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NASH
TECHNICAL NOTE 2
Six-Star Energy Efficiency Measures For Houses

NASH™
NATIONAL ASSOCIATION OF STEEL-FRAMED HOUSING INC.

Kingspan AIR-CELL Insulbreak wall insulation

Since 2003, the Building Code of Australia (BCA) has contained provisions aimed at minimising greenhouse gas emissions by controlling both the amount and type of operational energy usage in new buildings. These provisions apply to all materials and forms of construction. This Technical Note explains the background to the current provisions and how to comply with Performance Requirement P2.6.1 in BCA 2011 Volume 2 for Class 1 buildings (eg detached and town houses) and Class 10a buildings (sheds, garages) with a conditioned space. Class 10a buildings without a conditioned space have no energy efficiency requirements.

Two compliance paths are available – energy rating software or acceptable construction. Common forms of steel-framed construction together with readily available insulation products easily meet BCA energy efficiency requirements.

PRINCIPLES OF ENERGY EFFICIENT DESIGN

The energy consumed by an average home to maintain comfortable living conditions is influenced by many factors including its location, size, geometry, orientation, room layout, materials, detail design, construction and finishing quality, fuel availability and occupant habits. External to the building, the extent to which north-facing walls are shaded by awnings or landscaping features may have a significant effect on thermal comfort.

High volume standardised housing constructed to minimum standards on small allotments has less scope to be energy efficient than individually designed dwellings. However, where multiple dwellings are developed as a group it may be possible to arrange the subdivision and dwelling orientation to achieve better overall thermal conditions. Smaller living spaces and buildings may allow less energy to be used than in larger living spaces and buildings.

WHAT DOES "6-STAR ENERGY RATING" MEAN?

The Commonwealth Department of Climate Change and Energy Efficiency administers the Nationwide House Energy Rating Scheme (NatHERS), which currently divides Australia into 69 climate regions. The scheme assigns ratings based on the amount of energy per square metre required to maintain thermal comfort in a dwelling, using a scale of zero to 10 stars.

The more stars, the less cooling and heating energy is required to maintain occupant comfort within a stipulated range. At the highest rating of 10 stars, only tropical locations are permitted significant energy use for heating and cooling.

As a guide, houses built in 1990 averaged about 1 star on the NatHERS scale. Before the introduction of national energy efficiency regulations for houses in 2003, less than 1 per cent of Australian houses achieved 5 stars.

Energy consumption by hot water systems, lights or household appliances is not included in the rating but other BCA requirements apply to hot water systems and lighting.

WHAT APPLIES WHERE?

BCA 2010 was adopted in all States and Territories on 1 May 2010. BCA 2010 included a significant change to energy efficiency requirements – the move to "6-star" energy rating for residential buildings and significant energy improvements for other buildings. The residential requirements already apply in Queensland, South Australia and the ACT. Western Australia and Victoria are scheduled to adopt 6-star requirements on 1 May 2011. The other states and territories have committed themselves to adopting 6-star requirements through the Council of Australian Government (COAG) process. BCA 2011 released on 1 May 2011 contains some additional explanatory information on 6-Star requirements.

ENERGY RATING SOFTWARE

From BCA 2010, energy efficiency performance requirements may be demonstrated either by the use of compliant Energy Rating Software or by using prescribed forms of Acceptable Construction for specific building elements – floors, walls, windows, roofs and roof lights.

As the level of new building energy efficiency required by regulation has progressively increased, prescribed solutions for all elements of the building fabric in all climate zones have become complex, and in some cases impractical. In particular wall framing may not always be deep enough to allow adequate thickness of readily available insulation, and large volumes of ceiling insulation may interfere with building services or create condensation hazards.

Consequently, BCA 2010 increased the regulator's preference towards a star-rating software approach to meeting energy efficiency requirements.

Energy Rating Software applies thermodynamic and fluid mechanics principles to simulate energy flows into, out of and within the building to determine its heating and cooling requirements. It then uses the NatHERS target levels to determine the star rating for a particular house design in its planned location, with the user selecting material options and features to achieve the required star rating.

