Energy-efficiency in Housing for the Aged

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Karol E. Energy efficiency in housing for the aged. Gerontechnology 2003; 2(3):267-270. This paper reports on a case study that showed that when medium density housing for the aged in a temperate climate was designed to be energy efficient, indoor temperatures in summer and winter were outside an acceptable temperature range. The findings indicate that the current benchmarks for energy efficient design do not account for the relatively small floor area of aged persons' housing and the concerns of the elderly in relation to large areas of glazing.

Key words: energy efficient design, housing for the aged, temperate climate

One part of a doctoral thesis by the author of this paper looked at energy efficient design in medium density public housing for the aged in the temperate climate of Perth, Western Australia. Perth has a mean summer temperature of 24°C with low humidity (summer RH of 44%) and a mean winter temperature of 14°C[1].

The study of energy efficiency in housing for the aged is considered important at a time when the population is ageing. There is pressure to reduce dependence on fossil fuel for space heating and cooling. National building regulations are being proclaimed in Australia that require housing to be energy efficient and, concurrently, the Australian state and federal governments are encouraging the elderly to age in place. Energy efficient design can reduce dependence on fossil fuels and can minimize thermal stress on the frail aged without imposing an ongoing financial burden.

METHOD

In January 1999 six households from an award winning, energy-efficient public housing development for the aged in Perth (see picture on cover of this Issue) were asked to participate in a study looking at energy efficiency in public housing for the aged[2].

The development consists of nine, one and two bedroom single-storey, semi-detached dwellings between 50 and 65 m^2 in floor area. Each dwelling has a gas space heater. This particular development was chosen as the buildings closely adopted particular aspects of a well-established series of design benchmarks for energy efficient housing in Perth[3] such as an elongated plan proportion with the long axis running east west, a large area of northerly glazing and insulation requirements in the roof. However some aspects of design were identified as not complying with the design benchmarks[3]. Occupant behavior relating to indoor thermal conditions was assessed during two interviews, one in summer and the other in winter.

Indoor air temperatures in the dwellings were monitored during both summer and winter. One typical hot summer day (maximum 36.9°C and minimum 20.3°C) and one typical cold winter day (maximum 18.3°C and minimum 9.8°C) were identified as 'design' days[4]. Indoor temperatures on those design days were compared with temperatures considered to be acceptable in non-air-conditioned buildings[5] (Table 1).

As the monitored temperatures were found to be outside an acceptable range, a typi-

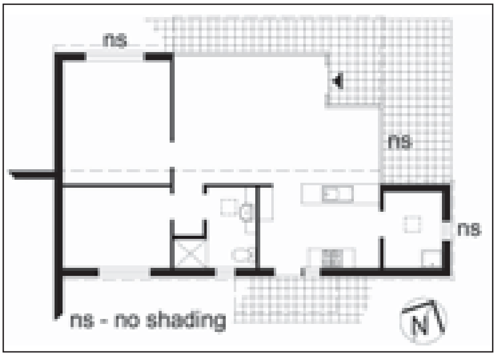

Figure 1. Plan of typical 2 bedroom dwelling

cal design (Figure 1) was modified to comply with benchmark requirements whilst still retaining the existing site plan and floor plan layouts. The modified design was empirically tested using a validated computer program, the Nationwide House Energy Rating Scheme for Australian conditions (NatHERS)[6]. This software, nominated for use in the national building regulations, analyses heat flows in a building and predicts hourly indoor temperatures.

RESULTS

Three significant building elements that did not comply with benchmark requirements were: (i) excessive glazing on the east side, (ii) some northerly and easterly unshaded glazing, (iii) lack of thermal mass in internal walls.

A summary of pertinent occupant responses regarding behaviour related to thermal conditions in the development is shown in Table 2. The percentages refer to the number of occupants giving a positive response to the issue compared to the total number of occupants interviewed in this development. Table 1 indicates four sets of temperatures on the design days: outdoor temperatures, average monitored indoor temperatures in non-air-conditioned dwellings, simulated temperatures in the typical dwelling if the dwelling is benchmark compliant, and acceptable indoor temperatures.

