Timbercrete Pty Ltd

Thermal Properties of Timbercrete

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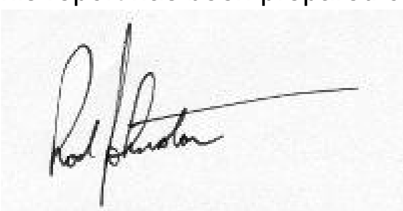

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Thermal Properties of Timbercrete

Scope
This report considers thermal properties of Timbercrete for use in determining its contribution to the thermal performance of buildings, in particular, housing.

Background
All building design must comply with the relevant State Building Regulations, which are set out in the BCA (Building Code of Australia) Volumes 1 and 2. The BCA defines the performance requirements, generally in very broad terms, and the means of compliance through:

- Deemed-to-Satisfy Provisions, which may include:
  - Acceptable Construction Manuals (e.g. nominated Australian Standards and the like)
  - Acceptable Construction Practice (e.g. forms of construction reproduced in the BCA itself

  or

- Alternative Solutions (e.g. Designs based on test results and engineering principles).

Each of these paths to compliance has equal status under the BCA.

Designers are often asked to incorporate new products into their designs. The performance of such products is justified by test because they are outside the scope of the various forms of construction specified by the BCA as Deemed-to-Satisfy. The requirements are set out in BCA Vol 1 Clauses A0.8, A0.9 and A0.10, and BCA Vol 2 Clauses 1.0.8, 1.0.9 and 1.0.10.

In many cases, designers prefer to use the Deemed-to-Satisfy Solutions. However, one exception is Energy Efficiency, where the Deemed-to-Satisfy provisions are not necessarily the most cost-effective means of providing the required performance. In this case, it may be preferable to use simulation software (such as AccuRATE) to verify performance as an Alternative Solution.

Methodology to be Used
This report provides the properties of Timbercrete, relevant to its verification in buildings assessed using software such as AccuRATE as an Alternative Solution, in accordance with the following BCA Clauses.

Alternative Solutions [BCA Vol 2 Clause 1.0.8]

→ Assessment Method using Verification Method in the BCA [BCA Vol 2 Clause 1.0.9(b)(i)]

→ Relevant Performance Requirement [BCA Vol 2 Clause 1.0.10(c)]

→ Verification Methods [BCA Vol 2 Clause V2.6]

Test Results

The properties of Timbercrete have been tested and reported by Engineered Energy and Environmental Control Systems - Ensys Limited, in their assessment of the thermal properties of six Timbercrete with a Hot Disk Thermal Analyser, at University of Canterbury, Christchurch, New Zealand. Appendix 1 reproduces the test information.

Thermal Properties of Timbercrete Material

The following information is based on test results reported by Engineered Energy and reproduced in Appendix 1.

Thermal Properties of Timbercrete Material					
	Material density γ kg/m^3	Thermal conductivity k W/m.K	Specific heat s J/kg.K	Thermal resistivity r m.K/W	Volumetric thermal capacitance MJ/m^3.K
Timbercrete (Solid - Low density)	900	0.234	737	4.274	663
Timbercrete (Solid - Medium density)	1,000	0.314	850	3.185	850
Timbercrete (Solid - High density)	1,100	0.414	759	2.415	835
Notes This data is based on the mean results of three samples of different density Timbercrete blocks (each consisting of two specimens), tested by the Hot Disk 'basic method' at University of Canterbury, Christchurch, New Zealand by Ensys Limited.					

Consistency with Data in AccuRATE

The thermal resistivity determined above for solid medium-density Timbercrete is consistent with the following values used in the AccuRATE simulation software. However, the volumetric thermal capacitance determined above for solid medium-density Timbercrete is 73% of the following values used in the AccuRATE simulation software, suggesting that the software may overestimate the thermal lag associated with the product.

Timbercrete Thermal Properties in AccuRATE Simulation Software		
	Thermal resistivity m.K/W	Volumetric thermal capacitance MJ/m^3.K
Timbercrete (Solid)	3.205	1,171
Timbercrete (Hollow)	3.205	834

Use of the Thermal Properties

- When the density of the Timbercrete product is known, the exact value from the tests may be used.
- When the density of the Timbercrete product is not known, the default values in AccuRATE should be used.

