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# Improved Standards of Insulation in Cavity Walls with an Outer Leaf of Facing Brickwork

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THE BRICK DEVELOPMENT ASSOCIATION

## INTRODUCTION

This Note deals with the implications for cavity walls with an outer leaf of facing brickwork when complying with the improved thermal insulation standards for external walls required by the Approved Document L1 1990 Edition of the Building Regulations. (Table 1) [1].

Designers are directed to the BDA publications "Cavity Insulated Walls — Specifiers Guide" [2] and "Good Practice Notes" [3] which give detailed guidance on the specification, design and construction of cavity walls incorporating insulation material in the cavity. The information contained in those publications remains valid for constructions meeting the improved levels of thermal insulation. Reference should always be made to the technical information supplied by the manufacturers of the particular insulating material being used.

This Note is restricted to the ways in which the improved standard can be met by the use of cavity insulation. Consideration is given to the significant contribution that can be made by the inner leaf.

Surface insulants fixed to the outer or inner surfaces of the cavity wall are outside the scope of this Note.

### *Table 1. The Improved Thermal Insulation Standards: 1990*

| Building Type | Maximum 'U' value (W/m²K) | | | | | |
|---|---|---|---|---|---|---|
| | Wall | | Roof | | Ground Floor | |
| | Former | Improved | Former | Improved | Former | Improved |
| Dwellings | 0.60 | **0.45** | 0.35 | **0.25** | None | **0.45** |
| Industrial Buildings | 0.70 | **0.45** | 0.70 | **0.45** | None | **0.45** |
| Other Buildings (e.g. Offices) | 0.60 | **0.45** | 0.60 | **0.45** | None | **0.45** |



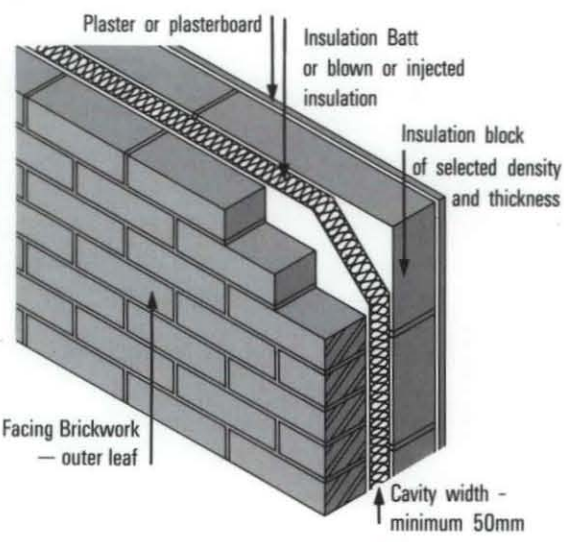
## CAVITY INSULATION SYSTEMS

Many specifers feel that it is an advantage to retain an air space between the outer leaf of the cavity wall and any insulation placed in the cavity because this feature maintains the "status quo" of the traditional cavity wall concept. Insulation, in slab or board form, fastened securely to the inner leaf masonry can achieve this partial-fill form of construction in new-build situations.

Full-fill cavity insulation can be built-in as construction proceeds by incorporating batts of glass fibres or mineral fibres. Alternatively the cavity may be filled after construction (retro-fit) by injecting plastic foam, or by blowing in glass fibre, or mineral fibre, or polystyrene beads or granules.

Building-in insulation is a simple and straight forward procedure but care is required to avoid distortion of the batts and the deposition of debris and mortar in the joints. An advantage of retro-fit methods is that the cavity can be visually checked before the insulation is installed.

Table 2 shows the properties of various types of cavity insulation materials.