Each construction option or feature selected has associated thermal properties that the software uses to determine the energy demand. Note that Energy Rating Software for compliance with P2.6.1 does not judge the social or economic merits of alternative energy efficiency solutions or energy sources.

Some jurisdictions such as NSW use a hybrid approach (BASIX) that assesses both energy efficiency and sources of energy as well as water efficiency.

Whilst the software path involves the cost of an energy efficiency assessment, it allows trade-offs between building features to achieve the overall rating as efficiently and practically as possible. Note that the software does not cover some energy-related building features, with requirements such as thermal breaks, ceiling insulation adjustment for openings and floor edge insulation needing to be considered separately.

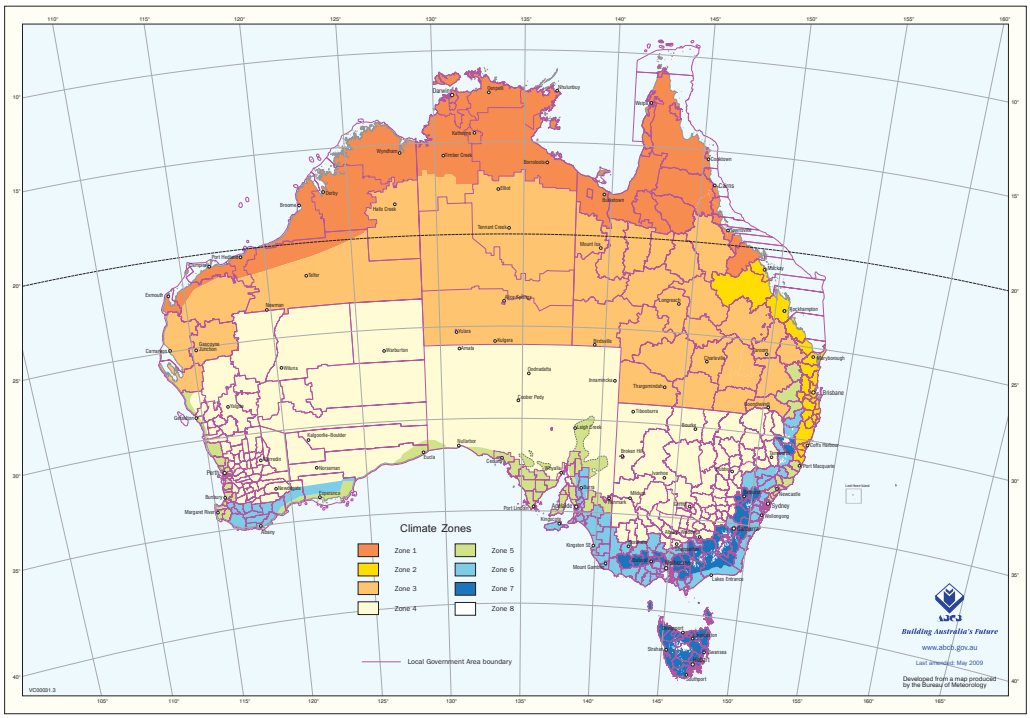
Energy Rating Software used to demonstrate compliance with P2.6.1 must comply with the ABCB Protocol for House Energy Rating Software Version 2006.1. Software systems in common use are:

- AccuRate (CSIRO/Hearn Scientific Software)
- FirstRate5 (Sustainability Victoria)
- BERS Pro (Solar Logic/SmartRate)

A recent HIA national survey of 710 builders published in Housing, September 2010 revealed that 42% used energy rating software with 58% using acceptable construction. However, this is strongly swayed by the large number of small builders – less than 10 homes pa – with around two-thirds using acceptable construction. At the other end of the scale, software is used by around 80% of builders of more than 100 homes pa.

ACCEPTABLE CONSTRUCTION

The BCA defines 8 climate zones for Australia, with 1 being the hottest and 8 the coldest. Detailed climate zone maps for Australia and each state are available on the ABCB website.



