Thermal performance – putting the heat on residential housing standards

The challenge for concrete

While we know concrete offers unique advantages in terms of thermal performance we still have a limited ability to accurately measure these benefits. For example, although it's known that concrete passively absorbs energy from the sun, the benefits gained from this process depend on a number of factors, such as the orientation of the building to the sun, the window area and insulation methods.

Research currently underway will help clarify these issues, and provide not only the necessary evidence to allow for changes to the codes, standards and regulations, but also proof of performance for those wanting to get more comfort from their homes.

New Zealand, like most developed countries, has legislated minimum performance requirements for buildings. The Building Act 1991 sets out to safeguard building users against such things as injury and illness, 'loss of amenity', or damage to other property – and also calls for an efficient use of energy. It is this last objective – the efficient use of energy – and how it relates to residential buildings, that is the focus of this article.

Another important issue related to energy efficiency is the topic of internal moisture control (NZ Building Code Section E3).

How the legislation works

The New Zealand Building Code is a schedule which contains the requirements for meeting the purposes of the Building Act. It is performance based – in other words, the Building Code says only what has to be achieved, it does not specify how to achieve it.

The Building Industry Authority (BIA) is a crown agency established under the Building Act as the sole regulatory body for building controls in New Zealand. The BIA therefore administers the Building Code.

The basic idea behind a performance-based code is that owners are free to use any materials and construction methods they like, provided they can demonstrate that they meet the performance requirements of the Code. By not specifying materials and methods, the code aims to encourage innovation. Certainly, some building owners have benefited from the freedom of choice that this performance-based code allows.

Most home owners however, still prefer to have clear guidance on materials and methods. The code allows for this by setting out 'Acceptable Solutions' for compliance with the code. In practice, these acceptable solutions are usually described in 'Approved Documents' – commonly in the form of New Zealand Standards. Territorial Authorities have the ultimate responsibility for ensuring buildings meet the requirements of the building code. The flexibility exists for compliance to be by way of an 'acceptable' or 'alternative' solution to the code.

The case for commercial and industrial buildings

The objective of Section H1 of the Building Code is 'to facilitate the efficient use of energy'. However, at present the code provides only non-quantified requirements for energy efficiency for building types other than houses – such as commercial and industrial buildings – with NZS 4220: 1982 providing the guidance on suggested ways of complying.

Energy efficiency of commercial and industrial buildings is an important issue and it has been suggested that the code requirements should be more stringent. A proposed new H1 clause is much more specific and a new Standard 4243: 1996 has been written and is awaiting official adoption. This issue is still under debate – we will return to this subject in a future issue of concrete.

For houses, the code requires that the 'building performance index' must not exceed 0.13kWh. The building performance index is 'the energy from a depletable resource needed to maintain the house at a constant internal temperature of 20°C (per m^2 floor area and per degree day) for the period 1 May to 31 August'. It also makes assumptions about how the building is used, such as air change rate, heat emissions from internal sources (including people and equipment), and so on.

Selecting the standard

NZS 4218P is currently approved as an acceptable solution to the H1 requirements for housing. However, a revision of H1 is awaiting passage through government and, when approved, will cite NZS 4218:1996 'Energy Efficiency – Housing and Small Building Envelope' as the acceptable solution rather than NZS 4218P.

In practice the Territorial Authorities have for some time accepted NZS 4218:1996, so further discussion will focus on the provisions of this revised standard.

The energy cost factors

What is interesting is that the code committee, in defining the minimum insulation values, used the financial cost of energy as a means of establishing a sensible minimum requirement. A study[1] was commissioned by the BIA and the Energy Efficiency and Conservation Authority (EECA) specifically to establish, through energy modelling and economic analysis, appropriate insulation requirements.

The study considered the home owner's as well as the national economic perspective. It made recommendations for changes (or for maintaining the status quo) based on this economic analysis. The analysis was based on life cycle cost of energy efficiency measures in a selection of houses. Two houses (one with $100m^2$ floor area and the other $200m^2$) were modelled[2] for a range of construction types in Auckland, Wellington, Christchurch and Invercargill. The table on page 18 details the key assumptions made for the purposes of the analysis.

Recognising regional differences

The study concluded that increases in insulation requirements were not appropriate for Auckland but were justified on economic grounds in 'cooler' regions, which included all the South Island and much of the Central North Island. The subsequent revision of NZS 4218 accepted

Zone 1 & 2 – R 0.6 min. – strapping and lining of blockwork as minimum requirement
Zone 3 R 1.0 min. – Strapping and lining without adding additional insulation material does not comply (unless specifically designed using calculation or modelling methods approved within NZS 4218).

Analysis Issue	Owner	National
Energy price	Regional	Specific to fuel type. Based on marginal generation & transmission
Discount rate	Real mortgage (8%)	5% real
	20 year period	50 year period
Insulation salvage value	zero	zero
Heating regime	20°C day (living spaces) 16°C night (all spaces) As required throughout year	

this recommendation and introduced three climate zones (Auckland and Northland [zone 1], South Island and Central North Island [zone 2], and the remainder of the North Island [zone 3]). (See map above.)

