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Dimensional stability of thermally modified Radiata Pine

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Report information sheet

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Executive summary

The problem

Dimensional stability is a key wood property that determines how wood will perform in service. Wood changes dimensions with changes in moisture content, either from contact with liquid water, or from changes in air humidity. Having data on the dimensional stability of a particular type of wood (modified, or unmodified) is important for understanding the in-service behaviour of the wood.

This project

Ben Campbell from Abodo Wood read a Scion journal article comparing different methods of measuring dimensional stability and asked for a report comparing the dimensional stability of thermally modified radiata pine with a range of other commercially available wood types (including a range of wood species, plus modified radiata pine). This involved re-analysing existing Scion data, plus measuring three new wood species, and preparing a brief report on the results.

Key results

The dimensional stability of thermally modified radiata pine was significantly better than unmodified radiata pine and was similar to Western Red Cedar. Accoya and Kebony radiata pine were significantly more dimensionally stable with changes in relative humidity, but when soaked in water levels of swelling were not significantly different to thermally modified radiata pine. Eucalyptus grandis, Siberian larch and Sapele all swelled significantly more than thermally modified radiata pine when soaked in water. Levels of swelling from these species were similar to, or greater than, unmodified radiata pine.

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Introduction

Dimensional stability is a measure of the amount wood shrinks and swells due to changes in moisture content. These changes can occur when the wood comes in contact with water (e.g., exterior timber in the rain) or through changes in air humidity. Poor dimensional stability is associated with issues such as surface checking, poor paint adhesion and cracking and loosening of joints and glue lines. Thermal modification improves the dimensional stability of wood, and consequently should reduce the incidence of these types of issues.
Understanding the dimensional stability of thermally modified radiata pine compared to other species, and to other commercially available wood modifications, is beneficial for promoting the benefits of thermal modification, and to help users understand how thermally modified wood will perform in service.

Materials and methods

Dimensional stability was assessed using two methods: the swellometer test and long-term humidity cycling. These tests are described in detail in Sargent (2022).

Briefly:

- The swellometer test involves soaking thin wood samples in water for three days and continuously measuring the change in tangential dimension during soaking.
- The long-term humidity cycling test involves equilibrating small samples to several environments ranging from low to high relative humidity and measuring the radial and tangential dimensions of the samples at each condition.

For the swellometer test, the maximum tangential swelling after 3 days of soaking is calculated. Because the swellometer test samples are equilibrated under standard conditions (25°C, 65%RH) prior to soaking, the maximum swelling is essentially the same as the tangential dimension change between 12% EMC and fibre saturation. However, it should be noted that thermally modified wood has a much lower equilibrium moisture content compared to unmodified wood, so would have been well below 12% MC during this testing.

For the long-term stability test the percentage dimension change for every 1% change in relative humidity is calculated for both the radial and tangential grain directions.

Eight commercially-available wood and modified wood types were assessed:

- Unmodified radiata pine
- Thermally modified radiata pine (230°C schedule)
- Accoya (acetylated) radiata pine
- Kebony (furfurylated) radiata pine
- Western Red Cedar
- Victorian Ash (mix of *Eucalyptus delegatensis, E. obliqua and E. regnans*)
- White Oak
- *Cupressus lusitanica*

These timbers were purchased from a range of sources including New Zealand sawmills, and New Zealand and Australian timber importers.

Additionally, three imported timber species were supplied by Abodo for inclusion in the swellometer testing:

- *Eucalyptus grandis*
- Siberian larch
- Sapele

Results and discussion

Swellometer

The maximum swelling after three days of water soaking is shown in Figure 1. The thermally modified radiata pine swelled substantially less than the unmodified radiata pine, and was not significantly different to the Kebony, Accoya, and Western Red Cedar. These are all known for being dimensionally stable, so this is a positive result. The white oak swelled nearly twice as much as the unmodified radiata pine, and the *C. lusitanica* and Victorian ash had levels of swelling that were in between those of the unmodified and thermally modified radiata pine. Sapele and Siberian larch swelled slightly more than the unmodified radiata pine. *E. grandis* swelled more than the unmodified radiata pine, but less than the White oak.

