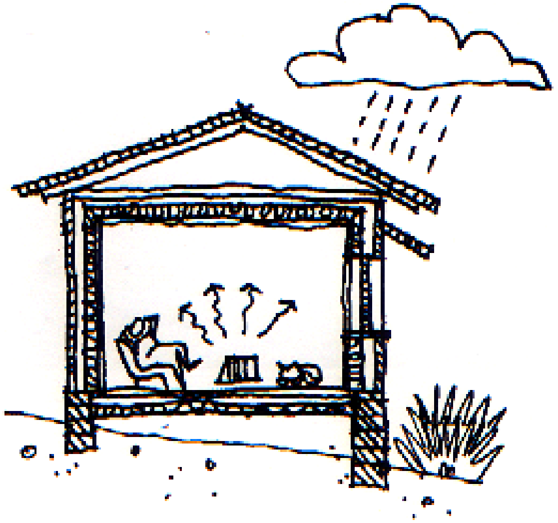
R-values for Timber Framed Building Elements



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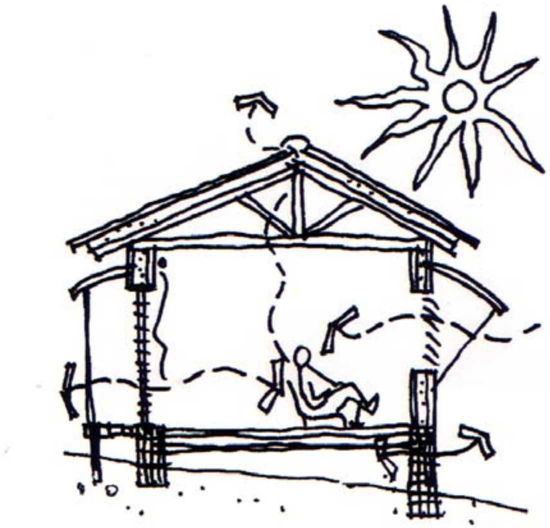

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R-values for Timber Framed Building Elements

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Attention Building Material and Product Suppliers

New materials and products are constantly being introduced to the building industry. To discuss the inclusion of new information in this guide, please contact your State timber organisation listed on the back cover.

Disclaimer

While every effort has been made to ensure the R-values given are accurate, the University of Adelaide, its employees and agents disclaim any responsibility for inaccuracies contained within the publication including those due to any negligence in the preparation or publication of the publication. The publication has been compiled as a design aid and the data should be verified before any person uses it. The user should also establish the applicability of the R-values in relation to specific circumstances and applications.

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ABBREVIATIONS

RFL reflective foil laminate

TCRI thermo-cellular reflective insulation

BBM breathable building membrane

INTRODUCTION

This publication provides authoritative estimates of the R-value of common building construction elements incorporating timber-framed construction. These may be required to satisfy minimum energy efficiency standards introduced by building regulatory authorities throughout Australia. The R-values have been calculated using two computer programs *Rvalues2.for* (walls and roof/ceilings) and *FlorsU2.for* (floors). These programs include an iterative calculation of the thermal resistance of all components, including air gaps and spaces, to produce accurate values for the assumed external and internal temperature conditions. The various assumptions inherent in the calculations are explained in this Introduction. It should be noted that any variation to these variables may result in a different R-value for the element.

NOTES ON THE CALCULATION OF R-VALUES

General

The R-value of a building element is the TOTAL THERMAL RESISTANCE (R_T) including surface thermal resistances of the air on either side of the building element.

The total thermal resistance of a planar building element consisting of layers perpendicular to the heat flow is calculated using the expression:

$$R_T = R_{si} + R_1 + R_2 + \ldots\ldots + R_n + R_{se}$$

Where: R_T is the total resistance

R_{si} is the internal surface resistance;

R_1, R_2, ...R_n are the thermal resistances of each layer, including bridged layers;

R_{se} is the external surface resistance.

Surface resistance values adopted in the calculations are given in ***Table 1***.

The thermal resistance of an element that is not continuous but is bridged by timber frames is determined by the method given in *NZS 4214: Methods of determining the total thermal resistance of parts of buildings*.

