Thermal resistance measurements on brick veneer walls insulated with reflective foil

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Introduction

Increasingly high standards of thermal performance are being demanded from buildings as are low capital and running costs. To satisfy these sometimes conflicting requirements the designer must be equipped with the best possible information on the thermal performance of the building envelope. There is no shortage of available information on individual components, i.e. building materials, insulating materials and sealed airspaces. Unfortunately the performance of a built up wall or roof section is not always easy to characterise in terms of the component elements and the effects of air infiltration, ventilation, radiation and solar gain can be hard to quantify without direct experimental data.

This paper outlines an experimental project which has investigated brick veneer walls for winter conditions with particular reference to the increase in thermal resistance which can be provided by reflective foil insulation (RFI). Brick veneer is of particular interest as the majority of new houses built in Australia use this method of construction. Although there is growing interest in other forms of insulation for walls, reflective foil is the most popular insulation currently available.

The thermal resistance of brick veneer walls

Australian Standards AS 1903Q[1] and AS 1904Q[2] give a specification for RFI and a code of practice for its installation in brick veneer walls. It is usually fixed to the outside of the wall frame so that the wall cavity is divided into two reflectively bounded airspaces. Each of these airspaces has a higher thermal resistance than that of a single non-reflective airspace and since their contributions are additive, a much improved overall thermal resistance is possible.

There is no universally accepted set of thermal resistance values for brick veneer walls in Australia. The AIRAH Design Data ManualQ[3] is a popular source and gives the values reproduced in Figure 1, which apply for a non-ventilated cavity with isothermal surfaces and an air to air temperature difference of 12K across the wall.

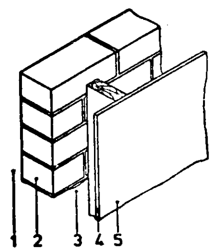
The values given, 0.5 m^2K/W and 1.5 m^2K/W for uninsulated and RFI insulated walls respectively, are convenient numerical values but they are specific to the conditions described above and if applied elsewhere are likely to be in error.

The thermal resistance of a brick veneer wall is influenced by many factors relating both to the construction of the wall itself and to external conditions. The thermal resistances of the airspaces are dependent upon the temperature differences across them, the rate of ventilation through and between them and the emittance of their surfaces. The thermal resistances of the other wall components, bricks, timber and interior lining are also temperature dependent but are generally small in relation to the overall thermal resistance of the wall. Finally there are the inside and outside film coefficients which are determined mainly by the rate of air movement across the surfaces but also by the nature of the surfaces.

Of the many influences on thermal resistance, ventilation of the cavity has been least well understood and regarded as potentially the most serious likely cause of reduced performance. In an uninsulated wall the entire cavity is ventilated to the roof space and also to the subfloor space if the house has suspended timber floors. With RFI attached to the outer edge of the frame, the outer airspace is still ventilated but the inner airspace is nominally sealed.

Further ventilation effects arise through the presence of interior wall vents and other gaps in the interior lining as well as through openings and penetrations in the RFI which allow exchange of air between the two airspaces. Negligible information has been available on the rate of air movement which can be expected in typical walls. Considering just the ventilated cavity, it

Construction	Resistance, R ($m^2.K/W$)
BRICK VENEER	
1. Outdoor air film	0.04
2. 90 mm brickwork	0.078
3. 150 mm airspace*	0.16
4. 10 mm gypsum board	0.059
5. Indoor air film	0.12
Total resistance, R_T	0.457
WITH RFL ON THE OUTSIDE OF FRAME:	
1. Outdoor air film	0.04
2. 90 mm brickwork	0.078
3. 50 mm reflective airspace#	0.61
4. Reflective foil laminate	0
5. 100 mm reflective airspace	0.61
6. 10 mm gypsum board	0.059
7. Indoor air film	0.12
Total resistance, R_T	1.517



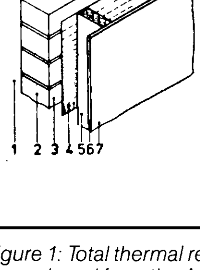


Figure 1: Total thermal resistance of brick veneer walls with and without RFI insulation (reproduced from the AIRAH Design Data Manual (1978) which has the term RFL (reflective foil laminate)).

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is likely that in relatively calm conditions the airflow is upwards due to natural convection. In gusty conditions, the speed and direction of airflow is much less predictable and likely to be highly variable. It is taken for granted that increased ventilation levels lead to lower thermal resistance in winter although the temperature and source of ventilation air are clearly relevant.

