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Technical Report

Charring Model for Australian Oak MASSLAM

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1 Executive Summary

Australian Sustainable Hardwoods (ASH) has engaged Halliwell to prepare a technical report assessing the charring rate and effective char depth of glue-laminated timber (GLT) beams and columns manufactured from Australian Oak timber when exposed to fire conditions in accordance with AS 1530.4:2014. ASH brands its GLT products under the brand name MASSLAM, and as such, the GLT elements manufactured from Australian Oak will be referred to as Australian Oak MASSLAM throughout this report.

AS/NZS 1720.4:2019 provides a method for determining the charring rate of timber, including GLT. However, its application is conditional on the GLT being manufactured in accordance with AS/NZS 1328.1, using approved structural adhesives such as phenol, resorcinol, phenol-resorcinol, or poly-phenolic adhesives. However, the Australian Oak MASSLAM is bonded using Henkel Purbond HBS polyurethane adhesive, which does not fall within the list of approved adhesives under AS/NZS 1328.1. Therefore, the standard charring models outlined in the code are not applicable. To address this, bespoke fire testing was conducted to evaluate the fire performance characteristics.

The referenced test, FRT251605 R1.0, involved exposing a representative Australian Oak MASSLAM beam to a standard fire curve, with thermocouples embedded at various depths to monitor internal temperatures and identify the progression of charring. The data collected was used to establish a conservative linear charring model.

The analysis resulted in a charring rate of 0.59 mm/min, and when accounting for the zero-strength layer (ZSL), the effective char depth (in mm) is defined by the following model:

$$d_{eff} = 0.59 \times t + 7$$

This model provides a basis for evaluating the residual section of Australian Oak MASSLAM when exposed to AS 1530.4:2014 fire conditions and can be used to support structural fire design in accordance with AS/NZS 1720.4:2019.

The outcome of this assessment is valid till 31 August 2030.

2 Introduction

2.1 General

Australian Sustainable Hardwoods (ASH) has engaged Halliwell to prepare a technical report outlining the charring rate and effective char depth of glue-laminated timber (GLT) beams and columns manufactured from Australian Oak timber when exposed to fire conditions in accordance with AS 1530.4:2014.

While AS/NZS 1720.4:2019 provides a method for determining the charring rate of timber, including GLT, its application is conditional on the GLT being manufactured in accordance with AS/NZS 1328.1, using approved structural adhesives such as phenol, resorcinol, phenol-resorcinol, or poly-phenolic adhesives. However, the Australian Oak MASSLAM is bonded using Henkel Purbond HBS polyurethane adhesive, which does not fall within the list of approved adhesives under AS/NZS 1328.1.

Due to this deviation, an experimental investigation was undertaken to determine the charring behaviour of ASH's Australian Oak GLT. This report presents the findings of that investigation and subsequently develops an appropriate charring model specific to the Australian Oak MASSLAM.

2.2 The scope and limitations of this report

The scope of the technical report is limited to the below:

- This report provides the expected charring rate for Australian Oak MASSLAM when exposed to AS 1530.4:2014 fire conditions only. The response of these GLT for any other fire scenario is not part of the scope of this report.
- The outcome of this report is only applicable for beams and columns made of Australian Oak GLT.
- The design of Australian Oak MASSLAM beams and columns is not part of the scope of this report.
- The density Australian Oak MASSLAM is nominally 650 kg/ m^3.
- This report has been prepared based on information provided by the report sponsor including test reports and material properties. We have not independently verified the accuracy of this information and therefore cannot be held responsible for any errors or omissions that may be present in this report as a result.
- This report was prepared at the request of Australian Sustainable Hardwoods (ASH) for their specific purposes. Structural engineers, fire safety engineers, building certifiers, approval authorities, and other third parties are responsible for determining the suitability of using the outcomes of this report for a given construction circumstance.
- The client must withdraw this report from circulation if the component or element of structure is the subject of a fire test by a test authority in accordance with the standard against which this

report is being prepared and the results are not in agreement with this report. They must also withdraw this report if they get to know any information that could adversely affect the conclusions of this report.