Climate zone map (reproduced with permission of ABCB)

Acceptable (deemed-to-satisfy) construction is described for roofs, walls and floors for each climate zone, comprising typical construction plus additional insulation to achieve a minimum R-Value for the building element. The R-value is the thermal resistance of the building element in $m^2.^{\circ}K/W$. The higher the R-value, the less energy is transmitted through the element under given conditions. The BCA intent is that combinations of acceptable construction will result in overall thermal resistances producing close to the required star rating. The general approach for roofs, walls and floors is:

1. Look up the Minimum Total R-Value required for the element in the appropriate BCA table. This typically depends on the climate zone and on the mass, composition, colour and shading of the particular element. Concessions for roof space and wall cavity ventilation apply in some situations. The direction of heat flow for the Total R-Value required is important for roofs and floors.
2. Look up the deemed R-Value of the type of construction proposed in the appropriate BCA table. Table entries exist for most common forms of residential construction, while other forms will require a calculation.
3. Determine the minimum additional insulation R-Value required for the building element as the difference between 1 and 2.
4. For roofs, adjust the ceiling insulation to allow for areas of loss such as flues, exhaust fans and downlights.
5. Select an insulation product or system that has the required R-Value when installed in the relevant form of construction.
6. Make any adjustments required for attached Class 10a buildings (eg garages) to preserve the overall energy performance of the building.

Foilboard wall insulation

EXAMPLE HOUSE

To illustrate various solutions this Technical Note makes reference to an example dwelling that:

- is in Climate Zone 5 – perhaps Newcastle, Adelaide or Perth
- has an unventilated pitched light grey pre-painted steel roof with horizontal ceiling
- has unshaded 90 mm steel framed walls with part brick veneer and part fibre-cement cladding
- has a low-level enclosed suspended floor with particleboard flooring on steel joists and
- has 1.8% of ceiling insulation area lost to downlights, fans and ducts.

The following sections show how acceptable construction solutions can be determined for the roof, walls and floor of this building.

ROOF SYSTEMS

REQUIREMENTS

BCA VOLUME 2 TABLE 3.12.1.1A LISTS THE MINIMUM TOTAL R-VALUE FOR ROOFS AND CEILINGS OF CLASS 1 AND CONDITIONED CLASS 10 BUILDINGS:

Climate Zone	1	2		3	4 & 5	6 & 7	8
		Altitude < 300 m	Altitude ≥ 300 m				
Direction of heat flow	Downwards		Downwards & upwards		Upwards		
Roof with solar absorptance ≤ 0.4	4.1		4.1		4.1		6.3
Roof with solar absorptance > 0.4 and ≤ 0.6	4.6		4.6		4.6		6.3
Roof with solar absorptance > 0.6	5.1		5.1		5.1		6.3

Where the roof construction involves metal sheet roofing directly fixed to metal purlins, metal rafters or metal battens and has no internal ceiling lining, or a lining fixed directly to the same member as the sheet roofing, a thermal break of R-Value at least 0.2 must be installed between the metal sheet roofing and the supporting roof framing. It is not required where the internal ceiling lining is fixed to battens or furring channels.

Expanded polystyrene 12 mm thick, compressed bulk insulation or timber 20 mm thick are deemed to achieve the required thermal break R-Value. Manufacturers of externally fitted insulation boards and wraps should confirm the thermal break compliance of their products.

SOLUTIONS

THE TABLE BELOW SHOWS SOME EXAMPLES FOR COMMON ROOF CONSTRUCTION WITH ADDITIONAL INSULATION:

Roof Configuration	Ventilation	Direction of Heat Flow	Inherent R-Value	Additional Insulation	Total R-Value
Pitched METAL roof with FLAT ceiling	Ventilated	Down	0.72	R3.5 ceiling batts	4.1
		Up	0.21		3.9
	Unventilated	Down	0.54		3.9
		Up	0.39		4.1
Pitched METAL roof with FLAT ceiling	Ventilated	Down	0.72	Foil-faced R1.3 blanket plus R3.5 ceiling batts	6.2
		Up	0.21		5.6
	Unventilated	Down	0.54		5.9
		Up	0.39		5.8
Pitched TILE roof with FLAT ceiling	Ventilated	Down	0.74	R3.5 ceiling batts	4.1
		Up	0.23		3.9
	Unventilated	Down	0.56		4.1
		Up	0.41		3.9
Pitched TILE roof with FLAT ceiling	Ventilated	Down	0.74	Single-sided polyweave foil plus R3.5 ceiling batts	5.2
		Up	0.23		4.4
	Unventilated	Down	0.56		4.9
		Up	0.41		4.6