The effect of temperature difference on the thermal resistance of isolated airspaces is well understood as indicated in Figure 2 which is derived from the experimental results of Robinson and Powlitch.[4] These curves do not apply strictly for an airspace which is not sealed although the same trends may be expected at low ventilation rates. Specifically, the lower the temperature difference the higher the thermal resistance of an airspace, the effect being much greater with reflective airspaces. This can be viewed in terms of the driving forces for convection which decrease with falling temperature difference. For a given overall temperature difference, the use of multiple airspaces to achieve low individual temperature differences is therefore attractive.

Laboratory measurements

Laboratory measurements were undertaken in a guarded hot box heat transfer apparatus (see Figure 3). This was constructed essentially according to the ASTM standard,[5] with the addition of a facility to ventilate the cavity with a stable and adjustable updraft of cold air. The test wall was held between two chambers controlled at different temperatures representing indoors and outdoors and the heat flow through that part of the test wall covered by the metering box was measured. This was an area 920 mm x 1200 mm within the 2400 mm square test wall. In operation, temperatures within the chambers are set and regulated electrically with proportional controllers. These work in conjunction with adjustable base load cooling, provided where required by refrigeration systems which run continuously.

The brick veneer test wall was installed with the brick leaf within the cold chamber and the frame within the guard chamber which could be moved back on rails to open up the wall and allow access. Clearly this feature precluded the use of brick ties. Otherwise the test wall was of conventional construction, using 460 mm stud centres, full width noggings and 10 mm gypsum board lining. The 110 mm brick leaf was spaced 35 mm away from the frame with the wall closed up.

When RFI was used, it was installed on the outside face of the timber frame with the edges just reaching the top of the top plate and the bottom of the bottom plate. Two layers of 1350 mm wide foil were used giving an overlap of 300 mm at mid-height. Damage to the RFI was simulated with a standardised opening, consisting of pairs of crossed cuts 100 mm long with the edges bent inwards about 45°. These were distributed evenly over the test wall.

For tests involving antiglare RFI, a sample with an emittance of 0.15 was used. Samples from the manufacturers were measured and the emittance found to range from 0.07 to 0.30.

Thermal resistance measurements in the guarded hot box improved in accuracy as the temperature difference across the test wall was increased. For this reason a relatively high value of temperature difference was used for the majority of tests. The value of 18K was chosen because it is of the order of the highest temperature difference likely to occur in practice. On the other end of the scale, the 6K temperature tests provided results in the region of the lowest temperature difference likely to occur in winter. Actual temperature differnces and thermal resistance values will usually be between these two limits.

Field measurements

Guarded hot box measurements were made over a wide range of ventilation rates from zero up to almost 1 m/s in the 35 mm cavity. A field study was undertaken in order to determine within what limits cavity ventilation rates lie in

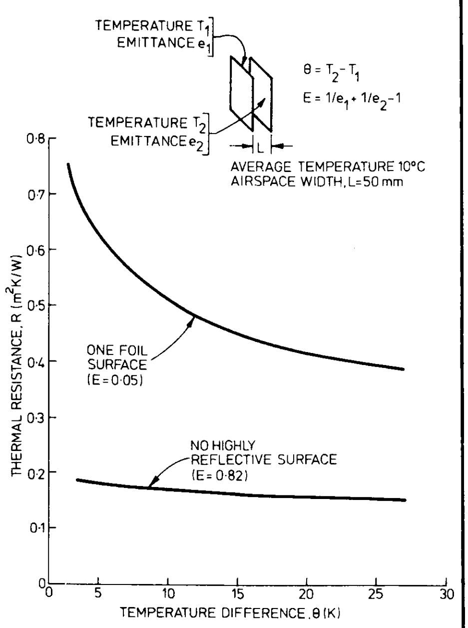

Figure 2: Thermal resistance of a plane vertical airspace for horizontal heat flow (calculated from data derived from Robinson & Powlitch (1954)).

