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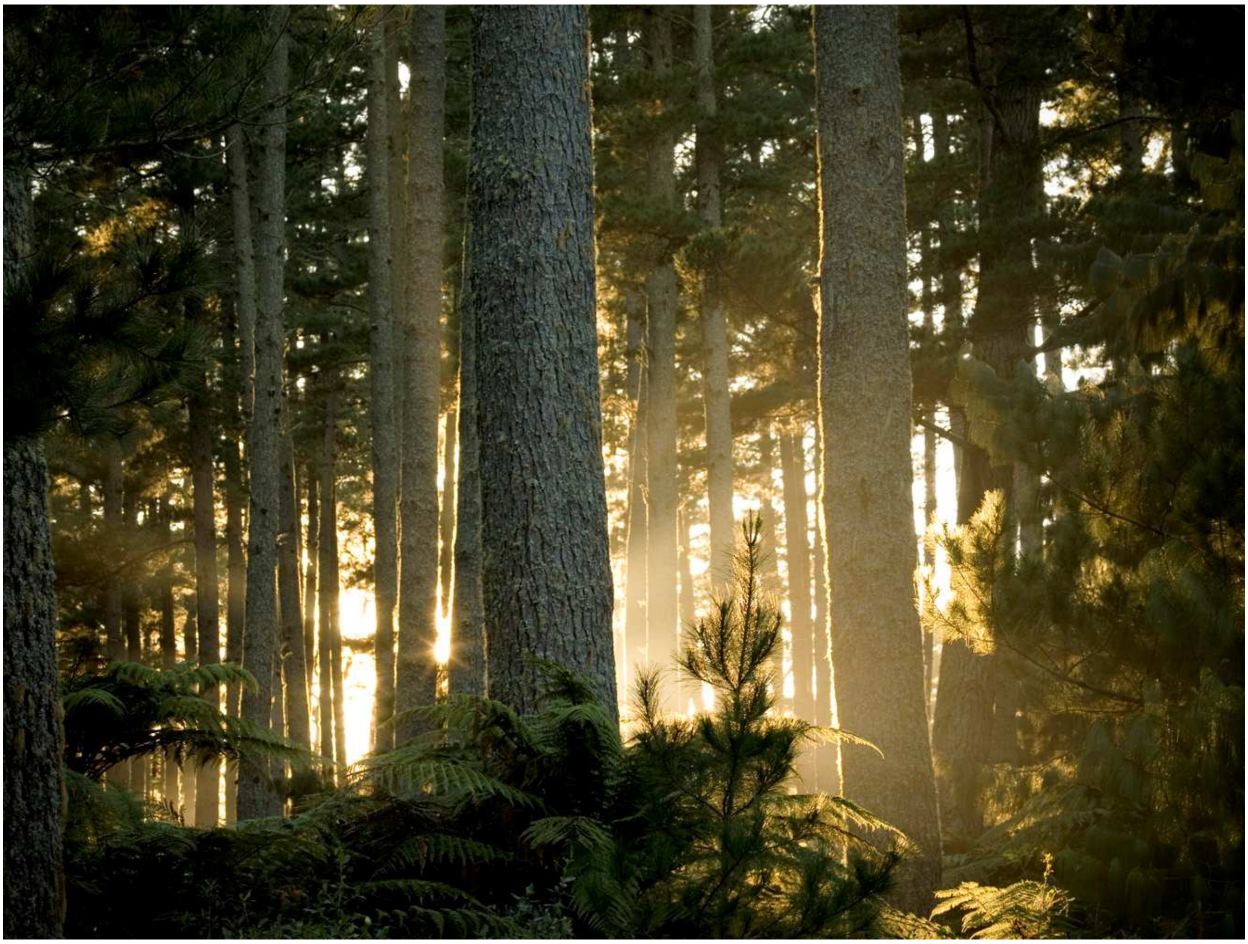

# MOISTURE METER CORRECTION FIGURES FOR J-FRAME LVL FRAMING

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# MOISTURE METER CORRECTION FIGURES FOR J-FRAME LVL FRAMING

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## INTRODUCTION

Moisture meters are widely used in the timber and building industry to check the moisture content of structural timber and house framing. Moisture meters are known to be affected by timber preservatives. Juken New Zealand Ltd (JNL) Masterton are producing J-Frame which is structural radiata pine LVL treated with Boron or CCA.