Table 1 Comparison and evaluation of temperatures in Summer and Winter season

	Summer (°C)		Winter (°C)	
	Maximum	Minimum	Maximum	Minimum
Design day outdoor	36.9	20.3	18.3	9.8
Monitored	33.3	24.0	20.8	15.6
Benchmark compliant	30.5	25.0	24.8	19.5
Acceptable	27.4 –without fan 30.4 –with fan	22.4	24.8	19.8

Table 2 Occupant responses to thermal conditions in energy efficient developments

Occupant Response	%
Curtains drawn to overcome lack of privacy	50
Excessive glare	33
Windows closed on summer nights to address security concerns	66
Occupant does a lot to reduce need for space heating	0
Difficulty with wide curtains	33
Air-conditioner installed by resident	50

DISCUSSION

If heating depends on direct solar radiation, the area of glazing needs to be sufficient to allow heat build-up during the day in winter to balance heat losses at night and there must be sufficient mass exposed to direct solar radiation and the indoor air to enable adequate thermal storage[7]. However in housing for the aged large areas of glazing, as required by benchmarks, create problems for the elderly, as indicated by occupant responses (Table 2), resulting in curtains being drawn to avoid concerns such as:

(i) high sensitivity to glare from direct sunlight[2,8];

(ii) a propensity to fall when floor surfaces have a high contrast in light levels; such as a patch of sunlight surrounded by shade[9];

(iii) a loss of perceived privacy as housing for the aged is more dense than typical suburban housing[2];

(iv) difficulty with maintaining and manually opening and closing wide curtains[2];

(v) potential for overheating on warm winter days .

When curtains are closed at night in winter and space heating is used, large areas of glazing are still problematic. In the monitored dwellings, curtains had no pelmets and generally were light-weight thus providing little resistance to heat transfer through glazing.

Irrespective of glazing area, in summer, shading of all glazing is essential for energy efficiency. In the typical dwelling, northerly glazing in the bedroom and easterly glazing in the living area were not shaded thus accounting for the high summer maximum temperature (33.3°C, Table 1). This lack of shading in all the dwellings accounts for the inordinately high number of occupants (50%) in this development that had decided to install an air-conditioner (Table 2). However, even if shaded, the heat gains during the day through any large areas of glazing are also problematic as seen in the benchmark compliant scenario (Table 1) where the minimum indoor temperature was 25°C although outdoor temperature fell to 20.3°C.

A lack of exposure of thermal mass in the floor slab to direct solar radiation and indoor air was noted in many dwellings. This is the result of either occupants generally moving into housing for the aged from larger premises and bringing a significant quantity of personal belongings, including furniture, that covers much of the floor area in smaller premises, or wall-to-wall carpet that insulates the thermal mass.

When the lack of exposure of thermal mass in the floor slab is considered in conjunction with the identified inadequate volume of thermal mass in brick walls compared to the benchmark requirements and in conjunction with occupants concerns with large areas of glazing, it seems that a proven form of indirect solar gain may be appropriate in housing for the aged. A Trombe wall[10] can be used. A Trombe wall is an equator-facing wall that is high in mass, high in conductivity and dark in colour, with glazing placed 20 to 50 millimetres in front of it. The air space between the glass and the wall is sealed so that solar radiation is mostly absorbed by the mass wall. This indirect solar collector can replace up to half the northerly glazing and reduces the problems associated with excessive glazing areas whilst still retaining window sizes typical in housing for the aged in Perth[2]. As a Trombe wall has at least double the thermal mass of a typical internal masonry wall, it would also contribute to stabilizing indoor temperatures.

A further modification to the current approach to energy efficient design would be to reconsider the recommended plan form as shown in Figure 1, where north and south walls are significantly longer than east and west walls, to allow maximum solar penetration on the north side. In buildings of small floor area the required area of northerly solar collection, (approximately 25% of floor area)[3], would readily accommodate a north wall that was no greater in length than the east or west wall. The resulting increased length of common walls between semi-detached dwellings would reduce the overall heat transfer through external walls and provide greater flexibility in site planning for energy efficient, medium density housing for the aged.

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