Market Knowledge & Development

Project No. PN05.1014

Australian Government

Forest and Wood Products
Research and Development
Corporation

Insulation Solutions to Enhance the Thermal Resistance of Suspended Timber Floor Systems in Australia

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Final report received by the FWPRDC in March 2005

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Insulation Solutions to Enhance the Thermal Resistance of Suspended Timber Floor Systems in Australia

Prepared for the

Forest & Wood Products
Research & Development Corporation

by

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The FWPRDC is jointly funded by the Australian forest and wood products industry and the Australian Government.

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Summary and Recommendations

This report is a review of the range of thermal insulation materials and products that their manufacturers recommend as suitable for installation with timber floors. The report is aimed at providing information and to initiate industry discussions in response to the increasing mandatory thermal performance requirements for Class 1 buildings throughout Australia. The findings and associated recommendations of this study are summarised below; they represent a range of issues including statutory guidance, insulation product information and both design and construction techniques pertinent to insulated timber floors.

The materials and products were identified by an extensive Australian-wide and overseas survey. This survey collected product data and anecdotal evidence regarding the installation and performance of the systems. Requirements of the Building Code of Australia (BCA) and its referenced Standards as they relate to residential construction using timber-framed floors were reviewed, in addition to popular construction practices, advice given by Timber Associations to builders, and advice given by government agencies and departments to consumers.

Taken together the information collected provided the input to create a set of data sheets which list R-values of the overall insulated floor system for a range of site and construction configurations. Physical properties of the materials and installation methods used in the data sheets have been taken from the manufacturers product information (except where noted otherwise). In addition, performance parameters of the product and floor structure, both in-construction and in-service are listed for each insulation system. The data sheets are in common format to permit addition of further products and systems as they become available. During the compilation of the data sheets it became apparent that there are noticeable information gaps in Australian Standards relating to thermal and constructional performance of floor systems incorporating insulation materials and, in many cases, from manufacturers specifications.

Of critical importance to the thermal performance of suspended timber floors is the assumption of under-floor ventilation rates. The international standard ISO 13370:1998 *Thermal performance of buildings - Heat transfer via the ground - Calculation methods* implies effective ventilation rates much lower than the few measurements undertaken in Australian conditions. It is *recommended* that the timber industry undertake research to determine the range of sub-floor ventilation rates that apply to Australian construction practices. Also it is *recommended* that the timber industry work to ensure a more realistic representation of suspended timber floors in rating scheme software such as NatHERS, FirstRate and AccuRate to better account for sub-floor ventilation rates.

A general finding of this study was that adverse issues related to the installation of underfloor thermal insulation appeared to be based mainly on anecdotal evidence that was unable to be verified or negated within the scope of this research. In these instances it is *recommended* that a research programme be undertaken to thoroughly investigate such perceived problems, as described in particular recommendations below.

For the purpose of designing and installing acceptable insulated timber floor systems, this study found that existing provisions of the Building Code of Australia and Standards relating to thermal performance lack information necessary to validate design assumptions and construction detailing, and *recommends* that these matters be brought to the attention of the Australian Building Codes Board as soon as possible.

When reviewing insulation manufacturers' product information and data, this study found many examples which lacked clarity, completeness or limitations of application, which could lead to an unexpected negative performance of the insulated floor system, and *recommends* that manufacturers be informed of the range of criteria and limitation of application to aid consumers. It is noted that the lack of BCA guidance may be a contributing factor in this matter.

For the construction of *low-set lightweight buildings*, this study found that significant thermal performance advantages can be gained by enclosing the sub-floor, and *recommends* that designers/builders conduct feasibility studies to assess the net benefit of enclosure.

For the construction of *high-set* or *elevated lightweight buildings*, this study found there is only a small thermal performance advantage gained by enclosing the sub-floor space. Further it is suggested in such cases where the sub-floor is not enclosed, because of wind effects, the installation of flexible sheet insulation materials (such as reflective foil products) is not appropriate, and *recommends* that structurally adequate and aesthetically suitable products be used and protected with an under-floor lining.

For the practice of *pre-installing* insulation in construction using *platform floors*, this study found it to be unsuitable in geographical locations known to have predictable rainfall during construction periods, and *recommends* that in these locations the practice be discouraged. In the event that it does occur, it is *recommended* that stringent guidelines be introduced to protect the performance of both the flooring and its insulation components, and that the guidelines of AS 1684 clause 5.2 be strictly enforced.

With regard to the likelihood of *moisture entrapment* due to condensation within an insulated timber floor system, this study found it to be a complex matter and a source of confusion to both practitioners and consumers alike, and *recommends* that a comprehensive research programme be conducted to measure the degree of various environmental parameters and regional differences to establish improved design methods and installation techniques and the impact on rating tools.

With regard to the likelihood of *vermin nesting* occurring within the products and installation methods of systems reviewed, this study found it to be negligible (no greater than current insulated wall, ceiling and roof systems), and *recommends* that building designers, insulation manufacturers, contractors and building certifiers be informed to maintain records to monitor future occurrences and causes.

Increasingly prescriptive regulation by the BCA and statutory authorities to increase the thermal performance of the building envelope as a means to achieving the goal of reduced greenhouse gas emissions is contrary to the intention of the 'Performance-based Code' in the sense that there is insufficient guidance for both designers and certifiers to provide an 'Alternative Solution'. In many circumstances timber floors for residential construction may be an obviously more appropriate solution compared with other flooring alternatives in a broader, holistic evaluation. It is therefore *recommended* that the timber industry continue to actively promote the advantages of timber floor construction on clear sustainability grounds of; using renewable resources, creating minimal environmental disturbance, providing low embodied energy and carbon sequestration building products.

Finally, it is *recommended* that a comprehensive research programme be undertaken to address and resolve the issue of condensation in suspended timber floor constructions and providing clear direction for designers, manufacturers, builders and building certifiers alike.

Preamble

Effective insulation (higher R-value) of suspended timber floors will improve the thermal performance of dwellings. Increasing ‘energy-efficiency’ stringency requirements for Class 1 buildings throughout Australia necessitate attention directed at improving the thermal resistance of suspended timber floor constructions. Good thermal insulation results from the installation of suitable insulating material(s) as well as the provision of appropriate sub-floor ventilation rates. Materials for insulating suspended timber floors used in Australia and around the world include mineral wool (batts and blankets), polystyrene (extruded and beads), forms of loose-fill or blown insulation, as well as reflective insulation materials.

The general requirements for building thermal insulation materials in Australia are given in Australian Standard AS/NZS 4859.1:2002 *Materials for the thermal insulation of Buildings Part 1: General criteria and technical provisions.* It states,

Except as specifically provided in this Standard, the characteristics of thermal insulation materials and systems, including integral covering, finishing or binding agents, shall be suitable for the purpose. Characteristics to consider in determining suitability for purpose include— (a) known safety issues; and (b) freedom from objectionable odour; and (c) the influence of aging.

This Standard also includes tests for corrosion potential. However, no Standard exists in Australia for the calculation of standard R-values of elements or systems, or a Code of Practice for the acceptable installation of insulation materials. In the absence of such a Standard & Code there is little guidance on acceptable practices for the building industry and consumers.

Introduction

This report is a review and evaluation of a range of insulation products and systems currently available on the Australian market and overseas that the manufacturers recommend as suitable to enhance the thermal resistance of suspended timber floors in residential buildings. The review of both products and resulting floor constructions is made in the context of a wide array of inter-related site, construction, environmental and statutory influences where weather, construction sequence and safety, installation techniques, performance in-use and overall costs all contribute to product selection.

Whereas timber floors have historically been an iconic element of Australian vernacular architecture regardless of the variety of superstructure types and forms, there has never been a tradition of insulating the floor systems of residential buildings in Australia. This has become evident during the research. For example there is no guidance in the BCA or its referenced standards to calculate the thermal resistance of insulated floor systems nor for performance criteria of particular materials and systems both during construction and in-service. Further, the review of product data sheets of various insulation materials indicates a wide range of specification details particularly in relation to installation and in-service performance (as manufacturers acknowledge that residential floor insulation has not been perceived as a major market area). And since the practice of insulated timber floor construction has not been mandatory, there are a limited number of examples of the performance of systems installed. The evidence gathered of in-service performance is in the main limited to anecdotal evidence. The lack of identified widespread problems would seem to indicate the general satisfactory performance of products and systems in current use.

However, the proposed transition to a higher house envelope Star Rating in Victoria in July 2005, the BCA's current preparation for introducing increased stringency levels to the energy-efficiency provisions for Class 1 and 10 buildings, and Standards Australia's planned review of AS 2627.1 1993 *"Thermal insulation of buildings – thermal insulation of roof/ceilings and walls in dwellings"* and related energy standards to commence in February 2005, all signal the need for a broader understanding and regulatory guidance on this issue. This study investigates some of the contributing factors that need to be addressed to move the debate forward.

Methodology

Collecting Thermal Insulation Product Data

The survey and collection of insulation products, data, specifications and samples, either currently or potentially used in timber floor systems, was first carried out by phone/email contact with manufacturers associations in Australia and overseas, including AFIA, ICANZ, EUIMA, NAIMA, PIMA (see Appendix A) and requested that an information sheet be circularised to members. This effort unfortunately produced little result; only 3 members of AFIA responded despite several follow up contacts. Australian Bulk Insulation manufactured products information was then sourced via websites, S.A. state office, and local distributors. Products other than mineral wools and foils were searched by a number of ways including yellow pages, trade websites *infolink* http://www.infolink.com.au and *selector* http://www.selector.com . In addition, other general web searches leads and suggestions from interviewees were followed generally with satisfactory results.

All existing and potential products have been identified.

BCA review and Standards searches

The Building Code of Australia – Volume 2 (Class-1 and Class-10) was reviewed both in respect of construction provisions and energy efficiency provisions, as well as the ABCB Regulatory Proposal for revised energy efficiency provisions (Regulation Document RD 2004-02), November 2004 and associated referenced reports.

A search of Australian / New Zealand standards which relate to timber floor construction and indirectly referenced through BCA, and those which relate to thermal insulation and thermal performance of buildings was undertaken via a web search, and the list forwarded to Standards Australia for ratification and comment. Their response provided both confirmation and additional references; the list is recorded in Appendix B

A search of ISO standards related to thermal insulation and performance of buildings was carried out via website, and forwarded to the ISO secretariat (Swedish Standards Institute) for verification. Despite follow up, no reply was received. A list of ISO standards is recorded in Appendix C. A similar search of ASTM standards related to thermal insulation and performance of buildings was carried out via website.

Interviews

A number of telephone interviews were conducted with persons having special interest in this subject across a wide range of fields. These included Building Contractors and carpenters, Building Certifiers, Insulation manufacturers and installers, Timber industry Association representatives and Researchers. This provided a wide perspective of opinion and experience.

Review of consumer advice by Government authorities

Selected booklets and brochures published by the Australian Greenhouse Office and various State Energy/Sustainability Departments and agencies for consumer guidance were reviewed to gauge the type of advice currently available to the industry and householders. All cited information dealt with RFL and bulk insulation requirements and installation in a generic way (see for example, *Your Home – Technical Manual*, Online: Available http://www.greenhouse.gov.au/yourhome/technical/fs16b_7.htm)

Insulation Products / Systems

Mineral wool batts and blankets

These products include glasswool, rockwool, polyester and wool-blend batts produced by the major Australian manufacturers, members of the ICANZ, namely *CSR Bradford*, *Insulco* and *Insulation Solutions*. Very late responses were received from two companies following two requests for information, so data was collected via interviews of state offices, local distributors, product data sheets, installers and internet web-pages.

Insulation Solutions product data sheets did not recommend any of their products for under-floor insulation. *Insulco* did not recommend either their polyester or wool-blend products for under-floor application. None of the manufacturers recommended their foil-backed blankets for under-floor applications. These products were therefore were not evaluated further.

CSR Bradford recommend both their glasswool (Gold wall & floor) batts and rockwool (Fibertex) products for underfloor thermal insulation application. These products are also treated and claimed to be water repellent. *Insulco* recommend both their glasswool (Fat batts) and polyester batts for underfloor thermal insulation application. In both cases installation is by packing between floor joists and batts are manufactured in both 430mm and 580mm dimensions to accommodate standard floor framing dimensions. *CSR Bradford* recommends fixing/support by either of zigzag nylon twine or chicken wire for enclosed sub-floors or light-duty breather foil fixed to the underside of the joists for open sub-floors. *Insulco* has no recommended fixing /support specification. The Table below provides a summary of products and associated R-values.

Manufacturer	Product	Brand name	R-value	Thickness
CSR Bradford	rockwool	Fibertex	1.5	60mm
			2.0	80mm
	glasswool	Gold W&F	1.5	75mm
			2.0	95mm
Insulco	glasswool	Fat Wall Batt	1.5	70mm
			2.0	85mm
	polyester	Polyester Batt	1.5	85mm
			2.0	100mm

Aluminium Foils

These products include plain, concertina and cellular foils produced by the major Australian manufacturers, members of AFIA, namely *Wren Industries*, *Air-cell* and *Battmans* all of whom provided written responses, product data and samples to our request for information. No responses were received from other AFIA member manufacturers.

Wren Industries recommend their Concertina Foil Batt (double-sided aluminium foil) for under-floor thermal insulation application. Installation is between the joists by stapling to joist sides near the bottom of joists for enclosed sub-floors. For open sub-floor construction it recommends that concertina batts be stapled at mid-depth of joist, and a continuous, plain breather foil stapled to the underside of the joists, foil side down.

Air-cell recommend their Retroshield product for under-floor insulation. This is a sandwich of low density polyethelene open cells between two layers of unperforated reflective foil, 7mm thick. Recommended installation is a continuous layer fixed to top of bearers prior to fixing timber floor joists. No distinction is made between open and enclosed sub-floors.

Battmans recommend Neofoil 914 (perforated double-sided plain foil) and Weatherproof (single-sided perforated plain foil) products suitable for under-floor application. Installation is either by draping a continuous layer over the top of floor joists, fixed by stapling and taping laps or by stapling continuous layers to the underside of joists. No distinction is made between open and enclosed sub-floors.

Expanded polystyrene sheets & batts

This study investigated three products, two foil-faced sheets of Australian manufacture, and one plain surface, profiled section batt of New Zealand manufacture.

Foil Board Insulation Panel Australia Pty.Ltd product, FoilBoard sheets are manufactured in 10, 15 and 25mm thicknesses, lined with unperforated foil, one face reflective, one face anti-glare in standard sheet sizes 1200 x 2440mm. Standard-10 and Super-15 are recommended for under-floor application. Installation is by fixing sheets to underside of joists with proprietary fasteners. No distinction is made between open and enclosed sub-floors.

Battmans product, Thermaboard, is a similar product to Foil Board. Foil-backed sheets come in 10, 15, 20, and 25mm thicknesses, recommended for wall applications only. *Battmans* are reluctant to recommend under-floor application due to concerns of difficulty of installation.

