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Thermal Performance in Timber-framed Buildings

To be used in conjunction with Guides 23 and 24

Technical Design Guide issued by Forest and Wood Products Australia

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Where required, the text is supported by compliance and example drawings.

Some of the Guide topics include:

- Timber-framed construction
- Building with timber in bushfire-prone areas
- Designing for durability
- Timber finishes
- Stairs, balustrades and handrails
- Timber flooring and decking
- Timber windows and doors
- Fire compliance
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- Thermal performance

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This document brings together key considerations from:

Guide 23: Using thermal mass in timber-framed buildings in Australia: Effective use of thermal mass for increased comfort and energy efficiency by Ben Slee and Dr Richard Hyde, University of Sydney.

Guide 24: Thermal performance for timber-framed residential construction: Building comfortable and energy-efficient timber houses, by Dr Mark Dewsbury and Associate Professor Gregory Nolan, University of Tasmania.

Compiled by Scott Willey as a guide to the above publications.

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Introduction

If thermal mass is used correctly within housing it can moderate daily temperature fluctuations, leading to more comfortable interiors, and reduce the energy used for artificial heating or cooling. If thermal mass is used incorrectly, the opposite occurs.

This Guide gives a simple step-by-step overview of housing design for greater thermal comfort.

The design considerations listed are covered in greater detail in two FWPA publications which focus specifically on the thermal performance of timber framed houses:

Guide 23: Using thermal mass in timber-framed buildings (see page 10)

Guide 24: Thermal performance for timber-framed residential construction (see page 11)

References to these and other useful resources are listed at the base of each design consideration.

It is worth remembering that a house built today might still be providing shelter and comfort in more than 60 years time. Thoughtful design and construction offer benefits over the life of a house:

- The earlier in the design phase decisions are made to improve comfort, the more cost effective they can be.
- Exceeding minimum ‘star’ ratings offers greater comfort for residents.
- Greater comfort means less energy is needed for heating and cooling.
- Careful detailing can avoid maintenance problems with moisture build-up.

Refer to Technical Design Guides under the Resources section of the WoodSolutions website (www.woodsolutions.com.au) for the above publications..

Timber and thermal comfort in housing

Most existing houses in Australia are timber-framed and new homes continue this tradition. Many modern homes perceived to be ‘brick’ houses are actually timber-framed houses with bricks used only as a cladding.

Modern construction methods mean an increasing number of low-rise apartment buildings, traditionally constructed out of masonry for fire-resistance, are now being built with timber frames as well.

Designing for timber thermally

As construction technology has developed standards of fire-resistance, acoustic separation and thermal comfort in timber buildings have improved. This guide provides design and construction knowledge on how to achieve superior thermal comfort and better thermal performance which delivers:

- more comfort for residents
- less energy use for heating and cooling
- less greenhouse gas emissions

Decreasing emissions - increasing comfort

Timber-framed houses tend to be more responsive to heating and cooling than buildings with higher thermal mass. Keeping occupants comfortable is achieved by moderating internal temperatures to avoid extremes. Comfort and energy efficiency can be maximised by a focus on avoiding unwanted heat loss or gain through the building envelope. This Guide gives solutions for achieving this with:

- fewer greenhouse gas emissions
- well insulated building envelope
- avoiding air infiltration

High performing social housing
Hopkins Street Affordable Housing Project is a multi-residential timber framed building with a 7.3-8.1 Star Rating (Source: Xsquared Architects, Photographer: Ray Joyce)

House design and orientation

1 Designing for Residents' Needs

Successful house design works best when it is tailored for its residents, which is why thermal comfort is important.

When a home is designed to pair comfort to occupant's lifestyles they will want to use less heating and cooling and thus use less energy.

For example, a house designed for retired residents might have a greater focus on daytime living. A younger working family's house design is more likely to focus on comfort in the evening.

If the future residents are not known then design should focus on the needs of the most likely residents.

More information:

- *Your Home: www.yourhome.gov.au/you-begin/preliminary-research*

2 Designing for Climate

To increase both comfort and energy efficiency, a house design should work with the local climate rather than against it.

Seasonal temperature and humidity variations are strong drivers of climate-responsive design.