TYPICAL FULL-FILL INSULATION SYSTEM

## *Table 2. Typical Properties of Cavity Insulation Materials*

| Product | British Standard | Density (kg/m³) | Thermal conductivity (W/mK) |
|---|---|---|---|
| **Partial Filled Cavity** | | | |
| RIGID SLABS OR BOARDS | | | |
| Expanded polystyrene bead board | 3837 | 15 – 20 | 0.034 – 0.037 |
| Extruded expanded polystyrene | | 20 | 0.028 |
| Mineral fibre | | 23 – 50 | 0.033 – 0.037 |
| Polyurethane boards | | 32 | 0.022 |
| Polyisocyanurate boards | | 28 | 0.022 |
| Foamed glass slabs | | 125 | 0.042 |
| Glass fibre slabs | | 16 – 28 | 0.033 – 0.037 |
| **Fully Filled Cavity** | | | |
| BATTS | | | |
| Mineral fibre | 6676 | 16 – 50 | 0.033 – 0.037 |
| Glass fibre | | | |
| BLOWN | | | |
| Mineral wool or fibre | 6232 | 30 – 70 | 0.037 – 0.040 |
| Glass fibre | | 18 – 22 | 0.031 |
| Polystyrene beads | | 12 – 18 | 0.035 – 0.040 |
| Polystyrene granules | | | |
| FOAMED | | | |
| Urea formaldehyde | 5617 | 10 | 0.040 |
| Polyurethane foam | | 11 – 16 | 0.037 |
| Polyurethane foam (cavity stabilisation) | | 36 – 40 | 0.023 |

## *DESIGN OPTIONS*

The calculation of a 'U' value for an external wall of 103mm brick, 50mm glass fibre insulation-filled cavity and 103mm brick produces a calculated figure of 0.6 W/m²K. This does not meet the new requirement. To improve the value to the required 0.45 W/m²K with double leaf construction several options are available.

(1) Thicker Insulation

(2) Insulation of Less Thermal Conductivity

(3) Thicker Inner Leaf

(4) Inner Leaf of Less Thermal Conductivity

(5) Plasterboard Dry Lining

(6) Combinations of any or all of above options

Tables 3 and 4 show the various cavity wall constructions that achieve a 'U' value of 0.45 W/m²K. Cavity walls may have an inner leaf of 100mm dense block through to 200mm of ultra lightweight block, with either wet plastered or dry lined plaster board finishes. The information given in Table 3 applies to a partially filled cavity wall. Table 4 refers to a wall in which the cavity is completely filled by insulation.

Four different Thermal Conductivity values of cavity insulating material are listed. This range which covers the majority of the insulating materials used in practice (see Table 2).

The thicknesses of cavity insulation have been calculated to give a 'U' value of exactly 0.45 W/m²K. In practice, the thickness of the insulation will be determined by commercial availability of the slabs or batts, or in the case of injected insulation (retro-fit), by the width of the cavity. The use of greater thicknesses than given will provide lower 'U' values than 0.45 W/m²K.

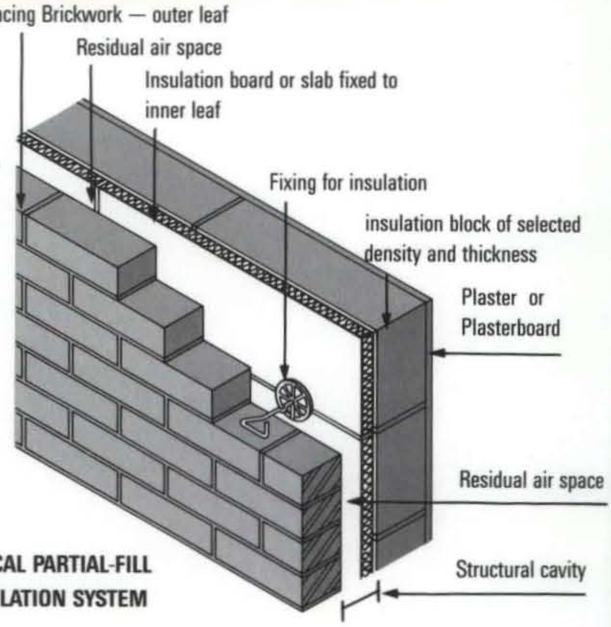
## OUTER LEAF OF FACING BRICKWORK

For the purposes of calculation in producing the tables of constructions (Table 3 and 4) the density of the brickwork in the outer leaf has been taken as 1800Kg/m$^3$ together with a moisture content of 5% by volume giving a corresponding Thermal Conductivity of 0.96 W/mK.