Expol is a New Zealand manufacturer of expanded polystyrene foam insulation batts. One product, Expol Underfloor Insulation, is specifically made for timber floor application. 55mm thick profiled batts 1200mm long are available in 560, 470, 410 and 360mm widths. Installation is between floor joists, either self-supporting for enclosed sub-floors or with nylon angle cleats side-fixed to joists for open sub-floors. The profile incorporates 2 longitudinal ribs 20mm high which touch the underside of flooring (creating a 20mm air gap), and 2 longitudinal grooves at board edges which snap-off or cut-off to adjust dimensional tolerances of joists.

Extruded polystyrene boards

Dow Chemicals product, Styrofoam was the only one investigated in this study, although Owens Corning and others produce similar products. *Aerodynamic Developments Pty.Ltd.* is the Australian distributor. Boards recommended for residential underfloor insulation are 2500 x 600 mm, in 25, 30, and 50 mm thicknesses. Boards are T&G on four edges and fixed by nailing directly to timber (using galvanised steel clouts). Two alternative installations are recommended; either by nailing directly to the underside of flooring or by nailing to the underside of bearers.

Polyisocyanurate sheets

Xtratherm UK Ltd recommends its product Xtratherm Thin-R for under-floor insulation. Their 1200x2400mm foil-backed sheets come in a wide range of thicknesses from 25mm to 100mm. Recommended installation for residential timber floors is by placing between joists. Availability and cost in Australia is not yet known.

The American Polyisocyanurate Insulation Manufacturers Association (PIMA) member companies recommend a wide range of roof, ceiling and wall applications, but this study has not found a recommended under-floor product.

Polyurethane foams

Demilec (USA) product, Sealection-500, a two-component, open celled, semi-rigid polyurethane foam is preparing to enter the Australian market at the time of writing. The fully water blown foam system is applied by spraying to the underside of flooring to a semi-rigid insulation and air seal. The product appears to comply with USA and Canadian building authority requirements based on ASTM test results, but is yet to complete tests and compliance requirements for Australian conditions. While the company was helpful to supply information, insufficient detail was available for inclusion in the data sheets of this report.

US based *Huntsman* and local *Australian Urethane and Styrene Foam Insulation* supply a major portion of the product to the Australian market. Three application companies were interviewed; *Foamed Insulations Pty.Ltd* (Sydney) *Coat-O-Foam* (Melbourne) and *Gunspray* (Adelaide). All reported similar information; most of their work is industrial applications and although they have completed underfloor housing projects and get enquiries, it is a small part of their market, due probably to adverse public perception of sprays and the higher cost when compared with other products.

Construction Factors

Building Code of Australia

The Building Code of Australia Volume-2, Section-3 prescribes Acceptable Construction for house construction. Where construction includes timber-framed floors, the Code has provisions for the ground surface under the floor, suitable external surface drainage away from the building, and the installation of physical/chemical termite barriers in prescribed locations of the country. It further prescribes that construction comply with AS 1684 1999 Residential timber-framed construction.

Where the sub-floor space is enclosed by perimeter walls the Code prescribes minimum levels of sub-floor ventilation (clause 3.4.1) and minimum clearance between the underside of the floor structure and the finished ground surface. Values are given in Table 3.4.1.2. Ground clearance is 150mm in non-termite areas and 400mm to underside of bearer in termite areas.

Sub-floor ventilation is expressed as the area of openings (mm^2) per metre of the perimeter wall according to 3 zones of varying relative humidity, where Zone-1 is the lowest (central arid regions), Zone-2 (middle regions) and Zone-3 is the highest (coastal & tropical regions). These 3 zones are referred to in the data sheets of this report for the calculation of total floor R-values.

AS 1684 1999 Residential timber-framed construction

Several clauses of AS 1684 contain matters pertinent to the selection and installation of insulation products and are discussed briefly here.

AS 1684 Section-4 Floor Framing

Cl. 4.1.2 Materials: "Any timber species can be used for floor framing provided it is kept dry; that is , not exposed to weather, well ventilated, not in contact with or close to the ground" Supplements provide span tables for selection of member sizes for a range of stress grades of both seasoned and unseasoned timbers.

Cl. 4.1.5 Shrinkage: "Shrinkage associated with the use of seasoned or small section unseasoned bearers and joists (overall depth of floor frame less than 200mm) is usually of minimal significance to the overall performance of the structure"

AS 1684 Section-5 Flooring, specifies requirements for T&G strip flooring as well as plywood and particleboard sheeting.

Cl. 5.2 – Platform Floors: "Where platform floor construction is used, the flooring shall be protected from wetting by rain and wet trades. Note: During construction all flooring should be flood-coated with a water repellent sealer"

Cl. 5.5.2.1 Cramping General: "Tongues shall be fitted into grooves and boards cramped together ensuring that the boards are bedded firmly on floor joists". This is traditionally achieved using 'flooring dogs' which grip to and crawl along joists to apply cramping pressure.

Cl. 5.5.4 Particleboard General: "Particleboard flooring shall be laid & fixed in accordance with AS 1860

Cl. 5.5.4.3 Particleboard Fixing: "Sheets shall be securely glued and nailed to the top edge of the joists"

AS 1684 Appendix-C provides information about the durability of construction timber or "exposure to insect attack or moisture which could cause decay"

AS 1684 Appendix-F provides information about the moisture content and shrinkage of construction timber. Table F1 lists equilibrium moisture content (EMC) for flooring in each of the three zones for sub-floor ventilation.

Industry practice

Despite a wide range of stress grades and sizes of both seasoned and unseasoned timbers available for bearers and joists in the Supplements to AS 1684, typical construction is limited to only a few configurations of joists, bearers and stumps / strip footings / dwarf walls, varying only in species between regions. For example, the Timber Promotion Council of Victoria consider the following configurations to be efficient and recommend with stress grades limited generally to F17s, and F27s.

Kiln Dried H/W joists & bearers typically 90x35 or 90x45 framing depth = 180mm

Unseasoned H/W (F8) joists typically 100x50 on 100x75 bearers framing depth = 200mm

Kiln Dried H/W low profile (in-plane joists & bearers) framing depth 90mm

Kiln Dried H/W long span joists typically 190x35 to dwarf walls

Large span LVL / I joists supported by Glulam bearers or trusses

The R-values calculated in the data sheets are based on kiln-dried hardwood flooring and framing of 90mm joists and 90mm bearers

The survey found no use of prefabricated flooring systems that may facilitate the easy installation of thermal insulation.

Interviews & Issues

Many respondents raised a number of common issues, so rather than report individual interviews with repetition, this section attempts to group the comments into issue topics.

Causes of additional construction costs

Apart from the direct cost of the insulation material (and any support materials and fixings) a number of indirect costs were identified by a number of respondents.

Installation costs will vary according to the ease of sub-floor access and site topography. For example, retrofitting the insulation for *low-set buildings* could multiply installation cost by a factor of two to three over pre-installation, whereas for *high-set* or *elevated buildings* with open sub-floor, installation costs would be similar for pre-install and retrofit. In the case of foam sprays, housing applications attract additional cost over larger industrial sites – perhaps 75% - due to the increased time in preparing and dismantling equipment.

Flat site retrofit

Insulation installers inform that 600mm is the absolute minimum clear height (from underside of bearers to ground surface) needed for installation. This results in building floor level being elevated at least 200mm higher than otherwise required in a termite prone location (450mm in a non-termite location), with increased costs of stumps or dwarf walls, sub-floor enclosure materials and additional entrance steps. In some jurisdictions this increased height to gutter level may require installing safety hand-railing for roofing workers to comply with OH&S regulations.

Sub-floor enclosure

In many regions, lightweight construction including pole-frames are constructed without enclosing the sub-floor. Where enclosure is decided in order to improve the floor's thermal performance, additional costs accrue to the supply and fixing of the enclosure. This cost increases with slope of the allotment and increased wind loads on the building may increase the sub-floor structure, footings and bracing. In termite prone areas, instead of treating and inspecting at the stumps, additional perimeter termite barriers and surface drainage treatments add to the construction cost.

Moisture properties of timber

One respondent informed that (with his long experience as a carpenter) timber is a living material that needs a natural environment around it. So if the top surface of a timber floor is exposed to constant changes of temperature and moisture while the underside is sealed, strange things may happen – like significant shrinkage.

Other carpenter/builders commented on the changing nature of construction timbers supplied to the housing market. For example, thirty years ago hardwood timbers were harvested from natural growth forests and the milled timber was air-dried over time to provide a stable moisture content; whereas now the combination of plantation timbers and very quick kiln drying (softwood) has resulted in a different response material, even though there is a recommended on-site environmental adjustment period.

Wider comments (both builders and regulators) expressed concerns that insulation which was incorrectly located would create condensation inside the floor system leading to deterioration of the timber.

Pre-installation difficulties

While several respondents described the cost implications of retrofitting floor insulation, many comments were offered about experiences with the alternative of pre-installing insulation.

One group of observations relate to instances where the insulated floor systems were completed prior to cladding walls and roofs, using particleboard sheet flooring in platform construction. The projects were subjected to persistent rain causing saturation and loss of integrity of the particleboard. In these instances, whole floor systems needed to be replaced. In cases where the insulation material was mineral wool, it was observed to be retaining significant moisture, and in cases where foil was the insulating medium, it was assessed to be a major factor in the particleboard's inability to dry out.

The popularity of platform floor construction was cited as the cheapest solution for compliance with construction safety regulations and perhaps some benefit to construction time and cost. However a number of builders responded that when bulk insulation is pre-installed in platform floors and the job is subject to rain prior to roof/wall cladding, there is significant risk of wetting of insulation and necessitating its possible replacement.

A regulatory case study

One building certifier related his experiences with insulated floors when employed by Phillip Island Council some 15 years ago in the late 1980's. At that time, Council regulated for insulated timber floors. Typical building applications were for lightweight construction holiday houses on sloping sites where the sub-floor was not enclosed.

The first insulation technique was to lay reflective foil rolls on top of joists. However, particleboard manufacturers raised the issue that foil prevented the glued connection between joists and particleboard, so they would not warrantee the installation. Rain-damaged particleboard (described above) compounded the problems of this method.

A second insulation technique was to staple reflective foil to the underside of floor joists. Instances of birds and ants invading the space were observed during inspections, and because many were holiday houses, there wasn't sufficient owner maintenance to remove these problems. Complaints by owners of the flapping noise made by the foil exacerbated the problems with this method.

A third insulation technique was to install mineral wool batts between joists. Problems experienced with this method included examples of significant wetting of batts during construction and the use of unsuitable support materials resulting in the sagging and collapse of the material

At last, with all the problems experienced, Council deleted the requirement for floor insulation and in fact 'banned' the use of insulated floor systems.

These experiences appear to be the main source of reports and rumours regarding the undesirable uses of thermal insulation under suspended timber floors.

Discussion

Overview

Several states, the ACT, and local councils have imposed minimum energy efficiency requirements for residential building envelopes. In particular, with the introduction of 5-star house energy rating requirements in Victoria on 1 July 2004, concern has been expressed by the timber industry that for houses with suspended timber floors, achieving 5 stars will be considerably more difficult compared with houses with concrete slab-on-ground floors. The one-dimensional techniques aimed at achieving building envelope energy-efficiency operate to the detriment of holistic approaches to achieving environmentally responsible building.

For example, construction of houses on sloping sites or in flood-prone areas is much more efficiently achieved by framed construction. This type of solution results in much less environmental impact and has a lower embodied energy compared with a concrete slab-on-ground alternative.

Australian Standards

In circumstances where higher stringency levels of building envelope thermal resistance is being applied by an increasing number of jurisdictions, it is puzzling that AS 2627.1 1993 *"Thermal insulation of buildings – thermal insulation of roof/ceilings and walls in dwellings"* excludes the evaluation of floor insulation.

The provisions of AS/NZS 4859.1: 2002 *"Materials for the thermal insulation of buildings. Part 1: General criteria and technical provisions"* do not provide information sufficient for a nationally consistent calculation of R-values, particularly in relation to insulated floors[1]. As a result there is no industry consensus for values of several design parameters including, but not limited to, floor framing depth to accommodate insulation materials and still-air spaces, ventilation rates as a function of sub-floor conditions and height, wind speeds and terrain, prevention or management of formation of condensation, influence of drainage holes on the assumption of still air resistance, formation of dust on reflective surfaces reducing emissivity. As a consequence AFIA has produced its own set of guidelines and assumptions to provide internal consistency for the Aluminium Foil Insulation group.

The provisions of AS 1684 : 1999 *"Residential timber-framed construction"* do not provide information sufficient (as normative clauses) for the influence of temperature gradients in the insulated floor space with respect to durability and equilibrium moisture content of both flooring and floor framing.

The remainder of this section evaluates various installation solutions and perceived in-service problems, which hopefully will stimulate further comment and debate.

Pre-installing Insulation

[1] This matter is currently (March 2005) under review and an amendment to AS 4859:1 is scheduled for release mid 2005.

Installing the underfloor insulation prior to fixing the flooring is most suited to *low-set buildings* where post-construction access is more difficult, particularly in the case of rigid sheets and boards where the sub-floor is enclosed. In this application, all insulation materials will be subject to some risk of construction damage during floor installation (tearing, puncturing or contaminating), however small. Products depending on reflective surfaces facing up to the flooring (including foils and foil-faced rigid sheets) are at risk of entrapping wind-blown dust, sawdust or general debris during floor installation, thus de-rating their design emissivity. Cleaning or vacuuming these surfaces immediately prior to floor installation may be required. The likelihood of these problems arising without constant supervision of the work will, to a large extent, be influenced by the skill and care of carpenters and service trades both prior to and during flooring operations. It is reasonable to expect the risk to increase in the case of high volume housing projects where construction budgets may be lower and profit depending on speed of completion of the work.

Pre-installing floor insulation after the roof and wall claddings have been installed (fitted floors) offers potentially better protection to the flooring, framing and insulation than platform floor construction, both in terms of air-borne dust accumulation and rain damage, and ultimately perhaps provides a more cost-effective and higher thermal performance solution for the building.

The popularity and claimed advantages of platform floors in that they provide a working platform during construction which improves worker safety and speed of construction (and more recently to meet OH&S standards of some jurisdictions) may well be offset by rain damage to the flooring and its effect on framing timbers, particularly with particleboard flooring. Large changes in moisture content of floor components during a short construction period will reduce the performance of the system in-use. This condition is magnified if built in conjunction with a sealed insulation system which does not permit drainage or drying of the wetted timber frame. In the case where mineral wool batts become wetted in this situation, they suffer reduced thermal characteristics. *CSR Bradford* manufactures a 'water-repellent' product for wall and floor applications, which goes in some way to address this situation.

For the above reasons, it is considered that the method of platform floor construction in conjunction with underfloor insulation is unsuitable where there is a likelihood of significant rainfall during construction. In cases where it is used, insulation materials capable of absorbing water (eg mineral fibre) or allowing water to collect (eg unperforated foil) should be avoided.