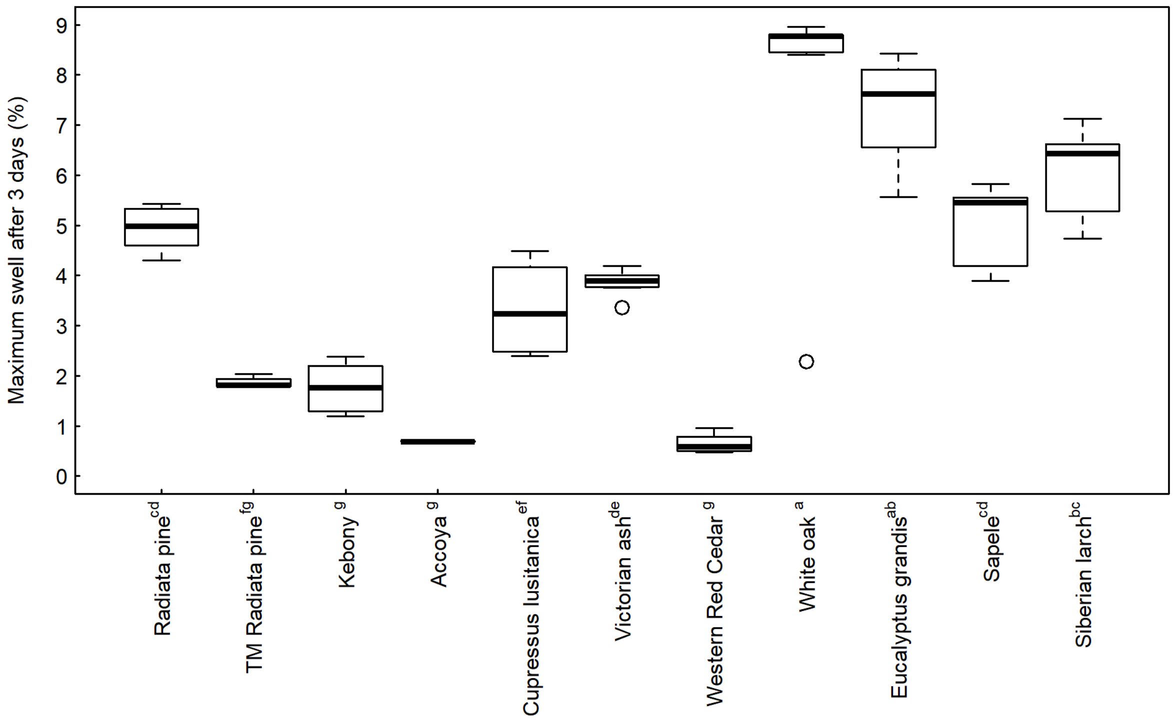


Figure 1. Maximum swelling following 3 days water soaking in the Swellometer test. Superscript letters indicate grouping that are not significantly different (95% confidence level).

Long term humidity cycling

The dimensional changes in the radial and tangential grain directions with changes in air humidity are shown in Figure 2. The thermally modified radiata pine showed significantly lower dimension changes than the unmodified radiata pine. Compared to Western Red Cedar, the thermally modified radiata pine swelled less in the tangential dimension, and a similar amount in the radial dimension. Both the Kebony and Accoya changed dimension significantly less than the thermally modified radiata pine. Both the Victorian ash and white oak changed dimension more than the unmodified radiata pine, while the *C. lusitanica* changed less.

