# Thermal insulation

## With electricity costs on the increase and air pollution a serious issue, thermal insulation has an essential role in keeping a building warm, dry and comfortable for its occupants while helping to preserve the environment.

**By Nigel Isaacs**, BRANZ Principal Scientist

Very early New Zealand homes made use of natural materials that either had good thermal performance (such as raupo reeds), or kept out wind (such as earth). When European style balloon framing replaced the older style construction, its enclosed cavities still provided reasonable thermal insulation and draught control. Lyndon Bastings of the Dominion Physical Laboratory of the DSIR estimated that nearly 90% of houses built between 1890 and 1910 were of 4 × 2 inch (100 × 50 mm) timber framework, lined externally with weatherboards and internally with rough lining, scrim and wallpaper. Ceilings and floors were also of timber, with corrugated iron roofs. Good craftsmanship and thoroughly seasoned timber gave a tight construction, double-hung sash windows provided well controlled ventilation, and open fireplaces gave background ventilation. As a result, houses were warm, dry, and usually well ventilated.

Winstone van – Home Insulation Services, 1955. (Photo from Fletcher Challenge Archives.)

### Cold and damp creeps in

Construction changed in the 1930s, with the use of green timber for framing which needed ventilated wall cavities for drying; poorer quality workmanship; roof tiles that provided considerable ventilation to the roof space; casement windows that would not easily provide draughtless ventilation; and a chimney remaining only in the living room.

By the 1940s it was reported that the ceilings and walls of over 50% of new dwellings were suffering from mould. Bastings concluded that the solution was to increase both thermal insulation and ventilation, but these were expensive.

### First measured R-values in 1940s

The first measurements of wall R-values were published in 1946. In 1950, Bastings and Roy Benseman published measurements of 42 walls, revealing R-values from as low as R0.27 (concrete veneer with 50 mm ventilated cavity and plaster and pumice sandwich board) to a high of R1.35 (asbestos cement board, 100 mm mineral wool filled cavity, hardboard lining). Their paper provided the first set of recommended R-values for New Zealand houses.

In 1958, the first edition of Bastings' 'Handbook on the insulation and heating of buildings with special reference to dwellings' provided information for householders on how to keep warm during winter and reduce mould problems. He compared the traditional 1920s wall section (weatherboard with rough timber lining and an airtight cavity), with the 1950s walls (brick veneer and lath and plaster) and found that the R-value had fallen by 50% from R0.6 to R0.3 – nearly as good as a tent. Similar comparisons for roofs showed reductions in the R-values due to changing materials and constructions, adding strength to the argument that it was changes in the houses, not in the occupants, that were promoting mould growth.

### Insulation catches on

Until the early 1960s, when the local manufacture of glass fibre began, all house insulants were imported, and had a limited market of wealthy or knowledgeable householders.

In 1971, the Waimairi County became the first local authority to implement a thermal insulation bylaw. The objective was clean air, as the region had recurring air pollution problems. Its near neighbour, the Christchurch City Council, followed in 1972 with a range of R-values based on the windows as a proportion of wall area – some 35 years in advance of the new 2007 New Zealand Building Code Clause H1/AS1.

In 1972, BRANZ published a study of the economics of thermal insulation, prepared by Harry Trethowen and Ed Hubbard, which presented a proposal for minimum levels of house insulation based on calculation of the 'optimum expenditure on thermal insulation … to give the lowest overall capital plus running cost'. The analysis suggested the use of a recommended thermal standard at a 'level appropriate to the milder climate' – namely Auckland. This analysis later supported the development of NZS 4218P: 1977 *Minimum thermal insulation requirements for residential buildings*.

In April 1975, following the 1973/74 'oil shock' and the low hydro-lake storage, the Government implemented an interest-free loan scheme for insulating houses to minimum levels, and requirements were also established for houses built by or for Housing Corporation.

## Insulation made compulsory in 1977

On 25 November 1977, legislation was introduced making it compulsory for new homes to be insulated. These requirements came into force on 1 April 1978 and used NZS 4218P: 1977 ('P' for provisional). This was used as the Acceptable Solution (H1/AS1) under the Building Code. NZBC Clause H1 1992 also added a Verification Method (H1/VM1) based on the Building Performance Index (BPI) which was calculated using BRANZ's ALF tool.

In 1993 the Building Industry Authority started work to update the requirements, leading to a new standard, NZS 4218: 1996 *Energy efficiency – housing and small building envelope*. It was not until 26 June 2000 that the new requirements were promulgated and a further 6 months before they came into force, replacing NZS 4218P: 1977.

NZS 4218 was again updated in 2004, the main change being a limitation of the proportion of window area and the use of double glazing under the Schedule Method. Now, in 2007, NZBC Clause H1 is again being updated.

## Do-it-better recommended

The thermal insulation levels in the various NZS 4218 standards have always been minimums. 'Do-it-better' levels were a requirement of the Electricity Corporation of New Zealand's (ECNZ) 'Medallion Award Home' programme. PAS 4244: 2004 *Insulation of lightweight-framed and solid-timber houses,* supported by EECA, provided a range of 'better' and 'best' options for designers or householders wanting confidence in improving the thermal performance beyond the NZBC minimum. Interestingly enough, in the warmer parts of the country it is still possible to achieve minimum external heating requirements by the use of higher levels of thermal insulation.

**Table 1: Schedule method component R-values (mandatory levels in bold).**

| Year | Source and date | Roof $m^2$ °C/W | Wall $m^2$ °C/W | Floor $m^2$ °C/W | Glazing $m^2$ °C/W |
|---|---|---|---|---|---|
| 1950 | Bastings and Benseman | 0.6 | 0.7 | 0.7 | – |
| 1964 | Bastings | 0.6 | 0.7 | 0.7 | – |
| 1971 | Waimairi County | 1.2 | 0.7 | 0.9 | – |
| 1972 | Christchurch City | 1.0 | 1.0 | 1.1 | – |
| 1972 | BRANZ | 1.6 | 1.1 | 0.9 | – |
| 1975 | Government loan scheme minima | 1.6 | 1.6 | – | – |
| 1975 | NZ Housing Corporation | 1.6 | 0.9 | 0.8 | – |
| **1978** | **NZS 4218P: 1977** | **1.9** | **1.5** | **0.9** | – |
| 1987 | DZ4218 (review draft) | 2.6 | 2.0 | 0.9 | – |
| 1990 | DZ4218 (draft) | 3.0 | 2.0 | 0.9 | – |
| 1989 | Ministry of Energy (recommended) | 3.2 | 2.0 | 1.3 | – |
| 1991 | ECNZ Medallion Award | 3.0 | 1.5 | 2.0 | – |
| **1992** | **NZBC Clause H1/AS1** | **1.9** | **1.5** | **0.9** | – |
| 1996 | NZS 4218: 1996 * | 1.9 | 1.5 | 1.3 | – |
| **2000** | **NZBC Clause H1/AS1** | **1.9** | **1.5** | **1.3** | – |
| 2003 | PAS 4244: 2003 (Best) | 3.3 | 2.6 | 3.1 | 0.43 |
| 2004 | NZS 4218: 2004 | 1.9 | 1.5 | 1.3 | 0.15 |
| **2007** | **NZBC Clause H1/AS1** | **2.9** | **1.9** | **1.3** | **0.26** |

Note: * floor R-value calculation changed in 1996.

Values based on Wellington (climate zone 2) or named location.