Good Old Design Principles

Traditional buildings generally managed the variations of climate, and achieved consistent thermal comfort for occupants, in all but the most extreme weather conditions. Today, for year-round thermal comfort, we tend to rely more on a vast range of heating and cooling appliances – rather than the simple and sound 'good old' passive design principles.

Are we so caught up in technology that we are ignoring centuries of practical knowledge? Are we instead designing towards an excessive reliance on energy consuming heating and cooling devices?

Energy efficient house design is becoming more and more important with the push for Australia to reduce greenhouse gas emissions. The largest proportion of energy use in a home is attributed to artificial heating and cooling and the recent surge in the uptake of air-conditioners will increase the burden on infrastructure as the peak energy loads increase.

Designing and constructing an energy efficient house has the potential to substantially and permanently reduce the amount of energy consumed in space heating and cooling.

Through scientific research, Cathy Inglis examines the age old principle of thermal mass for energy efficient design.

Materials for Energy Efficient Design

Insulation and thermal mass – two of the elements of passive design – are reliant on building materials. The most common measure of the thermal performance of a building material is its R-value. An R-value is a measure of the thermal resistance of a material. Although the use of a single number is convenient and easily understood, the R-value is only a measure of the material's ability to insulate. The R-value is not a complete measure of a material's thermal performance. In fact, the thermal performance of the building fabric is reliant on a complicated interaction of properties.

Broadly, materials with beneficial thermal properties will be either:

- insulating materials, or
- materials with thermal mass

When only the R-value is considered, only one material property is being included – insulation. It is important to remember that an appropriate combination of both insulation and thermal mass is required. Walls with the same R-value will have the same insulation ability, but not necessarily the same thermal performance.

Is there hard evidence?

There is plenty of good anecdotal evidence available on the benefits of bricks. But the brick industry has realised that in today's competitive, construction environment, designers and builders are looking for hard scientific evidence to back up the claims of the virtues of bricks by building product companies.

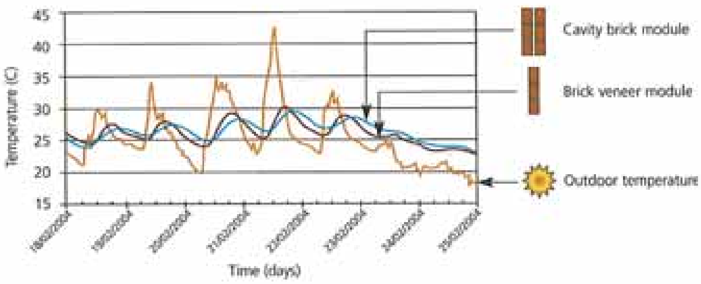
A quantitative research program is underway at The University of Newcastle. Four full-scale test housing modules have been built at the university to compare typical Australian housing forms including brick veneer, cavity brick and lightweight construction. The houses have been comprehensively instrumented with temperature, humidity, solar radiation and heat flux sensors to monitor year-round thermal performance.

R Value is not the right measure

A high R-value indicates a material with a high level or resistance to heat flow. The R-value of individual materials such as bulk insulation and reflective insulation is often stated. The R-value of a whole wall construction can also be determined by laboratory testing. The research at the University of Newcastle determined the following steady state R-values for typical masonry walls:

Wall Construction	R-Value
Brick Veneer with reflective foil	1.14
Cavity Brick	0.82

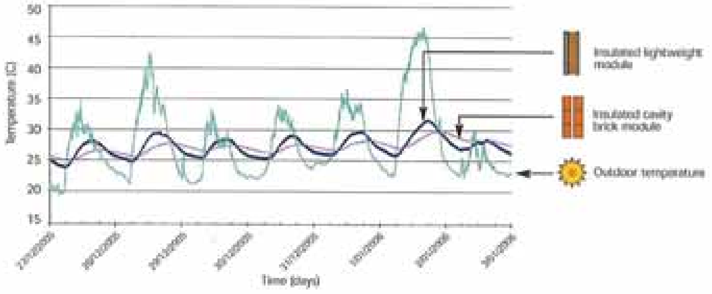
Analysis of the building modules, one of brick veneer construction, the other of cavity brick, showed that external temperature fluctuations were moderated to a range more consistent with human comfort to demonstrate the benefits of thermal mass during a summer heat wave.



Comparison of the internal temperature of the brick test modules.

It is important to note that the cavity brick construction moderated the temperature fluctuations to a larger extent than the brick veneer construction, although it has a lower R-value. The R-value is not representative of the overall thermal performance of a material and should not be the only consideration when selecting a material.

More recently a fourth module was built using insulated lightweight walls. The lightweight module was subject to greater temperature variations than the insulated cavity brick module over the same period. This variance can only be attributed to the greater thermal mass of the cavity brick module, as both walls have similar R-values.



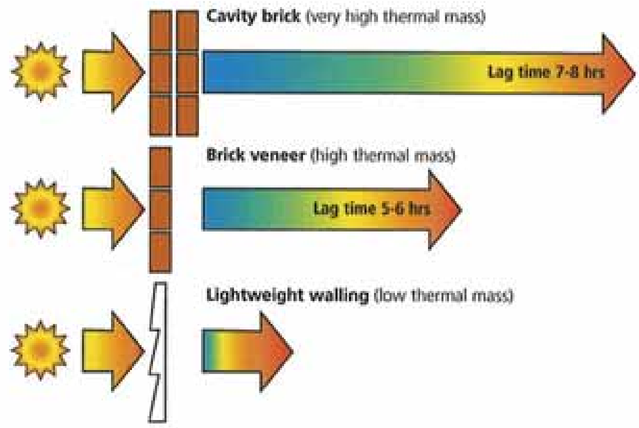
Air temperatures inside the insulated lightweight module showed greater fluctuations than those in the insulated cavity brick module.