Thermal Properties of Timbercrete Blocks

The following table provides the Surface Mass, Thermal Resistance and Thermal Capacitance of various thicknesses and configurations of Timbercrete Blocks for use in energy efficiency calculations.

Thermal Properties of Timbercrete Blocks					
Material	Material density γ kg/m^3	Thickness t mm	Surface mass m kg/m^2	Thermal resistance R m^2.K/W	Thermal capacitance C kJ/m^2.K
Timbercrete - Low density	900	**90 solid**	81	**0.38**	60
		110 solid	99	**0.47**	73
		120 solid	108	**0.51**	80
		200 solid	180	**0.85**	133
		250 solid	225	**1.07**	166
		300 solid	270	**1.28**	199
		250 hollow	184	**0.94**	136
		250 laminated Including 60 polystyrene	172	**2.57**	127
Timbercrete - Medium density	1,000	**90 solid**	90	**0.29**	77
		110 solid	110	**0.35**	94
		120 solid	120	**0.38**	102
		200 solid	200	**0.64**	170
		250 solid	250	**0.80**	213
		300 solid	300	**0.96**	255
		250 hollow	204	**0.73**	173
		250 laminated Including 60 polystyrene	191	**2.37**	163
Timbercrete - High density	1,100	**90 solid**	99	**0.22**	75
		110 solid	121	**0.27**	92
		120 solid	132	**0.29**	100
		200 solid	220	**0.48**	167
		250 solid	275	**0.60**	209
		300 solid	330	**0.72**	250
		250 hollow	225	**0.58**	171
		250 laminated Including 60 polystyrene	210	**2.22**	159

Notes

Block dimensions (based on mould and core drawings) are 484 x 190 x 242 mm (length x height x width),with two cores, each 152 x 190 x 60 mm. During the manufacturing process, the blocks will slump a little, leading to an increase in overall wall thickness. Therefore, use of the mould dimensions leads to a slightly conservative result.

The Thermal Conductivity, k (W/m.K) has been determined for solid units from the thermal properties determined above, from mean results of three samples of different density Timbercrete blocks (each consisting of two specimens), tested by the Hot Disk 'basic method' at University of Canterbury, Christchurch, New Zealand by Ensys Limited. The Thermal Conductivities, k, used in these calculations are 0.234 W/m.K (for density 900 kg/m^3), 0.314 W/m.K (for density 1,000 kg/m^3) and 0.414 W/m.K (for density 1,100 kg/m^3)

The thermal resistance of the hollow blocks are calculated by determining the combined heat flow through webs, cores and mortar joints in parallel, and then in series with the two face shells.

The thermal resistance of hollow Timbercrete blocks depends on the external dimensions, core configuration, material density and thermal properties. If the hollow cores are filled with mortar or grout (as is sometimes the case) the thermal resistance will approach the value for solid blocks.

The incorporation of a continuous 60 mm wide polystyrene layer will enhance the thermal resistance by 1.76 m^2.K/W.

Thermal Resistance of Single Leaf Timbercrete Walls, Including Air Films
When determining the thermal resistance of single-leaf walls, the effect of internal and external air films must be added to the thermal resistance of the blocks.

Predicted Thermal Resistance of Solid Single Leaf Timbercrete Walls

Material	Material density γ kg/m³	Thickness t mm	Air Film Thermal resistance R m².K/W	Block Thermal resistance R M².K/W	**Total Thermal resistance R M².K/W**
Timbercrete - Low density	900	**90 solid**	0.15	**0.38**	**0.53**
		110 solid	0.15	**0.47**	**0.62**
		120 solid	0.15	**0.51**	**0.66**
		200 solid	0.15	**0.85**	**1.00**
		250 solid	0.15	**1.07**	**1.22**
		300 solid	0.15	**1.28**	**1.43**
		250 hollow	0.15	**0.94**	**1.09**
		250 laminated Including 60 polystyrene	0.15	**2.57**	**2.72**
Timbercrete - Medium density	1,000	**90 solid**	0.15	**0.29**	**0.44**
		110 solid	0.15	**0.35**	**0.50**
		120 solid	0.15	**0.38**	**0.53**
		200 solid	0.15	**0.64**	**0.79**
		250 solid	0.15	**0.80**	**0.95**
		300 solid	0.15	**0.96**	**1.11**
		250 hollow	0.15	**0.73**	**0.88**
		250 laminated Including 60 polystyrene	0.15	**2.37**	**2.52**
Timbercrete - High density	1,100	**90 solid**	0.15	**0.22**	**0.37**
		110 solid	0.15	**0.27**	**0.42**
		120 solid	0.15	**0.29**	**0.44**
		200 solid	0.15	**0.48**	**0.63**
		250 solid	0.15	**0.60**	**0.75**
		300 solid	0.15	**0.72**	**0.87**
		250 hollow	0.15	**0.58**	**0.73**
		250 laminated Including 60 polystyrene	0.15	**2.22**	**2.37**