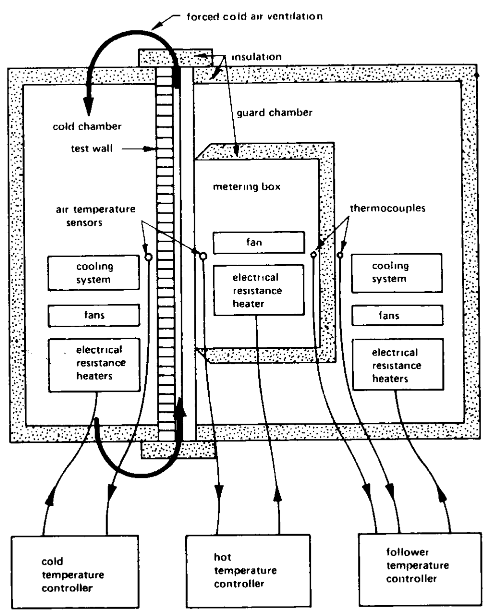

Figure 3: Guarded hot box schematic

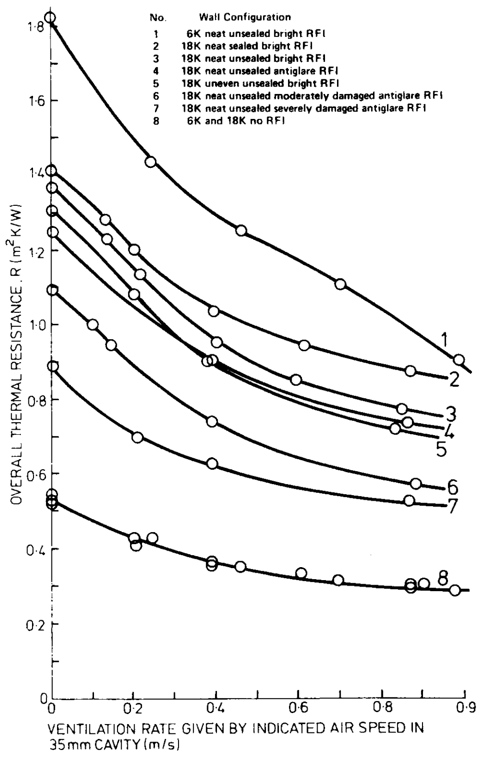

Figure 4: Measured overall thermal resistance of various wall configurations as a function of cavity ventilation rate.

actual houses. It was made possible by the development of two low cost thermal instruments, one for measuring the speed and the other for resolving the direction of very low speed air flow.

Ten test houses, which conveniently were new and not yet occupied, were available, most from the Victorian Ministry of Housing. The houses were of typical modern brick veneer construction; single storey with tiled roofs and on fairly flat ground on single building blocks with high paling fences between neighbours.

There was reasonable variety in floor and window type and locality. Three of the houses were of concrete slab on ground construction, the remaining seven having suspended timber floors. One house with uninsulated walls was included as a comparison. Despite being unoccupied, most houses were heated under timeclock control to follow a typical living pattern.

Probes for the speed and direction indicator were inserted side by side through 19 mm diameter holes drilled from outside through the bricks at about mid-height in the wall. Clear areas of wall were selected, carefully avoiding gas meters, switch boxes, external appliances, wall flues and areas with obvious plumbing.

Results

Results of the guarded hot box measurements are shown in Figure 4. Points representing individual experimental results are joined by smooth curves which represent a series of measurements of a particular wall configuration with different cavity ventilation rates: The ventilation rate has been specified in terms of air speed in the cavity since this is an easier quantity to deal with than volume flow rate per unit of wall length.

Curves 1 and 3 demonstrate the temperature dependent behaviour of reflective airspaces. The overall thermal resistance of this wall was about 25 per cent higher at a temperature difference of 6K than at 18K. This is a considerable difference but it is consistent with the airspace thermal resistance values at zero velocity suggested by Figure 2.

Curves 2 and 3 compare two test walls identical except for the degree of sealing around the RFI. For curve 3 the RFI was applied neatly with flat top and bottom edges and overlap. Nevertheless an improvement was evident when all these edges were taped over as curve 2 shows. The increae in thermal resistance was greatest at high ventilation rates, amounting to 12 per cent, suggesting that at lower ventilation rates, neatly applied RFI can seal off the inner airspace reasonably well.

When the bright RFI was replaced with antiglare RFI (with 0.15 emittance), careful attention was given to maintaining the same standard and detail of installation so that a comparison could be made directly. The result obtained is shown in curve 4. When compared with curve 3 a reduction in performance is visible ranging from nine per cent at zero ventilation rate to about four per cent at the highest ventilation rate. As one would expect, the difference is most substantial when the cavity is unventilated and therefore contributing a greater fraction to the overall thermal resistance of the wall.

To assess the importance or otherwise of a high standard of installation, a test was prepared where the RFI was applied rather poorly with few fixings and slightly buckled surfaces. This left slightly larger cracks at the overlap and at the top and bottom plates. The result is shown in curve 5 which is of similar shape to curve 3 but lower by about 0.05 m^2k/W. Although there is not a great loss in performance, neither was the condition of the RFI particularly bad.

When real damage was caused to the RFI curtain by making regular penetrations, the effects were considerable. This is shown with curves 6 and 7 for which the terms 'moderate' and 'severe' damage have been coined. The damage consisted of ten or thirty small penetrations as previously described, evenly distributed over the whole foil. It is notable that the value of the foil as a radiation barrier was negligibly affected by this level of damage, as less than one per cent of the foil area was involved, suggesting that the increased heat loss was caused by convection. Curves 6 and 7 should be compared with curve 4 as a case of neatly applied antiglare RFI and are lower by 17 per cent and 33 per cent respectively at zero cavity velocity.