In practice, brickwork densities commonly vary from 1600 to 2000 Kg/m$^3$, (corresponding to Thermal Conductivities varying from 0.73 to 1.24 W/mK).The outer leaf of brickwork only contributes about 5% to the overall thermal resistance and any variation in the density of the brickwork has a very small effect on the thermal performance of the cavity wall.

## INNER LEAF OF FACING BRICKWORK

In some situations the inner leaf of a cavity wall may be required as facing brickwork with no internal plastering or lining. Tables 3 and 4 include such walls based on brickwork of 1800 Kg/m$^3$ density with a moisture content of 1% by volume giving a corresponding Thermal Conductivity of 0.71 W/mK.



**TYPICAL PARTIAL-FILL INSULATION SYSTEM**



### *Table 3. Thickness of Insulation (mm) within a Partially Filled Cavity required to achieve U-V*

| Inner Leaf* | | Ultra lightweight block 475 kg/m$^3$ 0.11 W/mK | | | | | | | | Lightweight block 600 kg/m$^3$ 0.19 W/mK | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Internal surface finish | | Wet plaster | | | | Plasterboard drylining | | | | Wet plaster | | | | Plasterboard drylining | | | |
| Thermal conductivity of cavity insulation | | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 |
| Inner leaf block thickness (mm) | 100 | 17 | 27 | 31 | 34 | 13 | 21 | 24 | 27 | 25 | 40 | 46 | 52 | 22 | 35 | 40 | 44 |
| | 125 | 12 | 19 | 22 | 24 | 8 | 13 | 15 | 17 | 22 | 36 | 41 | 46 | 19 | 30 | 34 | 38 |
| | 150 | | 11 | 12 | 14 | | 5 | 6 | 7 | | 31 | 35 | 40 | | 25 | 29 | 32 |
| | 200 | | 0 | 0 | 0 | | 0 | 0 | 0 | | 22 | 25 | 28 | | 16 | 18 | 21 |

* Thermal conductivity values for blockwork and brickwork are taken fr

## INNER LEAF MATERIALS

It is the cavity insulation which normally makes the major contribution to the overall thermal resistance of the wall: the inner leaf contributes to varying degrees depending upon its density and thickness.

Lower density blocks have better insulating properties than those of higher density. In recent years very low density concrete blocks have been made available in response to requirements for improved thermal resistance in masonry walls. However, low density is associated with low compressive strength and the structural requirement of a wall can dictate a certain minimum compressive strength which precludes the use of blocks of very high thermal resistance.

Four different densities of blocks for the internal leaf of the wall are considered in the Tables of Constructions (Tables 3 and 4). These densities are typical for the concrete blocks commonly available for cavity wall contruction.

Some hollow blocks contain insulating material within their voids or insulating material may be bonded to the face of the block. These composites have not been included in Tables 3 and 4 due to the wide range available. Designers may substitute such composites as appropriate.

## INTERNAL FINISHES

The two most common internal finishes are wet plaster and plaster board dry lining. The latter contributes more to the overall thermal resistance of the wall. Composite boards having insulants prebonded to plasterboard are available as dry lining to the inner leaf of masonry. Owing to their wide variety these are not included in the examples in the tables.



**ue of 0.45 W/m²K (Facing Brickwork Outer Leaf)**

| Medium density block 1400 kg/m³ 0.51 W/mK | | | | | | | | Dense block 2300 kg/m³ 1.63 W/mK | | | | | | | | Brickwork 1800 kg/m³ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wet plaster | | | | Plasterboard drylining | | | | Wet plaster | | | | Plasterboard drylining | | | | Brickwork | | | |
| )22 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 |
| 32 | 52 | 59 | 66 | 29 | 46 | 52 | 59 | 35 | 56 | 65 | 73 | 32 | 50 | 58 | 65 | 35 | 56 | 64 | 73 |
| 31 | 50 | 57 | 64 | 28 | 45 | 51 | 57 | 35 | 56 | 64 | 72 | 32 | 50 | 58 | 65 | | | | |
| | 48 | 55 | 62 | | 43 | 49 | 55 | | 55 | 63 | 71 | | 50 | 57 | 64 | | | | |
| | 45 | 51 | 58 | | 39 | 45 | 50 | | 54 | 62 | 70 | | 49 | 56 | 63 | | | | |

n C.I.B.S.E. Guide A3 Thermal Properties of Building Structures 1980.