There is no widely accepted method of quantifying thermal mass, and it is not adequately represented by the R-value. Indeed, materials that have thermal mass are thermally more effective than their R-value indicates.

Materials with Thermal Mass

Dense materials with high thermal mass, such as clay brickwork and concrete slabs, have the ability to absorb heat when subjected to a temperature differential, thereby slowing its passage through the wall. The combination of thermal capacitance and heat conduction allow these materials to act as an extremely effective 'thermal battery'. Thermal mass helps stabilise temperature variations and this natural moderation reduces our dependence on mechanical heating and cooling.

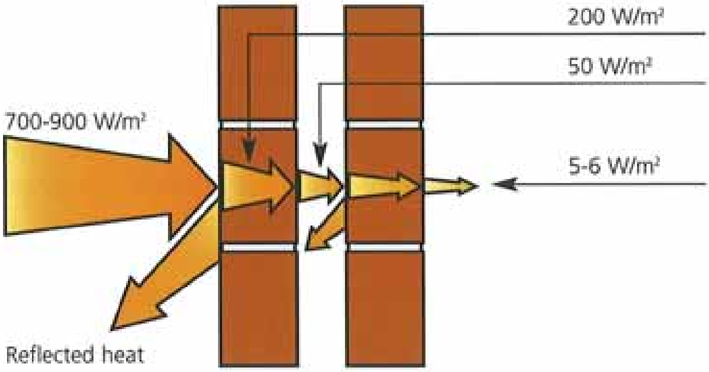
The thermal lag of the brick veneer and cavity brick constructions were able to be quantified by this research. Thermal lag is a measure of the extent to



Brick walls slow the passage of heat through the wall.

which thermal mass absorbs heat and slows down its transfer. The higher the level of thermal mass, the longer the lag time.

The research also showed that only a small proportion of heat striking a west-facing cavity brick wall in summer passes through the wall. Most is reflected and some is absorbed, leaving less than one percent (5-6 W/m2) to penetrate the wall. This can be compared to the massive 120W/m2 measured to enter through a shaded north-facing window.



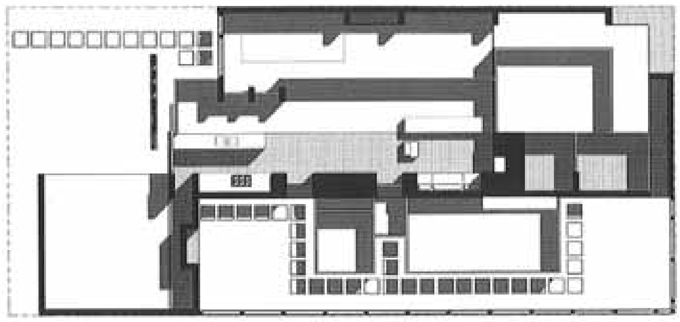
Less than one percent of heat penetrates a west-facing cavity brick wall.

Thermal Mass put to good use in Design

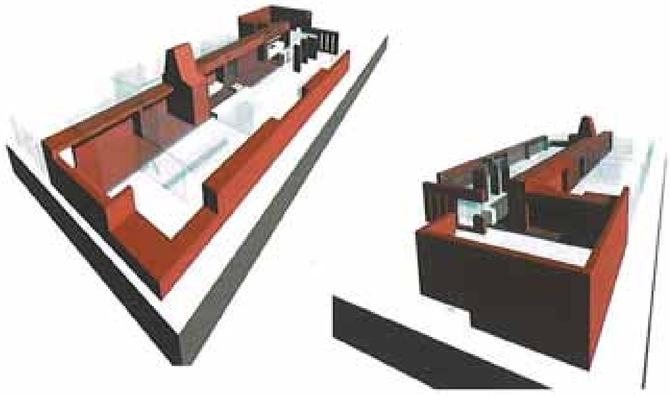
Now that you have the evidence – what about in practice?

A recent project by the brick industry body, Think Brick Australia, (formally the Clay Brick and Paver Institute) approached seven of Australia's most respected architects to fulfil one simple brief: To Innovate with Brick. Known as the 'About Face Project' the results were amazing – seven inspirational designs, which represent an imagination-stretching palette causing many design and building professionals and home owners to rethink their attitudes to bricks. The projects use brick to provide thermal comfort and to address security, acoustics and privacy.

The 'Seaside Sculpture' designed by Fairweather Proberts is inspired by bricks inherent flexibility and is a perfect example of how to make the most of thermal mass. The design, suitable for a small suburban block on the Sunshine Coast in Queensland, has perimeter walls of brick to provide visual and acoustic privacy. Clay bricks are further used to form a spine down the centre of the home, which becomes a large area of isolated vertical thermal mass to regulate the temperature naturally. The glazing is located in the roof with large celestial windows above the living space. In winter



these windows provide sufficient solar access to the internal brick wall which will store the heat. The shutters on the windows can then be closed at night to keep the stored heat in. With the glazing located in the roof the solar access will not be affected by overshadowing from neighbouring houses or vegetation. In summer, the shutters remain closed during the day and can be opened at night to allow the radiation of heat to the night sky to quickly cool the home.



Importantly, in terms of energy efficiency, the design rated well and achieved an Accurate score of nine stars.

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