The data sheets of this report give two instances where pre-installing insulation is the only option; these are *Battmans*' 'foil over joist' solution (Data Sheet 1) and *Air-Cell's* preferred installation of fixing the cellular foil over bearers (Data Sheet 4). Both have the facility for draining described in the specification. Note that the R-values given in the Sheets have not de-rated the top surface emissivity relative to other foils.

Retrofitting Insulation

Installing the underfloor insulation after the flooring is in place is suited to *elevated buildings* and *high-set buildings* (1.5-2.5m) on steep sloping sites. It is also suited to gentler slopes (800-1200mm) where the sub-floor is open. Flat sites, particularly with enclosed sub-floors, are the most difficult and expensive alternative and in some instances, for example rigid sheets and sprays, may not be possible. A further disadvantage of flat sites is the difficulty of inspecting the installation. Advantages of this method are that they remove the potential risks associated with pre-installed floor insulation described above, namely construction damage, rain associated problems and the performance of reflective surfaces. Where platform floors are used, or when floor framing is of unseasoned timber, retrofitting insulation may be more confidently installed after moisture testing timber floor components to have attained their equilibrium moisture content (AS 1684: 1999, Table F1)

The data sheets of this report give two instances where retrofitting insulation is the only option; these are polyurethane spray foams applied directly to flooring, and extruded polystyrene boards nailed directly to the underside of flooring. In the latter example an alternative installation method is fixing to the underside of bearers.

Sub-floor ventilation

The thermal resistance of insulated timber floors in residential construction is significantly affected by the sub-floor environment, regardless of the direction of heat flow and of the insulating medium. R-values tabulated in the data sheets demonstrate this effect in all of the insulating materials and systems reviewed. It is of particular interest to note that regardless of whether a house is built in a sheltered (typically urban) or exposed (typically rural) location or whether it is in a high (coastal) or low (inland) humidity climate, houses built near the ground have a markedly higher R-value if the sub-floor is enclosed rather than open, yet for the same house built high above the ground (2.5m) the existence of sub-floor enclosure has little influence on the R-value.

Assumptions made about *underfloor ventilation rates* are a critical factor in the calculation of steady-state R-value [or U-value] and in more advanced dynamic computer simulations. The present AccuRate assumptions are derived (reasonably so) from several ventilation tests carried out during an ARC/NAFI Linkage project some years ago (Bennetts, H., & Williamson, T.J. (Eds.). (2000). *Design of Environmentally Responsible Housing for Australia: With Emphasis on the Use of Timber*. Adelaide: Adelaide University; School of Architecture, Landscape Architecture & Urban Design.). These tests involved mainly brick veneer constructions in Melbourne. The ventilation tests appeared to indicate significant air flow via wall cavities in addition to air flow through the sub-floor ventilators as shown in Figure 1.

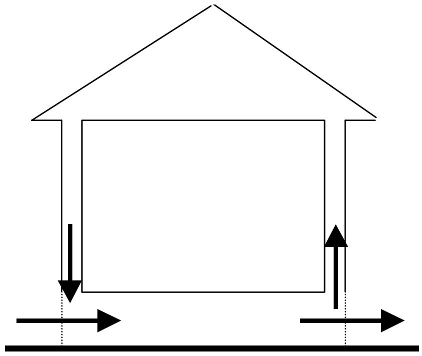


Figure 1: Assumed air flow paths for the sub-floor ventilation

Other forms of construction (eg brick cavity & lightweight framing) do not have this air flow path and therefore the present version of AccuRate appears to be inappropriately modelling the floor heat flows in these forms of construction. In discussions with Dr Angelo Delsante it was suggested that adding an extra question in the input data for subfloors to determine if wall cavity ventilation exists would enable better modelling of suspended timber floors. If this ventilation path does not exist then ventilation would be determined according to installed sub-floor ventilation areas by a method set out by Pat Walsh at CSIRO around 25 years ago. Calculations in data sheet A4 of this study show that reducing sub-floor ventilation (no wall cavity ventilation) and adopting ventilation areas corresponding to BCA Table F1.12 can add approximately 0.5 to the R-value of the floor. AGO, the sponsor of AccuRate have agreed that the change should be implemented.

The thermal performance of timber floors in brick veneer construction could be improved if the cavity air flow path was eliminated by adding a 'flashing' across the wall cavity as shown in Figure 2. This option may be significantly more economical than adding extra insulation.

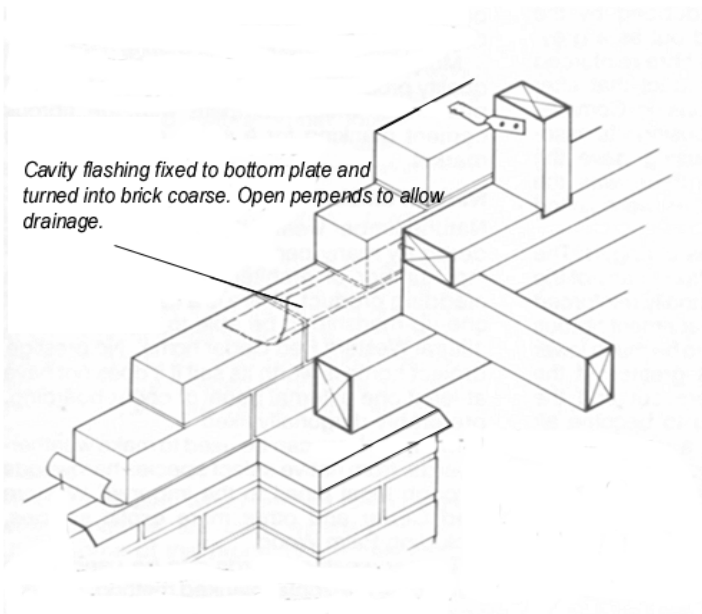


Figure 2: Possible placing of cavity flashing

Since brick-cavity and brick-veneer buildings are necessarily constructed with sub-floor walls, the decision of whether or not to build sub-floor enclosures applies only to lightweight construction. The benefits of increased R-value and lower insulation costs (concertina foil batts and mineral wools require an additional layer of foil for installations with open sub-floors) may well outweigh the extra cost of cladding and termite treatment.

However, as the site topography changes from flat to increasing ground slope, the relative gains in thermal performance diminish and enclosure costs increase (along with increased wind loads) resulting in open sub-floor construction becoming a more feasible solution. (Other considerations, for example, construction in bush fire prone areas may necessitate the sub-floor being enclosed). Yet as the floor height above ground increases and the sub-floor space becomes more useable, it also becomes more visible and subject to greater positive wind pressure. The selection of insulating systems then introduces other criteria including structural performance (particularly connections), aesthetics of the underfloor ‘ceiling’ and wind generated noise from foils. Under these conditions, plywood or fibre-cement sheets (similar to eaves lining) are likely to be preferred solutions to support mineral wool or foil insulation but possible condensation effects need to be determined for the particular insulation method. Alternatively, rigid sheet insulation or foam sprays may be suitable.

For the reasons stated above, foil-type insulations are considered to be generally unsuitable solutions for houses on sloping sites with open sub-floors, and if rigid sheet insulation is proposed, it will need to satisfy structural criteria.

Vermin Nesting Potential

Vermin, as applied to health and amenity issues for residential building, commonly refer to rodents and insects, as well as birds and marsupials such as possums. In evaluating the potential for nesting two conditions need to be met; firstly that the materials are attractive as either a source of food or a source of comfort (warmth/coolth, moisture) and secondly there is suitable access to the space.

Throughout the period of this study, only one respondent reported vermin nesting, as previously documented. While lessons from that report can and probably have been learnt, it is considered to be a rare example. The potential for vermin nesting in insulated floor systems is considered no greater than in insulated wall, ceiling and roofs.

Regarding materials, manufacturers of all insulating products considered in this report (including mineral wools, reflective foils, plain and foil-faced expanded polystyrene, extruded polystyrene, polyisocyanurates and polyurethane foam sprays) declare their products to be resistant to vermin, as can be attested to by years of performance in ceiling, roof and wall applications. Interviews conducted for this study revealed that product manufacturers’ representatives were not aware of instances of vermin nesting in underfloor applications of their product.

In the case of possible vermin access to buildings with enclosed sub-floors, regions which are subject to termite infestation are required to provide termite barriers, including at ventilation openings. In non-termite regions, installing similar fine-gauge mesh to wall vents will ensure no possible access by vermin to under-floor spaces. In cavity wall construction, vermin entering the building from ventilated eaves could travel down the wall cavity but would need to breech the cavity flashing to enter the sub-floor space. In the case of buildings with open sub-floors, concertina foil batts and mineral wool batts are installed with an additional layer of perforated reflective foil fixed to the underside of joists (manufacturers' recommendation). All insulated floor systems therefore present vermin with continuous horizontal barrier to the space between insulation and flooring. Suitable framing details should also ensure that horizontal access points are blocked. In the unlikely event that gaps opened on laps of foil sheets, these are easily visible and subject to simple maintenance. In the case of foil surfaces it has been previously recommended that for structural, aesthetic and noise reasons, foils be replaced by a structural cladding. All other solutions provide a rigid barrier to migration of vermin into the floor space.

Moisture entrapment

The two primary sources of moisture being retained within the insulated floor system are the drying out of flooring and framing materials after installation – particularly if platform floors are subjected to rain prior to enclosure – and condensation. The consequences of moisture retention in the insulation space are firstly the potential for rotting of framing timber and/ or the build-up of mould under the flooring, and secondly, reduction of the thermal resistance of some insulating materials. The first source has been discussed above and methods have been proposed to avoid the problem.

The onset of condensation and its management however is a more complex issue. It starts with a design problem of determining performance criteria to calculate occurrence of condensation. For example, daily/monthly average ambient external air temperatures and relative humidity are established for a large number of regional centres in Australia. But for a particular building within that centre the data will be influenced by the Terrain Category (the degree of surface roughness which alters design wind speed at the floor level) and the degree of sub-floor ventilation.

The issue then continues into management of the moisture after it has formed. It is here that divergent approaches of various products occurs. Some recommend the use of perforated reflective foils (reducing vapour pressure) combined with drainage holes or slits (releasing moisture) while others recommend unperforated reflective foils with no drainage. Specific recommendations can be seen on individual data sheets. Of the systems reviewed in this report, there is no instance where product data make a distinction between climatic regions. Proponents of drainage holes or slits do not account for convective heat gains/losses and reduction of still-air conductivity, while proponents for sealed underfloor systems which fit between joists, do not explain the method to seal those edges. Proponents of systems which expose the underside of joists to permit 'breathing' of timber in order to overcome moisture entrapment do not address the issue of thermal bridging, while proponents of sealing the underfloor system do not address the issue of moisture entrapment.

Looking to the BCA and its referenced documents, no guidance was found for either performance criteria to establish a basis for condensation calculations, nor to principles to be employed in the management of condensation formation. Information received from Standards Australia indicated that the committee responsible for AS2627.1 1993 *"Thermal insulation of buildings – thermal insulation of roof/ceilings and walls in dwellings"* will convene in late February 2005 to consider future directions of this standard and related issues.

In view of the complexity in establishing design and performance criteria for condensation calculations for insulated floor systems combined with imprecise and potentially misleading or misinterpreted information supplied by manufactures – at least in part due to lack of authoritative references from the BCA and referenced Standards – it is recommended that a comprehensive research programme be undertaken to address and resolve this issue and providing clear direction for designers, manufacturers, builders and building certifiers alike.

Data Sheets

Contents

Explanatory Notes

Building parameters

Data Sheets A1 to A5 show the influence of various site and construction configurations on the thermal resistance of an uninsulated timber floor. The relative influence of each parameter may be used as a guide to its effect on any of the insulated timber floors in Data Sheets 1 to 15. Some items are of particular note;

Floor Area

For any given configuration, changing the area of the ground floor has no effect on the overall floor R-value

A/P ratio

The ratio of Area (m^2) to Perimeter (m) of the ground floor of a building has a noticeable effect on the overall floor R-value, as shown in Sheet A3. R-values for insulated floors are based on A/P = 2.5 and floor area of 175 m^2.

Wall Ventilation

Brick veneer construction may not include a wall cavity flashing in which case the building sub-floor is subjected to additional ventilation area. This has a noticeable effect on the floor's R-value as seen in Data Sheet A4. R-values in Data Sheets 1 to 15 are calculated without cavity ventilation.

Floor height above ground

Data Sheets 1 to 15 provide R-values for low-set (0.5m) and elevated (2.5m) buildings. In the case of high-set buildings on sloping sites, Data Sheet A5 may be used as a guide to interpolate between the two extremes.

Material Properties

In general the calculations for R-values in the Data Sheets take values of the thermal properties of materials from the manufacturer's literature. Where these were not available, values were taken from the Australian Institute of Refrigeration, Air-Conditioning and Heating Handbook (Millennium Edition). One exception to these material properties is the value of emissivity for reflective foil laminates. The calculations adopt the following values, while recognising that this is a national issue which still awaits resolution;

Reflective face up e = 0.08

Reflective face down e = 0.03

Anti-glare face e = 0.2

Using the Data Sheets

General

Each Data Sheet selects a particular product as a representative example of typical materials and systems that are used in local construction practice and where the manufacturer has recommended the product as applicable to under-floor insulation. While selecting these product examples, this study in no way warrants or certifies the resulting R-values for the products.

Sub-Floor

Each data sheet provides R-values separately for OPEN sub-floors and ENCLOSED sub-floors. In both cases R-values are given for 'Heat Flow Down' (Heat Flow *OUT* of the building in cold weather) and 'Heat Flow Up' (Heat Flow *INto* the building in hot weather). Both values must be reported to assess the total space heating and cooling implications of insulation techniques. For open sub-floors, the row '% open' allows for the effects of some obstructions or perhaps open slats. The figures demonstrate that where the sub-floor is at least 50% open, the obstructions have no impact on the total R-value. For enclosed sub-floors, the row 'R.H.Zone' refers to the 3 relative humidity zones defined in section 3.1 of the BCA which establish the minimum sub-floor ventilation areas. (refer to the map in Appendix E).

Terrain

Sub-floor ventilation is influenced by the prevailing wind speed, which in turn is a function of the surface roughness of the terrain. These data sheets consider two terrain types;

'Sheltered Location' may be approximated to typical suburban environments where there are significant low level obstructions to wind in the vicinity of the building, whereas

‘Exposed Location’ is typical of open rural environments where there are few low level obstructions to wind.

Soil Type

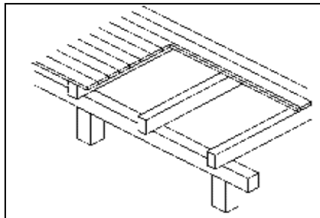
Ground coupling (heat flow to ground) is acknowledged in the data sheets by considering two soil types, clay and sand. The effect on overall floor R-value can be quite noticeable for low-set buildings (this also applies to concrete slab-on-ground construction).