Daily temperature variation also need to be considered. For example, hot, dry climates often have nights that are significantly cooler than days. Houses can respond by closing down during the heat of the day and opening up in the cool at night.

Alternatively, responsive design in a hot, humid climate opens in the day to take advantage of cooling breezes.

Refer to the National Construction Code for the specific climate zone for your project.

More information:

- *Guide 23: Section 6, Thermal Mass in Australian Climates*
- *Guide 24: Section 3.2, Designing for Climate, 3.4 Considerations for Specific Climates*
- *Your Home: www.yourhome.gov.au/passive-design/design-climate*
- *Bureau of Meteorology: www.bom.gov.au/climate*

3 Orientation - Working with the Sun

For most Australian climates, houses should orientate to the north to maximise daylight, especially in winter.

In cooler climates, capturing the warmth of the winter sun is a priority.

In hot climates, orienting toward cooling breezes and avoiding the sun all year round can determine the best orientation.

It may be that the cooling breezes in warmer months come from a different direction to winter sun.

Views, privacy, road noise and bushfire risk are just some of the other considerations that need to be considered when deciding which direction to face a house and how open it should be.

More information:

- *Guide 24: Section 3.3, Designing for Sun, Section 4.1 Planning and Site Selection*
- *Your Home: www.yourhome.gov.au/passive-design/orientation*

Planning and form

4 Room Zoning

Beyond the other functional needs in planning a house, dividing rooms by occupation type can determine their orientation priority.

Morning sun can be welcome in eastern bedrooms, particularly in colder climates. Northern living areas allow residents to take advantage of the best daylight and the sun's warmth in winter.

Non-occupied spaces such as garages or utility rooms can be placed to the west to block undesirable afternoon summer sun.

Zoning rooms together with similar heating and cooling requirements aids efficiency.

Adding doors to halls and between living areas can prevent unwanted loss of heated or cooled air.

More information:

- *Guide 24: Section 3.3, Designing for Sun*
- *Guide 24: Section 4, Planning Strategies*
- *Your Home: www.yourhome.gov.au/passive-design/orientation*

5 Controlling Surface Area with Form

As the floors, external walls and roof all form part of the building envelope, these surfaces form the primary line of control for heat entering and leaving a building.

The greater the surface area – the greater the potential heat transfer.

Some climates warrant elongated, more lineal floor plans designed to catch warming sun or cooling breezes.

Compact house forms minimise the area of the exposed envelope to external temperatures, and are more appropriate for extreme climates.

More information:

- *Guide 24: Section 4.2, Site Master Planning*
- *Guide 24: Section 5, Envelope Strategies*

Controlling heat gain & loss

6 Capturing the Sun - Glazing Design

Glazed windows and doors allow access to views and natural light and, if openable, allow ventilation as well. Windows become 'thermal holes' in the envelope and their design needs careful consideration.

Direct sun admitted to a building can quickly cause overheating. The area of glazing requires careful consideration of the amount of solar warmth required for a particular orientation.

In most climates, western facing windows admit too much heat in summer, and should be limited.

The poor insulative property of glass leads to high heat loss in cooler weather. In cooler climates, minimise southern glazing, as it loses winter warmth while never gaining warming sun.

More information:

- *Guide 23: Section 4.2.5 Window Size*
- *Guide 24: Section 5.6, Windows*
- *Your Home: www.yourhome.gov.au/ passive-design/passive-solar-heating, yourhome.gov.au/passive-design/glazing*

7 Capturing breezes - Ventilation

Any house needs constant ventilation to exhaust odours and provide fresh air for occupants, though the amount needed for this is small.

When ventilating for cooling, it is important that cross ventilation be well designed to maximise airflow, even in calm conditions. Narrow floor plans allow for greater cross ventilation.

In cooler weather, unwanted air movement equals unwanted loss of heat. In summer, the reverse is true for air-conditioned spaces.

Well-designed ventilation should consider wet weather, flying insects, wind gusts, etc. If security is not considered in window design, residents are less likely to be able to leave windows open when needed, including overnight.