Source: ICANZ Insulation Handbook www.icanz.org.au

SOLUTIONS CONTINUED

As examples of suitable product solutions, Foilboard Australia and Kingspan Insulation have provided the following options for particular roof configurations. *Refer to manufacturers directly for detailed product specifications and installation recommendations.*

Roof Configuration	Foilboard® Product Solution	Total R-Value
Pitched METAL roof with FLAT 10 mm plasterboard ceiling (unventilated)	Reflective foil sarking fixed between roof sheeting and battens 10 mm Foilboard® panel fixed between roof battens and trusses R2.5 bulk insulation to ceiling	6.8 DOWN 4.3 UP
Pitched METAL roof with CATHEDRAL 10mm plasterboard ceiling (unventilated)	Reflective foil sarking fixed between roof sheeting and battens 10 mm Foilboard® panel fixed between roof battens and trusses	4.1 DOWN 1.8 UP

Source: Foilboard Australia Pty Ltd – Refer to manufacturer for further information

Roof Configuration	Kingspan® Product Solution	Total R-Value
Pitched METAL roof with FLAT 10 mm plasterboard ceiling (unventilated)	Kingspan AIR-CELL Insulbreak® 65 fixed between battens and trusses R3.5 bulk insulation to ceiling	6.0 DOWN 5.1 UP
Pitched METAL roof with CATHEDRAL 10mm plasterboard ceiling (unventilated)	Kingspan AIR-CELL Insulbreak® 65 fixed between battens and trusses 70 mm Kingspan Kooltherm® K12	6.4 DOWN 5.1 UP

Source: Kingspan Insulation Pty Ltd – Refer to manufacturer for further information

SOLUTIONS CONTINUED

The example house roof requires a minimum total R-Value of 4.6 upwards. This is selected from the middle line of the BCA table based on the manufacturer providing evidence that the light grey prepainted steel roof has a solar absorptance value of greater than 0.4 but not greater than 0.6. A concession in the Minimum R-Values is available in climate zones 1-5 where prescribed roof ventilation is present (subject to ember protection requirements in bushfire prone areas). Since the example house roofspace is unventilated, the concession of 0.5 does not apply.

Calculation Item		R-Value
Required minimum R-Value, from BCA Table 3.12.1.1a (upwards)	(1)	4.60
Concession for roofspace ventilation	(2)	0.00
Deemed R-Value for basic construction, from BCA Figure 3.12.1.1	(3)	0.39
Required additional insulation (1) - (2) – (3)	**(4)**	**4.21**
Additional insulation at roof level (foil + 55 mm blanket)	(5)	1.30
Additional resistance due to reflective roof airspace	(6)	0.38
Remaining insulation required at ceiling level (4) – (5) - (6)	(7)	2.53
This exceeds 50% of total additional (4) as required by BCA		
Adjusted R-Value for lost area due to ceiling penetrations	**(8)**	**3.10**

The adjustment for ceiling penetrations is looked up in BCA Volume 2 Table 3.12.1.1b. The final step is to select an appropriate ceiling insulation product from manufacturers' literature to give an R-Value of 3.7. If rooflights form part of the design, Clause 3.12.1.3 provides acceptable construction requirements.