Notes
For derivation and basis of the properties of Timbercrete blocks, refer to the notes attached to "Thermal Properties of Timbercrete Blocks".

The thermal resistance of the hollow blocks are calculated by determining the combined heat flow through webs, cores and mortar joints in parallel, and then in series with the two face shells.

The thermal resistance of the external air film is 0.03 m².K/W in accordance with BCA Vol 2.

The thermal resistance of the internal air film is 0.12 m².K/W in accordance with BCA Vol 2.

Thus the combined internal and external air film thermal resistance is 0.15 m².K/W.

Thermal Resistance of Timbercrete Veneer Walls, Including Air Films, Plasterboard and Cavity Space

When determining the thermal resistance of Solid Timbercrete Veneer Walls, the effect of internal and external air films, plasterboard and cavity spaces must be added to the thermal resistance of the blocks.

Predicted Thermal Resistance of Timbercrete Veneer Walls, Including Air Films, Plasterboard and Cavity Space

Material	Material density γ kg/m^3	Thickness t mm	Air Film Thermal resistance R m^2.K/W	Block Thermal resistance R M^2.K/W	Total Thermal resistance R M^2.K/W
Timbercrete - Low density	900	**90 solid**	0.36	**0.38**	**0.74**
		110 solid	0.36	**0.47**	**0.83**
		120 solid	0.36	**0.51**	**0.87**
		200 solid	0.36	**0.85**	**1.21**
Timbercrete - Medium density	1,000	**90 solid**	0.36	**0.29**	**0.65**
		110 solid	0.36	**0.35**	**0.71**
		120 solid	0.36	**0.38**	**0.74**
		200 solid	0.36	**0.64**	**1.00**
Timbercrete - High density	1,100	**90 solid**	0.36	**0.22**	**0.58**
		110 solid	0.36	**0.27**	**0.63**
		120 solid	0.36	**0.29**	**0.65**
		200 solid	0.36	**0.48**	**0.84**

Notes

For derivation and basis of the properties of Timbercrete blocks, refer to the notes attached to "Thermal Properties of Timbercrete Blocks".

The thermal resistance of the external air film is 0.03 m^2.K/W in accordance with BCA Vol 2.

The thermal resistance of the internal air film is 0.12 m^2.K/W in accordance with BCA Vol 2.

The thermal resistance of a 50 mm cavity is 0.15 m^2.K/W in accordance with BCA Vol 2.

The thermal resistance of the plasterboard is 0.0.06 m^2.K/W in accordance with BCA Vol 2.

Thus the combined internal and external air film thermal resistance is 0.36 m^2.K/W.

By installing in the cavity a semi-rigid reflective installation board such as "E-THERM" or

"FOIL BOARD"

the total thermal resistance (R value) will increase by a factor of R 2

Example: 0.74 + 2 = **R 2.74**

Appendix 1
Test Results Reported by Engineered Energy and Environmental Control Systems - Ensys Limited

Refer to Ensys Limited Report - ASSESSMENT OF THE THERMAL PROPERTIES OF TIMBERCRETE WITH A HOT DISK THERMAL ANALYSER

Experimental Method

Six Timbercrete samples, with nominal size 100x100x45 mm, were supplied by Timbercrete Ltd for testing by the University of Canterbury, Christchurch, New Zealand. The samples were cast more than three months prior to testing and were cured indoors at room temperature. They were conditioned at 21°C for five days prior to testing and were then tested at 21°C.

The Hot Disk 'basic method' was used to test the Timbercrete samples. A 16.5 mm diameter sensor (Number 4922) was sandwiched between the large faces of two Timbercrete samples of the same nominal density. Measurements were taken with a power of 0.3 Watts applied to the sensor for 160 seconds, resulting in an estimated probing depth of 15-20 mm in each sample. After a delay of six hours the opposite ends of the matching pair of samples were tested in the same way.