This report presents moisture meter correction figures for J-Frame LVL framing, for a resistance type moisture meter (Carrel & Carrel) and a capacitance type moisture meter (Wagner L612).

## PROCEDURE

- Juken New Zealand Ltd (JNL) Masterton supplied 90x45 mm radiata pine LVL framing timber for this study. Twenty 1 m long pieces were untreated J-Frame, 20 were Boron H 1.2 treated (Osmose El-bor) and 20 were H 3.2 treated with CCA (Sarmix Oxide 110%).
- The adhesive used for the LVL manufacture was Orica Sylvic 6003 resin (76% by weight), Hexion Modal wood flour extender (5%), Weston Milling wheat flour (8%) and water (10%).
- Each 1 m length was cut to give five 200 mm long end-matched samples.
- One sample from each original 1 m length was placed in one of four controlled environment rooms operating at 25°C, and approximately 7%, 14%, 17% and 19% moisture content.
- The samples were allowed to equilibrate in each environment for 7 weeks.
- The moisture content of each sample was measured using a:
  - Carrel & Carrel C201 resistance type moisture meter calibrated to NZS 1080.1. The moisture meter was set to a temperature of 20°C and Species of 0 (zero). The insulated electrode pins were inserted into the face of the LVL, parallel to the long edge of the sample. Readings were taken with a sliding hammer type of electrode, with the electrode inserted 15 mm into the face of the wood sample.
  - Wagner L612 capacitance type moisture meter. The specific gravity setting of the meter was 0.46. A meter reading was taken on one face of each sample.
  - The calibration of the moisture meters was checked against the manufacturers' standard at intervals during testing.
  - Each sample was weighed after the moisture meter measurements were taken.
- The moisture meter readings were not temperature corrected as the wood temperature was close to 20°C.

- The actual moisture content of each sample was determined by oven drying (AS/NZS 1997).
- The relationship between moisture meter reading and actual moisture content was modeled, and correction figures and 95% confidence limits were determined.

## RESULTS

Table 1 shows the correction figures for a resistance type moisture meter for untreated and treated radiata pine J-Frame. Table 2 shows the correction figures for a capacitance type moisture meter for untreated and treated radiata pine J-Frame.

LVL significantly affects the resistance moisture meter. Table 1 shows that a meter reading of 48 corresponds to a predicted moisture content of 20% for untreated, boron and CCA treated J-Frame. This effect is most likely due to the increased conductivity provided by the adhesive used in the LVL construction (MSDS sheet for P6003 resin specifies that resin has a pH of 11-13, Orica Chemicals; 2005).

There is a large meter correction with the capacitance type moisture meter. This is likely to be caused by the increased density of the LVL compared to sawn timber. Average basic density of sawlogs is between 385 and 440 kg/m$^3$ (Cown, 1999). The density of 10 LVL samples at the time of testing ranged from 453 to 504 kg/m$^3$. The calibration of the Wagner L612 can be altered by changing the Specific Gravity (S.G.) setting. An S.G. setting of 0.46 was used for this study, but a higher value of S.G. will alter the relationship between meter reading and moisture content.

The effect of preservative treatment is small for the resistance and capacitance meters. Figures 7 and 8 show that the regression lines are superimposed, indicating that there is small difference between the two types of treated LVL and the untreated LVL.

Figures 1 to 3 in the Appendix show large 95% confidence intervals for the data points and this is due to the large scatter of data around the prediction line. The alternate dash\dot line shows the confidence around an individual result and this is what is relevant when using the meter in practice. The resistance meter confidence interval is so high that the use of such a meter to determine moisture content is questionable. However, marked with a box in each plot is the reading at which one would be certain 95% of the time that the wood has a moisture content of 20% or less.

Table 5 in the Recommendations shows the maximum meter readings for each LVL type to determine a maximum actual moisture content of 20%.

The capacitance meter confidence is $< \pm 4$ at 15% meter reading and is acceptable at low moisture contents but questionable at higher moisture contents.

Tables 3 and 4 show moisture meter correction figures for untreated radiata pine sawn timber for comparative purposes.