Cost Index

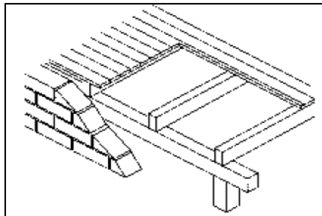
These are indicative only and in some cases represent a South Australian bias. For the more popular materials, material and installation costs were identified separately, but for the less familiar applications, supply and install prices were provided by contractors as a single unit. Material prices were generally taken from major distributors (Bunnings, Mitre-10) or direct from the manufacturer. Price rates are based on gross product area, no allowance for wastage and no reduction for framing. Installation prices are based on a range (easiest to most difficult) where ‘easiest’ is similar to the installation price for ground floor walls. The values resulted from an averaging of opinions of several contractors and manufacturers.

The simplest and cheapest form of floor thermal insulation considered in this study is the “Foil-over-Joists” solution shown in Data Sheet 1. At the time of writing, an indicative supply-and-install cost for this solution was $ 4.20 /m^2 All other solutions have been indexed against this price.

Sheet A1 ***Uninsulated Timber Floor : Effect of Floor Overlay***

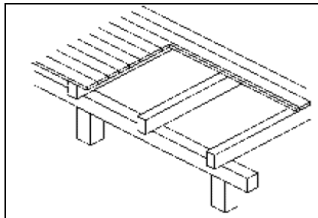


		Sub-Floor OPEN A/P = 2.5	BARE TIMBER FLOOR						with CARPET overlay						with CERAMIC TILE overlay					
			TOTAL R-value of Floor						TOTAL R-value of Floor						TOTAL R-value of Floor					
		Heat Flow	DOWN			UP			DOWN			UP			DOWN			UP		
		% Open	50	75	100	50	75	100	50	75	100	50	75	100	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	0.8	0.7	0.7	0.6	0.5	0.5	1.1	1.1	1.0	0.9	0.8	0.8	0.9	0.8	0.8	0.6	0.5	0.5
		Sandy soil	0.8	0.7	0.7	0.6	0.5	0.5	1.1	1.0	1.0	0.9	0.8	0.8	0.8	0.8	0.8	0.6	0.5	0.5
	Exposed Location	*Clay soil*	0.8	0.7	0.7	0.5	0.5	0.5	1.1	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.6	0.5	0.5
		Sandy soil	0.8	0.7	0.7	0.5	0.5	0.5	1.1	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	0.8	0.7	0.7	0.5	0.5	0.5	1.1	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5
		Sandy soil	0.8	0.7	0.7	0.5	0.5	0.5	1.1	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5
	Exposed Location	*Clay soil*	0.7	0.7	0.7	0.5	0.5	0.5	1.1	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5
		Sandy soil	0.7	0.7	0.7	0.5	0.5	0.5	1.0	1.0	1.0	0.8	0.8	0.8	0.8	0.8	0.8	0.5	0.5	0.5

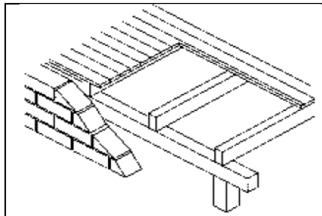


		Sub-Floor ENCLOSED A/P = 2.5	BARE TIMBER FLOOR						with CARPET overlay						with CERAMIC TILE overlay					
			TOTAL R-value of Floor						TOTAL R-value of Floor						TOTAL R-value of Floor					
		Heat Flow	DOWN			UP			DOWN			UP			DOWN			UP		
		RH Zone	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	1.4	1.3	1.2	1.2	1.1	1.0	1.7	1.7	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.1
		Sandy soil	1.3	1.2	1.2	1.1	1.0	1.0	1.6	1.6	1.5	1.5	1.4	1.3	1.3	1.3	1.2	1.1	1.1	1.0
	Exposed Location	*Clay soil*	1.3	1.2	1.1	1.1	1.0	0.9	1.6	1.5	1.5	1.4	1.3	1.2	1.3	1.2	1.2	1.1	1.0	1.0
		Sandy soil	1.2	1.1	1.1	1.0	0.9	0.9	1.6	1.5	1.4	1.4	1.3	1.2	1.3	1.2	1.1	1.1	1.0	0.9
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	0.9	0.9	0.9	0.7	0.7	0.7	1.2	1.2	1.2	1.0	1.0	1.0	1.0	1.0	1.0	0.7	0.7	0.7
		Sandy soil	0.9	0.9	0.9	0.7	0.7	0.6	1.2	1.2	1.2	1.0	1.0	1.0	0.9	0.9	0.9	0.7	0.7	0.7
	Exposed Location	*Clay soil*	0.9	0.9	0.9	0.7	0.7	0.6	1.2	1.2	1.2	1.0	1.0	0.9	1.0	0.9	0.9	0.7	0.7	0.7
		Sandy soil	0.9	0.9	0.9	0.7	0.6	0.6	1.2	1.2	1.2	1.0	0.9	0.9	0.9	0.9	0.9	0.7	0.7	0.7

Sheet A2 *Uninsulated Timber Floor : Effect of Floor Area*

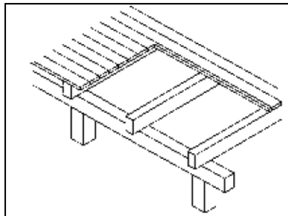


		Sub-Floor OPEN A/P = 2.5	FLOOR AREA = 125m^2						FLOOR AREA = 175m^2						FLOOR AREA = 225m^2					
			TOTAL R-value of Floor						TOTAL R-value of Floor						TOTAL R-value of Floor					
		Heat Flow	DOWN			UP			DOWN			UP			DOWN			UP		
		% Open	50	75	100	50	75	100	50	75	100	50	75	100	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	0.8	0.7	0.7	0.6	0.5	0.5	0.8	0.7	0.7	0.6	0.5	0.5	0.8	0.7	0.7	0.6	0.5	0.5
		Sandy soil	0.8	0.7	0.7	0.6	0.5	0.5	0.8	0.7	0.7	0.6	0.5	0.5	0.8	0.7	0.7	0.6	0.5	0.5
	Exposed Location	*Clay soil*	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5
		Sandy soil	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5
		Sandy soil	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5	0.8	0.7	0.7	0.5	0.5	0.5
	Exposed Location	*Clay soil*	0.8	0.7	0.7	0.5	0.5	0.5	0.7	0.7	0.7	0.5	0.5	0.5	0.7	0.7	0.7	0.5	0.5	0.5
		Sandy soil	0.7	0.7	0.7	0.5	0.5	0.5	0.7	0.7	0.7	0.5	0.5	0.5	0.7	0.7	0.7	0.5	0.5	0.5

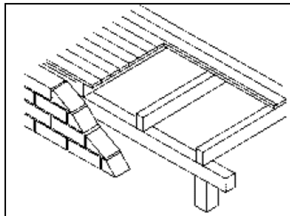


		Sub-Floor ENCLOSED A/P = 2.5	FLOOR AREA = 125m^2						FLOOR AREA = 175m^2						FLOOR AREA = 225m^2					
			TOTAL R-value of Floor						TOTAL R-value of Floor						TOTAL R-value of Floor					
		Heat Flow	DOWN			UP			DOWN			UP			DOWN			UP		
		RH Zone	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	1.4	1.3	1.2	1.2	1.1	1.0	1.4	1.3	1.2	1.2	1.1	1.0	1.4	1.3	1.2	1.2	1.1	1.0
		Sandy soil	1.3	1.2	1.2	1.1	1.0	1.0	1.3	1.2	1.2	1.1	1.0	1.0	1.3	1.2	1.2	1.1	1.0	1.0
	Exposed Location	*Clay soil*	1.3	1.2	1.1	1.1	1.0	0.9	1.3	1.2	1.1	1.1	1.0	0.9	1.3	1.2	1.1	1.1	1.0	0.9
		Sandy soil	1.2	1.1	1.1	1.0	0.9	0.9	1.2	1.1	1.1	1.0	0.9	0.9	1.2	1.1	1.1	1.0	0.9	0.9
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	0.9	0.9	0.9	0.7	0.7	0.7	0.9	0.9	0.9	0.7	0.7	0.7	0.9	0.9	0.9	0.7	0.7	0.7
		Sandy soil	0.9	0.9	0.9	0.7	0.7	0.6	0.9	0.9	0.9	0.7	0.7	0.6	0.9	0.9	0.9	0.7	0.7	0.6
	Exposed Location	*Clay soil*	0.9	0.9	0.9	0.7	0.7	0.6	0.9	0.9	0.9	0.7	0.7	0.6	0.9	0.9	0.9	0.7	0.7	0.6
		Sandy soil	0.9	0.9	0.9	0.7	0.6	0.6	0.9	0.9	0.9	0.7	0.6	0.6	0.9	0.9	0.9	0.7	0.6	0.6

Sheet A3 *Uninsulated Timber Floor : Effect of A/P ratio*

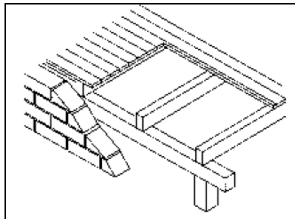


		Sub-Floor OPEN A = 175m2	**BARE TIMBER FLOOR** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% Open	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	0.9	0.8	0.7	0.6	0.5	0.5
		A/P = 2.5	0.8	0.7	0.7	0.6	0.5	0.5
		A/P = 1.5	0.8	0.7	0.7	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.8	0.8	0.7	0.6	0.5	0.5
		A/P = 2.5	0.8	0.7	0.7	0.6	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
LOW-SET BUILDING 0.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 2.5	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 2.5	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
ELEVATED BUILDING 2.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	0.8	0.8	0.7	0.5	0.5	0.5
		A/P = 2.5	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 2.5	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
ELEVATED BUILDING 2.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 2.5	0.7	0.7	0.7	0.5	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.8	0.7	0.7	0.5	0.5	0.5
		A/P = 2.5	0.7	0.7	0.7	0.5	0.5	0.5
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5

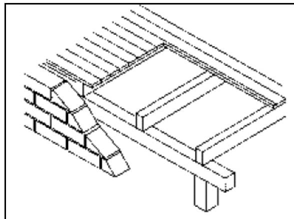


		Sub-Floor ENCLOSED A = 175m2	**BARE TIMBER FLOOR** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		RH Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.6	1.5	1.5	1.4	1.4	1.3
		A/P = 2.5	1.4	1.3	1.2	1.2	1.1	1.0
		A/P = 1.5	1.1	1.0	1.0	0.9	0.8	0.8
	Sandy Soil	*A/P = 3.5*	1.5	1.4	1.4	1.3	1.3	1.2
		A/P = 2.5	1.3	1.2	1.2	1.1	1.0	1.0
		A/P = 1.5	1.0	1.0	1.0	0.8	0.8	0.8
LOW-SET BUILDING 0.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.5	1.4	1.3	1.3	1.2	1.1
		A/P = 2.5	1.3	1.2	1.1	1.1	1.0	0.9
		A/P = 1.5	1.0	1.0	0.9	0.8	0.8	0.7
	Sandy Soil	*A/P = 3.5*	1.4	1.3	1.2	1.3	1.1	1.1
		A/P = 2.5	1.2	1.1	1.1	1.0	0.9	0.9
		A/P = 1.5	1.0	0.9	0.9	0.8	0.7	0.7
ELEVATED BUILDING 2.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.8	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.7	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.6
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
ELEVATED BUILDING 2.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.7	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.6
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.0	1.0	0.9	0.7	0.7	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.6	0.6
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6

Sheet A4 ***Uninsulated Timber Floor : Effect of Wall Ventilation***

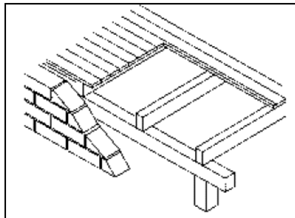


		No Wall Ventilation *A = 175m²*	TIMBER FLOOR - BRICK VENEER					
			TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		RH Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.6	1.5	1.5	1.4	1.4	1.3
		A/P = 2.5	1.4	1.3	1.2	1.2	1.1	1.0
		A/P = 1.5	1.1	1.0	1.0	0.9	0.8	0.8
	Sandy Soil	*A/P = 3.5*	1.5	1.4	1.4	1.3	1.3	1.2
		A/P = 2.5	1.3	1.2	1.2	1.1	1.0	1.0
		A/P = 1.5	1.0	1.0	1.0	0.8	0.8	0.8
LOW-SET BUILDING 0.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.5	1.4	1.3	1.3	1.2	1.1
		A/P = 2.5	1.3	1.2	1.1	1.1	1.0	0.9
		A/P = 1.5	1.0	1.0	0.9	0.8	0.8	0.7
	Sandy Soil	*A/P = 3.5*	1.4	1.3	1.2	1.3	1.1	1.1
		A/P = 2.5	1.2	1.1	1.1	1.0	0.9	0.9
		A/P = 1.5	1.0	0.9	0.9	0.8	0.7	0.7
ELEVATED BUILDING 2.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.8	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.7	0.7	0.7	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.7	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.6
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
ELEVATED BUILDING 2.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.7	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.6
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.0	1.0	0.9	0.7	0.7	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.6	0.6
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6

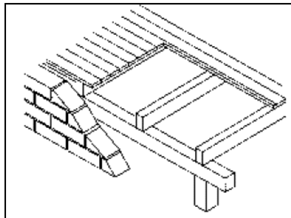


		Inc. Wall Ventilation *A = 175m²*	TIMBER FLOOR - BRICK VENEER					
			TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		RH Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.1	1.1	1.0	0.8	0.8	0.8
		A/P = 2.5	1.0	1.0	0.9	0.7	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.8	0.8
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
LOW-SET BUILDING 0.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 2.5	0.8	0.8	0.8	0.6	0.6	0.6
		A/P = 1.5	0.8	0.8	0.8	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 2.5	0.8	0.8	0.8	0.6	0.6	0.6
		A/P = 1.5	0.8	0.8	0.8	0.5	0.5	0.5
ELEVATED BUILDING 2.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	0.9	0.9	0.9	0.6	0.6	0.6
		A/P = 2.5	0.8	0.8	0.8	0.6	0.6	0.6
		A/P = 1.5	0.8	0.8	0.8	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.9	0.9	0.9	0.6	0.6	0.6
		A/P = 2.5	0.8	0.8	0.8	0.6	0.6	0.6
		A/P = 1.5	0.8	0.8	0.8	0.5	0.5	0.5
ELEVATED BUILDING 2.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	0.9	0.9	0.8	0.6	0.6	0.6
		A/P = 2.5	0.8	0.8	0.8	0.6	0.5	0.5
		A/P = 1.5	0.8	0.8	0.8	0.5	0.5	0.5
	Sandy Soil	*A/P = 3.5*	0.8	0.8	0.8	0.6	0.6	0.6
		A/P = 2.5	0.8	0.8	0.8	0.5	0.5	0.5
		A/P = 1.5	0.8	0.8	0.8	0.5	0.5	0.5