Curve 8 is the superposition of three separate test results for uninsulated walls, two with 18K temperature difference and one with a temperature differnce of 6K. Within experimental error the three results were indistinguishable and a single best-fit curve is shown. These results are in accord with Figure 2 where the thermal resistance of an airspace with no highly reflective surfaces is shown as largely independent of the temperature difference.

Field study results for air speeds are summarised in Table 1. Data presented apply for the chosen heating period of 0600-2300 hours daily but these did not differ significantly from the results (not presented) for the full 24 hours daily. These results reflect the considerable variability in the long term average air speed which was encountered from wall to wall. Minute to minute and hour to hour variations were also considerable in some walls.

The direction of air movement was generally upwards, with occasional reversals which were more prevalent under gusty outside conditions. In the walls studied, air speeds were lower when concrete slab-on-ground construction was used but the sample was too small for this to be conclusively established.

The average velocity of ventilating air measured in the nine houses with RFI insulated walls was 0.06 m/s and correlation with outdoor wind speed was low. It should be noted that at this air speed the accuracy of the anemometers is no better than $\pm$ 0.02 m/sec. When the relatively small size of the sample of test walls is also considered it can be seen that 0.06 m/s may be regarded only as an indicative value of the cavity air speed.

However, if the measured thermal resistance values which correspond to this air speed are rounded to one decimal place they are proposed as reasonable estimates for practical use. These data are tabulated in Table 2 for both plain and antiglare surfaces and apply for a good standard of installation of the reflective foil. The resistance values for 18K and 6K temeprature differences were obtained directly from Figure 4 which shows that a loss in resistance of approximately five per cent may be attributed to the effects of cavity ventilation at 0.06 m/s. The values for 12K and 9K temperature differences were obtained by interpolation using Figure 2 in conjunction with the 18K and 6K data.

It is not a straighforward task to specify an appropriate temperature difference across brick veneer walls as it will depend upon time of day, time of year and locality as well as on internal temperature. Furthermore, as figure 2 suggests, the relationship between temperature difference and thermal resistance is not linear. The implication of this is that for a wall under varying conditions of temperature difference, the average thermal resistance is higher than the value of thermal resistance at the average temperature difference. It is difficult to quantify the extent of this effect since it is dependent upon the standard deviation of the temperature difference over the heating period.

Conclusions

The key element of this study has been the measurement under winter conditions of the thermal resistance of a number of brick veneer walls over a wide range of cavity air speeds, the results of which are shown in Figure 4. In fact, air speeds measured in the field were quite low, averaging 0.06 m/s as shown in Table 1. The thermal resistance values at about this rate of ventilation are therefore of greatest practical significance. These, as Table 2 shows, are in the region of 1.5 m^2 K/W for insulated walls where installation standards are good, but may be a little higher or lower depending on other conditions.

TABLE 1: Average air speeds in the wall cavities of ten test houses for the heating period 0600-2300 daily.

Length of test in days	House No.	Floor type	Comments	Average speed (m/s) N	S	E	W	Ave.
9	1	timber	no RFI	0.01	0.09	0.06	0.00	0.04
7	2	timber		0.13	0.02	0.12	0.20	0.12
7	3	concrete	same house	0.04	0.01	0.03	0.00	0.02
7	3		same house	0.03	0.02	0.02	0.00	0.02
8	4	timber		0.13	0.04	0.14	0.02	0.08
7	5	timber		0.02	0.02	0.01	0.03	0.02
13	6	timber		0.10	0.01	0.09	0.00	0.05
7	7	concrete		0.02	0.01	0.01	0.10	0.04
7	8	timber		0.05	0.12	0.17	0.01	0.09
8	9	timber		0.15	0.03	0.11	0.04	0.08
7	10	concrete		0.08	0.02	0.01	0.08	0.05

The published standard values for the thermal resistance of brick veneer walls have been found to be essentially correct under their assumed conditions. However, they fail to account for cavity ventilation and are therefore about five per cent optimistic compared with the figures in Table 2.

What has greatest bearing on the actual thermal resistance is the state of the RFI in terms of its surface emittance, condition and fixing detail and there is cause for concern about installation standards in the field. It may be optimistic to assume that the foil curtain will generally be neat, flat, complete and without penetrations. At the same time, local damage in a few stud-spaces will have little overall signifiance.

The thermal resistance of brick veneer walls depends also on the temperature difference at the time and will vary over the heating hours. This factor may complicate heat loss calculations but must be taken into account along with all the other factors if these calculations are to be accurate.