TABLE 1: Correction figures for a resistance type moisture meter for untreated and treated J-Frame

| | If a resistance type moisture meter reads: | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 12 | 14 | 16 | 18 | 20 | 22 | 24 | 26 | 28 | 30 | 32 | 34 | 36 | 38 | 40 | 42 | 44 | 46 | 48 | 50 | 52 | 54 | 56 | 58 | 60 |
| | Corrected moisture content (%) is: | | | | | | | | | | | | | | | | | | | | | | | | | |
| Untreated J-Frame | - | 6 | 8 | 9 | 11 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | **20** | **20** | 21 | 21 | 21 | 22 | 22 |
| Boron treated J-Frame | 7 | 8 | 10 | 11 | 12 | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | **20** | **20** | 21 | 21 | 21 | 22 | 22 | 22 |
| CCA treated J-Frame | 3 | 9 | 10 | 12 | 13 | 14 | 14 | 15 | 16 | 16 | 17 | 17 | 18 | 18 | 19 | 19 | 19 | **20** | **20** | **20** | 21 | 21 | 21 | 22 | 22 | 22 |

Note: Confidence interval is large. See notes.

TABLE 2: Correction figures for a capacitance type moisture meter for untreated and treated J-Frame

| | If a capacitance type moisture meter reads: | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | Corrected moisture content (%) is: | | | | | | | | | | | | | | | | | | | | | | | | |
| Untreated J-Frame | - | 4 | 5 | 7 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 14 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | 17 | 18 |
| Boron treated J-Frame | - | - | 6 | 7 | 8 | 9 | 10 | 11 | 11 | 12 | 12 | 13 | 13 | 14 | 14 | 14 | 15 | 15 | 15 | 16 | 16 | 16 | 17 | 17 | 17 |
| CCA treated J-Frame | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 10 | 11 | 11 | 12 | 13 | 13 | 14 | 15 | 15 | 16 | 17 | 17 | 18 | 19 | 19 | **20** | 21 |

Note: Confidence interval is large. See notes.

TABLE 3: Correction figures for a resistance type moisture meter for Untreated radiata pine sawn timber

| | If a resistance type moisture meter reads: | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | Corrected moisture content (%) is: | | | | | | | | | | | | | | | | | | | | | | | | |
| Untreated sawn timber | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | **21** | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |

Note: Confidence interval is ± 4.0 Acceptable

TABLE 4: Correction figures for a capacitance type moisture meter for Untreated radiata pine sawn timber

| | If a capacitance type moisture meter reads: | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| | Corrected moisture content (%) is: | | | | | | | | | | | | | | | | | | | | | | | | |
| Untreated sawn timber | 4 | 6 | 7 | 8 | 10 | 11 | 13 | 14 | 15 | 17 | 18 | **20** | 21 | 22 | 24 | 25 | 27 | 28 | 30 | - | - | - | - | - | - |

Note: Confidence interval for Untreated is ± 2.3 Acceptable

## CONCLUSIONS

- LVL has a major effect on both types of moisture meter.
- A resistance meter reading of 44 corresponds to a predicted moisture content of 20% for untreated, boron and CCA treated J-Frame.
- There is a large scatter in the resistance meter readings which means great care must be exercised when interpreting the results.
- The large correction for resistance meters may cause a problem for moisture meters which do not display to such high meter readings.
- The two preservative treatments (Boron and CCA) have a smaller effect on the moisture meter than the effect due to the LVL.

## RECOMMENDATIONS

- When using a moisture meter to determine if a piece of LVL is below 20% moisture content, use the upper confidence interval for individual readings. See Table 5.

TABLE 5: Maximum moisture meter reading to predict a moisture content of less that 20% (95 times in 100 times)

| Moisture meter | LVL Untreated | LVL Boron treated | LVL CCA treated |
|---|---|---|---|
| Resistance (Carrel & Carrel C201) | 25 | 24 | 23 |
| Capacitance (Wagner L612) | 29 | 27 | 25 |

- Procedures for testing the moisture content of house framing are defined by BRANZ (BRANZ, 2002). This publication recommends that resistance type moisture meters are used for testing house framing as the capacitance type meters are insensitive to moisture gradients.
- Moisture meter operators should be aware that moisture meters do not give a precise measure of moisture content. It is important to take moisture meter readings from throughout the population of wood to get a good measure of the moisture content. The New Zealand standard includes recommendations on the use of moisture meters and indicates the number of measurements that should be taken (AS/NZS 1997).