Sheet A5 *Uninsulated Timber Floor : Effect of Floor Height & Exposure*

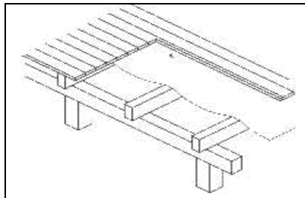


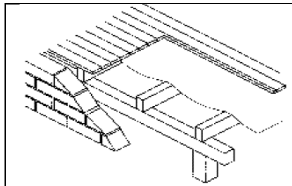
		No Wall Ventilation $A = 175m^2$	SUB-FLOOR ENCLOSED — TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		RH Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.6	1.5	1.5	1.4	1.4	1.3
		A/P = 2.5	1.4	1.3	1.2	1.2	1.1	1.0
		A/P = 1.5	1.1	1.0	1.0	0.9	0.8	0.8
	Sandy Soil	*A/P = 3.5*	1.5	1.4	1.4	1.3	1.3	1.2
		A/P = 2.5	1.3	1.2	1.2	1.1	1.0	1.0
		A/P = 1.5	1.0	1.0	1.0	0.8	0.8	0.8
HIGH-SET BUILDING 1.0m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.3	1.3	1.2	1.1	1.0	1.0
		A/P = 2.5	1.1	1.1	1.1	0.9	0.9	0.8
		A/P = 1.5	0.9	0.9	0.9	0.7	0.7	0.7
	Sandy Soil	*A/P = 3.5*	1.2	1.2	1.2	1.0	1.0	1.0
		A/P = 2.5	1.1	1.0	1.0	0.9	0.8	0.8
		A/P = 1.5	0.9	0.9	0.9	0.7	0.7	0.7
HIGH-SET BUILDING 1.5m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.2	1.1	1.1	0.9	0.9	0.9
		A/P = 2.5	1.0	1.0	1.0	0.8	0.8	0.7
		A/P = 1.5	0.9	0.9	0.9	0.7	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.1	1.1	1.1	0.9	0.9	0.8
		A/P = 2.5	1.0	1.0	1.0	0.8	0.7	0.7
		A/P = 1.5	0.9	0.8	0.8	0.6	0.6	0.6
HIGH-SET BUILDING 2.0m high SHELTERED LOCATION	*Clay Soil*	*A/P = 3.5*	1.1	1.1	1.0	0.8	0.8	0.8
		A/P = 2.5	1.0	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.8	0.8
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6



		No Wall Ventilation $A = 175m^2$	SUB-FLOOR ENCLOSED — TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		RH Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.5	1.4	1.3	1.3	1.2	1.1
		A/P = 2.5	1.3	1.2	1.1	1.1	1.0	0.9
		A/P = 1.5	1.0	1.0	0.9	0.8	0.8	0.7
	Sandy Soil	*A/P = 3.5*	1.4	1.3	1.2	1.3	1.1	1.1
		A/P = 2.5	1.2	1.1	1.1	1.0	0.9	0.9
		A/P = 1.5	1.0	0.9	0.9	0.8	0.7	0.7
HIGH-SET BUILDING 1.0m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.3	1.2	1.1	1.0	1.0	0.9
		A/P = 2.5	1.1	1.0	1.0	0.9	0.8	0.8
		A/P = 1.5	0.9	0.9	0.9	0.7	0.7	0.6
	Sandy Soil	*A/P = 3.5*	1.2	1.1	1.1	1.0	0.9	0.9
		A/P = 2.5	1.1	1.0	1.0	0.8	0.8	0.8
		A/P = 1.5	0.9	0.9	0.8	0.7	0.7	0.6
HIGH-SET BUILDING 1.5m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.1	1.1	1.1	0.9	0.9	0.8
		A/P = 2.5	1.0	1.0	1.0	0.8	0.7	0.7
		A/P = 1.5	0.9	0.9	0.8	0.6	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.1	1.1	1.0	0.9	0.8	0.8
		A/P = 2.5	1.0	0.9	0.9	0.8	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
HIGH-SET BUILDING 2.0m high EXPOSED LOCATION	*Clay Soil*	*A/P = 3.5*	1.1	1.0	1.0	0.8	0.8	0.7
		A/P = 2.5	1.0	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6
	Sandy Soil	*A/P = 3.5*	1.0	1.0	1.0	0.8	0.8	0.7
		A/P = 2.5	0.9	0.9	0.9	0.7	0.7	0.7
		A/P = 1.5	0.8	0.8	0.8	0.6	0.6	0.6

Sheet 1 Reflective Foil Laminate

		$A = 175m^2$ $A/P = 2.5$	**FOIL OVER JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor OPEN		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	1.7	1.6	1.6	0.9	0.8	0.8
		Sandy soil	1.7	1.6	1.6	0.9	0.8	0.8
	Exposed Location	*Clay soil*	1.6	1.6	1.6	0.8	0.8	0.8
		Sandy soil	1.6	1.6	1.6	0.8	0.8	0.8
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	1.6	1.6	1.6	0.8	0.8	0.8
		Sandy soil	1.6	1.6	1.6	0.8	0.8	0.8
	Exposed Location	*Clay soil*	1.6	1.6	1.6	0.8	0.8	0.8
		Sandy soil	1.6	1.6	1.6	0.8	0.8	0.8

		$A = 175m^2$ $A/P = 2.5$	**FOIL OVER JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor ENCLOSED		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.4	2.3	2.3	1.6	1.5	1.4
		Sandy soil	2.4	2.3	2.2	1.5	1.5	1.4
	Exposed Location	*Clay soil*	2.3	2.2	2.1	1.5	1.4	1.3
		Sandy soil	2.3	2.2	2.1	1.5	1.4	1.3
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	1.8	1.8	1.8	1.0	1.0	1.0
		Sandy soil	1.8	1.8	1.8	1.0	1.0	1.0
	Exposed Location	*Clay soil*	1.8	1.8	1.8	1.0	1.0	1.0
		Sandy soil	1.8	1.8	1.8	1.0	1.0	1.0

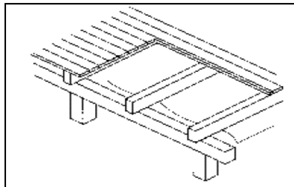
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**NEOFOIL 914**
Manufacturer	Battmans Natural Insulation
Product Description	Aluminium Foil (perforated), anti-glare
Product Unit Size	Roll 60m x 1350mm
Emissivity	0.03 down, 0.2 up
Installation Schedule	PRE-INSTALL only
Installation Method	Draped over joists & stapled to joist side
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Possible tearing & dust entrapment *Sub-Fl. open* : possible wind damage
Vermin nesting Potential	*Sub-Fl. open* : Possible at laps if not taped
Reduced Timber Durability Potential	*Flooring* : Possible with platform floors *Framing :* Nil
Noise Potential	*Sub-Fl. open* : Wind flapping possible
Availability	Distributors all States
Cost Index	**1.00**

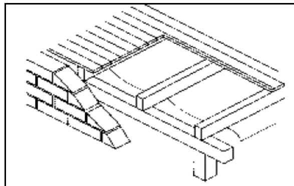
Comments

1. Simplest, fastest and most cost effective method.
2. Not suitable for Strip & Particleboard flooring
3. System believed to be used in NZ

Sheet 2 Reflective Foil Laminate



Sub-Floor OPEN		*A = 175m²* *A/P = 2.5*	FOIL UNDER JOISTS – TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	1.8	1.7	1.7	0.9	0.8	0.8
		Sandy soil	1.8	1.7	1.7	0.9	0.8	0.8
	Exposed Location	*Clay soil*	1.7	1.7	1.7	0.9	0.8	0.8
		Sandy soil	1.7	1.7	1.7	0.9	0.8	0.8
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	1.7	1.7	1.7	0.8	0.8	0.8
		Sandy soil	1.7	1.7	1.7	0.8	0.8	0.8
	Exposed Location	*Clay soil*	1.7	1.7	1.7	0.8	0.8	0.8
		Sandy soil	1.7	1.7	1.7	0.8	0.8	0.8



Sub-Floor ENCLOSED		*A = 175m²* *A/P = 2.5*	FOIL UNDER JOISTS – TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.5	2.5	2.4	1.6	1.5	1.5
		Sandy soil	2.5	2.4	2.4	1.6	1.5	1.4
	Exposed Location	*Clay soil*	2.4	2.3	2.2	1.5	1.4	1.3
		Sandy soil	2.4	2.3	2.2	1.5	1.4	1.3
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	1.9	1.9	1.9	1.0	1.0	1.0
		Sandy soil	1.9	1.9	1.9	1.0	1.0	1.0
	Exposed Location	*Clay soil*	1.9	1.9	1.9	1.0	1.0	1.0
		Sandy soil	1.9	1.9	1.9	1.0	1.0	1.0

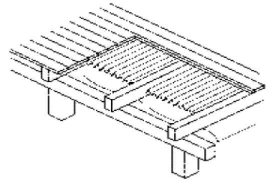
* *HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**NEOFOIL 914**
Manufacturer	Battmans Natural Insulation
Product Description	Aluminium Foil (perforated), anti-glare
Product Unit Size	Roll 60m x 1350mm
Emissivity	0.03 down, 0.2 up
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Stapled to underside of joists
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 *Pre-install* : Possible tearing & dust *Sub-Fl. open* : possible wind damage
Vermin nesting Potential	*Sub-Fl. open* : Possible at laps if not taped
Reduced Timber Durability Potential	*Flooring* : Unlikely *Framing :* Possible to joists
Noise Potential	*Sub-Fl. open* : Wind flapping possible
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **1.1 – 1.6** *Sub-Fl. enclosed* : **1.1 – 1.7**

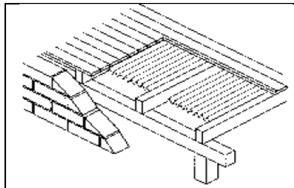
Comments

1. Likely wind effects for high-set buildings with open sub-floor

Sheet 3 Concertina Foil Laminate



Sub-Floor OPEN		*A = 175m²* *A/P = 2.5*	**FOIL BETWEEN JOISTS + RFL** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.5	3.4	3.4	1.3	1.3	1.2
		Sandy soil	3.4	3.4	3.3	1.3	1.3	1.2
	Exposed Location	*Clay soil*	3.4	3.3	3.3	1.3	1.2	1.2
		Sandy soil	3.4	3.3	3.3	1.3	1.2	1.2
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	3.4	3.3	3.3	1.2	1.2	1.2
		Sandy soil	3.4	3.3	3.3	1.2	1.2	1.2
	Exposed Location	*Clay soil*	3.3	3.3	3.3	1.2	1.2	1.2
		Sandy soil	3.3	3.3	3.3	1.2	1.2	1.2



Sub-Floor ENCLOSED		*A = 175m²* *A/P = 2.5*	**FOIL BETWEEN JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.1	3.0	2.9	1.7	1.6	1.5
		Sandy soil	3.1	3.0	2.9	1.6	1.6	1.5
	Exposed Location	*Clay soil*	3.0	2.8	2.7	1.6	1.5	1.4
		Sandy soil	2.9	2.8	2.7	1.5	1.4	1.3
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.4	2.4	2.4	1.1	1.1	1.1
		Sandy soil	2.4	2.4	2.4	1.1	1.1	1.1
	Exposed Location	*Clay soil*	2.4	2.4	2.4	1.1	1.1	1.1
		Sandy soil	2.4	2.4	2.4	1.1	1.1	1.1

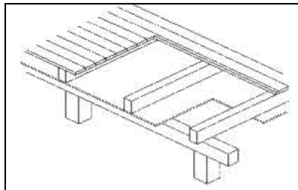
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**CONCERTINA FOIL BATTS**
Manufacturer	Wren Industries Pty. Ltd
Product Description	Aluminium foil laminate (2 reflective faces)
Product Unit Size	Batts 1350 x 450 (25/pack)
Emissivity	0.03 down, 0.08 up
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Stapled between joists
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Pre-cut holes in valley
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 *Pre-install* : Possible tearing & dust *Sub-Fl. open* : possible wind damage
Vermin nesting Potential	*S.F. open* : Access possible if laps not taped
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Unlikely
Noise Potential	*S.F. open* : Wind flapping possible
Availability	Delivered ex Melbourne
Cost Index	*Sub-Fl. open* : **2.4 – 3.6** *Sub-Fl. enclosed* : **1.5 – 2.1**

Comments

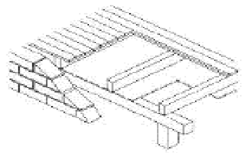
1. Efficient installation, especially in low-set retrofit situation
2. High-set open sub-floor issues as sheet 2

Sheet 4 Cellular Foil Laminate



Sub-Floor OPEN

		A = 175m² *A/P = 2.5*	FOIL OVER BEARERS — TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor OPEN		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	1.9	1.8	1.8	1.0	0.9	0.9
		Sandy soil	1.9	1.8	1.8	1.0	0.9	0.9
	Exposed Location	*Clay soil*	1.8	1.8	1.8	1.0	0.9	0.9
		Sandy soil	1.8	1.8	1.8	1.0	0.9	0.9
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	1.8	1.8	1.8	0.9	0.9	0.9
		Sandy soil	1.8	1.8	1.8	0.9	0.9	0.9
	Exposed Location	*Clay soil*	1.8	1.8	1.8	0.9	0.9	0.9
		Sandy soil	1.8	1.8	1.8	0.9	0.9	0.9



		A = 175m² *A/P = 2.5*	FOIL OVER BEARERS — TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor ENCLOSED		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.6	2.6	2.5	1.7	1.6	1.6
		Sandy soil	2.6	2.5	2.5	1.7	1.6	1.5
	Exposed Location	*Clay soil*	2.6	2.4	2.3	1.6	1.5	1.4
		Sandy soil	2.5	2.4	2.3	1.6	1.5	1.4
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.0	2.0	2.0	1.1	1.1	1.1
		Sandy soil	2.0	2.0	2.0	1.1	1.1	1.1
	Exposed Location	*Clay soil*	2.0	2.0	2.0	1.1	1.1	1.1
		Sandy soil	2.0	2.0	2.0	1.1	1.1	1.1

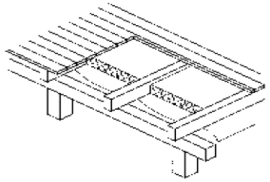
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**AIR-CELL RETROSHIELD**
Manufacturer	Air-cell Building Insulation
Product Description	Polyethylene & air between Aluminium foils
Product Unit Size	Roll 1350 x 22.25m (30m2)
Emissivity	0.03 down, 0.2 up
Installation Schedule	PRE-INSALL only (before joists)
Installation Method	Draped over bearers
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Knife cuts or untapped laps
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Possible tearing & dust entrapment *Sub-Fl. open* : possible wind damage
Vermin nesting Potential	*S.F. open* : Access possible if laps not taped
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible
Noise Potential	*Sub-Fl. open* : Wind flapping possible
Availability	Distributors most States
Cost Index	*Sub-Fl. open* : **2.8** *Sub-Fl. enclosed* : **2.8**

