks (September 2018)

Deck panels

Test samples are exposed on a horizontal plane on 90 x 90 mm CCA-treated bearers in direct contact with the ground. Spacers, 90 x 20 mm are placed between the bearer surface and test panel. One spacer is untreated Radiata pine, and at the other end is H3.2 treated Radiata pine.

Note the ends of the deck boards were sealed with paint to avoid end splitting of the short lengths.

Trial Decks (September 2018)

RATING SYSTEM USED FOR SAMPLE ASSESSMENT

The flat panels are individually removed from the frame and assessed according to the rating system described in Appendix C.

The assessment includes fungal decay (and insect damage if present), surface checking, and visual observations (colour, surface staining and/or mould).

After inspection the samples are returned to the same position on the frame rack or deck bearers.

RESULTS AND DISCUSSION

The sample surface softness is checked visually and then with a probe at contact points with the supporting frame or strips. Any change in condition is recorded. The individual sample results are summarised in tables for each set for flat panels exposed on the racks and deck boards respectively.

The moisture content of samples can make timber seem softer and therefore indicates possible decay and then at a later inspection the samples may be drier and more resistant to the probe. Also, if decay mycelium is present on the underside surface and very active with some softness but later the fungus dries, the surface/ sample may appear to be harder. This can result in score ratings being different between inspections.

Therefore, anything that is rated 9 or better can be taken as being generally sound. The only area of concern is where there could be internal decay that may not be obvious until well-established.

The results are presented separately for flat panels and deck samples, for each treatment regime.

Flat panels on racks

Radiata pine

The Radiata pine treatment and sample rating results are summarised in Table 2.

After 94 months exposure, the untreated samples (Set J) are decayed. Untreated Radiata pine has a durability class 4 (perishable) and expected above ground life expectancy of less than 7 years [1]. The results from this flat panel trial indicate this test exposure method and

trial location have a decay hazard that has yielded results compatible with the expected durability range of the untreated control samples.

The LOSP (propiconazole, tebuconazole, permethrin) treated (H3.1) Radiata pine samples remain in a mainly sound condition after 94 months exposure. A few samples have some softening so were not rated as 10.

The CCA treated (H3.2) Radiata pine samples (Set L) previously showed some minor fungal decay, which appears to have originated from contact with the back support panel. After 94 months this has developed further, with five samples showing established decay in the ends. Given the long history of use of CCA, the results were surprising, but do highlight the vulnerability of treatments in contact with untreated timber with active fungal decay.

After 91 months (~7 ½ years) exposure, the samples of Abodo thermally modified 230ºC Radiata pine (Set E) were in better condition than the CCA treated pine, and similar to the LOSP azole treated pine. The Abodo thermally modified 230ºC Plywood 12 mm (5 ply) Radiata pine samples are relatively sound after 83 months.

Samples typically will show decay well advanced from the bottom of the sample edges in contact with the panel rack.

Untreated Radiata pine extensive decay across the cross-section at 67 months

Table 2:
Summary of Radiata pine treatments and sample results for decay and checking

Treatment	Set	Number of samples	Exposure period (months)	Decay rating average (range)	Checking average (range)
Untreated	J	10	17	6.7 (4-10)	1.7 (1-2)
			42	5.7 (4-9)	4
			67	0.7* (0-7)	2.4*
			94	0	3.3
LOSP – Propiconazole, tebuconazole, permethrin (H3.1)	K	20	17	9.7 (9-10)	1.6 (1-2)
			42	9.9 (9-10)	1.8 (1-4)
			67	10 (T-10)	1.6 (1-4)
			94	9.7 (8-10)	2.2 (1-4)
CCA (H3.2)	L	14	17	9.0 (8-10)	2.3 (2-3)
			42	9.3 (9-10)	3.6 (2-4)
			67	9.3 (8-10)	2.8 (2-4)
			94	7.1 (4-10)	3.4 (3-4)
Abodo thermally modified 230ºC	E	10	14	9.9 (9-10)	2.4 (2-3)
			39	10	4
			54	10	2.9 (2-3)
			91	9.5 (8-10)	3.4 (3-4)
Abodo thermally modified 230ºC Plywood 12mm	O	10	13	9.7 (8**-10)	2
			38	9.8 (8-10)	4
			63	10	2
			83	9.6 (9-10)	2

* Single sample rated ‘7’ for decay, rest of samples degraded
** Softening, possible decay but not confirmed

Eucalyptus grandis

The *Eucalyptus grandis* sample rating results are summarised in Table 3.