3 Background Information

3.1 General

This technical report was prepared based on the test evidence listed in Table 1.

Table 1 Test evidence

Report	Issuing authority	Test date
FRT251605 R1.0	Jensen Hughes	7 July 2025

3.2 Evidence

3.2.1 Fire test report

The fire test report FRT251605 R1.0 presents the fire resistance performance of a non-loadbearing Australian Oak MASSLAM beam tested in accordance with AS 1530.4:2014. The tested specimen measured 300 mm wide × 400 mm deep × 1000 mm long and was manufactured by ASH using Australian Oak (Eucalyptus regnans, Eucalyptus delegatensis, and Eucalyptus obliqua), bonded with a polyurethane adhesive.

The beam was fabricated from 18 lamellae measuring 43.5 mm wide × 133 mm high × 1000 mm long and 3 lamellae measuring 39 mm wide × 133 mm high × 1000 mm long, with a measured density of 684 kg/m³ and an average moisture content of 12%. Thermocouples were embedded at various depths along both the bottom face and side face of the specimen to record internal temperature rise and monitor charring development throughout the fire exposure

The fire exposure duration was 181 minutes, conducted in accordance with AS 1530.4:2014, and the test provided valuable data on the charring characteristics and thermal response of Australian Oak MASSLAM.

4 Technical discussion

This technical report aims to develop a charring rate model under AS 1530.4:2014 standard fire exposure for Australian Oak MASSLAM produced by ASH. As the GLT uses Henkel Purbond HBS polyurethane adhesive, which is not included in the list of approved structural adhesives under AS/NZS 1328.1, the charring rate models prescribed in AS/NZS 1720.4:2019 cannot be applied. Consequently, an experimental investigation was necessary to determine the charring behaviour of this material.

To support this, the results from fire test FRT251605 R1.0 were used. As detailed in Section 3.2.1, the test specimen included a 1000 mm long instrumented Australian Oak MASSLAM beam, specifically designed to capture temperature data for charring analysis. Figure 1 illustrates the internal thermocouple (TC) layout, with TCs strategically positioned along both the vertical and horizontal axes of the beam at various depths.