More information:

- *Guide 23: Section 4.2.4, Controlled Ventilation*
- *Guide 24: Section 4.2.7, Natural Ventilation*
- *Your Home: www.yourhome.gov.au/ passive-design/passive-cooling*

8 Controlling Solar Gain with Shading

The sun's heat can be as much as that from a 1000 watt single-bar electric heater on every square metre of the building it contacts. Roof overhangs limit the amount of heat reaching external walls. The hotter the climate, the more important this is.

As winter sun comes at a lower altitude to summer sun, well-designed roof overhangs and awnings can allow winter sun while providing shade in the warmer months. Fortunately, in the higher latitudes where winter sun is more important, this effect is more pronounced. Verandahs, pergolas, trellises and external blinds can all be used to control sun while also adding visual interest.

More information:

- *Guide 24: Section 5.7, Eaves and external shading*
- *Your Home: www.yourhome.gov.au/ passive-design/shading*

- Your Home: Orientation: www.yourhome.gov.au/passive-design/orientation

Penetration design

9 Controlling Heat Conduction with Insulation

As the building envelope is the line at which heat is lost or gained in a building, the ability to control heat movement through it is critical.

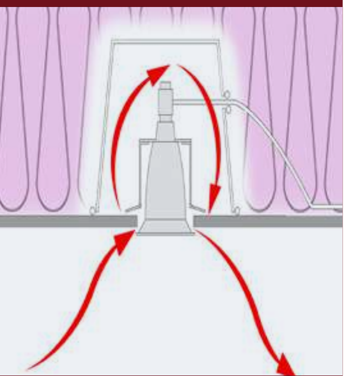
Insulation is valued for its ability to resist heat flow, and thus a higher 'R' value indicates greater insulative ability. Insulation products work to slow heat conduction, and reflect radiant heat.

Insulating roofs, ceilings, walls and under floors has become common practice. It is important however, that the insulation provided is detailed and installed correctly to maximise its value. Beware thermal short-circuiting known as 'thermal bridging'.

Double glazed windows with 'thermally broken' frames prevent heat loss in cold climates, and heat gain for air-conditioned buildings in hot climates.

More information:

- *Guide 24: Section 5.4, Thermal Insulation*
- *Your Home: www.yourhome.gov.au/passive-design/sealing-your-home*



10 Controlling Air Leakage

Uncontrolled air movement brings unwanted heat movement. Creating more airtight construction will give greater comfort and greater energy efficiency – leaving ventilation control to the operation of windows and doors by occupants.

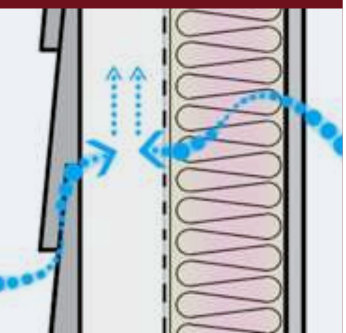
Using sarking in roofs and quality building wrapping over walls inhibits the flow of air through the building fabric.

It is important the building wrap is continuous and that wrap joints and penetrations are well lapped and sealed with tape.

The underside of raised timber floors can also be wrapped, although it is important to ensure timber members are able to breathe, and no moisture is trapped.

More information:

- *Guide 24: Section 5.3, Air-tightness*
- *Your Home: www.yourhome.gov.au/passive-design/shading*



11 Avoiding Moisture Build-up

Air inside and outside buildings contains moisture. Condensation occurs when moist air hits cool surfaces.

In cool weather, when air passing outward from the building interior contacts the back of the external cladding, condensation can form within the building fabric.

Similarly, condensation can form when outside air contacts the back of the internal cladding of an air-conditioned building.

To avoid deterioration of building materials and potential health problems, houses should be detailed and wrapped well to avoid moisture vapour movement through the building envelope. Construction should also allow for any trapped condensation to evaporate.

More information:

- *Guide 24: Section 5.1, Structural moisture control*

Adjusting mass and testing

12 Moderating Temperatures with Thermal Mass

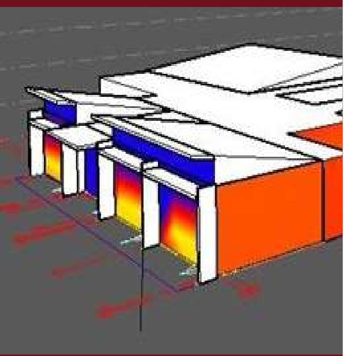
Solid and heavy materials often have an ability to store and release heat. This ability can be utilised to even out daily temperature extremes. This ability is commonly known as 'thermal mass'.