TABLE 2: Estimated thermal resistance of typical brick veneer walls with bright and antiglare reflective foil insulation and without insulation, based on experimental data from the guarded hot box with a ventilation rate of 0.06 m/s in the wall cavity and a good standard of installation

Air to air temperature difference (K)	Overall thermal resistance (m^2K/W) for the given insulation configuration: bright RFI	antiglare RFI	no RFI
6	1.7	1.5	0.5
9	1.5	1.4	0.5
12	1.4	1.3	0.5
18	1.3	1.2	0.5

References

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FEATURE

Seasonal thermal resistance of brick veneer walls incorporating RFI

By L. F. O'Brien, J. W. Spencer and R. E. Clarke

For a brick veneer wall insulated with reflective foil insulation (RFI), the thermal resistance is very dependent on the temperature difference across the wall. This paper describes a method for establishing a single-valued measure of the added resistance of brick veneer walls incorporating RFI for wintertime.

Summary

It has been customary to quote a single value for the thermal resistance of an element of a building, ignoring any temperature effects on the resistances of the individual components which could affect the overall result. For a brick veneer wall insulated with reflective foil insulation (RFI), the resistance is very dependent on the temperature difference across the wall. Recent work has established overall thermal resistance values for such walls for a range of temperature differences. For regulatory purposes, it would be convenient to have equivalent single values for the 'added' resistance provided by RFI which take into account the temperature effect.

This paper describes a method for establishing a single-valued measure of the added resistance for that period of the year when substantial home heating is required. It has been applied to the values of thermal resistance for shaded walls, for two heating regimes, and for 'bright' and 'antiglare' foil. Results are presented for six climatic locations representative of population centres in the temperate regions of Australia.

Introduction

Recent research by Clarke and O'Brien (1985) has provided steady state values of overall thermal resistance for a brick veneer wall with reflective foil insulation attached to the outer face of the timber frame (Fig. 1). The results were presented for a range of air-to-air temperature differences across the wall which are likely to occur in areas of Australia where substantial winter heating is required. Obtaining results for a range of temperature differences was necessary because it is well known that vertical airspaces, as occur in such a wall, have thermal resistances which are dependent on the temperature differences across them. (Within practical limits the results are not sensitive to the absolute temperature of the system.)

Presentation of results in this manner, however, has caused some difficulties because the temperature difference applicable for a given situation is uncertain. In particular, when regulations are contemplated concerning the mandatory insulation of dwellings with the requirement being stated in terms of 'added R values', such as those proposed by the Department of Minerals and Energy, Victoria (1984), it becomes desirable to provide single figures for the values of added resistance due to the presence of RFI.

This report establishes representative single values of added thermal resistance for a heated dwelling, by considering the hourly values of temperature difference occurring across a wall during the hours of heating over a number of heating seasons. The average of the resistances appropriate to the temperature differences provides a representative value of overall thermal resistance, for each location considered, from which added values are readily obtained. It is recognised that these values apply only to the particular wall used to establish the basic data obtained by Clarke and O'Brien; variations in construction technique and materials will result in differences in resistance but within Australia these are known to be small compared with the resistances of the reflective airspaces within the wall.

Further considerations

Neutral temperature

In determining the temperature difference across a wall of a heated dwelling, an assumption is required concerning the internal air temperature. It has been assumed that some form of thermostatic control on heating is present.

There is not a great amount of information available at present concerning preferred internal temperatures for Australian winter conditions. Australian Standard AS 2627 (Standards Association of Australia 1983) states 'with respect to T_i (the mean internal air temperature for a heating season) records of temperatures of heated (living) areas of partially insulated dwellings indicate a most common figure of 18°C'. Humphreys (1978), after analysing published comfort studies, has found a relationship between neutral temperature and mean outdoor temperature. The neutral temperature is that which provides conditions considered neither warm nor cold. Examination of 30 years of records provided by the Australian Bureau of Meteorology (1956), have provided mean outdoor temperatures for the cities listed in Table 1. Included in the table is the neutral temperature appropriate for each mean outdoor temperature, as suggested by Humphreys (1978). The standard error of prediction for this work is quoted at 1.5°C and so it is convenient to ignore the slightly higher neutral temperature for Perth and to adopt 21°C as the neutral temperature provided by Humphreys for all locations. In this paper, winter was considered as extending from April to October in line with AS 2627 Part 1 (1983), and average values of added thermal resistance for both 18°C and 21°C have been provided.

Heating regime

In this paper, the thermal resistance is considered only during the hours of heating. As published data are not available on patterns of heater operation, an 'intermittent' mode of operation has

Table 1. Mean winter (April to October inclusive) and neutral temperatures for listed Australian cities.