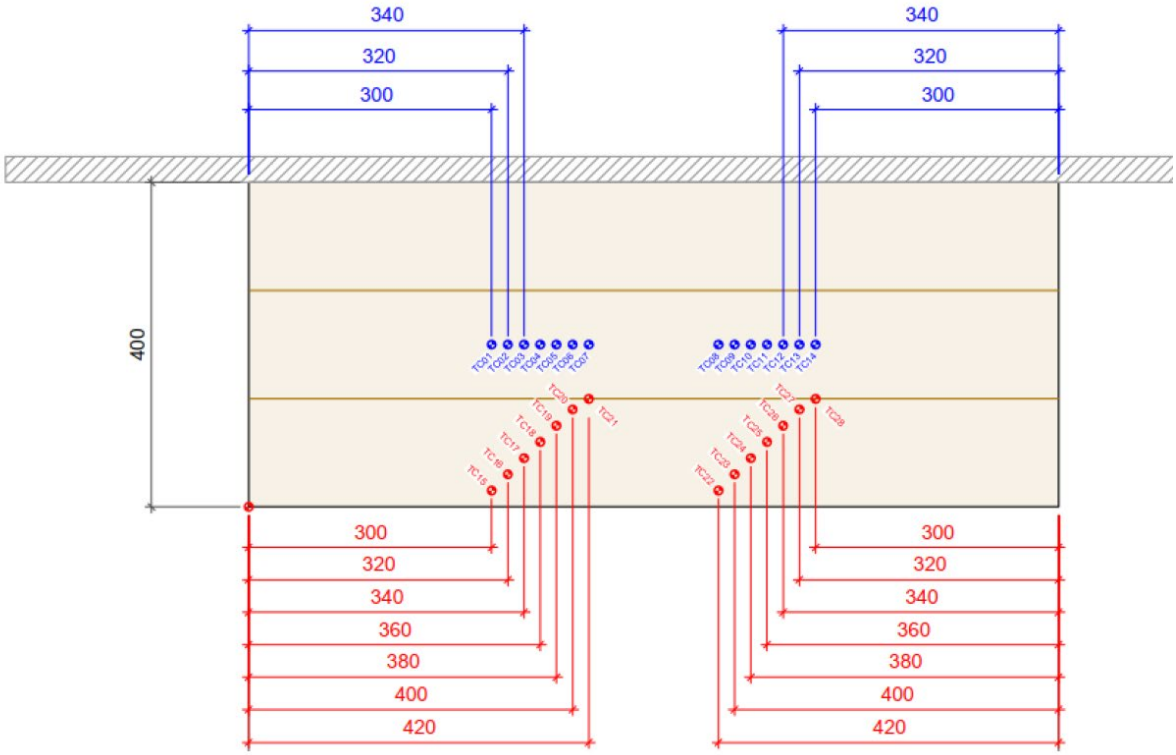

Figure 1 Internal thermocouple locations

These thermocouples were used to evaluate the thermal penetration and charring behaviour of the GLT specimen. Charring was considered to occur when the temperature at a given depth reached 300 °C. By analysing the time taken for each internal thermocouple to reach this threshold, the progression of the char front within the beam could be determined, enabling the derivation of a representative charring rate model for Australian Oak MASSLAM.

Table 2 Internal thermocouple measurements

	Thermocouple ID	Depth (mm)	Time to reach 300 °C (in minutes)
Beam side face – Set 1	TC_01	20	31.00
	TC_02	40	82.40
	TC_03	45	89.60
	TC_04	60	119.93
	TC_05	80	147.76
	TC_06	100	–
	TC_07	120	–
Beam side face – Set 2	TC_08	20	42.40
	TC_09	40	77.83
	TC_10	45	94.10
	TC_11	60	118.36
	TC_12	80	158.86
	TC_13	100	–
	TC_14	120	–
Beam bottom face – Set 1	TC_15	20	52.50
	TC_16	40	67.30
	TC_17	60	103.06
	TC_18	80	133.63
	TC_19	100	171.36
	TC_20	120	–
	TC_21	133	–
Beam bottom face – Set 2	TC_22	20	47.46
	TC_23	40	69.86
	TC_24	60	101.83
	TC_25	80	138.43
	TC_26	100	165.33
	TC_27	120	–
	TC_28	133	–

Table 2 presents the internal thermocouple measurements, showing the time at which each thermocouple reached the 300 °C threshold – indicating the point at which charring initiated at the corresponding depth.

