3.0 Thermal Performance

Introduction

Energy savings in the operation of buildings are of particular importance as the cost of energy for heating and air conditioning in most cases represent the major cost factor in the operating cost of a building. The energy retention or loss characteristics of a building are directly related to the thermal performance of the building components.

The entrained air in the cellular structure of CSR Hebel AAC gives the product excellent thermal insulation properties, as well as good heat retention characteristics. These characteristics contribute significantly to the energy saving performance of the building, as highlighted in the example at the end of this section.

The thermal performance of buildings is an extensive subject which can not be dealt with thoroughly or given justice here. This section gives an overview of thermal performance, explanations of common terms, benefits of thermal insulation, and building regulations. This section should be read in conjunction with Appendix B, which provides a more descriptive explanations of the terms and background of thermal modelling.

An example is provided to emphasise the outstanding thermal performance of CSR Hebel AAC compared to traditional competitors of brickwork and blockwork.

Thermal Performance

Thermal performance is concerned with the energy retention or loss characteristics of a building system.

The thermal performance of buildings is affected by a complex relationship between all components of the structure, and the environment. Some elements of this relationship include:

- Windows which occupy a large percentage of the perimeter of the building. Their thermal performance depends very much upon the existence and operation of internal and external shading;
- The materials of which the walls are constructed affect not only steady state heat transfer, but also the transient response of the internal environment to daily external temperature changes. In this respect mass and specific heat are important physical properties;
- Ventilation is variable, depending both upon wind velocity, direction and site exposure, and on the management of windows and doors;
- Internal temperatures which vary throughout the day and from room to room; and
- During the day, solar radiation produces external temperatures which are higher than ambient “shade air” temperature, and which vary around the building envelop in accordance with orientation and exposure to the sun.

To accurately assess the influence of these various elements computer models have been developed to simulate the thermal performance of the total building system (see Appendix B). A less accurate method will be presented here, which can be used to obtain a feel for the thermal performance of a building component.

Why Thermally Insulate Buildings?

Thermal insulation for buildings is important for many reasons:

- Provide a very comfortable building environment, even in very hot climates;
- Protection of the structure against climatic influences leading to harmful moisture effects by means of water vapour condensation;
- Considerably less energy consumed by heating and cooling systems, and associated reduction of emissions into the atmosphere;
- Down-scaling the thermal design requirements; and
- Cost reduction for procurement and maintenance of down-scaled heating and cooling equipment.

Heat Transfer

Heat transfer occurs by heat flowing from a hot region to a cool region. In winter when buildings require internal heating, it is desirable to minimise the heat loss which flowing outwards through the external building components. Conversely in summer, it is desirable to minimise the thermal transmission which is flowing inwards through the external building components, especially through those that are directly exposed to the sun.

Heat flow is a function of three mechanisms; radiation, conduction and convection. These mechanisms are discussed more thoroughly in Appendix B.

Thermal Conductivity, λ

The thermal conductivity is a property of the material, which represents the quantity of heat per unit time in watts, that flows through a 1m thick even layer of material with an area of $1m^2$, across a temperature gradient of 1 K (Kelvin) in the direction of the heat flow.

Thermal Conductivity, λ The lower the value, the better the thermal insulation

Total Thermal Resistance of a Building Component, R_T

The total thermal resistance of a building component, R_T is equal to the sum of a number of individual thermal resistances, which are related to material type, internal and external surface air film, and air spaces. Following is a brief introduction to these thermal resistances, further more descriptive explanations are presented in Appendix B.

Thermal Resistance of a Material, R or R-value

The thermal resistance of a material is the resistance to heat flow between two surfaces at different temperatures. The thermal resistance of a material is expressed as the R-value and is a function of the material thickness and thermal conductivity. The calculation of the R-value of a material can be found in Appendix B. R-values for the various CSR Hebel products are set out in Table 3.1.

Thermal Resistance, R The greater the value, the better the thermal insulation

Table 3.1: Thermal Resistances for CSR Hebel Products

CSR Hebel Product		Product Dry Density (kg/m³)	Dry State Thermal Conductivity (W/m.K)	Product Thickness (mm)	Dry State Thermal Resistance R_{dry} (m².K/W)	5% M.C. Thermal Resistance R_{5MC} (m².K/W)
Thermoblok		470	0.11	100 150 200 250 300	0.86 1.29 1.72 2.15 2.58	0.71 1.07 1.43 1.79 2.15
Panels	Floor	550	0.13	100 150 200 250 300	0.72 1.09 1.45 1.81 2.18	0.60 0.90 1.21 1.51 1.81
	Wall	580	0.14	100 150 200 250 300	0.68 1.03 1.37 1.71 2.06	0.57 0.85 1.14 1.43 1.71
Sonoblok, Lintels		650	0.16	100 150 200 250 300	0.60 0.91 1.21 1.52 1.82	0.50 0.76 1.01 1.26 1.52

M.C. denotes moisture content of ACC.

Thermal Resistance of Air Spaces

When accurately calculating the total thermal resistance of a building component the thermal resistance of air spaces needs to be considered.

> **Thermal Resistance of Air Spaces**
> **The greater the value,**
> **the better the thermal insulation**

Thermal Resistance of Surface Air Film, R_S

When calculating the total thermal resistance of the building component between internal and external environments, the thermal resistance of the air layers adjacent to the surfaces, R_S must be considered.