## REFERENCES

AS/NZS 1080.1: 1997. Timber – Methods of test. Method 1: Moisture content.

Blakemore, P., 2003. The use of hand-held electrical moisture meters with commercially important Australian hardwoods. Part 1. Forest and Wood Products Research & Development Corporation. Project No. PN01.1306.

BRANZ, 2002. Measuring moisture on building sites. Bulletin 424.

Cown, D.J.; 1999. New Zealand pine and Douglas fir. Suitability for processing. Forest Research Bulletin 216.

Orica Chemicals, 2005. MSDS sheet for Sylvic P6003 Phenol formaldehyde resin.

Simpson, I.G.; 1996. Measuring the moisture content of wood. Forest Research Bulletin No. 200.

## APPENDIX

Figures 1-3 show the prediction lines and confidence intervals for each type of LVL for the C201 resistance type moisture meter, and Figures 4-6 show the graphs for the Wagner capacitance type moisture meter.

The solid line in each graph shows the predicted moisture content. The dashed lines show the 95% confidence intervals for the prediction line of actual moisture content, and the outer pair of lines (alternate dash\dot) shows the 95% confidence intervals for individual readings.

**Fig 1: C201 - Untreated J-Frame**

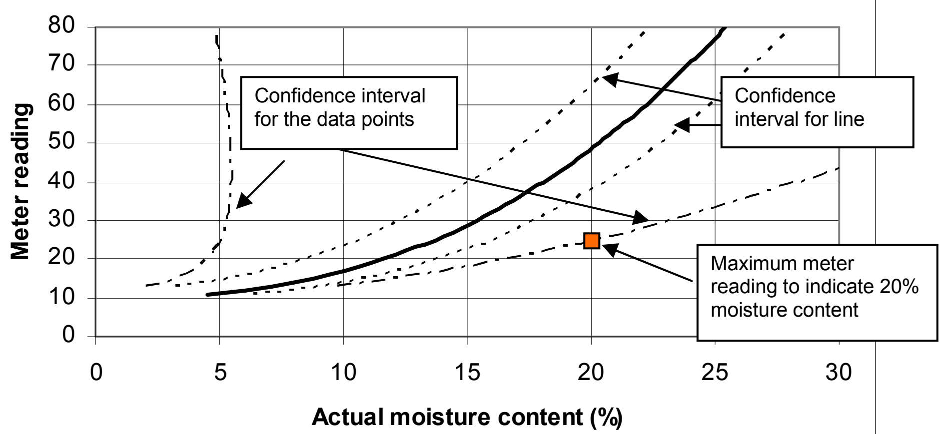



**Fig 2: C201 - Boron treated J-Frame**

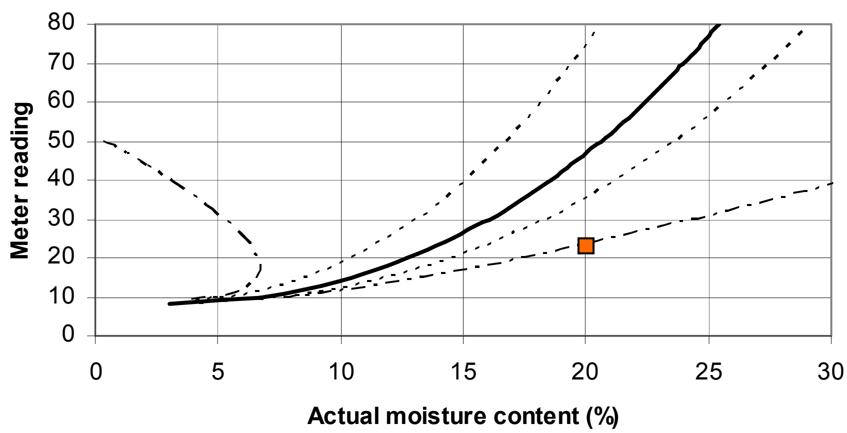
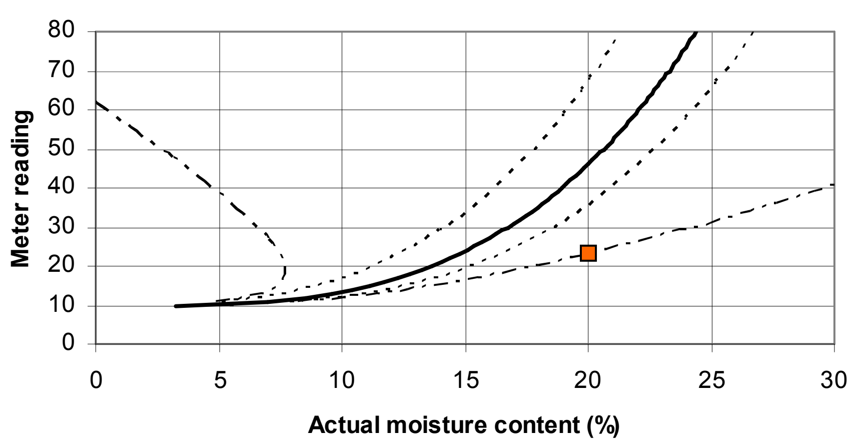