COLORBOND® Steel Solar Absorptances ≤ 0.6	
Colour	**Solar Absorptance**
Classic Cream™	0.31
Surfmist®	0.32
Paperbark®	0.42
Evening Haze®	0.43
Shale Grey™	0.43
Sandbank®	0.46
Dune®	0.47
Windspray®	0.58
Pale Eucalypt®	0.60

Source: BlueScope Steel Ltd

Note that NSW BASIX and BCA Volume 1 (Class 2-9 buildings) have different threshold values of solar absorptance. This may place some colours in different categories. For more information as well as data for other colours, refer to BlueScope Steel Ltd.

WALL SYSTEMS

REQUIREMENTS

BCA VOLUME 2 TABLE 3.12.1.3A LISTS THE MINIMUM TOTAL R-VALUES FOR FRAMED WALLS WITH CLADDING OR BRICK VENEER:

Climate Zone	Options	
1, 2, 3, 4 & 5	Either	2.8
	or	2.4 + specified shading
6 & 7	2.8	
8	3.8	

Where the wall construction involves lightweight external cladding such as weatherboards, fibre-cement or metal sheeting and has no internal lining, or lining fixed directly to wall framing, a thermal break of R-Value at least 0.2 must be installed between the external lightweight cladding and the steel frame.

It is not required for brick veneer construction, or where the internal lining is fixed to battens or furring channels. The thermal break does not form part of any additional insulation the wall may require unless it extends beyond the frame across the entire wall. Expanded polystyrene 12 mm thick or timber 20 mm thick are deemed to achieve the required thermal break R-Value. Manufacturers of externally fitted insulation boards and wraps should confirm the thermal break compliance of their products.

SOLUTIONS

The following table shows some examples for common wall construction with additional insulation. Note that the BCA does not have separate requirements for inward and outward resistance for walls. However, for completeness both inward and outward values have been included in the following tables.

Wall Configuration	Direction of Heat Flow	Inherent R-Value	Additional Insulation	Total R-Value
Fibre-cement sheet Thermal break 90 mm steel stud 10 mm plasterboard	Inwards	0.42	Single-sided polyweave with R2.5 wall batts	2.8
	Outwards			3.1
Fibre-cement sheet Steel batten 90 mm steel stud 10 mm plasterboard	Inwards	0.42	Single-sided polyweave foil with R2.5 wall batts	2.8
	Outwards			3.1
Fibre-cement sheet Steel batten 70/75 mm steel stud 10 mm plasterboard	Inwards	0.42	Double-sided antiglare foil with R2.0 wall batts	2.7
	Outwards			3.0
110 mm brick veneer 70/75/90 mm steel stud with 10 mm plasterboard lining	Inwards	0.56	Single-sided polyweave foil with R2.5 wall batts	3.0
	Outwards			3.2
110 mm brick veneer 70/75/90 mm steel stud with 10 mm plasterboard lining	Inwards	0.56	Double-sided polyweave foil with R2.0 wall batts	2.9
	Outwards			3.2

Source: ICANZ Insulation Handbook www.icanz.org.au

SOLUTIONS CONTINUED

As examples of suitable product solutions, Foilboard Australia and Kingspan Insulation have provided the following options for brick veneer and clad framing to achieve R2.8. *Refer to manufacturers directly for detailed product specifications and installation recommendations.*

Wall Configuration	Foilboard® Product Solution	Total R-Value
110 mm brick veneer 75 mm steel framing 10 mm plasterboard lining	Standard 10 mm Foilboard® panel and R1.5 fibreglass insulation	2.9 IN 3.0 OUT
110 mm brick veneer 75 mm steel framing 10 mm plasterboard lining	Ultra 20 mm Foilboard® panel	2.6 IN 2.8 OUT
9 mm fibre-cement cladding 20 mm steel batten 75 mm steel framing 10 mm plasterboard lining	Standard 10 mm Foilboard® panel and R1.5 fibreglass insulation	2.7 IN 2.8 OUT
Steel cladding 75 mm steel framing 10 mm plasterboard lining	Ultra 20 mm Foilboard® panel and R1.5 fibreglass insulation	3.1 IN 3.2 OUT
Timber cladding 75 mm steel framing 10 mm plasterboard lining	Ultra 20 mm Foilboard® panel	2.8 IN 2.8 OUT