City	Mean winter temperature (°C)	Neutral temperature (°C)
Hobart	10.3	21.0
Melbourne	12.2	21.0
Mildura	13.5	21.5
Perth	15.2	22.0
Wagga	12.1	21.0

Source: Australian Bureau of Meteorology (1956)

L. F. O'Brien, J. W. Spencer and R. E. Clarke are employed by the CSIRO Division of Building Research.

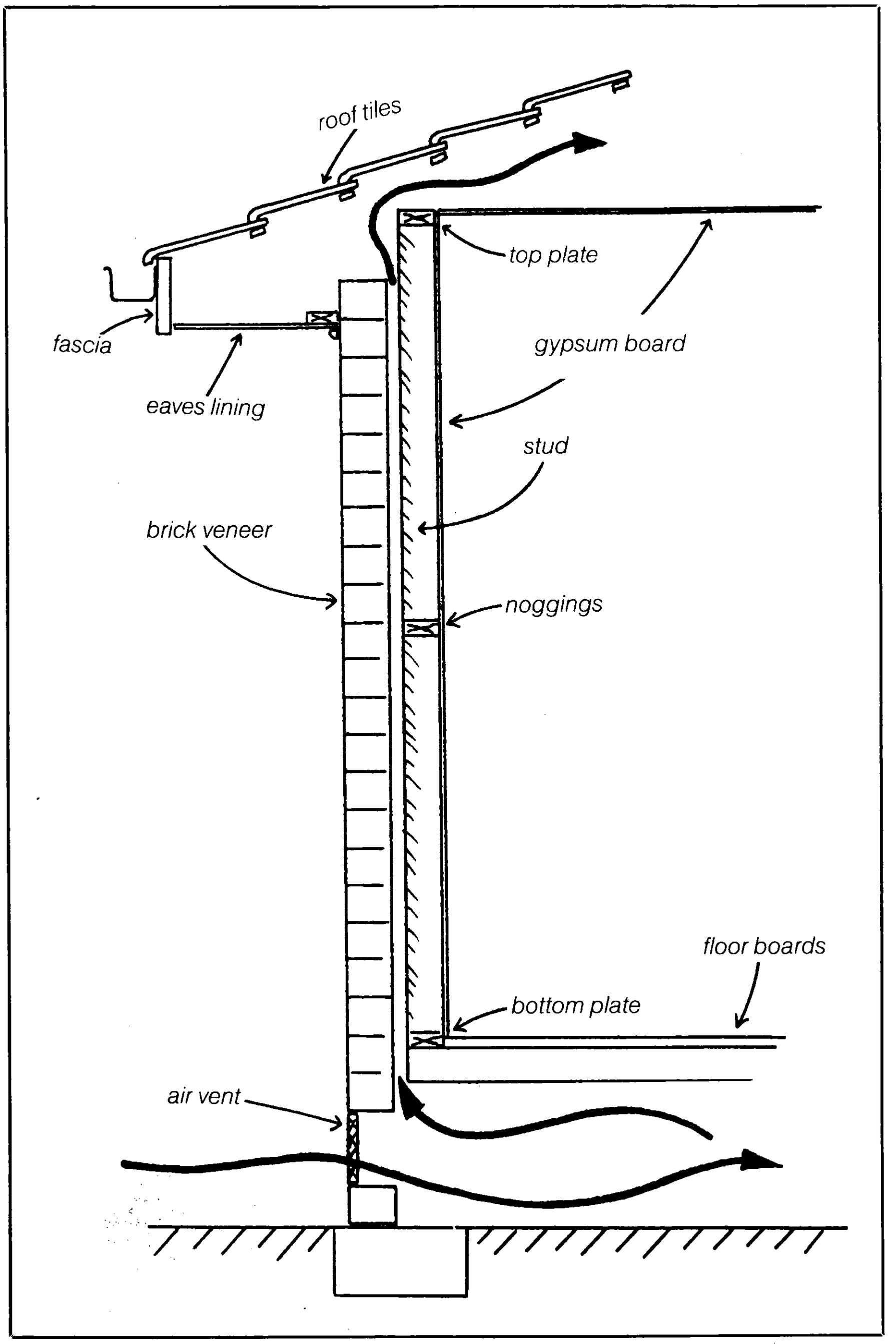

Figure 1. Typical brick veneer wall showing ventilation paths and position of RFI (some members omitted for clarity).

been assumed with heating provided between the hours of 0700-1000 and 1600-2200 and a 'continuous' mode which assumes heating between the hours 0700 and 2300.