**Fig 3: C201 - CCA treated J-Frame**



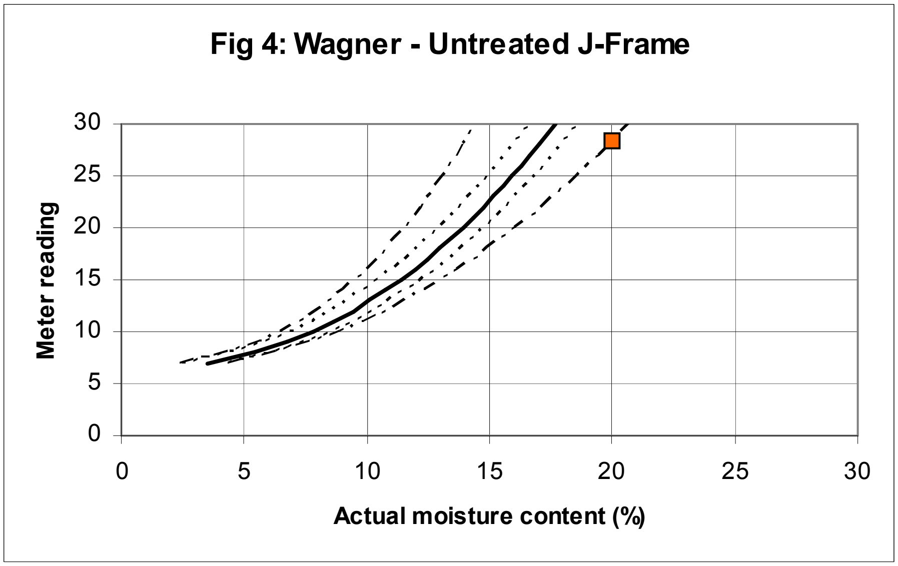


Fig 4: Wagner - Untreated J-Frame
Meter reading
Actual moisture content (%)
0
5
10
15
20
25
30

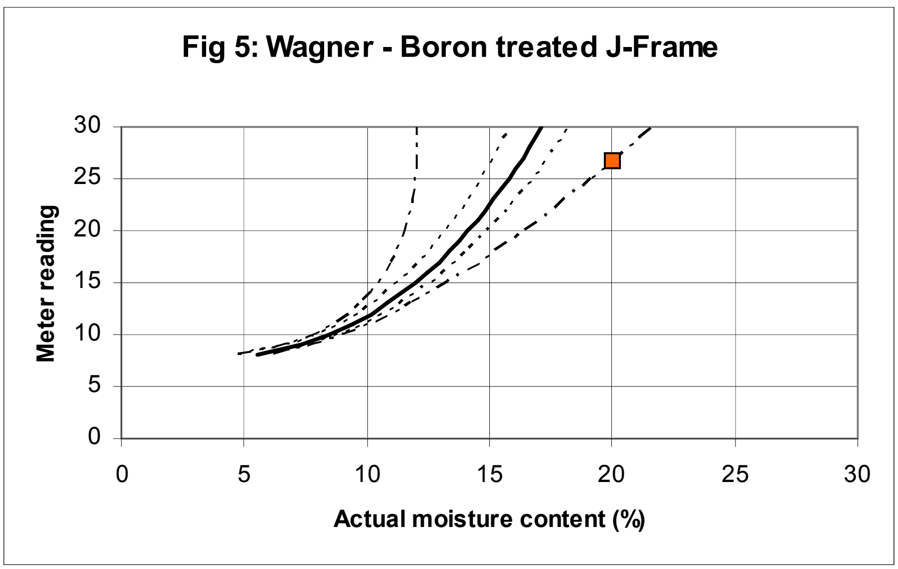


Fig 5: Wagner - Boron treated J-Frame
Meter reading
Actual moisture content (%)
0
5
10
15
20
25
30