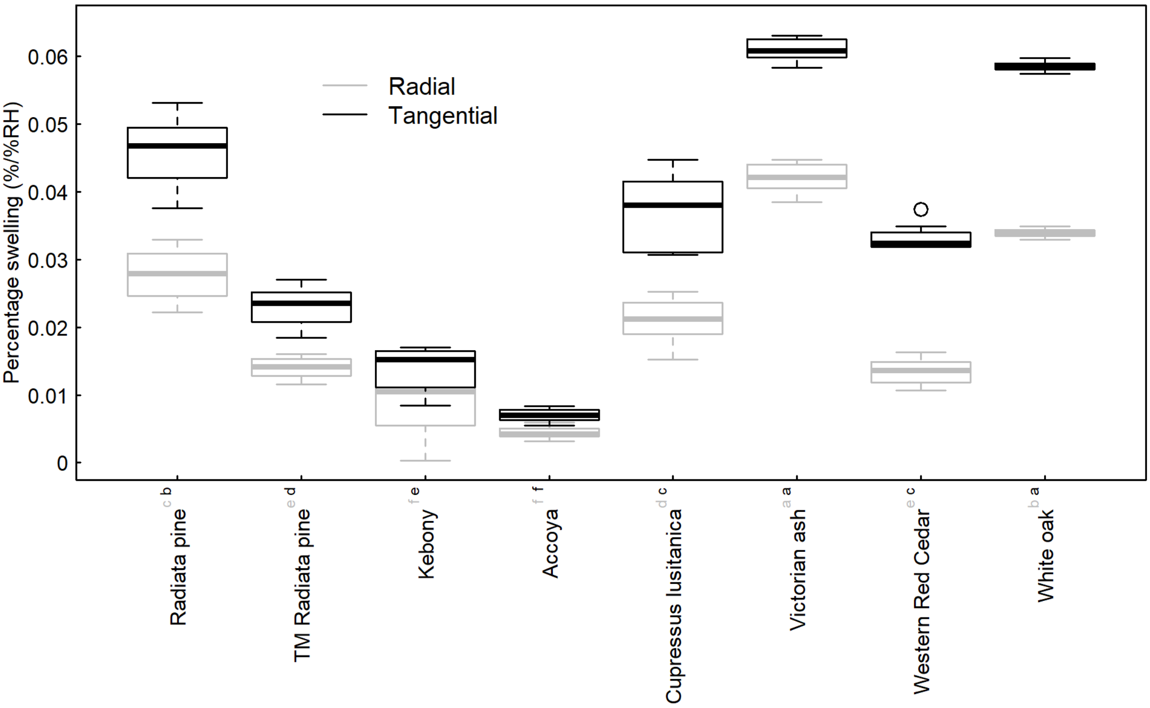


Figure 2. Percentage swelling for every 1% change in relative humidity for each wood type in the tangential and radial directions (shown as black and grey boxes respectively). Superscript letters indicate grouping that are not significantly different (95% confidence level).

Recommendations and conclusions

Under conditions of both water soaking and air humidity changes, thermally modified radiata pine was significantly more dimensionally stable than unmodified radiata pine, and it performed similarly to Western Red Cedar, a species renowned for its dimensional stability. Kebony and Accoya radiata pine were more dimensionally stable than thermally modified radiata pine in relation to changes in air humidity, while when soaked in water the levels of swelling were not significantly different to thermally modified radiata pine. With the exception of Western red cedar, all the imported species swelled as much as, or more than unmodified radiata pine, and consequently swelled substantially more than thermally modified radiata pine.

Acknowledgements

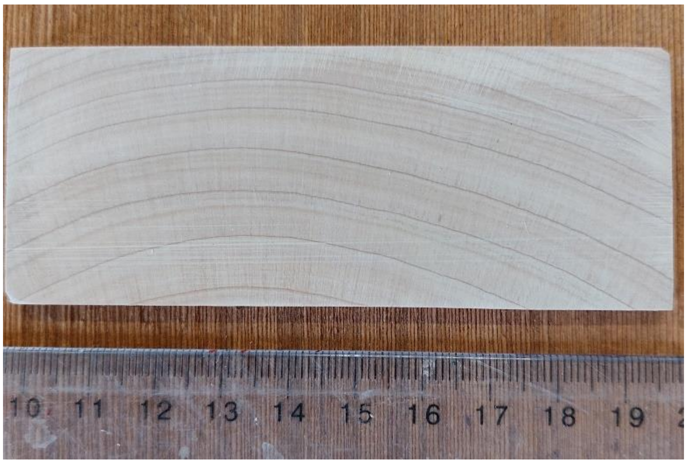
Gathering the data presented in this work was partly funded by the New Zealand Ministry for Business, Innovation and Employment Strategic Science Investment Fund under Scion's Manufactured Products from Trees Science Platform (C04X1703). Maxine Smith and Bruce Kenah assisted with the experimental measurements for both dimensional stability tests. Jamie Agnew and Gavin Durbin assisted with sample preparation.