Source: Foilboard Australia Pty Ltd - Refer to manufacturer for further information

Wall Configuration	Kingspan® Product Solution	Total R-Value
110 mm brick veneer 90 mm steel framing 10 mm plasterboard lining	Kingspan AIR-CELL Permishield® 65 20 mm Kingspan Kooltherm® K12 (between studs)	3.6 IN 3.8 OUT
110 mm brick veneer 90 mm steel framing 10 mm plasterboard lining	25 mm Kingspan Kooltherm® K12 (in cavity)	2.9 IN 3.1 OUT
110 mm brick veneer 90 mm steel framing 10 mm plasterboard lining	35 mm Kingspan Kooltherm® K12 (in cavity)	3.4 IN 3.6 OUT
110 mm brick veneer 90 mm steel framing OR 70 mm frame + 20 mm spacer 10 mm plasterboard lining	Kingspan AIR-CELL Permishield® 65	1.9 IN 2.2 OUT
9 mm fibre-cement cladding 70/75 mm steel framing 10 mm plasterboard lining	Kingspan AIR-CELL Permishield® 65 R1.3 fibreglass insulation	2.9 IN 3.0 OUT
Steel cladding 70/75/90 mm steel framing 10 mm plasterboard lining	Kingspan AIR-CELL Permishield® 65 R1.78 70 mm HD fibreglass insulation	2.8 IN 2.9 OUT
Steel cladding 90 mm steel framing 10 mm plasterboard lining	Kingspan AIR-CELL Permishield® 65 R2.5 90 mm fibreglass insulation	2.9 IN 2.9 OUT
90 mm steel framing 10 mm plasterboard lining	50 mm Kingspan Kooltherm® K5	2.9 IN 2.9 OUT

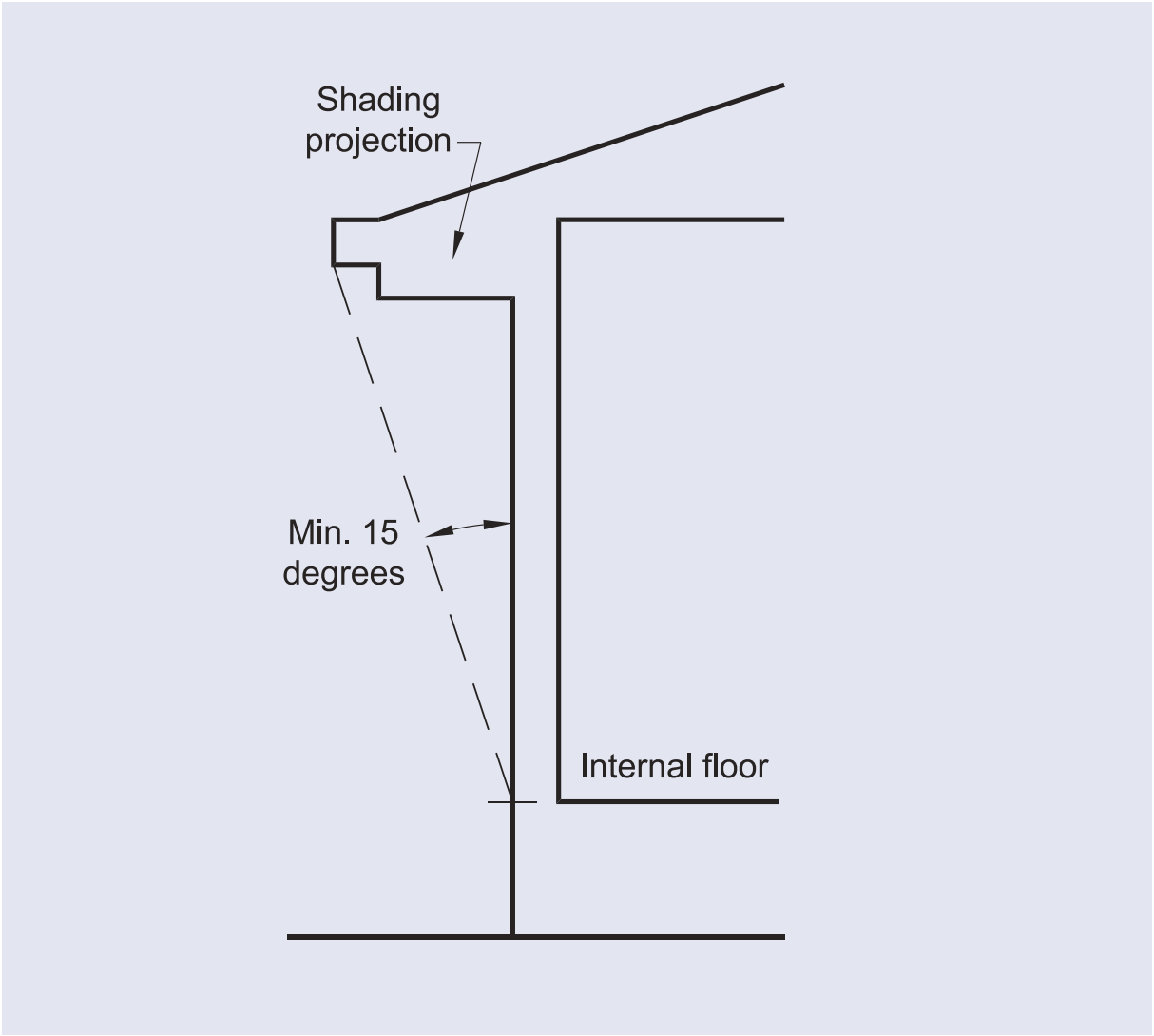
Source: Kingspan Insulation Pty Ltd - Refer to manufacturer for further information