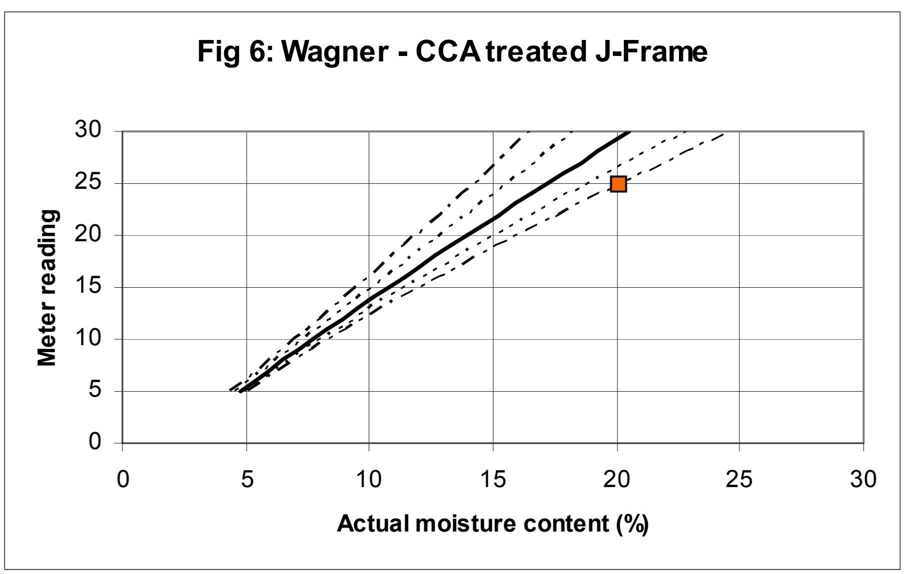


Fig 6: Wagner - CCA treated J-Frame
Meter reading
Actual moisture content (%)
0
5
10
15
20
25
30

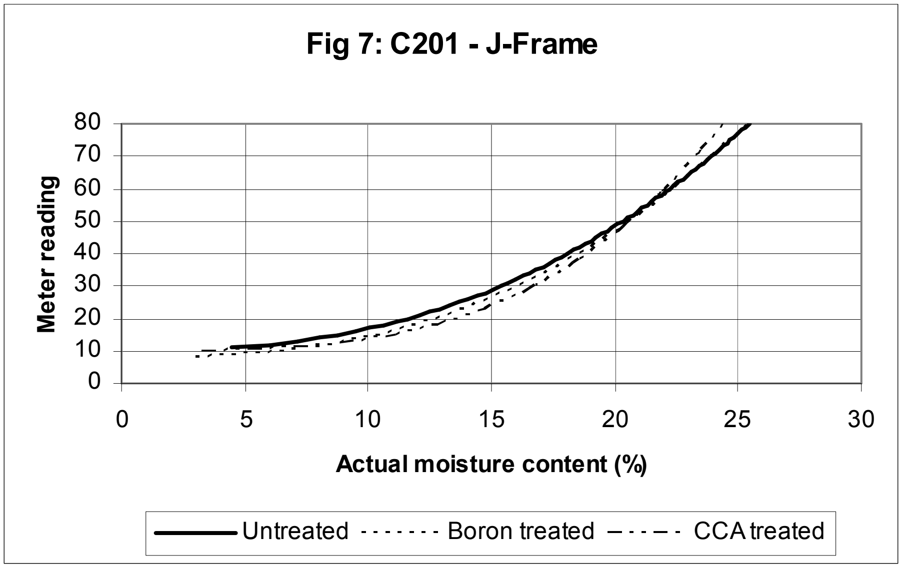


Fig 7: C201 - J-Frame
Meter reading
Actual moisture content (%)
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
Untreated
Boron treated
CCA treated