## APPLICATION OF TABLES

Some examples of how these tables can be used for determining alternative solutions are given below.

**Case 1 — Determine Blown Insulation for an Existing Cavity Wall**

Inner Leaf:
wet plastered, lightweight block (100mm).

Cavity: 50mm

Outer Leaf:
103mm clay or calcium silicate facing brick (1800 Kg/m³).

What types of injected insulation can be used to obtain a 'U' value of at least 0.45 W/m²K?

Referring to Table 4, it shows under the lightweight block/wet plastered column, that a Thermal Conductivity for the insulation between 0.035 and 0.040 W/mK is required. Table 2 shows that the majority of retro-fit applied materials are likely to meet, or exceed, this requirment.

**Case 2 — Determine Thickness of Partial Fill in a Proposed Wall Design**

Inner leaf:
Wet plastered ultra lightweight block (150mm).

Cavity: 50mm.

Outer Leaf:
103mm clay or calcium silicate facing brick (1800 Kg/m³).

What thickness of expanded polystyrene bead board fixed in the cavity is required to ensure that a maximum 'U' value of 0.45 is not exceeded?

Reference to Table 2 gives a typical thermal conductivity for eps board of 0.035 W/mK. Looking under the appropriate column in Table 3 shows that a minimim thickness of 11mm is required. Commercially available 25mm thick board would therefore be more than adequate. This would mean that the residual air space in the cavity would be restricted to 25mm if a standard 50mm structural cavity was specified. The residual air space would present difficulties of construction and present a risk of water penetration. An increase of structural width to 75mm should therefore be considered so that a residual air space of 50mm is provided.



***Table 4. Thickness of Insulation (mm) within a Completely Filled Cavity required to achieve U***

| Inner leaf* | | Ultra lightweight block 475 kg/m³ 0.11 W/mK | | | | | | | | Lightweight block 600 kg/m³ 0.19 W/mK | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Internal surface finish | | Wet plaster | | | | Plasterboard drylining | | | | Wet plaster | | | | Plasterboard drylining | | | |
| Thermal conductivity of cavity insulation | | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .04 |
| Inner leaf block thickness (mm) | 100 | 21 | 33 | 38 | 43 | 17 | 27 | 31 | 35 | 29 | 46 | 53 | 59 | 25 | 41 | 46 | 52 |
| | 125 | 16 | 25 | 29 | 32 | 14 | 22 | 26 | 29 | 26 | 42 | 48 | 54 | 22 | 36 | 41 | 46 |
| | 150 | | 17 | 20 | 22 | | 12 | 13 | 15 | | 37 | 42 | 48 | | 32 | 36 | 41 |
| | 200 | | 1 | 1 | 1 | | 0 | 0 | 0 | | 28 | 32 | 36 | | 22 | 26 | 29 |

*Thermal conductivity values for blockwork and brickwork are taken

**Case 3 — Determine Inner Leaf Thickness Required in Conjuction With Full Fill Insulation**

Inner leaf:
Wet plastered lightweight block.

Cavity:
50mm filled with eps beads (thermal conductivity 0.040 W/mK)

Outer leaf:
103mm clay or calcium silicate facing brick (1800 Kg/$m^3$).

What thickness of inner leaf block is required to ensure that a 'U' value of 0.45 is not exceeded?

Referring to Table 4, it shows that a 125mm block is required. Alternatively a 100mm block would meet the requirements if a plasterboard drylining finish was used instead of wet plastering.

The tables give general guidance to a designer when various combinations of components are being considered. Where the tables indicate that compliance is critical any final decision should be checked by calculation using the appropriate Thermal Conductivities for the proprietary material and the method described in the C.I.B.S.E. Guide A3

Controlling Authorities may also require calculation to prove conformity with requirements.