Note that the proprietary insulation products in the above clad systems provide the required thermal break between the external cladding and frame.

SOLUTIONS CONTINUED

The example house external wall requires a minimum total R-Value of 2.8 which can be reduced to 2.4 if the wall is shaded (see diagram). Various combinations of products can be used to provide this insulation performance. Some sheet insulation materials are placed on the outside of the frame while conventional fibreglass or mineral wool can be placed between the wall studs. Where 70/75 mm wall studs are used, options may be more limited or more costly, as there is less wall thickness available for bulk insulation.

Calculation Item		FC Cladding	Brick Veneer
Required minimum R-Value, from BCA table	(1)	2.80	2.80
Deemed R-Value for construction, from BCA table	(2)	0.42	0.56
Required additional insulation (1) – (2)	**(3)**	**2.38**	**2.24**
Additional bulk insulation between studs	(4)	2.50	1.80
PLUS reflective foil insulation	(5)	-	0.50
LESS loss of cavity airspace	(6)	-0.14	-
Nett additional R-Value (4) + (5) – (6)	**(7)**	**2.36**	**2.30**



Shading diagram - BCA Fig. 3.12.1.2 (reproduced with permission of ABCB)

FLOOR SYSTEMS

REQUIREMENTS

BCA VOLUME 2 TABLE 3.12.1.4 LISTS THE MINIMUM TOTAL R-VALUES FOR SUSPENDED FLOORS (EXCLUDING INTERMEDIATE FLOORS):

Climate Zone	1	2	3	4	5	6	7	8
	Direction of heat flow							
	Upwards			Downwards				
Minimum Total R-Value	1.50	1.00	1.50	2.25	1.00	2.25	2.75	3.25

Where the perimeter of the underfloor space is enclosed, the underfloor airspace and its enclosure may be included in the total R-Value calculation. A barrier is required to prevent convection into wall cavities.

Concrete slabs, both on-ground and suspended, have specific insulation requirements where in-slab heating is installed, and slabs-on-ground require insulation in very cold climates.

SOLUTIONS

The next table shows some examples for common floor construction of various heights with additional insulation. The enclosed cases apply when BCA minimum ventilation requirements are used. Higher ventilation rates will reduce R-Values.

Whilst floors may be insulated with batts, a supporting panel or membrane is needed to keep them in place between the floor joists.