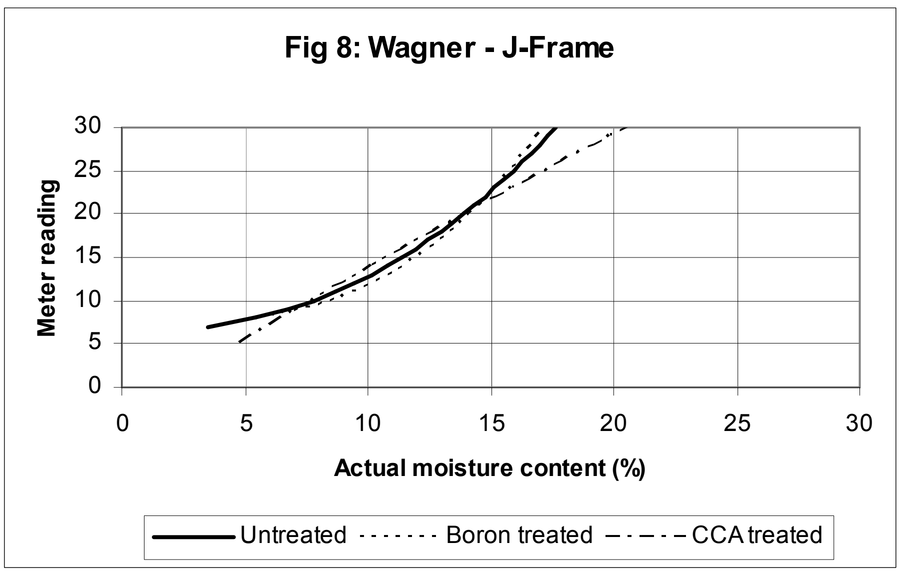


Fig 8: Wagner - J-Frame
Meter reading
Actual moisture content (%)
0
5
10
15
20
25
30
0
5
10
15
20
25
30
Untreated
Boron treated
CCA treated

# CALCULATION OF CONFIDENCE INTERVALS FOR LVL

**Rod Ball**

The LVL data, with variance increasing markedly with moisture content, did not lend itself to a single linear fit.

Using the NLME (Pinheiro and Bates 2000) and lmesplines (Ball 2003) R packages, a smoothing spline model was fitted to the meter calibration data. Residual variance was non-homogenous, with increasing variance for increasing moisture content, so a power model was fitted to the residual variance:

$$\mathrm{var}(r_i) = C \times \left(\sigma^2\right)^t \tag{1}$$

where $r_i$ denotes the $i$th residual.

Parameters *C, t* were estimated as part of the model fitting process. Different values of the constant *C* were fitted for the different treatments for each meter (C201 and Wagner), and different values of *t* were fitted for each meter.

Estimated values of *C, t* were as follows:

| Meter | *C* | | | *t* |
|---|---|---|---|---|
| | Untreated | Boron treated | CCA treated | |
| C201 | 1.000 | 0.6297 | 0.5299 | 2.152 |
| Wagner | 1.000 | .06126 | 0.8259 | 1.547 |

Flexi (Upsdell 1994, 1996; Wheeler and Upsdell 1997) was used to obtain confidence limits as follows. Using the above model for residual variance, an adjusted predictor was formed by transforming the residuals to constant variance and adding these to the fitted spline curve. Then flexi curves and confidence limits were estimated for the adjusted predictor. Finally the confidence limits were back-transformed by the inverse of the transformation used to standardise the residuals, and shown in Figure 1.

Tables of predicted moisture content based on meter reading were developed. Confidence intervals were calculated for the actual moisture content and for individual points.

A non-linear model with a power transform of the actual moisture content as explanatory variable, and also a power model for residual variance. There was a problem predicting moisture content from meter reading with some of the curves previously fitted (due to low slopes or non-monotonicity, i.e. decreasing then increasing) giving unstable predictions. Fieller's formula was applied to a refitted linear model with the transformed x-variable to get the confidence intervals for the curve of MC versus meter reading, and a component of variance for individual points (based on the slope of the curve and the residual variance for given MC) added to that to get the confidence intervals for individual points.

References

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## LVL ADHESIVE SPECIFICATION

This is the specification for the resin used in the manufacture of the LVL evaluated in this study (Juken New Zealand Ltd (JNL) Masterton Doc No: LV23-991-2, June 2007).

- 76% Orica Chemicals phenol formaldehyde resin P6003
- 8% wheat flour
- 6% Hexion Modul glue extender
- 10% water