Temperature difference

The temperature differences have been calculated as $(T_{iA}-T_{oA})$ for $T_{oA} < (T_{iA}-3)$ where T_{iA} and T_{oA} are the indoor and outdoor air temperatures respectively. The assumption has been made that heating is not required until the outdoor air temperature falls to less than $(T_{iA}-3)$. This is based on experience in the United States of America where, traditionally, degree days are calculated to a base temperature of 18.3°C which is considered equal to the 'balance point' of buildings, the balance point being defined as that external air temperature at which a building ceases to require heating. The difference of 2.8 K in air temperature between the balance point and the considered comfort temperature of 21.1°C is supplied by fortuitous gains from such sources as people, machinery, and lighting.

In this paper, the 2.8 K has been rounded to 3 K. Recent considerations [Burch and Hunt (1977), Mayer and Benjamini (1978)] have shown that modern, well-insulated homes with low air permeability have balance points less than those traditionally used. Application of thermal insulation lowered the balance point of the house studied by Burch and Hunt to 13.6°C.

Investigations into the appropriate balance point for Australian homes have not been reported in the literature and this paper takes it to be the traditional value of 3 K less than the internal air temperature.

Data

The variation of overall thermal resistance of a brick veneer wall insulated with RFI as a function of air-to-air temperature difference, ΔT, across the wall is presented in Fig. 2 for bright and antiglare foil for a cavity air velocity of 0.06 m/s. The curves were established from Fig. 2 of Clarke and O'Brien (1985) for $6 \leq \Delta T \leq 18$ K. Extension of the curves beyond this range established further data for $\Delta T = 3$ and 22.5 K. In addition, Robinson and Powlitch (1954) provided the basis for calculating the resistances of the airspaces within an RFI insulated brick veneer wall for $\Delta T = 0$ which, together with the resistances of the individual components, enabled an overall thermal resistance to be calculated. The points defining these curves are given in Table 2.

Since no theory was available to suggest any specific form of the relationship between ΔT and the resistance, polynomials in ΔT were obtained by using quasi-orthogonal Chebychev polynomials to fit the resistance values. A check was made to see that the resulting curves were smooth. The results are given in equations (1) and (2) below, where E_1 and E_2 are the emittances of the inward and outward facing foil surfaces respectively and where R_0 is the overall thermal resistance of the wall in m^2K/W.

(a) Bright foil ($E_1 = 0.05, E_2 = 0.05$):

$$R_0 = 3.133 - 0.492\,\Delta T + 0.0644(\Delta T)^2 - 0.00461(\Delta T)^3 + 0.000168(\Delta T)^4 - 0.0000024(\Delta)^5. \quad (1)$$

(b) Antiglare foil ($E_1 = 0.05, E_2 = 0.15$):

$$R_0 = 2.778 - 0.372\,\Delta T + 0.0369(\Delta T)^2 - 0.00181(\Delta T)^3 + 0.0000409(\Delta T)^4 - 0.0000003(\Delta T)^5. \quad (2)$$

Calculations

Hourly temperatures for each of the cities listed in Table 3 were taken from the Australian Climatic Data Bank [Walsh *et al.* 1983]. Hourly temperature differences were derived, R_0 values calculated using equations (1) and (2) for each relevant hour for continuous and intermittent heating, and the average overall thermal resistance for each case derived therefrom. The time for which records were examined to arrive at an average added resistance ranged from 7 years for Perth to 13 years for Melbourne.

As Clarke and O'Brien (1985) had measured the overall resistance of an uninsulated brick veneer wall to be $0.5m^2K/W$, average values of added resistance, R, were easily obtained by subtraction. This uninsulated resistance is unchanged regardless of temperature difference, the effect of temperature being small for the non-reflective surfaces involved.

Table 2. Data for establishing equations relating to air-to-air temperature difference, ΔT, and overall thermal resistance, R_o

ΔT (K)	R_o (m2K/W)		
	Bright	Antiglare	
0.0	3.10	2.78	
3.0	2.08	1.95	
6.0	1.71	1.53	
9.0	1.51	1.35	
12.0	1.41	1.27	
15.0	1.34	1.22	
18.0	1.30	1.18	
22.5	1.25	1.13	

Source: Clarke and O'Brien (1985).

Results

The results are summarized in Table 3 in which values of added thermal resistance have been presented for the 48 combinations of the four factors studied.

It can be noted that, generally, to the accuracy of presentation of results, the resistance is not dependent on the heating regime adopted. The results quoted in Table 3 show a maximum difference of 0.1 m^2K/W between heating modes, and as the implied accuracy of the table is 0.05 m^2K/W, the difference is not significant.

Table 3 shows that higher added resistances are obtained in the warmer climates as a result of the smaller temperature differences across the wall. The rapidly increasing overall thermal resistance as ΔT becomes smaller is apparent in Figure 2 which is produced from Table 2.