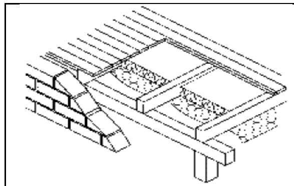
Comments

1. Risk of construction damage & surface dirt depends on carpenters
2. High-set open sub-floor issues as sheet 2, particularly wind effects on long span foil

Sheet 5 Glasswool Batts R 1.5



Sub-Floor OPEN		*A = 175m²* *A/P = 2.5*	**BATTS BETWEEN JOISTS + RFL** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.8	2.7	2.7	2.3	2.2	2.2
		Sandy soil	2.8	2.7	2.7	2.3	2.2	2.2
	Exposed Location	*Clay soil*	2.7	2.7	2.7	2.2	2.2	2.2
		Sandy soil	2.7	2.7	2.7	2.2	2.2	2.2
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.7	2.7	2.7	2.2	2.2	2.2
		Sandy soil	2.7	2.7	2.7	2.2	2.2	2.2
	Exposed Location	*Clay soil*	2.7	2.7	2.7	2.2	2.2	2.1
		Sandy soil	2.7	2.7	2.7	2.2	2.2	2.1



Sub-Floor ENCLOSED		*A = 175m²* *A/P = 2.5*	**BATTS BETWEEN JOIST + MESH** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.6	3.5	3.4	3.1	3.0	2.9
		Sandy soil	3.4	3.4	3.3	2.9	2.9	2.8
	Exposed Location	*Clay soil*	3.4	3.2	3.2	2.9	2.7	2.7
		Sandy soil	3.3	3.2	3.1	2.8	2.7	2.7
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.9	2.9	2.9	2.4	2.4	2.4
		Sandy soil	2.9	2.9	2.9	2.4	2.4	2.4
	Exposed Location	*Clay soil*	2.9	2.9	2.9	2.4	2.4	2.3
		Sandy soil	2.9	2.9	2.8	2.4	2.4	2.3

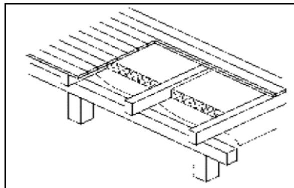
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**GOLD BATTS™ for Walls**
Manufacturer	CSR Bradford Insulation
Product Description	Glass wool
Product Unit Size	Batts 1170 x 580 (430) x 75 thick
Thermal Resistance	R 1.5
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Pack between joists
Support Method	*Sub-Fl. open* : Staple foil under joists *Sub-Fl. enclosed* : wire mesh or twine
Moisture Drainage	Not stated for open sub-floor
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Pre-install possible wetting Sub-Fl. Open; possible wind damage to foil
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible
Noise Potential	*Sub-Fl. open* : Wind flapping possible
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **2.4 – 3.6** *Sub-Fl. enclosed* : **2.2 – 3.4**

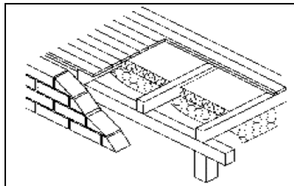
Comments

1. Wetting damage risk for pre-installed with platform floors
2. Drainage for open sub-floors not known
3. High-set open sub-floor issues as for sheet 2

Sheet 6 Glasswool Batts R 2



Sub-Floor OPEN		*A = 175m²* *A/P = 2.5*	**BATTS BETWEEN JOISTS + RFL** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.1	3.0	3.0	2.6	2.6	2.5
		Sandy soil	3.1	3.0	3.0	2.6	2.6	2.5
	Exposed Location	*Clay soil*	3.0	3.0	3.0	2.6	2.6	2.5
		Sandy soil	3.0	3.0	3.0	2.6	2.5	2.5
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	3.0	3.0	3.0	2.6	2.5	2.5
		Sandy soil	3.0	3.0	3.0	2.6	2.5	2.5
	Exposed Location	*Clay soil*	3.0	3.0	3.0	2.5	2.5	2.5
		Sandy soil	3.0	3.0	3.0	2.5	2.5	2.5



Sub-Floor ENCLOSED		*A = 175m²* *A/P = 2.5*	**BATTS BETWEEN JOIST + MESH** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.6	3.5	3.4	3.3	3.2	3.2
		Sandy soil	3.5	3.4	3.4	3.3	3.2	3.1
	Exposed Location	*Clay soil*	3.5	3.3	3.2	3.2	3.1	3.0
		Sandy soil	3.4	3.3	3.2	3.2	3.1	3.0
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	3.0	3.0	2.9	2.7	2.7	2.7
		Sandy soil	3.0	2.9	2.9	2.7	2.7	2.7
	Exposed Location	*Clay soil*	3.0	2.9	2.9	2.7	2.7	2.7
		Sandy soil	3.0	2.9	2.9	2.7	2.7	2.7

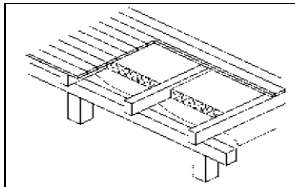
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

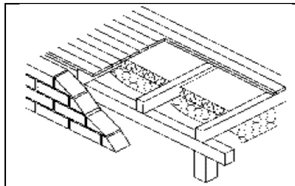
Product Name	**GOLD BATTS™ for Walls**
Manufacturer	CSR Bradford Insulation
Product Description	Glass wool
Product Unit Size	Batts 1170 x 580 (430) x 95 thick
Emissivity	R 2
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Pack between joists
Support Method	*Sub-Fl. open* : Staple foil under joists *Sub-Fl. enclosed* : wire mesh or twine
Moisture Drainage	Not stated for open sub-floor
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Pre-install possible wetting Sub-Fl. Open; possible wind damage to foil
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Possible *Framing :* Possible
Noise Potential	*Sub-Fl. open* : Wind flapping possible
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **2.3 – 3.5** *Sub-Fl. enclosed* : **2.1 – 3.3**

Comments

1. As for sheet 5

Sheet 7 Rockwool Batts R 1.5

 *Sub-Floor OPEN*		*A = 175m²* *A/P = 2.5*	**BATTS BETWEEN JOISTS + RFL** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.8	2.7	2.7	2.3	2.2	2.2
		Sandy soil	2.8	2.7	2.7	2.3	2.2	2.2
	Exposed Location	*Clay soil*	2.7	2.7	2.7	2.2	2.2	2.2
		Sandy soil	2.7	2.7	2.7	2.2	2.2	2.2
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.7	2.7	2.7	2.2	2.2	2.2
		Sandy soil	2.7	2.7	2.7	2.2	2.2	2.2
	Exposed Location	*Clay soil*	2.7	2.7	2.7	2.2	2.2	2.2
		Sandy soil	2.7	2.7	2.7	2.2	2.2	2.2

 *Sub-Floor ENCLOSED*		*A = 175m²* *A/P = 2.5*	**BATTS BETWEEN JOIST + MESH** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.2	3.2	3.1	3.0	2.9	2.8
		Sandy soil	3.2	3.1	3.0	2.9	2.8	2.8
	Exposed Location	*Clay soil*	3.1	3.0	2.9	2.9	2.7	2.6
		Sandy soil	3.1	3.0	2.9	2.8	2.7	2.6
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.7	2.6	2.6	2.3	2.3	2.3
		Sandy soil	2.6	2.6	2.6	2.3	2.3	2.3
	Exposed Location	*Clay soil*	2.6	2.6	2.6	2.3	2.3	2.3
		Sandy soil	2.6	2.6	2.6	2.3	2.3	2.3

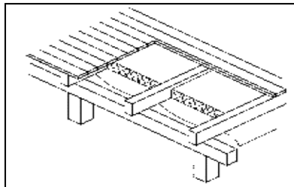
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

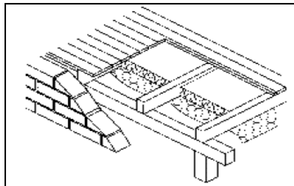
Product Name	**FIBERTEX™**
Manufacturer	CSR Bradford Insulation
Product Description	Rock wool
Product Unit Size	Batts 1170 x 580 (430) x 60 thick
Emissivity	R 1.5
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Pack between joists
Support Method	*Sub-Fl. Open* : Staple foil under joists *Sub-Fl. enclosed* : wire mesh or twine
Moisture Drainage	Not stated for open sub-floor
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Pre-install possible wetting Sub-Fl. Open; possible wind damage to foil
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible
Noise Potential	*Sub-Fl. Open* : Wind flapping possible
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **3.5 – 4.7** *Sub-Fl. enclosed* : **3.3 – 4.5**

Comments

1. As for sheet 5

Sheet 8 Rockwool Batts R 2

		*A = $175m^2$* *A/P = 2.5*	**BATTS BETWEEN JOISTS + RFL**					
			TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor OPEN		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.2	3.2	3.1	2.8	2.7	2.7
		Sandy soil	3.2	3.2	3.1	2.8	2.7	2.7
	Exposed Location	*Clay soil*	3.2	3.1	3.1	2.7	2.7	2.7
		Sandy soil	3.2	3.1	3.1	2.7	2.7	2.7
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	3.2	3.1	3.1	2.7	2.7	2.7
		Sandy soil	3.2	3.1	3.1	2.7	2.7	2.7
	Exposed Location	*Clay soil*	3.2	3.1	3.1	2.7	2.7	2.7
		Sandy soil	3.2	3.1	3.1	2.7	2.7	2.7

		*A = $175m^2$* *A/P = 2.5*	**BATTS BETWEEN JOIST + MESH**					
			TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor ENCLOSED		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.7	3.6	3.6	3.5	3.4	3.3
		Sandy soil	3.7	3.6	3.5	3.4	3.3	3.3
	Exposed Location	*Clay soil*	3.6	3.5	3.4	3.4	3.2	3.1
		Sandy soil	3.6	3.5	3.4	3.3	3.2	3.1
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	3.1	3.1	3.1	2.8	2.8	2.8
		Sandy soil	3.1	3.1	3.1	2.8	2.8	2.8
	Exposed Location	*Clay soil*	3.1	3.1	3.1	2.8	2.8	2.8
		Sandy soil	3.1	3.1	3.1	2.8	2.8	2.8

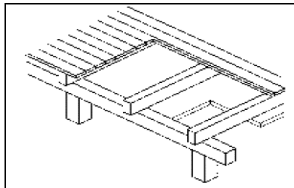
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

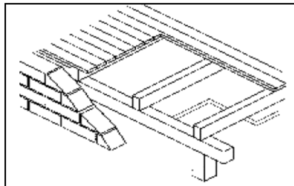
Product Name	**FIBERTEX™**
Manufacturer	CSR Bradford Insulation
Product Description	Rock wool
Product Unit Size	Batts 1170 x 580 (430) x 80 thick
Emissivity	R 2
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Pack between joists
Support Method	*Sub-Fl. Open* : Staple foil under joists *Sub-Fl. enclosed* : wire mesh or twine
Moisture Drainage	Not stated for open sub-floor
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Pre-install possible wetting Sub-Fl. Open; possible wind damage to foil
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible
Noise Potential	*Sub-Fl. Open* : Wind flapping possible
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **4.0 – 5.2** *Sub-Fl. enclosed* : **3.8 – 5.0**

Comments

1. As for sheet 5

Sheet 9 Expanded Polystyrene Sheets 15mm

 Sub-Floor OPEN		*A = 175m²* *A/P = 2.5*	**SHEETS UNDER JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.1	2.1	2.0	1.3	1.2	1.2
		Sandy soil	2.1	2.1	2.0	1.3	1.2	1.2
	Exposed Location	*Clay soil*	2.1	2.0	2.0	1.2	1.2	1.2
		Sandy soil	2.1	2.0	2.0	1.2	1.2	1.2
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.1	2.0	2.0	1.2	1.2	1.2
		Sandy soil	2.1	2.0	2.0	1.2	1.2	1.2
	Exposed Location	*Clay soil*	2.1	2.0	2.0	1.2	1.2	1.2
		Sandy soil	2.1	2.0	2.0	1.2	1.2	1.2

 Sub-Floor ENCLOSED		*A = 175m²* *A/P = 2.5*	**SHEETS UNDER JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.9	2.8	2.7	2.0	1.9	1.8
		Sandy soil	2.9	2.8	2.7	2.0	1.9	1.8
	Exposed Location	*Clay soil*	2.8	2.7	2.6	1.9	1.8	1.7
		Sandy soil	2.8	2.6	2.5	1.9	1.8	1.7
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.3	2.3	2.2	1.4	1.4	1.4
		Sandy soil	2.3	2.3	2.2	1.4	1.4	1.4
	Exposed Location	*Clay soil*	2.3	2.3	2.2	1.4	1.4	1.4
		Sandy soil	2.3	2.3	2.2	1.4	1.4	1.3

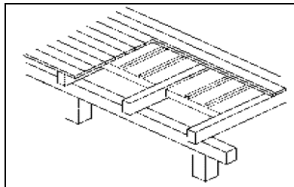
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

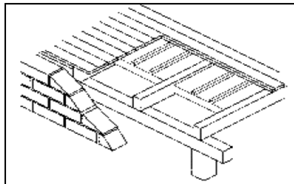
Product Name	**FOIL BOARD INSULATION PANEL**
Manufacturer	Foilboard Insulation Panel Aust. Pty.Ltd
Product Description	Expanded polystyrene sheets, foil-faced
Product Unit Size	Sheet: 2400 x 1200 x 15thick
Emissivity	0.2 up, 0.03 down
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Fix to underside of joists
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Possible for pre-install Most unlikely
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible to joists
Noise Potential	Nil
Availability	Distributed from Melbourne
Cost Index	*Sub-Fl. open* : **2.7 – 3.8** *Sub-Fl. enclosed* : **2.9 – 4.0**

Comments

1. Thermal conductivity used = 0.043
2. Installation difficulties with low-set retrofit conditions
3. Sheets must be cut ; wastage consideration

Sheet 10 Expanded Polystyrene Batts 55mm

		*A = $175m^2$* *A/P = 2.5*	**BATTS BETWEEN JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor OPEN		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.3	2.2	2.2	2.0	1.9	1.9
		Sandy soil	2.3	2.2	2.2	2.0	1.9	1.9
	Exposed Location	*Clay soil*	2.2	2.2	2.2	1.9	1.9	1.9
		Sandy soil	2.2	2.2	2.2	1.9	1.9	1.9
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.2	2.2	2.2	1.9	1.9	1.9
		Sandy soil	2.2	2.2	2.2	1.9	1.9	1.9
	Exposed Location	*Clay soil*	2.2	2.2	2.2	1.9	1.9	1.9
		Sandy soil	2.2	2.2	2.2	1.9	1.9	1.9

		*A = $175m^2$* *A/P = 2.5*	**BATTS BETWEEN JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor ENCLOSED		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.0	2.9	2.8	2.7	2.6	2.5
		Sandy soil	2.9	2.9	2.8	2.7	2.6	2.5
	Exposed Location	*Clay soil*	2.9	2.8	2.7	2.6	2.5	2.4
		Sandy soil	2.9	2.7	2.7	2.6	2.5	2.4
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.4	2.4	2.4	2.1	2.1	2.1
		Sandy soil	2.4	2.4	2.4	2.1	2.1	2.1
	Exposed Location	*Clay soil*	2.4	2.4	2.4	2.1	2.1	2.1
		Sandy soil	2.4	2.4	2.4	2.1	2.1	2.1

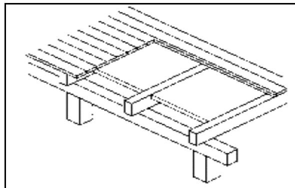
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**EXPOL Underfloor Insulation**
Manufacturer	Expol Ltd. Expanded polystyrene Insulation
Product Description	Expanded polystyrene batts, profiled
Product Unit Size	Batt: 1200 x 560 (470, 410, 360) x 55thick
Conductivity	0.043 (BRANZ Rated)
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Fix between joists
Support Method	*Sub-Fl. open* : nylon cleats *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Possible for pre-install Most unlikely
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible to joists
Noise Potential	Nil
Availability	New Zealand product; no Australian Dist.
Cost Index	*Sub-Fl. open* : **3.1 – 3.8** *Sub-Fl. enclosed* : **2.9 – 3.6**

Comments

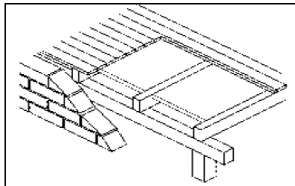
1.