After 94 months, the untreated heartwood sample decay ratings vary from 0 (decayed) to 9 (decay <3% of cross-section). There are white/bleached flecks/streaks on sample surfaces indicating signs of white rot, and some decay of edges originating from the supporting frame. This highlighted that there may be more severe decay within the samples that is not always visible or identifiable from the surface.

***Eucalyptus grandis* decay sample after 94 months**

Table 3:
Summary of *Eucalyptus grandis* and sample results for decay and checking.

Treatment	Set	Number of samples	Exposure period (months)	Decay rating average (range)	Checking average (range)
Untreated	N	19	17	9.4 (7-10)	2.6 (2-4)
			42	9.4 (7-10)	3.8 (3-4)
			67	9.0 (7-10)	(1.9) (1.2)
			94	2.4 (0-9)	3.0 (3)

Western red cedar

The Western red cedar sample rating results are summarised in Table 4.

The decay ratings vary, from 0 (decayed) to 9 (<3% cross-section decayed) and from the bottom of the test sample. The fungal degradation appears to be a consequence of decay establishing in the back-support panel for the test samples. The assessments at 94 months show a significant increase in decay establishment from the previous assessment.

Western red cedar decay on back of sample and supporting panel/rack (17 months exposure)

Weathering

The exposed surface of all samples were weathered to various shades of grey. The back unexposed faces mostly retain the original appearance/colour.

Checking

The Western red cedar surfaces had pronounced ridging (raised grain) and some cupping.

Table 4:
Summary of Western red cedar sample results for decay and checking

Treatment	Set	Number of samples	Exposure period (months)	Decay rating average (range)	Checking average (range)
Untreated	M	18	17	8.7 (6-10)	1.4 (1-2)
			42	9.1 (6-10)	2.3 (2-3)
			67	9.1 (6-10)	2.3 (2-3)
			94	4.2 (0-9)	1.6 (1-3)

Deck boards

Radiata pine

The Radiata pine treatment and sample rating results are summarised in Table 5. The assessment was done on the underside of the deck boards in contact with either the untreated or preservative treated spacer strip.

After 93 months exposure, the untreated Radiata Pine samples have significant decay. All the boards have decayed completely.

The LOSP (propiconazole, tebuconazole, permethrin) (H3.1) Radiata pine samples were rated 9.9 so are still sound. As a H3.1 treatment, this is not included as a decking treatment under the New Zealand standard NZS3640.

The CCA treated (H3.2) samples had a mean rating of 10, so remain sound.

After 90 months the Abodo thermally modified 230°C samples had a mean rating of 10.

After 93 months the Abodo thermally modified 230°C Plywood 12 mm also had a mean rating of 10.

The Abodo thermally modified timber is performing equivalent to the preservative treated samples in this decking trial.

Table 5:
Summary of Radiata pine treatments and sample results for decay and checking.

Treatment	Set	Number of samples	Exposure period (months)	Decay rating average untreated	Decay rating average treated
Untreated	J	9	17	10	10
			42	7.7	10
			67	2.8	7.9
			93	0	6.2
LOSP Propiconazole, tebuconazole, permethrin (H3.1)	K	10	17	10	10
			42	10	10
			67	10	10
			93	9.9	10
CCA (H3.2)	L	14	17	10	10
			42	9.9	10
			67	9.9	10
			93	10	10
Abodo thermally modified 230ºC	E	10	14	10	10
			42	10	10
			64	9.6	10
			90	10	10
Abodo thermally modified 230ºC Plywood 12mm	O	10	13	10	10
			38	10	10
			63	10	10
			89	10	10

Eucalyptus grandis

The *Eucalyptus grandis* treatment and sample rating results are summarised in Table 6.

The untreated heartwood sample decay ratings vary from 6 (well-established decay, 30-50% cross-section) to 10 (sound).

Table 6:
Summary of *Eucalyptus grandis* treatments and sample results for decay and checking.