The antiglare surface for which these results were obtained had an emittance of 0.15. Samples available from the three principal manufacturers in the market place were measured and found to vary from 0.07 to 0.30. Obviously this variation would have considerable effect on the thermal resistance e.g. for Melbourne conditions, a change in emittance from 0.05 to 0.15 resulted in a loss of resistance of 20 per cent for intermittent heating. The results indicate that manufacturers should pay some attention to a method of achieving a consistent antiglare surface of low emittance.

These results apply to shaded walls, as the treatment of sunlit walls was outside the original field of investigation. There is a need for experimental research into the effect of sun on reflectively insulated brick veneer walls and its effect on the heat transmission. The increase in temperature of the sunlit brickwork would result in a decrease in the temperature drop across the reflectively insulated airspaces with a consequent increase in resistance of the airspaces. The effect, however, is expected to be small.

Conclusions

Single-valued estimates of added thermal resistance for shaded brick veneer walls insulated with two forms of RFI have been established for wintertime (1 April to 31 October) for six Australian cities which require substantial winter heating on the basis of a 3 K temperature increment from fortuitous gains.

It has been shown that:

(1) for the studied temperate regions of Australia, as represented by the data, single-valued estimates of added thermal resistance for walls insulated with bright foil ranged from 1.1 to 1.3 m^2K/W and from 0.9 to 1.2 m^2K/W for antiglare foil, for an indoor air temperature of 18°C.

(2) raising the internal air temperature from 18°C to 21°C resulted in a decrease of up to 11 per cent in resistance, and

(3) the regime of heating, i.e. continuous or intermittent as defined in this report, has no appreciable effect on the resistance.

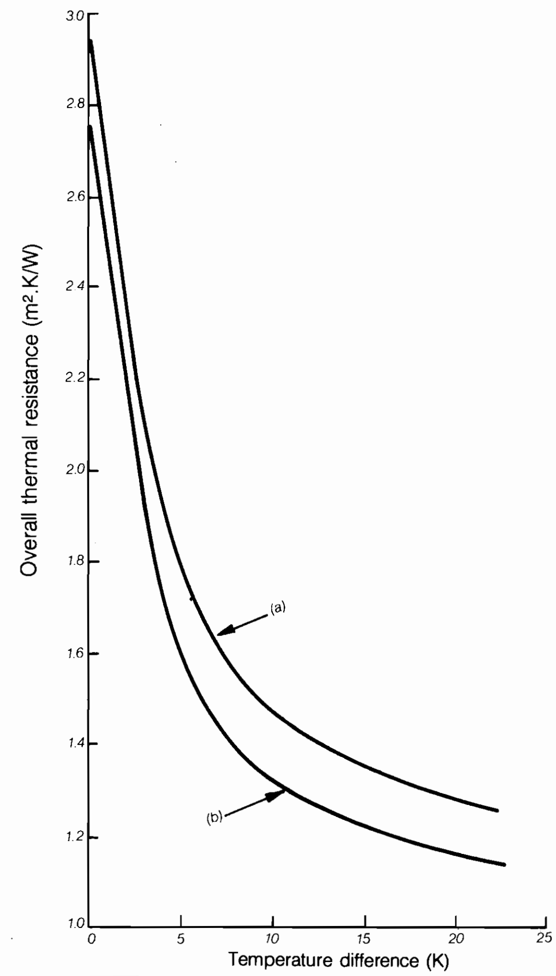

Figure 2. Variation of overall thermal resistance of a brick veneer wall incorporating RFI with air-to-air temperature difference. Curve (a) is for bright foil, and curve (b) is for 'antiglare' foil with one surface of emittance 0.15.

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Table 3. Mean added thermal resistance provided by RFI in a brick veneer wall in winter (April to October inclusive)

internal air temp. (°C)	Emittance of RFI surfaces	Heating mode	Mean added resistance, R (m^2K/W)					
			Hobart	Melb	Mildura	Perth	Wagga	Williamstown
18	0.05,0.05	Continuous	1.1	1.2	1.2	1.3	1.1	1.2
		Intermittent	1.1	1.2	1.2	1.3	1.1	1.2
	0.05,0.15	Continuous	1.0	1.0	1.0	1.2	1.0	1.1
		Intermittent	0.9	1.0	1.0	1.2	0.9	1.1
21	0.05,0.05	Continuous	1.0	1.1	1.1	1.2	1.0	1.2
		Intermittent	1.0	1.1	1.1	1.2	1.0	1.1
	0.05,0.15	Continuous	0.9	0.9	0.9	1.1	0.9	1.0
		Intermittent	0.8	0.9	0.9	1.1	0.9	1.0