Thermal Properties

The results of the experimental measurements are shown in Table 1. It can be seen that thermal conductivity of Timbercrete increases from 0.234-0.414 W/mK as its density varies from 900-1100 kg/m^3. And it can be seen that there is a non-linear relationship between the thermal conductivity of Timbercrete and its density.

Timbercrete's thermal conductivity is less than that of ordinary concrete (approx. 1.3 W/mK) and solid clay bricks (approx. 1.2 W/mK).

Wall R-value

As Timbercrete is a homegenous material the total thermal resistance of a solid Timbercrete wall can be found from:

$R = L/k + R_{si} + R_{so}$ m^{2}K/W

where L (m) is the wall thickness, k (W/mK) is the thermal conductivity and R_{si} and R_{so} (m^{2}K/W) are the internal and external surface resistances respectively.

Following Interim New Zealand Standard NZS 4214(Int):2002 *Methods of determining the total thermal resistance of parts of buildings* the standard total thermal resistance of a 0.2 m thick, fine sawdust Timbercrete wall, for example, is:

$R = 0.2/0.234 + 0.09 + 0.03 = 0.975$ m^{2}K/W. (NZ)

$R = 0.2/0.234 + 0.12 + 0.04 = 1.015$ m^{2}K/W. (Aus)

Table 1 Thermal test results for Timbercrete samples

Product Type	Test Number	Thermal Conductivity (W/mK)	Thermal Diffusivity (mm^2/s)	Volumetric Heat Capacity (MJ/m^{3}K)
Fine sawdust Timbercrete (nominally 900 kg/m^3)	1	0.2295	0.3470	0.6612
	2	0.2384	0.3585	0.6651
	Mean @ 21°C	**0.234±0.005**	**0.353**	**0.663**
Low density Timbercrete (nominally 1000 kg/m^3)	1	0.3053	0.3535	0.8638
	2	0.3235	0.4025	0.8369
	Mean @ 21°C	**0.314±0.006**	**0.378**	**0.850**
High density Timbercrete (nominally 1100 kg/m^3)	1	0.3953	0.4484	0.8816
	2	0.4334	0.5497	0.7884
	Mean @ 21°C	**0.414±0.008**	**0.499**	**0.835**

Thermal Resistance of Timbercrete Double Brick Walls, Including Air Films, and Cavity Space

When determining the thermal resistance of Solid Timbercrete Double Brick Walls, the effect of internal and external air films, and cavity spaces must be added to the thermal resistance of the blocks.

Predicted Thermal Resistance of Timbercrete Double Brick Walls, Including Air Films and Cavity Space

Material	Material density γ kg/m^3	Thickness t mm	Air Film Thermal resistance R $m^2.K/W$	Brick x 2 Thermal resistance R $M^2.K/W$	**Total Thermal resistance R $M^2.K/W$**
Timbercrete - Low density	900	**90 solid**	0.30	**0.76**	**1.06**
		110 solid	0.30	**0.94**	**1.24**
		120 solid	0.30	**1.02**	**1.32**
Timbercrete - Medium density	1,000	**90 solid**	0.30	**0.58**	**0.88**
		110 solid	0.30	**0.70**	**1.00**
		120 solid	0.30	**0.76**	**1.06**
Timbercrete - High density	1,100	**90 solid**	0.30	**0.44**	**0.74**
		110 solid	0.30	**0.54**	**0.84**
		120 solid	0.30	**0.58**	**0.88**

Notes

Being double brick the thermal resistance for the range has been multiplied by two. For deviation of the standard brick thicknesses above, refer to the notes attached to "Thermal Properties of Timbercrete Blocks".

The thermal resistance of the external air film is 0.03 $m^2.K/W$ in accordance with BCA Vol 2.

The thermal resistance of the internal air film is 0.12 $m^2.K/W$ in accordance with BCA Vol 2.

The thermal resistance of a 50 mm cavity is 0.15 $m^2.K/W$ in accordance with BCA Vol 2.

Thus the combined internal, external air film + cavity thermal resistance is 0.30 $m^2.K/W$.

By installing in the cavity a semi-rigid reflective installation board such as "E-THERM" or

"FOIL BOARD"

the total thermal resistance (R value) will increase by a factor of R 2

Example: 1.06 + 2 = **R 3.06**