Floor Configuration	Enclosure Wall	Direction of Heat Flow	Inherent R-Value	Additional Insulation	Total R-Value
Timber flooring on steel frame ≤ 600 mm high - enclosed	Single skin masonry	Upwards	0.88	R1.5 batts	2.3
		Downwards	1.01		2.6
	Lightweight cladding	Upwards	0.77		2.2
		Downwards	0.90		2.5
Timber flooring on steel frame 600 – 1200 mm high - enclosed	Single skin masonry	Upwards	0.76		2.1
		Downwards	0.89		2.5
	Lightweight cladding	Upwards	0.65		2.0
		Downwards	0.77		2.4
Timber flooring on steel frame > 1200 mm high - enclosed	Single skin masonry	Upwards	0.67		2.1
		Downwards	0.79		2.4
	Lightweight cladding	Upwards	0.57		2.0
		Downwards	0.69		2.3
Timber flooring on steel frame - unenclosed	None	Upwards	0.34		1.8
		Downwards	0.40		1.9
Timber flooring on steel frame ≤ 600 mm high - enclosed	Single skin masonry	Upwards	0.88	Perforated double-sided anti-glare foil	1.4
		Downwards	1.01		2.5
	Lightweight cladding	Upwards	0.77		1.3
		Downwards	0.90		2.4
Timber flooring on steel frame 600 – 1200 mm high - enclosed	Single skin masonry	Upwards	0.76		1.2
		Downwards	0.89		2.3
	Lightweight cladding	Upwards	0.65		1.1
		Downwards	0.77		2.2
Timber flooring on steel frame > 1200 mm high - enclosed	Single skin masonry	Upwards	0.67		1.2
		Downwards	0.79		2.3
	Lightweight cladding	Upwards	0.57		1.1
		Downwards	0.69		2.2
Timber flooring on steel frame - unenclosed	None	Upwards	0.34		0.6
		Downwards	0.40		1.2

Notes

1. Values based on BCA 2011 and ICANZ Insulation Handbook
2. Lightweight cladding includes steel sheeting, fibre-cement and weatherboard.

SOLUTIONS CONTINUED

As examples of suitable product solutions, Foilboard Australia and Kingspan Insulation have provided the following options for typical suspended floor systems. *Refer to manufacturers directly for detailed product specifications and installation recommendations.*

Floor Configuration	Foilboard® Product Solution	Total R-Value
Timber flooring on steel frame, 75/90 mm airspace, open subfloor	Super 15 mm Foilboard® panel	1.3 UP 3.6 DOWN
Timber flooring on steel frame, 75/90 mm airspace, open subfloor	Standard 10 mm Foilboard® panel	1.3 UP 3.4 DOWN

Source: Foilboard Australia Pty Ltd - Refer to manufacturer for further information

Floor Configuration	Kingspan® Product Solution	Total R-Value
Timber flooring on steel frame, 75 mm airspace, open subfloor	Kingspan AIR-CELL Insulbreak® 80 to underside of joists	1.4 UP 2.1 DOWN
Timber flooring on steel frame, open subfloor	25 mm Kingspan Kooltherm® K3 between joists	1.5 UP 1.6 DOWN

Source: Kingspan Insulation Pty Ltd - Refer to manufacturer for further information

In the example house, a low-level (less than 600 mm) floor enclosed with single skin masonry enclosure has a deemed downward R-Value of 1.01. Therefore no additional floor insulation is required in Climate Zone 5.

FOR MORE INFORMATION

Australian Building Codes Board (ABCB)
Website: www.abcb.gov.au

BlueScope Steel Ltd
Website: www.bluescopesteel.com.au

Insulation Council of Australia
& New Zealand (ICANZ)
Website: www.icanz.org.au

Foilboard Australia Pty Ltd
Website: www.foilboard.com.au

Kingspan Insulation Pty Ltd
Website: www.kingspaninsulation.com.au

National Association of Steel-Framed Housing Inc (NASH)
PO Box 1085, Hartwell, VIC 3124

E info@nash.asn.au
P 03 9809 1333
W www.nash.asn.au