The thermal resistance of an air space within a building element depends on the effective emissivity of the space as well as the mean temperature and the difference in temperatures either side of the space. It follows therefore that the calculation of the R-value of a building element containing air spaces depends on the conditions assumed externally and internally. Similarly the conductivity of bulk insulation materials will vary with the temperature of the material. These factors are taken into account when determining the R-values given for both “Heat Flow *IN*” and “Heat Flow *OUT*” in this publication. The internal and external temperatures, temperature differences and mean temperatures used in the calculations are taken from *AS/NZS 4859.1*:

Heat flow out: Indoors 18°C, outdoors 12°C (6°K difference) mean 15°C
Heat flow in: Indoors 24°C, outdoors 36°C (12°K difference) mean 30°C

The R-values given in this publication are intended to give a good indication of the overall performance of an element in Heat Flow *IN* and Heat Flow *OUT* situations. It is important to realise that the boundary conditions and other factors used in the calculation of the R-values may differ with assumptions made in other sources of data.

CHANGES IN EDITION 2.1

The original version of *R-values for timber framed building elements* is updated in line with assumptions in the BCA (2007) and Australian Standard AS 4859.1 *Materials for the thermal insulation of buildings Part 1: General criteria and technical provisions* (2006). In many cases this process involves significant changes to the values used in the calculations and, consequently, the R-values in this new edition may differ from those in version 1.2

The most significant assumptions that are different are discussed below.

Material properties, construction and other details

Standard values for the conductivity of common building materials included in the BCA are now used in the calculations. ***Table 4*** gives the thermal conductivity of materials used in the calculations.

Standard assumptions taken from AS 4859.1, Appendix K are now used in the calculations. These include,

framing sizes

soil conductivity

internal and external temperatures

wind speed

emissivities

Emissivity values used in the calculations are shown in ***Table 3***.

Resistances of air films, attic spaces, air spaces

Air film and attic space resistances specified in the BCA and AS4859.1, are used in the calculations. ***Table 1*** shows air film resistances and ***Table 2*** shows attic space thermal resistance values.

The thermal resistance of air spaces is calculated by the method given in Robinson and Powlitch (1954).

The air film on the lower surface of the floor is assumed to be still.

Ventilation

Ventilation assumptions for roof/attic spaces are taken from AS 4859.1.

Tiled roofs, without reflective foil or blanket type insulation, are assumed to be naturally vented. Metal roofs and tiled roofs with reflective foil or blanket type insulation are assumed to non-vented. Wall cavities are assumed to be non-vented.

Calculation method for floors

The previous calculations were based on the CIBSE Guide (1986), while the new calculations are based on the method described in the International Standard ISO 13370 *Thermal performance of buildings — Heat transfer via the ground — Calculation method.* The calculation of the R-value takes into account the total resistance due to conduction, convection, radiation and ventilation. The computer program, *FlorsU2.for* performs the required calculations. Standard input parameters adopted in the calculations are shown in ***Table 5***.

Table 1: Thermal Resistance of Air Films (m2K/W)

	Position of Surface	Direction of Heat Flow	Surface Emissivity	
			High Emittance	Low Emittance
Still Air	Horizontal	Up Down	0.11 0.16	0.23 0.80
	Sloping 45°	Up Down	0.11 0.13	0.24 0.39
	Sloping 22.5°	Up Down	0.11 0.15	0.24 0.60
	Vertical	Horizontal	0.12	0.30
Moving Air	Any Orientation 3.0 m/s	Any	0.04	

Source: AS 4859.1 Materials for the thermal insulation of buildings
Note: Materials with e=0.05 or less are referred to as low emittance and those with e=0.9 are high emittance.

Table 2: Thermal Resistance of Attic Spaces (m2K/W)

Roof Space Type	Direction of Heat Flow	Surface Emissivity	
		High emittance	Low emittance surface
Non-ventilated	Up (winter) Down (summer)	0.18 0.28	0.56 1.09
Natural Ventilation	Up (Winter) Down (Summer)	0.00 0.46	0.34 1.36

Source: AS 4859.1 Materials for the thermal insulation of buildings

Table 3: Emissivity of Materials

Material	Emissivity
Aluminum reflective foil	
No dust cover	0.03
Slight dust cover	0.03+0.05
Moderate dust cover	0.03+0.25
Aluminum foil with anti-glare treatment, building wrap (upper surface)	0.20
Breathable building membrane	0.5
Common building materials	0.90

Source: AS 4859.1 Materials for the thermal insulation of buildings
Note: Materials with e=0.05 or less are referred to as low emittance and those with e=0.9 are high emittance.