Treatment	Set	Number of samples	Exposure period (months)	Decay rating average untreated bearer	Decay rating average treated bearer
Untreated	N	10	17	9.9	10
			42	9.8	10
			67	9.1	10
			93	8.5	10

Western red cedar

The Western red cedar deck sample rating results are summarised in Table 7. All samples were rated from a 6 (30-50% decay) to 10 (sound) with a mean 7.6, when in contact with the untreated strip after 93 months exposure. In this assessment there is some softness in samples in contact with the preservative treated strip but no confirmed decay.

Table 7:
Summary of Western red cedar sample results for decay and checking.

Treatment	Set	Number of samples	Exposure period (months)	Decay rating average untreated bearer	Decay rating average treated bearer
Untreated	M	10	17	10	10
			42	9.8	10
			67	8.8	9.6
			87	7.6	9.9

APPENDIX A

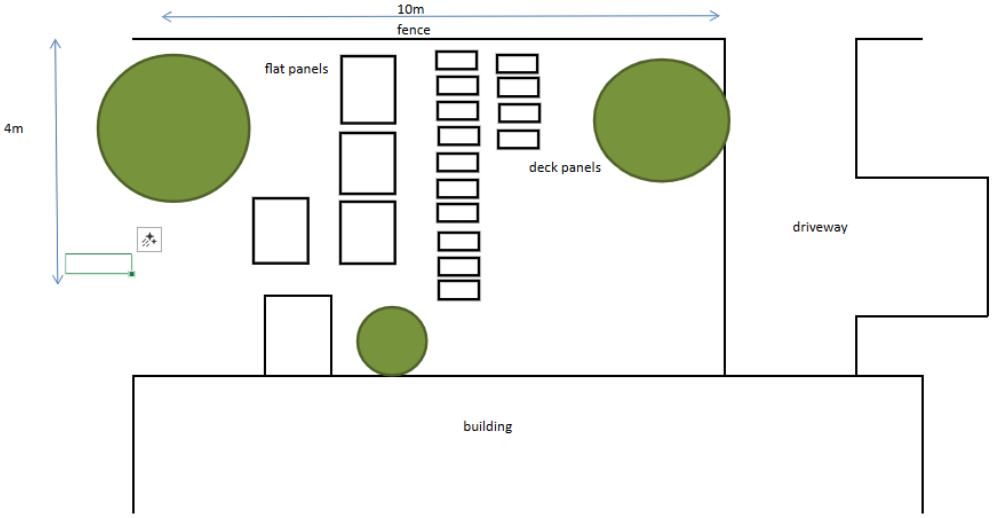
Test samples and identification

Timber	Description	Set code	Samples and Number	Installation Date
Radiata pine	Sapwood, untreated	J	Boards 1-10 (10) Panels 11-20 (10)	8 May 2017
Radiata pine	Sapwood, H3.1 LOSP treatment (propiconazole, tebuconazole, permethrin)	K	Boards 1-10 (10) Panels 11- 29 (20)	8 May 2017
Radiata pine	Commercial product (not selected for sapwood), H3.2 CCA treatment	L	Boards 1-10 (10) Panels 11- 24 (14)	8 May 2017
Radiata pine	Sapwood, Abodo thermally modified 230ºC open process	E	Boards 1-10 (10) Panels 11-20 (10)	10 August 2017
Radiata pine	Plywood 12mm (5 ply), Abodo thermally modified 230ºC open process	O	Boards 1-10 (10) Panels 11-20 (10)	5 September 2017
Eucalyptus grandis	Heartwood, untreated	N	Boards 1-10 (10) Panels 11-29 (19)	8 May 2107
Western red cedar	Commercial product (old growth, coastal British Columbia)	M	Boards 1-10 (10) Panels 11-28 (18)	8 May 2017