Sheet 11 Extruded Polystyrene Boards 30mm



Sub-Floor OPEN

		A = 175m², A/P = 2.5	BOARDS UNDER FLOORING – TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.0	2.0	1.9	1.8	1.7	1.7
		Sandy soil	2.0	2.0	1.9	1.8	1.7	1.7
	Exposed Location	*Clay soil*	2.0	1.9	1.9	1.7	1.7	1.7
		Sandy soil	2.0	1.9	1.9	1.7	1.7	1.7
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.0	2.0	1.9	1.7	1.7	1.7
		Sandy soil	2.0	1.9	1.9	1.7	1.7	1.7
	Exposed Location	*Clay soil*	2.0	1.9	1.9	1.7	1.7	1.7
		Sandy soil	2.0	1.9	1.9	1.7	1.7	1.7



Sub-Floor ENCLOSED

		A = 175m², A/P = 2.5	BOARDS UNDER FLOORING – TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.7	2.6	2.6	2.5	2.4	2.3
		Sandy soil	2.7	2.6	2.5	2.5	2.4	2.3
	Exposed Location	*Clay soil*	2.6	2.5	2.4	2.4	2.3	2.2
		Sandy soil	2.6	2.5	2.4	2.4	2.2	2.2
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.2	2.1	2.1	1.9	1.9	1.9
		Sandy soil	2.1	2.1	2.1	1.9	1.9	1.9
	Exposed Location	*Clay soil*	2.1	2.1	2.1	1.9	1.9	1.8
		Sandy soil	2.1	2.1	2.1	1.9	1.9	1.8

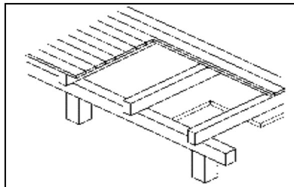
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**STYROFOAM**
Manufacturer	Dow Chemical
Product Description	Extruded polystyrene boards T&G
Product Unit Size	Board: 2500 x 600 x 30 thick
Conductivity	0.025 W/m.K
Installation Schedule	RETROFIT only
Installation Method	Fix to underside of flooring
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Nil Most unlikely
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Possible *Framing :* Nil
Noise Potential	Nil
Availability	National & State Distributors
Cost Index	*Sub-Fl. open* : **4.9 – 6.0** *Sub-Fl. enclosed* : **5.0 – 6.2**

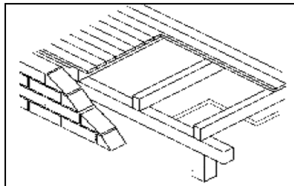
Comments

1. Cutting boards full length, and wastage are disadvantages
2. Thermal bridging not stated
3. Boards produced in a range of thicknesses

Sheet 12 Extruded Polystyrene Boards 30mm



Sub-Floor OPEN		A = 175m² A/P = 2.5	BOARDS UNDER BEARERS — TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.3	2.2	2.2	1.9	1.8	1.8
		Sandy soil	2.2	2.2	2.2	1.8	1.8	1.8
	Exposed Location	*Clay soil*	2.2	2.2	2.2	1.8	1.8	1.8
		Sandy soil	2.2	2.2	2.2	1.8	1.8	1.8
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.2	2.2	2.2	1.8	1.8	1.8
		Sandy soil	2.2	2.2	2.2	1.8	1.8	1.8
	Exposed Location	*Clay soil*	2.2	2.2	2.2	1.8	1.8	1.8
		Sandy soil	2.2	2.2	2.2	1.8	1.8	1.8



Sub-Floor ENCLOSED		A = 175m² A/P = 2.5	BOARDS UNDER BEARERS — TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.9	2.9	2.8	2.6	2.6	2.5
		Sandy soil	2.9	2.8	2.8	2.6	2.5	2.5
	Exposed Location	*Clay soil*	2.9	2.7	2.6	2.6	2.4	2.3
		Sandy soil	2.8	2.7	2.6	2.5	2.4	2.3
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.4	2.4	2.4	2.0	2.0	2.0
		Sandy soil	2.4	2.4	2.3	2.0	2.0	2.0
	Exposed Location	*Clay soil*	2.4	2.3	2.3	2.0	2.0	2.0
		Sandy soil	2.4	2.3	2.3	2.0	2.0	2.0

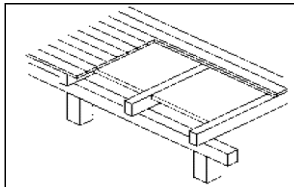
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**STYROFOAM**
Manufacturer	Dow Chemical
Product Description	Extruded polystyrene boards T&G
Product Unit Size	Board: 2500 x 600 x 30 thick
Emissivity	0.025 W/m.K
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Fix to underside of bearers
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Possible for pre-install Most unlikely
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible
Noise Potential	Nil
Availability	National & State Distributors
Cost Index	*Sub-Fl. open* : **4.9 – 6.0** *Sub-Fl. enclosed* : **5.0 – 6.2**

Comments

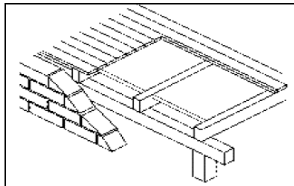
1. Suited to high-set buildings with open sub-floor.
2. Drainage issues not stated

Sheet 13 Extruded Polyisocyanurate Sheets 30mm



Sub-Floor OPEN

A = 175m² *A/P = 2.5*			**BOARDS BETWEEN JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.7	2.6	2.6	2.1	2.1	2.0
		Sandy soil	2.7	2.6	2.6	2.1	2.1	2.0
	Exposed Location	*Clay soil*	2.6	2.6	2.6	2.1	2.0	2.0
		Sandy soil	2.6	2.6	2.6	2.1	2.0	2.0
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.6	2.6	2.6	2.1	2.0	2.0
		Sandy soil	2.6	2.6	2.6	2.1	2.0	2.0
	Exposed Location	*Clay soil*	2.6	2.6	2.6	2.0	2.0	2.0
		Sandy soil	2.6	2.6	2.6	2.0	2.0	2.0



Sub-Floor ENCLOSED

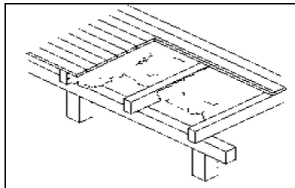
A = 175m² *A/P = 2.5*			**BOARDS BETWEEN JOISTS** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.5	3.4	3.3	2.9	2.8	2.7
		Sandy soil	3.4	3.3	3.3	2.9	2.8	2.7
	Exposed Location	*Clay soil*	3.3	3.2	3.1	2.8	2.7	2.6
		Sandy soil	3.3	3.2	3.1	2.8	2.7	2.6
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.8	2.8	2.8	2.3	2.3	2.2
		Sandy soil	2.8	2.8	2.8	2.3	2.2	2.2
	Exposed Location	*Clay soil*	2.8	2.8	2.8	2.3	2.2	2.2
		Sandy soil	2.8	2.8	2.7	2.3	2.2	2.2

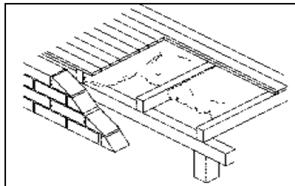
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**EXTRATHERM THIN-R**
Manufacturer	Extratherm UK Ltd
Product Description	Polyisocyanurate sheets, foil-faced
Product Unit Size	Board: 2400 x 100 x 30 thick
Emissivity	0.9 up, 0.03 down
Installation Schedule	PRE-INSTALL or RETROFIT
Installation Method	Fix between joists
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	Not stated
Condensation Potential	Climate dependant
Damage Potential *Construction stage* *In-service stage*	 Possible for pre-install Most unlikely
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Nil *Framing :* Possible
Noise Potential	Nil
Availability	UK product, no Australian Distributors
Cost Index	*Not available*

Comments
1. Thermal conductivity = 0.022 W/mK EN 13165:2001
2. Sheets available in thicknesses from 10mm to 100mm
3. Sheets require cutting; wastage considerations

Sheet 14 Polyurethane Spray Foam 25mm

		*A = 175m²* *A/P = 2.5*	**SPRAY UNDER FLOORING** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor OPEN		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.0	2.0	1.9	1.8	1.7	1.7
		Sandy soil	2.0	2.0	1.9	1.8	1.7	1.7
	Exposed Location	*Clay soil*	2.0	1.9	1.9	1.7	1.7	1.7
		Sandy soil	2.0	1.9	1.9	1.7	1.7	1.7
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.0	2.0	1.9	1.7	1.7	1.7
		Sandy soil	2.0	1.9	1.9	1.7	1.7	1.7
	Exposed Location	*Clay soil*	2.0	1.9	1.9	1.7	1.7	1.7
		Sandy soil	2.0	1.9	1.9	1.7	1.7	1.7

		*A = 175m²* *A/P = 2.5*	**SPRAY UNDER FLOORING** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
Sub-Floor ENCLOSED		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.7	2.6	2.6	2.5	2.4	2.3
		Sandy soil	2.7	2.6	2.5	2.5	2.4	2.3
	Exposed Location	*Clay soil*	2.6	2.5	2.4	2.4	2.3	2.2
		Sandy soil	2.6	2.5	2.4	2.4	2.2	2.2
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.2	2.1	2.1	1.9	1.9	1.9
		Sandy soil	2.1	2.1	2.1	1.9	1.9	1.9
	Exposed Location	*Clay soil*	2.1	2.1	2.1	1.9	1.9	1.8
		Sandy soil	2.1	2.1	2.1	1.9	1.9	1.8

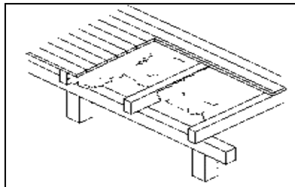
** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**Generic**
Manufacturer	Huntsman
Product Description	2-comp polyurethane water-based spray-on
Product Unit Size	200 litre drums
Conductivity	0.025 W/mK
Installation Schedule	RETROFIT only
Installation Method	Spray to underside of flooring
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	N/A
Condensation Potential	Most Unlikely
Damage Potential *Construction stage* *In-service stage*	 Nil Nil
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Possible *Framing :* Nil
Noise Potential	Nil
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **5.4 – 6.7** *Sub-Fl. enclosed* : **6.0 – 6.9**

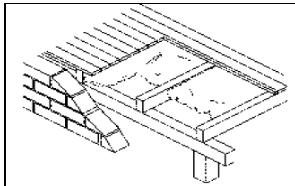
Comments

1. More cost efficient in large industrial areas
2. Low-set buildings require greater access space for equipment

Sheet 15 Polyurethane Spray Foam 50mm



Sub-Floor OPEN		*A = 175m²* *A/P = 2.5*	**SPRAY UNDER FLOORING** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		% OPEN	50	75	100	50	75	100
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	2.8	2.8	2.8	2.6	2.5	2.5
		Sandy soil	2.8	2.8	2.7	2.6	2.5	2.5
	Exposed Location	*Clay soil*	2.8	2.7	2.7	2.5	2.5	2.5
		Sandy soil	2.8	2.7	2.7	2.5	2.5	2.5
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	2.8	2.8	2.7	2.5	2.5	2.5
		Sandy soil	2.8	2.8	2.7	2.5	2.5	2.5
	Exposed Location	*Clay soil*	2.8	2.7	2.7	2.5	2.5	2.5
		Sandy soil	2.8	2.7	2.7	2.5	2.5	2.5



Sub-Floor ENCLOSED		*A = 175m²* *A/P = 2.5*	**SPRAY UNDER FLOORING** TOTAL R-value of Floor					
		Heat Flow	DOWN			UP		
		R.H. Zone	1	2	3	1	2	3
LOW-SET BUILDING 0.5m high	*Sheltered Location*	*Clay soil*	3.6	3.5	3.4	3.3	3.2	3.2
		Sandy soil	3.5	3.4	3.4	3.3	3.2	3.2
	Exposed Location	*Clay soil*	3.5	3.3	3.2	3.2	3.1	3.0
		Sandy soil	3.4	3.3	3.2	3.2	3.1	3.0
ELEVATED BUILDING 2.5m high	*Sheltered Location*	*Clay soil*	3.0	3.0	2.9	2.7	2.7	2.7
		Sandy soil	3.0	2.9	2.9	2.7	2.7	2.7
	Exposed Location	*Clay soil*	3.0	2.9	2.9	2.7	2.7	2.7
		Sandy soil	3.0	2.9	2.9	2.7	2.7	2.7

** HIGH-SET BUILDING : Interpolate between LOW-SET & ELEVATED Buildings*

Product Name	**Generic**
Manufacturer	Huntsman
Product Description	2-comp polyurethane water-based spray-on
Product Unit Size	200 litre drums
Emissivity	0.025 W/mK
Installation Schedule	RETROFIT only
Installation Method	Spray to underside of flooring
Support Method	*Sub-Fl. open* : Nil *Sub-Fl. enclosed* : Nil
Moisture Drainage	N/A
Condensation Potential	Most Unlikely
Damage Potential *Construction stage* *In-service stage*	 Nil Nil
Vermin nesting Potential	Nil
Reduced Timber Durability Potential	*Flooring* : Possible *Framing :* Nil
Noise Potential	Nil
Availability	Distributors all States
Cost Index	*Sub-Fl. open* : **6.4 – 7.9** *Sub-Fl. enclosed* : **7.1 – 8.6**

Comments

1. See sheet 14

Appendix A Glossary of terms

Elevated building : L/W framed building on flat or sloping site with 2.1m minimum clearance from ground surface to underside of floor frame

Enclosed sub-floor : a perimeter wall of either H/W or L/W construction built between the external ground surface and the building floor level

Flooring : the structural floor surface supported by joists. It will be either particleboard or plywood sheets, or floor boards. It is not necessarily the finished floor surface

Flooring overlay (overlay) : the material of the finished floor surface. It may be carpet, tiles, vinyl or other material placed over the *flooring*

Floor frame : the joist/bearer system supported by the sub-structure which supports the flooring

Floor structure : the floor frame and flooring system

Fitted floor : Wall framing is built on the floor framing, and flooring installed later

Heavy-weight construction (H/W) : Brick cavity, concrete block external walls, and brick/block internal walls

High-set building : L/W framed building on sloping site with or without sub-floor enclosure (refer AS/NZS 1170.2: 2002 "Structural design actions. Part 2: Wind actions

Light-weight construction (L/W) : Timber framed walls, roof and floor, on stumps or brick build-up. No cavity in external walls

Low-set building : L/W building on flat site with floor level as close to ground surface as permitted by BCA

Medium-weight construction (M/W) : Brick veneer external walls, framed internal walls

Open sub-floor : no walls or other physical obstruction between the under-floor ground surface and the building floor

Platform floor : Wall framing is built after the flooring is installed

Pre-Install : Installation of floor insulation before flooring is installed

Retrofit : Installation of floor insulation after flooring is installed.