> **Thermal Resistance of Surface Air Film, R_S**
> **The greater the value,**
> **the better the thermal insulation**

Thermal Transmittance, U

The thermal transmittance, U is a direct measure of the thermal insulating ability of a given building component air to air. It is obtained by reciprocating the total thermal resistance of the building component, R_T (i.e., $U = 1/R_T$).

> **Thermal Transmittance, U**
> **The lower the value,**
> **the better the thermal insulation**

Quantity of Transferred Energy, Q

The quantity of energy, Q (kWh) flowing through the building component can be calculated by multiplying the considered surface area and the heat flow rate of the building component. Energy can be determined from the following expression:

$Q = U . A . \Delta t . T \times 10^{-3}$

where,

U is the thermal transmittance of the building component ($W/(m^2.K)$)

A is the area of the building component under consideration (m^2)

Δt is the temperature difference between internal and external environments (K)

Note: a change in temperature of 1˚C is equal to a change in temperature of 1K

T is the period of time (hours)

Transferred Energy, Q
The lower the value,
the better the thermal insulation

This expression will give an indication of thermal performance, but the actual behaviour is more complex due to the non-uniform temperature behaviour of both internal and external environments, and the subsequent interaction with the building component. To quantify this behaviour computer models have been developed to simulate the thermal movements in a building system, for further information refer to Appendix B.

Building Regulations

In building regulations and standards, there are requirements to limit the amount of heat loss or thermal transmission through the external building components.

Some states such as the Victoria and the ACT, and some councils within other states, now require the thermal performance of a building to be assessed in order to obtain building approval. The method to be used, and the minimum standard to be achieved varies between states and councils. The most common form of regulation requires one of two methods of compliance to be used, the first being performance based, and the second being deemed to satisfy prescriptions. Either a minimum star rating is to be obtained from a thermal simulation program such as NatHERS or BERS (refer to Appendix B), or prescriptive measures relating to minimum insulation levels, and sometimes other measures relating to orientation and shading of windows and ventilation provisions.

The advantage of using the performance based path towards compliance is that it is possible to trade things which add amenity but reduce thermal performance for an increase in thermal performance elsewhere in the house. For example, west facing picture windows may take advantage of a wonderful view, but will increase the probability of overheating the house in the afternoon in summer. This could be offset by providing better ventilation or better contact with the cooler ground below the floor.

Prescriptive measures relating to the levels of insulation vary, depending on the authority requiring compliance. They may be described in terms of minimum additional R value of insulation required in the wall, ceiling or floor, or minimum total R value of the wall, ceiling or floor. Air film resistance may or may not be included in the total R value.

Condensation Control

Atmospheric water vapour will condense when it, or air containing it, comes into contact with a surface that is at or below the dew point temperature. Condensation of vapour within the building system should be considered by the designer. For an introduction to condensation control and calculations, see Appendix C. The calculations can be used to determine a minimum thickness of the base material to minimise the occurrence of condensation forming.

EXAMPLE

Thermal resistance calculation of uninsulated building elements, and what reduction in heat loss can be expected from using CSR Hebel AAC Wall System.

A dwelling with 120m^2 wall area. Basing calculations on an average minimum outside temperature of 5˚C (cold winter conditions) and an inside temperature of 20˚C.

Internal and External Surface Film Resistances are not included in the following examples.

- 200mm CSR Hebel AAC Block Wall with 2-3mm external texture coating + 10mm Gyprock® plasterboard internal lining.

  Total Resistance, R : 1.75 (m^2.K)/W
  Transmittance, U = (1)/R : 0.571 W/(m^2.K)

- Cavity Brick Wall with a 50mm Airspace

  Total Resistance, R : 0.82 (m^2.K)/W
  Transmittance, U = (1)/R : 1.22 W/(m^2.K)

- 190mm Core-filled Concrete Block Wall (2000kg/m^3)

  Total Resistance, R : 0.54 (m^2.K)/W
  Transmittance, U = (1)/R : 1.85 W/(m^2.K)

Heat loss through AAC wall, Q_{Hebel}
= U . A . Δt . T = 0.571 W/m^2.K x 120 m^2 x 15˚C x 10^{-3} = 1.028 kWh

Heat loss through 270mm cavity brickwall, $Q_{Cavity\ Brick}$
= U . A . Δt . T = 1.22 W/m^2.K x 120 m^2 x 15˚C x 10^{-3} = 2.196 kWh

Heat loss through 190mm core-filled concrete blockwall, $Q_{Core\text{-}filled\ Concrete\ Block}$
= U . A . Δt . T = 1.85 W/m^2.K x 120 m^2 x 15˚C x 10^{-3} = 3.330 kWh

Reduction in heat transfer over cavity brickwall = (1 – 1.028/2.196) x 100%
= 53.1%

Reduction in heat transfer over concrete blockwall = (1 – 1.028/3.330) x 100%
= 69.1%

Reduction in heat transfer by adopting Hebel AAC wall,
in place of 270mm cavity brickwork = 53.1%, or
in place of 200mm concrete blockwork (2000kg/m^3)= 69.1%

See Appendices B & C for further heat flow and condensation calculations.