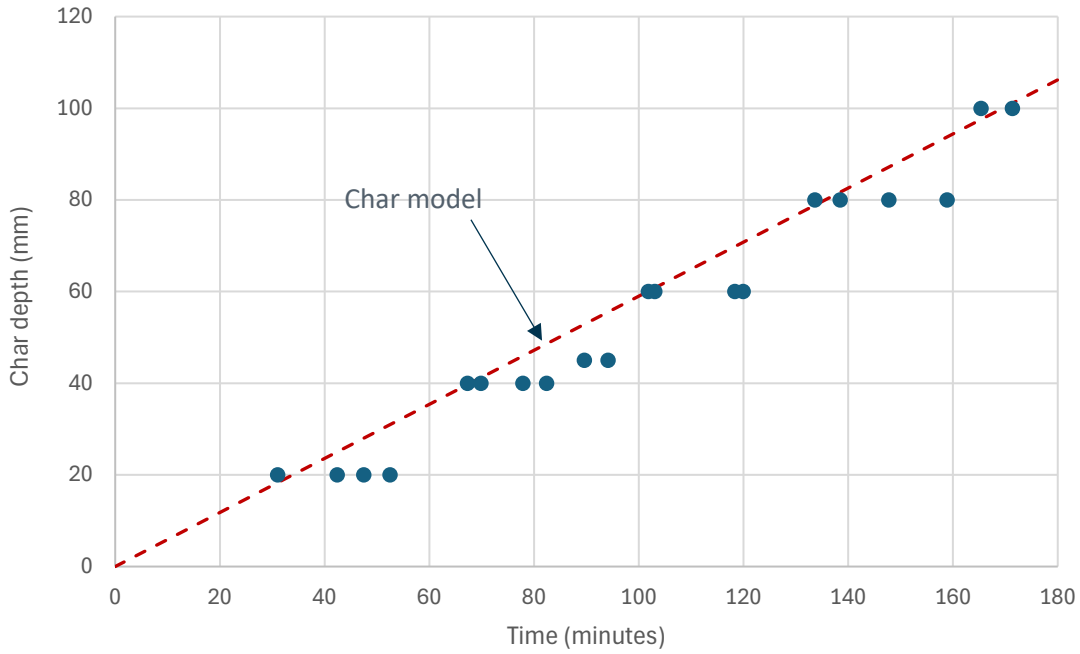

Figure 2 Proposed char model

Figure 2 presents the measured char depths plotted against the corresponding times to reach each depth, derived from internal thermocouple data. For comparison, the proposed charring rate model is also shown on the same graph. The results demonstrate that the model follows a conservative trend, with 16 out of 20 data points (80%) falling below the model line. Furthermore, the maximum difference between the model's predicted time to reach a given char depth and the actual test time was 8.6%, while the overall average difference was -12.6%. This indicates that, on average, the model predicts shorter times to reach a given char depth than observed in the test, confirming its conservatism. This indicates that the developed model provides a robust and reliable representation of the charring behaviour of Australian Oak MASSLAM under standard fire exposure conditions.

Based on the results, the developed charring model for Australian Oak MASSLAM under AS 1530.4:2014 fire exposure is expressed as:

$$d = 0.59 \times t$$

where:

- d = char depth (mm)
- t = time of exposure (min)

To account for the zero-strength layer (ZSL) as per AS/NZS 1720.4:2019, the effective char depth is calculated using:

$$d_{eff} = 0.59 \times t + 7$$

5 Conclusions

This report has established a charring rate model for Australian Oak MASSLAM when exposed to standard fire conditions in accordance with AS 1530.4:2014. Due to the use of a non-listed adhesive (Henkel Purbond HBS polyurethane), standard charring models from AS/NZS 1720.4:2019 could not be directly applied, necessitating an experimental investigation.

Based on results of fire test report FRT251605 R1.0, a linear charring rate of 0.59 mm/min has been developed. When accounting for the zero-strength layer ZSL, the effective char depth (in mm) is given by:

$$d_{eff} = 0.59 \times t + 7$$

This model provides a basis for evaluating the residual section of Australian Oak MASSLAM when exposed to AS 1530.4:2014 fire conditions and can be used to support structural fire design in accordance with AS/NZS 1720.4:2019.

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Appendix A – Experience and Qualifications of Halliwell

Halliwell Fire Science within the Halliwell is a group of highly qualified international experts in fire safety science and engineering with extensive experience in passive fire product/system development, fire testing and fire assessments. Our team is well-versed in providing research-based expert services related to fire testing and fire assessments conforming to Australian, New Zealand and European test standards.

Role	Personnel	Qualifications and relevant experience
Author	Dr. Imran Ahamed	BSc (Civil Engineering) PhD (Structural Fire Engineering) CPEng (Structural and Fire Safety) MIEAust NER, RPEQ, PE (VIC) IFE Level 3 Certificate in passive fire protection 10 years of experience in fire research, testing and assessments
Reviewer	Dr. Ryan Hilditch	BSc (Fire Safety Engineering) PhD (Fire Safety Engineering) CPEng (Fire Safety) MIEAust NER, RPEQ, PE (VIC), APEC Eng, IntPE(Aus) 15 years of experience in fire safety strategy and quantitative assessments