References

Sargent R (2022) Evaluating Dimensional Stability in Modified Wood: An Experimental Comparison of Test Methods. Forests 13:613.

Appendix: Representative images of samples from each wood type

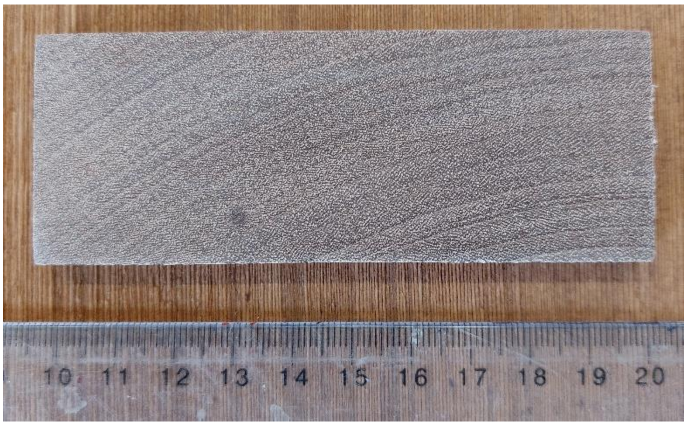
Accoya



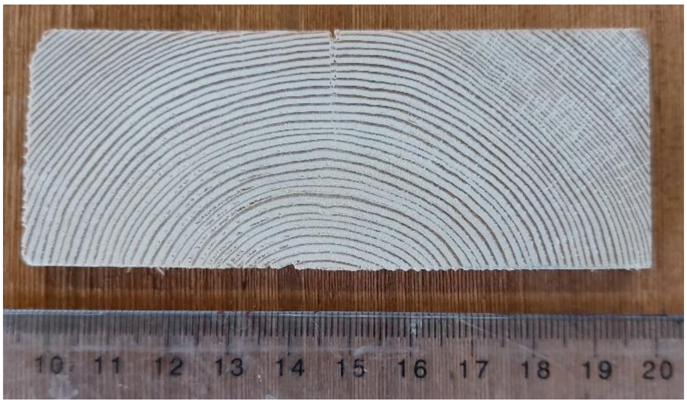
C. lusitanica

E. grandis

Kebony

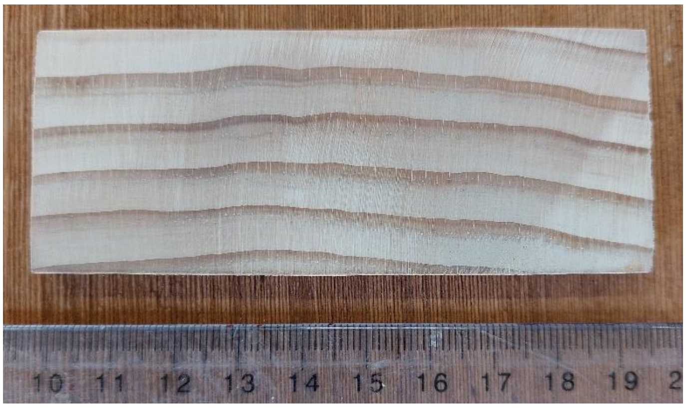


Sapele

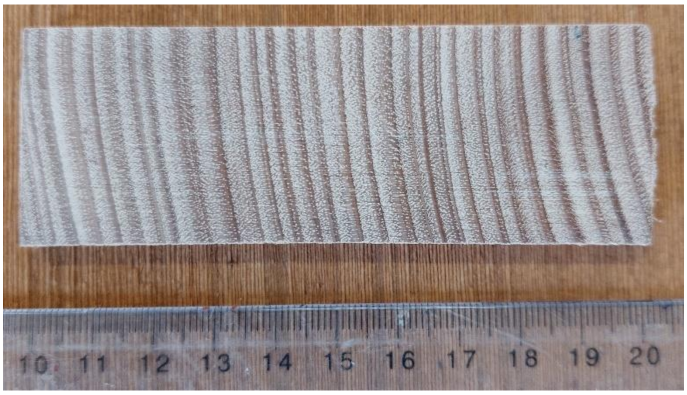


Siberian Larch

Thermally Modified radiata pine



Unmodified radiata pine



Victorian Ash

White Oak

Western Red Cedar