Table 4: Thermal Conductivity of Materials

Material	Material Density (kg/m^3)	Thermal Conductivity (W/m.K)
Aluminium roof sheeting	2680	210
Carpet + underlay		0.05
Cellulose fibre – loose fill (with fire retardant)[1]		0.04
Ceramic tiles1		1.136
Brickwork - extruded[2]	1580	0.61
Brickwork - pressed[2]	2120	1.03
Autoclaved aerated concrete	650	0.13
Concrete or terracotta tiles	1922	0.81
Solid concrete	2400	1.44
Dense hollow concrete block, 90mm	1650	0.75
Fibre cement sheet	1360	0.25
Glassfibre - batts[1]	12	0.044
Gypsum plasterboard	880	0.17
Lightweight concrete block, 140mm	1050	0.67
90mm	1360	0.55
Linoleum[1]	1300	0.22
Particle board	640	0.12
Plywood	530	0.14
Polystyrene – expanded[1]		0.039
Polystyrene – extruded[1]		0.028
Rockwool – batts[1]		0.033
Rockwool – loose fill[1]		0.040
Steel sheeting	7850	47.5
Timber framing Kiln dried hardwood across grain	677	0.16
Timber framing Radiata pine across grain	506	0.10
Vinyl floor tiles	2050	0.79
Weatherboards – softwood	506	0.10

Note: Values for materials are from BCA (2007) unless noted. Conductivity values given in this table are generally measured at 23^{o}C. The conductivity of bulk insulation materials is varied as a function of the temperature of the material in accordance with AS 4859.1 *Materials for the thermal insulation of buildings*, Figure 2.1.

[1] Source: CSIRO (2006) **AccuRate Material Properties.** Melbourne: Commonwealth Scientific and Industrial Research Organisation.

[2] Source: AIRAH. (2000). **Handbook: Millennium Edition**. Melbourne: The Australian Institute of Refrigeration, Air-Condtioning and Heating.

Table 5: Standard Values Assumed in Suspended Floor Calculations

Variable	Assumed Standard Value		
Soil			
Clay density	1300 kg/m3		
Thermal conductivity	*1.5 W/m.K*		
Wind speed (10m height)	3.0 m/s		
Sub-floor ventilation			
Enclosed spaces*	Zone 3	Zone 2	Zone 1
In accordance with BCA Part 3.4.1 and Table 3.4.1.2 (Adjacent Figure 1 reproduced from BCA)	6000mm^2/m	4000mm^2/m	2000mm^2/m

* Enclosed sub-floor ventilation rates can be reduced if an impervious membrane is used to cover the ground (see BCA, Table 3.4.1.2)

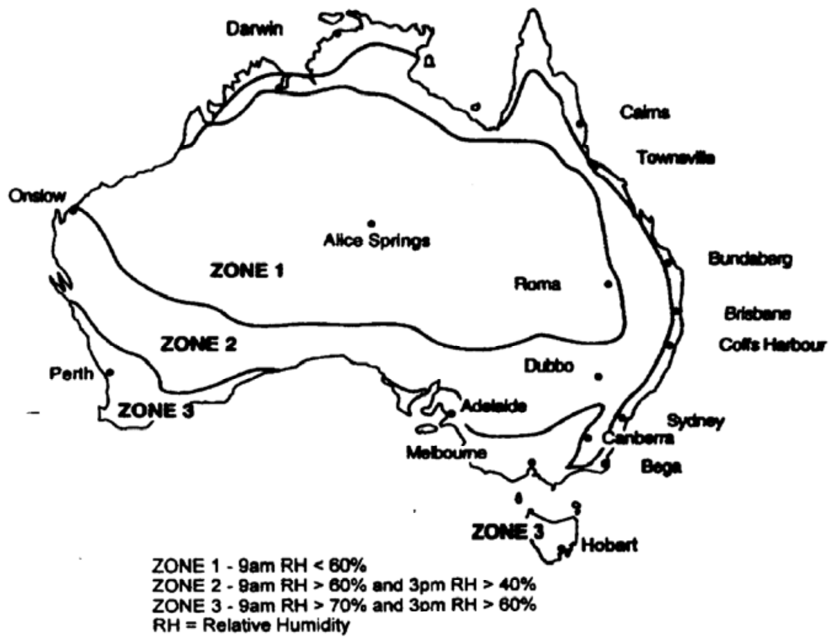

Figure 1: Sub-Floor Ventilation Zone

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