**Application of 'Super' Insulation Materials**

Some materials suitable for cavity insulation have a thermal conductivity value which is appreciably lower than the more conventional materials.

Expanded polyurethane has a thermal conductivity value of 0.020 — 0.022 W/mK and similar values are quoted for polyisocyanurate board. These materials are more expensive than conventional thermal insulants but in certain situations may provide a convenient solution to the problem of meeting more stringent 'U' value requirements. Tables 3 and 4 include these materials.



***lue of 0.45 W/m²K (Facing Brickwork Outer Leaf)***

| Medium density block 1400 kg/$m^3$ 0.51 W/mK | | | | | | | | Dense block 2300 kg/$m^3$ 1.63 W/mK | | | | | | | | Brickwork 1800 kg/$m^3$ | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wet plaster | | | | Plasterboard drylining | | | | Wet plaster | | | | Plasterboard drylining | | | | Brickwork | | | |
| 22 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 | .022 | .035 | .040 | .045 |
| 36 | 58 | 66 | 74 | 33 | 52 | 60 | 67 | 39 | 63 | 72 | 81 | 37 | 57 | 65 | 73 | 43 | 68 | 77 | 87 |
| 35 | 56 | 64 | 72 | 32 | 51 | 58 | 72 | 39 | 62 | 71 | 80 | 35 | 56 | 64 | 72 | | | | |
| | 55 | 62 | 70 | | 49 | 56 | 63 | | 62 | 70 | 79 | | 56 | 64 | 72 | | | | |
| | 51 | 58 | 66 | | 46 | 52 | 59 | | 61 | 69 | 78 | | 55 | 63 | 71 | | | | |

m C.I.B.S.E. Guide A3 Thermal Properties of Building Structures 1980.

## TECHNICAL CONSIDERATIONS

**Durability of Outer Leaf Materials**

Although the use of cavity insulation will influence the temperature of the outer leaf, in practice there is no evidence to show that insulation values of 0·6 $W/m^2K$ induce frost damage in walls which are properly specified, designed and constructed. It is unlikely that improved insulation values would change this situation.

**Rain Penetration**

When improving the insulation value of walls to 0·45 $W/m^2K$ no departure from established techniques of cavity insulation need be made and therefore the likelihood of water penetration will not be increased. When using partial-fill systems the residual air spaces should not be less than 50mm. However, the British Board of Agrément does permit the use of certain partial-fill systems with residual air spaces of less than 50mm in walls sheltered from exposure to wind driven rain. When using such materials careful compliance with the manufacturers instructions regarding application and installation is essential.

**Wall Ties in Wider Cavities**

Some of the options for achieving the improved 'U' value require cavities wider than the standard 50mm.

Table 3 shows that the maximum cavity width to meet the 0.45 $W/m^2K$ requirement can be greater than 100mm when an adequate allowance is made for the residual air space.

The double triangle tie to B.S.1243:1978[4] is appropriate for use in cavities not exceeding 100mm wide. In all wider situations the vertical twist steel tie to the same B.S. must be used. The ties are offered in standard sizes and in all cases the correct length is the cavity width plus a minimum embedment of 50mm into each leaf of the masonry. In partially filled cavities the position of the wall tie drip must be related to the residual air space.

**Cold Bridging**

As thermal insulation standards for walls improve, more care must be taken when designing the construction to avoid cold bridging across the cavity at positions such as the jambs, cills and heads of openings.



## REFERENCES

**1.** Building Regulations 1985. Conservation of Fuel and Power. Approved Document L1.1990 Edition.

**2.** Cavity Insulated Walls Specifiers Guide. B.D.A. Reference CIW-2, January 1987

**3.** Good Practice Notes. B.D.A. Reference CIW-1, September 1984

**4.** BS 1243:1978. Specification for Metal Ties for Cavity Wall Construction.

*Front Cover:The Needham Research Institute, Cambridge.*
*Architects: Lyster, Grillet & Harding.*
*Facing Brickwork: 75 mm expanded polystyrene board partial fill insulation: 100 mm lightweight concrete block inner leaf — the construction has a calculated U-value of 0.32 $W/m^2K$*

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