Utilising well-designed thermal mass can provide more comfortable interiors. However, if not designed well, too much mass can create interiors that are hard to keep comfortable.

For any climate there is a point at which adding thermal mass provides little or no benefit. The location of the mass within a room is also important. As heat rises, mass in ceilings can be used to absorb heat for optimal cooling and when used for heating, solar-heated mass in the floor is best.

More information:

- *Guide 23: Section 4, Placing Thermal Mass*
- *Guide 24: Section 5.8, Thermal Mass and Thermal Capacity*
- *Your Home: www.yourhome.gov.au/ passive-design/thermal-mass*



13 Testing the Design

Computer modelling thermal performance allows building designers to test which design changes will be the most effective for enhancing thermal comfort. Allowing for additional experimentation with the building design and testing before the design is locked-in will produce the most effective results.

An optimal design will save money on construction and energy usage.

More information:

- *Guide 24: Section 2.3 Thermal simulation*
- *Nathers: www.nathers.gov.au/accredited-software/how-nathers-software-works/star-ratingscale*

14 Informed Occupants

Like anyone buying a new appliance, new home owners appreciate understanding what they have bought, and how it is designed to operate.

Good passive design and a high energy star rating on a house can be unwittingly over-ridden by a 'one-star occupant'.

Many home owners will presume they will need air-conditioning or ducted heating systems, based on their previous living experiences. As thermal performance standards increase, it can be valuable for future occupants to be made aware of the performance they can expect from their new home, before they commit to heating and cooling systems that are oversized, or not needed at all.

More information:

- *www.yourhome.gov.au/passive-design*

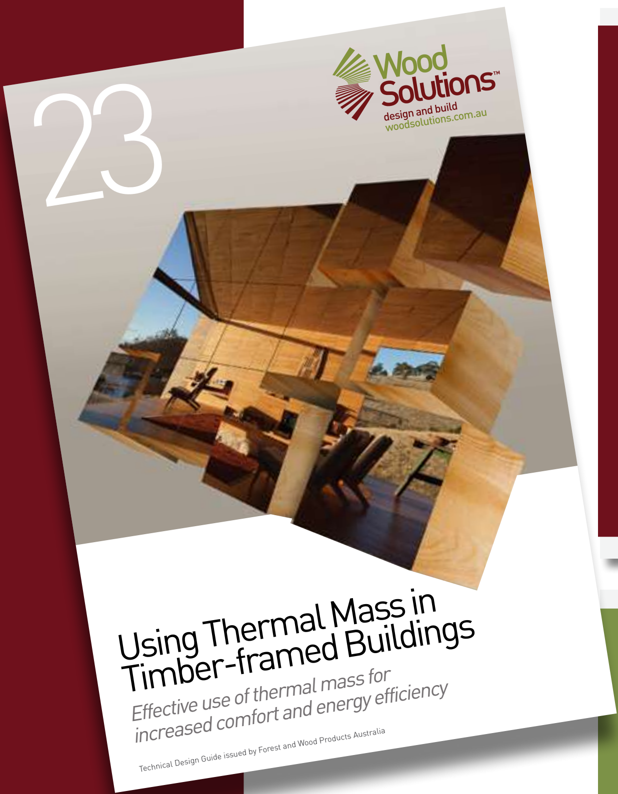
Guide 23 - Using Thermal Mass in Timber-framed Buildings