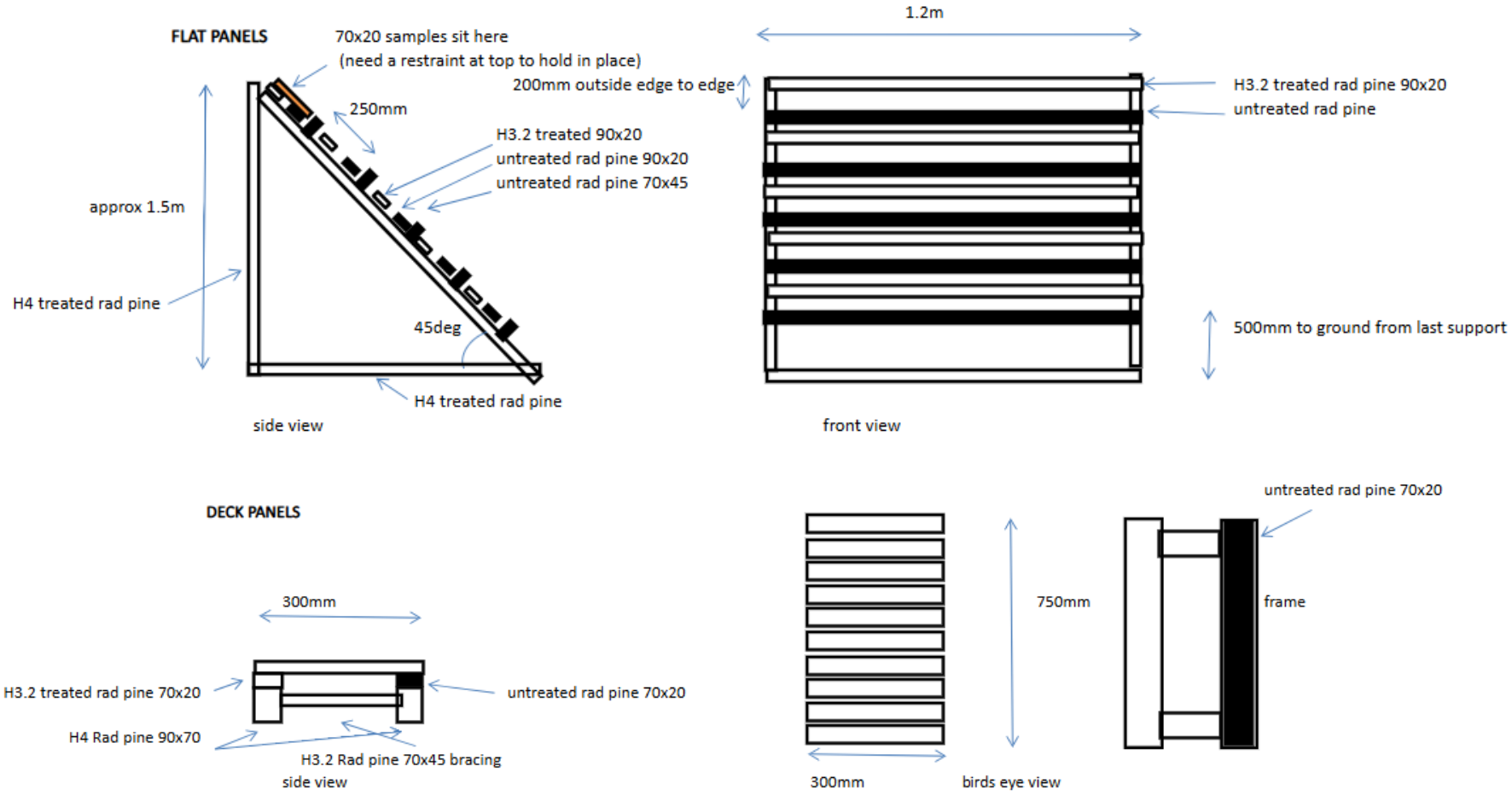
APPENDIX B

Location of trial site (original view before trial installation)

Layout of test site showing rack units (for panels) and decks



Drawings of test racks



A-frame test racks for exposure of samples T at first inspection time

A-frame racks after ~ 67 months exposure (December 2022)

APPENDIX C

Rating system for sample assessments

DECAY/INSECT DAMAGE

Rating	Description
10	No decay (or insect) damage.
T	Trace; decay suspected but not positively identified.
9	Minor decay or damage at defects; less that 3% of the cross-section affected.
8	Minor but established decay; 3 to 10% of the cross-section affected.
7	Well -established pockets or extensive surface damage; 30 to 50% of cross-section affected.
6	Extensive established and deepening decay; 30 to 50% of cross-section affected.
4	Deep and severe decay; more than 50% of cross-section affected.
0	Sample failed; disintegrating, breaking apart.

CHECKING

Rating	Description
1	No surface checks, fine knot checks not visible in damp weather.
2	Minor checks to 0.5 mm wide; not obvious in damp weather.
3	Well established checks to 1 mm wide and through 50% of the panel thickness.
4	Many or deep checks, and severe checks over 1 mm wide.
5	Board completely split and allowing obvious water ingress.