The revision to NZS 4218 increased the prescriptive requirements for insulation in the cooler zone, but did not alter the requirements in the other zones.

The case for 'solid' vs 'non-solid' wall systems

The benefits of thermal mass in wall systems such as concrete block and pre-cast concrete were recognised in NZS 4218P: 1977, and as a result, 'solid' wall systems were allowed to meet a lower insulation value than lightweight wall systems (timber frame). This recognition of the benefit of the thermal mass of concrete construction was carried through to the new code.

Using the SUNCODE computer simulation, which allows for the 'thermal mass effect', the study found that in the cooler zone there was justification for increasing the R value requirement for solid wall construction from 0.6 to 1.0. In effect, this meant that in the cooler South Island and Central North Island zone, traditional strapping and lining – without the addition of other insulating materials – would no longer comply with the scheduled code requirements.

However, it is possible to achieve compliance (with a strapped and lined wall) by increasing insulation levels in other building elements – such as the roof and floor – and using calculation or modelling methods, approved within the code, to demonstrate compliance.

For the rest of the country, there was no economic justification for changing the existing R 0.6 requirement. The Standards Committee accepted this recommendation and the new NZS 4218: 1996 specifies R 0.6 for the warmer zones. Traditional strapping and lining of blockwork therefore remains an acceptable means of complying in these zones.

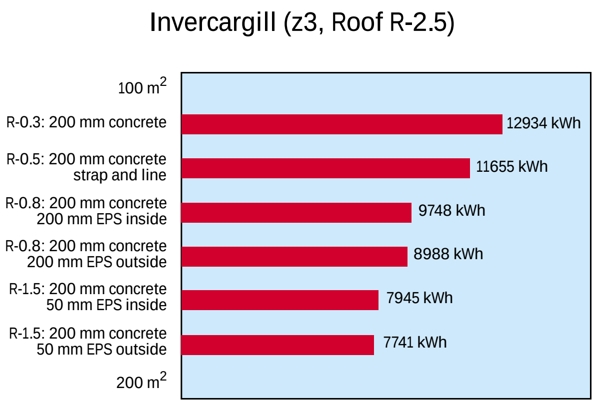
Thermal mass – maximising the benefit

Although neither NZS 4218P nor NZS 4218:1996 specify how and where insulation should be added to a solid wall, there is theoretical evidence for believing that thermal performance would be increased if the insulation is placed on the exterior of the wall, rather than the interior, as is the common practice.

In 1997, the C&CA commissioned BRANZ to undertake a study[3] into the effects of thermal mass. Part of this study looked at external versus internal insulation. This study concluded that "from an energy standpoint, the placement of the insulation externally shows a marginal improvement over placing the insulation internal to the blocks". Further computer simulations were carried out by BRANZ in June 1999. Again, the results suggested a relatively small advantage of external insulation over internal. (See graph on page 19.)

Looking for the 'real' answers

While a change to the standard may not appear to be justified on the strength of this study, it's worth noting that the evaluations undertaken by BRANZ were made by computer simulation, and that many assumptions are made with all methods of computer modelling.



Not much difference between inside and outside placement of insulation. Major gains can be made by increasing the level of insulation beyond the minimum code requirements. Reprinted courtesy of BRANZ.

In order to find some 'real' answers C&CA is undertaking further research at Lincoln University measuring thermal mass effects in real buildings (see progress report on page....). A major national study is also being conducted by BRANZ, monitoring real houses in use. We anticipate that this research will help to better quantify the thermal mass effects and how to maximise them. This will ultimately inform those making future changes to the code.

Equally important, this work will allow designers, builders and home owners to make informed choices about improving the comfort of their homes above and beyond the minimum requirements of the current building code.

The future

Few of us in the construction industry or even in the wider community would doubt that energy efficiency will become an increasingly important issue as we move into the 21st century.

An example of this is a Private Members' Bill, The Energy Efficiency Bill, which was introduced into the house last year by Jeanette Fitzsimons. The purpose of the Bill includes the promotion of renewable sources of energy and delegating the power to make regulations rather than rules.

The Transport and Environment Select Committee tabled its report on submissions on 16th July this year. The Committee has recommended that the Bill be passed with a number of significant amendments. While it's not clear how this bill will relate to the energy efficiency requirements of the building code, what is clear is that if it is passed it will ultimately have an impact on all areas of energy efficiency, including our industry. C

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1. *A sensible step to energy efficiency: 1995 revision of NZBC Clause H1*
2. *SUNCODE – PC Thermal simulation model*
3. *The Effects of Thermal Mass on Energy Consumption and Indoor Climate.* A Pollard & A Stoecklein. August 1997