Sub-floor space : the volume between the finished ground surface under the building and the underside of the floor framing system.

Sub-structure : All of the building support structure below the flooring

Superstructure : All of the building support structure above the flooring

Acronyms

AFIA – Aluminium Foil Insulation Association Inc. http://www.afia.com.au

ICANZ – Insulation Council of Australia and New Zealand http://www.icanz.org.au

EURIMA – European Mineral Wool Manufacturers Association http://www.eurima.org

NAIMA – North American Insulation Manufacturers Association http://www.naima.org

PIMA – Polyisocyanurate Insulation Manufacturers Association http://www.pima.com

Appendix B Australian Standards & References

Related to Energy & thermal performance

AS/NZS 4859.1 2002 Materials for the thermal insulation of buildings – general criteria and technical provisions

AS 2627.1 1993 Thermal insulation of buildings – thermal insulation of roof/ceilings and walls in dwellings

AS 3999 1992 Thermal insulation of buildings – bulk insulation – installation requirements

AS/NZS 4200.1 & .2 Pliable building membranes and underlays (materials & installation requirements

BRANZ Bulletin 429 Calculating R-values for Timber-Framed Walls

HB 63 Home insulation in Australia – Recommended insulation levels for all States as per Australian Standard AS 2627.1

NZS 4218 2004 Energy Efficiency – Housing and small building envelope

Related to timber-framed construction

AS 1684.2 1999 Residential Timber-framed construction - non-cyclonic areas

DR 99463 – Timber Flooring Pt-1 Installation

DR 99464 – Timber flooring Pt-2 Sanding & finishing

AS 1860 1998 Installation of Particleboard flooring

AS 1860.1 2002 Particleboard flooring - specifications

AS/NZS 2269-1994 Structural Plywood

AS 2870 Residential Slabs and Footings

AS 3660.1 2000 Termite management – New building work

Appendix C ISO Standards

Technical Committee 163 : Thermal performance and energy use in the built environment

Secretariat : Swedish Standards Institute (SIS)
Secretary : Ms. Margareta Andersson margareta.andersson@sis.se

Sub-committees
TC-163 / SC 1 Test and measurement methods
TC-163 / SC 2 Calculation methods
TC-163 / SC 3 Thermal insulation products

Major meeting calendar
October 2005 : Tokyo, TC-163 and sub-committees

International organisations in liaison
CIB, EC, EUMEPS, EURIMA, EuroWindoor, FESI, RILEM, UN/ECE, WCO

List of technical committees

TC 163/SC 1
Test and measurement methods

Projects

ISO/DIS 9972	Thermal performance of buildings -- Determination of air permeability of buildings -- Fan pressurization method
ISO/FDIS 12567-2	Thermal performance of windows and doors -- Determination of thermal transmittance by hot box method -- Part 2: Roof windows and other projecting windows
ISO/CD 18393	Thermal insulation -- Ageing of thermal insulation materials -- Determination of settling of fibrous loose-fill thermal insulation used in attic applications
ISO/DIS 21129	Hygrothermal performance of building materials and products -- Determination of water vapour transmission properties -- Box methods
ISO/AWI 24353	Hygrothermal performance of building materials and products -- Determination of moisture adsorption/desorption properties in response to humidity variation

List of technical committees

TC 163/SC 2
Calculation methods

Projects

ISO/CD 6946	Building components and building elements -- Thermal resistance and thermal transmittance -- Calculation method
ISO/DIS 10077-1	Thermal performance of windows, doors and shutters -- Calculation of thermal transmittance -- Part 1: General
ISO/CD 10211	Thermal bridges in building construction -- Heat flows and surface temperatures -- Detailed calculations
ISO/CD 10456	Building materials and products -- Hygrothermal properties -- Tabulated design values and procedures for determining declared and design thermal values
ISO/CD 13370	Thermal performance of buildings -- Heat transfer via the ground -- Calculation methods
ISO/DIS 13786	Thermal performance of building components -- Dynamic thermal characteristics -- Calculation methods
ISO/CD 13789	Thermal performance of buildings -- Transmission heat loss coefficient -- Calculation method
ISO/CD 13790	Thermal performance of buildings -- Calculation of energy use for space heating
ISO/CD 14683	Thermal bridges in building construction -- Linear thermal transmittance -- Simplified methods and default values
ISO/FDIS 15927-4	Hygrothermal performance of buildings -- Calculation and presentation of climatic data -- Part 4: Hourly data for assessing the annual energy use for heating and cooling
ISO/DIS 15927-6	Hygrothermal performance of buildings -- Calculation and presentation of climatic data -- Part 6: Accumulated temperature differences (degree days)
ISO/DIS 23993	Thermal insulation products for building equipment and industrial installations -- Determination of design values for thermal conductivity
ISO/WD 23994	Building materials and products -- Hygrothermal properties -- Tabulated design values
ISO/DIS 23995	Thermal insulation for building equipment and industrial installations - Thermal transmittance - Determination of correction terms

List of technical committees

TC 163/SC 3
Thermal insulation products

Projects

ISO/NP 9076-1	Thermal insulation -- Mineral wool loose-fill for ventilated roof spaces -- Part 1: Material product specification
ISO/NP 9076-2	Thermal insulation -- Mineral wool loose-fill for ventilated roof spaces -- Part 2: Installer's responsibilities -- Guidelines
ISO/NP 12574-1	Thermal insulation -- Cellulose loose fill for horizontal applications in ventilated roof spaces -- Part 1: Materials
ISO/NP 12574-2	Thermal insulation -- Cellulose loose fill for horizontal applications in ventilated roof spaces -- Part 2: Installer's responsibilities -- Guidelines
ISO/CD 12574-3	Thermal insulation -- Cellulose loose fill for horizontal applications in ventilated roof spaces -- Part 3: Test methods
ISO/DIS 12575-1	Thermal insulation -- Exterior insulating systems for foundations -- Part 1: Specification
ISO/DIS 12575-2	Thermal insulation -- Exterior insulating systems for foundations -- Part 2: Installer's responsibilities
ISO/CD 12575-3	Thermal insulation -- Exterior insulating systems for foundations -- Part 3: Test methods
ISO/AWI 12576-2	Thermal insulation -- Insulating materials and products for buildings -- Conformity control systems -- Part 2: Site-made products

Appendix D List of Respondents

The authors wish to acknowledge and thank the following people for their time and information which has provided significant input to this study.

Kylie Goodwin - *Standards Australia*
Robin Bectel - *NAIMA*
Geoff Westaway – *Gippsland Building Approvals*
Greg Nolan – *University of Tasmania*
Robin Clarke - *CSIRO*
Neville Taylor, Ray Thompson – *CSR Bradford*
Graeme Gifford, David Cagney – *CSR Bradford*
Darren Davies, Michael Bosmakis - *Insulco*
Michael Guenther – *Foilboard*
Tim Renouf – *Wren Industries*
Scott Rankin – *Battmans*
Brian Tikey, James Pinyon – *Air-Cell*
Terry Mischefski – *Expol*
Stuart Wilson – *Wilson Homes*
Bruce Langford-Jones – *Langford-Jones Homes*
Brian O'Donnell – *Hamlyn Homes*
Gary Rickard – *Swenrick Homes*
Peter Org – *Cosywrap Insulation*
Nathan Campbell – *Aerodynamic Developments*
Pam Fisher - *Foamex*
Lawrence Wolf – *Foamed Insulations*
Peter Llewellyn – *Timber Development Association*
Boris Iskra – *Timber Promotion Council*
Colin Mackenzie – *Timber Queensland*

Appendix E Notes On The Calculation Of R-Values

Introduction

The R-values have been calculated using a computer program *Rvalues.for*. This program 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 Appendix. It should be noted that any variation to these variables may result in a different R-value for the element.

General

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

The total thermal resistance of a plane building element consisting of layers perpendicular to the heat flow are 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 2.

The thermal resistance of an element that is not continuous but is bridged by timber frames is determined by the method given in ASHRAE Handbook of Fundamentals (1998) Section F22. The average of the parallel flow and isothermal planes methods is assumed.

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 in this document. R-values for both “Heat Flow *IN*” and “Heat Flow *OUT*” are given. The boundary condition assumptions used in the calculations are shown in Table 1.

It is important to realize that the boundary conditions and other factors used in the calculation of an R-value of an element (temperature & solar radiation) may differ from criteria used to determine the appropriate R-value that an element should achieve in a particular location.

Thermal Conductivity of Materials

Table 3 gives the thermal conductivity of materials used in the calculations. Unless otherwise noted all values have been taken from the AIRAH Handbook (2000).

Air Space Thermal Resistance

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

Table 1: Boundary Condition Assumptions for Floor Calculations

Heat Flow ***IN***	
Internal Temperature	24°C
External Temperature	36°C
Heat Flow ***OUT***	
Internal Temperature	18°C
External Temperature	6°C

Table 2: Surface Resistance Values (m2.K/W) Moving and Still Air

Position of Surface	**Direction of Heat Flow**	**Surface Emissivity**		
		e=0.90 Non-reflective	**e=0.2 Partly reflective**	**e=0.05 Reflective**
Still Air				
Horizontal	Down	0.16	0.47	0.80
Sloping 22.5°	Down	0.15	0.38	0.60
Sloping 45°	Down	0.13	0.29	0.39
Vertical	Horizontal	0.12	0.24	0.30
Sloping 45°	Up	0.11	0.20	0.24
Sloping 22.5°	Up	0.11	0.20	0.24
Horizontal	Up	0.11	0.19	0.23
Moving Air				
Any Orientation				
3.35 m/s	Any	0.044		
6.70 m/s	Any	0.030		
Internal air				
Moving	Any	0.08		

Source :AIRAH Handbook (2000)

Table 3: Thermal Conductivity of Materials

Material	Density (Kg/m^3)	Conductivity (W/m.K)
Brickwork – generic extruded 110mm	1580	0.611
Brickwork – generic extruded 90mm	1630	0.600
Carpet underlay		0.040
Cellulose fibre – loose fill (with fire retardant)	29	0.038
Concrete – Aerated blocks 100mm	650	0.13
Concrete blocks – solid, 90mm	1800	0.750
Concrete blocks – hollow 390*190*90	1800	0.785
Concrete blockwork – hollow 390*190*140	1410	0.957
Concrete, crushed rock 1:2:4	2400	1.44
Fibre-cement sheet	1360	0.250
Glasswool - batts	18	0.036
Plaster – gypsum board	880	0.170
Plaster – cement, sand 1:4	1570	0.530
Plywood	530	0.140
Particle board	640	0.120
Polystyrene - expanded	16	0.035
Polystyrene - extruded	32	0.028
Rockwool - batts	32	0.033
Rockwool – loose fill	64	0.040
Timber/Wood – hardwood (Alpine Ash)	688	0.160
Timber/Wood – softwood	506	0.100
Weatherboards, pine	506	0.100
Weatherboards, stringy bark	712	0.140

Note: Conductivity values given in this Table are generally measured at 23^{o}C. The conductivity of bulk insulation materials varies as a function of the temperature of the material in accordance with AS 4859 Materials for the thermal insulation of buildings, Figure E1.

Table 4: Emissivity of Materials

Material	Emissivity
Common building materials	0.90
Aluminum Reflective Foil	0.03
Aluminum Foil (anti-glare treatment)	0.20

Table 5: Default Values Assumed in suspended floor calculations.

Variable	Assumed Standard Value		
Soil			
Clay density	1300 kg/m3		
moisture content	10%		
Thermal conductivity	*0.55 W/m.k*		
Sand density	1800 kg/m^3		
moisture content	6%		
Thermal conductivity	*1.64 W/m.k*		
Wind speed (10m height)	3.0 m/s		
Ventilation	Low	Med	High
Sub-floor Open	50% open	75% open	100% open
Sub-floor Enclosed	Zone 1	Zone 2	Zone 3
In accordance with BCA Clause F1.12 and Table F1.12 (See Figure 3)	2000mm^2/m	4000mm^2/m	6000mm^2/m

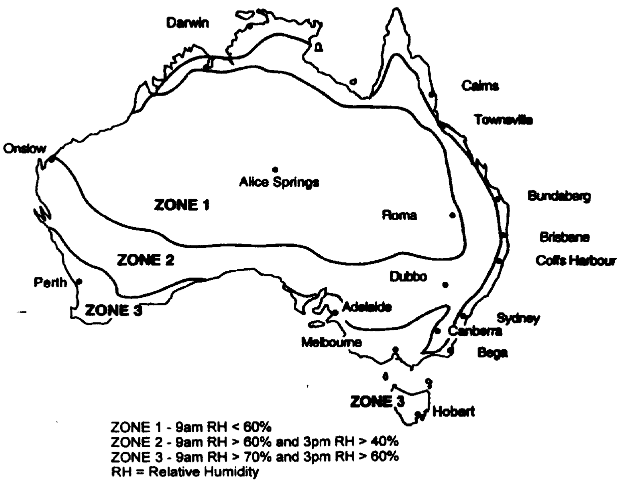


Figure 1: Sub-floor Ventilation Zones

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Robinson, H. E., & Powlitch, F. J. (1954). **Housing Research Paper 32. The Thermal Insulating Value of Airspaces**. Washington, DC: Housing and Home Finance Agency.

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