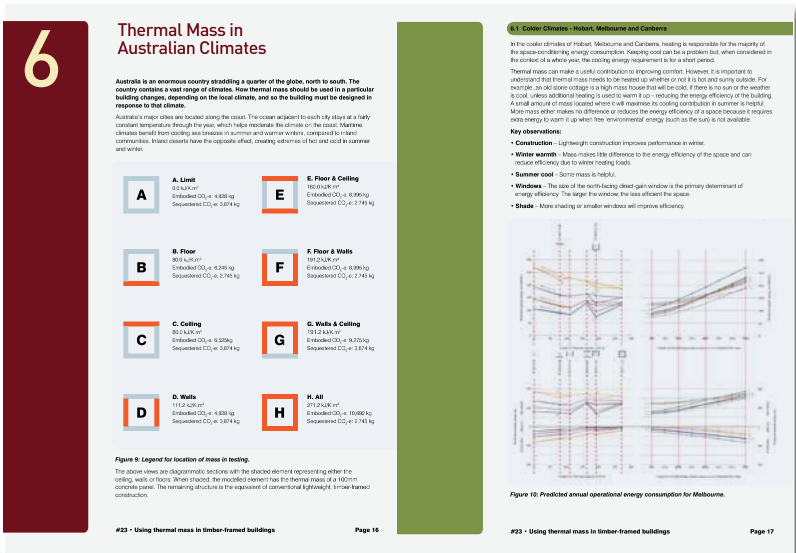
Effective use of thermal mass for increased comfort and energy efficiency

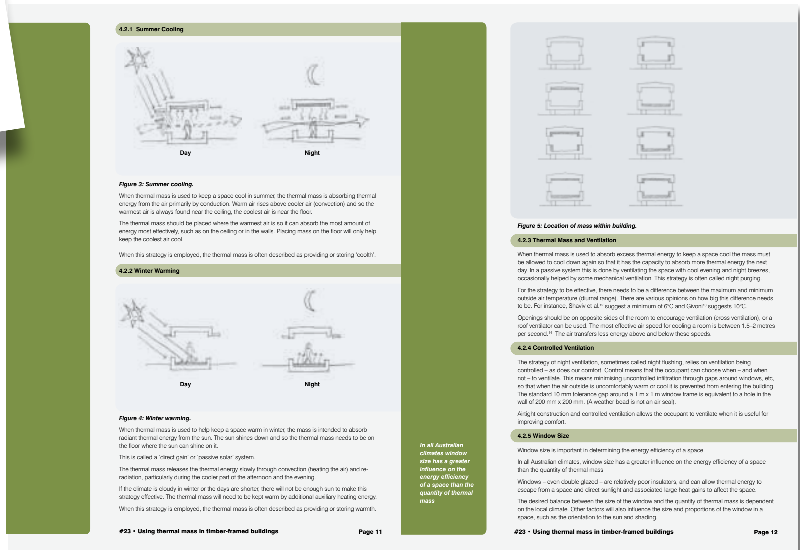
Traditional cultures have long understood the value of thermal mass in buildings for moderating internal temperatures. However if used in the wrong proportions, too much thermal mass can actually decrease comfort.

Modern Australian homes tend to use the same lighter-weight, brick veneer and timber construction across a wide variety of climatic conditions, yet with remarkably little design variation. In this Guide the authors explain thermal comfort is not only dependant on the proportion of thermal mass but also the size and location of glazing in a building.

Thermal mass can be used to carry the warmth of the day into cool nights, or inversely - the cool of the evening into hot days. A series of simulations demonstrate that the height mass is placed within a space will vary its value in enhancing heating or cooling.





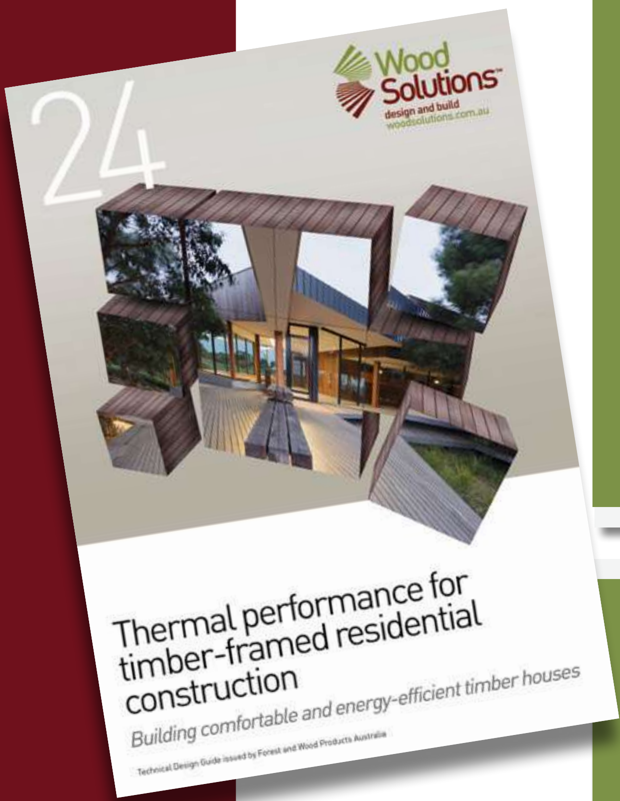


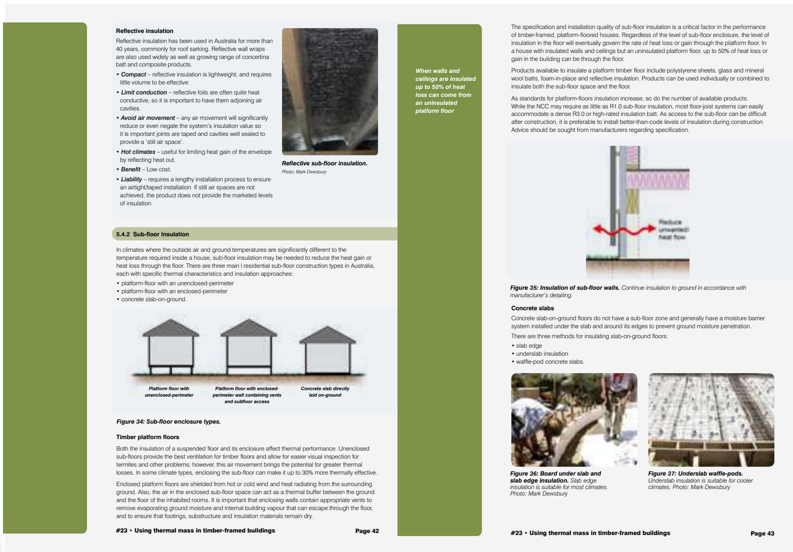
Guide 24 - Thermal performance for timber-framed residential construction

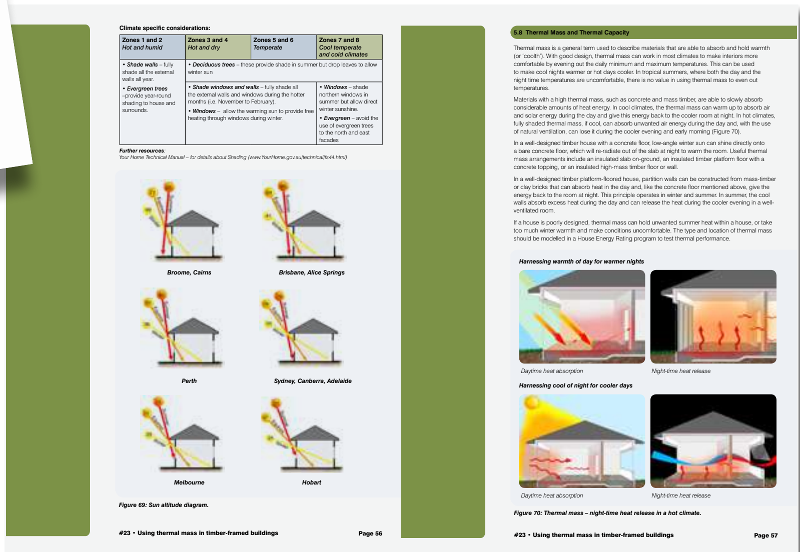
Building comfortable and energy-efficient timber houses

Maximising occupant thermal comfort and therefore increasing energy efficiency is achieved by balancing a combination of design factors. These vary from the basics such as orientation up to more elaborate concepts such as thermal bringing and the control of moisture vapour within building elements. This Guide uses many diagrams and photographs to illustrate in detail how to design for increased energy efficiency.

The authors use the modelled thermal performance of two typical project homes to contrast how minor design variations give significant gains in energy efficiency - especially when customised to climate.







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